



# Proceeding of

The 5<sup>th</sup> International Conference on Agro-Industry  
“Agroindustry 4.0 : Digital Transformation in Agro-Food Value Chains”



Endorsed by



Hosted by  
Department of Agro-industrial Technology  
Universitas Gadjah Mada

2018  
**ICoA**  
International Conference on Agro-Industry

Sponsored by



**RNI**



**PROCEEDING OF  
THE 5<sup>TH</sup> INTERNATIONAL CONFERENCE  
ON AGRO-INDUSTRY**

*“Agroindustry 4.0 – Digital Transformation on Agro-food Value Chains”*

26-27 September 2018

The Anvaya Beach Resort, Bali, Indonesia

**DEPARTMENT OF AGRO-INDUSTRIAL TECHNOLOGY  
FACULTY OF AGRICULTURAL TECHNOLOGY  
UNIVERSITAS GADJAH MADA**

## PROCEEDING OF THE 5<sup>TH</sup> INTERNATIONAL CONFERENCE ON AGRO-INDUSTRY

### Agroindustry 4.0 – Digital Transformation on Agro-food Value Chains

#### Organizing Committee

General Chair : Dr. Adi Djoko Guritno  
 General Co-Chair : Dr. Wahyu Supartono  
 Secretary : Dr. Nafis Khuriyati  
 Treasury : Dr. Novita Erma Kristanti  
 Arrangement Chair : Dr. Anggoro Cahyo Sukartiko  
 IT Support : Darmawan Ari Nugroho STP, MP  
 Logistic & Accommodation: Muhammad Prasetya Kurniawan, STP, M.Sc; Moh. Wahyudin, STP, M.Sc; Annisa Dwi Astari, STP, MT; Megita Ryanjani Tanuputri, STP, M.Sc

Steering Committee : Dr. Adi Djoko Guritno  
 Prof. Dr. I Ketut Satriawan  
 Dr. Luh Putu Wrsiati

Peer Review : Dr. Adi Djoko Guritno – Universitas Gadjah Mada – Indonesia  
 Dr. Bjorn Santos – De La Salle University Araneta – Philippines  
 Prof. Dr. Yu-Pin Lin – National Taiwan University – Taiwan  
 Dr. Pornthap Thanonkeo – Khon Kaen University – Thailand  
 Prof. Dr. I Ketut Satriawan – Udayana University – Indonesia  
 Dr. Imam Santoso – Brawijaya University – Indonesia  
 Dr. Budiyanto – Bengkulu University – Indonesia  
 Dr. Totok Pujiyanto – Padjadjaran University – Indonesia  
 Dr. Wahyu Supartono – Universitas Gadjah Mada – Indonesia  
 Dr. Anggoro Cahyo Sukartiko – Universitas Gadjah Mada – Indonesia  
 Dr. Nafis Khuriyati – Universitas Gadjah Mada – Indonesia  
 Dr. Novita Erma Kristanti – Universitas Gadjah Mada – Indonesia

Editor-in-Chief : Dr. Adi Djoko Guritno

Layout : Annisa Dwi Astari, STP., MT.  
 Rizky Brisha Nuary, STP  
 Rosa Amalia, STP

ISBN : 978-979-18918-6-8

**Publisher:**

Departemen Teknologi Industri Pertanian

Fakultas Teknologi Pertanian

Universitas Gadjah Mada

Flora No. 1 Bulaksumur, Yogyakarta- Indonesia 55281

Telp and Fax : (0274) 551219

Email : [tip@ugm.ac.id](mailto:tip@ugm.ac.id) <http://tip.ugm.ac.id/>

1<sup>st</sup> Edition, October 2019

xii + 197 pgs., 21 x 29,7 cm



## Editorial Preface

The 5<sup>th</sup> International Conference on Agro-industry (ICoA) was held on September 26-27, 2018 in Bali, Indonesia. The conference is organized by Department of Agro-industrial Technology, Universitas Gadjah Mada in collaboration with Department of Agro-industrial Technology, Universitas Udayana. The conference also held in conjunction with the annual meeting of Indonesian Association of Agro-industry Technologist (APTA) and well joined by our distinguished colleagues from Ehime University, De La Salle Araneta University, Kasetsart University and International University of Japan. In its 5<sup>th</sup> implementation, ICoA was attended by more than 100 participants from various countries, such as Indonesia, Germany, Japan, Taiwan, Thailand and Myanmar. The 5<sup>th</sup> ICoA 2018 also brought together academics, experts and researchers who presented and discussed the most recent developments and future trends in agro-industrial sector.

The theme chosen for 5<sup>th</sup> ICoA 2018 is “Agro-industry 4.0 – Digital Transformation on Agro-food Value Chains”. The topics covered included but were not limited to: supply chain management, marketing and consumer issues, food and science technology, engineering and production system in agroindustry, and sustainable agroindustry. This proceeding is a compilation of selected papers that presented during the 5<sup>th</sup> ICoA 2018. We hope that these papers will immensely benefit to the agro-industry society, academics and industrial practices. Lastly, on behalf the conference organizers we would like to thank the program chairs, reviewers, scientific committee, and supporting staff for their contributions to the publication of 5<sup>th</sup> ICoA 2018 Proceeding.

Editor-in-Chief

Dr. Adi Djoko Guritno

## General Chair Greeting

The development of agro-industry is something that should be augmented and reinforced as this sector has been regarded to have a significant contribution to economic growth. The agro-industrial sector provides plenty of opportunities for transforming its comparative advantages into competitive ones because of its linkages to both upstream and downstream industries. Nevertheless, there are some aspects in agro-industry that should be strengthened and improved particularly to enter the current era of industry 4.0.

Industry 4.0 was marked by a rapid pace of transformation in which the aspect of technological mastery become the key determinants of competitiveness. Some technologies especially digital ones such as Artificial Intelligence, Big Data, and Internet of Things (IoT) have become the main technology that supports the implementation of industry 4.0. In the agro-industrial sector, the digital transformation will bring many changes with all the consequences. The integration between digitalization and agro-industry (Agro-industry 4.0) is projected to further maximize the potential development of business and innovation, as well as to improve the process and delivery of its value. This opportunity is also expected to potentially allow agro-industry to be more sustainable and conserved its presence.

Trying to enrich the synergy development of agro-industry 4.0, the Department of Agro-industrial Technology, Universitas Gadjah Mada, Indonesia is initiating a contribution to the development of agro-industry that is capable to meet changing market requirement, both nationally and globally. Supported in a fund by Tetra Pak, Rajawali Nusantara Indonesia, Aneka Tambang, and Gruene Punkt, we proudly hold the 5<sup>th</sup> International Conference on Agro-Industry (ICoA) 2018: Agro-industry 4.0 – Digital Transformation on Agro-food Value Chains. This event is well joined by our distinguished colleagues from Udayana University, Ehime University, De La Salle Araneta University, Kasetsart University and International University of Japan. The ICoA 2018 had invited academics, professionals and researchers to presented and discussed the most recent developments and future trends in agro-industry from various aspects. Thus, we hope that the ICoA 2018 will immensely benefits for the development of agro-industrial sector.

Finally, we would like to express our sincere gratitude to the editors, guest editors, scientific committee, and organizing committee for the valuable contribution upon the publication of this international proceedings.

Yogyakarta, September 2019

General Chair of ICoA

Dr. Adi Djoko Guritno

## Table of Contents

Editorial Preface .....	iv
General Chairman Greeting .....	v
Keynote Speaker Profile .....	viii
Invited Speaker Profile .....	x
 <b>Preparation of Standard Operating Procedures (SOP) of Broccoli Handling at PT. X Bandung</b>	
Totok Pujianto, Arif Rahman and Irfan Ardiansah .....	1
<b>Consumer's Awareness and Adoption for QR Payment at Traditional Trade in Bangkok</b>	
Passaraporn Thongtha and Ajchara Kessuvan .....	13
<b>Discriminant Analysis of Consumer Intention to Use Green Packaging in Thailand</b>	
Boonsita Vichienvanitchkul, Apichaya Lilavanichakul .....	19
<b>Designing Herbal Cosmetics Marketing Channel</b>	
Preuk Petsophonsakul and Chutima Waisarayutt.....	26
<b>Purwaceng Coffee Formulation Based on Consumers Preference</b>	
Julianisa, D.S., Aziz, I.W.F and Jumeri .....	35
<b>Development Marketing Strategy of Salak Pondoh (<i>Sallaca Zalazza</i> (Gaert.) Voss.) Based on Marketing Mix</b>	
Pitaloka Ayustina, Novita Erma Kristanti, Suharno.....	41
<b>Black Rice Agroindustry in Sleman, Yogyakarta: Early Analysis</b>	
Dyah Ismoyowati, Anisah Riyadi, Ardhan Rifai, Endy Suwondo and Tririni Nuringtyas....	51
<b>Analysis of Consumers Perceptions of the Important Factors in Soygurt Products and Marketing Strategies</b>	
Atris Suyantohadi, Mirwan Ushada and Dody Kastono .....	55
<b>The Effectiveness of Instagram Use in Florist Marketing</b>	
Geraldo Herawan, Suharno and Nafis Khuriyati .....	64
<b>Analysis of Consumer Preference Towards Organic Products at Istana Sayur Grocery Shop Malang City Indonesia</b>	
Ika Atsari Dewi, Panji Deoranto, and Diannisa Hadianiti.....	77
<b>Nursery Garden Development Strategy as Educational Tourism Using Swot Analysis and Multi-Attribute Utility Theory (MAUT) (Case Study On Kebun Bibit Kediri)</b>	
Panji Deoranto, Septiana Rosari and Rizky L.R Silalahi .....	84
<b>Immature Black Vinegar Extract Activates Macrophages</b>	
Eri Ishii, Kosuke Nishi, Momoko Ishida, Masanobu Nagano, Kazunori Hashiguchi, Akira Fujii and Takuya Sugahara .....	92

<b>Anti-Inflammatory Effect of Placenta Water-Soluble Extract on Macrophages</b>	
Miyuki Yokotani, Kosuke Nishi, Yoshiharu Sasaki and Takuya Sugahara.....	98
<b>Anti-Allergic Effect of Clove</b>	
Ange Murielle DjidjouTagne, Momoko Ishida, Hiroyuki Onda, Kosuke Nishi and Takuya Sugahara .....	104
<b>Anti-Inflammatory Effect of Aqueous Extract from Kawachi-Bankan Peel on Lipopolysaccharide-Induced Inflammatory Responses in RAW264.7 Cells</b>	
Momoko Ishida, Chihiro Takekuni, Kosuke Nishi and Takuya Sugahara .....	110
<b>Anti-Inflammatory Effect of Lysozyme</b>	
Ayuka Tagashira, Kosuke Nishi, Shinya Matsumoto and Takuya Sugahara .....	115
<b>Inhibitory Effect of Caffeine on Degranulation of RBL-2H3 Cells</b>	
Arita Dewi Nugrahini, Momoko Ishida, Kosuke Nishi and Takuya Sugahara .....	123
<b>Constraints in The Use of Balanced Scorecard Performance Measurement Parameters on Small-Medium Enterprises (Case Study on The Application of SMEs Performance Measurement at CV. X and Y)</b>	
Totok Pujianto .....	128
<b>Trust as a Human Factor for Sustainable Ergonomics Application in Agro-industry</b>	
Mirwan Ushada, Titis Wijayanto and Fitri Trapsilawati .....	136
<b>Cost Analysis for Sugarcane Transporting Improvement from Loading Station to Sugar mill</b>	
Kris Promsiri and Jumpol Vorasayan.....	141
<b>A Concept of Engineering Education Program to Improve the Competitiveness of Human Resources in Agroindustry</b>	
Elisa Anggraeni, Muhammad Romli and Suprihatin Suprihatin .....	151
<b>Quality and Packaging Analysis of Fresh Strawberry (<i>Fragaria</i> Sp) During Storage in Controlled Environment</b>	
Agustina R.P. Andam Dewi, Pujo Saroyo and Mohammad Affan Fajar Falah.....	164
<b>Supply Chain Analysis of Local Beef in Malang, Indonesia</b>	
Retno Astuti, Sucipto and Titik Prastiani.....	177
<b>Analysis of Supply Chain Institutions to the Performance and Competitiveness of Tempeh Chips SMEs Cluster in Sanan, Malang</b>	
Siti Asmaul Mustaniroh, Rizky LR Silalahi and Adinda Wardhani.....	187

## Keynote Speaker Profile



### Speaker 1 – Prof. Dr. Yu Pin Lin

Department of Bioenvironmental Systems Engineering,  
National Taiwan University

Education:

- Ph.D. in Civil and Environmental Engineering, Georgia Institute of Technology, USA
- M.S. in Civil and Environmental Engineering, Georgia Institute of Technology, USA

Academic Experience:

- Department Chair, Department of Bioenvironmental Systems Engineering, National Taiwan University, 2015/8~2018/7
- Convener, Sustainable Development Division, Ministry of Science and Technology, Taiwan, 2013/1~2015/12

Honors:

- Ministry of Science and Technology, Outstanding Research Award, 2016
- Ministry of Science and Technology, Advisor of Undergraduate Student Research Creation Award 2016



### Speaker 2 – Prof. Dr. Moch. Maksum

Department of Agroindustrial Technology,  
Universitas Gadjah Mada

Education:

- M.S. in Agricultural Engineering (Crop Post-Harvest Engineering and Technology) University of the Philippines at Los Baños
- Ph.D Agricultural Economics University of the Philippines at los Baños, Philippines

Expertise:

- Agroindustrial Economics
- International Trade
- Industrial Policy



### Speaker 3 – Bjorn Santos

De La Salle Araneta University, Philippines

Education:

- Bachelor of Science (bs), Agricultural Engineering University of Philippines
- Master, Biological and Agricultural Engineering Texas A&M University
- PhD Biological and Agricultural Engineering

Experience:

- President De La Salle University Octo 2016-present
- Vice Chancellor for Academic and Research 2014-2016



#### **Speaker 4 – Helmut Schmidt**

Director Communication-Public Affairs  
Gruene Punkt, Germany



#### **Speaker 5 – Reza Andreanto**

Environment Manager Tetra Pak Indonesia

Education:

- Undergraduate, Computer Science Gadjah Mada University
- MBA Business Administration and Management Swiss German University

Career Experience:

- Business Development and Marketing Specialist DUPONT
- Key Account Manager Trimitra Cikarang
- Senior Sales Representative Trimitra Swadaya



#### **Speaker 6 – B. Didik Prasetyo**

President Director of PT Rajawali Nusantara Indonesia (Persero)

Education:

- Undergraduate. Forestry Management Bogor Agricultural Institute
- Ms. Economic Law University of Indonesia

Career Experience:

- Deputy Assistant to the Ministry of Energy, Mining, Printing and Tourism Business Affairs
- Commissioner Rajawali Nusantara Indonesia 2008-2013

## Invited Speaker Profile



### **Speaker 1 – Dr. Adi Djoko Guritno**

Department of Agroindustrial Technology  
Faculty of Agricultural Technology, Universitas Gadjah Mada

#### Education:

M.T Bandung Institute of Technology  
Dr. Ehime University, Japan

#### Expertise:

- Supply chain management
- Risk management
- Operation management



### **Speaker 2 – Prof. I Ketut Satriawan**

Faculty of Agricultural Technology, Udayana University

#### Education:

M.T Bogor Agricultural Institute  
Dr. Bogor Agricultural Institute

#### Expertise:

- Productivity analysis
- Engineering Economic Analysis
- Production Planning and Inventory Control



### **Speaker 3 – Prof. Sugahara, Takuya**

Graduate School of Agriculture Department of Bioscience, Ehime University

#### Academic & Professional Experience:

- 2016, Graduate School of Agriculture, Ehime University, Department of Bioscience, Professor
- 2007, Ehime University
- 2006 - 2007, Ehime University
- 2002, University of Texas Health Center at Tyler
- 1994 - 2006, Ehime University

#### Research Areas:

- Agricultural Chemistry, Food science
- Process/Chemical engineering, Biofunction/Bioprocess
- Society medicine, Hygiene and public health





#### **Speaker 4 – Kiwi Aliwarga**

Chief Executive Officer and Co-Owner UMG Myanmar

##### Education:

- Master's degree, Engineering Asian Institute of Technology
- S2, System Dynamics Massachusetts Institute of Technology-Sloan School of Management

##### Experience:

- CEO UMG MYANMAR
- GENERAL MANAGER Win Progress Co.Ltd
- Manager PT. Astra International



#### **Speaker 5 – Prof Hiroki Oue**

Science and Technology for Biological Resources And Environment, Ehime University

##### Education:

- 1989 Kyoto University Graduate School, Division of Agriculture
- 1987 Kyoto University Graduate School, Division of Agriculture
- 1985 Kyoto University Faculty of Agriculture

##### Research Areas:

- Earth and planetary science,
- Meteorology/Physical
- oceanography/Hydrology

##### Research Interest:

- Micrometeorology, Hydrology, Irrigation, and drainage, Oceanography and Hydrology



FP-SCM-014-ID073

# Preparation of Standard Operating Procedures (SOP) of Broccoli Handling at PT. X Bandung

Totok Pujianto<sup>1,\*</sup>, Arif Rahman<sup>1</sup> and Irfan Ardiansah<sup>1</sup>

<sup>1</sup> Dept. of Agroindustrial Technology; totok.pujianto@unpad.ac.id

\* Correspondence: totok.pujianto@unpad.ac.id; Tel.: +62-856-212-6252

Received: 14 August 2018; Accepted: 25 August 2019; Published: 6 January 2020

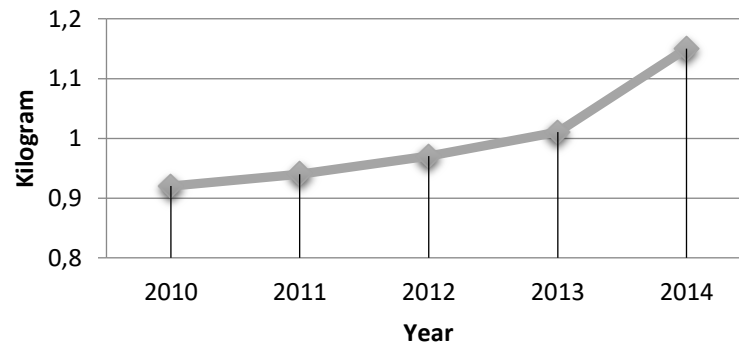
**Abstract:** PT. X is a company that is classified as an agroindustry, especially in the field of post-harvest handling of vegetables and fruits. Some supermarkets in the Jakarta, West Java and Banten regions are consumers of the company, of which broccoli is one of the vegetable commodities that have high demand and high selling prices. Until now PT. X has not followed the standard of good vegetable handling activities in handling broccoli, which raises several problems, including: (1) excessive use of packaging materials, (2) various handling times, and a decrease in quality. This study aims to develop a Standard Operating Procedure (SOP) for handling broccoli at PT. X, as an effort to improve broccoli handling activities. Standards that are structured are useful for handling broccoli in similar companies. Standards are made to consider the rules of SOP compilation according to SNI and Good Handling Practice according to the Minister of Agriculture Regulation No: 73/Permentan/OT.140/7/2013, with research stages: (1) in-depth observation of handling activities, in-depth interviews, data collection on quantities operating time for each process and identification of technical problems, (2) literature study related to observations and problems found, aimed at improving procedures and problem solving, (3) preparation of SOPs and (4) verification to experts and companies. Through this study, SOPs were prepared which resulted in improvements of 39% items. The important points of improvement are: (1) employee self-sanitation, (2) sanitation of equipment and work tools, (3) controlled and recorded packaging usage, (4) the determination of standard operating time, and (5) work instructions for each process successfully arranged.

**Keywords:** standard operating procedures, broccoli, good handling practice, process and product quality

---

## 1. Introduction

Broccoli is a prospective agricultural commodity to be developed as an agro-industrial activity in Indonesia. Broccoli has high economic value and benefits. Broccoli production in Indonesia is still low, both in quality and quantity. This broccoli production area is dominated by highland areas where broccoli is able to adapt well, such as Lembang (West Java), Brastagi (North Sumatra), Malang (East Java), and Bedugul (Bali) [1]. In Indonesia, broccoli consumption in Indonesia tends to increase every year. The prospect of domestic demand for vegetables tends to increase. This is in line with the increase in population, increasing community income, as well as the development of urban, industrial and tourism. Data from the Central Bureau of Statistics regarding consumption that has increased every year is directly proportional to the increasing market demand, as shown in Figure 1 [2]. This increase in demand needs to be balanced with a good supply of broccoli in terms of quality. Presenting quality broccoli requires special treatment starting from the upstream to downstream sub-systems so that product quality is maintained until the end consumer.



**Figure 1.** Broccoli consumption in Indonesia per capita in 2010-2014

PT. X, is a company engaged in post-harvest handling of 127 types of fruits and vegetables, packing and then supplying it to supermarkets located in DKI Jakarta, West Java and Banten, namely DC Carrefour (District Central), Hypermart, Lottemart, Market City, Hero, Ramayana and Aeon. Broccoli is one of the vegetable commodities which has a high demand (170-200 Kg) and has a high selling value. It is unfortunate that PT X has not implemented a standard post-harvest handling of broccoli properly, thus causing problems such as excessive use of packaging materials, length of handling that is still not standard, and lack of self-sanitation activities. These problems have an impact on inefficiency and low quality of handling, such as broccoli stems broken, broccoli packed withered.

Pursuant to the regulation of the Minister of Agriculture of the Republic of Indonesia Number 73/Permentan/OT.140/7/2013 concerning Good Handling Practice (GHP) which requires business actors to follow a food safety program by compiling a Standard Operating Procedure (SOP), then PT. X needs to prepare a SOP for post-harvest handling of broccoli [3]. The application of SOP is motivated by consumer demand for products that are more better from the aspect of quality, and quantity to timeliness of acceptance [4].

PT. X in carrying out its activities only has one SOP not written and generally applicable. While the written SOP for each vegetable commodity have not been compiled. This is a weakness in post-harvest handling activities, given that each vegetable commodity has different characteristics. Therefore, it is very necessary to develop special SOPs regarding post-harvest handling of broccoli

This study aims to compile SOPs for broccoli post-harvest handling to increase productivity, efficiency and as an effort to maintain product quality. In addition, SOP is expected to be able to be used as a SOP specifically in post-harvest handling of broccoli by similar companies.

The scope of the research is the preparation of SOPs related to employees as operators, production tools used, standard handling time and Work Instructions (IK) from broccoli post-harvest handling activities starting with receiving, sorting, trimming, grading, packaging, labeling, checking / TLM, and product distribution. All of these activities are carried out by PT. X.

## 2. Materials and Methods

This research is classified as applied research that is an attempt to get a solution to the problem through engineering methods to compile SOP for handling post-harvest broccoli at PT. X. The preparation of the SOP refers to the regulation of the Minister of Agriculture of the Republic of Indonesia No: 73/Permentan/OT.140/7/2013, and ISO/TR 10013 namely "guidelines for quality management system documentations" [3,5].

This research was carried out with the following steps: (1) in-depth observation of handling activities, in-depth interviews, data collection on quantities operating time for each process and identification of technical problems, (2) literature study related to observations and problems found, aimed at improving procedures and problem solving, (3) preparation of SOPs and (4) verification to experts and companies.

In steps no (1) and (2) the topic is understanding each type of broccoli post-harvest handling process. Searching for each process includes the objectives, scope, main and supporting materials, work procedures, equipment used, operators and other related employees, related work guidelines, work environment, and the time needed to complete the process. Especially regarding the completion time of a process, the cycle time is measured to then set the normal time, then the standard time of the process is determined. The normal time of a process is the cycle time multiplied by the rating factor (using Westinghouse System of Rating), while the standard time of a process is the normal time added to the allowance factor. Standard time determination of a process in this research refers to the rules of determining "standard time" for work that has a cycle [6,7] .

The results in steps no (1) and (2) are used to compile the SOP for each process. The preparation of the SOP substance (step number (3)) refers to the regulation of the Minister of Agriculture of the Republic of Indonesia Number 73 / Permentan / OT. 140/7/2013 concerning Good Handling Practice (GHP), while the writing guide refers to ISO / TR 10013 is modified. The compiled SOP is then verified by the expert and the company to evaluate the possibility of its application which includes comprehensiveness, completeness of SOP material, and logical work procedures. If the evaluation results of the SOP draft are declared as not fulfilling all three of these, then the SOP design is corrected. After verification activities, a trial of the implementation of SOP was conducted as a form of validation of the draft SOP.

### 3. Results and Discussion

#### 3.1. Series of Broccoli Post-Harvest Handling Processes

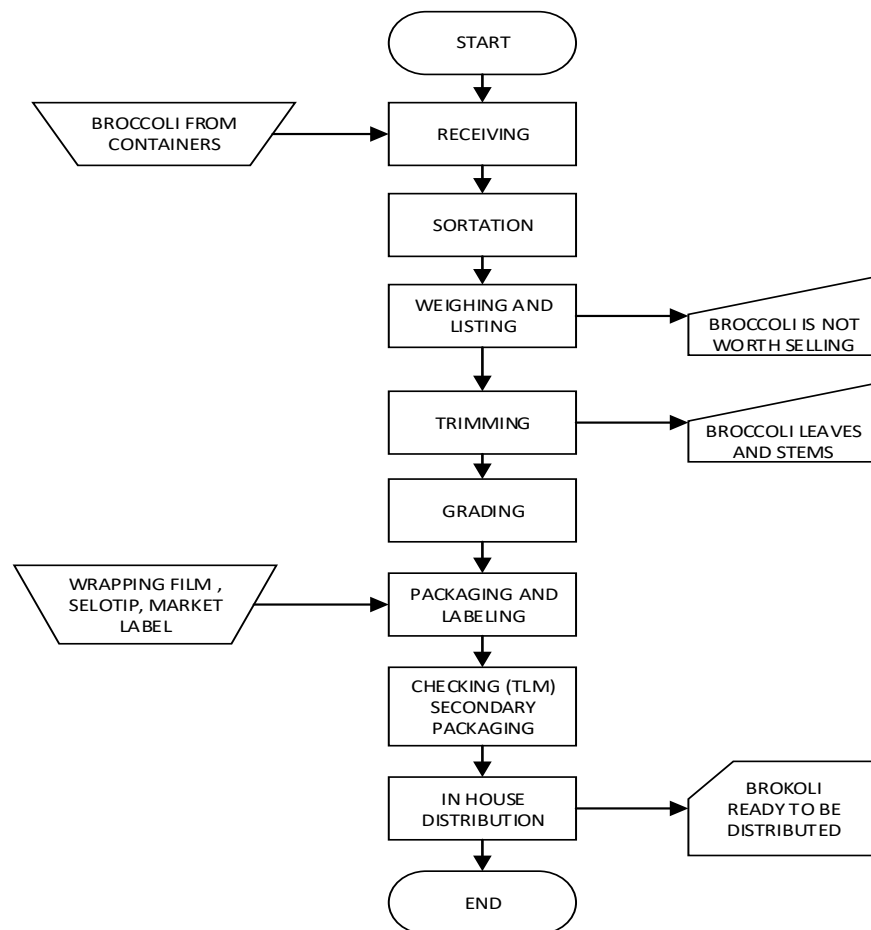
Description of the results of an in-depth understanding of the broccoli post-harvest handling system that occurred at PT. X is based on the work process framework from upstream to downstream. The series of work processes (upstream to downstream) starts from the availability of raw materials (ie the arrival of harvested broccoli in a basket transported by a box car parked in front of the workshop door) until broccoli is packed with secondary packaging ready to be distributed to each supermarket (first buyer). A series of broccoli post-harvest handling processes are presented in Figure 2.

##### 3.1.1. Receiving and Sortation

Broccoli from supplier received by PT. X is in a plastic container, it is clean from leaves, the size of weight and physical condition varies, for example there are black or yellow spots on the part of broccoli flowers. Therefore, the sorting process is carried out.

The sorting process aims to get good quality broccoli based on the diameter of the flower, stalk length, weight and color. The sorting process is carried out manually by the operator through checking the diameter of the flower, the length of the stalk and the color of the broccoli flower. Broccoli is held by the operator without using gloves. This has the potential to accelerate the decay of broccoli due to exposure to contaminants from the hands of employees [3]. The sorting process takes place in a workshop with 2 sides of an open wall, so it has good lighting because it is always carried out during the day. There are at least 3 containers as a container to separate broccoli that passes sorting with broccoli which does not pass sorting.

Broccoli, which is of good quality in containers, is weighed at the same time to find out the amount of payment to suppliers. Broccoli in containers as temporary storage is pushed on the floor (to reduce the operator's workload due to the relatively heavy weight of broccoli (30 kg) per container) towards the trimming process. Broccoli passes sorting can be seen in Figure 3. The characteristics of broccoli set by the company to pass the sorting process can be seen in Table 1.



**Figure 2.** Operating Process Chart for Broccoli Post Harvest Handling at PT. X



**Figure 3.** Physical appearance of broccoli that passes sorting; Source: Research team, 2018

**Table 1.** Characteristic requirements of broccoli that pass sorting

No	Attribute	Specification
1	Flower diameter	9 cm – 15 cm
2	Stem length	9 cm – 10 cm
3	Weight	250 gram – 350 gram
4	Color	Flowers are dark green and have no black or yellow spots.

Source: Processed data research, 2018

### 3.1.2. Trimming and Grading

In the process of trimming and grading, broccoli is examined against the presence of pests and diseases such as caterpillars and black spots, then the stem is removed from the bulge by cutting using a knife. Broccoli is held using the left, and the knife is on the right hand, because the right hand is

considered to have a better balance. Broccoli stems that have been cleaned are cut to a maximum length of 10 cm, to meet the standards set by the market, and avoid packaging damage in distribution activities. The remaining cutting stems are weighed and recorded at the receiving part as a factor to reduce overall broccoli weight to adjust the amount of payment to suppliers.

Trimming tools used in this activity are knives, sorting tables and containers that are prepared in a clean condition, but sometimes used in a dirty state. This is because companies that have not set hygiene standards for trimming activities, in this activity employees do not use gloves. This can endanger operator safety, considering the use of knives as trimming tools. Workers who do not use completeness can be seen in Figure 4.



**Figure 4.** The process of trimming broccoli; Source: Research team, 2018

Broccoli is transferred to the grading operator which is located on the right side of the trimming operator for grading. Broccoli is classified into 2 grades (grades A and B), stored in different container containers. The classification of broccoli in this company is determined by the shape, color, texture and size of the flower. The criteria for each broccoli grade can be seen in Table 2.

**Table 2.** Characteristic requirements of broccoli that pass so

Quality Criteria	Grade A	Grade B
Diameter	9-15 cm	9-15 cm
Stem length	Max 10 cm	Max 10 cm
Weight	200-450 g/ piece	200-450 g/ piece
Color and shape of flowers	Even dark green, round like umbrellas, fresh flowers and stalks, free of disease, relatively the same size	Even dark green, round like an umbrella, fresh flowers and stems, free of disease, size varies greatly
Surface	Seamless, non-defective, non-contaminant	Seamless, slightly defective, non-contaminant
Packaging	<i>Wrapping</i>	<i>Wrapping</i>
Quality	Equally	Varies
Shelf life	One day	One day
Customer	<i>Medium &amp; high income</i>	<i>Low income</i>

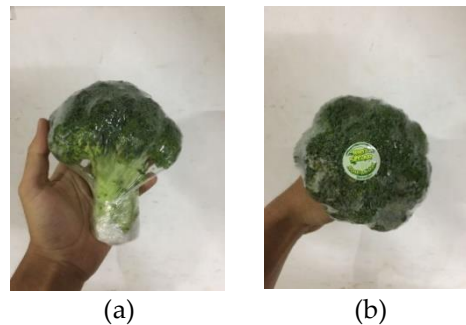
Source: PT. X, 2018

### 3.1.3. Packaging and Labelling

The packaging process begins by arranging the hand wrapper machine to turn on and showing the heat scale at number 3. The packaging used is wrapping Polyvinyl chloride-based film, has a width of 30 cm in an effort to reduce the level of mechanical and biological damage to broccoli. The packaging process is carried out in the afternoon until the evening, carried out on a work table made of aluminum with a height of 90 cm, lighting coming from outside the room because the iron curtain is converted as a wall in the packing room, while at night the lighting comes from fluorescent lamps colored white. Adhesive material in the form of transparent masking tape to avoid damage due to wrapping of films

that do not stick well. The company has not set a maximum standard for using adhesive tape. Here the problem arises in the form of careless use of masking tape and tends to be excessive.

The next process is labeling using a sticker that contains information about the company name. The stickers are placed on the outside of the packaging right in the middle of the broccoli flower. Sticker design differs according to the purpose of delivery. Broccoli that has been labeled can be seen in Figure 5.



**Figure 5.** (a) Broccoli that has been packaged; (b) labeled

Packaged broccoli is then stored in containers that have been coated with scrap paper, to minimize damage to the packaging and bruising on broccoli, which is caused by collision and friction with the cavity of the container that has a hollow surface and has some sharp parts. The use of used paper is intended to reduce the amount of company expenditure.

#### 3.1.4. Total Loss Management (TLM) and Secondary Packaging

Next is the process of Total Loss Management (TLM) which is weighing broccoli using a sitting scale, broccoli weight data recorded and adjusted to the order amount by the admin. The operator in this process is at least 2 people, one is assigned as an admin who enters broccoli data on the computer, and another weighs. Broccoli is then moved to the distribution section, to be included in each container according to their respective order quantities, while checking the quality of the packaging. If damage occurs, it will be repackaged by the packaging section. Admin checks the order data on the computer, then weighs broccoli according to the number of orders and the destination of delivery, with excess tolerance of 1 broccoli or about 350 grams for each shipping destination. This addition is to anticipate the differences in scales used between PT. X with the ordering party. Broccoli is packaged using cardboard boxes with a length of 50 cm, 30 cm wide and 40 cm high.

#### 3.1.5. In House Distribution and Shipping

There are different treatments in the distribution process. This is based on an agreement between the company and the buyer, including the determination of the selling price. The purpose of shipping to DC Carrefour is the main priority of shipping, because it provides greater benefits compared to other shipping destinations. Broccoli sent to DC Carrefour is classified as grade A, stored temporarily on wooden beams. As for shipping to Ramayana, Aeon, Lotte and Hero, broccoli which is classified as grade B is put into containers along with other commodities.

Broccoli shipped at 01:00 AM using a box car without cooling, the selection of the delivery time aims to avoid congestion on the highway, and avoid high temperatures so that the quality of broccoli is maintained in the course of 140 km.

### 3.2. Identification of Problems and Improvements to Broccoli Post Harvest Handling Systems

In-depth analysis was carried out on every work process related to the work system that actually happened compared to the Good Handling Practice guidelines. Analysis material refers to aspects of the objectives, scope, main and supporting materials, work procedures, equipment used, operators and other related employees, related work guidelines, work environment, and the time needed to complete the process. In the analysis include discussing the problems that occur in each process and or event

between processes. The overall results of the problem analysis are presented in Appendix A Table 1. Improvements were made as much as 39%, in the form of SOP preparation, preparation of work instructions, determination of standard time, recording of container materials used, as well as determining the maximum limit for the use of container materials.

### *3.3. Preparation of Work Instructions*

Work instruction is a work mechanism document that regulates in detail and clearly the sequence of activities which only involves one function as a support for quality procedures. Procedures usually involve several parts and describe the process or activity in general, in contrast to work instructions that describe a particular process, carried out by certain parts, and contain a detailed mechanism [5]. General work instructions consist of: (1) Description of the equipment needed; (2) The main material and supporting materials used; (3) Work activities, including preparation activities to implementation; (4) Parties involved in every job; (5) Job tolerance; and (6) Examination. Work instructions are prepared for each process in the post-harvest broccoli handling activities. The preparation of instructions follows the rules as stated above.

### *3.4. Employee Self Sanitation and Use of Work Completeness*

The employee's self-sanitation activities are one of the important factors in the implementation of agricultural production activities, these activities prevent agricultural products contaminated by pathogenic microbes carried by human hands. Employee self-sanitation activities can be carried out with hand-washing activities before and after handling agricultural products, proper hand washing includes the use of soap, rubbing the palms together to produce foam, alternately washing the back of the hand, rubbing between fingers and inside nail, then rinse using clean running water [8].

Apart from hand washing activities, the use of employee work completeness is an effort to protect agricultural products from contamination from human hands, one of which is the use of gloves. There are two types of gloves commonly used, namely thick rubber gloves that can be used repeatedly and disposable gloves [8].

The use of gloves recommended in handling post-harvest vegetables is thick rubber gloves that have a thickness between 0.3 mm to 0.6 mm, because they are considered to have better resistance compared to disposable gloves, considering the use of pesticides (chemicals) in aquaculture who can irritate the hands of employees. Included can be used many times, thereby reducing the cost of purchasing production equipment. Gloves must be washed and replaced regularly to ensure hygiene and do not cause contamination of the product. In addition, the use of gloves is useful as a protective tool for employees if the implementation of activities using sharp tools such as knives [9].

### *3.5. Recording and Determining the Maximum Use of Packing Materials*

The purpose of recording and determining the maximum limit for the use of raw materials is to improve production efficiency, encourage compliance with company policies, and as an effort to check the use of container materials. Recording method can be done by recording continuously about incoming and used items, so that every item used in each activity can be known at any time [10].

Recording at PT. X can be done by weighing the roll wrapping film, then recorded in a special book that contains the recording of the use of goods or packaging materials used every day, with a writing format that shows the number of packaged broccoli, the initial weight of packing material, the final weight of the packing material after use and the reduction results between the initial weight and the final weight of the packing material.

Determination of the maximum limit for the use of containerized materials is done by measuring the length of masking tape when employees carry out packaging activities. The masking tape length can be seen in Table 3.

**Table 3.** Tape length for packaging activities

No	Tape Length (cm)						
	Employee						
	1	2	3	4	5	6	7
1	6,0	4,3	3,0	4,5	4,5	3,0	4,0
2	4,5	5,1	4,5	3,0	5,0	4,0	5,0
3	5,0	5,0	5,0	3,5	5,3	4,0	3,5
4	4,5	5,5	4,0	3,5	4,8	5,0	4,0
5	5,0	5,0	5,5	6,0	4,0	3,5	6,0
<b>Average</b>							4,5

Source: Processed data research, 2018

Suggestions for improvement regarding the determination of the maximum limit for the use of masking tape for packaging activities are carried out by measuring each of the first joints of the right hand thumbs of the employees. Employees are expected to do tape withdrawal activities limited to the first joint joints. Data from the first joint segment measurement of the employee's right thumb can be seen in Table 4.

**Table 4.** Employee's first thumb length

Employee	1	2	3	4	5	6	7	Average
First thumb length (cm)	3,0	2,9	3,1	3,1	2,8	2,7	3,2	3,0

Source: Processed data research, 2018

From each of the data obtained, it can be seen that the average use of 4.5 cm masking tape and improvement advice given based on the first right hand length of the thumb is 3 cm, so that the suggested improvement can save as much as 1.5 cm of tape for every packaged broccoli or 33.3%.

### 3.6. Determination of The Standard Time for Each Process

In determining the standard time of each process, the first step is to measure the cycle time, then calculating the normal time using the Westinghouse adjustment factor, then by adding the allowance time then the standard time is obtained. Calculation data can be seen in Table 5. There is a difference between the standard time and the average cycle time of the measurement results. Standard time is relatively longer than the cycle time. This is due to the calculation of standard time included with the value of adjustments and concessions, which take into account several aspects, namely the type of activities, skills, working conditions, and employee consistency.

**Table 5.** Time Measurement (in seconds)

No	Process	Cyclic time	Rating factor	Allow- ance factor	Normal time	Standard time
1	Sortation	5,4	0,14	14	4,7	5,5
2	Weighing	10,0	0,12	29	8,6	10,3
3	Trimming & Grading	8,4	0,13	27	7,3	9,7
4	Packaging	17,9	0,09	27	16,2	21,4
5	Compile a Packaging Cardboard	183,2	0,12	28	161,2	214,4
6	Weighing for distribution	4,0	0,12	21	3,4	4,1
7	Stepping speed in distributing (10 m)	8,5	0,12	21	7,3	8,7

Source: Processed data research, 2018

Allowance factors are given for three reasons, namely personal needs such as urinating, relieving fatigue, as well as disturbances that may occur and cannot be avoided by employees, such as having to sharpen cutting equipment. Adjustments are given to assess how far the employee's irregularities are



caused by working without seriousness, very fast as if time is hunted, employees encounter difficulties such as poor room conditions, and the appropriateness of the assessors who are lacking because they are not experienced in the type of work being measured [6].

#### **4. Conclusion**

The results of this study are the composition of standard operating procedures (SOP) post-broccoli handling at PT. X. The results of the analysis showed that the required improvements as much as 39% of the entire process in handling broccoli post-harvest activities at PT. X. These improvements are in the form of preparing work instructions, determining employee self-sanitation, determining the use of completeness of employee work, determining the standard time of activities, and determining the maximum limit for the use of container materials.

#### **5. Patent**

The Standard Operational Procedure for post-harvest handling of broccoli that has been successfully compiled is currently being completed in accordance with the requirements for obtaining the proposed patent in order to obtain its patent rights through the patent service institute of Padjadjaran University. Therefore this SOP cannot be included in this paper.

## Appendix A

Activities	Good Handling Practice (GHP)	Real Condition	Suit-ability	Details
Receiving	The existence of calibrated scale.	1	Yes	
	Using a proper and clean transport container	1	Yes	
	The existence of loading dock shelter	1	Yes	
	The existence of receiving work instruction	0	No	The work instruction is designed as a guideline for activity
	Weighing the container and its content	1	Yes	
	Hiring skilled and trained workers	1	Yes	
Sorting	The workers do self-sanitation	0	No	The workers are required to do self-sanitation and use hand gloves before the activity begin
	Weighing and recording correctly	1	Yes	
	Separating products that qualified and not qualified	1	Yes	
	The existence of sorting work instruction	0	No	The work instruction is designed as a guideline for activity
Trimming	A clean place for sorting	1	Yes	
	Hiring skilled and trained workers	1	Yes	
	The workers do self-sanitation	0	No	The workers are required to do self-sanitation before the activity begin
	Transferring the products that have been trimmed well	0	No	The workers are required to transfer the products slowly and carefully
	The existence of trimming work instruction	0	No	The work instruction is designed as a guideline for activity
	Using a proper tools for trimming	1	Yes	
	Using a clean tools	0	No	The workers are required to clean the equipment before use
	The workers are using work equipment	0	No	The workers are required to use work equipment
Grading	Hiring skilled and trained workers	1	Yes	
	Classifying product based on specified quality	1	Yes	
	Putting product on a container based on its quality	1	Yes	
	The existence of grading working instruction	0	No	The work instruction is designed as a guideline for activity
	Using a good and clean tools or machine	0	No	The workers are required to clean the equipment before use

Activities	Good Handling Practice (GHP)	Real Condition	Suit-ability	Details
	The workers are using work equipment	0	No	The workers are required to use work equipment
	The existence of packaging work instruction	0	No	The work instruction is designed as a guideline for activity
	Preparing tools and materials for packaging	1	Yes	
	A sign on package	1	Yes	
Packaging	A temporary storage and additional protective material	1	Yes	
Labelling	The workers listing the amount of used packaging materials	0	No	The workers are required to record the amount of packaging that used
	Preparing product and label that will be used	1	Yes	
	Preparing a strong product label /persistent	1	Yes	
	The existence of labelling work instruction	0	No	The work instruction is designed as a guideline for activity
	Using informative label	1	Yes	
	The existence of calibrated scale	1	Yes	
Total Loss Management (TLM)	The existence of TLM work instruction	0	No	The work instruction is designed as a guideline for activity
	Using a good and clean container	1	Yes	
	Recording the amount of products	1	Yes	
	Preparing tools and materials for packaging	1	Yes	
	The existence of TLM work instruction	0	No	A guideline for broccoli packaging is designed
	A sign on package	1	Yes	
In House Distributing	Preparing a temporary storage	1	Yes	
	Using a good and clean container	1	Yes	
	The existence of distribution work instruction	0	No	The work instruction is designed as a guideline for activity
	Recording the amount of products	1	Yes	
	1 =	27	61%	
	0 =	17	39%	

## References

1. Nuringtyas, T. R. & Ismoyowati, D. 2016. *Development of Pigmented Rice for The Rural Community*. SEARCA Seed Fund For Research and Training (SFRT) Program, Vol 8, No 6.
2. Kristantini, Taryono, P. Basunanda, R, H. Murti, dan Supriyanta. 2012. *Morphological of Genetic Relationships among Black Rice Landraces from Yogyakarta and Surrounding Areas*. *ARPN Journal of Agricultural and Viological Science*. 7(12) : 982-989.
3. Wuryadani, Shafira. Arita, N. Dyah, I. 2016. *STP Analysis on Marketing Pigmented Rice as Functional Food*. *ICoA Conference Proceeding*.
4. Yawadio, R., S. Sanimori and N. Morita. 2007. *Identification Of Phenolic Coumpound Isolated From Pigmented Rice And Their Aldose Reductase Inhibitory Activities*. *Food Chem*. 1001(4): 1616-162.
5. Chaudhary, R.C. 2003. *Speciality rice of the world : Effect of WTIO and IPR on its production trend and marketing*. *J. Food Agric. Env*. 1 (2) : 34 – 41.
6. Anindita, K. P. Dyah, I. Endy, S. (2016) (Unpublished). *Analisis Rantai Nilai Beras Berwarna: Studi Kasus di Kabupaten Sleman D.I Yogyakarta*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.
7. Riyadi, A. Dyah, I. Kuncoro H. W. 2018 (Unpublished). *Strategi Pengembangan Kinerja Rantai Pasok Beras Hitam di Kabupaten Sleman, D.I Yogyakarta*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.
8. Chopra, S., and Meindl, P. 2013. *Supply Chain Management: Strategy, Planning & Operations Third Edition*. Pearson Prentice Hall. New Jersey.
9. Rifai, A. Dyah, I. M. Affan F.F. 2018 (Unpublished). *Analisis Preferensi Konsumen Terhadap Warna Beras Hitam di D.I Yogyakarta*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.
10. Mutmainnah, D. H. Dyah, I. Anggoro C. S. 2017 (Unpublished). *Analisis Pengaruh Perilaku Terhadap Loyalitas Pelanggan Bisnis untuk Perumusan Strategi Pemasaran Beras Berwarna*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-002-ID005

# Consumer's Awareness and Adoption for QR Payment at Traditional Trade in Bangkok

Passaraporn Thongtha<sup>1</sup> and Ajchara Kessuvan<sup>2,\*</sup>

<sup>1</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand; passaraporn.th@ku.th

<sup>2</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand; Ajchara.ke@ku.ac.th

\* Correspondence: Ajchara.ke@ku.ac.th; Tel.: +66-2562-5091; Fax: +66-2562-5092

Received: 6 July 2018; Accepted: 20 December 2018; Published: 6 January 2020

**Abstract:** e-Payment is now becoming a significant mean of business transaction in Thailand since the government has set up a national e-Payment master plan for enhancing Thai economy. In marketing aspect, the research on consumer's adoption for QR payment to reveal the application environment has limited. This research aims to investigate the awareness and adoption of consumers and other stakeholders toward the QR payment service in Bangkok. The depth interviews and survey research are conducted at the traditional trade including flea market, weekend market, grocery stores and street food shops based on Technology Acceptance Model (TAM). The data is analyzed using mix methods including qualitative and quantitative approach. The result indicates that consumer's knowledge, perceived ease of use and perceived trust are main factors affecting consumer's adoption of QR payment. The implications of the research will provide the deep understanding and guideline for the relevant stakeholders and extend the body of marketing research.

**Keywords:** awareness; adoption; QR payment; traditional trade; TAM

---

## 1. Introduction

The human lifestyle has changed according to the advancement of technology that has developed consistently to seek for more comfort in life [1]. Technology changes play a vital role in financial transactions from time to time. Commercial banks need to adapt to digital economy to create a competitive advantage by using different technologies to service their customer [2]. Since the customers prefer convenient services, they would not rather to spend more time to do financial transactions. While commercial banks want to expand their businesses, they need to invest large amount of budget to propose other new alternatives to customers [3]. Regarding to Thailand, one of the financial transaction services have evolved to become popular and growing continuously is electronic payment system or e-Payment [4]. The financial transaction statistical of the Bank of Thailand during 2010-2015 indicated that both of volumes and value of electronic payments were growing continuously, especially in 2015, up to 34.9% over the previous year. The proportion of electronic payment through financial institutions and non-financial institutions accounted for 64.1% and 35.9%, respectively [4].

e-Payment is a part of the national e-Payment master plan that Thai government is currently encouraging. This policy was set up for creating consumer's awareness to reduce cash usage and to prevent counterfeit banknotes [5]. In 2017, Thailand has launched a new financial transaction service known as QR code payment or QR payment. The users will be able to use banking application through smartphone to scan QR code at the point of purchase for paying [6]. Currently, there are eight banks in Thailand which are licensed by the Bank of Thailand to launch QR payment service [7]. As a result, QR payment service has been adopted by many traditional trades as well as modern trades in Bangkok. However, on the consumer side, the number of users are limited due to lack of trust in financial transaction service. Therefore, most consumer still rely on the traditional payment system. This research aims to investigate the awareness and adoption of consumers and other stakeholders toward

the QR payment service in traditional trades in Bangkok. Understanding the awareness and adoption of consumers would help the relevant stakeholders of QR payment to develop the guidelines that easy to understand and proper for consumer's payment behaviors for increasing financial transaction.

## 2. Materials and methods

### 2.1 Qualitative approach

The depth interviews were conducted with relevant stakeholders including eight financial service providers or commercial banks and ten merchandisers in the traditional trade. The 54 information from depth interviews were analyzed by content analysis method. Several key factors affecting consumer's adoption of QR payment was explored.

### 2.2 Quantitative approach

The survey research using structural questionnaire was conducted by face to face interviews. The questionnaire was developed from content analysis result as a guideline based on Technology Acceptance Model: TAM [8]. The questionnaire was divided into four parts; demographic information, consumer's payment behavior, consumer's awareness and consumer's adoption of QR payment. The third and fourth part of questionnaire applied a five-point likert scale. The consumer survey was conducted at flea market, weekend market, grocery stores and street food shops in Bangkok. The demographic was analyzed by descriptive statistics. The relationship between payment behavior and consumer's adoption was analyzed by one-way ANOVA. Finally, logistics regression analysis was conducted to investigate the factors affecting the consumer's adoption of QR payment.

## 3. Results

### 3.1 Descriptive analysis

A total of 358 completed questionnaires are collected. All respondents are aware of QR payment. Among total respondents, 53% are QR payment adopters and 47% are non-adopters. The demographic information of adopters and non-adopters are slightly differences in all attributes. About 67% of total respondents are female and 33% are male. In addition, 35% of female and 18% of male are non-adopters, while 32% of female and 15% of male are adopters. Half of respondents (49%) are generation Y who are between 23 and 40 years old [9], in which 25% are non-adopters and 24% are adopters. The majority of respondents (68%) have obtained the bachelor degree, in which 37% are non-adopters and 31% are adopters. Most respondents (43%) are graduate students, while the percentage of adopters is equal to non-adopters (21.5%). Monthly income shows that respondents mostly earn less than 10,000 Baht per month, in which 17% are non-adopters and 14% are adopters.

Table 1 describes the consumer's payment behavior in details. All respondents who have indicated their payment behaviors are QR payment adopters. Siam commercial bank (SCB) was the most preferable for financial transaction service by majority of adopters (35%). The reason for using QR payment about 63% was convenience, while 20% was cash reduction. Over a half of the adopters (57%) indicated that the influencer encouraging them to use QR payment was themselves, followed by merchandiser (23%), friend (8%) and bank staff (7%). The majority of adopters (32%) used QR payment at the flea market or weekend market, which was slightly higher than modern trade and restaurant. Most adopters (51%) used QR payment when purchased foods or beverages, followed by clothes. The highest proportion of adopters (84%) revealed that they were loyalty customer with only one bank. In term of the frequency of using QR payment, most of customers (73%) used QR payment 1-2 times per month.

**Table 1.** The payment behaviors of QR payment adopters

Payment behaviors		Proportion (%)
1. Most preferable bank of QR payment	Siam Commercial Bank	35.3
	Kasikorn Bank	22.4
	Bangkok Bank	15.9
	Krungthai Bank	15.3
	Thai Military Bank	7.6
	Others	3.5
2. The reason for using QR payment	Convenience	63.5
	Cash reduction	20
	Modern	10.6
	Promotion	5.9
3. QR payment influencer	Themselves	56.5
	Merchandiser	22.9
	Friend	8.2
	Bank staff	7.1
	Others (family, boyfriend/girlfriend)	5.3
4. Channel of QR payment	Flea market/weekend market	32.3
	Others (modern trade, restaurant)	28.8
	Grocery	21.8
	Street food shop	15.9
	Fresh-food market	1.2
5. Product purchased by QR payment	Food/beverage	51.2
	Clothes	32.3
	Others (cosmetics, accessories)	16.5
6. QR payment style	Use only 1 bank	83.5
	Change to use other banks when they launched new promotion	14.1
	Use multiple bank	2.4
7. Frequency of using QR payment	1-2 times/month	73
	3-5 times/month	18.8
	More than 10 times/month	8.2

### 3.2 The relationship between payment behavior and consumer's adoption of QR payment

The relationship between payment behavior and consumer's adoption was explored by one-way ANOVA. The independent variables were seven payment behaviors which were most preferable bank of QR payment, the reason for using QR payment, QR payment influencer, channel of QR payment, product purchased by QR payment, QR payment style and frequency of using QR payment. The dependent variable was consumer's adoption of QR payment. The result of the relationship between payment behavior and consumer's adoption was shown in table 2. The reason for using QR payment and product purchased by QR payment had significantly effected on consumer's adoption.

However, the result from one-way ANOVA would not be able to provide the detailed information on the differences among the study groups. The test of the differences among each variable using post hoc multiple comparison [10] must be conducted to understand the group differences as a result of ANOVA. According to four groups of the reason for using QR payment, the results showed that there were the significant differences among the consumers who used QR payment because of promotion and the consumers who used QR payment because of modern, convenience and cash reduction.

Considering the average of adoption score, it was found that the consumers who had the reason for modern, convenience and cash reduction tended to adopt QR payment more than the influence by promotion. In addition, the result of the types of product purchased by QR payment showed the significant differences either. The consumers who purchased food or beverage by QR payment had adoption behavior which differentiated from the consumers who purchased other products which were cosmetics and accessories. The average adoption score of the consumers who purchased cosmetics and accessories was relatively higher, therefore they tended to be a QR payment adopter more than the consumers who purchased clothes and food or beverage.

**Table 2.** The results of testing the relationship between payment behaviors and adoption score

Payment behaviors	Sig	The average of adoption score
1. The reason of using QR payment	0.001*	
1) Modern		4.06 <sup>a</sup>
2) Convenience		4.00 <sup>a</sup>
3) Cash reduction		3.88 <sup>a</sup>
4) Promotion		3.20 <sup>b</sup>
2. Product purchased by QR payment	0.044*	
1) Other products		4.17 <sup>a</sup>
2) Clothes		3.96 <sup>ab</sup>
3) Food/beverage		3.83 <sup>b</sup>

Note: \*p-value  $\leq 0.05$ ; <sup>a,b</sup> different letters show significantly difference in adoption score

### 3.3 Factors affecting the consumer's adoption of QR payment

The logistic regression model was used to examine factors affecting the consumer's adoption. The independent variables included consumer's knowledge, communication strategy, perceived ease of use, perceived usefulness and perceived trust. The dependent variable was consumer's adoption. The consumer's adoption of QR payment was measured by binary choices of respondents where 1 was adopted and 0 was non-adopted. The results from binary logistics regression was shown in table 3. The predictive efficiency was 70.1%. Therefore, this model was accuracy classification. Consumer's knowledge, perceived ease of use and perceived trust significantly affected on the consumer's adoption of QR payment.

More specifically, the odd ratio or odds could interpret the probability of interesting event [11]. The results of odds or Exp(B) of consumer's knowledge, perceived ease of use and perceived trust were greater than one, as a result these three factors had positive effect on the adoption of QR payment. This mean that when these factors increased then the adoption of QR payment increased. For example, the odds of consumer's knowledge was 2.079. Therefore, when the consumer's knowledge increased by 1 unit, the consumer's adoption increased 2.079 times, regardless of other factors. Other factors could be described as the same pattern as consumer's knowledge.

**Table 3.** Logistics regression analysis of consumer's adoption of QR payment

Factors	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Knowledge	.732	.214	11.726	1	.001*	2.079	1.367	3.160
Communication	-.012	.172	.005	1	.945	.988	.706	1.384
Ease of use	.484	.232	4.338	1	.037*	1.622	1.029	2.556
Usefulness	.168	.214	.616	1	.432	1.183	.777	1.801
Trust	.664	.203	10.713	1	.001*	1.942	1.305	2.890
Constant	-7.563	.972	60.592	1	.000	.001		

Note: \*p-value  $\leq 0.05$

## 4. Discussion



The relationship between payment behavior and consumer's adoption indicated that the reason for using QR payment had significantly impact on consumer's adoption as shown in the process of adoption [12] which was the decision process to accept or reject the innovation. In this regard, there were five stages; awareness, interest, evaluation, trial and adoption stage. In evaluation stage, people who would like to try innovative product will consider about advantage and disadvantage by comparing the new product with the traditional one. Therefore, product information would be considered as a reason to adopt it. In trial stage, consumers would try the innovative product/service if they perceived that the benefit was higher, then they decided to adopt it.

Moreover, the type of product purchased by QR payment had significantly effected on consumer's adoption. The analysis of payment behaviors showed that most adopters used QR payment to purchase food or beverage and clothes because the main product selling in traditional trade was consumer goods as food and clothes [13]. Since the consumer goods was easy to find, consumers were familiar with QR payment, that may caused the consumer adopted QR payment. Furthermore, the consumers tended to use QR payment at the channel with large number of adopted merchandiser. Currently, QR payment service in Thailand was widespread in modern trade and traditional trade including grocery store, flea market, weekend market and street food shop [14]. Therefore, it was convenient for consumers to purchase food and consumer goods by using QR payment in several traditional markets.

The result of logistics regression analysis revealed that perceived ease of use and perceived trust were significantly effect on consumer's adoption of QR payment. It was obviously understand that consumers often welcome and quickly adopted new innovative product/service which were beneficial and not too complicated to use [15], as proposed in previous research. Author [16] found that perceived ease of use became the most significant factor affecting the adoption of Internet banking in Mauritius. Furthermore, author [17] revealed that there was a positive relationship between perceived ease of use and acceptance of e-banking by customers. In addition, perceived trust was the important factor for financial transactional service. The results from this study was consistent with author [18] who identified that online services needed the trust element, since trust was one of the main factors influencing the electronic setting. It was implied that the consumers had concerned about safety of banking service. Trust in electronic channels was very important because of some risks involved in using electronic media for financial transaction [19]. As security was the main concern in online transactions, commitments and promises such as keeping private information and transactions safe and secure must be fulfilled [19]. If consumers had a trust in banking service, they would be willing to adopt it.

Consumer's knowledge was one of the awareness factors. This research found that the knowledge had significantly impact on consumer's adoption of QR payment. The same effect was found in the work of author [20] who showed that awareness was positively related to the adoption and usage of online services in Oman. According to author [12] which explained about process of adoption in awareness stage that was often accidental perception. The consumer may need to learn more because the product/service may solve the weakness of traditional product. Therefore, awareness was leaded to adopt or non-adopt for innovative product.

## 5. Conclusions

This study aimed to investigate the awareness and adoption of consumers toward the QR payment service in Bangkok. The depth interviews and consumer survey were conducted at the traditional trade including flea market, weekend market, grocery stores and street food shops. Regarding the relationship between payment behavior and consumer's adoption of QR payment, the result revealed that the reason for using QR payment and the type of product purchased by QR payment had significantly related to consumer's adoption. For factors affecting the consumer's adoption, the logistics regression analysis indicated that consumer's knowledge, perceived ease of use and perceived trust had significantly effected on consumer's adoption of QR payment.

As limitations, since QR payment service was launched in Thailand in 2017, this service was widespread in Bangkok but not much popular in other provinces. This study is only focus on the sample group who live in Bangkok metropolitan. Therefore, further research suggests if the sample should be

cover consumers who live in other provinces, particularly main provinces of each regional Thailand. The result will lead to more understandings of Thai consumers' QR payment adoption behavior throughout the country. Finally, it might be interesting for future investigation of consumer adoption of QR payment across the different categories of the product as well as considering other aspects regarding the lifestyle or psychological variables which could be influence the consumer's adoption behavior.

## References

1. Saetang, A. Attitudes and Behavior of Consumers towards Using Services of Mobile Banking in Bangkok Area. Master Thesis, Srinakharinwirot University, Bangkok, Thailand, 2011.
2. Kongjaroen, W. Acceptance of Innovation Factors Affecting the Satisfaction of Mobile Banking Users in Bangkok Metropolitan Area. Master Thesis, Bangkok University, Pathumthani, Thailand, 2015.
3. Thedsawatwong, A. Attitudes and Behavior in Using Mobile Financial Service of Consumer in Bangkok Metropolitan Area. Master Thesis, Srinakharinwirot University, Bangkok, Thailand, 2010.
4. Financial institution in digital society. Available online: [https://www.gsb.or.th/getattachment/8d7a5d95-b808-49b4-a871-7f985f1f7d38/2IN\\_hotissue\\_Digital\\_bank\\_detail.aspx](https://www.gsb.or.th/getattachment/8d7a5d95-b808-49b4-a871-7f985f1f7d38/2IN_hotissue_Digital_bank_detail.aspx) (accessed on 16 August 2018).
5. Electronic payment system. Available online: <http://www.epayment.go.th/home/app/> (accessed on 1 August 2018).
6. Bank of Thailand launches 'QR Code Standard' to transform Thailand into a cashless society. Available online: <https://thestandard.co/standardqrcode/> (accessed on 16 August 2018).
7. Trend of QR payment. Available online: <http://www.thansettakij.com/index.php/content/246538> (accessed on 16 August 2018).
8. Venkatesh, V.; Davis, F.D. A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science* 2000, 46, 186–204.
9. Gray, R.; Pattaravanich, U.; Lucktong, A. *Quality of Life among Employed Population by Generations*, 1st ed.; October printing Co., Ltd., Bangkok, Thailand, 2016; pp.11, ISBN 978–616–279–950–1.
10. McHugh, M.L. Multiple comparison analysis testing in ANOVA. *The journal of Croatian Society of Medical Biochemistry and Laboratory Medicine* 2011, 21(3), 203–209.
11. Kaiyawan, Y. Principle and Using Logistics Regression Analysis for research. *RMUTSV Research Journal* 2012, 4(1), 1–12.
12. Roger, E.M.; Shoemaker, F.F. *Communication of Innovation: A Cross-Cultural Approach*. The free press 1971, New York.
13. Tiplerlerd, P. Factors Influencing Consumers' Purchasing Decision from Traditional Trade on the Bangkok Metropolitan Area. Master Thesis, Thammasat University, Patumthani, Thailand, 2015.
14. QR payment strategy battle. Available online: <https://www.marketingoops.com/news/biz-news/> (accessed on 16 August 2018).
15. Lin, C.; Nguyen, C. Exploring e-Payment Adoption in Vietnam and Taiwan. *The Journal of Computer Information Systems* 2011, 51, 41–52.
16. Padachi, K.; Rojid, S.; Seetanah, B. Analyzing the Factors that Influence the Adoption of Internet Banking in Mauritius. *Proceedings of the 2007 Computer Science and IT Education Conference*.
17. Odumeru, J. The Acceptance of e-banking by Customers in Nigeria. *World Review of Business Research* 2012, 2, 62–74.
18. Nor, K.M.; Shanab, E.A.; Pearson, J.M. Internet Banking Acceptance in Malaysia Based on the Theory of Reasoned Action. *Journal of Information Systems and Technology Management* 2008, 5, 3–14.
19. Fo, O. Factors Influencing Intention to Adopt Internet Banking by Postgraduate Student of the University of Ibadan, Nigeria. *Journal of Internet Banking Commerce* 2015, 20:123.
20. Shatat, A. Factors Affecting the Adoption and Usage of Online Services in Qman. *Journal of Internet Banking Commerce* 2017, 22, S7:020.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license

(<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-003-ID008

# Discriminant Analysis of Consumer Intention to Use Green Packaging in Thailand

Boonsita Vichienvanitchkul<sup>1</sup>, Apichaya Lilavanichakul<sup>2,\*</sup>

<sup>1</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand; boon.boonsita@gmail.com

<sup>2</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand; apichaya.l@ku.ac.th

\* Correspondence: apichaya.l@ku.ac.th; Tel.: +66-2562-5000 ext 5374

Received: 8 July 2018; Accepted: 26 December 2018; Published: 6 January 2020

**Abstract:** Plastic pollution and waste management, especially single used plastic from food consumption has become one of serious issues in Thailand. Green packaging has been developed for alleviating plastic problems, but it is unacquainted for Thai consumers. This research aims to analyze factors segmenting consumer intention to use green packaging by using discriminant analysis technique. Empirical results from 281 Thai consumers reveals a significant relationship between consumer intention to use green packaging and the factors based on consumer attitudes, value for money and consumption values. Findings show that consumer perceive in term of added cost on green packaging is the most influential in segmenting consumer intention to use green packaging followed by the social value, consumer attitude toward environmental concern, and the conditional value. The classification result show that overall 80.1% were correctly classified. For marketing implication, marketing communications on environmental costs and perceived value, building a positive image for green packaging, and offering environmental campaigns are mainly suggested to influencing consumers to use green packaging.

**Keywords:** discriminant analysis; green packaging; consumer behavior; Thailand

---

## 1. Introduction

The numbers of plastic packaging consumption have been increasing in Thailand, especially single used plastic from food consumption with the expected growth around 8-10 percent annually. Food plastic packaging is divided into several types where one type that causes disposed waste is single used plastic including plastic food pan, spoon, fork and knife plastic, plastic bag, plastic grass, and plastic straw. With a high demand for convenient, inexpensive, and time-efficient foods, the quick service restaurant (QSR) and a high number of convenience stores are the main channel for single used plastic [1,2]. Furthermore, a rapid growth of food delivery service and food events in Thailand reach to 1 Billion USD in 2018 [3]. Incorrect use of plastic packaging affects not only environment pollution and waste management problems, but also hygiene issue. According to report on waste disposal sites in Thailand, the amount of garbage is about 27.37 million tons and can divided into 43 percent for properly disposed, 31 percent for recycle garbage, and 26 percent for incorrect disposed [4]. The percentage of plastic garbage is 12 percent of incorrect disposed waste or 339,400 tons/year [5]. In 2015, Thailand is one of the top five countries in the world with plastic waste in the ocean [6].

Nowadays, several alternative eco-friendly choices are applied to cope the environment challenge such as cloth bag, substituting materials (e.g. paper). Bioplastic packaging or green packaging is one of alternative way for alleviating plastic problems. Currently, compostable bioplastic packaging has been applied in the past 10 years, but the application uses are limited with a small market. One reason is that the production cost of bioplastic is high when compared with the regular plastic. Another reason is Thai consumers are unacquainted with bioplastic due to technology adoption. Moreover, consumer awareness of environmental needs is uncertain. Previous literatures on segmenting consumer intention

to use green packaging have been studied in various countries, but a few researches have been done in Thailand. Study on factors affecting to use bioplastic packaging in Bangkok by author [7] found that environmental exposure factors, environment concern factor, perceived consumer effectiveness factor, impact of using plastic factor, participation in environmental protection factor and environment knowledges have positive effect to choose green packaging, while author [8] found that green marketing communications, green product attitude, environment concern, trust in the green product, green brand, environmental knowledge affect to green products purchasing behavior of the consumer. Author [9] studied about segmentation consumer into active green activists and passive green activists by using discriminant analysis. Author [10] mainly focused on classifying environmental concerned segment and found that environmental knowledge is the greatest value for classifying consumer followed by perceived consumer effectiveness, environmentally friendly buying behavior, recycling, environmental activism, resource saving, economic factor, environmental concern and skepticism towards environmental claims. A consumer loyalty in green perspective based on consumption value was studied by author [11] and the result showed that functional value, economic value, emotional value and social value have a significant on consumer perspective.

The objective of this research is to analyze factors segmenting consumer intention to use green packaging by using discriminant analysis technique. The results will become a guideline of consumer study for food service business and marketer to encourage consumers to use green packaging products instead of plastic packaging.

## 2. Materials and Methods

Both primary and secondary data were conducted in this study. In-depth interview was conducted with an expert on green plastic packaging. The preliminary data related to green packaging knowledges and property of green packaging was collected from the discussion and developed in the questionnaire. The questionnaires were divided into 3 sections: (1.) respondents' general demographic information (2.) The consumer attitude toward environment concern and value for money (3.) Consumption values on buy or not buy a green packaging including emotional value, functional value, social value, conditional value and epistemic value regarding to the theory of consumption value [12]. These data were conducted by using 5-point Likert Scale which are 1 = strongly disagree and 5 = strongly agree. Surveys on consumer intention to use green packaging was conducted during April to July 2018 by face to face interview. The cluster random sampling method was applied by collecting data from Thai consumers who over 20 years old in Bangkok. The data were analyzed by using descriptive statistics and discriminant analysis.

### 2.1. Discriminant Analysis

This technique is appropriate statistic when independent variable is categorical and the independent variables are quantitative. This method is used to predict group membership from a set of metric predictors (independent variable,  $x$ ). The model is composed of a discriminant function based on linear combinations of predictor variables as called "Linear Discriminant Analysis (LDA)" [13]. The model is derived as follows:

$$D = v_1x_1 + v_2x_2 + \dots + v_ix_i + a \quad (1)$$

where  $D$  = discriminant function

$v$  = discriminant coefficient

$x_i$  = independent variable

$a$  = a constant

$i$  = the number of predictor variables

In this study, two distinct groups were defined to intention to use green packaging ( $D=1$ ) and do not use green packaging ( $D=0$ ). The independent variables included three type of factors: consumer attitude toward environment concern ( $x_1$ -  $x_3$ ), value for money ( $x_4$ ), and consumption value ( $x_5$ - $x_{12}$ ) where the definition of each variable was presented in Table 2. The stepwise method was selected for

discriminant analysis because this technique is suitable for the model that contains several predators and selects the best model by entering the predators at each step based on F to Enter value that exceeds the entry criteria value [14].

### 3. Results

#### 3.1. Descriptive

Total number of respondents were 281 as presented in Table 1. The majority of respondents are female (71.5%). Most respondents are 20 to 30 years old accounted for 61.6% and 74.4% of sample respondents have education level on graduate. Almost half of respondents have income lower than 20,000 Baht/month. In addition, private employee represent majority with 42.0% followed by student accounted for 25.3% and government service accounted for 14.9%.

**Table 1.** Sample Descriptive

Variable	Range	Frequency	Percentage
Gender	Male	80	28.5
	Female	201	71.5
Age	20-30 years old	173	61.6
	31-40 years old	52	18.5
	41-50 years old	39	13.9
	51-60 years old	12	4.3
	Over 60 years old	5	1.8
Education	Undergraduate	17	6
	Graduate	209	74.4
	Post graduate	55	19.6
Occupation	Private employee	118	42
	Student	71	25.3
	Government service	42	14.9
	Business	20	7.1
	Contractors	13	4.6
	Unemployed	8	2.8
	Other	4	1.4
Income	less than 10,000 Baht/month	65	23.1
	10,001-20,000 Baht/month	69	24.6
	20,001-30,000 Baht/month	67	23.8
	30,001-40,000 Baht/month	28	10
	40,001-50,000 Baht/month	14	5
	Over 50,000 Baht/month	38	13.5

#### 3.2. Reliability Statistics of Measure

Reliability test is the degree of consistency or dependability with which an instrument measures the attribute [15]. The reliability coefficient between 0.70 to 0.90 is considered as acceptable range with the reliability of items [16]. As presented in Table 2, Cronbach's alpha was computed to be 0.830 with item-to-total reliability of all twelve statements (X1-X12), interpreting that the statements have relatively high internal consistency.

**Table 2.** Reliability Statistics of dependent variable

Factors	Variable name	Statement	Item-to-total Cronbach's	
			reliability	Alpha
Consumer attitude toward environment concern	Reduce Plastic (x <sub>1</sub> )	You want to reduce using plastic packaging to save the world.	0.818	0.830
	Long term Solve (x <sub>2</sub> )	Green packaging can alleviate long term environment problem.	0.814	
	Laws (x <sub>3</sub> )	Laws have helped propel the use of green packaging.	0.838	
Value for money	Accept Added Cost (x <sub>4</sub> )	You accept the added cost of using green products.	0.811	
Emotional value	Unique (x <sub>5</sub> )	The unique characteristic of green products makes you feel good to green products.	0.807	
	Biodegradable Word (x <sub>6</sub> )	"Biodegradable 100%" on the products make you trust in green products.	0.804	
Functional value	Heat Resistant (x <sub>7</sub> )	You concern about heat resistant of packaging product.	0.831	
Social value	Social (x <sub>8</sub> )	Using green packaging impact on society and well-being.	0.812	
	Be Accepted (x <sub>9</sub> )	Using green product make you feel be accepted and have a good image.	0.821	
Condition value	Shop Provide (x <sub>10</sub> )	If the restaurants provide green packaging option, you will choose it.	0.808	
	Campaign (x <sub>11</sub> )	If environment campaign is promoted, you will choose green products.	0.804	
Epistemic value	Try New Thing (x <sub>12</sub> )	You want to try new green packaging which you have never used it before.	0.832	

### 3.3 Discriminant Analysis

The summarized results of the stepwise discriminant analysis were shown in Table 3. Most variables preformed statistically significant canonical functions at alpha 0.01 level, excepting one variable: Laws (x<sub>3</sub>). The Wilks' lambda value explains a spread between the clusters' mean, which Laws variable (x<sub>3</sub>) had the highest value that could be interpreted as a larger spread between the clusters' mean or the least of membership of the group. F-test presents the test of mean of each variable among the groups. If the value is significant, it indicated that the mean of the variable in intention to use green packaging group is significantly different from the mean of that variable in intention to do not use green packaging group [17].

**Table 3.** Tests of Equality of Group Means

Variable	Wilks' lambda	F
Reduce Plastic (x <sub>1</sub> )	0.829	57.428***
Long term Solve (x <sub>2</sub> )	0.931	20.742***
Laws (x <sub>3</sub> )	0.989	3.158*
Accept Added Cost (x <sub>4</sub> )	0.784	77.039***
Unique (x <sub>5</sub> )	0.874	40.269***
Biodegradable Word (x <sub>6</sub> )	0.856	47.001***

**Table 3.** Tests of Equality of Group Means (continued)

Variable	Wilks' lambda	F
Heat Resistant (x <sub>7</sub> )	0.972	8.003***
Social (x <sub>8</sub> )	0.913	26.727***
Be Accepted (x <sub>9</sub> )	0.864	43.772***
Shop Provide (x <sub>10</sub> )	0.894	33.080***
Campaign (x <sub>11</sub> )	0.853	48.173***
Try New Thing (x <sub>12</sub> )	0.964	10.435***

Note: \* significant at 0.10 level; \*\* significant at 0.05 level; \*\*\* significant at 0.01 level

In Table 4, the stepwise discriminant analysis performed the best 4 variables for classify group: Accept added cost (x<sub>4</sub>), Be accepted (x<sub>9</sub>), Reduce plastic (x<sub>1</sub>) and Campaign (x<sub>11</sub>) with an acceptable tolerance value. Note that a variable with low tolerance value (< 0.20) suggests that little information contributed to the model, thus it is removed from the model [18].

**Table 4.** Variable in the analysis

Variable	Tolerance	F to enter
Accept added cost (x <sub>4</sub> )	0.863	21.644
Be accepted (x <sub>9</sub> )	0.942	12.123
Reduce plastic (x <sub>1</sub> )	0.842	8.691
Campaign (x <sub>11</sub> )	0.872	7.597

After the discriminant function was derived with 4 variables (Table 5.), the performance of the model was explained by the statistical test. The eigenvalue of 0.481 and the canonical relation of 0.570 demonstrated a function is quite strong and discriminates well. Moreover, Wilks' lambda indicated the significance of the discriminant function at alpha 0.01 level [17].

The interpretation of discriminant coefficients was explained by the important of each predictor as higher value as more important [17]. Results of discriminant function indicated that the accept added cost (x<sub>4</sub>) variable was strongest predictor to classify the group of consumers intention to use green packaging followed by Be accepted (x<sub>9</sub>), Reduce plastic (x<sub>1</sub>) and Campaign (x<sub>11</sub>), respectively. All variables presented the positive correlation with the intention to use green packaging, given the insight into the marketing potential of green consumers.

**Table 5.** Standardized canonical discriminant function's coefficients

Variable	Coefficients
Reduce Plastic (x <sub>1</sub> )	0.334
Accept added cost (x <sub>4</sub> )	0.509
Campaign (x <sub>11</sub> )	0.307
Be accepted (x <sub>9</sub> )	0.371
<b>Eigenvalue</b>	<b>0.481</b>
<b>Canonical Relation</b>	<b>0.570</b>
<b>Wilks' lambda</b>	<b>0.675***</b>

Note: \*\*\* significant at 0.01 level

After the discriminant function was derived, the test on the correction rate was shown in Table 6. The result indicated that the model was correctly classified at 80.1%. The class 'Intention to use green packaging group' can predict correctly at the correction rate of 88.5%, while the class 'Intention to do not use green packaging group' can forecast properly at the correction rate of 66.4%.

**Table 6.** Classification result

Real Group	Predicted Group		Total	Correction rate
	Intention to use green packaging	Intention to do not use green packaging		
Intention to use green packaging	154	20	174	88.5%
Intention to do not use green packaging	36	71	107	66.4%
<b>Overall</b>	190	91	281	<b>80.1%</b>

#### 4. Discussion

The results showed that several dimensions of variables were the key element to determine the intention to use of green packaging. The value for money carried the most influential factor. According to value for money literature, consumers choose products what satisfied them as per usage and as per the money spent on it [19]. In this study, the value for money is interpreted as consumers' willingness to accept added cost of green packaging. Therefore, the retailers and food service business should focus on the pricing of green packaging products including the way to communicate benefit and cost of green packaging in order to encourage consumers using environmentally friendly products. In addition, social value was one of driven factors to use green packaging because the use of eco-friendly products may build a personal positive image and be accepted from the society. Author [11] stated that perceived social value is one of the most important for green consumers.

Intention to reduce using plastic is one of attitude toward environmental concerns, thus consumers who have viewpoint of decrease the use of plastic packaging are more likely to use the eco-friendly packaging. Studies by author [20] and [21] indicated that having a positive attitude and green perceived value toward green products affected to intention of customers to buy green products. Lastly, consumers perceived on condition value in the aspect of environmental campaign. If environmental campaign is promoted heavily and it can acknowledge consumer understanding of green products including change their attitudes toward environment and accumulate consumers' confidence on green products, consumers tend to use environmentally friendly products [22]. This condition value related to media exposure of consumer which may motivate the attitude or habits of consumers. Media exposure of environment campaign through social media, poster, exhibition and influencers has a positive impact to intention to use green products [7]. Hence, building a positive image for green packaging and offering environmental campaigns are mainly suggested to influencing consumers to use green packaging.

#### 5. Conclusions

As green packaging has been implemented as one of eco-friendly choices, technology adoption of Thai consumers can be a challenge to reduce environmental pollution problems. According to discriminant analysis, added cost, be accepted, reduce plastic, and campaign were considered as predictor whether Thai consumer intention to use green packaging or not. The cross validated classification showed that the classifying model performed at the correction rate of 80.1%. Four key factors are mainly suggested to food service business and the marketer to encourage consumers to have pro-environmental behavior and decide to use green packaging. Moreover, the outcome can be used as the guideline to create the position of the business and launch the marketing campaign.

**Acknowledgments:** This project has received funding from National Research Council of Thailand (NRCT) and National Science and Technology Development Agency (NSTDA) in the project of Formulation Development and Marketing Feasibility Study of Thermoplastic Starch-Based Blends.



## References

1. Sirikeratikul, S. (United States Department of Agriculture, Bangkok,Thailand). Food Service - Hotel Restaurant Institutional, 2017.
2. Ngamprasertkit, S. (United States Department of Agriculture, Bangkok,Thailand). Retail Foods, 2018.
3. 3. Foodpanda and Line Are Fighting to Feed Bangkok: <https://www.bloomberg.com/news/articles/2018-03-19/foodpanda-uber-take-meal-apps-battle-to-bangkok-s-food-paradise> (accessed on 26 August 2018).
4. Pollution Control Department. (Ministry of Natural Resources and Environment, Bangkok, Thailand). Situation Report of Community Waste Disposal in Thailand in 2017, 2018.
5. 5. Simachaya, V. (Ministry of Natural Resources and Environment, Bangkok,Thailand). Waste situation in Thailand, 2018.
6. Stemming the Tide: Land-based strategies for a plastic- free ocean: <https://oceanconservancy.org/wp-content/uploads/2017/04/full-report-stemming-the.pdf>(accessed on 26 August 2018).
7. Preechanaruechitkul, S. Factors affecting the Using on Bioplastic Packaging of Working people in Bangkok Metropolis. Master's Degree, Thammasat University, Bangkok, Thailand, 17 April 2011.
8. Nisaisuk, N. Factor Affecting Green Products Purchasing Behavior of Consumer. Master's Degree, Suranaree University of Technology, Nakhon Ratchasima, Thailand, 2013.
9. Modi, A.G.; Patel, J.D. Classifying Consumers Based Upon Their Proenvironmental Behaviour: An Empirical Investigation. *Asian Academy of Management Journal* 2013, 18, 85-104.
10. Paco, A.M.F.; Raposo, M.L.B.; Filho, W.L. Identifying the green consumer:A segmentation study. *Journal of Targeting, Measurement and Analysis for Marketing* 2009, 17,17-25, DOI 10.1057/jt.2008.28.
11. Koller, M.; Floh, A.; Zauner, A. Further Insights into Perceived Value and Consumer Loyalty: A "Green" Perspective. *Psychology & Marketing* 2011, 28(2), DOI 1154-1176, 10.1002/mar.20432.
12. Sheth, J.N.; Newman, B.I.; Gross, B.L. Why We Buy What We Buy: A Theory of Consumption Values. *Journal of Business Research* 1991, 22, 150-170, DOI 10.1016/0148-2963(91)90050-8.
13. Balakrishnama,S. (Mississippi State University, Mississippi State, the United States); Ganapathiraju, A. (Mississippi State University, Mississippi State, the United States). *Linear Discriminant Analysis-A Brief Tutorial*, 1998.
14. Stepwise Discriminant Analysis:
15. [https://www.ibm.com/support/knowledgecenter/SS3RA7\\_sub/modeler\\_tutorial\\_ddita/spss/tutorials/discrim\\_telco\\_stepwise.html](https://www.ibm.com/support/knowledgecenter/SS3RA7_sub/modeler_tutorial_ddita/spss/tutorials/discrim_telco_stepwise.html)(accessed on 25 August 2018).
16. Chonbach, L.J. Coefficient Alpha and the Internal Structure of Test. *Psychometrika* 1951, 16, 297-334.
17. Tavakol, M.; Dennick, R. Making sense of Cronbach's alpha. *International Journal of Medical Education* 2011, 2, 53-55, DOI: 10.5116/ijme.4dfb.8dfd.
18. Banerjee, S.; Pawar, S. Predicting Consumer Purchase Intention: A Discriminant Analysis Approach. *NMIMS Management Review* 2013, 13, 113-129.
19. 18. Mernald, S. *Applied Logistic Regression Analysis*, 2nd edition; Sage Publication, Inc: Thousand Oaks, The United States, 2002; pp. 41-63, ISBN 0-7619-2208-3.
20. Glendinning, R. The Concept of Value for Money. *International Journal of Public Sector Management* 1988, 1, 42-50.
21. Vazifehdoust, H.; Taleghani, M.; Esmailpour, F.; Nazari, K.; Khadang, M. Purchasing green to become greener: Factors influence consumers' green purchasing behavior. *Management Science Letters* 2013, 3, 2489-2500, DOI 10.5267/j.msl.2013.08.013.
22. Grob, A. A structural model of environmental attitudes and behavior. *Journal of Environmental Psychology* 1995, 15, 209-220, DOI 10.1016/0272-4944(95)90004-7.
23. Chen,S.C.; Hung, C.W. Elucidating the Factors Influencing the Acceptance of Green Products: An Extension of Theory of Planned Behavior. *Technological Forecasting & Social Change* (Elsevier Inc, Accepted 24 August 2016; in press).



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-005-ID036

# Designing Herbal Cosmetics Marketing Channel

Preuk Petsophonsakul<sup>1</sup> and Chutima Waisarayutt<sup>2,\*</sup>

<sup>1</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand; preuk.p@gmail.com

<sup>2</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand; chutima.w@ku.ac.th

\* Correspondence: chutima.w@ku.ac.th; Tel.: +66-2562-5093

Received: 4 August 2018; Accepted: 26 December 2018; Published: 6 January 2020

**Abstract:** Nowadays, the demand of herbal cosmetics has been growing in Thailand because Trend of health and wellness. Consumer would prefer the natural or herbal based products. There are a many products on the market from the global and local manufacturers which affects to high competition in term of products quality, price and marketing channels. Therefore, the competitive advantage from competitors depends on brand strategy. This research aims to examine consumer in both generation X and Y, their behaviors, life styles on market channel, design and develop appropriate market channels that deliver value of cosmetic products and develop business strategy by experiment using oral herbal product as a case. The business research included in-depth interview, market survey research, segmenting consumer life style by using cluster analysis technique. The result indicate that either customer in generation X or Y, both generations interested products made from natural and prefer originality. Consumer's life style, and product knowledge are key factors affecting the marketing channel preference. The implication of the research will provide the deep understanding, create channels that respond consumer needs and herbal cosmetics business growth.

**Keywords:** herbal cosmetic; channel design; business research; Thailand

---

## 1. Introduction

Thailand has a potential for herbal based production because Thailand locate in the tropical area with high biodiversity; [1] consequently, there are many natural herbal materials with high production capacity and growth rate ranked number 8th in the world. Herbal used as many type of products including medicine, used as food ingredients, supplements and cosmetic base. The utility of herbal base substitute chemical and support from the expansion of related industries affect the growth of herbal in country. [2] Market overview in 2016 herbal and traditional products is worth almost US\$ 37 billion about 17% of global consumer health industry.

The Herbal cosmetic products about 70% used ingredients form herbs [3] in year 2015 products sale volume is 5.5 hundred thousand tons and expandable about 2.2 % form year 2014. The amount of value opportunity, many major and minor manufacturers had come to this market with competitive technologies process and ingredients for herbal cosmetics. Affects to high competition in term of products quality and price war. Therefore, the competitive advantage from business sector depends on marketing strategy.

Most studies focus only on factors affecting decision on herbal product. In additional most segmentation studies of market channel have been conducted in the United States [4] despite cultural differences among countries. Only a few studies on market channel in Thailand, mainly studies on online channel.

The relevant decision for consumer segmentation, is consumer 's life style. [5] The individuals with similar socio-demographic characteristics can have different behaviors. [6] Only socio-demographic characteristics are not sufficient for the analysis of consumer behavior. [7] Lifestyle are psychographic variables that distinguish patterns of personal or social beliefs or even characteristics represented by a

set of particular activities and [8] lifestyle are variables that refer to the perception of life, attitudes, opinions, hobbies or interests.

Therefore, the main objective of this study is to perform a segmentation to identify groups of herbal oral cosmetic consumers in each generation in terms of Demographic and lifestyle. This important factor to use to design market channel for consumer Generation and Generation Y.

The following hypotheses are proposed.

- H1. Consumer's generation has affect to heterogeneous among their life style according to herbal oral cosmetic.
- H2. Consumer's life style of cluster in each generation are heterogeneous.

## 2. Materials and Methods

### 2.1. Sampling and fieldwork

A questionnaire was developed based on a literature review on market channel and consumer behavior and in-depth interview. The target is [9] consumers generation X, age 38-53 years old and generation Y, age 18-37 years old who use oral herbal products. Data were collected by face-to-face interview, this study the data were use to segment consumer lifestyle in each generation. The questionnaire consisted of five parts. The first part captured the demographic profile data of respondents, including gender, age, educational level, occupation, income per month and hobby. The second part captured the consumer's behavior on the herbal oral product including product type, recommended information, purchase frequency, the market channel used. The third examined consumer's lifestyle by five points Likert scale; respondents were asked to indicate their agreement/disagreement (from 1 indicating strongly disagree to 4 indicating strongly agree and 0 indicating disagree). The forth examined factors influencing on buying decision towards oral herbal products by five points scale; respondents were asked to indicate their affected / not affected (from 1 indicating strongly not affected to 4 indicating strongly affected and 0 not affected). The fifth examined problems from the consumer on each market channel; the market channel includes internet or online channel, pharmacy store, trade show, herbal store, dental clinic, shopping center, agent or direct sale, supermarket, and convenience store. The descriptive analysis of the data is shown in Table 1.

**Table 1.** Herbal oral cosmetics consumer demographic' profile

Variable	Categories	Percentage
Gender	Men	27.7%
	Women	72.3%
Age	Generation Y (18-37)	50.0%
	Generation X (38-53)	50.0%
Marital status	Single	61.4%
	Married, no child	9.1%
	Married with child	29.5%
Educational level	High school	37.3%
	High Vocational Certificate	6.4%
	B.A. (Bachelor of Arts)	45.9%
	Over Bachelor of Arts	10.5%
Employment status	Student	43.2%
	Government officer	7.1%
	Company employee	12.4%
	Business owner	11.3%
	Employee	14.6%
	Retired	11.4%

**Table 1.** Herbal oral cosmetics consumer demographic' profile (continued)

Variable	Categories	Percentage
Household income per month	Under 10,000 baht	42.3%
	10,000 – 20,000 baht	25.5%
	20,000 – 30,000 baht	20.5%
	Over 30,000 baht	11.8%

The target population in this survey shows that herbal oral cosmetic consumer is mainly female, although there was different from men about 44.6 % more women than men. Furthermore, we separate the sample into to Generation Y (18-37 years of age) 50% and Generation X (38-53 year of age) 50%. The group was mainly single (61.4%). In terms of educational attainment, the majority of the group had a Bachelor of Arts (45.9% of the sample) and 43.2% of the sample was the student. Income per month, mainly under 10,000 baht (42.3%) of the population.

## 2.2. Technique and research variables

The population from a survey questionnaire, 220 respondent we test the hypothesis by using statistic ANOVA. First, we test hypothesis H1 to confirm that consumer's generation affects to heterogeneous among their lifestyle. Then after segmentation consumer generation, we test the hypothesis H2 to confirms cluster differentiate.

Two-step cluster analysis was used to determine the number of segment and segment result. The cluster analysis examines the relationships among variables to establish a grouping of individuals. This research used the quantitative data, consumer's demographics including gender, age, educational level and Household income per month and qualitative data, consumer's lifestyle to identify segment. The method used to measure distance is Log likelihood and determine the number of the cluster by determining automatically.

## 3. Results

### 3.1. Segmenting customer

To examine hypothesis H1, in which Consumer's generation has affected to heterogeneous among their lifestyle according to herbal oral cosmetic. In the ANOVA test, generation of customer affects to their lifestyle which was statistically significant ( $p=0.000$ ), as indicated by the ANOVA results. It can be concluded that hypothesis H1 can be accepted, which means that generation of consumer affects to heterogeneous among their lifestyle according to herbal oral cosmetic.

The segmented of consumer' generation base on demographic and lifestyle who use oral herbal cosmetics. The mean scores on a scale 0 – 4 for each of variable and groups included in the analysis were calculated to find the main differences between segments. By using a two-step cluster analysis, there are four clusters and each generation has two clusters. The result shows that the cluster quality is good for generation Y and X. We use ANOVA test to confirm that two clusters in each generation, it can be concluded that hypothesis H2 can be accepted how that consumer's lifestyle of Cluster in each generation are heterogeneous were statistically significant ( $p=0.000$ ). The clusters result (Table 2) generation Y, cluster Y-2 was the largest, representing 47.2% of the sample, and generation X, cluster X-1 was the largest, representing 77.3% of the sample.

**Table 2.** Segmentation of consumer's life style base on demographic and life style

Life style	Generation Y		Generation X	
	Cluster Y-1	Cluster Y-2	Cluster X-1	Cluster X-2
	-47.20%	-52.80%	-77.30%	-22.70%
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD
Nature	2.83 <sub>a</sub> $\pm$ 0.66	3.62 <sub>b</sub> $\pm$ 0.42	3.27 <sub>c</sub> $\pm$ 0.52	2.26 <sub>d</sub> $\pm$ 0.56
Innovative	1.92 <sub>a</sub> $\pm$ 0.42	2.55 <sub>b</sub> $\pm$ 0.55	2.43 <sub>b</sub> $\pm$ 0.56	1.62 <sub>c</sub> $\pm$ 0.49
Conservative	2.73 <sub>a</sub> $\pm$ 0.37	3.08 <sub>b</sub> $\pm$ 0.29	2.97 <sub>b</sub> $\pm$ 0.31	1.90 <sub>c</sub> $\pm$ 0.36
Healthy herbal	1.65 <sub>a</sub> $\pm$ 0.57	2.41 <sub>b</sub> $\pm$ 0.54	2.21 <sub>b</sub> $\pm$ 0.52	1.30 <sub>c</sub> $\pm$ 0.48

Note: a b c the mean difference is significant at the .05 level.

From table 2, consumer's lifestyle was divided into four categories including Nature (consumer who prefer natural products which fewer additives and chemical ingredient), Innovative; a group of consumer who interested in product that has new innovation and/or gimmick, Conservative is a category of conservatism consumer and prefer biodegradable packaging, and the last category is Healthy herbal (consumer who like to go to herbal shop and search and/or attend about herbal's news).

- **Cluster Y-1:** The consumer's lifestyle score in this generation are lowest all of category, the lowest score is *healthy herbal*. It's mean that consumer's lifestyle in this cluster had few unconcerned herbal products but they more concerned in nature category. In term of socio-demographic, this group the main consumer are female (80.8%), single (96.2%). For education level is high school (75.0%), they are a student (88.5%) and household income per month are under 10,000 baht (73.1%).
- **Cluster Y-2:** The consumer's lifestyle score in this generation are highest all of category, with the highest score is *nature*. Cluster member in this group mainly member are female (87.9%), most of them are single (96.6%) and enrolled in high school (60.3%). They are a student (84.5%) and household income per month are under 10,000 baht (69.0%).
- **Cluster X-1:** The largest cluster member in generation X with lifestyle core are highest all of category including *nature*, *innovative*, *conservative* and *herbal*. The highest score is *nature* similarity cluster Y-2 but the score is below than cluster Y-2. The cluster profile mainly is female (60.0%) and married with child (51.8%). Educational level mainly are Bachelor of Arts, work for employee (25.9%) and household income per month are 20,000 - 30,000 baht (37.6%)
- **Cluster X-2:** The smallest cluster member consist with lower consumer's lifestyle score all of the categories, the lowest score is *healthy herbal* and high score is *nature* similarity cluster Y-1. The most member are female (60.0%), married with child (72.0%) and had an education level Bachelor of Arts (52.0%). Mainly member worked on business owner and employee (24.0%) and household income per month are 10,000 - 20,000 baht (40.0%).

Overall, generation Y, consumer's lifestyle in cluster Y-1 and Y-2 all category has significantly different with a high score in cluster Y-2, Generation X, both cluster has significantly different with the highest score in cluster X-1. It's mean consumer in cluster Y-2 and X-1 matches on this lifestyle including nature, innovative, conservative and healthy herbal. In both generations, all categories in cluster Y-2 and X-1 are on significantly different except for nature category is significantly different.

**Table 3.** Segmentation of the different cluster according to socio - demographic variable.

Variable	Categories	Generation Y (n=110)		Generation X (n=110)	
		Cluster Y-1	Cluster Y-2	Cluster X-1	Cluster X-2
		47.2%	52.8%	77.3%	22.7%
Gender (chi-square: 3.828; sig = 0.148)	Male	19.2	12.1	40.0	40.0
	Female	80.8	87.9	60.0	60.0

**Table 3.** Segmentation of the different cluster according to socio - demographic variable (continued)

Variable	Categories	Generation Y (n=110)		Generation X (n=110)	
		Cluster	Cluster	Cluster	Cluster
		Y-1	Y-2	X-1	X-2
		47.2%	52.8%	77.3%	22.7%
Marital status (chi-square: 12.404; sig = 0.002)	Single	96.2	96.6	27.1	24.0
	Married, no child	0.0	1.7	21.2	4.0
	Married with child	3.8	1.7	51.8	72.0
Educational level (chi-square: 8.216; sig = 0.042)	High school	75.0	60.3	3.5	20.0
	High Vocational Certificate	0.0	0.0	12.9	12.0
	B.A. (Bachelor of Arts)	19.2	31.0	70.7	52.0
	Over Bachelor of Arts	5.8	8.6	12.9	16.0
Employment status (chi-square: 19.057; sig = 0.008)	Student	88.5	84.5	0.0	0.0
	Government officer	3.8	1.7	11.8	16.0
	Company employee	0.0	8.6	15.3	20.0
	Business owner	1.9	0.0	23.5	24.0
	Employee	3.8	0.0	25.9	24.0
	Retired	1.9	0	23.5	16
Household income per month (chi-square: 10.883; sig = 0.012)	Under 10,000 baht	73.1	69	12.9	16
	10,000 – 20,000 baht	21.2	22.4	25.9	40
	20,000 – 30,000 baht	5.8	5.2	37.6	28
	Over 30,000 baht	0	3.4	23.5	16

After the segmentation consumer's generation was identified according to their lifestyle. And, the socio-demographic variables (gender, marital status, education level, employment status, and household income per month) is used to examine the relationship between socio-demographic and cluster by using the chi-square statistic test (table 3). The result shows that only gender variable has no relationship with clusters.

**Table 4.** Segmentation of the different cluster according to consumer's behavior variable.

Variable	Categories	Generation Y (n=110)		Generation X (n=110)	
		Cluster	Cluster	Cluster	Cluster
		Y-1	Y-2	X-1	X-2
Product type	Herbal toothpaste	73.8	77.5	75.2	79.3
	Herbal mouth wash	15.4	15.5	10.5	10.3
	Herbal mouth spray	6.2	5.6	3.8	3.4
	Herbal Tooth polishing powder	4.6	1.4	10.5	6.9
Product brand	Salz - herbal + salt	16.7	13.9	14.9	16.9
	Colgate	24.7	20.3	21.3	28.6
	Systema } herbal + Fluoride	11.8	12.7	11.2	7.8
	Darlie	9.7	11.6	15.5	10.4

**Table 4.** Segmentation of the different cluster according to consumer's behavior variable (continued).

Variable	Categories	Generation Y (n=110)		Generation X (n=110)	
		Cluster	Cluster	Cluster	Cluster
		Y-1	Y-2	X-1	X-2
With Fluoride	Dentiste	10.2	13.9	7.9	7.8
	Twin lotus	10.8	9.2	14.9	19.5
	Abhaiherb	3.8	2.8	2.1	0
	Bamboo	0	0.8	0.3	1.3
	Viset-Niyom	2.7	3.2	3.3	0
	Tepthai	3.2	3.2	4	2.6
	Kok-liang	1.6	2.4	0.9	1.3
	Kolbadent	2.2	1.6	1.2	1.3
	Tip-Niyom	1.6	1.2	1.5	0
	Other	1.1	3.2	0.9	2.6
Acknowledge information	Internet	31.2	30.4	13.3	15
	Trade show	6.5	10.4	14.7	15
	Media	36.6	30.4	48	52.5
	Herbal store	3.2	11.2	10	5
	Family / Friend	21.5	14.4	10.7	7.5
	Other	1.1	3.2	3.3	5
Purchase frequency	Every week	5.8	1.7	2.4	4
	Every 2 week	11.5	6.9	17.6	12
	1 time per month	53.8	67.2	60	72
	2-3 time per month	28.8	24.1	20	12
When purchasing products	Monday - Friday	32.7	29.3	60	72
	Saturday - Sunday	51.9	67.2	31.8	24
	Holiday – Festival	15.4	3.4	8.2	4
Purchasing behavior	Purchase used brand	47.3	42.9	50.7	58.3
	Purchase when promotion	35.2	26.7	22	22.2
	Purchase when new product available	3.3	10.5	6	2.8
	Purchase when trail product	9.9	10.5	13.3	11.1
	Unconditional purchase	3.3	6.7	5.3	5.6
	Other	1.1	2.9	2.7	0
Payment	Cash	78.1	83.8	79.2	92.6
	Credit / Debit card	20.3	13.2	19.8	7.4
	E-payment	1.6	2.9	10	0
Marketing channels used	Internet	3.3	2.4	2	1.4
	Pharmacy	11.3	15.1	6.9	2.9
	Herbal store	2.7	7.8	3.2	5.7
	Dental Clinic	1.3	1.8	0.4	1.4
	Department store / Shopping mall	29.3	28.3	26.2	0
	Agent / Direct sale	3.3	2.4	2	32.9
	Hypermarket / Supermarket	20	16.3	20.2	4.3

**Table 4.** Segmentation of the different cluster according to consumer's behavior variable (continued).

Variable	Categories	Generation Y (n=110)		Generation X (n=110)	
		Cluster	Cluster	Cluster	Cluster
		Y-1	Y-2	X-1	X-2
Marketing channels used	Convenient store	22.7	21.7	25.8	12.9
	Trade show	2.7	2.4	6	27.1

Note: blue color: highest percentage in each variable

**Table 5.** Segmentation of the different cluster according to consumer's behavior variable by ranking.

Variable		Generation Y (n=110)		Generation X (n=110)	
		Cluster Y-1	Cluster Y-2	Cluster X-1	Cluster X-2
The most channels used	No.1	Convenient store	Convenient store	Convenient store	Convenient store
	No.2	Hypermarket	Hypermarket	Hypermarket	Department store
	No.3	Department store	Department store	Department store	Hypermarket
Reasons to purchase	No.1	Product features	Product features	Product features	Product features
	No.2	Reasonable price	Reasonable price	Necessary product	Necessary product
	No.3	Necessary product	Standard certification	Standard certification	Reasonable price

The consumer behavior in a different cluster (table 4). Cluster Y-1, the most consumer in this cluster used herbal toothpaste (73.8%) with Colgate brand (24.7%). They acknowledge from media channel such as television, brochure (36.6%), purchasing every month for 1 time (53.8%) and mainly purchasing on Saturday – Sunday (51.9%). For purchasing behavior, purchase used brand or brand royalty (47.3%), payment by cash (78.1%), they use market channel majority are Department store or shopping mall (29.3%). Cluster Y-2 this cluster consumer's behavior profile quite similar cluster Y-1 except for acknowledging information, they attend on media and internet (30.4%). Cluster X-1 majority consumer used herbal toothpaste (75.2%) with Colgate brand (20.3%). They acknowledge from media channel such as television, brochure (48.0%), purchasing every month for 1 time (60.0%) and mainly purchasing on Monday – Friday (60.0%). Purchasing behavior includes purchase used brand or brand royalty (50.7%), payment by cash (79.2%), they use market channel majority are Department store or shopping mall (26.2%). And cluster X-2 this cluster consumer's behavior profile quite similar cluster X-1 except for they use marketing channel on an agent or direct sale (32.9%). The suggestion of marketer, consumer generation Y and X, their usually purchase herbal toothpaste more than another, the majority they use the herbal product that mix fluoride, can connect information with them by internet and media, most of them had brand loyalty marketer should find the way to retain customers.

In table 5, the first variable is the most channels used. The result shows that the most channels used of cluster Y-1, Y-2, and X-1 are the same which No.1 is a convenient store, No. 2 is hypermarket, and No.3 is the department store. For, Cluster X-2 consumer selected convenient store in first ranked follow by the department store and hypermarket. Overall in the market channel, can be said that the marketer can launch the product on three channels including the convenience store, hypermarket, and department store. In term of reasons to purchase herbal oral cosmetic all of cluster selected by product feature in the first rank but another rank are the different reasons. In the second rank, both generations are different. Generation Y both clusters are reasonable price only cluster Y-1 has two reasons in similar rank. For generation X, the main reason that both clusters purchase the product because it is a necessary product. From the above information, the marketer or developer should focus on the product feature, however, the main reason that consumer purchases the product because it is the necessary product.



#### 4. Discussion

This research uses the data from each cluster to determination and/or design the suitable market channel to deliver herbal oral cosmetics which had interested point below.

- Two clusters of generation Y were no significantly different due to consumer in this generation has knowledge and understand about herbal. the interesting of herbal and natural products was medium level which related with previous research; [10] studied about herbal knowledge and understanding of consumer and majority of population (67.5%) had age range between 20 to 35 years old (generation Y), the result indicated average of consumer who had knowledge and understand about herbal at 62.25% in addition new generation consumer has high variation of products that sell in different market channel while generation X consumer show significantly different on different clusters by the cluster who interesting in herbal products had 70% follow up the new information about herbal because most of they familiar with herbal and often used herbal oral cosmetics related with [11] studied about consumer's attitude and usage-purchasing behavior toward the herbal toothpaste.
- The studied about market channel, both generation selected convenient store as 1st rank which major of population was female related with research of [12] studied about the market channel on a convenience store. Place and conveniences such as has car parking or easy to reach were a factors that effect to making a decision of consumer.
- For determination and/or design market channel, [13] said business that has varied market channel was enhance competitive opportunity and can reach consumer more than single market channel due to the increasing of convenience to reach consumer needed goods.
- Consumer buying behavior on herbal oral cosmetic, majority consumer consider on products feature and buying the same brand that they use before or brand loyalty related with [14] studied about multi-channel shopping found that service quality and product quality are the most significant determinants affecting loyalty.

#### 5. Conclusions

Consumer indicated that age is the important factor that affects to consumer's lifestyle which divided in to 2 generations; generation Y (age 18-37) and generation X (age 38-54) then the generation were segmented, both of generations had 2 significantly different clusters which divided by different score of herbal interesting (Y-1 and X-2 were low levels while Y-2 and X-1 were high levels of herbal interesting). Now we know the consumer target from socio-demographic (table 3), understand what they concern/unconcern and can create content to connect the consumer target by their lifestyle (table 2), how to approach them and which channel should be select (table 5). This data will be used for determination and/or design market channel for sale herbal oral cosmetics and it also benefit for the marketer, developer or entrepreneur, guideline the optimal solution helps them get opportunities for competition and sustainable business.

#### References

1. Busakorn P. Thai Herbs Wisdom to the World Market. Bangkokbiznews, available online: <http://www.bangkokbiznews.com/news/detail/772552>. August 25, 2018.
2. Sureeporn Sahawat. Thai Herbs on Threshold of a New Economy. Thai herb innobiz network, 2017.
3. Department of Industry Promotion (DIP), Ministry of Industry of Thailand 2017. Industry Trends and 230 Market Size of Herbal Businesses. Available online: <https://bsid.dip.go.th/download-content/quality-control/qs-trensherbsproduct>. August 25, 2018.
4. Ruiz, J.P., Chebat, J.C., Hansen, P., 2004. Another trip to the mall: a segmentation study of customers based on their activities. *Journal of Retail. Consumer. Serv.* 11 (6), 333–350.
5. González, A.M., Bello, L., Muñoz, N., 2000. Orientación de la empresa turística del s. XXI a los valores personales y los estilos de vida de los turistas. *Cuad. Cienc. Econ. Empresa.* 39, 59–86.
6. Du Preez, R., Visser, E.E., Zietsman, L., 2007. Profiling male apparel consumers: life style, shopping orientation, patronage behaviour and shopping mall behavior. *Manag. Dyn.* 16 (1), 2–19.

7. Green, G.T., Gordell, H.K., Betz, G.J., 2006. Construction and validation of the national survey on recreation and the environment's lifestyles scale. *J. Leis. Res.* 38 (4),513–535.
8. Valentine, D.B., Powers, T.L., 2013. Generation Y values and lifestyle segments. *J. Consum. Mark.* 30 (7), 597–606.
9. Novak, J. 2012. The six living generations in America. Available Source: <http://www.marketingteacher.com/the-six-living-generations-in-america/> , March 4, 2017.
10. Reungtorsang C. Factor Affectig Herbal Cosmetic Consumption Behaviors. Master's degree Thesis, Master of public administration Burapha University, Chonburi, 2015.
11. Thitinart J., The effect of marketing communication exposure on the Bangkok metropolitan consumer's attitude and usage-purchasing behavior toward the herbal toothpaste. Master's degree Thesis, Master of Marketing Communication University of the Thai Chamber of Commerce, Bangkok, 2006
12. Wantana R., Market channel analysis on convenient store in Changmai province. Master's degree Thesis, Master of Economics changmai university, Changmai, 2005.
13. Snoenbachler, D.D. and Gordon, G.L. (2002). Multi – channel shopping: Understanding what drives channel choice. *Journal of Consumer marketing* 19(1): 42 – 53.
14. Chummanond N. and Rotchanakitumnuai S. 2010. Determining the Online Purchasing Loyalty for Thai Herbal Products. *Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering.* 228 4 (4), 393-396.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-006-ID042

# Purwaceng Coffee Formulation Based on Consumers Preference

Julianisa, D.S.<sup>1</sup>, Aziz, I.W.F.<sup>2</sup>, and Jumeri<sup>2,\*</sup>

<sup>1</sup> Student of Agroindustrial Technology Department, Faculty of Agriculture Technology, Universitas Gadjah Mada, Yogyakarta, Indonesia; dyas.selvi@gmail.com

<sup>2</sup> Lecturer of Agroindustrial Technology Department, Faculty of Agricultural Technology, Universitas Gadjah Mada, Yogyakarta, Indonesia; ibnu.wahid@gmail.com

\* Correspondence: jumerimw@ugm.ac.id; Tel. : +62 812 1549 5571

Received: 5 August 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** Purwaceng (*Pimpinella pruatjan* Molk.) is one of Indonesian herb used to improve stamina and blood circulation, therefore, it has potential to be functional food. As functional food component, it could be blend with other material such as coffee which improve customers acceptance. The aim of the research is to identify the quality attributes of purwaceng coffee beverage desired by consumers and to develop the concept of purwaceng coffee beverage in accordance to consumer preferences. Value Engineering approach was used to formulate purwaceng coffee, which consists of three phases: information phase, creative phase, and analysis phase. Information phase consists of in-depth interview and gathering information using questionnaire. Creative phase consists of creating FAST diagram and obtaining product concepts using Fully Randomized Design. Analysis phase consists of sensory analysis to obtain product performance and value. According to the research, there are 4 preferable attributes which considered on purwaceng coffee formulation: health benefit, aroma, taste, and intensity. The best concept was composed of robusta coffee powder (7.5 g), full cream milk powder (2.5 g), sugar (15 g), and purwaceng powder (0.35 g). Compared with market product as competitors, the selected concept has advantages on the aroma, taste, intensity, and the performance.

**Keywords:** coffee, functional food, purwaceng, quality attributes, value engineering

---

## 1. Introduction

Food Supplements are found both in the form of beverage products and of tablets or pills. Many people consume this supplement food to stay their healthy and to improve their stamina. However, long term consumption of food supplement have implicated on human health because of their side effects [1]. The best way to improve the quality of life is having a healthy diet. The functional compounds contained in foods or beverages has a positive effect on one's physical and spiritual health in addition to its nutritional content and taste.

Purwaceng is herb used for ingredient in the functional food which allegedly could increase human stamina. Purwaceng can be used as a medicine or as an additive for any kind of beverages, such as coffee. It has a bitter taste, which was almost similar to that of coffee, let to combined both of them into a healthy coffee drinks. However, the research concerning consumer preference on purwaceng coffee products was not so far available. Therefore, it is necessary to optimize the purwaceng coffee formula by exploring their quality attributes according to consumer preferences. In this study, purwaceng coffee products were developed using value engineering methods approach. The value in value engineering is determined by the lowest cost to fulfill the functions or services needed in the certain time and place with basic quality [2]. The aim of this study is to identify the quality attributes of purwaceng coffee products desired by consumers, to develop the concept of purwaceng coffee products in accordance with consumer preferences and to determine the level of consumer preference for the products developed.

## 2. Materials and Methods

The main material used in this research were robusta coffee from Gunung Kelir, Semarang, Central Java and purwaceng (*Pimpinella pruatjan* Molk) harvested from Dieng, Wonosobo, Central Java. Both of these were then formulated with additional substances to be herb coffee regarding on customer preferences.

Formulation of purwaceng coffee was performed by value engineering using the steps as follow:

### 2.1. Information phase.

Information phase in this study aims to find out customer desires toward the product being developed. Information phase consists of product quality attributes data collection and importance level determination. In this study, product quality attributes collected by in-depth interview and questionnaire. Then, the priority order of product quality attributes was measured by calculating importance level and weight. Importance level is the average of importance of each quality product attribute. Importance level was measured by Formula 1.

$$\text{Importance level} = \frac{\text{the importance value number of each quality product attribute}}{\text{the number of respondents}}, \quad (1)$$

Importance weight is the percentage of importance level of each quality product attribute compared to total importance level. Importance weight was measured by Formula 2.

$$\text{Importance weight} = \frac{\text{the importance level of each quality product attribute}}{\text{total importance level}} \times 100\%, \quad (2)$$

### 2.2. Creative phase.

The aim of creative phase is to develop alternatives to fulfill its main function. This phase consists of creating FAST diagram, determination of product specification, developing concept and creating purwaceng coffee prototype. FAST diagram is used to create product specification which obtained by the translation of customer desires become a technical requirement. Product specification obtained was then used to develop product concepts. In this study, product concepts developed by using Completely Randomized Design. Product concepts were then made into prototype for further analyzed in the next phase.

### 2.3. Analysis phase.

In this phase, purwaceng coffee prototypes were analyzed by using organoleptic test to get the number of performance and value. The chosen concept will be compared to the similar commercialized product. Organoleptic tests was carried out on the prototype through giving scores to the product quality attributes by at least 30 responses [3]. The result of organoleptic test is used to calculate performance using Formula 3.

$$\text{Performance} = \text{quality attribute weight} \times \text{the number of respondent rating} \quad (3)$$

Furthermore, value was then calculated to determine which concept will be selected as the best concept. The selected concept has highest value among the other. The value was calculated using Formula 4.

$$\text{Value} = \frac{\text{Performance}}{\text{Cost}}, \quad (4)$$

### 3. Results

#### 3.1. Product Quality Attributes and Importance Level Determination

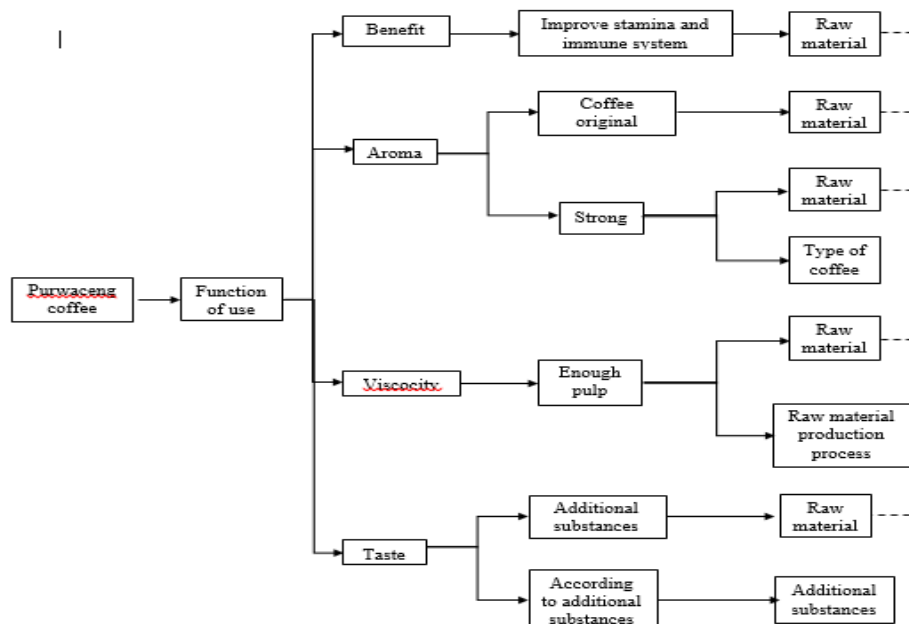
In this study, product quality attribute was obtained by in-depth interview and questionnaire. The result showed that customer have consider on their taste, viscosity, aroma, and benefit. Importance level and weight of product quality attribute was described in Table 1.

**Table 1.** Importance level and weight of product quality attribute

Primary Attributes	Secondary Attributes	Importance Level	Importance Weight (%)	Rank
Benefit	Improve stamina and immune system	3.63	16.26	1
Aroma	Original coffee	3.35	15.01	2
Taste	Balance	3.35	15.01	3
Aroma	Strong	3.10	13.89	4
Viscosity	Enough pulp	3.09	13.84	5
Taste	Contain additional substances	3.00	13.44	6
Aroma	According to additional substances	2.80	12.54	7
Total		22.32	100.00	

#### 3.2. Product Concept Creation

Product quality attributes were identified and analyzed in order to find the factors influencing product quality attributes. Correlation between factors was presented on FAST diagram. Purwaceng coffee FAST diagram was shown in Figure 1. Based on FAST diagram, purwaceng coffee specification consists of robusta coffee powder as the main substance, purwaceng plant was in the form of simplicia, sugar used as sweetener, and milk used as additional substances. According to [4], maximum dose of purwaceng simplicia without any healthy risk was 500 mg.



**Figure 1.** Purwaceng coffee FAST diagram

Drafting of purwaceng coffee concept refers to product specification. It was created by Factorial Completely Randomized Design. There were four factors used to create the concepts, i.e. the amount of robusta coffee powder, full cream milk powder, sugar and purwaceng powder as presented in Tabel 2. Each factors consists of three levels. Product specification created into 9 concepts which was presented in Table 3.

**Table 2.** Variation of purwaceng coffee composition

Factors		Level		
		1	2	3
A	The amount of robusta coffee powder (g)	5	7,5	10
B	The amount of full cream milk powder (g)	7,5	5	2,5
C	The amount of sugar (g)	10	12,5	15
D	The amount of purwaceng powder (g)	0,2	0,35	0,5

**Table 3.** Purwaceng coffee concept

Concepts	Factors (gram)			
	The amount of robusta coffee powder	The amount of full cream milk powder	The amount of sugar	The amount of purwaceng powder
A	5	7,5	10	0,2
B	5	5	12,5	0,35
C	5	2,5	15	0,5
D	7,5	7,5	12,5	0,5
E	7,5	5	10	0,2
F	7,5	2,5	15	0,35
G	10	7,5	15	0,35
H	10	5	10	0,5
I	10	2,5	12,5	0,2

Organoleptic test was used to analyze and identify these 9 prototypes to get the best concept. Quality product attributes which consists of taste, aroma, and viscosity were used as judgment parameter in this test. The result of organoleptic test showed that concept F has the highest value on taste, aroma and viscosity.

### 3.3. Product Performance Analysis

The result of organoleptic test and product quality attribute influence the amount of product performance [5]. The result of product performance calculation was shown in Table 4.

**Table 4.** The result of prototype analysis

Concepts	Product Quality Attribute			Performance	Cost	Value
	Taste	Aroma	Viscosity			
A	110	137	133	127	1,550.00	0.0819
B	130	133	127	130	1,518.75	0.0856
C	132	132	125	130	1,487.50	0.0872
D	131	136	133	133	2,143.75	0.0622
E	123	130	131	128	1,575.00	0.0813
F	150	139	144	144	1,587.50	0.0909
G	139	150	142	144	2,287.50	0.0629

**Table 4.** The result of prototype analysis (continued)

Concepts	Product Quality Attribute			Performance	Cost	Value
	Taste	Aroma	Viscosity			
H	104	126	123	118	2,125.00	0.0555
I	128	137	135	133	1,643.75	0.0812

Each purwaceng coffee concept has different performance. The highest performance obtained by concept F and G, conversely, the lowest performance obtained by concept H.

### 3.4. Cost Analysis

In this study, expenses other than material expenses was ignored. As shown in Table 4, purwaceng coffee concepts has various total cost, possibly caused by the different amount of material and material cost. Total cost of concept G was highest and those of concept B was lowest.

### 3.5. Value Analysis

Value of a product influenced by the amount of performance and cost. The amount of performance has linier comparison to product value. Meanwhile, the amount of total cost has inverse comparison to product value. The best concept of purwaceng coffee was once that has the highest value. Each value of purwaceng coffee concepts showed in Table 4.

According to Table 4, the chosen product was concept F that has the highest value, which supported by the high performance and the low total production cost. Concept F was then compared to the similar product sold in market in order to identify customer level of preference. The comparison between product F and the competitors were shown in Table 5.

**Table 5.** Comparison between selected product and their competitors

Characteristics	Product F	Product X	Product Y	Product Z
Size	25,35 gram	25 gram	7 gram	25 gram
Composition				
Purwaceng	Yes	Yes	Yes	Yes
Coffee	Robusta powder	Powder	Powder	Powder
Sweetener	Sugar	Glucose	No	Sugar
Addition	Milk	No	No	No
Other herbs	No	Ginger	Ginger	No
		Habbatussauda		
		Cinnamon	Habbatussauda	
		Cardamon		

Organoleptic test is used to identify the level of customer preference between selected concept and their competitor. Based on the result, concept F has the highest value on taste, aroma and viscosity. Concept F has the highest performance among the samples. Performance of each sample showed in Table 6.

**Table 6.** Performance of selected product and their competitors

Consept	Quality Product Attribute			Performance
	Taste	Aroma	Viscosity	
F	105	111	104	107
X	96	82	86	88
Y	51	72	77	67
Z	99	94	87	93
Total	351	359	354	

#### 4. Conclusions

The quality attributes of purwaceng coffee considered in the product formulation were the health benefits, aroma, taste, and texture. The F concept was selected from total 9 developed concepts using a Completely Randomized Design. Compared to the competitor product found in the market, the F concept has advantages in terms of taste, aroma, viscosity and performance.

#### References

1. Bjelakovic G.; Nikolova D.; Gluud L.L.; Simonetti R.G.; Gluud C. Mortality in randomized trials of antioxidant supplements for primary and secondary prevention; systematic review and meta-analysis. *Journal of The American Medical Association* 2007, 299 (2), 765 – 766.
2. King, T.R. Value Engineering, Theory and Practice in Industry. The Lawrence D. Miles Value Foundation, Washington DC, 2000.
3. Mehran. Tata Laksana Uji Organoleptik Nasi. Balai Pengkajian Teknologi Pertanian Aceh, Banda Aceh, 2015.
4. Adiguna, B.S. Pengaruh minuman suplemen herbal berenergi purica terhadap peningkatan stamina atlet sepakbola UNY. Skripsi, Fakultas Ilmu Keolahragaan UNY, Yogyakarta, 2013.
5. Umar, H. Riset pemasaran dan perilaku konsumen. PT Gramedia Pustaka Utama, Jakarta, 2005.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).



FP-MCI-009-ID049

# Development Marketing Strategy of Salak Pondoh (*Sallaca Zalazza (Gaert.) Voss.*) Based on Marketing Mix

Pitaloka Ayustina<sup>1</sup>, Novita Erma Kristanti<sup>2</sup>, Suharno<sup>3,\*</sup>

1 Departement of Agroindustrial Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada , ayustinapitaloka@gmail.com2

2 Departement of Agroindustrial Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada , erma@tip-ugm.org

3 Departement of Agroindustrial Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada , suharnodmx@gmail.com

\* Correspondence: erma@tip-ugm.org ; Tel. : +62 857 1435 9461

Received: 9 August 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** Salak (*Salacca zalacca*) is a species of palm tree (family Arecaceae) native to Java and Sumatra in Indonesia. Salak pondoh (*Sallaca Zalazza (Gaert.) Voss.*) is a local fruit product of Indonesia with the largest production in Central Java province at 39.49%, North Sumatra at 31.64% and Yogyakarta is 6.77%. Production of salak pondoh in Yogyakarta Province are in Sleman Regency with the total production in 2015 of 741,326 quintal and in 2016 amount to 765,340 quintal. The price of salak pondoh fruit is fluctuating, while in the harvest season the price drops. The importance of applying the right marketing strategy for this research so that the goals based on marketing mix attribute consist of product, price, place, and promotion. Marketing strategy is a way of marketing from a business unit to achieve marketing goals. In determining the marketing strategy can be done with a combination of segmentation, targeting, and positioning with the marketing mix to achieve the company's goals. The purpose of this study was to analyze the role of the supply chain of salak pondoh fruit, to identify the segmentation, targeting, and positioning to develop a marketing strategy for salak pondoh fruit based on the marketing mix for the salak pondoh. The result of this research are marketing strategy salak pondoh with improvement quality of salak pondoh to get the better price, improvement promotion to get better price, and improvement place to sell product to increase sale.

**Keywords:** marketing strategy, Analytic Hierarchy Process, consumers

## 1. Introduction

There are three subdistrict that become central production salak in Sleman Regency. The quantity of production salak in three subdistrict and production percentage if compared with total production in Sleman Regency are Turi Subdistrict with production 512,863 quintal or 69.18% in 2015 and 521,882 quintal or 68.19% in 2016; Tempel Subdistrict with production 149,825 quintal or 20.21% in 2015 and 159,192 quintal or 20.80% in 2016; and Pakem Subdistrict with production 61,453 quintal or 8.29% in 2015 and 64,295 quintal or 8.4% in 2016.

The price fluctuation of salak always happen every year. In harvest season the price of salak fruit will drop. Harvest season of salak fruit between December until January. On January until December 2015 the average price of salak Rp 8,283.00/kg while On January until December 2016 the price of salak Rp 4,720.00/kg. The price of salak in 2016 decreased 43% than 2015. The price in 2016 decreased because the quantity of salak pondoh in 2016 increased than 2015. The optimum price of salak pondoh Rp6,000.00/kg with production quantity 755,000 quintal (BPS Kabupaten Sleman, 2017).

Promotion process of salak in Sleman Regency with direct selling of word of mouth. Many supply chain agents of salak in Sleman Regency are not used internet for promotion their product. Promotion process must be improvement to increased the sell with attract customer to buy salak pondoh.

Place that used by supply chain agents to sell the product in Turi Subdistrict for now to reach their local target. Development place to sell salak pondoh with national target and global target must to do because salak have potention in product and price.

Supply of salak pondoh in local area as well as global area will be prove with appropriate supply chain management and marketing. The important supply chain management applied to improved business to reach their success with improvement product quality, revenue, and efisiensy distribution of lead time, cost, inventory, and error forecasting [1]. The important of marketing to introduce salak pondoh to society and attract customer to buy salak pondoh.

Appropriate marketing strategy have improve to in face with competitor. Marketing strategy consider marketing mix of product important to reach goal and target company. The important to applied appropriate marketing strategy is constitute to do this research.

## **2. Materials and Methods**

### *2.1. Market Identification in Supply Chain*

Object of this research used supply chain agents salak pondoh included farmers, collectors, whole salers, and retailers in Turi Subdistrict that become production central of salak pondoh in Sleman Rregency and customer salak pondoh in Yogyakarta City.

### *2.2. Data*

Data that used in this research included primery data and secondary data. Primary data got from indepth interview included salak pondoh distribution, distributor task, and criteria every marketing mix; preliminary questionnaire to know assessment by customer, and core questionnaire to know assessment supply chain agents. Secondary data got from Badan Pusat Statistika included quantity of salak pondoh and price of salak pondoh.

### *2.3. Sampling*

Sampling that used are purposive sampling and snowball sampling. Purposive sampling to determine sample that will used in this research with give appropriate requirement so the sample that used in this research will representative the population. Based on purposive sampling the sample quantity that used 30 sample (Teddlie, 2007). Snowball sampling used to know the flow of product distribution with the related respondents that used in this research [2].

### *2.4. Segmentation, Targeting, and Positioning*

Segmentation to divide market become group of customer into same want, characteristic, or customer attitude [3]. Targeting to determine market segment that will be used to reach company target market [4]. Positioning is used to make company image so company will have special place in the mind of target market [5].

The arrangement of segmentation, targeting, and positioning with cluster analysis and correspondence analysis. Cluster analysis to group respondents in one segment that have same characteristic [6]. Cluster analysis used cluster non – hierarchy with K – Means method. K – Means method clustering used because this method easy and simple to analyse sample, can use to analyse sample in big quantity, and process to found same data in cluster more quick [7]. Correspondence analysis use to connect two variable to determine market target and positioning [8]. Two variable that used are sub criteria of marketing mix and cluster.

## 2.5. Analytic Hierarchy Process

Analytic Hierarchy Process developed by Thomas L. Saaty. This method is framework to make decision of complex problem become simple problem and to make decision process more quick with break the problem into some part, arrange the part or variable in hierarchy, give numeric value in subjective opinion every variable and consider variable that have the biggest priority and have impact for the result [9].

Analytic Hierarchy process used to solve problem in Multi Criteria Decision Making with pair comparison to know the best option that become alternative in criteria [10]. The simple shape to make structure hierarchy in problem decision making of analytic hierarchy process formed into three level are goal, criteria, and alternative [11]. The main strength of Analytic Hierarchy Process to solve problem from subjective opinion and to got quantitative priority in every important alternative [12].

In calculation of Analytic Hierarchy Process used calculating of priority vector to determine the biggest weight from criteria and subcriteria that will become alternative. After that determine eigenvalue from the data to testing consistency. The formula matrix pair comparison, vector priority ( $w_n$ ) and eigenvalue ( $n$ ) can show below [11].

$$\begin{pmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \dots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \dots & \frac{w_2}{w_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \dots & \frac{w_n}{w_n} \end{pmatrix} \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} = n \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} \quad (1)$$

The formula of Consistency Index (CI) and Consistency Ratio (CR) can show below [11].

$$CI = (\lambda_{max} - n) / (n - 1) \quad (2)$$

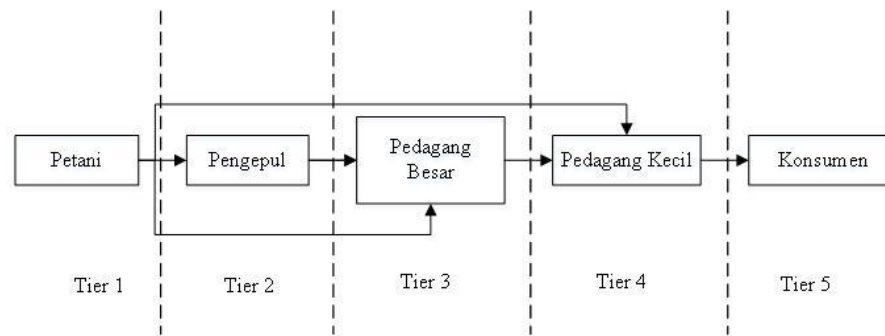
Where eigenvalue ( $\lambda_{max}$ ) and number of row and column ( $n$ )

$$CR = \frac{CI}{RI} \quad (3)$$

## 3. Results

### 3.1. Supply Chain Flow

Supply chain salak pondoh for domestic market in Turi Subdistrict, Sleman Regency is process distribution salak pondoh from producer to customer. Distribution process salak pondoh from producer in Turi Subdistrict that serve domestic market in some area of Java island, Sumatera island, Kalimantan island, Sulawesi island, and Bali island. Distribution process of salak pondoh from four tier of supply chain agents are farmers, collectors, whole salers, and retailers. Picture 1 show flow of supply chain salak pondoh in Turi Subdistrict.



**Figure 1.** Flow Supply Chain Salak Pondoh in Turi Subdistrict

### 3.2. Task of Supply Chain Agents

Farmers have main task to produce salak pondoh. When farmers produced salak pondoh there are some tasks that have to be done by farmers to get the best quality of salak pondoh, starting from choosing seeds that will be planted until controlling salak before harvest.

There are some collector tasks. First, the collector village will collect salak pondoh from farmers. Second, separate salak pondoh based on the condition of salak pondoh that has good quality or all physical conditions of salak pondoh are not rotten. Third, clean salak pondoh from impurities that attach to salak pondoh.

Wholesalers have some tasks as follows. First, collect salak pondoh from farmers and collectors in village and traditional market. Wholesalers in traditional markets are Balerante, Turi, and Prayan. Second, separate salak pondoh based on grade. Wholesalers separate salak pondoh from 3 grade until 7 grade, but most of wholesalers separate into 3 grades (grade A, B, and C). Third, sort or separate salak pondoh based on the quality of salak pondoh that has good condition or salak pondoh are not rotten. Fourth, send salak pondoh to wholesalers in D.I. Yogyakarta Province or out from D. I. Yogyakarta Province.

Retailers in Turi Subdistricts have three tasks. First, separate salak pondoh based on grade. Separate grades of salak pondoh start from 2 grade until 3 grade. Most of retailers separate salak pondoh into 2 grades based on size (big and small). Second, sort salak pondoh based on good quality or salak pondoh are not rotten. Third, sell salak pondoh to end customer.

### 3.3. Segmentation, Targeting, and Positioning Analysis

Content validity is used to test compatibility content from every variable to measure the tool to analyze segmentation, targeting, and positioning and marketing strategy. The formula of Content Validity Ratio can be shown below.

$$CVR = \frac{n_e - (\frac{N}{2})}{(\frac{N}{2})} \quad (4)$$

Explanation :

$n_e$  : Total respondents that answer relevant and important

$N$  : Total respondents that use for research

The minimum value of Content Validity Ratio (CVR) 0,582 when total respondents 8 persons. The value of CVR in table Critical Value for Lawshe's determine with alpha (probability error 0,05 in one – tailed test [13].

Criteria marketing mix that valid then arrange become preliminary questionnaire after that the questionnaire will spread to customer. The result of data preliminary questionnaire will process with cluster analysis and correspondence analysis use SPSS. The table below show final cluster centers that classified criteria in cluster.

**Table 1.** Final Cluster Centers

	<i>Cluster</i>		
	<b>1</b>	<b>2</b>	<b>3</b>
Product salak pondoh have same uniformity (P1)	3,19	1,92	3,80
Product salak pondoh appropriate with customer need (P2)	2,81	1,76	3,73
Product salak pondoh are not defect (P3)	2,19	1,66	3,53
Product salak pondoh in good condition (P4)	2,19	1,75	3,87
Price achievable (H1)	1,85	1,69	3,73
Price influence customer to decision to buy product (H2)	1,96	1,83	3,47
Price competitive (H3)	2,69	2,22	3,13
Price appropriate with quality H4)	2,04	1,80	3,20
Promotion use internet (R1)	4,54	2,64	2,73
Promotion process are appropriate (R2)	3,96	2,36	2,80
Promotion through regional government or other (R3)	3,65	2,78	3,20
Branding salak pondoh (R4)	3,69	2,17	2,80
Good distribution product (T1)	2,85	2,19	3,20
Place for got salak pondoh are easy (T2)	2,35	1,93	3,33
Place easy to reach (T3)	2,62	1,93	3,47
Place for selling the product are strategic (T4)	2,96	2,05	3,60

The highest value of marketing mix criteria in table final cluster centers need to improvement. Based on the result of final cluster centers customer divide into three cluster based on marketing mix criteria to attract customers buy salak pondoh. Cluster 1 (Cluster middle) because customers need improvement in promotion. Cluster 2 (Cluster less aware) because customers are not need improvement in marketing mix. Cluster 3 (Cluster prominence) because customer need to improvement in all criteria of marketing mix.

Based on correspondence analysis the target market that choose is cluster 1 because have the biggest mass value or eigenvalue and cluster 3 have mass value or eigenvalue in second position. The two cluster was choose for targeting because total of respondents in cluster 1 are 26 respondents while total respondents that will analyse used core questionnaire based Analytic Hierarchy Process are 30 respondents so the cluster that choose cluster 1 and cluster 3 with total 41 respondents. Determine minimum total respondents are 30 respondents based on purposive sampling. Criteria P1, H3, R2, and T1 choose to attract customer interest in cluster 1 and criteria P3, H4, and T2 choose to attract customer interest in cluster 3 when buy salak pondoh. Four criteria marketing mix choose because have close distance with cluster 1 and cluster 3 so it indicate that two cluster have same correspondence between cluster and criteria. Targeting cluster 1 and cluster 3 to fulfill customer want with improvement in uniformity of salak pondoh, salak pondoh are not defect, the price competitive, price appropriate with quality, have good distribution process, salak pondoh easy to get, and appropriate promotion. Figure 2 show perceptual map in this research.

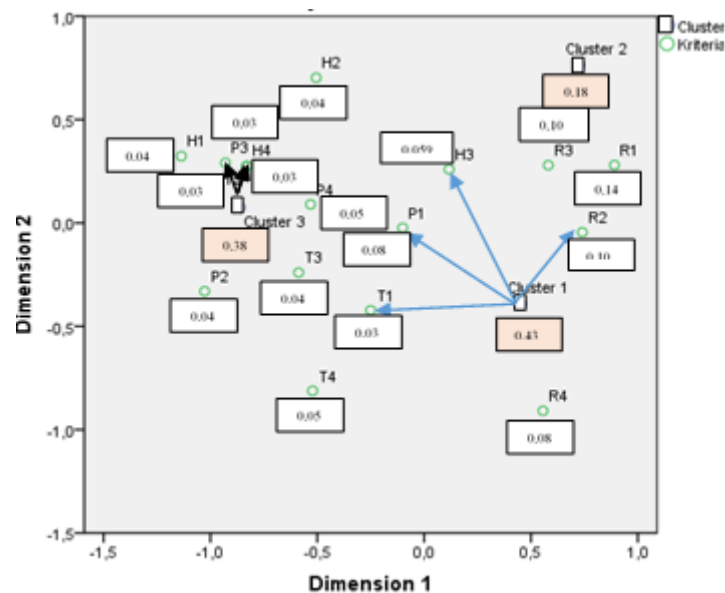


Figure 2. Perceptual Map

Positioning salak pondoh are place product in customer eye so can increased revenue for company. Positioning salak pondoh based on quality, cheap price, availability, and information easy to get. Four positioning salak pondoh place for customer in cluster 1 and cluster 3.

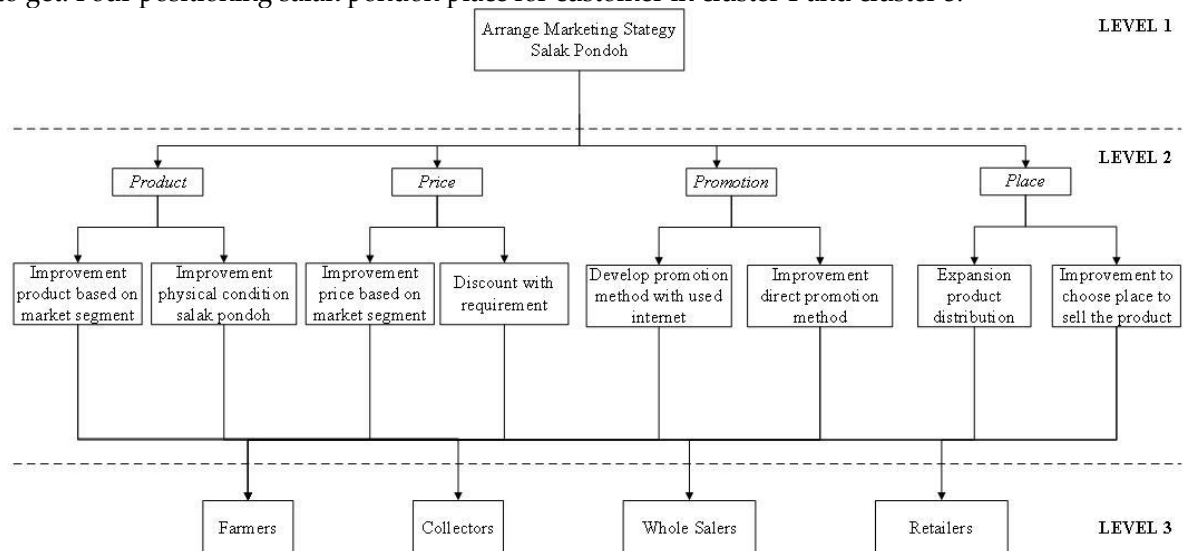


Figure 3. Hierarchy Marketing Strategy of Salak Pondoh

### 3.4. Marketing strategy analysis of supply chain agents salak pondoh

Marketing strategy analysis of supply chain agents salak pondoh used core questionnaire based on analytic hierarchy process. Core questionnaire spread to supply chain agents salak pondoh. Figure 3 show hierarchy in this research.

The recommendation of marketing strategy got after analysis data to determine marketing strategy with used Analytic Hierarchy Process. Marketing strategy in every tier supply chain agents got based on value of global weight in every criteria in marketing mix.

Marketing strategy of salak pondoh for farmers with improvement product because based on calculation of local weight and global weight have the biggest weight. The value can show in table 2. Marketing strategy recommendation product salak pondoh with improvement physical condition of salak pondoh. First, Control plant of salak pondoh from fertilization to make the supply nutrients in soil, supply nutrients balance with growth or blooming of plant, improvement the quality product, and

improvement plant productivity; cut salak pondoh leaves to improve the productivity in maximal condition and stimulate growth sheath female flower; and control Plant Vermin Organism that make decrease the productivity and fruit quality. Second, Decrease the quantity of product in every stalk to got the product that have good quality and optimum quantity. Third, Make food from salak pondoh to decrease the damage physical fresh fruit of salak pondoh.

**Table 2.** Local Weight and Global Weight Marketing Strategy Farmers

Criteria (Local weight)		Sub Criteria (Local weight)		Global weight
Farmer s		Farmers		Farmers
Product	0,48	Improvement product based on market segment	0,21	0,10
		Improvement physical condition salak pondoh	0,79	0,38
Price	0,22	Improvement price based on market segment	0,6	0,13
		Discount with requirement	0,4	0,09
Promotion	0,05	Develop promotion method with used internet	0,22	0,01
		Improvement direct promotion method	0,78	0,04
Place	0,25	Expansion product distribution	0,6	0,15
		Improvement to choose place to sell the product	0,4	0,10

Marketing strategy salak pondoh in collector do with improvement product because based on calculation of local weight and global weight have the biggest weight. The value can show in table 3. Marketing strategy recommendation product for collector with separate salak pondoh that have small size to increase sales, separate salak pondoh from salak pondoh that have defect condition to increase the sales, and separate salak pondoh from the highest ripe level to offer salak pondoh that have best quality to customer.

**Table 3.** Local Weight and Global Weight Marketing Strategy Collectors

Criteria (Local weight)		Sub Criteria (Local weight)		Global weight
Collectors		Collectors		Collectors
Product	0,50	Improvement product based on market segment	0,11	0,05
		Improvement physical condition salak pondoh	0,89	0,44
Price	0,23	Improvement price based on market segment	0,84	0,19
		Discount with requirement	0,16	0,04
Promotion	0,05	Develop promotion method with used internet	0,29	0,01
		Improvement direct promotion method	0,71	0,04
Place	0,22	Expansion product distribution	0,86	0,19
		Improvement to choose place to sell the product	0,14	0,03

Marketing strategy salak pondoh for whole salers do with improvement every criteria in marketing mix because have the close related with end customer and cluster that choose need to improvement in every criteria. Whole salers have the biggest value of local weight and global weight. The value can show in table 4. Marketing strategy product salak pondoh are improvement the physical condition salak pondoh based on supply of salak pondoh appropriate with demand, time for send salak immediately, improvement packaging process, and separate salak pondoh based on ripe level. Recommendation price of salak pondoh in whole salers are improvement price appropriate with market segmen that determine based on grade. Recommendation place on tier whole salers are improvement place for sell with choose place that strategic. Promotion recomendation with develop direct promotion method and develop promotion method with use internet. Develop direct promotion method with offer salak pondoh to other salers; supermarket; and exporter, spread leaflet to supplier salak pondoh in other region through expedition driver that distribute fruit to out D.I.Yogyakarta Province , attace label in packaging "Salak Pondoh Sleman", and join expo that held by regional goverment or other. Develop internet to promotion used website and social media.

**Table 4.** Local Weight and Global Weight Marketing Strategy Whole Salers

Criteria (Local weight)		Sub Criteria (Local weight)	Global weight	
	Whole Salers		Whole Salers	Whole Salers
Product	0,55	Improvement product based on market segment	0,50	0,28
		Improvement physical condition salak pondoh	0,50	0,28
Price	0,23	Improvement price based on market segment	0,73	0,17
		Discount with requirement	0,27	0,06
Promotion	0,06	Develop promotion method with used internet	0,58	0,03
		Improvement direct promotion method	0,42	0,03
Place	0,17	Expansion product distribution	0,30	0,05
		Improvement to choose place to sell the product	0,7	0,12

Marketing strategy salak pondoh for retailer do with improvement every criteria in marketing mix because have close relation with end customer and cluster that choose need to improvement in every criteria. Retailers have the biggest value of local weight and global weight. The value can show in table 5. Recommendation place for retailer with improvement to choose place for sell salak pondoh that strategic in slow lane and serve place to park. Price for retailers used with improvement price appropriate with market segment are separate salak pondoh based on the defect to increase sale salak pondoh and separate salak pondoh base on ripe level. Recommendation product salak pondoh for retailers with improve physical condition salak pondoh. It can do with separate salak pondoh from small size, separate salak pondoh from defect condition (peel the skin), and separate salak pondoh from roppen condition. Improvement promotion of salak pondoh with develop direct promotion method and develop promotion method with internet. Direct promotion method used with attach panflet of salak pondoh and the benefit. Promotion through internet with use website and sosial media (twitter, facebook, instagram, etc) to attract customer interest buy salak pondoh.



**Table 5.** Local Weight and Global Weight Marketing Strategy Retailers

Criteria (Local Weight)		Sub Criteria (Local Weight)	Global Weight	
	Retailers		Retailers	Retailers
Product	0,3	Improvement product based on market segment	0,28	0,08
		Improvement physical condition salak pondoh	0,72	0,22
Price	0,32	Improvement price based on market segment	0,76	0,24
		Discount with requirement	0,24	0,08
Promotion	0,06	Develop promotion method with used internet	0,43	0,03
		Improvement direct promotion method	0,57	0,03
Place	0,32	Expansion product distribution	0,22	0,07
		Improvement to choose place to sell the product	0,78	0,25

#### 4. Discussion

The results showed that the marketing activities of salak pondoh still needed to improve packaging for the upper middle segment with the aim of increasing the value of the product. In addition, processed salak pondoh for product can be an alternative to increasing profit in business salak pondoh fruit.

#### 5. Conclusions

The result of this research are marketing strategy salak pondoh with improvement quality of salak pondoh to get the better price, improvement promotion to get better price, and improvement place to sell product to increase sale.

#### References

1. Siahaya, Willem. 2016. *Sukses Supply Chain Management Akses Demand Chain Management*. Bogor : IN MEDIA.
2. Etikan, Ilker, Rukayya Alkassim, dan Sulaiman Abubakar. 2016. Comparision of Snowball Sampling and Sequential Sampling Technique. *Journal of Biometrics and Biostatistics International*, Vol. 3, No.1 : 55 – 56.
3. Tania, Debby dan Diah Dharmayanti. 2014. Market Segmentation, Targeting, dan Brand Positioning dari Winston Premier Surabaya. *Jurnal Manajemen Pemasaran Petra*, Vol. 2, No. 1 : 1 – 7.
4. Yudelston, Jerry. 2006. *Marketing Green Buildings Guide for Engineering, Construction, and Architecture*. The Fairmont Press, Inc. United States of America
5. Kotler, Philip dan Kevin Lane Keller. 2009. *Manajemen Pemasaran Edisi 13 Jilid 1*. Yogyakarta : Erlangga.
6. Romesburg, H. Charles. 2004. *Cluster Analysis for Researchers*. Lulu Press. United States of America.
7. Oyelade, O. J., O. O. Oladipupo, dan I.C. Obagbuwo. 2010. Application of k-Means Clustering algorithm for prediction of Students' Academic Performance. *International Journal of Computer Science and Information Security*, Vol. 7, No.1 : 292 – 295.
8. Li, Guohui, Song Lu, Heping Zhang, dan Siuming Lo. 2013. Correspondence Analysis on Exploring the Association Between Fire Causes and Influence Factors. *Procedia Engineering*, Vol. X, No. 62 : 581 – 591.
9. Batarius, Patrisius. 2013. Analisis Metode AHP dalam Penentuan Prestasi Gabungan Kelompok Tani. *Seminar Nasional Informasi dan Komunikasi* : 1 – 9.
10. Triantaphyllou, Evangelos. 2000. *Multi – Criteria Decision Making Methods : A Comparative Study*. Kluwer. Netherlands.
11. Saaty, Thomas L. 2000. *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*. McGraw Hill Publishers. New York.

12. Santos, Luiz Felipe se Oliveira Moura, Lauro Osiro, dan Rafael Henrique Palma Lima. 2017. A Model Based on 2 – Tuple Fuzzy Linguistic Representation and Analytic Hierarchy Process for Supplier Segmentation Using Qualitative and Quantitative Criteria. *Journal of Expert Systems with Applications*, Vol. 79, No. X : 53 – 64.
13. Ayre, Colin dan Andrew John Scally.2014. Critical Values for Lawshe's Content Validity Ratio :Revisiting the Original Methods of Calculation. *Jurnal SAGE*, Vol. 47, No. I : 79 -86.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-010-ID056

# Black Rice Agroindustry in Sleman, Yogyakarta: Early Analysis

Dyah Ismoyowati <sup>1,\*</sup>, Anisah Riyadi <sup>1</sup>, Ardhan Rifai <sup>1</sup>, Endy Suwondo<sup>1</sup>, and Tririni Nuringtyas<sup>2</sup>

<sup>1</sup> Faculty of Agricultural Technology, Universitas Gadjah Mada

<sup>2</sup> Faculty of Biology, Universitas Gadjah Mada

\* Correspondence: dyah\_ismoyowati@ugm.ac.id; Tel.: +62811254284

Received: 10 August 2018; Accepted: 28 August 2019; Published: 6 January 2020

**Abstract:** Black rice is getting more acknowledged by consumers for its function as a healthy intake. The demand may be reflected in the more obvious black rice product display on rice retailers shelves. Frequent availability may as well be detected within certain community market that is related to organic produce or health interest base. Sleman, Yogyakarta is a district in the Special Region of Yogyakarta, Indonesia where agriculture is stepping up toward higher value of agroindustry products such as pigmented rice, including black rice particularly. Limited studies on black rice lead us to do this early survey and analysis. The finding suggest that farmers in a small scale had been involved with black rice farming for almost a decade. The farming was not necessarily organic, but in most cases farmers had the idea to be more environment friendly. Local black rice Cultivar Sembada Hitam, used to be known as Pari Ireng should improve the value of this agroindustry in this area. Some marketing channels available and the supply chains exhibited the connection with suppliers from other area nearby. This phenomenon also the case in related with the buyers; Sleman black rice produce also sent to other area including Jakarta, and even to off-Java area. The role of local government in production side might be as important as private sectors in the market side to boost black rice agroindustry development.

**Keywords:** black rice; agroindustry; local cultivar; supply chain; market

---

## 1. Introduction

Increased public awareness on healthy lifestyle had led the consumption growth of healthy food products. Pigmented rice, in particular, facing high demand from consumers who want to be healthier because of the nutritional value is higher compared to white rice [1]. Demand of black rice as one kind of the pigmented rice continues to increase each year as well. Black rice is considered capable of reducing cholesterol levels that trigger the appearance of liquid coronary heart disease and stroke [2]. In Yogyakarta, the pigmented rice demand (including black rice) increased from 900 ton into 1200 ton in the last three years. This statement was supported by the increasing availability of pigmented rice in modern retail in Yogyakarta, which shows that there is a rising demand. In the year 2016 pigmented rice consumption index in Yogyakarta is 1.2 kg/capita/month with the purchase of an average of 3.5 kg/month. Pigmented rice demand is estimated to continue raising along with more awareness food consumption will slide. Most of the pigmented rice consumers has high health-awareness. Most of the consumers believed that consuming rice pigmented can prevent the risk of emergence of diseases [3].

The increased demand has not been in accordance with the availability of sufficient local black rice. In Sleman, Yogyakarta, there are many farmers who plant pigmented rice (black rice in particular). However, information on the production side i.e. number of farmers, planting location, the amount of rice production as well as other information about pigmented rice farming is limited. Whereas this information was very important to gather in order to find out the potency of black rice as healthier food and potency of those area. Based on this situation this paper aims to reveal some basic information and analysis of black rice agroindustry in Sleman, Yogyakarta as a start.

## 2. Object and Methods

The research object is the black rice agroindustry in Sleman District, Special Region of Yogyakarta, Indonesia. The research was started by collecting any information regarding black rice farming and business to the related service officers starting from the provincial, district, sub-district, and village level. The information included the individuals as well as groups of producer (farmer), broker, distributors, retailers, up to the consumers. Field survey has been conducted to gather the information covering the area of development, extents, farming systems, the number of production and productivity. Snowball sampling technique is used to identify black rice supply chain flow. A survey was conducted to find out the information from the side of the consumers. It was conducted using a questionnaire that involved 30 respondents with criteria that consumers ever buying and consuming black rice. The questionnaire was shared online and in interview in some healthy oriented community market.

## 3. Results and Discussion

### 3.1. Black Rice

Pigmented rice is often found in Indonesia included varieties of red rice and black rice. Dark purple of black rice seeds is caused by high anthocyanin content. The anthocyanin are stored in the seed *perikarpium* so the colors being purple toward the black. This increases the potential for black rice as food alternatives [4]. Black color on a rice reserved of compounds formed by anthocyanin in seed *aleurone* layer of rice [5]. Black rice have been long cultivated but not so evolved because it requires a longer growing period and relatively are not resistant to pest attack.

### 3.2. The Local Cultivar Sembada Hitam

Cultivar Sembada Hitam in Sleman, Yogyakarta still needs to be developed. In this district, black rice began to be developed since the year of 2008. In 2010 the planting area was 8,100 m<sup>2</sup> and increased to 9,600 m<sup>2</sup> in 2011. From year of 2012 to 2014, its development continued in area of 12,400, 10,600, and 28,500 m<sup>2</sup>, respectively. Table 1 shows the results of the survey that has been done both to the related local government officers and the farmers as well as the business players directly. In most area the farmer organizations cultivated black rice because of local government programs as an effort to maintain the sustainability of local cultivars so the role of local government in this particular District was significant.

**Table 1.** Black Rice Area in Sleman District

Year	Field Area (m <sup>2</sup> )	Production (kg)	Productivity (ton/Ha)	Annual Increase (%)		
				Field Area	Production	Productivity
2015	36,300	16,162.0	3.42	27%	N/A	N/A
2016	101,500	43,912.5	4.39	180%	172%	28%
2017*	113,300	48,157.5	4.13	12%	10%	-6%
2018*	130,000	60,000.0	4.75	15%	25%	15%

Source: Agricultural Government Office of Sleman District (2017) and Processed Data (2018\*)

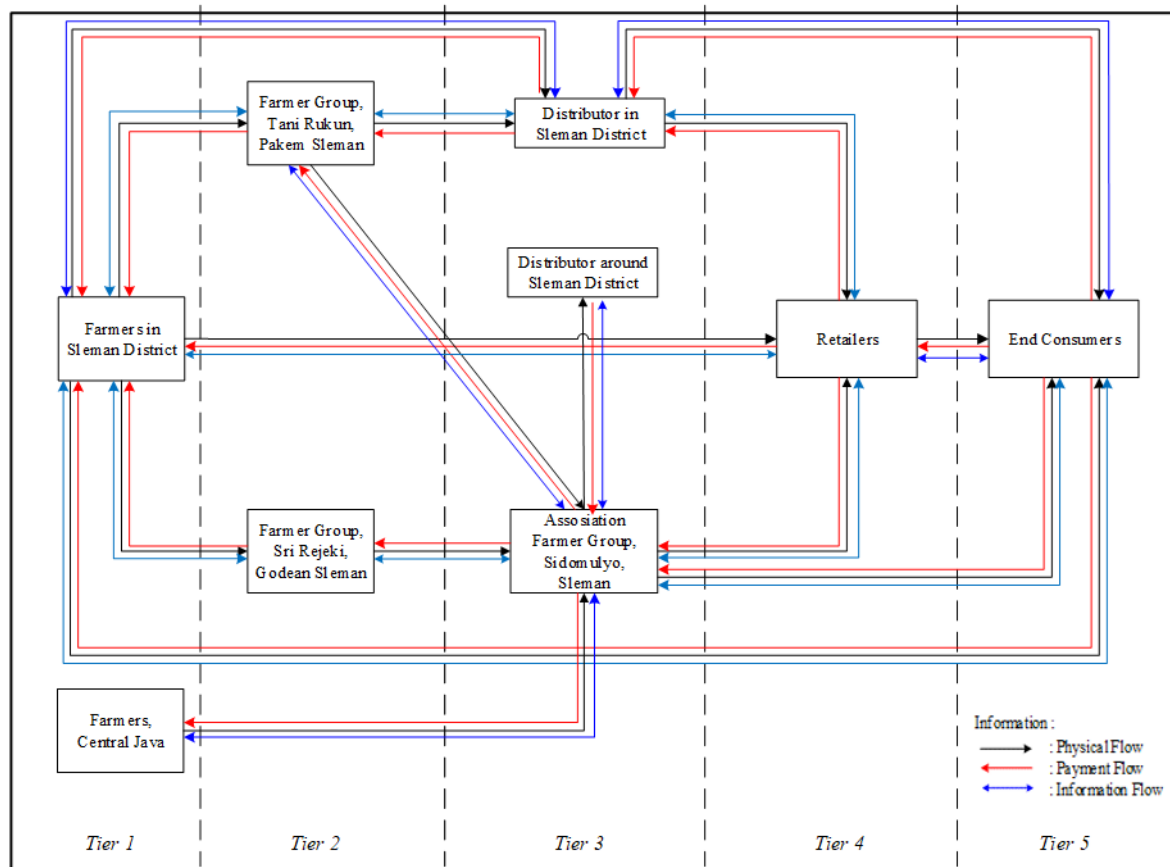
### 3.3. The Agroindustry

Black rice demand continues to rise as seen in the increasing amount of black rice packages on display in the shelves of rice retailers. It encouraged some farmers to start the business of black rice [6]. The transformation process of the harvested black rice before marketed was beginning with drying, milling, sorting, weighing, and packaging. The sizes adjusted to orders or requests from consumers, both the end consumer as well as business consumers. Before getting into the hands of the end consumer, the majority of the marketing channel flow as: farmers → farmer groups → distributors →

retailer → consumer [7]. Currently the local black rice Cultivar Sembada Hitam has been marketed both inside and outside of Yogyakarta.

### 3.4. The Supply Chain

The supply chain is a network consisting of several parties that is physically involved either directly or indirectly, in creating and submitting a product to the end consumer in the fulfillment of the customer's request [8]. The observed black rice supply chain depicted in Figure 1. The black rice supplied from farmers in Sleman and some parts of Central Java which is supplied in the form of grain. Then, farmer groups (Poktan) and its association of farmer groups (Gapoktan) processed the grain into black rice. Next, the black rice packages were distributed inside and outside of Sleman District such as to Semarang, Jakarta, Kalimantan, Aceh, and other areas in Indonesia.



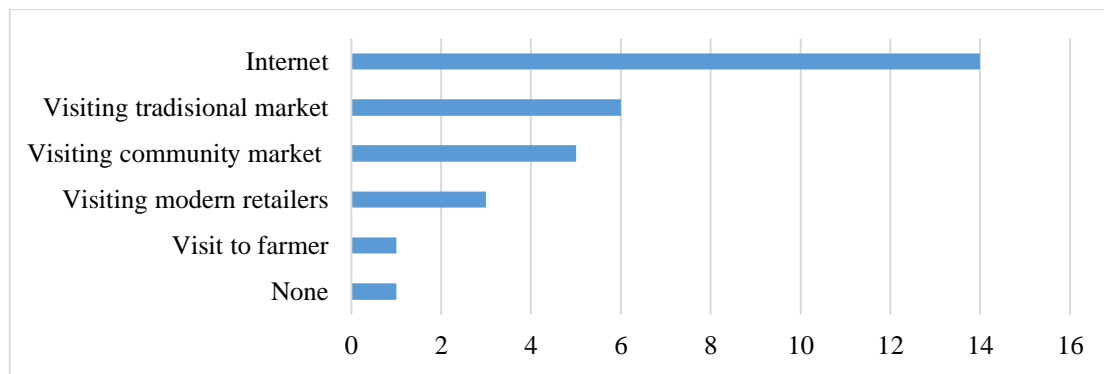
**Figure 1.** The Supply Chain in Sleman and its Surrounding

### 3.5. The Marketing

The marketing of black rice was currently done through various methods both conventional as well as online. Figure 2 shows various way how consumers looking for information about black rice. In the process of information search, the internet was chosen by most consumers (47%) .

According to consumer respondents, black rice appearance observed directly and through the screen of monitor (iPad) did not differ significantly [9]. It indicated that doing a search on the internet or by visiting to the black rice retailers directly was not different.

In addition to the appearance, the consumers were also very attentive to the product that will affect their loyalties [10], so the quality of the products and packaging must be considered in black rice marketing strategy.



**Figure 2.** Sources of consumer information searching

#### 4. Conclusion

The development of black rice in Sleman, Yogyakarta mostly continue to increase each year as shown in the production side. The suppliers must start to engage online marketing to respond many consumers tendency in searching information about black rice before buying. Aside from that, the high produce quality should be combined with proper packaging to fulfill customer's preferences. Government's role in this agroindustry is very important especially to introduce and develop black rice farming to farmers in addition to the role of private sector in the market side.

#### References

1. Nuringtyas, T. R. & Ismoyowati, D. 2016. *Development of Pigmented Rice for The Rural Community*. SEARCA Seed Fund For Research and Training (SFRT) Program, Vol 8, No 6.
2. Kristantini, Taryono, P. Basunanda, R, H. Murti, dan Supriyanta. 2012. *Morphological of Genetic Relationships among Black Rice Landraces from Yogyakarta and Surrounding Areas*. *ARNP Journal of Agricultural and Viological Science*. 7(12) : 982-989.
3. Wuryadani, Shafira. Arita, N. Dyah, I. 2016. *STP Analysis on Marketing Pigmented Rice as Functional Food*. *ICoA Conference Proceeding*.
4. Yawadio, R., S. Sanimori and N. Morita. 2007. *Identification Of Phenolic Coumpound Isolated From Pigmented Rice And Their Aldose Reductase Inhibitory Activities*. *Food Chem*. 1001(4): 1616-162.
5. Chaudhary, R.C. 2003. *Speciality rice of the world : Effect of WTIO and IPR on its production trend and marketing*. *J. Food Agric. Env*. 1 (2) : 34 – 41.
6. Anindita, K. P. Dyah, I. Endy, S. (2016) (Unpublished). *Analisis Rantai Nilai Beras Berwarna: Studi Kasus di Kabupaten Sleman D.I Yogyakarta*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.
7. Riyadi, A. Dyah, I. Kuncoro H. W. 2018 (Unpublished). *Strategi Pengembangan Kinerja Rantai Pasok Beras Hitam di Kabupaten Sleman, D.I Yogyakarta*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.
8. Chopra, S., and Meindl, P. 2013. *Supply Chain Management: Strategy, Planning & Operations Third Edition*. Pearson Prentice Hall. New Jersey.
9. Rifai, A. Dyah, I. M. Affan F.F. 2018 (Unpublished). *Analisis Preferensi Konsumen Terhadap Warna Beras Hitam di D.I Yogyakarta*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.
10. Mutmainnah, D. H. Dyah, I. Anggoro C. S. 2017 (Unpublished). *Analisis Pengaruh Perilaku Terhadap Loyalitas Pelanggan Bisnis untuk Perumusan Strategi Pemasaran Beras Berwarna*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.



FP-MCI-011-ID074

# Analysis of Consumers Perceptions of the Important Factors in Soygurt Products and Marketing Strategies

Atris Suyantohadi<sup>1,\*</sup>, Mirwan Ushada<sup>1</sup>, Dody Kastono<sup>2</sup>

<sup>1</sup> Agroindustrial Department, Agricultural Technology Faculty, Universitas Gadjah Mada, Jl Flora 1, Bulaksumur, Yogyakarta, Indonesia

<sup>2</sup> Agricultural Faculty, Universitas Gadjah Mada, Jl Flora 2, Bulaksumur, Yogyakarta, Indonesia

\* Correspondence: [atris@ugm.ac.id](mailto:atris@ugm.ac.id)

Received: 14 August 2018; Accepted: 28 August 2019; Published: 6 January 2020

**Abstract:** As a source of protein, soybean is important role in improving the society's nutrition needs. Yogurt products from soy (soygurt) contain high nutrients and vitamins and are a functional food product with low prices for the community. Soygurt product necessary to be produced and disseminated to the community. This study aims to analyze consumer perceptions of soygurt products to be able to determine the priority factors and also to develop a marketing strategy plan. The methodology of consumer perceptions are determined by rating the important factors using the Fuzzy AHP (Fuzzy Analytic Hierarchy Process) method. Fuzzy AHP analyzes the problems related to consumer perceptions of attribute factors. The results of the Fuzzy AHP analysis are used as a basis for determining the internal and external strengths of SMEs by using the SWOT method. The SWOT Method is used to obtain the concept of marketing strategy. Based on Fuzzy AHP analysis, the main criteria for the preference of soygurt product attributes consist of taste, packaging, brand, main raw material and product label. Fuzzy AHP test results show that the taste of adding strawberry and mango is more preferred than the original taste, bottle packaging, and the brand soygurt product. The strategy obtained for soygurt products is a strategy to increase production volume and expand marketing networks, improve product packaging to be more attractive, set prices with cost orientation, expand information dissemination and promotion. Marketing strategies based on SWOT analysis in the results of the study showed the hierarchy that needs by producers so that these products can be accepted by consumers.

**Keywords:** Soygurt, AHP, SWOT, consumer, perception.

---

## 1. Introduction

Soybeans are rich in iron, calcium, complex vitamin B, phosphorus, and fat [1]. With the shift in consumption patterns from animal food ingredients to plant foods, soybeans have a great opportunity to develop. Soy protein has an amino acid composition that is close to the composition of the essential amino acids of milk protein [2]. On the one hand, the diversification of soybean-based food processing is still very limited. Soybean milk also contains fat, carbohydrates, calcium, phosphorus, iron, provitamin A, Vitamin B complex (except B12), and water [3]. However, the level of consumption of soy milk in Indonesia is still relatively low, especially when compared with China, the Philippines or Thailand [4]. Soy milk is soy milk which is processed by destroying soybean seeds in cold or hot water [5]. Soybean milk can be made with simple technology and equipment and does not require special skills [6]. Because of its high protein content, soy milk is the best drink to replace cow's milk products for people who have lactose and casein intolerance [7]. Besides being used as a protein source, soybeans are also processed as functional food products that can prevent the onset of degenerative diseases. One of the soy-based functional food products is yogurt products from soy milk (*Soygurt*) because in this product there are probiotic bacteria *Streptococcus thermophilus* and *Lactobacillus bulgaricus* which can improve the balance of intestinal microflora so that it can accelerate human digestion.

Increasing the economic value of post-harvest results to provide incentives for soybean farmers is important to be done through the development of production centers that process post-harvest results towards the commercialization of products in agro-industries. Supply chain management distribution in the center of soybean production in the region of Grobogan Regency, Central Java [8] has been carried out well from the level of farmers, collectors, wholesalers, and consumers both industrial consumers and community consumers. After harvesting soybean, the rural community agroindustry in processing soybeans is able to increase the economic value of the product which is quite high. The group of community members in the soybean production center in Grobogan Regency has been producing soybean processing in the form of tofu and tempeh products for generations. The development of soybean processing products in addition to tofu and tempeh in the form of industry in the community is very much needed to support the diversification of soybean processed food products in the community. Processing soybeans into *Soygurt* products is one of the alternatives to increase the post-harvest economic value into one of the healthy, nutritious and necessary vegetable food products for the community. Industrialization at the level of community business groups will result in the formulation of *Soygurt* products and their derivatives in accordance with the criteria for perceptions of consumer needs and production cost targets. Soybeans [9,10] are commodities that have very high nutritional value and are very good for fulfilling vegetable protein needs in addition to other health supporting aspects. Soybean [8] is a commodity that has a high protein content which reaches 40% which is the highest content of various other vegetable protein ingredients. In line with the development of food processing technology, soybeans are very good to be processed into healthy functional food products such as soy milk and soy yogurt (*Soygurt*) [11].

The study aims to determine the extent to which consumer perceptions of *Soygurt* products developed by Soybean Production Centers Joint Business Group of Small and Medium Enterprises (UKM KUB) are in accordance with the attributes of the factors needed and the preparation of marketing strategies. Important factors that determine consumer perception of *Soygurt* products produced are used with the Fuzzy AHP (Analytic Hierarchy Process) method. Fuzzy AHP to determine the important factor attributes by rating the priority of product factors that are in accordance with consumer perceptions (Suyatno, 2011). Furthermore, the results of the Fuzzy AHP analysis are used as a basis for determining the internal and external strengths of SMEs which will then be analyzed using the SWOT method to get the right marketing strategy [12].

## 2. Materials and Methods

### 2.1. Research Objects

The product which is the object of this research is *Soygurt* which is produced by Setia Budi SME, Grobogan Regency, Central Java. The research focused on community perceptions by sampling in the Grobogan Regency area for determining product priority ratings. Product priorities are based on consideration of marketing mix elements (Product, Price, Place, and Promotion).

### 2.2. Research Method

In this research, data collecting technique was done through the interview and questionnaire. The AHP questionnaire aims to determine the priority rating of *Soygurt* products and the SWOT questionnaire is used in the preparation of the strategy. The AHP questionnaire respondents in this study were people who had consumed *Soygurt* in the Grobogan Regency. The sample collecting technique used in this study was nonprobability sampling, which is a sampling technique that gives an unequal opportunity or opportunity for each element or member of the population to be selected as a sample. Furthermore, the method used was purposive sampling, which is the determination of samples for specific purposes only.

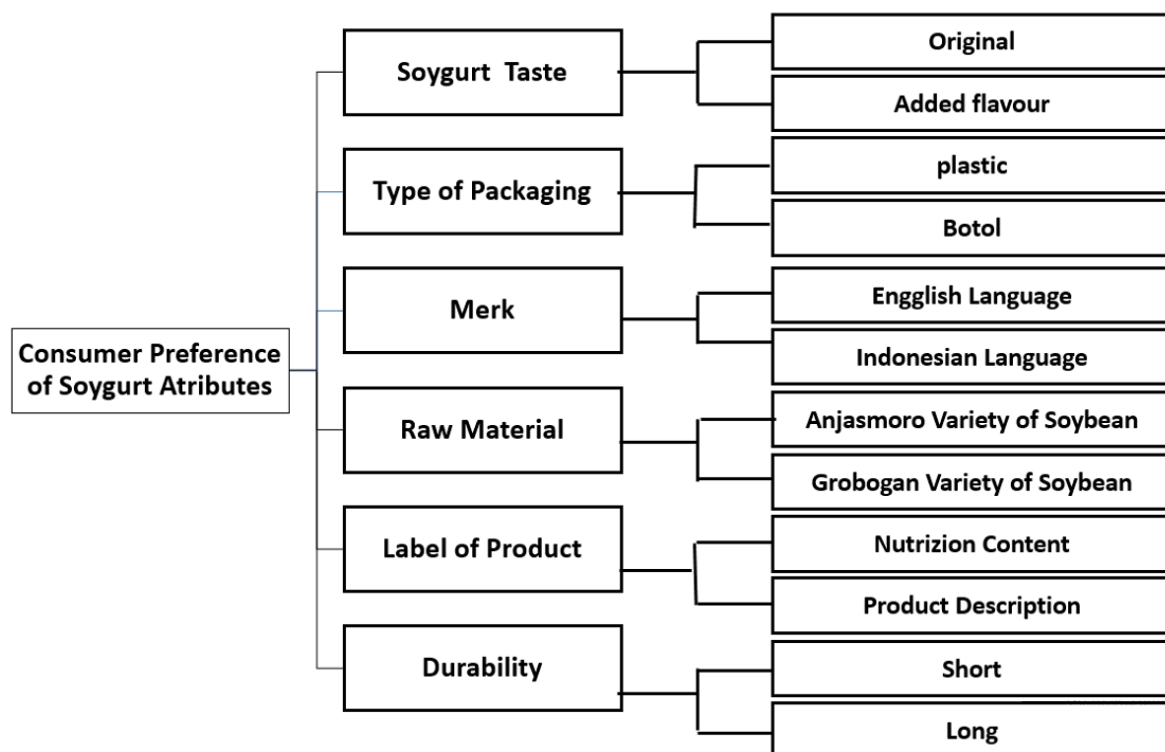


### 3. Result and Discussion

#### 3.1. Product Attributes Preference

Products are a set of tangible and intangible attributes [13]. While attributes are specific characteristics or certain characteristics designed in a product or service. Therefore, the product attributes of *Soygurt* are important to be noticed by producers so that their products are preferred by consumers in the market. Consumer preference [14] is a choice that is preferred by consumers compared to other types of choices. Consumers will prefer a *Soygurt* product because it is seen as giving more satisfaction preference to them. One of the consumers' consideration in choosing *Soygurt* products is *Soygurt* product attribute variables to be chosen. Consumers will tend to choose *Soygurt* products that have attributes according to their tastes. The consumer of *Soygurt* products who become respondents will compare a *Soygurt* product attribute with other attributes in the questionnaire with a value scale of 1-9. The results from the questionnaire and the processing were carried out by using Fuzzy AHP method. This method produces a sequence of *Soygurt* product attributes that are more important to consumers so that it can be input for Setia Budi SMEs in increasing marketing and sales activities of *Soygurt*.

The criteria of consumer preference for *Soygurt* products in Fuzzy AHP are the preferred attributes of *Soygurt* products, consisting of the attributes of taste, packaging, brand, main raw material, product shape, and durability. Taste attributes are an important factor in consumer preferences to assess a product [15, 16]. Beauty in packaging is a visual attraction that includes consideration of the use of colors, shapes, brands, or logos, illustrations, letters, layouts or layouts. A brand is a name or term to refer to a product and distinguish it from its competitors [15,17]. *Soygurt* is a yogurt product used with soybean raw materials. The use of several ingredients added more for the purpose of producing the different taste and flavor of *Soygurt* products such as strawberry, mango. Then the criteria are lowered into several sub-criteria. The consumer preference for *Soygurt* product attributes in Fuzzy AHP method as stated in Figure 1.



**Figure 1.** The Hierarchy of Consumer Preference on Soygurt Attributes

### 3.2. Questionnaire Composing

The assessment of consumer preferences through attributes of the factors that are emphasized in *Soygurt* products was done by filling out a questionnaire as a tool for data collection. In the main criteria section, the question comparing one *Soygurt* product attribute with other attributes was calculated in pairs. The questions used in the questionnaire are closed questions with a scale of 1-9.

### 3.3. Fuzzy AHP Testing

Fuzzy AHP that had been compiled was then carried out the testing phase of the results of the results of the calculation of the questionnaire obtained. The results of filling out the questionnaire from consideration of respondents preferences through Fuzzy AHP testing are needed for the sake of analysis of the results obtained. The results of filling in the main criteria and sub-criteria will then be formed into a pairwise comparison matrix. Furthermore, Fuzzy AHP testing is done through fuzzification calculation, ratio consistency, and defuzzification stages.

### 3.4. Main Criteria

The main criteria for *Soygurt* product attribute preferences consist of taste, packaging, brand, local soybean raw material, product shape, and durability of *Soygurt* products. This main criterion is the main consideration of a consumer in choosing *Soygurt* products produced by SMEs.

#### 3.4.1. Consistency Ratio Measurement

Consistency ratio (CR) is calculated to show the ability of respondents to compare the criteria used in pairwise comparisons of the attributes of consumer preferences taken into account. Consistency ratio is used to overcome the inconsistencies of respondents in comparing many criteria. A high CR value illustrates that the respondent's answer is less consistent, while the smaller CR value shows the consistent consistency of answers. A respondent is stated to be consistent if he has a CR value below 0.1. While for respondents who are inconsistent (CR value above 0.1), the results of the assessment of the questionnaire are declared null or not used in the next stage. Table 1 states that the pairwise comparison matrix of the respondents on the attributes given was assessed.

**Table 1.** Paired comparison matrix of respondents

Criteria	Taste	Type of Packaging	Merk	Raw Material	Product Label	Durability
Taste	1	3	5	3	5	1
Type of Packaging	1/3	1	7	1/3	5	1
Merk	1/5	1/7	1	1/5	1/3	1/7
Raw Material	1/3	3	5	1	5	1/5
Product Label	1/5	1/5	3	1/5	1	1/5
Durability	1	1	7	5	5	1

Source: data processing, 2017

Obtained from data processing the CR value obtained is less than 0.1 so it can be concluded that the results of the respondents' questionnaire are consistent for use. Furthermore, the Fuzzy AHP calculation is performed which shows that at this testing stage, the respondent chooses flavor attributes as the main consideration when choosing *Soygurt* products. The next consecutive product attributes that are prioritized by consumers are durability, packaging form, brand, raw material, and finally the *Soygurt* product label.

Taste is the main criterion that is most important for consumers in choosing a *Soygurt* product. Consumers will prefer *Soygurt* if the taste of *Soygurt* products is as expected and able to provide

maximum satisfaction. If the taste of *Soygurt* is not met, then it can be ascertained that consumers will not choose *Soygurt* products or are not interested in repurchasing. The second important criterion is the durability of the product. Good product durability will ensure consumers get the highest quality *Soygurt* products when consuming them. The third important criterion is the type of packaging. Packaging is a consumer attraction when choosing a *Soygurt* product. Unique types of packaging will be more noticed by consumers and have a greater chance of being selected. The fourth important product attribute is the brand. Brands describe a *Soygurt* product briefly and clearly so that a consumer will more easily recognize the product he likes. The fifth and sixth attributes are raw materials and product labels. Consumers do not think too much about these two product attributes as long as they get satisfaction from the *Soygurt* flavor they offer.

### 3.5. Sub Criteria

#### 3.5.1. Consistency Ratio

The measurement of consistency ratio in the sub criteria was done in the same way as in the main criteria. The aim is to ensure that the data processed using Fuzzy AHP comes from respondents who are able to answer questionnaires consistently. Before calculating consistency ratios, answers from respondents were formed into pairwise comparison ratio matrices Table 2 and Table 3.

**Table 2.** Paired comparison matrix of Product Taste

Taste	Original	Adding Flavour
Original	1	1/8
Adding Flavour	8	1

Source: Data Processing, 2017

**Table 3.** The Result of Consistency Rasio (CR)

Taste	Original	Adding Flavour	Weight
Original	1	1/8	0,111
Adding Flavour	8	1	0,889
$\lambda \max = 5,0625$ C.I. = 3,0625 R.I.= 0 C.R. = 0			

The CR value obtained is less than 0.1 so it can be concluded that the results of questionnaire 1 respondents are consistent. Meanwhile, the sub-criteria only compares 2 criteria. For example, the taste criteria only compare the original flavor and the addition of strawberry flavor. This condition makes a person be consistent in making choices. Viewed from the calculation side, in the random index table, the number of criteria 2 has the value of R.I. 0 so that the results of the C.I calculation divided by R.I. will get a CR value of 0 which means consistent. As a result, all respondents who answered the sub-criteria question were stated to be consistent. The results of filling out the sub-criteria questionnaire are then converted into fuzzy forms through the fuzzification process. Table 4.

**Tabel 4.** The Result of Fuzzy AHP on Sub Criteria

Criteria	Sub Criteria	Weight	Rank
Taste	Original	0,457357	2
	Adding Flavour	0,542643	1
Type of	Plastic	0,342199	2
Pacaking	Bottle	0,657801	1
Merk	Indonesia Language	0,394801	2
	English Language	0,605199	1
Raw Material	Anjasmoro Variety of Soybean	0,522052	1

**Table 4.** The Result of Fuzzy AHP on Sub Criteria (continued)

Criteria	Sub Criteria	Weight	Rank
Raw Material	Grobogan Variety of Soybean	0,477948	2
Product Label	Nutriiton Content	0,48797	2
	Product Descriptiont	0,51203	1
Durability	Short	0,372577	2
	Long	0,627423	1

The output of the Fuzzy AHP test shows that the taste of adding strawberries to *Soygurt* is preferable to the original taste. The choice of the flavor of strawberry addition can be affected because it is sweeter and more fragrant in the *Soygurt* that has been made. This choice of taste must be considered well by the manufacturer considering the flavor attribute as the most important attribute of consumers in choosing *Soygurt* products. Second, the type of bottle packaging is preferred by the respondent. This choice can be influenced because in the market *Soygurt* products have not been found with a variety of attractive designs and of course with bottle packaging proved to be able to maintain the quality of the product itself. Third, respondents prefer brands using foreign language terms. Brands with foreign language terms in the market are generally shorter and easier to remember by consumers so that they become more attractive. Fourth, the raw material for pure corn is chosen by the respondents. Fifth, the *Soygurt* product label that is preferred by respondents is displaying nutritional composition and description of *Soygurt* products. This type of consumer assesses that bottle packaging provides a more attractive product appearance. And finally, respondents prefer *Soygurt* products with long-lasting durability. Long durability makes a consumer able to buy large quantities of products for a long period of time so that they can save time and cost of purchase.

### 3.6. Marketing Strategy Analysis with SWOT Matrix

Strengths, weaknesses, opportunities and potential threats of *Soygurt* products are carried out through analysis using the SWOT method. SWOT analysis compares the external factors of opportunities and threats with internal factors of strength (weakness) and weakness (weakness). SWOT analysis systematically identifies various factors to formulate a company strategy. Analysis of internal factors is obtained from interviews and observations which are the identification of the factors that influence the success of the marketing of the instant corn rice industry. This complete internal environmental analysis can be seen in Table 5 and for its external environmental analysis in Table 6.

**Table 5.** Intern Environment Analysis

No	Items	Strength	Weakness
1.	The Advantage of Soygurt Product	√	
2.	Good quality	√	
3.	Good Product Price	√	
4.	Good packaging		√
5.	Soygurt product still needed promotion and communication for marketing		√
6.	Limited budgeting for SME		√
7.	Financial administration is still not done well		√
8.	Traditional Equipment in SME		√
9.	Good Cooperation between sellers and buyers	√	
10.	SMEs needed to improving and developing	√	
11.	SMEs have regular customers	√	

**Table 6.** Eksternal Environment Analysis

No	Items	Opportunity	Threat
1.	<i>Market leader</i>	√	
2.	Product competitor		√
3.	Difficulty for permanent worker		√
4.	The same of raw material used by Industry		√
5.	The development of Information System	√	
6.	Processing Technology Development	√	
7.	High Demand	√	
8.	Goverment Policy for increasing cost of gasoline or diesel raw material		√
9.	Climate Change		√
10.	Broad marketing area	√	

### 3.6.1. Determination of alternative strategies using the SWOT matrix.

This SWOT matrix contains four alternative strategies [12], where each strategy attempts to use strengths and opportunities to overcome weaknesses and threats. Based on the results of the determination of the strategies obtained for *Soygurt* products include:

#### 3.6.1.a. SO (Strengths-Opportunities) Strategy

The SO strategy is to use the power to take advantage of existing opportunities, can be formulated as follows:

- Increasing production volume
- Expanding the marketing network

#### 3.6.1.b WO (Weaknesses-Opportunities) Strategy

The WO strategy is to correct weaknesses to take advantage of existing opportunities, can be formulated as follows:

- Improving the type of product packaging to make it more attractive
- Maximizing promotions and streamlining production
- Improving the system and financial management

#### 3.6.1.c ST (Strengths-Threats) Strategy

The ST strategy is to use the power to anticipate or avoid threats that can be formulated as follows:

- Improving a comfortable working atmosphere in SMEs
- Setting the prices with a cost orientation

#### 3.6.1.d WT (Weaknesses-Threats) Strategy

The WT strategy is to improve weaknesses to overcome existing threats, can be formulated as follows:

- Expanding the information dissemination, promotion, and communication
- Renewing the production system

## 4. Conclusion

The results of the consumer preference that are prioritized on *Soygurt* product attributes in Setia Budi Small and Medium Enterprises have been obtained from research conducted so that these products can be accepted in the market and alternative strategies that need to be done by SMEs so that instant corn rice products are accepted by the market. The main criteria for *Soygurt* product attribute preferences consist of taste, type of packaging, brand, main raw material, product label, and product

durability. Testing the results of Fuzzy AHP shows that the taste of adding strawberries to *Soygurt* is more preferred than the original taste. The choice of preference prefers the type of bottle packaging, the brand uses foreign language terms, Anjasmoro local soybean raw material and instant corn rice products with long-lasting durability. The strategy obtained for *Soygurt* products is SO strategy on increasing production volumes and expanding marketing networks, WO strategy on improving the type of product packaging to be more attractive, maximizing promotion and streamlining production, system improvement, and financial management, ST strategy is carried out on building a comfortable working atmosphere in SMEs and setting prices with cost orientation, and WT's strategy to expand information dissemination, promotion and communication and renew the industrial systems.

## References

1. Radiyati, T. 1992. *Pengolahan Kedelai*. [Soybean Processing], BPTTG Puslitbang Fisika Terapan – LIPI. Subang.
2. Smith, AK., dan S.J. Circle, 1972. *Soybean Chemistry and Technology*, Vol. 1. The AVI Publishing Co. Inc., Westport, Connecticut.
3. Astuti, Dewi Herawati dan Arif, D. Wibawa. 2012. Pengaruh Konsentrasi Susu Skim dan Waktu Fermentasi Terhadap Hasil Pembuatan Soyghurt. [Effect of Skim Milk Concentration and Fermentation Time on Results of Soyghurt Production]. *Jurnal Ilmiah Teknik Lingkungan [Scientific Journal of Environmental Engineering]* Vol. 1 No. 2. Universitas Setia Budi; Surakarta
4. Ginting, Erlina, Satya, Sri Antarlina dan Widiowati, Sri. 2009. Varietas Unggul Kedelai Untuk Bahan Baku Industri Pangan [Superior Soybean Varieties for Food Industry Raw Materials], *Jurnal Litbang Pertanian [Agricultural Research and Development Journal]*, 28(3), 2009. Malang
5. Jumadi. 2009. Pengkajian Teknologi Pengolahan Susu kedelai [Assessment of Processing Technology for Soy Milk], dalam [in] Kartasasmita, Unang G., etal. *Buletin Teknik Pertanian [Agricultural Engineering Bulletin]* (Vol. 14, no. 1, hal. 34-36). Badan Penelitian dan Pengembangan Pertanian [Agricultural Research and Development Institution], Departemen Pertanian [Agricultural Department]: Jakarta.
6. Esti dan Sediadi. 2000. Susu kedelai. [Soybean Milk] Accessed on 26 November 2015, [http://www.warintek.riset.go.id/pangan\\_kesehatan/pangan/piwp/susu\\_kedelai.pdf](http://www.warintek.riset.go.id/pangan_kesehatan/pangan/piwp/susu_kedelai.pdf).
7. Drake, M., Cheng, X., Tamarapu, S. dan Leenanon, B., (2000). Soy protein fortification affects sensory, chemical, and microbiological properties of dairy yogurts. *Journal of Food Science*, 65(7): 1244-1247.
8. Endang, S.R. Kusnandar, J. Sutrisno, 2014, *Analisis Efisiensi Rantai Pasok Kedelai di Kabupaten Grobogan [Efficiency Analysis of Soybean Supply Chain in Grobogan Regency]*. Laporan Penelitian Hibah Pasca Sarjana [Post Graduated Grants Report], Universitas Sebelas Maret, Surakarta
9. Deddy M, 2010, *Kedelai komponen untuk Kesehatan [Soybean Component for Health]*, Penerbit Alfabeta, Jakarta
10. Wisnu C, 2007, *Kedelai Khasiat dan Teknologi [Soybean Benefits and Technology]*, Penerbit Bumi Aksara, Jakarta
11. Suyantohadi, A, 2012, *Desain dan Pengembangan Produk Susu Kedelai Bubuk berdasarkan Kriteria Persepsi Konsumen dan Target Costing dengan Integrasi Metoda Fuzzy Logic dan Value Engineering [Design and Development of Powdered Soy Milk Products based on Criteria for Consumer Perception and Target Costing with Integration of Fuzzy Logic Methods and Value Engineering]*, Laporan Penelitian Sekolah Vokasi D3 Agroindustri [Vocation Departement of Agroindustry], Universitas Gadjah Mada, Yogyakarta
12. Rangkuti, Freddy. 2006. *Analisis SWOT Teknik Membedah Kasus Bisnis, [SWOT Analysis of Business Case Techniques]*, PT Gramedia Pustaa Utama. Jakarta.
13. Shinta, Agustina. 2011. *Manajemen Pemasaran. [Marketing Management]*, Universitas Brawijaya Press. Malang.
14. Kotler, Philip dan Keller, Kevin Lane. 2009. *Manajemen Pemasaran. [Marketing Management]*, Edisi kedua belas, Jilid 1 [12 Edition, Jilid 1], PT Indeks. Jakarta.
15. Jansen, A. 2012. *Pengaruh Atribut Mutu Produk Terhadap Minat Beli Ulang Keripik Maich [The Influence of Product Quality Attributes to Interest in Repurchasing Maich Chips]*. Depok : Universitas Indonesia.
16. Mustafid & Gunawan, A. 2008. Pengaruh Atribut Produk Terhadap Keputusan Pembelian Kripik Pisang "Kenali" [The Effect of Product Attributes on the Decision to Purchase Banana Chips "Kenali"] Pada Pd Asa Wira Perkasa Di Bandar Lampung. *Jurnal Bisnis dan Manajemen*. Vol 4. No. 2, Hal 123-140
17. Stanton, W.J. (1993). *Marketing Management*. Jilid 1, Edisi 7. Jakarta: Erlangga.

© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the



Creative Commons Attribution (CC BY) license  
(<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-012-ID026

# The Effectiveness of Instagram Use in Florist Marketing

Geraldo Herawan <sup>1</sup>, Suharno <sup>2</sup> and Nafis Khuriyati <sup>2,\*</sup>

<sup>1</sup> Alumni of Agro-industrial Technology Department, Faculty of Agricultural Technology, UGM Yogyakarta; [geraldherawanf@gmail.com](mailto:geraldherawanf@gmail.com)

<sup>2</sup> Lecturer of Agro-industrial Technology Department, Faculty of Agricultural Technology UGM Yogyakarta; [suharno@ugm.ac.id](mailto:suharno@ugm.ac.id); [nafis.khuriyati@ugm.ac.id](mailto:nafis.khuriyati@ugm.ac.id)

\* Correspondence: [suharno@ugm.ac.id](mailto:suharno@ugm.ac.id) ; Tel.: +62-815-793-8741

Received: 9 July 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** Instagram is increasingly used by entrepreneurs to market their products. Some flower shops in Yogyakarta have used Instagram to market their products. The effectiveness of Instagram use in marketing has not been much known, so it is necessary to do research to know the effectiveness of Instagram in florist marketing. This study also measures the level of customer satisfaction based on 7P variables. This research positions Atelier Hanabira as the main object, followed by Floweridea and Mekar Florist. This study was conducted with a survey of 241 respondents to measure the effectiveness of Instagram and 255 respondents to measure the level of customer satisfaction. The sampling technique used is purposive sampling. Instagram's effectiveness as a marketing medium uses Customer Response Index (CRI) method and measurement of consumer satisfaction level using Customer Satisfaction Index (CSI) and Importance Performance Analysis (IPA). The results showed that the measurement of CRI Instagram on Atelier Hanabira was quite effective. While the CRI measurements on Floweridea and Mekar Florist are not effective. The value of CSI Atelier Hanabira is 72%, this value belongs to the "satisfied" category. There are 5 variables in the first quadrant of IPA diagram that need to be considered.

**Keywords:** Florist; Effectiveness; Instagram; Consumer satisfaction; AISAS; CRI; CSI; IPA

---

## 1. Introduction

Internet technology is growing rapidly in helping people's daily lives. Sellers and buyers use online applications to offer and shop goods. The purchase process is made easy by the availability of social media applications such as Instagram and Facebook. Digital communication using the internet and social media makes it very easy for customers to get information on the marketed products. Content facilities and conversations on social media are useful as communication media in various marketing activities. There are 700 million Instagram users, around 60 million photos are shared every day and reach 1.6 billion users like [1]. Instagram has great capabilities that can be used by companies to introduce their products to customers. One of Instagram's business users is the cut flower business and flower arrangement services. The development of cut flower business is related to the consumer mindset about beauty and aesthetics. When consumers type "florist Jogja" on the Instagram Search menu, consumers can find around 50 florist accounts in Yogyakarta. Atelier Hanabira is a florist located in Yogyakarta. Atelier Hanabira relies on Instagram for marketing activities and a means to introduce products to the public. This research put Atelier Hanabira as the main object, Floweridea and Mekar Florist as a comparison. These three florists have similarities in managing customers with Instagram. Atelier Hanabira and Floweridea have implemented the Instagram Business while Mekar Florist hasn't. The AISAS concept (Attention–Interest–Search–Action–Sharing) was successfully used to determine the effectiveness of Line as a medium to convey messages in the campaign [2]. The AISAS concept was used to determine the effectiveness of advertisements (promotions) and Line Shopping. The results



showed that the Customer Response Index (CRI) with the AISAS concept was claimed quite effective [3]. Thus, this study was conducted to determine the effectiveness of the use of Instagram as a florist marketing medium by using the Customer Response Index (CRI) method with the AISAS concept. Consumers will make positive recommendations when they are satisfied with the products and services they receive [4]. Therefore, analysis of customer satisfaction needs to be done to determine the level of customer satisfaction and to find out which variables have high priority for improving performance. Customer satisfaction is a function of product performance and consumer expectations. If product performance meets expectations, consumers will be satisfied. Satisfied consumers might repurchase and recommend these products to other consumers. So, it is important to measure the level of customer satisfaction using Instagram as a florist marketing medium. This study aims to (1) measure the effectiveness of Instagram usage as a marketing medium; (2) measure the level of customer satisfaction based on 7P variables (product, price, place, promotion, people, process, and physical evidence).

The florist business is promising and has good business prospects. Florist is a term used to describe the flower trade professionally including flower care and flower arrangement [5]. Social media is becoming popular because people can connect with each other in a variety of Interests including business activities. One most used popular social media is Instagram. Instagram provides space for users to present themselves and communicate to the public using photos and videos, assisted by text to write [6]. Effectiveness is basically related to output, namely the goals or objectives to be achieved [7]. Durianto, et al (2003) say that effective advertising makes the message delivered easy to digest and understand. Consumer satisfaction can be known after consumers use products and services. Customer satisfaction is evaluation after comparing what consumers feel with their expectations. Consumer satisfaction is what is felt for the use of products and services, the same or exceeds expectations [8]. Customer satisfaction is a function of views about product performance and consumer expectations. If performance meets expectations, then consumers will be satisfied. Satisfied consumers have the potential to make repeat purchases and recommend others to buy products [4].

Dentsu (2004) explains the use of a new consumer behavior model, namely AISAS (Attention, Interest, Search, Action, and Share). AISAS is the process of a consumer paying Attention to a product (Attention) and an Interest (Interest) arises from the product. Then collect all kinds of information (Search) about the product. After that, consumers make an assessment based on the information previously collected. If consumers are Interested in buying after Searching, the consumer will make a purchase. After the purchase process, consumers will deliver information to others by sending comments and talking in cyberspace (sharing) [9]. AISAS modeling is a nonlinear modeling that can be seen in Figure 1. With the existence of AISAS, companies are advised not to rely on advertising only but also to maintain the relationship between consumers and companies.

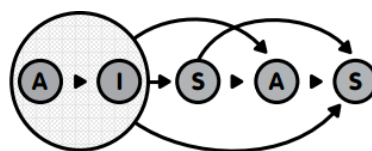
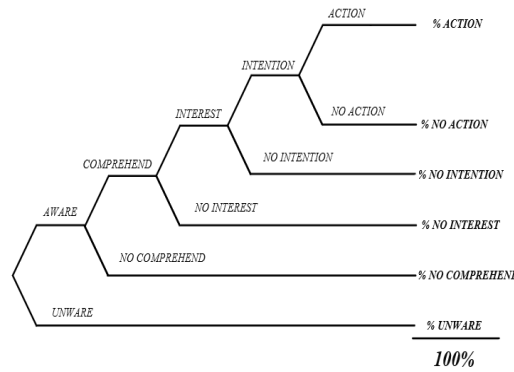


Figure 1. AISAS Model

## 2. Materials and Methods

This research used three florist companies Atelier Hanabira, Floweridea, and Mekar Florist where they all are located at Yogyakarta. All related data were collected from observation, interviews, and questionnaires. Respondents are those who have interacted with the three florists.

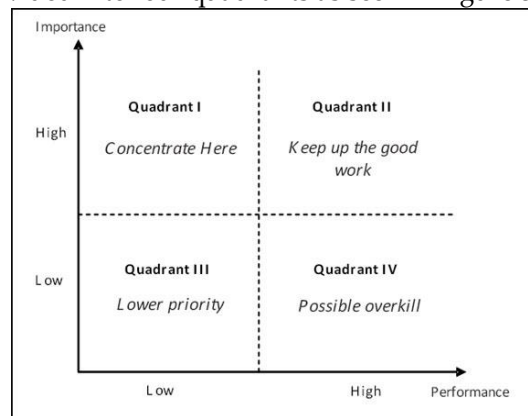
Customer Response Index (CRI). CRI is a tool to measure the effectiveness of communication carried out by advertisers. This CRI is the result of a link between awareness (awareness), comprehend (consumer understanding), Interest (Interest), intentions (intent to buy), and Action (purchase Action). CRI displays the purchasing process that starts from the emergence of consumer awareness, until finally consumers make purchase Actions (Durianto, 2003). The CRI model shown in Figure 2.



**Figure 2.** CRI Model

### 2.1. Importance Performance Analysis (IPA).

IPA can be used to analyze customer satisfaction [10]. This method measures the level of customer Interest in relation to what should be done by the company in order to produce high quality products or services. IPA combines measurement of importance and satisfaction levels in two-dimensional graphs. This IPA graph is divided into four quadrants as seen in Figure 3.



**Figure 3.** Importance Performance Analysis (IPA)

Quadrant I shows the factors that are considered to have a high level of importance but these factors still cannot satisfy customers. Quadrant II shows the elements of the product or service that the company has successfully carried out. Factors in this area are considered very important and very satisfying to customers. Quadrant III shows the factors that are considered less important to the customer and the implementation is normal. Quadrant IV shows the factors that affect customers are less important but the implementation is excessive.

Customer Satisfaction Index (CSI). CSI analysis is used to determine the level of overall customer satisfaction by considering the level of importance and level of performance of the quality of the attributes of the goods or services tested. Steps below are used in the CSI analysis:

1. Mean Importance Score (MIS) and Mean Satisfaction Score (MSS), Equation 1.

$$MIS = \frac{\sum_{i=1}^n Y_i}{n} \quad \text{and} \quad MSS = \frac{\sum_{i=1}^n X_i}{n} \quad (1)$$

Where:

$Y_i$  = Value of Interest Attribute to  $i^{\text{th}}$

$X_i$  = Value of Attribute Performance to  $i^{\text{th}}$

$N$  = Number of Respondents

2. Weighting Factor (WF), Equation 2.

$$WF = \frac{MIS_i}{Total\ MIS_i} \times 100\% \quad (2)$$

Where:

WF = Weighting Factors

MIS = Mean Important Score

i = Attribute to i<sup>th</sup>

3. Weighted Score (WS), Equation 3.

$$WS = MSS \times WF \quad (3)$$

Where:

WS = Weighted Score

WF = Weighting Factors

MSS = Mean Satisfaction Score

4. Customer Satisfaction Index (CSI).

CSI value in the form of a percentage that measures the level of customer satisfaction at Atelier Hanabira. Determination of satisfaction by matching the CSI value with the criteria as shown in Table 1. CSI is calculated using Equation 4:

$$CSI = \frac{\sum_{i=1}^p WS_i}{HS} \times 100\% \quad (4)$$

Where:

CSI = Customer Satisfaction Index

WS = Weighted Score

HS = Highest Score

**Table 1.** Customer Satisfaction Index (CSI) Criteria

Index Value (%)	Customer Satisfaction Index Criteria
81,00 – 100,00	Very satisfied
66,00 – 80,99	Satisfied
51,00 – 65,99	Quite satisfied
35,00 – 50,99	Less satisfied
0,00 – 34,99	Not satisfied

This study used Atelier Hanabira as the main object, while Floweridea and Mekar Florist were the comparison objects. This study includes observation, interviews with owners, questionnaires distribution for customers, and data analysis. The population used were consumers who knew Atelier Hanabira, Floweridea, and Mekar Florist from Instagram. Purposive sampling was used where the number of consumers who know the three florists was uncertain. The measurement of the sample size follows author [11] with the appropriate sample size (observation data) between 100-200 respondents, Equation 5.

$$n = 5 \times N \text{ to } 10 \times N \quad (5)$$

Where:

n = Number of samples

N = Number of variables

Variables used were 13 for measuring effectiveness of Instagram usage and 27 for measuring customer satisfaction. Thus, a decent sample size based on the criteria follows Equations 6 and 7:

$$n = 5 \times 13 \text{ to } 10 \times 13 = 65 \text{ to } 130 \quad (6)$$

$$n = 5 \times 27 \text{ to } 10 \times 27 = 135 \text{ to } 270 \quad (7)$$

The number of 65 respondents for the effectiveness of Instagram and 135 respondents for the level of satisfaction were considered sufficient. The use of these 13 variables is based on 5 main AISAS variables (3 Attention, 4 Interests, 2 Searches, 2 Actions, and 2 Shares) and 27 variables based on 7 main variables 7P (8 products, 3 prices, 3 promotions, 2 places, 5 people, 5 process, 1 physical evidence).

Calculation of the effectiveness of Instagram social media for marketing Atelier Hanabira using a modified CRI. It consists of awareness (awareness), comprehend (understanding of consumers), Interest (Interest), intentions (intentions to buy), and Actions (purchase Actions) that are modified to AISAS consisting of Attention, Interest, Search, Action, Share. Modified CRI was used because social media is interpersonal which will be effective when customer willing to Share [2].

The AISAS concept is not linear that can be modified into 4 models: CRI AISAS (Attention–Interest–Search–Action–Share), CRI AISS (Attention–Interest–Search–Share), CRI AISA (Attention–Interest–Search–Action), and CRI AIS (Attention–Interest–Share), shown in Figure 4.

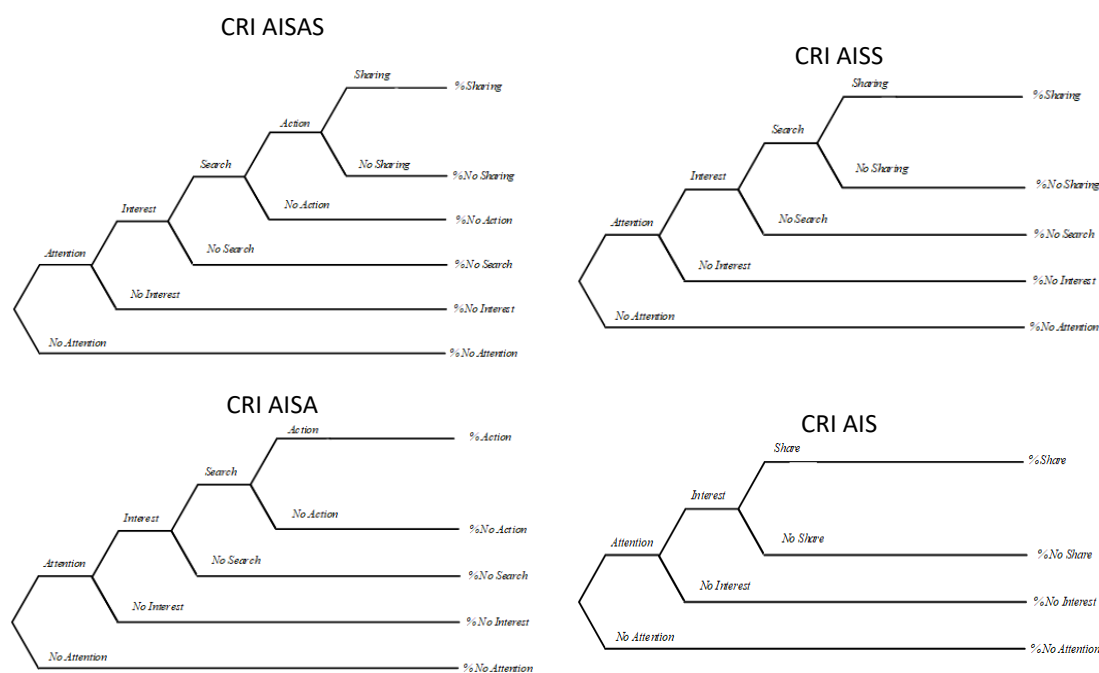


Figure 4. Four CRI AISAS Models

Formula to calculate CRI (Durianto, 2003):

AISAS CRI = Attention  $\times$  Interest  $\times$  Search  $\times$  Action  $\times$  Share

CRI AISS = Attention  $\times$  Interest  $\times$  Search  $\times$  Share

CRI AISA = Attention  $\times$  Interest  $\times$  Action  $\times$  Share

CRI AIS = Attention  $\times$  Interest  $\times$  Share

### 3. Results and Discussion

#### 3.1. Industrial Profile

Atelier Hanabira is one of the florists in Yogyakarta that has used Instagram as their marketing medium since the company was founded. In the first six months, they only rely on online sales, then they open their offline store. Atelier Hanabira's expertise not only arranges flowers on media buckets but also on various other media such as flower crowns, flower boxes, flower frames, flower jar, artificial flowers, decorations for weddings, and wedding equipment. The segmentation of Atelier Hanabira is middle to upper class society. The target market for this business is young people, especially college

students and socialites. Atelier Hanabira positioned itself as a flower design studio located in Yogyakarta.

### 3.2. CRI at Atelier Hanabira

Before calculating CRI at Atelier Hanabira, it is necessary to know the customer's response from the results of the questionnaire as in Table 2.

**Table 2.** Customer Response Atelier Hanabira

No.	Variable	Customer Response	Portion of Customer Response
1	Attention	Attention	96.92%
		No Attention	3.08%
2	Interest	Interest	93.85%
		No Interest	6.15%
3	Search	Search	70.77%
		No Search	29.23%
4	Action	Action	65.00%
		No Action	35.00%
5	Share	Share	66.92%
		No Share	33.08%

Based on the data in Table 2, the calculations are continued to obtain CRI\_AISAS, CRI\_AISS, CRI\_AISA, and CRI\_AIS

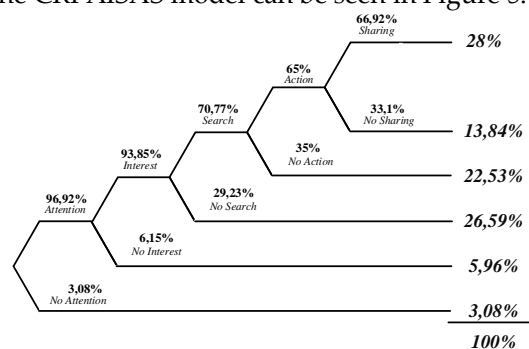
#### 3.2.1. CRI\_AISAS

In addition to calculating the final results of the model, the percentage of consumers who reach the Action stage through the stages of Attention, Interest and Search will also calculate the percentage of consumer number who have No Action, No Search, no Interest, and no Attention. CRI\_AISAS calculation results can be seen in Table 3.

**Table 3.** CRI Calculation for AISAS Model at Atelier Hanabira

No.	Variable	Formula	Calculation	Result
1	AISA	Attention x Interest x Search x Action	$96.92\% \times 93.85\% \times 70.77\% \times 65\%$	41.84%
2	No Action	Attention x Interest x Search x No Action	$96.92\% \times 93.85\% \times 70.77\% \times 35\%$	22.53%
3	No Search	Attention x Interest x No Search	$96.92\% \times 93.85\% \times 29.23\%$	26.59%
4	No Interest	Attention x No Interest	$96.92\% \times 6.15\%$	5.96%
5	No Attention	No Attention	3.08%	3.08%

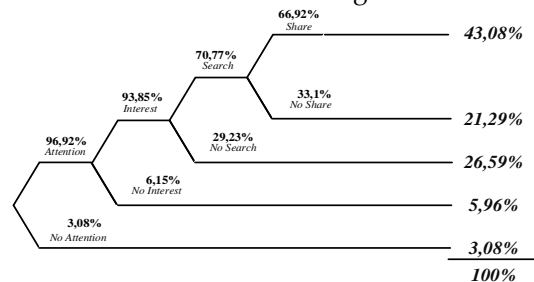
After the above calculation is complete, the calculation results are included in the CRI model structure. The structure of the CRI AISAS model can be seen in Figure 5.



**Figure 5.** CRI AISAS Model at Atelier Hanabira

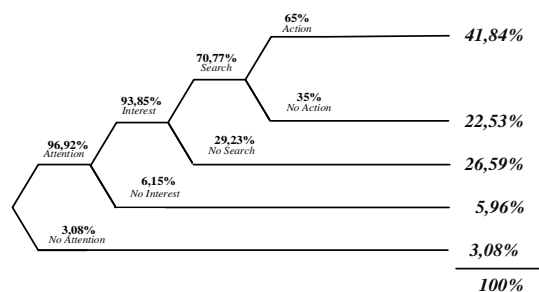
## 3.2.2. CRI\_AISS

In addition to calculating the final model results, the percentage of consumers who reach the stage of sharing through the stages of Attention, Interest, and Search, will also calculate the percentage of consumers who have No Action, No Search, no Interest, and no Attention. The calculation results are included in the CRI model structure that can be seen in Figure 6.

**Figure 6.** CRI AISS Model at Atelier Hanabira

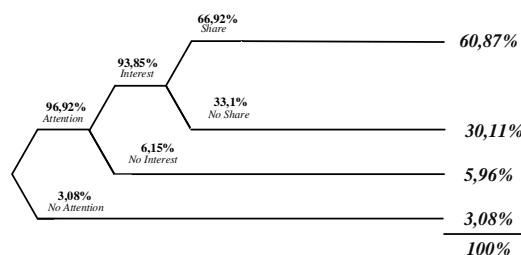
## 3.2.3. CRI\_AISA

Final results of the model, the percentage of consumers who reach the Action stage through the stages of Attention, Interest, and Search. The percentage of consumers with No Action, No Search, no Interest, and no Attention. The calculation results then are included in the CRI model structure shown in Figure 7.

**Figure 7.** CRI AISA Model on Atelier Hanabira

## 3.2.4. CRI\_AIS

In addition to calculating the final model results, the percentage of consumers who reach the stage of sharing through the stages of Attention, Interest, will also calculate the percentage of consumers who no Share, no Interest, and no Attention. The calculation results are included in the CRI model structure as shown in Figure 8.

**Figure 8.** CRI AISS Model on Atelier Hanabira

This research aims to find out the effectiveness of Instagram use as a marketing tool for florist products. It was found that the use of Instagram for florist marketing "Atelier Hanabira" was quite

effective on AISAS, AISS, AISA, and AIS. The percentage of respondents in each model were higher than the no Attention, no Interest, No Search, No Action, and no Share that can be seen in Table 7.

**Table 7.** CRI-AISAS Measurement Results at Atelier Hanabira

	<b>AISAS</b>	<b>AISA</b>	<b>AISS</b>	<b>AIS</b>
	<b>28%</b>	<b>41.84%</b>	<b>43.08%</b>	<b>60.87%</b>
	<b>Higher than</b>			
No Share	13.84%		21,29%	30,11%
No Action	22.53%	22.53%		
No Search	26.59%	26,59%	26,59%	
No Interest	5.96%	5,96%	5,96%	5,96%
No Attention	3.08%	3,08%	3,08%	3,08%

In the measurements of CRI\_AISAS (Attention–Interest–Search–Action–Share), the respondents who reached the Share by Action and Search first of 28.00%, there are still 72.00% respondents who were still able to achieve or who have not Share yet. At CRI\_AISA (Attention–Interest–Search–Action), the respondents who reached the Action stage through the Search phase without the Share of 41.84%, there are still 58.16% respondents who can still be achieved or who have not yet done Search. At CRI\_AISS (Attention–Interest–Search–Share), the respondents are up to the Share without doing the Action but doing a Search of 43.08%, there are still 56.92% respondents who are still able to achieve or who have yet to Share though an Action . In CRI\_AIS, the respondents who only reached the Share without going through the Action and Share of 60.87%, there are still 39.13% respondents who are still able to achieve or who have not yet Share without doing Action and Search. These data show that the use of Instagram as a marketing medium is effective as explained above but the results can still be maximized to see the results of the number of respondents that can still be achieved from every calculation of CRIS AISAS, AISA, AISS, and AIS.

Table 2 shows that the lowest AISAS stage is at the Action stage of 65% and Share of 66.92%. Atelier Hanabira is expected to improve the quality of the product and can adjust the development of consumer desires, so that more consumers make purchases and make recommendations to other potential customers. In addition to improving quality, Atelier Hanabira is expected to maintain the quality and quantity of each product offered. Catalog content with the product produced must be appropriate. While the highest stage is 96.92%, this shows that the Atelier Hanabira Instagram account page and the products offered have attracted the Attention of potential customers. In addition to improving quality, Atelier Hanabira is expected to maintain the quality and quantity of each product offered. Catalog content with the product produced must be appropriate. While the highest achievement was 96.92%, this shows that the Atelier Hanabira Instagram account page and the products offered attract many potential customers.

Before calculating CRI AISAS at Floweridea and Mekar Florist, it was necessary to know the customer response from the results of the questionnaire as summarized in Table 8.

**Table 8.** Floweridea and Mekar Florist Customer Response (CR)

No	Variable	Customer Response	Floweridea CR Portion	Mekar Florist CR Portion
1	Attention	Attention	89.16%	80.36%
		No Attention	10.84%	19.64%
2	Interest	Interest	90.96%	83.93%
		No Interest	9.04%	16.07%
3	Search	Search	62.65%	66.07%
		No Search	37.35%	33.93%
4	Action	Action	59.64%	55.36%
		No Action	40.36%	44.64%
5	Share	Share	51.20%	73.21%

No Share	48.80%	26.79%
----------	--------	--------

After calculating the respondents of Floweridea and Mekar Florist customers, CRI AISAS, AISA, AISS, and AIS were calculated as in the CRI calculation at Atelier Hanabira. The results of these calculations show that the effectiveness of Instagram use on Floweridea and Mekar Florist were not effective as shown in Table 9 for Floweridea and Table 10 for Mekar Florist.

**Table 9.** The results of the AISAS CRI Measurement Model at Floweridea

	<b>AISAS</b> <b>15.52%</b> <b>Lower</b>	<b>AISA</b> <b>30.30%</b> <b>Higher</b>	<b>AISS</b> <b>26.02%</b> <b>Lower</b>	<b>AIS</b> <b>41.53%</b> <b>Higher</b>
No Share	14.79%		24.79%	39.57%
No Action	20.51%	20.51%		
No Search	30.29%	30.29%	30.29%	
No Interest	8.06%	8.06%	8.06%	8.06%
No Attention	10.64%	10.84%	10.84%	10.84%

Data shows that Instagram use at Floweridea was ineffective, CRI's calculation for AISAS, CRI AISAS (15.52%) has a lower percentage of "No Action" (20.51%) and "No Search" (30.29%) and CRI AISS (24.79%) also has a lower percentage of "No Search" (30.29%). The ineffective CRI is CRI AISAS (Attention–Interest–Search–Action–Share) because the CRI AISAS value is lower than the "No Action" and "No Search".

**Table 10.** The results of the AISAS CRI Measurement Model at Mekar Florist

	<b>AISAS</b> <b>18.06%</b> <b>Lower</b>	<b>AISA</b> <b>24.67%</b> <b>Higher</b>	<b>AISS</b> <b>32.62%</b> <b>Higher</b>	<b>AIS</b> <b>41.53%</b> <b>Higher</b>
No Share	6.61%		32.2%	49.38%
No Action	19.89%	19.89%		
No Search	22.88%	22.88%	22.88%	
No Interest	12.91%	12.91%	12.91%	12.91%
No Attention	19.64%	19.64%	19.64%	19.64%

The use of Instagram at Mekar Florist and Floweridea was not so effective where CRI AISAS was 18.06% lower than the "No Action" (19.89%), "No Search" (22.88%), and "no Attention" (19.64%). The CRI AISAS (Attention–Interest–Search–Action–Share) on Atelier Hanabira was quite effective as shown in Table 7, while in Floweridea and Mekar Florist seems ineffective (Table 9 and Table 10). The effective "CRI AISAS" measurement indicates that there were consumers who aware of the existence of a product, who were Interested in the product, then find out more information about the product, then make a purchase, and finally they made recommendations to other potential customers. Instagram usage at Atelier Hanabira was quite effective for marketing tool where 52% of respondents knew Atelier Hanabira through Instagram social media. While at Floweridea 47% of respondents knew that Floweridea from Instagram social media and Mekar Florist was 36%. Atelier Hanabira was more sought after and recommended by consumers because the appearance and photos posted on Instagram are more attractive and have more variety of flower arrangements.

After measuring the level of effectiveness of Instagram use at Atelier Hanabira, then measured the level of customer satisfaction for Atelier Hanabira. Measurement of customer satisfaction was carried out to support the level of effectiveness of Instagram use. Satisfied consumers will share to other potential customers. Analysis of Customer Satisfaction Index (CSI) was used to measure the level of customer satisfaction with the product. CSI results in the form of percentage of customer satisfaction obtained after calculating the average level of expectations and reality, weighting factor, and weighting



score. Consumer satisfaction questionnaires used 7P variables (product, price, promo, place, people, process, and physical evidence). A summary of the results of CSI's analysis on Atelier Hanabira can be seen in Table 11.

**Table 11.** CSI Overall

No	Variable	MIS	MSS	WF	WS	CSI overall
1	Product 1	4.13	3.68	3.85%	0.14	
2	Product 2	4.11	3.64	3.82%	0.14	
3	Product 3	4.09	3.51	3.81%	0.13	
4	Product 4	4.25	4.01	3.96%	0.16	
5	Product 5	4.15	3.55	3.87%	0.14	
6	Product 6	4.26	4.14	3.97%	0.16	
7	Product 7	3.93	3.01	3.66%	0.11	
8	Product 8	4.11	3.87	3.83%	0.15	
9	Price 1	4.02	3.67	3.75%	0.14	
10	Price 2	3.96	3.71	3.69%	0.14	
11	Price 3	3.80	3.34	3.54%	0.12	
12	Promotion 1	4.14	4.06	3.85%	0.16	
13	Promotion 2	3.75	3.06	3.49%	0.11	
14	Promotion 3	3.92	3.43	3.65%	0.13	72.02%
15	Place 1	3.89	3.69	3.62%	0.13	
16	Place 2	3.62	2.71	3.37%	0.09	
17	People 1	3.93	3.58	3.66%	0.13	
18	People 2	3.84	3.34	3.57%	0.12	
19	People 3	3.97	3.75	3.70%	0.14	
20	People 4	3.82	3.49	3.55%	0.12	
21	People 5	3.93	3.70	3.66%	0.14	
22	Process 1	3.93	3.61	3.66%	0.13	
23	Process 2	4.09	3.91	3.81%	0.15	
24	Process 3	4.05	3.85	3.77%	0.15	
25	Process 4	3.98	3.85	3.71%	0.14	
26	Process 5	4.04	3.82	3.77%	0.14	
27	Physical Evidence	3.66	2.94	3.41%	0.10	
	Total	107.35	96.92	100%	3.60	

$$CSI = \frac{\sum_{i=1}^p WS_i}{HS} \times 100\% = \frac{3,60}{5} \times 100\% = 72,02\% \quad (8)$$

CSI value obtained from dividing the total weighting score with the maximum scale used in this study is 5. In Table 11, the total value of WS is 3.60 and the maximum scale is 5, so that CSI is 72.02%. Based on Table 1 about the CSI criteria that CSI is 72.02% into the "satisfied" category. So, it can be interpreted that consumers have felt satisfied overall with Atelier Hanabira. Product, price, promotion, place, people, process, and physical evidence have given satisfaction so that the variables are in accordance with the expectations of consumers. Variable Physical Evidence is a variable that is categorized as quite satisfied, giving information that the convenience of waiting for customers at Atelier Hanabira needs to be improved.

Importance Performance Analysis (IPA) method was used to measure the level of customer satisfaction by measuring the variables of the level of consumer expectations and the level of performance. The results of the IPA measurement shown in Table 12.

**Table 12.** Summary of IPA Measurement Results

No	Variable	Sum		Average	
		Expectation	Performance	Expectation	Performance
1	Product 1	1053	938	4.13	3.68
2	Product 2	1047	929	4.11	3.64
3	Product 3	1042	895	4.09	3.51
4	Product 4	1084	1023	4.25	4.01
5	Product 5	1058	904	4.15	3.55
6	Product 6	1086	1056	4.26	4.14
7	Product 7	1002	768	3.93	3.01
8	Product 8	1048	986	4.11	3.87
9	Price 1	1026	936	4.02	3.67
10	Price 2	1009	945	3.96	3.71
11	Price 3	968	852	3.80	3.34
12	Promo 1	1055	1035	4.14	4.06
13	Promo 2	955	781	3.75	3.06
14	Promo 3	999	875	3.92	3.43
14	Place 1	992	942	3.89	3.69
16	Place 2	922	691	3.62	2.71
17	People 1	1003	914	3.93	3.58
18	People 2	978	852	3.84	3.34
19	People 3	1013	955	3.97	3.75
20	People 4	973	889	3.82	3.49
21	People 5	1003	943	3.93	3.70
22	Process 1	1002	920	3.93	3.61
23	Process 2	1043	998	4.09	3.91
24	Process 3	1033	982	4.05	3.85
25	Process 4	1015	983	3.98	3.85
26	Process 5	1031	974	4.04	3.82
27	P7 Physical Evidence	934	794	3.66	2.94
Total		27374	24715	107.35	96.92

IPA Cartesian Diagram has the X axis and Y axis perpendicular to each other and has four areas: quadrant I, quadrant II, quadrant III, and quadrant IV. The X axis represents the average level of expectation and the Y axis represents the average level of performance. The average value of the level of expectations and the level of performance are used to determine the center line of the IPA Cartesian diagram as shown in Figure 9.

$$\sum \bar{x}_i = 96,92$$

$$\sum \bar{y}_i = 107,35$$

$$k = 27$$

$$\bar{\bar{X}} = \frac{\sum_{i=1}^n \bar{X}_i}{k} \quad (9)$$

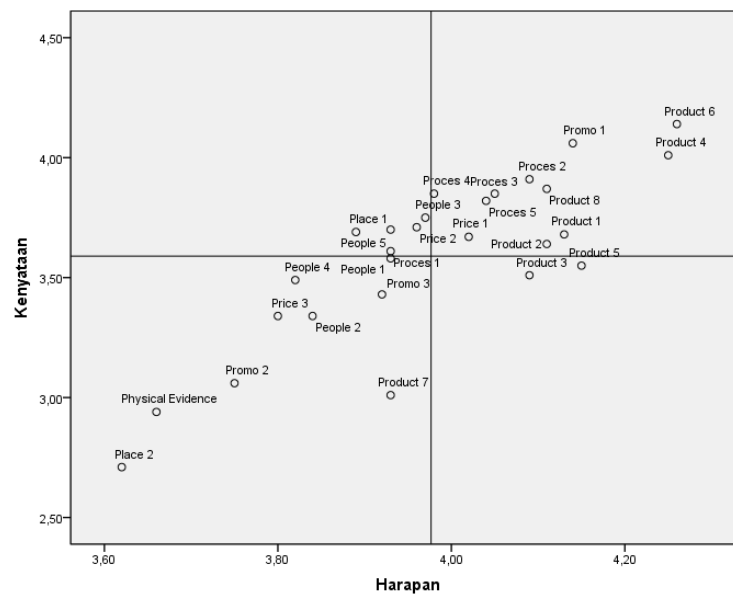
$$\bar{\bar{Y}} = \frac{\sum_{i=1}^n \bar{Y}_i}{k} \quad (10)$$

$$\bar{\bar{X}} = \frac{96,92}{27}$$

$$\bar{\bar{Y}} = \frac{107,35}{27}$$

$$\bar{\bar{X}} = 3,59$$

$$\bar{\bar{Y}} = 3,96$$



**Figure 9.** Importance Performance Analysis (IPA) Cartesian Diagram

**Quadrant I** contains variables that are important for customers but have not fulfill customer expectations yet (*Price 2; Place 1; People 3; People 5 and Process 1*). **Quadrant II** contains variables that are important for customers and have met customer expectations (*Product 1; Product 2; Product 4; Product 6; Product 8; Price 1; Promotion 1; Process 2; Process 3; Process 4 and Process 5*). **Quadrant III** contains variables that are less important for customers and their performance were not too special (*Product 7; Price 3; Promotion 2; Promotion 3; Place 2; People 1; People 2; People 4 and the outlet of Atelier Hanabira is comfortable to wait*). **Quadrant IV** contains variables that are less important for customers and their performance were too excessive (*Product 3 and Product 5*).

#### 4. Conclusions

Based on the research results it can be concluded. **First**, Instagram use at Atelier Hanabira was most effective compared to the use of it at Floweridea and Mekar Florist. CSI value at Atelier Hanabira was 72.02% that can be categorized as "Satisfied" as in the range of 66.00% - 80.99%. **Second**, five attributes that need to be improved by Atelier Hanabira are product prices, store locations, employee professionalism, patience in service, time to complete orders.

#### References

1. Dewaweb. 2018. 12 Tips dan Strategi Marketing Instagram Untuk Bisnis Anda. <https://www.dewaweb.com/blog/tips-dan-strategi-marketing-instagram-untuk-bisnis-anda>. Date 10 April 2018 time 21.00.
2. Faroktarina, F. Anastasia. 2014. "Line Sebagai Media Penyampai Pesan (Studi Deskriptif Mengenai Efektivitas Jejaring Sosial Line sebagai Media Penyampaian Pesan Kampanye WWF "Tiggy Tiger" Berdasarkan Perhitungan Customer Response Index pada Pengguna Line". Skripsi. Fakultas Ilmu Sosial dan Ilmu Politik. Universitas Atmajaya Yogyakarta.
3. Praja, Arya Widya. 2015. "Analisis Persentase Efektivitas Iklan (Promosi) dan Efektivitas Line Shopping Menggunakan Metode Customer Response Index (CRI). Skripsi. Fakultas Ekonomi dan Bisnis. Universitas Telkom Bandung.
4. Kotler, Philip. dan Armstrong, G. 2008. Manajemen Pemasaran. Jakarta: PT Gramedia Pustaka Utama.
5. Puspitasari, Ratna. 2015. "Analisis Kelayakan Usaha Bunga Rangkaian (Florist) Pada Jelita Florist di kota Bekasi". Skripsi. Departemen Agribisnis, Fakultas Ekonomi dan Manajemen, Institute Pertanian Bogor.
6. Ramadhanti, Tatia Ridho. 2016. Fenomena Pemanfaatan Instagram Sebagai Media Personal Branding. Skripsi. Fakultas Ilmu Sosial dan Ilmu Politik. Universitas Diponegoro.
7. Mardiasmo. 2009. Akuntansi Sektor Publik. Andi. Yogyakarta.

8. Yamit, Z. 2015. Manajemen Kualitas Produk dan Jasa-Edisi I. Yogyakarta.
9. Sugiyama, Kotaro, Tim Andree. 2010. The Denstu Way. McGraw-Hill.
10. Rangkuti, Freddy. 2006. Measuring Customer Satisfaction. Jakarta: PT. Gramedia Pustaka Utama
11. Hair, J.R., Anderson, R.E., Tatham, R.L., Black W.C. 2006. Multivariate Data Analysis 3th Edition. New York: Macmillan Publishing Company.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license  
<http://creativecommons.org/licenses/by/4.0/>.

FP-MCI-007-ID043

# Analysis of Consumer Preference Towards Organic Products at Istana Sayur Grocery Shop Malang City Indonesia

Ika Atsari Dewi<sup>1</sup>, Panji Deoranto<sup>1</sup>, and Diannisa Hadiani<sup>1</sup>

<sup>1</sup> Agroindustrial Technology Department Universitas Brawijaya Malang Indonesia

\* Correspondence: ikaatsaridewi@ub.ac.id; Tel.: +6281230968368

Received: 7 August 2018; Accepted: 28 August 2019; Published: 6 January 2020

**Abstract:** The growth of organic products market in Indonesia is seen by the increasing number of organic farmers, retailers and restaurants selling organic products. The main requirement that must be fulfilled by ventures to be successful in the competition is trying to achieve the goal to attract and maintain customers. To find out factors that affect purchasing decisions, investigation was done to determine the factors that construct customer preferences of organic product. The purpose of this study is to determine the effect of product attributes variable on consumer purchase decisions by using consumer preference as mediation variable. The research is conducted at UD Istana Sayur in Malang City Indonesia which sells organic rice and vegetables. Data collection was done by distributing questionnaires to 120 respondents using Likert scale 1-5. The obtained data were then processed using Partial Least Square (PLS). The results of the study indicated that good product attributes and consumer preference variables had certain influence in the increase of consumer purchasing decisions. In addition, consumer preference variable is able to mediate the relationship between product attributes and consumer purchase decisions variables.

**Keywords:** organic products; Partial Least Square (PLS); purchasing decision

---

## 1. Introduction

The government of Indonesia has proclaimed the 2010 Go Organic program to accelerate the realization of environmentally sound agribusiness development. One of its activities is promoting organic farming to consumers, farmers, market players and the community [1]. The growth of organic food market in Indonesia is reflected by the increasing numbers of organic farmers, supermarkets, and restaurants that sell organic products [2]. UD Istana Sayur a store in Malang that sells organic products, such as organic rice and organic vegetables since 2015. To stay competitive and to be able to achieve certain corporate goal, a company should attract and maintain its customers. To enhance customer satisfaction, a company needs to identify factors influencing purchasing decision by analyzing consumer product preferences [3]. Consumer preference refers to a prioritized characteristic of certain product [4]. The attributes of customer preference include quality, price, popularity, and lifestyle. One of factors that determines consumer preferences is product attributes. Product attributes are characteristics that differentiate a product from the others [5]. In this research, product attributes included chemical free status, packaging size, product color, packaging label, and packaging design. Customers' considerations upon product attributes can affect their purchase decision upon certain product. For consumers, purchase decision is an important process since there are sequential steps that take place before customers make decision. Purchase decision is a process of selecting one product among two or more alternative choices [6]. The purpose of this research is to determine the effect of product attributes on consumer purchase decision through consumer preference as the mediating variable.

## 2. Materials and Methods

This research took place in UD Istana Sayur Malang in Jalan Raya Tlogomas No 93 Lowokwaru District, Malang City, East Java Province, Indonesia. The focus of this study was limited to only analyzing vegetable commodities and organic rice sold at UD Istana Sayur Malang. This research started from a preliminary survey, literature study, identification of research problems and formulation and development of structural research models and hypotheses, determination of population and sample, questionnaire preparation, questionnaire distribution and interview, validity test, reliability test, linearity test, and data analysis using SmartPLS. Interviews were done with 120 vegetable and organic rice buyers at UD Istana Sayur Malang which data were then analyzed using PLS method. There were primary and secondary data in this research. Primary data were obtained from questionnaires and interviews. Respondents' responses toward the questionnaires were measured using a Likert scale. Descriptive analysis and inferential analysis were employed to analyze the obtained data. Descriptive analysis was administered to determine respondents' characteristics and the average score of respondents' answers for each item, question, indicator, and variable. This analysis was administered using SPSS 17.0 software. Meanwhile, inferential analysis was conducted to answer the hypothesis in this study using Partial Least Square (PLS) of SmartPLS. Latent variables and observed variables in the study are presented in Table 1. The hypotheses of this research were formulated as follows:

- H1: Product attributes influence consumer preference
- H2: Product attributes influence purchase decision
- H3: Consumer preference influences purchase decision
- H4: Consumer preference mediates the relationship between product attributes and purchase decision

### 3. Results

#### 3.1. Descriptive statistics

There were a total of 120 respondents interviewed consisting of 77 (64.17%) women and 43 (35.83%) men. The majority of respondents were 32-38 years old, working as employees (58.33%), earning an average income of around USD 123.44 up to USD 246.88 per month and had consumed organic products more than 3 times (82.5%).

#### 3.2. Validation of Research Instrument

##### 3.2.1. Validity Test

Validity test was done to ensure that the instrument precisely measured the intended item. The results of the data analysis showed R value for each indicator. Based on the value, the research indicators were considered valid since R value was found greater than R table [4].

##### 3.2.2. Reliability Test

Reliability test was conducted to guarantee the level of consistency of the instrument when it is used in different time. The results of the test showed that all variables used in this research were entirely reliable as the Cronbach's alpha value was found greater than 0.6 [7].

##### 3.2.3. Linearity Test

Linearity test was conducted to determine whether the relationship between independent variables and dependent variables was linear [8]. Reliability test was done using SPSS Statistics 17.0 software. The results of the test showed a value of  $> 0.05$ , indicating that the independent variable and the dependent variables shared a linear relationship.

**Table 1.** The Latent and Observed Variable in the Research

Latent Variable	Observed Variable (Indicator)	Code	Operational Definition
Product Attributes (X <sub>1</sub> )	Chemical-free Status	X <sub>11</sub>	Organic products are free from any chemical substances
	Packaging Size	X <sub>12</sub>	Variants of packaging size match the needs
	Product Color	X <sub>13</sub>	Product color is more interesting than non-organic products
	Packaging Label	X <sub>14</sub>	Packaging label contains complete information
	Packaging Design	X <sub>15</sub>	Packaging design in interesting
Consumer Preference (Y <sub>1</sub> )	Quality	Y <sub>11</sub>	Nutritional value of organic product is higher than the non-organic ones
	Price	Y <sub>12</sub>	Affordable price
	Popularity	Y <sub>13</sub>	Consumption based on trend
	Life Style	Y <sub>14</sub>	Consumption for healthier life
Purchase Decision(Y <sub>2</sub> )	Wants	Y <sub>21</sub>	Consumers want to try something different
	Needs	Y <sub>22</sub>	Products meet consumers' necessities

### 3.3. Path Diagram

The result of PLS model can be seen in Figure 1 which shows that the loading factor values of all research indicators are greater than 0.5. Loading factor is the strength of correlation between research indicator and its latent construct. Indicators with high loading factors have stronger contribution to reflect the latent construct. Conversely, indicators with low loading factors have weak contribution to reflect the latent construct [9].

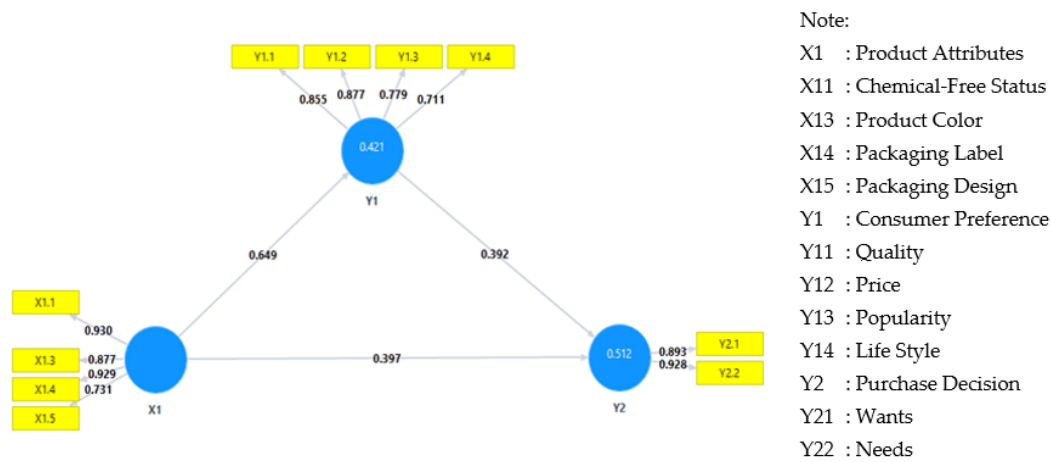
### 3.4. Goodness of Fit Evaluation

#### 3.4.1. Convergent Validity

Convergent validity was measured to determine the correlation across subscales. If theoretically, subscales share close relationship, correlational value will be high and the vice versa [9]. The indicator is said to adequately meet convergent validity if its loading factor ranges from 0.5 to 0.6. As seen in Table 2, all indicators and variables in this research have loading factor values greater than 0.5 that they have met the convergent validity requirements.

#### 3.4.2. Average Variance Extracted (AVE)

AVE value obtained in this research can be seen in Table 3. All research variables have been considered valid because the AVE values are greater than 0.5. The Average Variance Extracted (AVE) is valid if its value is greater than 0.5. AVE value describes the strength of the variant or the diversity of manifest variables that can be possessed by the latent construct. Valid AVE shows that the instrument used in a research has successfully measured the intended items [9].



**Figure 1.** Path Diagram from PLS

### 3.4.3. Cronbach's Alpha and Composite Reliability

Based on the Cronbach's Alpha value obtained in the reliability test, all variables of this research have been considered reliable. The value of Cronbach's alpha can be seen in Table 3. Reliability test was intended to guarantee the level of consistency of research instrument when it is used at different times. The instrument is stated reliable if the value of Cronbach's alpha  $> 0.6$ . All variables of this research have been considered reliable based on the values of composite reliability. The composite reliability values obtained in this research are shown in Table 3. Research variables are considered reliable if composite reliability value is greater than 0.7. If all of the assumptions are fulfilled, the indicator blocks in each construct have high consistency.

**Table 2.** Convergent Validity Results

Variable	Indicator	Loading Factor	Note
Product Attributes (X <sub>1</sub> )	Chemical-Free Status (X <sub>11</sub> )	0.930	Valid
	Product Color (X <sub>13</sub> )	0.877	Valid
	Packaging Label (X <sub>14</sub> )	0.929	Valid
	Packaging Design (X <sub>15</sub> )	0.731	Valid
Consumer Preference (Y <sub>1</sub> )	Quality (Y <sub>11</sub> )	0.855	Valid
	Price (Y <sub>12</sub> )	0.877	Valid
	Popularity (Y <sub>13</sub> )	0.779	Valid
	Life Style (Y <sub>14</sub> )	0.711	Valid
Purchase Decision (Y <sub>2</sub> )	Wants (Y <sub>21</sub> )	0.893	Valid
	Needs (Y <sub>22</sub> )	0.928	Valid

**Table 3.** The Average Values of Average Variance Extracted (AVE), Cronbach's Alpha and Composite Reliability

Variable	AVE	Cronbach's Alpha	Composite Reliability
Product Attributes (X <sub>1</sub> )	0.758	0.890	0.925
Consumer Preference (X <sub>2</sub> )	0.653	0.821	0.882
Purchase Decision (Y <sub>1</sub> )	0.830	0.797	0.907

### 3.5. Evaluation of Structural Model (Inner Model)

The structural model of this research was evaluated from the R-square value (R<sup>2</sup>). R-square value measures how far the model is able to explain the variation of the dependent variable. The R-square for



the innovation variable is 0.23 and the business performance is 0.32. Based on those R-square values, Q2 predictive relevance value can be determined as follows:

$$\begin{aligned} Q^2 &= 1 - (1-R^2)(1-R^2) \\ &= 1 - (1 - 0.421)(1 - 0.512) \\ &= 0.717 (71.7\%) \end{aligned}$$

Q2 predictive relevance value of 0.717 indicates that the observed value of the structural model has good predictive relevance and is appropriate to be used in a research.

## 4. Discussions

### 4.1. The Results of Direct and Indirect Hypotheses Testing

Path coefficient score for testing hypotheses was done using alpha ( $\alpha$ ) 5% (0.05). The results of direct hypothesis testing can be seen in Table 4. Whilst, the results of the indirect hypothesis testing is shown in Table 5.

#### 4.1.1. The Influence of Product Attributes on Consumer Preference

Hypothesis testing resulted in Product Attribute path coefficient of 0.649 and  $p$  value of 0.000 accepting H1. This results confirm the existence of a significant influence of Product Attribute variable on Consumer Preference variable. This shows that Product Attributes variable affect Consumer Preference. In addition to its significance, the path coefficient value is positive, which indicates that Product Attributes ( $X_1$ ) positively affect Consumer Preference ( $Y_1$ ).

This study shows that the attributes of organic products are able to increase consumer preferences. Currently, UD Istana Sayur Malang has sold organic products which have several advantages such as chemical-free status, attractive product colors, informative packaging labels, and attractive packaging designs. By selling products that have these advantages, consumers will grow their preference to purchase organic products from UD Istana Sayur Malang. This finding supports the results of research conducted by [10] which state that product attributes determine to what extent a product is accepted by consumers. Marketing actors need to understand customers' product attributes expectations. Therefore, consumer preferences can be measured by the level of usefulness and relative importance of each product attribute.

**Table 4.** The Result of Direct Hypothesis Testing

Hypothesis	Statistical Hypothesis	Path Coefficients	T value	T table	P values	Note
H <sub>1</sub>	(X <sub>1</sub> ) → (Y <sub>1</sub> )	0.649	9.2648	1.96	0.000	Significant
H <sub>2</sub>	(X <sub>1</sub> ) → (Y <sub>2</sub> )	0.397	2.4997	1.96	0.015	Significant
H <sub>3</sub>	(Y <sub>1</sub> ) → (Y <sub>2</sub> )	0.392	2.7871	1.96	0.005	Significant

**Table 5.** The Result of Indirect Hypothesis Testing

Variable	Direct Coefficient	Standard of Error	Indirect Coefficient	SE Sobel	T value	P Value
X1 - Y1 - Y2	0.649 0.392	0.074 0.138	0.254	0.094	2.702	0.007

#### 4.1.2. The Influence of Product Attributes on Purchase Decision

The results of the hypothesis testing showed path coefficient value of Product Attribute variable ( $X_1$ ) at 0.397 and  $p$  value of 0.014 to accept H<sub>2</sub>. It can be concluded from those values that a significant influence between Product Attribute variable on Purchase Decision variable exists. In addition to its significance, the positive mark in the path coefficient value also shows that the relationship between Product Attribute variable and Purchase Decision variable ( $Y_2$ ) is within an unidirectional pathway.

The results of this research show that the attributes of organic products are able to increase purchase decisions. It is important to focus on the attributes of organic products that are sold in order to increase consumer purchase decisions. It can be understood that the better the attributes of the products sold, the more interested consumers will be to buy those products. The results of this research reinforce the findings of previous research conducted by [11] which state that product attributes are one of consumers' consideration within purchase decision process. Producers should highlight certain attributes of a their products that strongly drive their consumers to purchase the products.

#### 4.1.3. The Influence of Consumer Preference on Purchase Decision

The path coefficient of Consumer Preferences ( $Y_1$ ) was obtained in the hypothesis testing at 0.392 and  $p$  value of 0.006. Therefore,  $H_3$  is accepted, implying the existence of a significant influence of Consumer Preference variable on Purchase Decision variable. In addition to its significance, a positive path coefficient mark indicates that the relationship between Consumer Preference ( $Y_1$ ) and Purchase Decision ( $Y_2$ ) is within an unidirectional pathway.

This research confirms that consumer preference has certain effect on the increase in purchase decision. Consumers prefer to buy products they like rather than products they dislike. If consumers like a product, the probability of the consumers to buy the product is higher. Consumer preferences can be influenced by several aspects including the nutritional value of organic products, the price of organic products, consumers' lifestyle and the popularity of organic products. The results of this research reinforces the finding of a previous research done by [12] which states that consumer preference is an important aspect that determines the success of product marketing as it is closely related to the success of the company in achieving its corporate goals which includes the purchase decisions based on customer preference.

#### 4.1.4. The Influence of Consumer Preference in Mediating the Relationship between Product Attributes and Purchase Decision

The testing of the fourth hypothesis shows that the relationship between Product Attributes and Purchase Decisions ( $Y_2$ ) through Consumer Preference resulted in indirect path coefficient of 0.254 with  $p$  value (0.007)  $< 0.05$  as presented in Table 3. These results imply that Consumer Preference has a significant influence in mediating the influence of Product Attributes on Purchase Decisions.

A set of tests done in this research has confirmed that product attribute have certain significant influence on purchase decisions mediated by consumer preference. Therefore, in this context, consumer preference acts as a mediating variable (intervening variable). In mediating the relationship, consumer preference partially intervenes the influence of product attributes toward purchase decisions. Product attributes are depicted with chemical-free organic products. Organic products are closely associated with chemical-free status among consumers who have strong awareness of health. Those customers prefer consuming products that are safe for consumption. Furthermore, consumers also prefer cheap products. Thus, the insight related to consumer preference about the preferred product price is expected to help producers improve the rate of consumer purchase decision. The results of this research show that consumers have stronger preference on chemical-free organic products with affordable price. It is expected that this data allows producers to improve their products to meet these preferences in order to increase the purchase decision.

## 5. Conclusions

Regarding to the results of this research done in UD Istana Sayur Malang, conclusions were drawn as follows.

- Product attributes have a positive and significant influence on consumer purchase decision. The attributes of products sold in UD Istana Sayur Malang affect the increase in customer purchase decision.

- Consumer preference is able to significantly and positively affect consumer decision. Thus, consumer preference is an aspect that counts in the improvement of purchase decision in UD Istana Sayur Malang.
- Product attributes share a significant and positive influence on consumer preference. Hence, product attributes are able to affect the improvement of consumer preference upon certain product.
- As a mediating variable, consumer preference shares a significant and positive partial influence in mediating the relationship between product attributes and purchase decision. Therefore, consumer preference should be taken into consideration for higher purchase decision.

**Acknowledgments:** Gratitude is expressed to *Hibah Peneliti Pemula Universitas Brawijaya* that funded this research based on the letter of agreement Number. 731.66 / UN10.C10/PN/2017. Gratitude also goes to the owner and employees of UD Istana Sayur Malang and any related parties that contributed in the completion of this research.

## References

1. Rusma, J; Hubeis, M; Suharjo, B. *Kajian Preferensi Konsumen Rumah Tangga Terhadap Beras Organik di Wilayah Kota Bogor*. Jurnal Ilmu Pertanian **2011**. 8(2), 20-32.
2. Thio, S. *Persepsi Konsumen Terhadap Makanan Organik di Surabaya*. Jurnal Manajemen Perhotelan **2008**. 4(1), 18-27.
3. Pramono dan Prabawani. *Analisis Faktor-Faktor Preferensi Konsumen yang Mempengaruhi Keputusan Pembelian Sayuran Organik*. Jurnal Studi Manajemen **2014**. 4(1), 14-20.
4. Munandar, J.M; Udin, F; Amelia, K. *Analisis Faktor yang Mempengaruhi Preferensi Konsumen Produk Air Minum dalam Kemasan di Bogor*. Jurnal Teknik Industri Pertanian **2014**. 13(3), 97-107.
5. Henly, C.D; Deborah, C.F; Johnson, D.E. *Label Design: Impact on Millenials' Perception of Wine*. Journal of Wine Business Research **2010**. 23(1), 33-40.
6. Schiffman, L.K dan Leslie, L. *Perilaku Konsumen*. Macana Jaya Cemerlang: Jakarta 2008.
7. Rossiter, J.R. *Measurement for the Social Sciences*. Springer: Berlin German. 2011. pp.13-28.
8. Hayes, A.F. *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Reggression – Based Approach*. Journal of Education Measurement **2014**. 51(3), 335-337.
9. Vinzi, E.V; Chin, W.W; Henseler, J; Wang, H. *Handbook of Partial Least Squares*. Springer: Berlin German. 2010.
10. Shivatanuu, B. *Factors Affecting Consumer Preference Towards the Organic Food Purchases*. Indian Journal of Science and Technology **2015**. 8(33), 33-42
11. Magistris, T; Gracia, A. *The Decision to Buy Organic Food Products in Southern Italy*. British Food Journal **2008**. 110(9), 929-947.
12. Yoridoe, E.K; Bonti, S; Martin, R.C. *Comparison of Consumer Perceptions and Preference Toward Organic Versus Conventionally Produced Foods*. Journal Renewable Agriculture and Food System **2008**. 20(4), 193-205.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-014-ID070

# Nursery Garden Development Strategy as Educational Tourism Using Swot Analysis and Multi-Attribute Utility Theory (MAUT) (Case Study On Kebun Bibit Kediri)

Panji Deoranto<sup>1,\*</sup>, Septiana Rosari<sup>1</sup> and Rizky L.R Silalahi<sup>1</sup>

<sup>1</sup> Department of Agro-Industrial, Faculty of Agricultural Technology, Universitas Brawijaya, Malang 65145

\* Correspondence: [deoranto@ub.ac.id](mailto:deoranto@ub.ac.id)

Received: 12 August 2018; Accepted: 28 August 2019; Published: 6 January 2020

**Abstract:** The purpose of this research are to know internal and external factors of Kebun Bibit Kediri, to determine alternative strategy, and strategic priority. This study, using SWOT analysis and MAUT. The results showed that the most influential internal factors are giving of interactive education with a weight score 0.258 and soft skills labor with a weight score 0.142. The most influential external factors are the change of mindset to prefer the nature-based educational tourism with a weight score 0.616 and competitor's educational facilities with a weight score 0.184. Alternative strategy of Kebun Bibit Kediri development as educational tourism based on SWOT matrix are to improve management of Kebun Bibit Kediri (ST1), development of educational variant (ST2), use of computer technology in work system (ST3), expand market segmentation (ST4), provide training to workers (ST5), increasing number of guide (ST7), enhancing education image of Kebun Bibit Kediri (ST7), improving promotion through advertisement and following the events (ST8), and adding educational tour facility (ST9). The priority of development strategy on Kebun Bibit Kediri as educational tourism based on MAUT are ST1 with total utility value of 0.8945, ST2 with total utility value of 0.871, and ST3 with total utility value of 0.867.

**Keywords:** Nursery Garden, Development, Educational Tourism.

---

## 1. Introduction

In 2016, the area of Kediri Regency is 138,605 Ha. According to the Minister of Agriculture Regulation number 08 / KPTS / RC.110 / J / 01/2017, optimization of land use is carried out by cultivating various types of plants. This development approach is carried out by developing sustainable agriculture to be able to preserve nature. One of the efforts made is to build a nursery. Nursery garden have an important role in providing various types of superior seeds and can also be developed into educational environments based on the natural environment which are attractive to visitors. One of the places that develops its business is a natural environment-based educational tour, namely UD. Alam Tani or better known as the Kebun Bibit Kediri. However, there are problems that become obstacles in the development of its business. This problem is closely related to the non-optimal development strategy at Kebun Bibit Kediri. According to David and Forest (2017), organizations without coherent direction and strategies can accelerate their own fall. In this study, used method analysis of Strength, Weakness, Opportunities, Threats (SWOT) and Multi-Attribute Utility Theory (MAUT). Based on SWOT analysis can determine alternative development strategies and to determine the priority of development strategies using MAUT. MAUT is used to evaluate alternatives by calculating the weight or utility value of each alternative. The utility value shows how well an alternative meets the criteria so that it can produce a better alternative evaluation quality (Ganiardi, 2014). In this study MAUT was chosen because it has the advantage of being able to take into account uncertainty and can combine decision-making preferences (Velasquez and Hester, 2013).

## 2. Materials and Methods

This research in Kebun Bibit Kediri, located on Jalan Raya Papar-Pare, Plemahan, Kediri. The time for research is March 2018 to May 2018. Data processing and analysis was carried out in Computing and System Analysis Laboratory, Department of Agricultural Industrial Technology, Faculty of Agricultural Technology, Brawijaya University Malang. The limitation of the problem in this study are that the attributes used in MAUT include the attributes of costs, time, infrastructure, and opinions of employers or experts and this research is only carried out until the priority stage of determining alternative strategies.

### 2.1. Determination of variables

The variables used in this study are based on internal factors and external factors of the Kebun Bibit Kediri. Determination of these factors and variables is the result of literature studies and preliminary research that has been adjusted to the conditions at the current Kebun Bibit Kediri. In this study using 5 respondents. A list of research variables can be seen in Table 1.

Factors	Variabels	Information
<b>Internal factors</b>		
Management	Planning	A booking system for predicting the number of visitors (S)
	Actuating	Briefing before educational tours begin (S)
Marketing	Product	Nature-based educational tours that are interesting to visit (S)
	Price	Price of educational tours (S)
	Place	Educational tourism is not in one place (W)
	Promotion	Parking area (W)
	Process	Promotional intensity (W)
		Market segmentation (W)
		Interactive education (S)
	Person	Educational tour package services (S)
		Soft skill workforce (W)
	Physical evidence	Number of guides (W)
		Atmosphere where educational tours (S)
Management information system	Software	Website (W)
<b>External factors</b>		
Micro environment	Level of competition	Competitor promotion (T)
	Threat of new entrants	Educational tourism competitor facility (T)
		The emergence of new educational tours (T)
Macro environment	Economy	Rising incomes (O)
	Social	Changes in mindset to prefer nature-based education tours (O)
	Political	Local government support (O)
	Technology	Technology development (O)

### 2.2. Questionnaire preparation

This study uses a questionnaire with three stages in filling out the questionnaire given, namely:

- Questionnaires to determine internal and external factor weights were filled by the owners of Kebun Bibit Kediri, the marketing department of Kebun Bibit Kediri, the Office of Youth and Sports Education of Kediri Regency, the Kediri Regency Tourism and Culture Office, and 1 academic.

- The rating determination questionnaire is filled by the owner of the Kebun Bibit Kediri, the marketing department of the Kebun Bibit Kediri, the Kediri District Youth and Sports Education Office, the Kediri Regency Tourism and Culture Office, and 1 academician.
- The questionnaire to determine the final decision using the MAUT model is filled by the owners of the Kebun Bibit Kediri and the Kediri Regency Tourism and Culture Office.

### 2.3. SWOT analysis

#### 2.3.1. Internal and External Factor Analysis

Analysis of internal factors and external factors is done through weighting and rating each variable by respondents. Weighting with paired comparison methods uses three scales (1 = less important, 2 = equally important, 3 = more important). Rating is done after knowing the weight of each attribute, the scale used is 4 scales including 4 if the strategic factor is the main strength / opportunity that has a large influence up to 1 if the strategic factor is a major weakness / threat that has a big influence. Weighting results and rating values are then multiplied so that we obtain the weight score on the IFE and EFE matrices.

#### 2.3.2. SWOT diagram

The SWOT diagram is used to determine the business position based on the IFE and EFE values which are divided into four quadrants, each quadrant has each strategy.

#### 2.3.3. SWOT matrix

The SWOT matrix is used to develop strategic plans that are expected in the future.

### 2.4. Multi-Attribute Utility Theory (MAUT)

MAUT is an analytical approach that is often used to solve complex problems (Nadeem et al, 2014). MAUT is used to change from several interests into numeric values with a scale of 0-1 with 0 representing the worst and 1 best choices. The final result of the MAUT calculation is the ranking order of alternative evaluations that describe the choices of decision makers. Attributes used in this study include attributes of costs, time, infrastructure, and opinions of entrepreneurs / experts in their fields.

## 3. Results

### 3.1. General Description of Kebun Bibit Kediri

UD. Alam Tani or better known as the Kebun Bibit Kediri is a business entity engaged in the cultivation and sale of plant seeds, especially fruits, organic fertilizers, and gazebos. Kebun Bibit Kediri was officially established by Mr. Agus Joko Susilo in 2013. Currently, the owner also develops his business into a nature-based educational tour and opens a cafe with the concept of a rest area. Visitors to educational tours that often come from schools start from the play group to high school level around Kediri Regency. Within a week there are about 3 times educational tours, with one visit totaling 30-180 people. Kebun Bibit Kediri educational tourism operating hours are from 08.00 WIB to 16.00 WIB.

### 3.2. Input stage

#### 3.2.1. IFE Matrix

IFE Matrix can be known after calculating the factors of strength and weakness. Based on the IFE matrix, it can be seen that the main strength has the biggest weight score and the main weakness that has the smallest score. The IFE matrix in the Kebun Bibit Kediri can be seen in Table 2.

**Table 2.** Matrix IFE

Internal factors	Weight	Rating	Score weight
<b>Strength</b>			
A booking system for predicting the number of visitors	0,048	2,200	0,106
Briefing before educational tours begin	0,071	3,000	0,213
Nature-based educational tours that are interesting to visit	0,070	3,400	0,238
Price of educational tours	0,062	3,200	0,198
Interactive education	0,076	3,400	0,258*
Educational tour package services	0,071	3,400	0,241
Atmosphere where educational tours	0,071	3,000	0,213

Table 2. Matrix IFE

Internal factors	Weight	Rating	Score weight
<b>Weakness</b>			
Educational tourism is not in one place	0,061	2,800	0,171
Parking area	0,064	2,400	0,154
Promotional intensity	0,092	2,000	0,184
Market segmentation	0,082	2,200	0,180
Soft skill workforce	0,089	1,600	0,142*
Number of guides	0,075	2,200	0,165
Website	0,068	2,800	0,190
<b>TOTAL IFE</b>	<b>1,000</b>		<b>2,653</b>

\* Main strengths / weaknesses; Source: Data Processed (2018)

The main strength is interactive education with a weight score of 0.258. Interactive education is the main force because Kebun Bibit Kediri provides educational tourism accompanied by guides so that it is more effective and visitors are not easily bored. In addition, it can practice direct educational activities that are not obtained while in the classroom. The main weakness is soft skill workforce with a score of 0.142. The majority of workers do not have good soft skiing. Whereas to achieve the targets set, workers are required to have good technical and non-technical abilities such as being easy to socialize, be creative, responsive and energetic. The IFE total value is 2,653 which indicates that the internal position in the moderate or average internal position.

### 3.2.2. EFE matrix

EFE Matrix can be known after calculating the opportunity and threat factors. Based on the EFE matrix, we can find the main opportunity that has the biggest weight score and the main threat that has the smallest score score. The EFE matrix in the Kebun Bibit Kediri can be seen in Table 3.

Table 3. Matrix EFE

External factors	Weight	Rating	Score weight
<b>Opportunities</b>			
Rising incomes	0,153	4,000	0,612
Changes in mindset to prefer nature-based education tours	0,171	3,600	0,616*
Local government support	0,188	3,000	0,564
Technology development	0,152	3,600	0,547
<b>Threats</b>			
Competitor promotion	0,117	2,600	0,304
Educational tourism competitor facility	0,102	1,800	0,184*
The emergence of new educational tours	0,117	1,800	0,210

TOTAL EFE	1,000	3,037
-----------	-------	-------

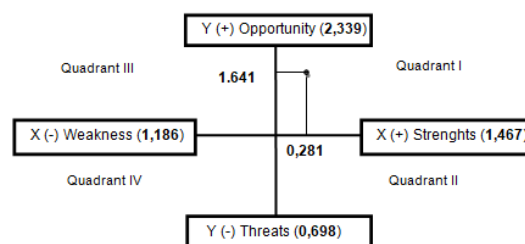
\* Main oportutites / threats; Source: Data Processed (2018)

The main opportunity is the change of mindset to prefer nature-based education tours with a weight score of 0.616. This change in mindset has become a major opportunity because Kebun Bibit Kediri provides educational tourism that have followed the trend of tourism activities in Indonesia. The main threat is competitors' educational tourism facilities with a score of 0.184. Educational tourism competitor facilities become a major threat because facilities are one of the important considerations of visitors. The total EFE value is 3.037 which indicates that the external position is in a strong external position.

### 3.3. Matching Stage

#### 3.3.1. SWOT Diagram

To determine the position of the coordinates of Kebun Bibit Kediri, the difference in scores from the two factors was calculated. The difference in the internal factor is 0.281 while the difference from the external factor is 1.641. The position of the coordinates of Kebun Bibit Kediri can be seen in Figure 1.



**Figure 1.** Position of the coordinates Kebun Bibit Kediri; Source: Data Processed (2018)

#### 3.3.2. SWOT Matrix

The SWOT matrix is a matching tool used to determine the development strategy of Kebun Bibit Kediri as an educational tour. Strategy formulation is carried out by combining internal factors with external factors so that four types of strategies are obtained, namely S-O strategy, W-O strategy, S-T strategy, and W-T strategy. Four types of development strategies in the SWOT matrix can be seen in Figure 2.



<div>Internal</div> <div>External</div>	<b>Strength (S)</b> 1. A booking system for predicting the number of visitors 2. Briefing before educational tours begin 3. Nature-based educational tours that are interesting to visit 4. Price of educational tours 5. Interactive education 6. Educational tour package services 7. Atmosphere where educational tours	<b>Weakness (W)</b> 1. Educational tourism is not in one place 2. Parking area 3. Promotional intensity 4. Market segmentation 5. Soft skill workforce 6. Number of guides 7. Website
	<b>Opportunity (O)</b> 1. Rising incomes 2. Changes in mindset to prefer nature-based education tours 3. Local government support 4. Technology development <b>Threat (T)</b> 1. Competitor promotion 2. Educational tourism competitor facility 3. The emergence of new educational tours	<b>Strategi S-O</b> • Improve management of the Kebun Bibit Kediri management (ST1) (S1,S2,O3) • Educational variant development (ST2)(S4,S6,O1,O2) • Use of computer technology in work systems (ST3)(S6,O4) <b>Strategi S-T</b> • Improve the image of Kebun Bibit Kediri education tourism (ST7) (S3, S5, S7,T3) <b>Strategi W-O</b> • Use of computer technology in work systems (ST4) (W4,O1,O2) • Providing training to workers (ST5)(W5,O3) • Increase the number of guides (ST7) (W6,O3) <b>Strategi W-T</b> • Increase promotions through advertisements and participate in certain events (ST8) (W3,W7,T1,T3) • Add educational tourism facilities (ST9) (W1,W2,T2,T3)

Figure 2. SWOT Matrix; Source: Data Processed (2018)

### 3.4. Decision Stage

#### 3.4.1. Multi Attribute Utility Theory (MAUT)

Determination of strategic alternative priorities using the MAUT model with several attributes considered, namely cost, time, infrastructure, and the opinions of entrepreneurs or experts in their fields. The MAUT model questionnaire was given to the owner of Kebun Bibit Kediri (R1) and the head of tourism development in the Kediri Regency Tourism Office (R2). Table 4 shows the weight of each attribute in the MAUT model that has been filled by the two respondents.

Table 4. Weight of MAUT Model Attributes

Attribute	R1		R2	
	Total	Weight	Total	Weight
1. Cost	4	0,2353	5	0,2941
2. Time	4	0,2353	3	0,1765
3. Infrastructure	5	0,2941	5	0,2941
4. The opinions of entrepreneurs or experts in their fields	4	0,2353	4	0,2353
Total	17	1,0000	17	1,0000

Source: Data Processed (2018)

If you know the attribute weight, then the respondent is required to assign values to all alternative strategies and determine the utility value of each attribute that will be calculated using the utility function. Then the total utility value is calculated for each alternative strategy using the formula by multiplying the utility value of each attribute with the attribute weight. The order of priority ranking is obtained from the calculation of the average of the two respondents. Table 5 shows the results of the strategic priority ranking of the two respondents.

Table 5. Results of Priority Strategy Ranking

Alternative strategy	Average	Ranking
----------------------	---------	---------

Improve management of the Kebun Bibit Kediri management	0,8945	I
Development of educational variants	0,871	II
Use of computer technology in work systems	0,8525	IV
Expand market segmentation	0,8445	V
Provide training to workers	0,867	III
Increase the number of guides	0,838	VI
Improve the image of Kediri Seed Garden education tourism	0,808	VII
Increase promotions through advertisements and follow certain events	0,7965	VIII
Add educational tourism facilities	0,7182	IX

Source: Data Processed (2018)

#### 4. Discussion

The results showed that the alternatives that occupy the three main priorities of the development strategy of Kebun Bibit Kediri as an educational tourism are improve management of the Kebun Bibit Kediri management (ST1), development of educational variants (ST2), and providing training to workers (ST5). ST1 and ST2 began to be applied but not optimal because they were hampered by the quantity and quality of human resources owned by Kebun Bibit Kediri. While ST5 has not been implemented and is considered by the owner to implement the strategy. ST1 needs to be implemented because all this time the management of poor management, such as the implementation of all activities that are only handled by the owner, will have an impact on workers' confusion and some related parties. The application of ST1 in the Kebun Bibit Kediri can be done by holding regular meetings and forming a clear organizational structure. ST2 began to be applied by the owners of the Kebun Bibit Kediri by innovating to open new tourism, namely a million color education tours in developing educational tourism packages that work with residents. Development of education variants that can be added in Kebun Bibit Kediri, which is the cultivation of plants that are in great demand by visitors. ST5 has not been implemented because currently the owners focus on developing the market and not paying enough attention to the quality of human resources. The application of ST5 is done by holding training, especially soft skills training for workers. This training is expected to be able to increase the knowledge and skills of workers so that they can work optimally.

#### 5. Conclusions

Based on the results of the study, the conclusions include:

- The internal factors that most influence the development of Kebun Bibit Kediri as an educational tourism in terms of strength are the provision of interactive education with a score of 0.258, while in terms of weaknesses, the soft skills of the workforce are 0.142. External factors that most influence in terms of opportunities are changes in mindset to prefer nature-based education tours with a score of 0.616 while in terms of threats, educational tourism competitors with a score of 0.184.
- Alternative development strategy for Kebun Bibit Kediri as an educational tourism based on the SWOT matrix which is improve management of the Kebun Bibit Kediri management (ST1), development of educational variants (ST2), use of computer technology in the work system (ST3), expanding market segmentation (ST4), providing training for workers (ST5), increasing the number of guides (ST7), improving the image of educational tourism Kebun Bibit Kediri (ST7), increasing promotion through advertising and participating in certain events (ST8), add educational tourism facilities (ST9).
- The priority sequence of the development strategy of Kebun Bibit Kediri as an educational tourism based on MAUT is ST1 with a total utility value of 0.8945, ST2 with a total utility value of 0.871, and ST3 with a total utility value of 0.867.

#### References

- 1) David, F.R.; Forest R.D. Strategic Management Concept Issue 15.; Salemba Empat, Jakarta, 2007, ISBN.
- 2) Ganiardi, M.A. The Housing Development Decision System uses the Analytical Hierarchy Process Method-Multi Attribute Utility Theory. Proceedings of the National Conference on Information Technology and Applications, Politeknik Negeri Sriwijaya, Palembang, 2007, pp.81-89.
- 3) Nadeem, A.; Juiping X.; Muhammad N.; Muhammad H.; Muhammad K.J. An Integrated Group Decision-making Process For Supplier Selection and Order Allocation Using Multi-attribute Utility Theory Under Fuzzy Environment. Science IJSBAR, 2014; Volume 14, pp. 205-224, ISBN.
- 4) Velasquez, M and Patrick H. An Analysis of Multi-Criteria Decision Making Methods. Operation Research, 2013; Volume 10, pp.56-66, ISBN.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license <http://creativecommons.org/licenses/by/4.0/>.

FP-FST-006-ID016

# Immature Black Vinegar Extract Activates Macrophages

Eri Ishii<sup>1</sup>, Kosuke Nishi<sup>1,2</sup>, Momoko Ishida<sup>1</sup>, Masanobu Nagano<sup>3</sup>, Kazunori Hashiguchi<sup>3</sup>, Akira Fujii<sup>3</sup> and Takuya Sugahara<sup>1,2,\*</sup>

1 Graduate School of Agriculture, Ehime University, Matsuyama, Ehime 790-8566, Japan

2 Food and Health Sciences Research Center, Ehime University, Matsuyama, Ehime 790-8566, Japan

3 Sakamoto Kurozu Inc., 21-15 Uenosono-cho, Kagoshima 890-0052, Japan

\* Corresponding author: mars95@agr.ehime-u.ac.jp

Received: 9 July 2018; Accepted: 4 December 2018; Published: 6 January 2020

**Abstract:** Black vinegar is a traditional rice vinegar produced in Kagoshima prefecture in Japan. This vinegar is produced by saccharification, fermentation, and aging in one pot. Wakazu is an immature black vinegar collected before aging for 1-3 years. Many researchers are studying on health functions of black vinegar, and various functions have been revealed such as antitumor and antiallergic effects. However, the studies on wakazu have not been done yet. Therefore, in this study, the immunostimulatory effect of wakazu on macrophages was investigated. Acetic acid was removed from wakazu by repeated freeze-drying. After centrifugation to remove insoluble substances, wakazu was dialyzed with a 14 kDa molecular weight cut off dialysis membrane against 10 mM sodium phosphate buffer before use. As a result, wakazu enhanced TNF- $\alpha$  and IL-6 production by mouse macrophage cell line, RAW264.7 cells. In addition, wakazu stimulated gene expression of these cytokines in RAW264.7 cells. Western blot analysis indicated that wakazu enhances translocation of NF- $\kappa$ B to nucleus and MAP kinase signal transduction in RAW264.7 cells. In conclusion, immature black vinegar, wakazu also has a potential as a health-promoting food with the immunostimulatory effect.

**Keywords:** Black vinegar; Macrophage; Cytokine production; IL-6; TNF- $\alpha$

---

## 1. Introduction

Macrophages are versatile cells that play crucial roles in the innate immune system for host defense. Macrophage activation is mediated primarily by recognition of active substances through specific receptors in the initial phase of the immune response. Macrophages bind to the activator via Toll-like receptor (TLR) 4, CD14, complement receptor 3, scavenger receptor, dectin-1, or mannose receptor [1]. This process initiates the activation of intracellular signaling cascades including mitogen-activated protein (MAP) kinases and NF- $\kappa$ B, thereby inducing macrophage activation. The activated macrophages secrete several mediators including inflammatory cytokines such as interleukin (IL)-1, IL-6, and tumor necrosis factor (TNF)- $\alpha$  and release some cytotoxic and inflammatory molecules such as nitric oxide (NO) [2]. These cytokines stimulate the antibody production by plasma cells and the synthesis of other inflammatory mediators that have antitumor and antibacterial activities. Furthermore, macrophages have phagocytosis activity which induces the activation of T cells and B cells and contribute to the activation of the adaptive immune response. Therefore, the activation of macrophages is very important in enhancing the entire immune system both of the innate and adaptive immune responses.

The black vinegar is a traditional vinegar manufactured with three components: steamed unpolished rice, a fermentation starter called koji, and water. Various microorganisms such as *Aspergillus*, yeasts, lactic acid bacteria, and acetic acid bacteria are involved in their process of fermentation and maturation such as saccharification, alcoholic fermentation, and acetic fermentation.

Wakazu is an immature black vinegar collected before aging for 1-3 years, and characterized by a light amber color and sour than black vinegar. Many researchers are studying on health functions of black vinegar, and various functions have been revealed such as antioxidative activity [3] and antiallergy effect [4]. However, the studies on wakazu have not been done yet. Therefore, in this study, the immunostimulatory effect of wakazu on macrophages was investigated.

## 2. Materials and methods

### 2.1. Sample preparation

Wakazu manufactured by Sakamoto Kurozu Inc. (Kagoshima, Japan) was repeatedly freeze-dried to remove acetic acid. It was then centrifuged at  $1,500 \times g$  for 10 min to remove insoluble substances, and the supernatant was collected and dialyzed with a 14,000 molecular weight cut off dialysis membrane (Wako Pure Chemical Industries, Osaka, Japan) against 10 mM sodium phosphate buffer (NaPB) for 24 h at 10°C. The dialyzed supernatant was filtrated through a 0.22  $\mu\text{m}$  membrane, and it was passed through Endo Trap (Hyglos GmbH - a bioMérieux company, Freistaat Bayern, Germany), which is an affinity matrix intended for removal of lipopolysaccharide from biological samples in aqueous solutions. Dry weight of wakazu components was measured after freeze-drying of wakazu preparation.

### 2.2 Cells and cell culture

RAW 264.7 cells, a mouse macrophage-like cell line, were obtained from Japanese Collection of Research Bioresources Cell Bank (Osaka, Japan). RAW264.7 cells were cultured in DMEM supplemented with 100 U/mL of penicillin, 100  $\mu\text{g/mL}$  of streptomycin, and 10% fetal bovine serum (FBS; Sigma-Aldrich, St. Louis, MO, USA) at 37°C under humidified 5% CO<sub>2</sub>. RAW264.7 cells were detached using phosphate-buffered saline (PBS) containing 0.25% trypsin and 0.02% ethylenediamine-N,N,N',N'-tetraacetic acid (Dojindo Laboratories, Kumamoto, Japan) for the subsequent experiments.

### 2.3. Determination of cytokine levels in culture medium

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 96-well cell culture plate (Corning, Corning, NY, USA) at  $6.0 \times 10^4$  cells/well and cultured for 16 h at 37°C. After washing with PBS, the cells were treated with 200  $\mu\text{L}$  of 10% FBS-DMEM containing various concentrations of wakazu, 10 mM NaPB as negative control, or 100 ng/mL of LPS from *E. coli* O26/B6 (Sigma-Aldrich) as positive control and incubated for 6 h at 37°C. After incubation, the concentrations of IL-6 and TNF- $\alpha$  in the culture media were measured by mouse IL-6 ELISA kit (Bio Legend, San Diego, CA, USA) and Mouse TNF $\alpha$  ELISA kit (eBioscience, San Diego, CA, USA), respectively.

### 2.4. Cell viability

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 96-well cell culture plate at  $6.0 \times 10^4$  cells/well and **cultured for 16 h at 37°C**. After washing with PBS, the cells were treated with 200  $\mu\text{L}$  of 10% FBS-DMEM containing various concentrations of wakazu, 10 mM NaPB as negative control, or 100 ng/mL of LPS as positive control and **incubated for 6 h at 37°C**. After incubation, the cell supernatant was collected for ELISA, and the cells were washed with PBS twice. Cell viability was measured using Cell Count Reagent SF (Nacalai Tesque, Kyoto, Japan).

### 2.5. Real time RT-PCR

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 24-well cell culture plate (BD Falcon, Franklin Lakes, NJ, USA) at  $3.0 \times 10^5$  cells/well and cultured for 16 h. After washing with PBS, the cells were treated with 1 mL of 10% FBS-DMEM containing various concentrations of wakazu, 10 mM NaPB as negative control, or 100 ng/mL of LPS as positive control and incubated for 3 h. Total RNA was isolated from the cells using Sepasol-RNA I Super G (Nacalai Tesque) according to the

manufacturer's instructions and used as a template for cDNA synthesis with MMLV-reverse transcriptase (Promega, Madison, WI, USA) and an oligo-(dT)<sub>20</sub> primer (Toyobo, Osaka, Japan). A real time RT-PCR mixture, with a final volume of 20 µL, consisted of Thunderbird SYBR qPCR Mix (Toyobo), 10 pmol of a forward primer, 10 pmol of a reverse primer, and 0.1 µg of a cDNA sample. Thermal cycling conditions were 20 s at 95°C, followed by 40 cycles of 3 s at 95°C and 30 s at 60°C. PCR products were measured on a StepOnePlus Real-time PCR System (Applied Biosystems, Foster City, CA, USA), and relative gene expression was calculated based on the comparative CT method using StepOne Software v2.1 (Applied Biosystems). Expression of the β-actin gene was used as an endogenous control. Specific oligonucleotide sequences for each gene are as follows. Mouse β-actin: sense, 5'-CATCCGTAAAGACCTCTATGCCAAC-3' and antisense, 5'-ATGGAGCCACCGATCCACA-3'; mouse TNF-α: sense, 5'-CTACTCCCAGGTTCTCTTCAA-3' and antisense, 5'-GCAGAGAGGAGGTTGACTTTC-3'; mouse IL-6: sense, 5'-AAGCCAGAGTCCTTCAGAGAGAT-3' and antisense, 5'-TTGGATGGTCTTGGTCCTTAGC-3'; mouse inducible nitric oxide synthase (iNOS): sense, 5'-CCAAGCCCTCACCTACTTCC-3' and antisense, 5'-CTCTGAGGGCTGACACAAGG-3'.

## 2.6. Griess assay

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 96-well cell culture plate at  $6.0 \times 10^4$  cells/well and cultured for 10 h. After washing with PBS, the cells were treated with 200 µL of 10% FBS-DMEM containing various concentrations of wakazu or 10 mM NaPB as negative control and incubated for 24 h. The concentration of nitric oxide (NO) in the culture media was measured by Griess Reagent System (Promega, Tokyo, Japan) according to the manufacturer's instructions.

## 2.7. Western blot analysis

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 35 mm dish (BD Falcon) at  $6.0 \times 10^5$  cells/dish at 2 mL and cultured for 16 h. After washing with PBS, the cells were treated with 2 mL of 10% FBS-DMEM containing various concentrations of wakazu, 10 mM NaPB as negative control, or 100 ng/mL of LPS as positive control and incubated for 15 min. Cytosolic and nuclear proteins were prepared using a CellLytic NuCLEAR Extraction Kit (Sigma-Aldrich) according to the manufacturer's instructions. The protein concentration of cell lysate was determined using a DC protein assay kit (Bio-Rad Laboratories, Hercules, Calif., U.S.A.) with BSA as a standard. Denatured proteins were then separated using SDS-PAGE and transferred onto a PVDF membrane (Hybond-P; GE Healthcare, Buckinghamshire, UK). Immunoblotting with various antibodies was performed as previously described [5].

## 2.8. Measurement of phagocytosis activity

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 24-well cell culture plate at  $3.0 \times 10^5$  cells/well and cultured for 16 h. After washing with PBS, the cells were treated with 1 mL of 10% FBS-DMEM containing various concentrations of wakazu, 10 mM NaPB as negative control, or 100 ng/mL of LPS as positive control and incubated for 6 h. After washing with PBS, 1 mL of 10% FBS-RPMI 1640 medium containing 40 µg of Texas Red-conjugated Zymosan A (*S. cerevisiae*) BioParticles (Molecular Probes, Eugene, Ore., U.S.A.) was added to each well and incubated for 1 h under a dark condition. After removing the culture medium, the cells were collected and centrifuged at  $160 \times g$  for 5 min at 4°C. The cells pellet was suspended with 1 mL of 2% FBS-PBS, and phagocytotic activity was measured on a flow cytometer (FACSCalibur; BD Biosciences, San Jose, CA, USA).

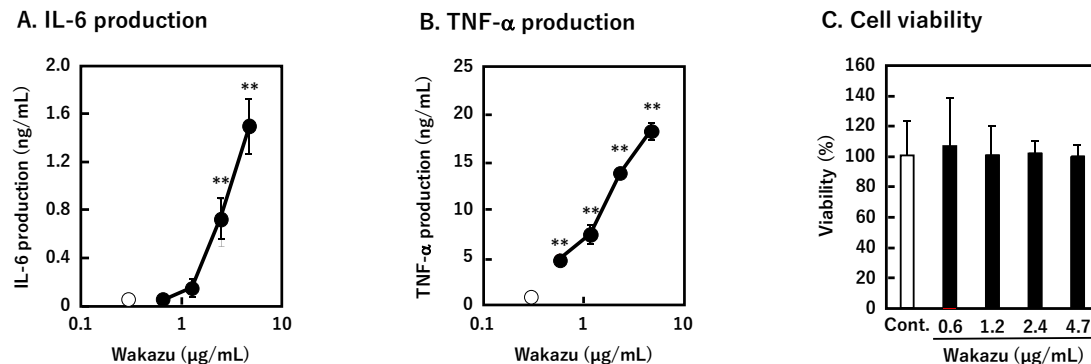
## 2.9. Statistical analysis

Data obtained were expressed as mean ± standard deviation. One way ANOVA followed by Tukey-Kramer test was used to assess the statistical significance of the difference. Values with \* $p < 0.05$  or \*\* $p < 0.01$  were considered statistically significant.

### 3. Results

#### 3.1 Effect of wakazu on cytokine production by RAW264.7 cells

The effect of wakazu on cytokine production by RAW264.7 cells was first examined. Wakazu was added to the culture media at various concentrations, and the cytokine concentration in the medium was measured by ELISA after incubation for 6 h. As shown in Figure 1, wakazu significantly enhanced the production of IL-6 and TNF- $\alpha$  by RAW264.7 cells in a dose-dependent manner.



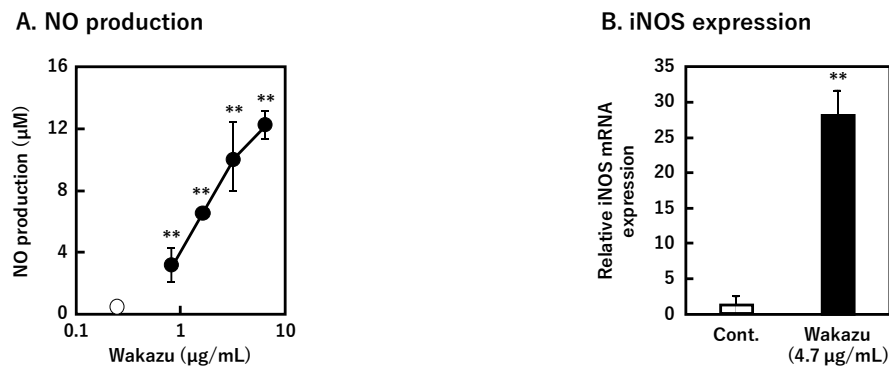
**Figure 1.** Effect of wakazu on cytokine production by RAW264.7 cells. (A, B) RAW264.7 cells were treated with 10% FBS-DMEM containing various concentrations of wakazu (gray circle) or 10 mM NaPB as control (open circle) and incubated for 6 h at 37°C. After incubation, the concentrations of IL-6 and TNF- $\alpha$  in the culture media were measured by ELISA. (C) Cell viability was measured after collecting the culture media from each well for ELISA. Experiments were performed in triplicate, and error bars indicate as the mean  $\pm$  standard deviation. \*\* $p < 0.01$  against control by Tukey-Kramer test.

#### 3.2 Effect of wakazu on cytokine gene expression levels in RAW264.7 cells

As mentioned above, wakazu stimulated the production on IL-6 and TNF- $\alpha$  by RAW264.7 cells. Hence, the effect of wakazu on mRNA expression levels of these cytokines was evaluated. Wakazu was added to the culture media at various concentrations, and the mRNA expression levels of IL-6 and TNF- $\alpha$  were evaluated by real-time RT-PCR. Wakazu significantly increased the mRNA expression levels of IL-6 and TNF- $\alpha$  in RAW264.7 cells. These results indicated that wakazu stimulates cytokine production by promoting the transcription process.

#### 3.3 Effect of wakazu on NO production and mRNA expression of iNOS in RAW264.7 cells

NO is recognized as one of the most versatile compounds in the immune system, and produced by macrophages which are activated by cytokines and microbial compounds. Therefore, we examined the effect of wakazu on NO produced by RAW264.7 cells. As shown in Figure 2A, wakazu significantly stimulated NO production by RAW264.7 cells. In addition, wakazu also enhanced the mRNA expression of iNOS in RAW264.7 cells (Figure 2B), suggesting that wakazu stimulates NO production by enhancing iNOS gene expression.



**Figure 2.** Effect of wakazu on NO production and mRNA expression of iNOS in RAW264.7 cells. (A) RAW264.7 cells were treated with 10% FBS-DMEM containing various concentrations of wakazu (gray circle) or 10 mM NaPB as control (open circle) and incubated for 24 h at 37°C. After incubation, the concentrations of NO in the culture media were measured by Griess assay. (B) RAW264.7 cells were treated with 10% FBS-DMEM containing 4.7 µg /mL of wakazu or 10 mM NaPB as control and incubated for 3 h. After incubation, mRNA expression levels of iNOS was evaluated by Real time RT-PCR. Experiments were performed in triplicate, and error bars indicate as the mean  $\pm$  standard deviation. \*\* $p < 0.01$  against control by Tukey-Kramer test.

### 3.4. Effect of wakazu on NF- $\kappa$ B and MAP kinase signaling pathways involved in macrophage activation

To examine the involvement of NF- $\kappa$ B and MAP kinase signaling pathways in the regulation of the TNF- $\alpha$  and IL-6 production, RAW264.7 cells were incubated in the medium containing wakazu for 15 min, and the protein levels of signal molecules were evaluated by western blot analysis. The result showed that the degradation of I $\kappa$ B $\alpha$  and the translocation of NF- $\kappa$ B into the nucleus were stimulated by wakazu (data not shown). In addition, the phosphorylation levels of ERK and JNK were increased by wakazu, whereas that of p38 was not affected. These results suggested that wakazu enhances translocation of NF- $\kappa$ B to the nucleus and MAP kinase signal transduction in RAW264.7 cells.

### 3.5. Effect of wakazu on phagocytotic activity of RAW264.7 cells

Phagocytosis occurs in specialized cells such as macrophages, dendritic cells, and neutrophils. It is the first step in triggering host defense and inflammation. Thus, the effect of wakazu on phagocytotic activity of RAW264.7 cells was examined. The phagocytotic activity of RAW264.7 cells was obviously elevated by wakazu (data not shown), suggesting that wakazu stimulates the phagocytotic activity of macrophages.

## 4. Discussion

Black vinegar is produced by saccharification, fermentation, and aging in one pot. Wakazu is an immature black vinegar collected before aging for 1-3 years. Various microorganisms such as *Aspergillus*, yeasts, lactic acid bacteria, and acetic acid bacteria are involved in their process of fermentation and maturation. Since many of the fermenting microorganisms die in this process, wakazu contains many components derived from the microorganisms such as endotoxin which activates macrophages. Therefore, we removed the endotoxin from wakazu before evaluating the activity of wakazu and studied the immunostimulatory effect of wakazu components not derived from endotoxins. Wakazu significantly enhanced the production of IL-6 and TNF- $\alpha$  by RAW264.7 cells. In addition, the expression levels of IL-6 and TNF- $\alpha$  genes in RAW264.7 cells were enhanced in dose-dependent manners. These results suggest that wakazu stimulates cytokine production by upregulating the transcription process of the cytokine genes.



Next, we examined the effect of wakazu on the signaling pathways involved in macrophage activation. The activation of macrophages is caused by NF- $\kappa$ B and MAP kinase cascades. The result showed that the phosphorylation levels of ERK and JNK were increased by treatment with wakazu. Wakazu also helped degradation of I $\kappa$ B $\alpha$  and translocation of NF- $\kappa$ B into the nucleus. These results suggest that wakazu stimulates cytokine production through upregulation of the NF- $\kappa$ B and MAP kinase cascades. In addition, wakazu stimulated NO production and phagocytotic activity of RAW264.7 cells. So far, the NF- $\kappa$ B and MAP kinase cascades have been reported to be involved in NO production and the phagocytosis activity of macrophages [6,7]. Therefore, the wakazu-induced NO production and phagocytosis activity of macrophages are considered to be due to the upregulation of the NF- $\kappa$ B and MAP kinase cascades.

## 5. Conclusions

Although several function of wakazu on human health are known, the immunostimulatory effect of wakazu components on macrophages has not been reported. In this study, we found that endotoxin free-wakazu has an immunostimulatory effect on macrophages. Our findings indicate that not only kurozu, but also wakazu is also expected to be effective on our health as functional food.

## References

1. Gordon, S. Pattern recognition receptors: doubling up for the innate immune respons. *Cell* **2002**, *111*, 927-930, 10.1016/S0092-8674(02)01201-1.
2. Nathan, C.F. Secretory products of macrophages. *J Clin Invest* **1987**, *79*, 319-326, 10.1172/JCI112815.
3. Nishidai, S.; Nakamura, Y.; Torikai, K.; Yamamoto, M.; Ishihara, N.; Mori, H.; Ohigashi, H. Kurozu, a traditional vinegar produced from unpolished rice, suppresses lipid peroxidation *in vitro* and in mouse skin. *Biosci Biotechnol Biochem* **2000**, *64*, 1909-1914, 10.1271/bbb.64.1909.
4. Awane, S.; Nishi, K.; Ishida, M.; Nagano, M.; Hashiguchi, K.; Fujii, A.; Sugahara, T. Inhibitory effect of Japanese black vinegar on IgE-mediated degranulation of RBL-2H3 cells and a murine model of Japanese cedar pollinosis. *Cytotechnology* **2018**, *70*, 961-974, 10.1007/s10616-018-0208-6.
5. Kumalasari, I.D.; Nishi, K.; Putra, A.B.; Sugahara, T. Activation of macrophages stimulated by bengkoang fiber extract through Toll-like receptor-4. *Food Funct* **2014**, *5*, 1403-1408, 10.1039/c3fo60360a.
6. Chen, B.-C.; Chen, Y.-H.; Lin, W.-W. Involvement of p38 mitogen-activated protein kinase in lipopolysaccharide-induced iNOS and COX-2 expression in J774 macrophages. *Immunology* **1999**, *97*, 124-129, 10.1046/j.1365-2567.1999.00747.x.
7. Blander J.M.; Medzhitov, R. Regulation of phagosome maturation by signals from Toll-Like receptors, *Science* **2004**, *304*, 1014-1018, 10.1126/science.1096158.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license

(<http://creativecommons.org/licenses/by/4.0/>).

FP-FST-007-ID017

# Anti-Inflammatory Effect of Placenta Water-Soluble Extract on Macrophages

Miyuki Yokotani<sup>1</sup>, Kosuke Nishi<sup>1,2</sup>, Yoshiharu Sasaki<sup>3</sup>, Takuya Sugahara<sup>1,2,\*</sup>

<sup>1</sup> Graduate School of Agriculture, Ehime University, Matsuyama, Ehime 790-8566, Japan

<sup>2</sup> Food and Health Sciences Research Center, Ehime University, Matsuyama, Ehime 790-8566, Japan

<sup>3</sup> Fine Japan Co., Ltd., Higashiyodogawa-ku, Osaka 533-0021, Japan

\* Corresponding author: mars95@agr.ehime-u.ac.jp; Tel.: +81-89-946-9863

Received: 9 July 2018; Accepted: 4 December 2018; Published: 6 January 2020

**Abstract:** The placenta is an organ attached to the lining of womb during pregnancy. It contains many kinds of substances such as amino acids, lipids, carbohydrates, vitamins, and minerals. It also has various health functions such as anti-allergy and anti-oxidant. We examined the anti-inflammatory effect of placenta water-soluble extract (PE) on lipopolysaccharide (LPS)-stimulated macrophages. PE significantly suppressed interleukin (IL)-6 and tumor necrosis factor (TNF)- $\alpha$  production by LPS-stimulated RAW264.7 cells and LPS-stimulated P-Mac without cytotoxicity. The gene expression levels of inflammatory cytokines in LPS-stimulated macrophages were significantly suppressed by PE. Then, the effect of PE on signal transduction for macrophage activation was evaluated. As a result, phosphorylation levels of ERK, JNK and p38 in MAPK cascade located at downstream of TLR4 signaling were decreased by PE treatment. In addition, heat-treatment of PE did not affect the inflammatory activity, so the active substance in PE is heat stable. As indicated here, our findings suggest that PE suppresses LPS-induced inflammation by inhibiting phosphorylation of MAPK cascade.

**Keywords:** RAW264.7, macrophage, anti-inflammatory, cytokine, MAPK

---

## 1. Introduction

The placenta is an organ attached to the lining of womb during pregnancy. It connects to fetus and provides oxygen and nutrients. In recent years, it is known that placenta has some health function such as anti-oxidant [1] and skin-whitening effects [2].

When infection occurs in the body, macrophages are induced to release inflammatory cytokines such as tumor necrosis factor (TNF)- $\alpha$ , interleukin (IL)-1, IL-12, IL-8, and IL-6. These cytokines activate immune cells [3]. However, the excessive production of these inflammatory cytokines is to trigger many disease such as obesity, Alzheimer's disease, and cancer. It is also reported that many cancers arise from sites of infection, chronic irritation and inflammation. In this study, the anti-inflammatory effect of placenta water-soluble extract (PE) on macrophages was examined.

## 2. Materials and Methods

### 2.1. Preparation of placenta water-soluble extract

Placenta powder was provided by Fine Japan Co., Ltd (Osaka, Japan). Placenta powder was suspended in 10 mM sodium phosphate buffer (NaPB; pH 7.4) at 0.1 g/mL at 10°C for 24 h. After centrifugation at 15,000  $\times$  g at 4°C for 20 min, the supernatant was collected and adjusted to pH 7.4. The supernatant was then filtrated through a 0.22  $\mu$ m membrane and used as PE. The protein concentration of PE was determined using a DC protein assay kit (Bio-Rad Laboratories, Hercules, CA, USA) with bovine serum albumin (BSA) as a standard.

## 2.2. Cells and cell culture

A mouse macrophage-like cell line, RAW264.7 cells were purchased from Japanese Collection of Research Bioresources Cell Bank (Osaka, Japan). RAW264.7 cells were cultured in DMEM supplement with 100 U/mL of penicillin, 100 µg/mL of streptomycin, and 10% FBS at 37°C under humidified 5% CO<sub>2</sub>. RAW264.7 cells were detached using phosphate-buffered saline (PBS) containing 0.25% trypsin and 0.02% ethylenediamine-*N*, *N*, *N'*, *N'*-tetraacetic acid (Dojindo Laboratories, Kumamoto, Japan) for the subsequent experiments.

## 2.3. Preparation of mouse primary peritoneal macrophages

Eight-week-old female BALB/c mice (Japan SLC, Shizuoka, Japan) were injected with 3.0% of thioglycolate medium (2 mL/body) in the peritoneum. Four days after injection, the mice were sacrificed and injected with 3 mL of PBS in the peritoneum to collect thioglycolate-elicited peritoneal macrophages (P-Mac). The collected cells were centrifuged at  $160 \times g$  for 5 min at 4°C, and the cell pellet was washed with PBS and centrifuged again. The cell pellet was suspended in RPMI 1640 medium supplemented with 100 U/mL of penicillin, 100 µg/mL of streptomycin, and 10% FBS. Cells were seeded into a 24-well culture plate (BD Falcon, Franklin Lakes, NJ, USA) at  $1.0 \times 10^6$  cells/well and cultured at 37°C under humidified 5% CO<sub>2</sub>. After cultivation for 1 h, the cells were washed with PBS three times to remove unattached cells such as neutrophils. P-Mac were cultured at 37°C under humidified 5% CO<sub>2</sub> overnight and used for the subsequent experiments.

## 2.4. Determination of cytokine levels in culture medium

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 96-well culture plate (Corning, Corning, NY, USA) at  $6.0 \times 10^4$  cells/well and cultured at 37°C overnight under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 200 µL of 10% FBS-DMEM containing 100 ng/mL of lipopolysaccharides (LPS; Sigma-Aldrich, St. Louis, MO, USA) and various concentrations of PE or 10 mM NaPB as a control and incubated for 6 h. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. P-Mac suspended in 10% FBS-RPMI 1640 medium were seeded into a 24-well culture plate at  $1.0 \times 10^6$  cells/well and cultured at 37°C under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 1.0 mL of 10% FBS-RPMI 1640 medium containing 100 ng/mL of LPS and various concentrations of PE or 10 mM of NaPB as control and incubated for 24 h. Blank cells were treated with 10% FBS-RPMI 1640 medium containing 10 mM NaPB alone. After the incubation, the concentrations of IL-6 and TNF-α in the culture media were measured by enzyme-linked immunosorbent assay (ELISA) using mouse IL-6 ELISA kit (BioLegend, San Diego, CA, USA) and mouse TNF-α ELISA kit (eBioscience, San Diego, CA, USA), respectively, according to the manufacturer's instructions.

## 2.5. Cell viability

Cytotoxicity of PE extract was examined using Cell Count Reagent SF (Nacalai Tesque, Kyoto, Japan) according to manufacturer's instructions after collecting the culture media from each well for ELISA.

## 2.6. Real time RT-PCR

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 48-well culture plate (BD Falcon) at  $1.5 \times 10^5$  cells/well and cultured at 37°C overnight under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 500 µL of 10% FBS-DMEM containing 100 ng/mL of LPS and various concentrations of PE or 10 mM NaPB as control and incubated for 6 h. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. P-Mac suspended in 10% FBS-RPMI 1640 medium was seeded into a 24-well culture plate at  $1.0 \times 10^6$  cells/well and cultured at 37°C under humidified 5% CO<sub>2</sub>. The cells were treated with 1.0 mL of 10% FBS-RPMI 1640 medium containing 100 ng/mL of LPS and various concentrations of PE or 10 mM NaPB as control and incubated for 24 h. Total

RNA was then isolated from the cells using Sepasol-RNA I Super G (Nacalai Tesque) according to the manufacturer's instructions and used as a template for cDNA synthesis with MMLV-reverse transcriptase (Promega, Madison, WI, USA) and an oligo-(dT)<sub>20</sub> primer (Toyobo, Osaka, Japan). A real-time PCR mixture, with a final volume of 20  $\mu$ L, consisted of Thunderbird SYBR qPCR Mix (Toyobo), 10 pmol of a forward primer, 10 pmol of a reverse primer, and 0.1  $\mu$ g of a cDNA sample. Thermal cycling conditions were 20 s at 95°C, followed by 40 cycles of 3 s at 95°C and 30 s at 60°C. PCR products were measured on a StepOnePlus Real-time PCR System (Applied Biosystems, Foster City, CA, USA), and relative gene expression was calculated based on the comparative CT method using StepOne Software v2.1 (Applied Biosystems). Expression of the  $\beta$ -actin gene was used as an endogenous control. Specific oligonucleotide sequences for each gene are as follows. Mouse  $\beta$ -actin: sense, 5'-CATCCGTAAAGACCTCTATGCCAAC-3' and antisense, 5'-ATGGAGCCACCGATCCACA-3'; mouse TNF- $\alpha$ : sense, 5'-CTACTCCAGGTTCTCTCAA-3' and antisense, 5'-GCAGAGAGGAGGTTGACTTTC-3'; mouse IL-6: sense, 5'-AAGCCAGAGTCCTTCAGAGAGAT-3' and antisense, 5'-TTGGATGGTCTTGGTCCTTAGC-3'; mouse inducible nitric oxide synthase (iNOS): sense, 5'-CCAAGCCCTCACCTACTTCC-3' and antisense, 5'-CTCTGAGGGCTGACACAAGG-3'.

### 2.7. Nitric oxide production assay

RAW264.7 cells suspended in 10% FBS-DMEM were inoculated into a 96-well cell culture plate at  $1.0 \times 10^4$  cells/well and cultured for 12 h. The cells were treated with 200  $\mu$ L of 10% FBS-DMEM containing 100 ng/mL of LPS and various concentrations of PE or 10 mM NaPB as control and incubated for 24 h. The concentration of nitric oxide (NO) was measured by Griess Reagent System (Promega) according to the manufacturer's instructions.

### 2.8. Immunoblot analysis

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 35 mm dish (BD Falcon) at  $1.0 \times 10^6$  cells/dish and cultured at 37°C for overnight under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 2.0 mL of 10% FBS-DMEM containing 100 ng/mL of LPS and 6200  $\mu$ g/mL of PE or 10 mM NaPB as control and incubated for 15 min. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. Cytosolic and nuclear proteins were prepared using a CellLytic NuCLEAR Extraction Kit (Sigma-Aldrich) according to the manufacturer's instructions. Denatured proteins were then separated using SDS-PAGE and transferred onto a PVDF membrane (Hybond-P; GE Healthcare, Buckinghamshire, UK). Immunoblotting with various antibodies was performed as previously described [4].

### 2.9. Heat-treatment of PE

To examine the effect of heat-treated PE on cytokine production by LPS-stimulated RAW264.7 cells, PE was heated at 100°C for 20 min and used for assay of activity.

### 2.10. Statistical analysis

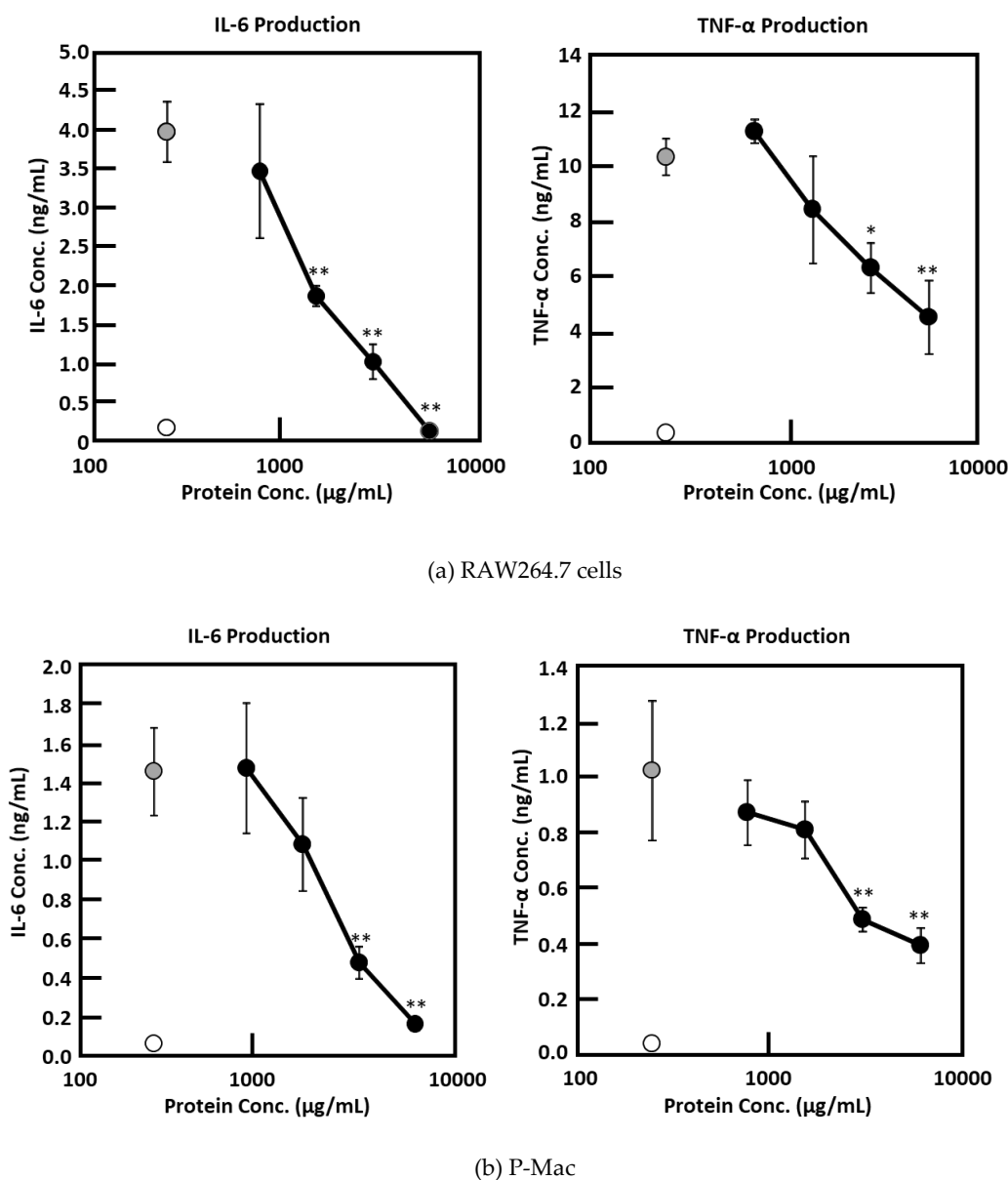
Data obtained were expressed as mean  $\pm$  standard deviation. One way ANOVA followed by Tukey-Kramer test was used to assess the statistical significance of the difference. Values with \* $p < 0.05$ , \*\* $p < 0.01$ , were considered statistically significant.

## 3. Results

### 3.1. Effect of PE on cytokine production by RAW264.7 cells and P-Mac

The effect of PE on cytokine production by RAW264.7 cells and P-Mac was first examined. As shown in Figure 1, PE significantly inhibited cytokine production by both RAW264.7 cells and P-Mac in dose-dependent manners. In addition, it showed that PE has no significant cytotoxicity to either cell

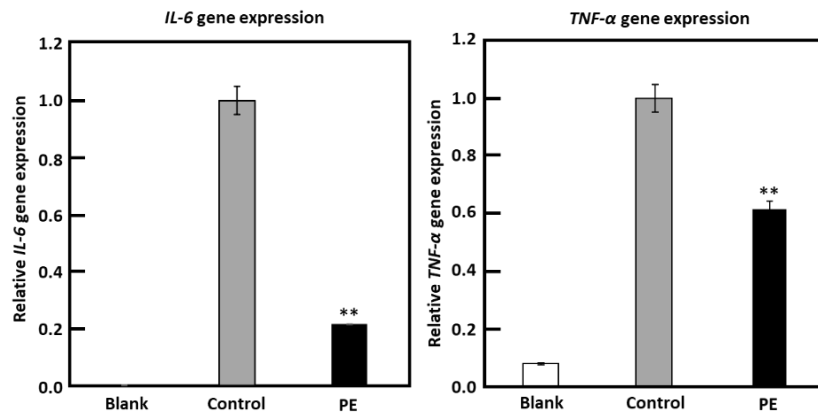
culture within the tested concentrations (data not shown). From these results, further experiments were performed at 6200  $\mu\text{g}$  protein/mL or lower concentrations of PE.



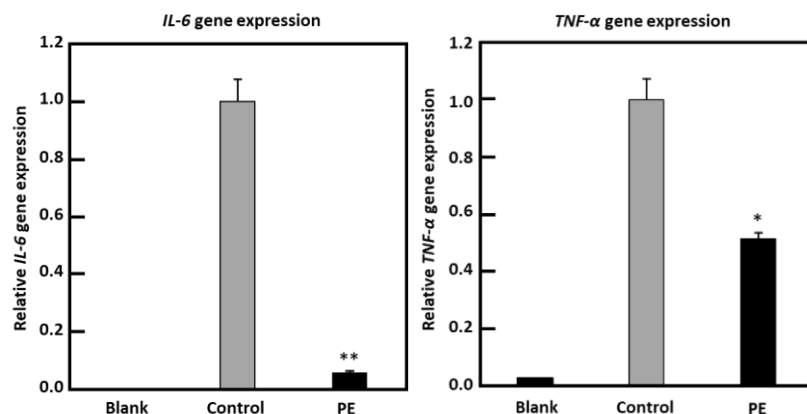
**Figure 1.** Effect of PE on cytokine production by RAW264.7 cells and P-Mac. (a) RAW264.7 cells and (b) P-Mac were incubated with 100 ng/mL of LPS and various concentrations of PE (closed circle) or 10 mM NaPB as control (gray circle). Blank cells (open circle) were treated with 10 mM NaPB alone. After incubation, the concentrations of IL-6 and TNF- $\alpha$  in the culture media were measured by ELISA. Experiments were performed in triplicate, and error bars indicate as the mean  $\pm$  standard deviation. \* $p < 0.05$ , \*\* $p < 0.01$ , against control by Tukey-Kramer test.

### 3.2. Effect of PE on cytokine gene expression levels in RAW264.7 cells and P-Mac

As described above, PE inhibited the production of IL-6 and TNF- $\alpha$  by both RAW264.7 cells and P-Mac. Hence, the effect of PE on mRNA expression levels of these cytokines was examined. As shown in Figure 2, PE significantly inhibited the mRNA expression levels of IL-6 and TNF- $\alpha$  in both RAW264.7 cells and P-Mac. It is suggested that the effect of PE on cytokine production is due to the downregulation of cytokine gene expression.



(a) RAW264.7 cells



(b) P-Mac

**Figure 2.** Effect of PE on cytokine gene expression levels by RAW264.7 cells and P-Mac. (a) RAW264.7 cells and (b) P-Mac were incubated with 100 ng/mL of LPS and various concentrations of PE (closed circle) or 10 mM NaPB as control (gray circle). Blank cells (open circle) were treated with 10 mM NaPB alone. After incubation, the gene expression levels of IL-6 and TNF-α were measured by real time RT-PCR. Experiments were performed in duplicate, and error bars indicate as the mean  $\pm$  standard deviation. \* $p < 0.05$ , \*\* $p < 0.01$ , against control by Tukey-Kramer test.

### 3.3. Effect of PE on NO production and mRNA expression of iNOS in RAW264.7 cells

NO is recognized as one of the most versatile compounds in the immune system and produced by macrophages activated by cytokines and microbial compounds. Therefore, we examined the effect of PE on NO production by LPS-stimulated RAW264.7 cells. The result showed that PE significantly inhibited NO production by LPS-stimulated RAW264.7 cells (data not shown). In addition, PE also suppressed the mRNA expression of iNOS in the cells, suggesting that PE inhibits NO production by suppressing iNOS gene expression.

### 3.4. Effect of PE on signaling pathways involved in macrophage activation

To examine the involvement of MAPK and NF-κB signaling pathways in the inhibition of the IL-6 and TNF-α production by treating with PE, the protein levels of signal molecules were evaluated by immunoblot analysis. As a result, the phosphorylation levels of ERK, JNK and p38 were decreased by PE treatment, whereas PE did not affect the translocation of NF-κB into the nucleus in LPS-stimulated RAW264.7 cells (data not shown). These results suggested that PE inhibits inflammatory cytokine production through downregulation of MAPK cascade.

### 3.5. Effect of heat-treated PE on cytokine production by RAW264.7 cells

To investigate whether the active substance in PE is heat-stable or not, PE was heated at 100°C for 20 min. The result showed that the cytokine production-suppressive activity of PE was not affected by heat treatment (data not shown), suggesting that the active substance in PE is heat-stable.

## 4. Discussion

In this study, we firstly measured cytokine concentration in the culture media to assess the anti-inflammatory activity of PE. PE significantly inhibited the production of IL-6 and TNF- $\alpha$  by both RAW264.7 cells and P-Mac in dose-dependent manners. PE also significantly suppressed the gene expression levels of IL-6 and TNF- $\alpha$  in both RAW264.7 cells and P-Mac. These results suggested that PE inhibits the cytokine production by suppressing the transcription process. In addition, PE inhibited NO production by suppressing the mRNA expression of iNOS in LPS-stimulated RAW264.7 cells, suggesting that PE inhibits NO production by suppressing iNOS gene expression.

There are two signaling pathways involved in the production of cytokines and NO by macrophages, namely, MAPK and NF- $\kappa$ B cascades. Therefore, we examined the effect of PE on MAPK and NF- $\kappa$ B cascades. The result showed that the phosphorylation levels of ERK, JNK, and p38 in MAPK cascade located at downstream of TLR4 signaling were decreased by PE treatment. On the other hand, PE did not affect the translocation of NF- $\kappa$ B into the nucleus in the LPS-stimulated cells. These results indicated that the activity of PE is due to the downregulation of MAPK cascade.

Furthermore, we investigated the properties of active substance in PE. The result showed that heat-treated PE has the inhibitory effect on cytokine production by LPS-stimulated RAW264.7 cells, suggesting that the active substance in PE is heat-stable.

## 5. Conclusions

Although macrophages have an important role to release cytokines when inflammation occurs, the excess of producing these cytokines causes diseases. In this study, we found that PE has anti-inflammatory effect on macrophages. In addition, our findings suggested that PE suppresses LPS-induced inflammation by inhibiting the activation of MAPK cascade. Taken together, these data indicate that placenta would be a beneficial functional food with anti-inflammatory effect on macrophages.

## References

1. Togashi, S.; Takahashi, N.; Iwama, M.; Watanabe, S.; Tamagawa, K.; Fukui, T. Antioxidative collagen-derived peptides in human-placenta extract. *Placenta* 2002, 23, 497-502, 10.1053/plac.2002.0833.
2. Yamasaki, M.; Hasegawa, S.; Takahashi, H.; Kobayashi, Y.; Sakai, C.; Ashizawa, Y.; Asai, Y.; Kanzaki, M.; Fukui, T. Placental extracts induce the expression of antioxidant enzyme genes and suppress melanogenesis in B16 melanoma cells. *Nat Prod Res* 2015, 29, 2103-2106, 10.1080/14786419.2014.986660.
3. Arango Duque, G.; Descoteaux, A. Macrophage cytokines: involvement in immunity and infectious diseases. *Front Immunol* 2014, 5, 491, 10.3389/fimmu.2014.00491.
4. Ishida, M.; Nishi, K.; Kunihiro, N.; Onda, H.; Nishimoto, S.; Sugahara, T. Immunostimulatory effect of aqueous extract of *Coriandrum sativum* L. seed on macrophages. *J Sci Food Agric* 2017, 97, 4727-4736, 10.1002/jsfa.8341.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license

(<http://creativecommons.org/licenses/by/4.0/>).

FP-FST-008-ID018

# Anti-Allergic Effect of Clove

Ange Murielle DjidjouTagne<sup>1</sup>, Momoko Ishida <sup>1</sup>, Hiroyuki Onda<sup>2</sup>, Kosuke Nishi <sup>1,3</sup>, Takuya Sugahara<sup>2,\*</sup>

<sup>1</sup> Graduate School of Agriculture, Ehime University, Matsuyama, Ehime 790-8566, Japan

<sup>2</sup> Research and Analysis Center, Research and Product Development Division, S&B FOODS Incorporated, Itabashi-ku, Tokyo 174-8651, Japan

<sup>3</sup> Food and Health Sciences Research Center, Ehime University, Matsuyama, Ehime 790-8566, Japan

\* Corresponding author: [mars95@agr.ehime-u.ac.jp](mailto:mars95@agr.ehime-u.ac.jp); Tel.: +81 89-946-9863

Received: 9 July 2018; Accepted: 4 December 2018; Published: 6 January 2020

**Abstract:** Allergic rhinitis is a common disease which has affected more than 500 million people worldwide over the last 20 years. Though not a severe disease, it has significant impacts on lowering quality of life due to its co-occurring symptoms like headache, asthma and sinusitis. Faced with this problem, scientists all over the world are constantly in search of active substances from natural sources to find the candidates for functional food materials. In this study, we focused on the anti-allergic effect of cloves; one of the spices used worldwide. Clove extract in 70% ethanol suppressed degranulation of rat basophilic leukemia cell line, RBL-2H3 cells. In addition, the elevation of intracellular  $\text{Ca}^{2+}$  concentration induced by antigen stimulation was obviously suppressed by clove extract. Cloves can thus be a good candidate for the food and pharmaceuticals industries.

**Keywords:** clove; anti-allergic effect; degranulation

---

## 1. Introduction

The rapid growth in the prevalence, severity, and complexity of allergic diseases in modern population has been of significant health concern. This is due to the burden they impose on patient's quality of life by displaying various symptoms such as asthma, chronic urticaria, allergic rhinitis, conjunctivitis and angioedema to life-threatening anaphylaxis [1-3]. Allergic rhinitis is a type I allergic disease induced by an immunoglobulin E (IgE) that has affected more than 500 million people worldwide over the last 20 years. Development of the disease commences with sensitisation to allergen, which elicits the predominant production of IgE by B cells [4]. The high-affinity IgE receptor (FcεRI) is expressed on mast cells and basophils. An allergic reaction is provoked by cross-linking of allergens to IgE bound on FcεRI, leading to FcεRI aggregation. Aggregation of FcεRI is followed by a rise in intracellular  $\text{Ca}^{2+}$  concentration and the degranulation of mast cells. Chemical mediators including histamine,  $\beta$ -hexosaminidase and inflammatory mediators such as prostaglandins are released from intracellular granules during mast cell degranulation [1,5]. Released chemical mediators are responsible for the nasal itching, and sneezing symptoms of allergic rhinitis. Thus prevention of degranulation of mast cells and basophils is one of the most effective approaches to attenuate allergic symptoms.

The drugs used to treat allergic diseases are usually, anti-histamine, mast cell stabilizer and leukotriene receptor antagonists. However, anti-histamine drugs have undesirable side effects, most notably drowsiness, dry mouth etc. The use of functional food has become more popular in recent years, a safe and effective management of allergic rhinitis and other atopic diseases through food resources has received much attention [6-8]. Grape seed, jujube fruits, citrus species, passion fruit seeds, mango peels [6,9-12] and many others, have been shown to possess anti-allergic and anti-anaphylactic activities. In addition, many other spices such as rosemary, cinnamon and ingredients such as *Aster yomena* and *Ocimum tenuiflorum* [3,5,13-14], have also been shown to stabilize mast cell and cause inhibition of the allergic markers such as histamine, IL-4, and  $\beta$ -hexosaminidase in IgE-mediated allergic reaction.



Clove (*Syzygium aromaticum*) is a spice widely used to add flavour to food preparations [15]. It is indigenous to east Africa and Asian countries like Indonesia, and it has been reported to have many therapeutic uses. Clove oil has been experimentally shown to have potent antimicrobial activity against dental caries-causing microorganisms promoting their use as antimicrobial agents in dentistry [16]. It is also used to relieve pain, to control nausea and vomiting, stomach distension and gastrointestinal spasm [16-18]. However the anti-allergic effects of cloves have not yet been revealed. This study was therefore aimed at analysing the potentials of clove in suppressing the development of allergic responses in mice cells.

## 2. Materials and Methods

### 2.1. Reagents

Dulbecco's modified Eagle's medium (DMEM), penicillin, streptomycin, bovine serum albumin (BSA), fetal bovine serum (FBS), mouse anti-dinitrophenol (DNP) monoclonal IgE, DNP-human serum albumin (HSA) conjugate, and Triton X-100 were products of Sigma-Aldrich (St. Louis, MO, USA). All other chemicals were purchased from Wako Pure Chemical Industries (Osaka, Japan) or Nacalai Tesque (Kyoto, Japan) unless otherwise noted.

### 2.2. Sample preparation

Clove seed powder was provided by S&B Foods Inc. (Tokyo, Japan). The powder was suspended in 70% ethanol at 0.05g/ml and extracted at 12°C for 24 h. The solution was then centrifuged at 4°C,  $15,000 \times g$  for 20 min to remove insoluble materials. The supernatant was filtered through a 0.22  $\mu$ m membrane filter, and concentrated using an evaporator and a freeze-drier. The final concentration was adjusted to 70mg/mL with 70% ethanol. It was sterilized by filtration through a 0.22  $\mu$ m membrane filter and the ethanol extract of clove (EEC) was used for the experiments described below.

### 2.3. Cell and cell culture

RBL-2H3 cells (rat basophilic leukemia cells) were obtained from American Type Culture Collection (Rockville, MD, USA) and cultured in DMEM supplemented with 100 U/mL of penicillin, 100  $\mu$ g/mL of streptomycin, and 5% FBS at 37°C under humidified 5% CO<sub>2</sub>.

### 2.4. $\beta$ -Hexosaminidase release assay

The assay was performed using the method of Nishi *et al.* and Hwang *et al.* [1,8] with some modifications. RBL-2H3 cells were seeded at  $4.0 \times 10^5$  cells/well into a 96-well plate (Corning, Corning, NY, USA) and sensitized with 50 ng/mL of anti-DNP IgE diluted in 5% FBS-DMEM for 24 h at 37°C. After washing with the modified Tyrode's (MT) buffer (20 mM HEPES, 135 mM NaCl, 5 mM KCl, 1.8 mM CaCl<sub>2</sub>, 1 mM MgCl<sub>2</sub>, 5.6 mM glucose, and 0.05% BSA, pH 7.4), the cells were treated with 120  $\mu$ L of various concentrations of EEC diluted in MT buffer for 10 min at 37°C. The cells were subsequently challenged for 30 min at 37°C by adding 10  $\mu$ L of DNP-HSA diluted in MT buffer at the final concentration of 0.625  $\mu$ g/mL. After the collection of supernatant, cells were sonicated in 130  $\mu$ L of MT buffer containing 0.1% Triton X-100 for 5 sec on ice. Both supernatant and cell lysate were transferred into a new 96-well microplate at 50  $\mu$ L/well and incubated for 5 min at 37°C. Then, 100  $\mu$ L of 3.3 mM 4-nitrophenyl 2-acetamido-2-deoxy- $\beta$ -D-glucopyranoside (Wako Pure Chemical Industries) dissolved in 0.1 M citrate buffer (pH 4.5) was added to each well and incubated at 37°C for 25 min. The enzyme reaction was terminated by the addition of 100  $\mu$ L of 2 M glycine buffer (pH 10.4), and the absorbance was measured at 415 nm using a microplate reader. The  $\beta$ -hexosaminidase release rate was calculated as:

$$100 \times \left[ \frac{OD_{\text{supernatant}} - OD_{\text{blank of supernatant}}}{\{(OD_{\text{supernatant}} - OD_{\text{blank of supernatant}}) + (OD_{\text{cell lysate}} - OD_{\text{blank of cell lysate}})\}} \right] \quad (1)$$

### 2.5. Cell viability assay

The cytotoxicity of EEC to RBL-2H3 cells was examined using Cell Count Reagent SF (Nacalai Tesque). RBL-2H3 cells were seeded, sensitized with anti-DNP IgE, treated with various concentrations of EEC, and challenged with DNP-HSA as described above. After the cells were washed with phosphate-buffered saline (PBS, pH 7.4) once, 100  $\mu$ L of DMEM containing 10  $\mu$ L of WST-8 solution was added to each well of the cell culture plate and incubated for 45 min at 37°C. The absorbance was then measured at 450 nm and 655 nm using a microplate reader.

### 2.6. Measurement of intracellular $\text{Ca}^{2+}$ concentration

The intracellular  $\text{Ca}^{2+}$  concentration ( $[\text{Ca}^{2+}]_i$ ) was measured using a Calcium KitFluo 3 (Dojindo Laboratories, Kumamoto, Japan) as reported by Nishi *et al.* [1], with some modifications. RBL-2H3 cells were seeded in a black 96-well culture plate and sensitized with anti-DNP IgE as described above for  $\beta$ -hexosaminidase assay. After washing with warm PBS twice, the IgE-sensitized cells were incubated with 100  $\mu$ L of Fluo-3 AM for 1 h. The cells were then washed with PBS, and treated with 100  $\mu$ L of various concentrations of EEC for 10 min. Basal reading was taken for 2 sec. Then, the cells were stimulated by the addition of 10  $\mu$ L of DNP-HSA diluted in MT buffer at the final concentration of 0.625  $\mu$ g/mL, and the fluorescence intensity was immediately monitored for the next 120 sec with an excitation wavelength of 485 nm and an emission wavelength of 530 nm using a fluorescence microplate reader.

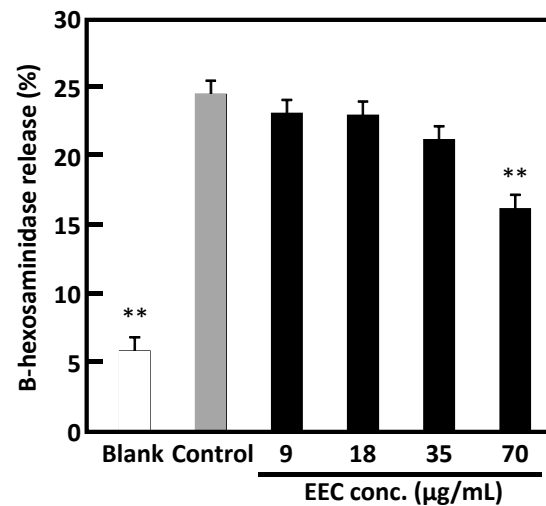
### 2.7. Statistical analysis

Data obtained were expressed as mean  $\pm$  standard deviation. One way ANOVA followed by Tukey-Kramer test as used to assess the statistical significance of the difference. Values with \* $p < 0.05$  or \*\* $p < 0.01$  were considered statistically significant.

## 3. Results

### 3.1. Effect of EEC on the rate of $\beta$ -hexosaminidase released

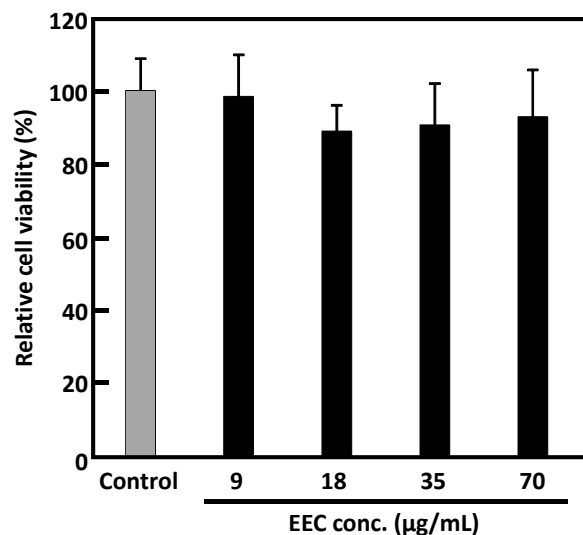
Mast cells are known to undergo degranulation upon sensitization with IgE and activation with allergens. In order to determine the effect of EEC on mast cell degranulation, RBL-2H3 cells were sensitized with anti-DNP IgE and challenged with DNP-HSA. The rate of degranulation was measured by the percentage of  $\beta$ -hexosaminidase release with or without pre-treatment of the cells with different concentrations of EEC. As shown in Figure 1, treatment of RBL-2H3 cells with EEC suppressed the amount of  $\beta$ -hexosaminidase released in a dose dependent manner.



**Figure 1.** Effect of EEC on degranulation of RBL-2H3 cells stimulated with antigen. Anti-DNP IgE-sensitized RBL-2H3 cells were treated with various concentrations of EEC or 0.07% ethanol (blank and control). Degranulation was induced by the addition of DNP-HSA diluted in MT buffer. Blank cells were treated with MT buffer alone. Released  $\beta$ -hexosaminidase was used as a marker of degranulation. Experiments were performed in triplicate, and error bars indicate standard deviation. \*\* $p < 0.01$  against control by Tukey-Kramer test.

### 3.2. Effect of EEC on the cell viability of RBL2H3 cells

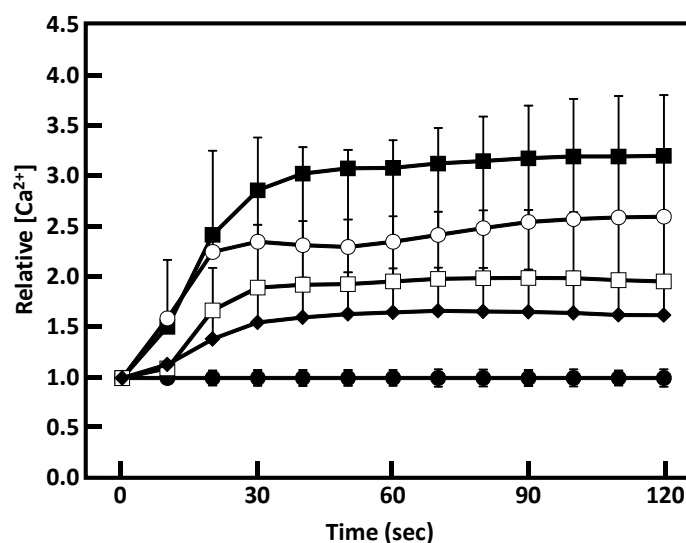
Cell viability assay using the WST-8 kit (Cell Count Reagent SF) revealed that the relative viability of RBL-2H3 cells after pre-treatment with various concentrations of EEC was not significantly different from the control (Figure 2), indicating that EEC was not toxic to the cells.



**Figure 2.** Effect of EEC on  $[Ca^{2+}]_i$  in RBL-2H3 cells stimulated with antigen. Anti-DNP IgE-sensitized RBL-2H3 cells were treated with various concentrations of EEC or 0.07% ethanol (control). Cell viability was measured using a WST-8 kit after stimulation with DNP-HSA. Experiments were performed in triplicate, and error bars indicate standard deviation. Tukey-Kramer test was used to assess the statistical significance of the difference against control.

### 3.3. Effect of EEC on the intracellular $\text{Ca}^{2+}$ concentration

Various cellular responses leading to mast cell degranulation are activated by the increase in intracellular  $\text{Ca}^{2+}$  concentration ( $[\text{Ca}^{2+}]_i$ ). To find out if the suppressive effect of EEC on mast cell degranulation is due to an inhibition of the elevation levels of intracellular  $\text{Ca}^{2+}$ , the  $[\text{Ca}^{2+}]_i$  in RBL-2H3 cells stimulated with antigen was measured using Fluo-3 AM. As shown in Figure 3, EEC inhibited the amount of intracellular  $\text{Ca}^{2+}$  in stimulated RBL-2H3 cells as compared with the control.



**Figure 3.** Effect of EEC on  $[\text{Ca}^{2+}]_i$  in RBL-2H3 cells stimulated with antigen. After anti-DNP IgE-sensitized RBL-2H3 cells were incubated with Fluo-3 AM, the cells were treated with various concentrations of EEC or ethanol as control. Fluorescence intensity was measured immediately after inducing degranulation by treating with DNP-HSA. Closed circle, ethanol-treated cells not stimulated with DNP-HSA; closed square, ethanol-treated cells stimulated with DNP-HSA; open circle, 18  $\mu\text{g/ml}$  of EEC-treated cells stimulated with DNP-HSA; open square, 35  $\mu\text{g/ml}$  of EEC-treated cells stimulated with DNP-HSA; closed diamond, 70  $\mu\text{g/ml}$  of EEC-treated cells stimulated with DNP-HSA. Experiments were performed in triplicate, and error bars indicate standard deviation.

## 4. Discussion

Screening in search of candidates for functional food materials revealed that EEC could have a significant effect in alleviating allergic symptoms. The release of the enzyme  $\beta$ -hexosaminidase which together with histamine is considered a major mediator of the acute inflammation and early hypersensitivity responses in allergic rhinitis was dose-dependently suppressed by EEC. Moreover, the relative viability of RBL-2H3 cells was not affected by all concentrations of EEC tested, indicating that the suppressive effect of EEC on degranulation of RBL-2H3 cells was not caused by cytotoxicity. Amit *et al.* [3], found similar results with the spice cinnamon. Our results also showed that there was a decrease in intracellular calcium concentration after treatment with EEC. It is known that intracellular calcium mobilization precedes mast cell degranulation. Also, the measurement of intracellular calcium serves as an important marker for mast cell activation and it has been shown to be inhibited in many other anti-allergic foodstuffs [1,5].

## 5. Conclusions

This study reveals that EEC inhibits mast cell allergic reactions by suppressing degranulation. However, the effect of EEC on degranulation *in vivo* and its effect on intracellular signaling pathways involved in degranulation process have not yet been clarified. Such experiments will be performed in the future.

## References

1. Nishi, K.; Teranishi, M.; Yasunaga, S.; Iitsuka, M.; Matsumoto, S.; Sugahara, T. The major whey protein  $\beta$ -lactoglobulin inhibits IgE-mediated degranulation of RBL-2H3 cells and passive cutaneous anaphylaxis in mice. *Int Dairy J* **2014**, *39*, 89-95, 10.1016/j.idairyj.2014.05.006.
2. Ren, M.; Tang, Q.; Chen, F.; Xing, X.; Huang, Y.; Tan, X. *MahuangFuZiXixin* decoction attenuates Th1 and Th2 responses in the treatment of ovalbumin-induced allergic inflammation in a rat model of allergic rhinitis. *J Immunol Res* **2017**, *2017*, 1-12, 10.1155/2017/8254324.
3. Kandhare, A.D.; Aswar, U.M.; Mohan, V.; Thakurdesai, P.A. Ameliorative effects of type-A procyanidins polyphenols from cinnamon bark in compound 48/80-induced mast cell degranulation. *Anat Cell Biol* **2017**, *50*, 275-283, 10.5115/acb.2017.50.4.275
4. Galli, S.J.; Tsai, M.; Piliponsky, A.M. The development of allergic inflammation. *Nature* **2008**, *454*, 445-454, 10.1038/nature07204.
5. Prakash, A.; Ebenezer, A.J.; Vasanth, S.; Nagarajan, G.; Elden B.T. Effect of *Ocimumtenuiflorum* Linn extract on histamine mediated allergic inflammation in human mast cells. *JBAPN* **2017**, *7*, 10-17, 10.1080/22311866.2016.1275983.
6. Bernstein, D.I.; Bernstein, C.K.; Deng, C.; Murphy, K.J.; Bernstein, I.L.; Bernstein, J.A.; Shukla, R. Evaluation of the clinical efficacy and safety of grapeseed extract in the treatment of fall seasonal allergic rhinitis; a pilot study. *Ann Allergy Asthma Immunol* **2002**, *88*, 272-278, 10.1016/S1081-1206(10)62008-X.
7. Resnick, E.S.; Bielory, B.P.; Bielory, L. Complementary therapy in allergic rhinitis. *Curr Allergy Asthma Rep* **2008**, *8*, 118-125, 10.1007/s11882-008-0021-y.
8. Hwang, K.-A.; Hwang, Y.-J.; Song, J. Anti-allergic effect of *Aster yomena* on ovalbumin-sensitized mouse and RHL-2H3 cells via Th1/Th2 cytokine balance. *J Funct foods* **2018**, *44*, 1-8, 10.1016/j.jff.2018.02.026
9. Naik, S.R.; Bhagat, S.; Shah, P.D.; Tare, A.A.; Ingawale, D.; Wadekar, R.R. Evaluation of anti-allergic and anti-anaphylactic activity of ethanolic extract of *Zizyphusjuzubafruits* in rodents. *Rev Bras Farmacogn* **2013**, *23*, 811-818, 10.1590/S0102-695X2013000500014.
10. Onishi, S.; Nishi, K.; Yasunaga, S.; Muranaka, A.; Maeyama, K.; Kadota, A.; Sugahara, T. Nobiletin, a polymethoxy flavonoid, exerts anti-allergic effect by suppressing activation of phosphoinositide 3-kinase. *J Funct Foods* **2014**, *6*, 606-614, 10.1016/j.jff.2013.12.005.
11. Mizusaki, A.; Nishi, K.; Nishiwaki, H.; Sugahara, T. Suppressive effect of ethanol extract from passion fruit seeds on IgE production. *J Funct Foods* **2017**, *32*, 176-184, 10.1016/j.jff.2017.02.030.
12. Ishida, M.; Sasaki, T.; Nishi, K.; Tamamoto, T.; Sugahara, T. Suppressive effect of ethanol extract from mango (*Mangifera indica* L.) peel on IgE production *in vitro* and *in vivo*. *Biosci Biotech Bioch* **2018**, *82*, 732-739, 10.1080/09168451.2017.1412250.
13. Osakabe, N.; Takano, H.; Sanbongi, C.; Yasuda, A.; Yanagisawa, R.; Inoue, K.; Yoshikawa, T. Anti-inflammatory and anti-allergic effect of rosmarinic acid (RA); inhibition of seasonal allergic rhinoconjunctivitis (SAR) and its mechanism. *Biofactors* **2004**, *21*, 127-131, 10.1002/biof.552210125.
14. Sim, J.H.; Lee, H.S.; Lee, S.; Park, D.E.; Oh, K.; Hwang, K.-A.; Kang, H.-R.; Ye, S.-K.; Kim, H.-R. Anti-asthmatic activities of an ethanol extract of *Aster yomena* in an ovalbumin-induced murine asthma model. *J Med Food* **2014**, *17*, 606-611, 10.1089/jmf.2013.2939.
15. Bachiega, T.F.; de Sousa, J.P.; Bastos, J.K.; Sforcin, J.M. Clove and eugenol in noncytotoxic concentrations exert immunomodulatory/anti-inflammatory action on cytokine production by murine macrophages. *J Pharm Pharmacol* **2012**, *64*, 610-616, 10.1111/j.2042-7158.2011.01440.x.
16. Xu, J.-S.; Li, Y.; Cao, X.; Cui, Y. The effect of eugenol on the cariogenic properties of *Streptococcus mutans* and dental caries development in rats. *Exp Ther Med* **2013**, *5*, 1667-1670, 10.3892/etm.2013.1066.
17. Sulieman, A.M.E.; Boshra, I.M.O.; El Khalifa, E.A.A. Nutritive value of clove (*Syzygium aromaticum*) and detection of antimicrobial effect of its bud oil. *Res J Microbiol* **2007**, *2*, 266-271, ISSN 1816-4935.
18. Tanko, Y.; Mohammed, A.; Okasha, M.A.; Umar, A.H.; Magaji, R.A. Anti-nociceptive and anti-inflammatory activities of ethanol extract of *Syzygium aromaticum* flower bud in wistar rats and mice. *Afr J Tradit Complement Altern Med* **2008**, *5*, 209-212, 10.4314/ajtcam.v5i2.31275.



FP-FST-009-ID021

# Anti-Inflammatory Effect of Aqueous Extract from Kawachi-Bankan Peel on Lipopolysaccharide-Induced Inflammatory Responses in RAW264.7 Cells

Momoko Ishida<sup>1</sup>, Chihiro Takekuni<sup>1</sup>, Kosuke Nishi<sup>1,2</sup> and Takuya Sugahara<sup>1,2,\*</sup>

<sup>1</sup> Graduate School of Agriculture, Ehime University, Matsuyama, Ehime 790-8566, Japan

<sup>2</sup> Food and Health Sciences Research Center, Ehime University, Matsuyama, Ehime 790-8566, Japan

\* Corresponding author: [mars95@agr.ehime-u.ac.jp](mailto:mars95@agr.ehime-u.ac.jp); Tel.: +81 89-946-9863

Received: 9 July 2018; Accepted: 4 December 2018; Published: 6 January 2020

**Abstract:** Kawachi-bankan (*Citrus maxima*) is one of the citruses produced in Ehime, Japan. Bioactive substances in citrus peel such as flavonoids and carotenoids have been studied very well. However, health functions of water-soluble substances in citrus peel have not been focused. We herein indicated the anti-inflammatory effect of Kawachi-bankan peel aqueous extract (KPE) on mouse macrophage-like RAW264.7 cells. RAW264.7 cells were treated with lipopolysaccharide (LPS) to induce inflammation, and the effect of KPE on LPS-induced hyperinflammatory response in the cells was examined. KPE significantly inhibited the production of inflammatory cytokines such as interleukin (IL)-6 and tumor necrosis factor (TNF)- $\alpha$  by LPS-stimulated RAW264.7 cells without cytotoxicity. KPE also significantly inhibited the mRNA expression levels of IL-6 and TNF- $\alpha$  in the cells, suggesting that KPE inhibits the production of inflammatory cytokines by suppressing the gene expression levels. Immunoblot analysis revealed that KPE suppressed the activation level of p38 MAPK and translocation of NF- $\kappa$ B into nucleus in the LPS-stimulated cells, suggesting that KPE shows an anti-inflammatory effect on macrophages through downregulation of MAPK and NF- $\kappa$ B cascades. Taken together, our findings indicated that KPE contributes to alleviating of a hyperinflammatory response in macrophages.

**Keywords:** Kawachi-bankan; anti-inflammatory effect; macrophages

---

## 1. Introduction

An inflammatory response is a local defense reaction to maintain homeostasis in a living body. The inflammatory response begins with recognition of the infection or injury by immune cells such as macrophages and dendritic cells. Recognition of them by macrophages causes the activation of mitogen-activated protein kinase (MAPK) and nuclear factor- $\kappa$ B (NF- $\kappa$ B) cascades. Eventually, the activated macrophages produce proinflammatory cytokines such as interleukin (IL)-6 and tumor necrosis factor (TNF)- $\alpha$  [1,2]. These actions lead to activation of other immune cells and contribute to the elimination of non-self substances. However, continued inflammatory state caused by excessive production of inflammatory substances leads to autoimmune diseases and chronic inflammatory diseases such as rheumatoid arthritis and Crohn's disease. Thus, the inhibition of excessive or chronic macrophage activation is great importance for the prevention and alleviation of these diseases.

Citrus peel contains abundant flavonoids and carotenoids such as hesperidin, naringin, and  $\beta$ -cryptoxanthin, and various biological functions based on these components have been reported. Kawachi-bankan (*Citrus maxima*) is one of the citruses produced in Ehime, Japan. The peel of Kawachi-bankan contains abundant auraptene, which is a kind of coumarin, as compared with other citrus peels [3]. It has been reported that auraptene has an immunomodulatory effect on lymphocytes [4] and anti-inflammatory effect on macrophages [5]. Although health functions of lipid-soluble substances in citrus peel such as auraptene have been studied very well, those of water-soluble substances in the peel have

not been focused. Therefore, we examined the anti-inflammatory effect of Kawachi-bankan peel aqueous extract (KPE) on mouse macrophage-like RAW264.7 cells.

## 2. Materials and Methods

### 2.1. Reagents

Dulbecco's modified Eagle's medium (DMEM), penicillin, streptomycin, bovine serum albumin (BSA), fetal bovine serum (FBS), and lipopolysaccharides (LPS) from *Escherichia coli* 026/B6 were products of Sigma-Aldrich (St. Louis, MO, USA). Goat anti-actin antibody and horseradish peroxidase-labeled (HRP-labeled) anti-goat IgG antibody were purchased from Santa Cruz Biotechnology (Santa Cruz, CA, USA). HRP-labeled anti-rabbit IgG antibody, HRP-labeled anti-mouse IgG antibody, mouse anti-I $\kappa$ B $\alpha$  antibody, and rabbit antibodies against histone H3, NF- $\kappa$ B p65, extracellular signal-regulated protein kinases (ERK)1/2, phosphorylated ERK1/2, c-Jun N-terminal kinase (JNK), phosphorylated JNK, p38 MAPK, and phosphorylated p38 MAPK were purchased from Cell Signaling Technology (Danvers, MA, USA). All other chemicals were purchased from Wako Pure Chemical Industries (Osaka, Japan) or Nacalai Tesque (Kyoto, Japan) unless otherwise noted.

### 2.2. Sample preparation

Fruits of Kawachi-bankan were harvested in Ehime, Japan. The peels were manually separated from the fresh fruit and freeze-dried. The dried peels were then powdered with a mill mixer (Iwatani, Tokyo, Japan) and used as Kawachi-bankan peel powder. The powder was suspended in 10 mM sodium phosphate buffer (NaPB; pH 7.4) at 0.1 g/mL at 12°C for 20 h. After centrifugation at 15,000  $\times$  g at 4°C for 20 min, the supernatant was collected and centrifuged at 270,000  $\times$  g at 4°C for 20 min. After centrifugation, the supernatant was collected and adjusted to pH 7.4. The supernatant was then filtrated through a 0.22  $\mu$ m membrane and used as Kawachi-bankan peel aqueous extract (KPE). Dry weight of KPE was measured by weighing a portion of freeze-dried samples.

### 2.3. Cells and cell culture

Mouse macrophage-like cell line RAW264.7 cells were obtained from the Japanese Collection of Research Bioresources Cell Bank (Osaka, Japan). RAW264.7 cells were cultured in DMEM supplemented with 100 U/mL of penicillin, 100  $\mu$ g/mL of streptomycin, and 10% FBS at 37°C under humidified 5% CO<sub>2</sub>. RAW264.7 cells were detached using phosphate-buffered saline (PBS) containing 0.25% trypsin and 0.02% ethylenediamine-*N,N,N',N'*-tetraacetic acid (Dojindo Laboratories, Kumamoto, Japan) for the subsequent experiments.

### 2.4. Cytokine production assay

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 96-well culture plate (Corning, Corning, NY, USA) at  $3.0 \times 10^4$  cells/well, and cultured for 12 h at 37°C under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 200  $\mu$ L of 10% FBS-DMEM containing 20 ng of LPS and various concentrations of KPE or 10 mM NaPB as control and incubated for 12 h at 37°C. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. After incubation, the concentrations of TNF- $\alpha$  and IL-6 in the culture media were measured by enzyme-linked immunosorbent assay (ELISA) using Mouse TNF- $\alpha$  ELISA Ready-SET-GO! (eBioscience, San Diego, CA, USA) and Mouse IL-6 ELISA MAX Standard Set (BioLegend, San Diego, CA, USA), respectively, according to the manufacturer's instructions. Cell viability was measured using Cell Count Reagent SF (Nacalai Tesque) after collecting the culture media from each well for ELISA.

### 2.5. Real-time RT-PCR

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 24-well culture plate (BD Falcon, Franklin Lakes, NJ, USA) at  $1.5 \times 10^5$  cells/well and cultured for 12 h at 37°C under humidified

5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 1 mL of 10% FBS-DMEM containing 100 ng of LPS and various concentrations of KPE or 10 mM NaPB as control, and incubated for 12 h at 37°C. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. Total RNA was then isolated from the cells using Sepasol-RNA I Super G (Nacalai Tesque) according to the manufacturer's instructions and used as a template for cDNA synthesis with MMLV-reverse transcriptase (Promega, Madison, WI, USA) and an oligo-(dT)<sub>20</sub> primer (Toyobo, Osaka, Japan). A real-time PCR mixture, with a final volume of 20 µL, consisted of Thunderbird SYBR qPCR Mix (Toyobo), 10 pmol of a forward primer, 10 pmol of a reverse primer, and 0.1 µg of a cDNA sample. Thermal cycling conditions were 20 s at 95°C, followed by 40 cycles of 3 s at 95°C and 30 s at 60°C. PCR products were measured on a StepOnePlus Real-time PCR System (Applied Biosystems, Foster City, CA, USA), and relative gene expression was calculated based on the comparative CT method using StepOne Software v2.1 (Applied Biosystems). Expression of the  $\beta$ -actin gene was used as an endogenous control. Specific oligonucleotide sequences for each gene are as follows. Mouse  $\beta$ -actin: sense, 5'-CATCCGTAAAGACCTCTATGCCAAC-3' and antisense, 5'-ATGGAGCCACCGATCCACA-3'; mouse TNF- $\alpha$ : sense, 5'-CTACTCCCAGGTTCTCTTCAA-3' and antisense, 5'-GCAGAGAGGAGGTTGACTTTC-3'; mouse IL-6: sense, 5'-AAGCCAGAGTCCTTCAGAGAGAT-3' and antisense, 5'-TTGGATGGTCTTGGTCCTTAGC-3'.

## 2.6. Immunoblot analysis

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 35 mm dish (BD Falcon) at  $1.0 \times 10^6$  cells/dish and cultured for 12 h at 37°C under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 2.0 mL of 10% FBS-DMEM containing 200 ng of LPS and 20 mg/mL of KPE or 10 mM NaPB as control and incubated for 15 min. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. Cytosolic and nuclear proteins were prepared using a CellLytic NuCLEAR Extraction Kit (Sigma-Aldrich) according to the manufacturer's instructions. Denatured proteins were then separated using SDS-PAGE and transferred onto a PVDF membrane (Hybond-P; GE Healthcare, Buckinghamshire, UK). Immunoblotting with various antibodies was performed as previously described [6].

## 2.7. Statistical analysis

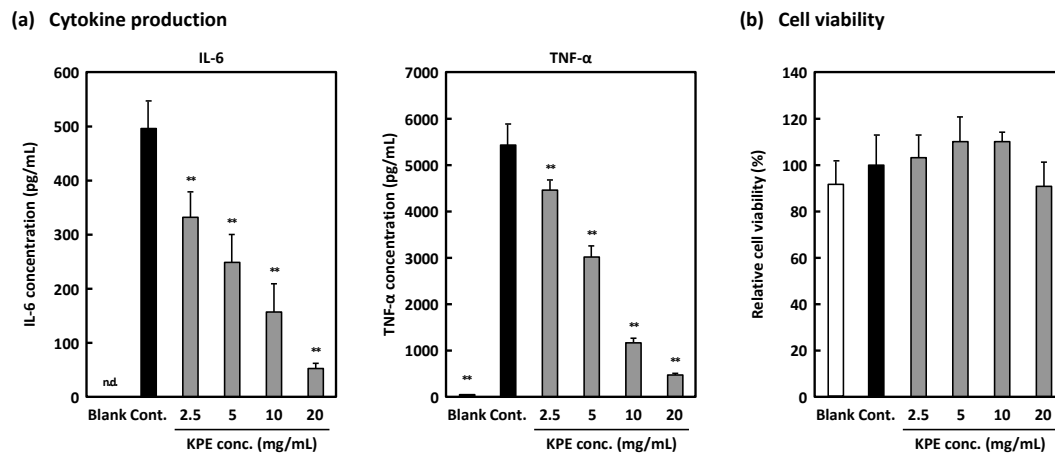
Data obtained were expressed as mean  $\pm$  standard deviation. One way ANOVA followed by Tukey-Kramer test as used to assess the statistical significance of the difference. Values with \* $p < 0.05$  or \*\* $p < 0.01$  were considered statistically significant.

# 3. Results

## 3.1. Effect of KPE on inflammatory cytokine production by LPS-stimulated RAW 264.7 cells

We first examined the effect of KPE on inflammatory cytokine production by LPS-stimulated RAW264.7 cells. As shown in Figure 1a, KPE significantly inhibited the production of IL-6 and TNF- $\alpha$  by LPS-stimulated RAW264.7 cells in a dose-dependent manner. The highest concentration of KPE showed the inhibition rate of approximately 90% for the production of both IL-6 and TNF- $\alpha$  compared to control. Cell viability test showed that KPE was not cytotoxic within the tested concentrations (Figure 1b). Therefore, we performed further experiments at 20 mg/mL or lower concentrations of KPE.





**Figure 1.** Effect of KPE on cytokine production and cell viability of RAW264.7 cells. (a) RAW264.7 cells were treated with 10% FBS-DMEM containing 100 ng/mL of LPS and various concentrations of KPE or 10 mM NaPB as control and incubated for 12 h. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. After incubation, the concentrations of TNF- $\alpha$  and IL-6 in the culture media were measured by ELISA. (b) Cell viability was measured after collecting the culture media from each well for ELISA. Experiments were performed in triplicate, and error bars indicate as the mean  $\pm$  standard deviation. \*\* $p < 0.01$  against control by Tukey-Kramer test. n.d. indicates not determined.

### 3.2. Effect of KPE on expression levels of IL-6 and TNF- $\alpha$ genes in RAW264.7 cells

Next, the effect of KPE on gene expression of inflammatory cytokines in LPS-stimulated RAW264.7 cells was examined. The result showed that KPE significantly inhibited the mRNA expression levels of IL-6 in the cells (data not shown). On the other hand, a suppression tendency was observed in the mRNA expression levels of TNF- $\alpha$ , although there was no significant difference. These results suggested that KPE inhibits the production of inflammatory cytokines by suppressing the gene expression levels.

### 3.3. Effect of KPE on the signaling pathways involved in macrophage activation

LPS, a major outer membrane component of gram-negative bacteria, binds to TLR4 on the cell surface of macrophages and leads to macrophage activation through MAPK and NF- $\kappa$ B cascades. Therefore, we examined the effect of KPE on the signal molecules in MAPK and NF- $\kappa$ B cascades. The result showed that the phosphorylation level of p38 MAPK was inhibited by KPE, whereas that of ERK or JNK was not affected (data not shown). In addition, KPE inhibited translocation of NF- $\kappa$ B into the nucleus in the LPS-stimulated cells, suggesting that KPE shows an anti-inflammatory effect on macrophages through downregulation of MAPK and NF- $\kappa$ B cascades.

## 4. Discussion

In this study, we found that KPE inhibits the production of IL-6 and TNF- $\alpha$  by LPS-stimulated RAW264.7 cells without cytotoxicity. KPE also inhibited the mRNA expression levels of IL-6 and TNF- $\alpha$  in the cells. These results suggested that KPE inhibits production of inflammatory cytokines by suppressing the gene expression of cytokines in LPS-stimulated RAW264.7 cells.

MAPK and NF- $\kappa$ B cascades play essential roles in macrophage activation. There are mainly three families of MAPKs: ERK, JNK, and p38 kinases. MAPKs are activated by specific MAPK kinases (MAPKKs) and eventually lead to the synthesis of transcription factors such as c-Jun and c-Fos. These transcription factors form the activator protein (AP)-1 dimers, which bind on DNA after translocating

into the nucleus, and promote the transcriptional activity of target genes. In addition, NF- $\kappa$ B is translocated into the nucleus after activation, and regulates the transcriptional activity as a transcription factor. KPE suppressed the phosphorylation level of p38 MAPK and translocation of NF- $\kappa$ B from cytosol to nucleus in the LPS-stimulated cells. Our data indicated here suggest that KPE suppresses the expression levels of cytokine genes through inhibition of AP-1 activity and NF- $\kappa$ B translocation.

## 5. Conclusions

Although bioactive substances in citrus peel such as flavonoids and carotenoids have been studied very well, health functions of water-soluble substances in citrus peel have not been focused. In this study, we found that KPE inhibits the excessive production of inflammatory cytokines by LPS-stimulated RAW264.7 cells through downregulation of MAPK and NF- $\kappa$ B cascades. Taken together, our findings indicated that KPE contributes to alleviating a hyperinflammatory response in macrophages.

## References

1. Aderem, A.; Ulevitch, R. J. Toll-like receptors in the induction of the innate immune response. *Nature* **2000**, *406*, 782-787, 10.1038/35021228.
2. Takeuchi, O.; Akira, S. Pattern recognition receptors and inflammation. *Cell* **2010**, *140*, 805-820, 10.1016/j.cell.2010.01.022.
3. Amakura, Y.; Yoshimura, M.; Ouchi, K.; Okuyama, S.; Furukawa, Y.; Yoshida, T. Characterization of constituents in the peel of *Citrus kawachiensis* (Kawachibankan). *Biosci Biotechnol Biochem* **2013**, *77*, 1977-1980, 10.1271/bbb.130324.
4. Nishimoto, S.; Muranaka, A.; Nishi, K.; Kadota, A.; Sugahara, T. Immunomodulatory effects of citrus fruit auraptene *in vitro* and *in vivo*. *J Funct foods* **2012**, *4*, 883-890, 10.1016/j.jff.2012.06.005.
5. Lin, S.; Hirai, S.; Goto, T.; Sakamoto, T.; Takahashi, N.; Yano, M.; Sasaki, T.; Yu, R.; Kawada, T. Auraptene suppresses inflammatory responses in activated RAW264 macrophages by inhibiting p38 mitogen-activated protein kinase activation. *Mol Nutr Food Res* **2013**, *57*, 1135-1144, 10.1002/mnfr.201200611.
6. Ishida, M.; Nishi, K.; Kunihiro, N.; Onda, H.; Nishimoto, S.; Sugahara, T. Immunostimulatory effect of aqueous extract of *Coriandrum sativum* L. seed on macrophages. *J Sci food Agric* **2017**, *97*, 4727-4736, 10.1002/jsfa.8341.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-FST-010-ID024

# Anti-Inflammatory Effect of Lysozyme

Ayuka Tagashira <sup>1</sup>, Kosuke Nishi <sup>2,3</sup>, Shinya Matsumoto <sup>2</sup> and Takuya Sugahara <sup>2,3,\*</sup><sup>1</sup> The United Graduate School of Agricultural Sciences, Ehime University, Matsuyama, Ehime 790-8566, Japan<sup>2</sup> Graduate School of Agriculture, Ehime University, Matsuyama, Ehime 790-8566, Japan<sup>3</sup> Food and Health Sciences Research Center, Ehime University, Matsuyama, Ehime 790-8566, Japan

\* Correspondence: mars95@agr.ehime-u.ac.jp; Tel.: +81-89-946-9863

Received: 9 July 2018; Accepted: 4 December 2018; Published: 6 January 2020

**Abstract:** Lysozyme is an antibacterial protein that is widely distributed in nature including egg white, fish, and insects. Lysozyme from hen egg white has been reported to possess an anti-inflammatory effect; however, little is known about its detailed mechanism. We examined the effect of lysozyme on macrophages involved in inflammatory responses and on lipopolysaccharide (LPS)-induced inflammation model mice. Lysozyme significantly suppressed the production of interleukin (IL)-6 and tumor necrosis factor (TNF)- $\alpha$  by mouse peritoneal macrophages (P-mac) in a dose-dependent manner by suppressing their gene expression levels. Zymosan A-mediated phagocytosis activity of P-mac was not affected by lysozyme, suggesting that lysozyme shows the anti-inflammatory effect without affecting the phagocytotic response against microbes. In addition, lysozyme inhibited phosphorylation of c-jun N-terminal kinase (JNK) that is a member of mitogen-activated protein kinase (MAPK) involved in the production of inflammatory cytokines by macrophages. Oral administration of lysozyme at 2,250 mg/kg body weight/day significantly decreased the serum IL-6 and TNF- $\alpha$  levels in LPS-induced inflammation model mice. These findings suggest that lysozyme suppresses the gene expression of inflammatory cytokines by inhibiting MAPK signaling pathway in macrophages, and mitigates the hyperinflammatory condition in vivo.

**Keywords:** Anti-inflammatory effect; Lysozyme; Peritoneal macrophages; Tumor necrosis factor- $\alpha$ ; Interleukin-6; Lipopolysaccharide-induced inflammation model mice

## 1. Introduction

Chronic inflammation closely related to the pathological base of chronic diseases such as cancer and lifestyle-related diseases has garnered attention [1,2]. Inflammation is a defensive reaction, which occurs when individuals are infected with pathogens such as viruses and bacteria. Macrophages involved in inflammation are multifunctional leucocytes related to innate immunity and remove foreign substances such as bacteria and dead cells. In addition, lipopolysaccharide (LPS), a component of the outer membrane of Gram-negative bacteria, is recognized by macrophages and promotes the release of various mediators such as cytokines, chemokines, and prostaglandins. The recognition of LPS by macrophages is caused by binding to Toll-like receptors (TLR) 4 on the cell surface, which activates the cells and promotes the production of inflammatory mediators, such as tumor necrosis factor (TNF)- $\alpha$  and interleukin (IL)-6. On the other hand, the overexpression of these inflammatory cytokine genes causes rheumatoid arthritis, insulin resistance, and arteriosclerosis.

Lysozyme is an antibacterial protein that breaks down bacterial cell walls, and widely distributed in nature including egg white, fish, and insects. Hen egg white lysozyme is a basic protein (pI = 11) composed of a single polypeptide chain with 129 amino acid residues. Previous studies have been reported that hen egg white lysozyme promotes antibody production by lymphocytes [3,4]. In addition, heat-treated lysozyme enhances the anti-bacterial and immunostimulatory activities [5,6]. Heat treatment in the food processing step of hen egg white is considered to enhance the immunostimulatory activity. Thus, we examined the health function of lysozyme derived from hen egg white in the immune system for application to functional foods. Lysozyme is well known to exhibit the anti-inflammatory

effect in addition to anti-bacterial and immunostimulatory activities [7-9]. Lysozyme has also been reported to attenuate inflammation in a porcine model of dextran sodium sulfate-induced colitis [10] and to suppress polyphosphate-mediated vascular inflammatory responses [11]. However, the detailed mechanism of the anti-inflammatory effect of lysozyme is still unknown. Hence, we examined the effect of lysozyme on macrophages involved in inflammatory responses and on LPS-induced inflammation model mice.

## 2. Materials and Methods

### 2.1. Reagents

Lysozyme from chicken egg white ( $\geq 90\%$ ), RPMI 1640 medium, penicillin, streptomycin, fetal bovine serum (FBS), and LPS from *Escherichia coli* 026/B6 were products from Sigma-Aldrich (St. Louis, Mo, USA). Goat anti-actin antibody and anti-goat IgG antibody labeled with horseradish peroxidase (HRP) were purchased from Santa Cruz Biotechnology (Santa Cruz, CA, USA). HRP-labeled anti-rabbit IgG antibody and rabbit antibodies against extracellular signal-regulated protein kinases (ERK) 1/2, phosphorylated ERK1/2, c-Jun N-terminal kinase (JNK), phosphorylated JNK, p38 mitogen-activated protein kinase (MAPK), and phosphorylated p38 MAPK, histone H3, and nuclear factor- $\kappa$ B (NF- $\kappa$ B) p65 were purchased from Cell Signaling Technology (Danvers, MA, USA). All other chemicals were purchased from Fujifilm Wako Pure Chemical (Osaka, Japan) or Nacalai Tesque (Kyoto, Japan) unless otherwise noted.

### 2.2. Animals

BALB/c mice were obtained from Japan SLC (Shizuoka, Japan) and kept in a temperature-controlled facility. All animals were maintained and examined according to the protocol approved by the Animal care and Use Committee of Ehime University.

### 2.3. Peritoneal macrophages

Peritoneal macrophages (P-Mac) were prepared as previously described [12] with some modifications. In brief, 8-week-old female BALB/c mice were injected with 3.0% thioglycolate medium (2 mL/body) into the peritoneum. Four days after injection, mice were sacrificed and injected with 3 mL of RPMI 1640 medium into the peritoneum to harvest thioglycollate-elicited P-Mac. Collected cells were centrifuged at  $160 \times g$  for 5 min at  $4^{\circ}\text{C}$ , and the cell pellet was washed with RPMI 1640 medium and centrifuged again. The cell pellet was then resuspended in RPMI 1640 medium supplemented with 100 U/mL of penicillin, 100  $\mu\text{g/mL}$  of streptomycin, and 10% FBS and cultured in a culture dish (Corning, Corning, NY, USA). After incubation at  $37^{\circ}\text{C}$  for 1 h, the cells were washed with phosphate-buffered saline (PBS; pH 7.4) three times to remove unattached cells such as neutrophils. In the subsequent experiments, P-Mac were detached by pipetting in cold PBS.

### 2.4. Cytokine production assay

Lysozyme was dissolved in 10 mM sodium phosphate buffer (NaPB; pH 7.4) and sterilized by filtration. P-Mac suspended in 10% FBS-RPMI 1640 medium were seeded into a 96-well culture plate (Corning) at  $6.0 \times 10^4$  cells/well and cultured at  $37^{\circ}\text{C}$  overnight under humidified 5%  $\text{CO}_2$ . After washing with PBS, P-Mac were pretreated with 100 ng/mL of LPS in 200  $\mu\text{L}$  of 10% FBS-RPMI 1640 medium at  $37^{\circ}\text{C}$ . After incubation for 1 h, the cells were washed with PBS to remove LPS. P-Mac were then treated with various concentrations of lysozyme in 200  $\mu\text{L}$  of 10% FBS-RPMI 1640 medium at  $37^{\circ}\text{C}$ . After incubation for 11 h, the concentrations of IL-6 and TNF- $\alpha$  in culture media were measured by enzyme-linked immunosorbent assay (ELISA) using mouse IL-6 ELISA MAX Standard (BioLegend, San Diego, CA, USA) and mouse TNF alpha ELISA Ready-SET-Go! (eBioscience, San Diego, CA, USA), respectively, according to the manufacturer's instructions.

## 2.5. Cell viability

Cytotoxicity of lysozyme to P-Mac was examined using a WST-8 assay kit (Nacalai Tesque) according to the manufacturer's instructions. P-Mac suspended in 10% FBS-RPMI 1640 medium were seeded into a 96-well culture plate at  $6.0 \times 10^4$  cells/well and cultured at 37°C overnight under humidified 5% CO<sub>2</sub>. After washing with PBS, P-Mac were pretreated with 100 ng/mL of LPS in 200 µL of 10% FBS-RPMI 1640 medium at 37°C. After incubation for 1 h, P-Mac were washed with PBS and treated with various concentrations of lysozyme in 200 µL of 10% FBS-RPMI 1640 medium at 37°C. After incubation for 11 h, the culture media were removed, and P-Mac were cultured in 100 µL of 10% FBS-RPMI 1640 medium containing 10% WST-8 solution for 40 min at 37°C under dark condition. The absorbance was then measured at 450 nm using a microplate reader.

## 2.6. Real-time RT-PCR

P-Mac suspended in 10% FBS-RPMI 1640 medium were seeded into a 24-well culture plate at  $5.0 \times 10^5$  cells/well and cultured at 37°C overnight under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were pretreated with 100 ng/mL of LPS in 1.0 mL of 10% FBS-RPMI 1640 medium at 37°C. After incubation for 1 h, the cells were washed with PBS and treated with 500 µg/mL of lysozyme in 1.0 mL of 10% FBS-RPMI 1640 medium at 37°C. After incubation for 5 h or 11 h, total RNA was isolated from the cells using Sepasol-RNA I Super G (Nacalai Tesque) according to the manufacturer's instructions and used as a template for cDNA synthesis with MML V-reverse transcriptase (Promega, Madison, WI, USA) and an oligo-(dT)<sub>20</sub> primer (Toyobo, Osaka, Japan). Real-time PCR was performed using Thunderbird SYBR qPCR Mix (Toyobo), 10 pmol of a forward primer, 10 pmol of a reverse primer, and 0.1 µg of a cDNA sample as previously described [13]. Thermal cycling conditions were 20 s at 95°C, and 40 cycles of 3 s at 95°C and 30 s at 60°C. PCR products were measured on a StepOnePlus Real-time PCR System (Applied Biosystems, Foster City, CA, USA), and relative gene expression was calculated based on the comparative CT method using StepOne Software v2.1 (Applied Biosystems). Expression of the β-actin gene was used as an endogenous control. Specific oligonucleotide sequences for each gene are as follows. Mouse β-actin: sense, 5'-CATCCGTAAAGACCTCTATGCCAAC-3' and antisense, 5'-ATGGAGCCACCGATCCACA-3'; mouse IL-6: sense, 5'-AAGCCAGATCCTTCAGAGAGAT-3' and antisense, 5'-TTGGATGGTCTTGGTCCTTAGC-3'; mouse TNF-α: sense, 5'-CTACTCCCAGTTCTCTTCAA-3' and antisense, 5'-GCAGAGAGGAGGTTGACTTTC-3'.

## 2.7. Phagocytosis activity

Phagocytosis activity was measured as previously described [12] with some modifications. P-Mac suspended in 10% FBS-RPMI 1640 medium were seeded into a 48-well culture plate at  $2.5 \times 10^5$  cells/well and cultured at 37°C under humidified 5% CO<sub>2</sub>. After incubation for 3 h, the cells were pretreated with 100 ng/mL of LPS in 0.5 mL of 10% FBS-RPMI 1640 medium. After incubation at 37°C for 1 h, the cells were washed with PBS and treated with 500 µg/mL of lysozyme in 0.5 mL of 10% FBS-RPMI 1640 medium for 5 h or 11 h. After washing with PBS, 0.5 mL of 10% FBS-RPMI 1640 medium containing 500 µg of Texas Red-conjugated zymosan A (*Saccharomyces cerevisiae*) BioParticles (Molecular Probes, Eugene, OR, USA) were added to each well and incubated for 1 h under dark condition. After removing the culture medium, the cells were suspended in PBS and centrifuged at  $160 \times g$  for 5 min at 4°C. The cell pellet was suspended in 1 mL of 2% FBS-PBS, and phagocytosis activity was measured on a flow cytometer (FACSCalibur; BD Biosciences, San Jose, CA, USA).

## 2.8. Immunoblot analysis

P-Mac suspended in 10% FBS-RPMI 1640 medium were seeded into a 35 mm culture dish (Corning) at  $5.0 \times 10^5$  cells/dish and cultured at 37°C overnight under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were pretreated with 100 ng/mL of LPS in 2 mL of 10% FBS-RPMI 1640 medium at 37°C. After incubation for 15 min, the cells were washed with PBS and treated with 500 µg/mL of lysozyme in 2 mL of 10% FBS-RPMI 1640 medium at 37°C. After incubation for 30 min,

cytosolic proteins were prepared using a CellLytic NuCLEAR Extraction Kit (Sigma-Aldrich) according to the manufacturer's instructions. Denatured proteins were then separated using SDS-PAGE and transferred onto a PVDF membrane (Hybond-P; GE Healthcare, Buckinghamshire, UK). Immunoblotting with various antibodies was performed as previously described [14].

### 2.9. Lipopolysaccharide-induced inflammation model mice

The assay was performed by the method of [15] with some modifications. After acclimatization to their housing environment for 1 week, 8-week-old female BALB/c mice were placed into 5 groups (7 mice per group). On day 0, mice were orally administered using feeding needles (Natsume Seisakusho, Tokyo, Japan) with 200  $\mu$ L of 10 mM NaPB for intact and control groups, 200  $\mu$ L of lysozyme at 4.5 mg/kg body weight/day for the low-dose group, 200  $\mu$ L of lysozyme at 450 mg/kg body weight/day for the middle-dose group, or 200  $\mu$ L of lysozyme at 2,250 mg/kg body weight/day for the high-dose group for seven consecutive days from day 0 to day 6. Two hours after oral administration on day 6, the control, low-dose, middle-dose, and high-dose groups were injected with 20  $\mu$ L of PBS containing LPS (5 mg/kg body weight) into the peritoneum to induce systemic inflammation. In contrast, the intact group was injected with 20  $\mu$ L of PBS alone. Blood was taken by cardiac puncture 2 h after intraperitoneal administration, and sera were collected. The concentrations of IL-6 and TNF- $\alpha$  in the serum were measured by ELISA.

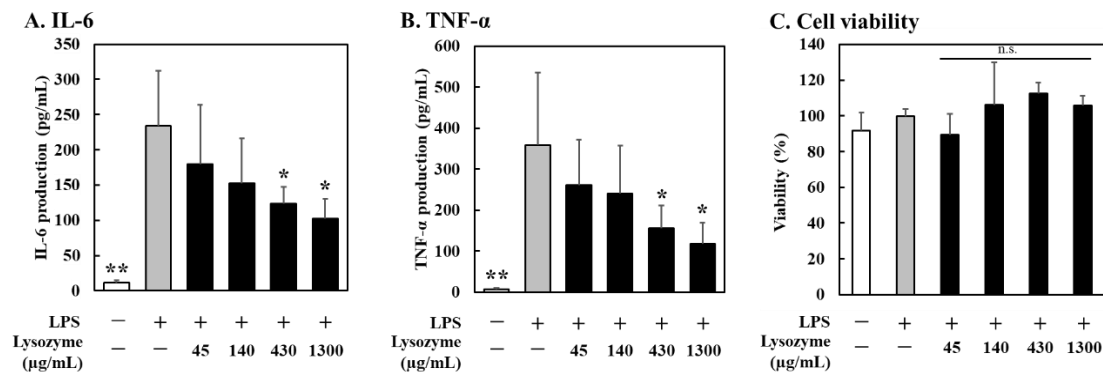
### 2.10. Statistical analysis

Data obtained were expressed as mean  $\pm$  standard deviation. One-way ANOVA followed by Dunnett's test or Tukey-Kramer test was used to assess the statistical significance of the difference. Values with \* $p$  < 0.05 or \*\* $p$  < 0.01 were considered statistically significant.

## 3. Results

### 3.1. Effect of lysozyme on inflammatory cytokine production

Firstly, the effect of lysozyme on inflammatory cytokine production by P-Mac was examined. After pretreatment with 100 ng/mL of LPS for 1 h, P-Mac were treated with lysozyme at various concentrations for 11 h, and the cytokine concentration in the medium was measured by ELISA. As shown in Fig. 1A and 1B, lysozyme significantly inhibited the production of IL-6 and TNF- $\alpha$  in dose-dependent manners. When P-Mac were treated with 500  $\mu$ g/mL of lysozyme, the production of IL-6 and TNF- $\alpha$  was suppressed by around 50% compared with control. The cytotoxicity of lysozyme was evaluated using the WST-8 assay. The result showed that lysozyme has no cytotoxicity to P-Mac at 1,000  $\mu$ g/mL (Fig. 1C). From these results, further experiments were performed at 500  $\mu$ g/mL of lysozyme.



**Figure 1.** The effect of lysozyme on inflammatory cytokine production and viability of P-Mac. (A) and (B), for cytokine production assay, P-Mac were pretreated with 100 ng/mL of LPS or 10 mM NaPB. After washing, the cells were treated with various concentrations of lysozyme or with 10 mM NaPB. After incubation for 11 h, the concentrations of IL-6 and TNF- $\alpha$  in the culture medium were measured by ELISA. Data were represented as mean  $\pm$  standard deviations ( $n = 6$ ). \* $p < 0.05$  or \*\* $p < 0.01$  against LPS (+) / Lysozyme (-) by Dunnett's test. (C), for cell viability assay, P-Mac were pretreated with 100 ng/mL of LPS or 10 mM NaPB. After washing, the cells were treated with various concentrations of lysozyme or with 10 mM NaPB. After incubation for 11 h, cell viability was measured using a WST-8 assay kit. Data were represented as mean  $\pm$  standard deviations ( $n = 9$ ). n.s. indicates no statistical significance against LPS (+) / Lysozyme (-) by Dunnett's test.

### 3.2. Effect of lysozyme on cytokine gene expression

As described above, lysozyme inhibited cytokine production by P-Mac without cytotoxicity. Hence, the effect of lysozyme on cytokine gene expression was examined. After pretreatment with 100 ng/mL of LPS for 1 h, P-Mac were treated with lysozyme at 500  $\mu$ g/mL for 5 h or 11 h. After that, the transcription level of the cytokine genes was evaluated by real-time RT-PCR. As a result, the expression of IL-6 and TNF- $\alpha$  genes was significantly inhibited by lysozyme in both treatment time (Data not shown). These results indicated that lysozyme downregulates the expression of IL-6 and TNF- $\alpha$  genes within 5 h after treatment, resulting in suppressed production of IL-6 and TNF- $\alpha$ . Furthermore, it was revealed that the effect of suppressed IL-6 and TNF- $\alpha$  gene expression by lysozyme continues at least for 11 h after treatment.

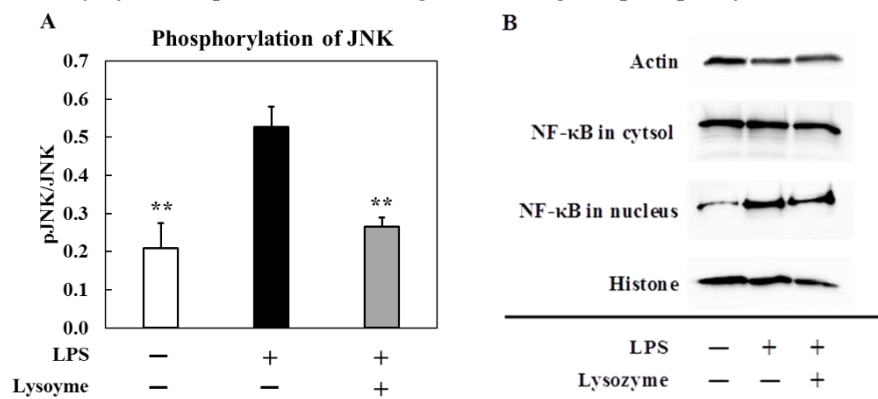
### 3.3. Effect of lysozyme on phagocytotic activity

Macrophages have an important role in innate immunity such as ingesting foreign materials and enhancing immune responses. We thus examined the effect of lysozyme on the phagocytosis activity of P-Mac using Texas Red-labeled zymosan A. P-Mac were treated with 500  $\mu$ g/mL of lysozyme for 5 h or 11 h after pretreatment with 100 ng/mL of LPS for 1 h. The cells were then treated with Texas Red-labeled zymosan A for 1 h. The results showed that the zymosan A-mediated phagocytosis activity of the P-Mac is not affected by lysozyme compared with control. Thus, lysozyme inhibits LPS-induced cytokine production by P-Mac, but does not modulate phagocytotic activity. These results suggested that lysozyme has an anti-inflammatory effect without inhibiting the innate immune response by macrophages.

### 3.4. Effect of lysozyme on the signaling pathways in macrophages

Macrophages are induced the expression of inflammatory cytokine genes by activating the MAPK and the NF- $\kappa$ B signaling pathways. The effect of lysozyme on MAPK and NF- $\kappa$ B signaling was then examined. P-Mac were treated with 500  $\mu$ g/mL of lysozyme for 30 min after pretreatment with 100 ng/mL of LPS for 15 min, and the cytosolic protein levels of the signal molecules were evaluated by immunoblot analysis. As summarized in Fig. 2A, the phosphorylation level of JNK was inhibited by lysozyme whereas those of ERK and p38 were not affected. In addition, lysozyme did not affect the

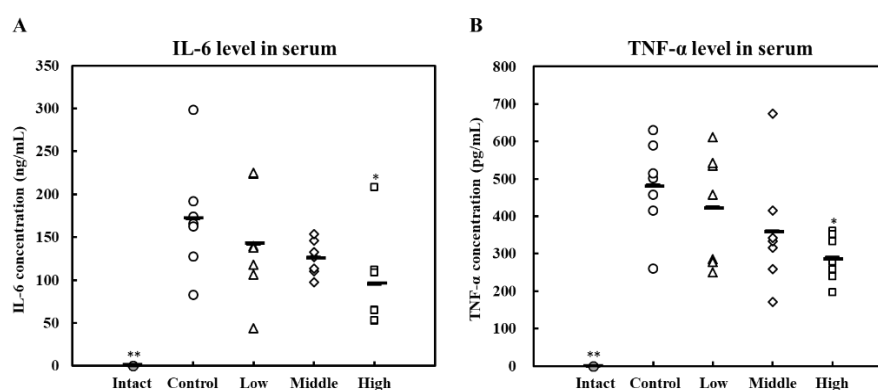
translocation of NF- $\kappa$ B from cytosol to the nucleus (Fig. 2B). These results suggest that lysozyme inhibits inflammatory cytokine production through inhibiting the phosphorylation of JNK.



**Figure 2.** The effect of lysozyme on the signaling pathways of macrophage activation. P-Mac were pretreated with 100 ng/mL of LPS or 10 mM NaPB for 15 min. After washing, the cells were treated with 500  $\mu$ g/mL of lysozyme or 10 mM NaPB for 30 min. (A), The result of densitometric analysis was expressed as the ratio of the amount of phosphorylated protein to that of whole protein. Data were represented as mean  $\pm$  standard deviations of three independent experiments. \*\* $p < 0.01$  against LPS (+) / Lysozyme (-) by Tukey-Kramer test. (B), The protein level of NF- $\kappa$ B was evaluated by immunoblot analysis.

### 3.5. Effect of lysozyme in LPS-induced inflammation model mice

The effect of lysozyme *in vivo* was evaluated by LPS-induced inflammation model mice. Oral administration of lysozyme to mice for 7 consecutive days did not change body weight in all lysozyme-treated groups. In this experiment, systemic inflammation in mice was induced by LPS at 5 mg/kg body weight via intraperitoneal administration. As indicated in Fig. 3, the amounts of IL-6 and TNF- $\alpha$  in sera were significantly decreased in the high-dose group (2,250 mg/kg body weight/day) compared to the control group. Furthermore, the amounts of IL-6 and TNF- $\alpha$  tended to be suppressed in the middle-dose group (450 mg/kg body weight/day). These results suggest that lysozyme alleviates systemic inflammation *in vivo*.



**Figure 3.** The effect of lysozyme on the amounts of inflammatory cytokines in serum. (A), (B), Seven-week-old female BALB/c mice were orally administered with 10 mM NaPB or lysozyme at various concentrations for seven consecutive days from day 0 to day 6. Two hours after oral administration on day 6, LPS (5 mg/kg body weight) in PBS was injected via peritoneum to induce systemic inflammation. In contrast, PBS was injected to intact group. Two hours after intraperitoneal administration, serum was collected. Then, the concentrations of IL-6 and TNF- $\alpha$  in serum were measured by ELISA. Data were represented as mean  $\pm$  standard deviations of three independent experiments. \* $p < 0.05$  or \* $p < 0.01$  against control by Tukey-Kramer test.



#### 4. Discussion

In this study, it was revealed that lysozyme suppresses production of IL-6 and TNF- $\alpha$  by suppressing their gene expression levels. It has been reported that lysozyme binds to LPS to form a complex and inhibits inflammatory reaction [16]. Moreover, several peptides derived from human lysozyme bind to TLR4 to show an antagonistic anti-inflammatory effect [17]. On the other hands, in this study, LPS was washed away with PBS before lysozyme treatment against P-Mac. Then, it is revealed that the suppressive effect of lysozyme on LPS-induced inflammation is not due to its antagonism activity against TLR4. Macrophages have an important role in innate immunity such as destroying microorganisms, ingesting foreign materials, removing dead cells, and enhancing acquired immune responses. As a result of examining the effect of lysozyme on the phagocytic activity of P-Mac, phagocytosis activity of P-Mac was not affected by lysozyme. These results suggested that lysozyme shows an anti-inflammatory effect without inhibiting the innate immune responses by macrophages. Next, the mechanism underlying the inhibition of inflammatory cytokine production by lysozyme was investigated. Macrophages are induced the expression of inflammatory cytokine genes by activating the MAPK and NF- $\kappa$ B cascades. LPS activates MAPK and NF- $\kappa$ B signaling to facilitate inflammatory cytokine production. To reveal how lysozyme affects these cascades, we examined the effect on the signal molecules in MAPK and NF- $\kappa$ B cascade. As summarized in Fig. 2, the phosphorylation level of JNK was significantly inhibited by lysozyme, whereas that of ERK or p38 was not affected, and lysozyme showed no effect on the translocation of NF- $\kappa$ B into the nucleus. These results suggest that lysozyme inhibits inflammatory cytokine production through inhibiting the phosphorylation of JNK. Finally, we investigated the effect of oral administration of lysozyme on LPS-induced inflammation model mice. As a result, oral administration of lysozyme significantly decreased the amounts of IL-6 and TNF- $\alpha$  in sera compared to the control group, suggesting that lysozyme mitigates the hyperinflammatory condition *in vivo*. These data indicate that lysozyme exhibits anti-inflammatory effect *in vitro* and *in vivo* and is expected to be effective as a functional food material.

#### 5. Conclusions

Although lysozyme is well known to exhibit the anti-inflammatory effect, the detailed mechanism of its effect is still unknown. In this study, we found that lysozyme inhibits phosphorylation of JNK to suppress pro-inflammatory cytokines. Moreover, lysozyme suppressed inflammatory cytokine levels in sera from LPS-induced inflammation model mice. Taken together, our data indicate that lysozyme exerts anti-inflammatory effect *in vitro* and *in vivo*.

**Acknowledgments:** This work was supported by a JSPS KAKENHI Grant-in-Aid for Scientific Research C (15K07432). Animal experiments were accomplished at the Division of Genetic Research of the Advanced Research Support Center (ADRES), Ehime University.

#### References

1. Coussens, L.M.; Zitvogel, L.; Palucka, A.K. Neutralizing tumor-promoting chronic inflammation: a magic bullet? *Science* **2013**, *339*, 286-291, 10.1126/science.1232227.
2. Manabe, I. Chronic inflammation links cardiovascular, metabolic and renal diseases. *Circ J*, **2011**, *75*, 2739-2748, 10.1253/circj.CJ-11-1184.
3. Murakami, F.; Sasaki, T.; Sugahara, T. Lysozyme stimulates immunoglobulin production by human-human hybridoma and human peripheral blood lymphocytes. *Cytotechnology* **1997**, *24*, 177-182, 10.1023/A:1007936629501.
4. Sugahara, T.; Murakami, F.; Yamada, Y.; Sasaki, T. The mode of actions of lysozyme as an immunoglobulin production stimulating factor. *Biochim Biophys Acta* **2000**, *1475*, 27-34, 10.1016/S0304-4165(00)00041-6.
5. Sugahara, T.; Yamada, Y.; Yano, S.; Sasaki, T. Heat denaturation enhanced immunoglobulin production stimulating activity of lysozyme from hen egg white. *Biochim Biophys Acta* **2002**, *1572*, 19-24, 10.1016/S0304-4165(02)00272-6.

6. Carrillo, W.; Gracia-Ruiz, A.; Recio, I.; Moreno-Arribas, M.V. Antibacterial activity of hen egg white lysozyme modified by heat and enzymatic treatments against oenological lactic acid bacteria and acetic acid bacteria. *J Food Prot* **2014**, *77*, 1732-1739, 10.4315/0362-028X.JFP-14-009.
7. Ogundele, M.O. A novel anti-inflammatory activity of lysozyme: modulation of serum complement activation. *Mediators Inflamm* **1998**, *7*, 363-365, 10.1080/09629359890893.
8. Lee, W.; Ku, S.K.; Na, D.H.; Bae, J.S. Anti-inflammatory effects of lysozyme against HMGB1 in human endothelial cells and in mice. *Inflammation* **2015**, *38*, 1911-1924, 10.1007/s10753-015-0171-8.
9. Carrillo, W.; Spindola, H.; Ramos, M.; Recio, I.; Carvalho, J.E. Anti-inflammatory and anti-nociceptive activities of native and modified hen egg white lysozyme. *J Med Food* **2016**, *19*, 978-982, 10.1089/jmf.2015.0141.
10. Lee, M.; Kovacs-Nolan, J.; Yang, C.; Archbold, T.; Fan, M.Z.; Mine, Y. Hen egg lysozyme attenuates inflammation and modulates local gene expression in a porcine model of dextran sodium sulfate (DSS)-induced colitis. *J Agric Food Chem* **2009**, *57*, 2233-2240, 10.1021/jf803133b.
11. Chung, J.; Ku, S.K.; Lee, S.; Bae, J.S. Suppressive effects of lysozyme on polyphosphate-mediated vascular inflammatory responses. *Biochem Biophys Res Commun* **2016**, *474*, 715-721, 10.1016/j.bbrc.2016.05.016.
12. Purta, A.B.N.; Morishige, H.; Nishimoto, S.; Nishi, K.; Shiraishi, R.; Doi, M.; Sugahara, T. Effect of collagens from jellyfish and bovine Achilles tendon on the activity of J774.1 and mouse peritoneal macrophages cells. *J Funct Foods* **2012**, *4*, 504-512, 10.1016/j.jff.2012.02.011.
13. Nishi, K.; Kondo, A.; Okamoto, T.; Nakano, H.; Daifuku, M.; Nishimoto, S.; Ochi, K.; Takaoka, T.; Sugahara, T. Immunostimulatory *in vitro* and *in vivo* effects of a water-soluble extract from kale. *Biosci Biotechnol Biochem* **2011**, *75*, 40-46, 10.1271/bbb.100490.
14. Kanda, K.; Nishi, K.; Kadota, A.; Nishimoto, S.; Liu, M.C.; Sugahara, T. Nobiletin suppresses adipocyte differentiation of 3T3-L1 cells by an insulin and IBMX mixture induction. *Biochem Biophys Acta* **2012**, *1820*, 461-468, 10.1016/j.bbagen.2011.11.015.
15. Mendes, S.J.F.; Sousa, F.I.A.B.; Pereira, D.M.S.; Ferro, T.A.F.; Pereira, I.C.P.; Silva, B.L.R.; Pinheiro, A.J.M.C.R.; Mouchrek, A.Q.S.; Monteiro-Neto, V.; Costa, S.K.P.; Nascimento, J.L.M.; Grisotto, M.A.G.; da Costa, R.; Fernandes, E.S. Cinnamaldehyde modulates LPS-induced systemic inflammatory response syndrome through TRPA1-dependent and independent mechanisms. *Int Immunopharmacol* **2016**, *34*, 60-70, 10.1016/j.intimp.2016.02.012.
16. Takada, K.; Ohno, N.; Yadomae, T.; Detoxification of lipopolysaccharide (LPS) by egg white lysozyme. *FEMS Immunol Med Microbiol* **1994**, *9*, 255-263, 10.1111/j.1574-695X.1994.tb00360.x.
17. Ibrahim, H.R.; Hamasaki, K.; Miyata, T. Novel peptide motifs from lysozyme suppress pro-inflammatory cytokines in macrophages by antagonizing toll-like receptor and LPS-scavenging action. *Eur J Pharm Sci* **2017**, *107*, 240-248, 10.1016/j.ejps.2017.07.005.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-FST-013-ID025

# Inhibitory Effect of Caffeine on Degranulation of RBL-2H3 Cells

Arita Dewi Nugrahini <sup>1,2</sup>, Momoko Ishida <sup>3</sup>, Kosuke Nishi <sup>3,4</sup> and Takuya Sugahara <sup>3,4\*</sup>

<sup>1</sup> Faculty of Agricultural Technology, Gadjah Mada University, Yogyakarta 55281, Indonesia

<sup>2</sup> The United Graduate School of Agricultural Sciences, Ehime University, Matsuyama, Ehime 790-8566, Japan

<sup>3</sup> Graduate School of Agriculture, Ehime University, Matsuyama, Ehime 790-8566, Japan

<sup>4</sup> Food and Health Sciences Research Center, Ehime University, Matsuyama, Ehime 790-8566, Japan

\* Correspondence: mars95@agr.ehime-u.ac.jp; Tel.: +81-89-946-9863

Received: 9 July 2018; Accepted: 4 December 2018; Published: 6 January 2020

**Abstract:** It is well known that caffeine can have positive health effects. Caffeine consumption may reduce some of the risks of chronic diseases, diabetes, liver disease, and cancer, as well as improve immune function. Although caffeine has been shown to provide several benefits to human health, there are no reports on anti-allergic activity. In this study, we focused on the inhibitory effect of caffeine on the degranulation of basophils that may indicate the inhibition of type I allergy. Effect of caffeine on antigen-induced degranulation by rat basophil cell line, RBL-2H3 cells was evaluated. As a result, caffeine significantly inhibited the release of  $\beta$ -hexosaminidase from RBL-2H3 cells in a dose-dependent manner without cytotoxicity. Besides, caffeine suppressed the elevation of intracellular  $\text{Ca}^{2+}$  concentration induced by antigen.

**Keywords:** caffeine; degranulation; mast cell; anti-allergy

---

## 1. Introduction

Allergic disorders increase dramatically in some developed countries. Allergy is a global healthcare problem that significantly affects daily activities, work productivity, learning, sleep, and quality of life in people of all ages [1]. Allergic reactions represent an immune response to allergens entering into our body from the environment. Allergens may be house dust, pollen, and also foods such as milk, eggs, and wheat [2].

Allergy is classified into four types. Among them, the type I allergy is the most common allergic reaction associated with asthma, hives, hay fever, and allergic dermatitis. During the initiation of type I allergic reaction, the allergen binds to IgE molecules binding to high-affinity IgE receptors ( $\text{Fc}\epsilon\text{RI}$ ) on cell surfaces of mast cells and basophils. The cross-linking between the cell-bound IgE- $\text{Fc}\epsilon\text{RI}$  complex and specific antigen causes the aggregation of  $\text{Fc}\epsilon\text{RI}$ , which induces a variety of cellular responses, including the release of chemical mediators such as histamine,  $\beta$ -hexosaminidase, leukotrienes, prostaglandins, pro-inflammatory cytokines, and chemokines [3-5]. The process of releasing such chemical mediators is defined as degranulation process which induces allergic reactions.

Caffeine (1,3,7-trimethylxanthine,  $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$ ) is a natural alkaloid or xanthine alkaloid found in coffee beans, tea leaves, cocoa beans, cola nuts, and other plants. It is one of the most widely used pharmacological substances in the world. Caffeine consumption in the world today is quite high. More than eighty percent of the world's population consumes caffeine every day both for stimulants, drug combinations and reducing jetlag [6-10]. This active compound can provide health benefits, such as a source of antioxidants, anti-cancer, anti-bacterial, and anti-inflammatory activities. This study aims to determine the inhibitory effect of caffeine on degranulation of RBL-2H3 cells.

## 2. Materials and Methods

### 2.1. Materials

The equipments used in this study were 15 mL and 50 mL centrifuge tubes, pH-meter, 5 mL syringe, 0.22  $\mu$ m filters, 1.5 mL sample tubes, 50 mL glass beaker, blade grinder, electronic balance, autoclave, rotary mixer, high-speed centrifuge, cell counter, 96-well plates, and plate reader.

While the materials used in this study were caffeine, sterilized distilled water (DW), rat basophilic leukemia RBL-2H3 cells, sterilized phosphate buffered saline (PBS), fetal bovine serum (FBS), Dulbecco's Modified Eagle's medium (DMEM), anti DNP-IgE, DNP-HSA, substrate solution, TritonX-100, trypsin-EDTA (0.25% trypsin-0.02% EDTA-PBS), tyrode's buffer, glycine buffer, loading buffer for blank and sample, loading medium, WST-8 Solution, PVDF membrane, Towbin buffer, running buffer, filter papers, TBS-t (0.1%), 5% skim milk-TBS-t, 1st antibodies, actin, 5% BSA-TBS-t, goat anti-rabbit IgG, HRP-linked antibody, donkey anti-goat IgG, HRP-linked antibody, MeOH, and distilled water (DW).

### 2.2. Methods

#### 2.2.1. Sample preparation

Caffeine was prepared with a concentration of 20 mM. Firstly, caffeine was weighed as much as 19.5 mg. A total of 3 mL of DW was added to dissolve caffeine. The pH of the sample was adjusted to 7.4 ( $\pm 0.1$ ), then DW was added to fill up to 5 mL. The caffeine solution was filtered using a 0.22  $\mu$ m filter, and then it was stored in the freezer.

#### 2.2.2. Cell seeding

RBL-2H3 cells were torn off by sterilized 0.05% EDTA-trypsin, stored in 15 mL centrifuge tube and centrifuged at 1,000 rpm for 5 min. This supernatant was removed, and the precipitated cells were suspended with 10% FBS-DMEM medium, and it was centrifuged at 1,000 rpm for 5 min. This supernatant was removed, and cell density was adjusted to  $2.0 \times 10^5$  cells/mL. Then, 200  $\mu$ L/well of suspension was added to 96-well culture plate and incubated for 18 h.

#### 2.2.3. Degranulation assay

First steps of degranulation assay were conducted on the clean bench. Eleven milliliters of 5% FBS-DMEM medium was prepared in centrifuge tube. One milliliter of the solution was taken out and put into sample tube (for blank). Anti-DNP IgE solution was prepared. Then the 96-well plate seeded with RBL-2H3 cells was washed with 200  $\mu$ L of PBS. After that, 120  $\mu$ L of anti-DNP IgE solution was added to the 96-well plate and incubated for 2 h. The sample solution was prepared. After 2 h, the 96-well plate was observed under a microscope, and anti-DNP IgE was removed from the 96-well plate. The cells were washed twice with 200  $\mu$ L of 1x Tyrode's buffer. Then 120  $\mu$ L of sample solution was added to the 96-well plate and incubated for 10 min. The sample solution was removed, and 120  $\mu$ L of 1x Tyrode's buffer was added to the plate. Then 10  $\mu$ L/well of DNP-HSA solution was added to the 96-well plate and incubated for 30 min. During the incubation, 0.1% TritonX-100 solution and substrate solution were prepared outside the clean bench. After 30 min, the 96-well plate was taken out from the incubator and put on ice for 10 min. The supernatant was moved into the other 96-well plate on ice. Then 130  $\mu$ L/well of 0.1% Triton X-100 solution was added to the cell lysate and crushed it using ultrasonic disintegrator for 5 sec/well on ice. After that, 50  $\mu$ L/well of supernatant and cell lysate were moved into the other 96-well plate. The 96-well plate was incubated at 37°C for 5 min. After the incubation, 100  $\mu$ L/wells of substrate solution and 100  $\mu$ L/ well of 2 M glycine buffer were added to the wells alternately and incubated at 37°C for 25 min. After the incubation, 100  $\mu$ L/well of substrate solution and 2 M glycine buffer were added to the wells on the reverse. Then the solutions in the 96-well plate were measured by optical absorbance at 405 nm.

### 2.2.4. Viability assay

After collection of culture supernatant, wells were washed with PBS. One hundred  $\mu\text{L}$  of 10% FBS-DMEM medium and 10  $\mu\text{L}$  of WST-8 were added to each well and plate was incubated in the dark. The absorbance was measured at 450 nm and the reference at 655 nm by a plate reader.

### 2.2.5. Intracellular $\text{Ca}^{2+}$ assay

Intracellular calcium assay was carried out after the cell seeding was conducted. Anti-DNP IgE was diluted with 10 mL of 5% FBS-DMEM at 10,000 folds. After 18 h of incubation (cell seeding), RBL-2H3 cells were taken out from the incubator, and the medium was removed from each well. The cells were washed with sterilized PBS, and 120  $\mu\text{L}$  of anti-DNP IgE solution was added to each well, then the plate was incubated for 2 h. During the incubation, loading buffers and loading medium were prepared. After the incubation, the cells were taken out from the incubator, and then anti DNP-IgE solution was removed. The cells were washed with PBS twice, and 100  $\mu\text{L}$  loading buffers (for blank and sample) were added to each well, then it was incubated for 1 h. During incubation, DNP-HSA solution was diluted at 16,000 folds. Then loading buffers were removed, and the cells were washed with PBS twice. After that, 100  $\mu\text{L}$  of recording medium was added to each well and then incubated for 10 min. After incubation, the plate was measured by fluorescence plate reader (at 0 min). Ten  $\mu\text{L}$  of DNP-HSA solution was added to each well (outside the clean bench), and then fluorescence intensity was measured by fluorescence plate reader (at 1-30 min).

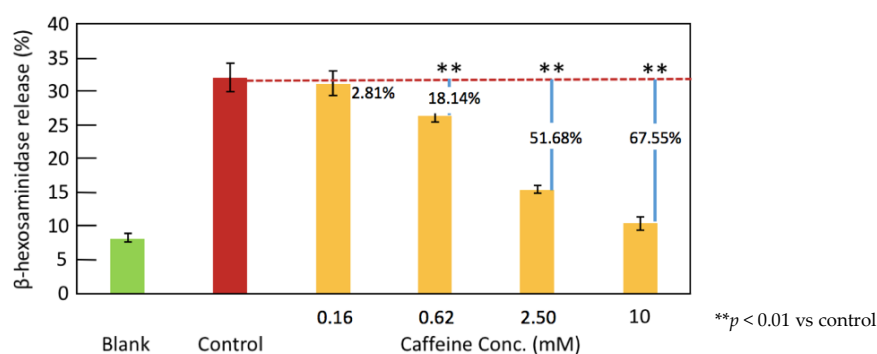
### 2.2.6. Statistical analysis

Data were represented as the mean  $\pm$  SD. Statistical analysis was performed using Dunnett's test to identify significant differences between groups.

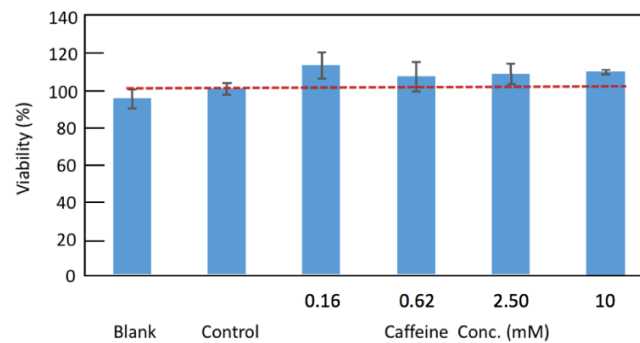
## 3. Results and Discussion

### 3.1. Effects of caffeine on the antigen-mediated degranulation of RBL-2H3 cells

We examined the effects of caffeine on the antigen-mediated degranulation of RBL-2H3 cells. This study was aimed to examine the inhibitory effect of caffeine on  $\beta$ -hexosaminidase release along with degranulation by RBL-2H3 cells. As shown in Fig. 1, caffeine inhibited the release of the  $\beta$ -hexosaminidase from antigen-induced RBL-2H3 cells, suggesting that caffeine can suppress the release of histamine. Caffeine concentrations used in this experiment were 0.16, 0.62, 2.5 and 10 mM, and caffeine at these concentrations inhibited the release of  $\beta$ -hexosaminidase by 2.8%, 18.1%, 51.7%, and 67.6%, respectively. We found that caffeine at higher concentration had a higher inhibitory effect on degranulation. In addition, caffeine had no cytotoxic effects on RBL-2H3 cells (Fig. 2).



**Figure 1.** Effect of caffeine on degranulation by RBL-2H3 cells



**Figure 2.** Cytotoxicity of caffeine on RBL-2H3 cells

### 3.2. Effects of caffeine on $\text{Ca}^{2+}$ concentration in RBL-2H3 cells

To clarify the mechanisms that underlie the inhibitory effects of caffeine on antigen-stimulated degranulation, we determined the degranulation-mediated  $\text{Ca}^{2+}$  influx upstream of degranulation response.  $\text{Ca}^{2+}$  concentration in RBL-2H3 cells is increased by the antigen-antibody induction. In this experiment, we examined the effect of caffeine on antigen-antibody induced increase in  $\text{Ca}^{2+}$  concentration in RBL-2H3 cells. As a result, caffeine suppressed increase in  $\text{Ca}^{2+}$  concentration induced by antigen in a dose-dependent manner.

## 4. Conclusions

Caffeine was found to be capable of inhibiting antigen-stimulated degranulation in RBL-2H3 cells. The inhibitory effects of caffeine on antigen-stimulated degranulation in RBL-2H3 cells were demonstrated, and this effect was related to the suppression of  $\text{Ca}^{2+}$  influx.

**Acknowledgement.** This work was supported by *Lembaga Pengelola Dana Pendidikan (LPDP)*; Indonesian Ministry of Finance; and Indonesian Ministry of Research, Technology and Higher Education.

## References

1. Yamada, T.; Saito, H.; and Fujieda, S. Present state of Japanese cedar pollinosis: the national affliction. *J Allergy Clin Immunol* **2014**, 133(3):632-639.
2. Campbell, D.E.; hILL, d.j.; Kemp, A.S. Enhanced IL-4 but normal interferon-gamma production in children with isolated IgE mediated food hypersensitivity. *Pediatr Allergy Immunol* **1998**, 9:68-72.
3. Broide, D.; Sriramaraio, P. Eosinophil trafficking to sites of allergic inflammation. *Immunol Rev* **2001**, 179:163-72.
4. Srivastava, K.D.; Qu, C.; Zhang, T. Food allergy herbal formula-2 silences peanut-induced anaphylaxis for a prolonged posttreatment period via IFN-gamma-producing CD8+ T cells. *J Allergy Clin Immunol* **2009**, 123:443-51.
5. Kalesnikoff, J.; Galli, S.J. New developments in mast cell biology. *Nat Immunol* **2008**, 9(11):1215-23.
6. Sadock, B.J.; Sadock, V.A. Kaplan & Sadock's Synopsis of Psychiatry: Behavioral Sciences. In *Clinical Psychiatry*, 10<sup>th</sup> ed. Lippincott Williams & Wilkins: New York, 2007; p.413- 7.
7. Norton, T.R.; Lazev, A.B.; Sullivan, M.J. The "Buzz" on caffeine: patterns of caffeine use in a convenience sample of college students. *Journal of Caffeine Research* **2011**, 1(1):35-40.
8. Juliano, L.M.; Griffiths, R.R. A critical review of caffeine withdrawal: empirical validation of symptoms and signs, incidence, severity and associated features. *Psychopharmacology* **2004**, 176: 1-29.
9. Waterhouse, J; Reily, T.; Atkinson, G.; Edwards, B. Jet lag: trends and coping strategies. *Lancet* **2007**, 369:1117-29.
10. Katzung, B.G.; Masters, S.B.; Trevor, A.J. *Basic and Clinical Pharmacology*, 12th ed. McGrawHill Medical: New York, 2012; p:565-80.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

*FP-EPS-002-ID047*

# Constraints in The Use of Balanced Scorecard Performance Measurement Parameters on Small-Medium Enterprises (Case Study on The Application of SMEs Performance Measurement at CV. X and Y)

**Totok Pujianto<sup>1,\*</sup>**<sup>1</sup> Dept. of Agroindustrial Technology; totok.pujianto@unpad.ac.id

\* Correspondence: totok.pujianto@unpad.ac.id; Tel.: +62-856-212-6252

Received: 8 August 2018; Accepted: 28 August 2019; Published: 6 January 2020

**Abstract:** Performance measurement method that are widely used to measure company performance is Balanced Scorecard (BSC). The BSC method consists of four perspectives, while from these, a company strategic objective will be designed. Pujianto et al (2016) conducted a study that produced performance measurement parameters based on BSC. Although performance parameters have been found, the accuracy and suitability still needs to be evaluated. This is based on the validation of a number of parameters in the process of measuring the performance of two small producers of snack foods as case studies. When applied there are some obstacles, where there are parameters that are difficult or even impossible to calculate for various reasons. Moreover, even measurement parameters are considered less precise to be used. It is therefore necessary to discuss some of the constraints that arise when those parameters are used to measure the performance of SMEs as well as the reasons why they are considered less precise. The study included: identification of measurement parameters along with a number of variables needed, compiling a number of questions as a discussion guide, arranging for possible grouping of constraint types. Field study was conducted in the form of in-depth discussions with a number of business actors and or managers related to each performance measurement parameter. The method of analysis through a small group discussion is qualitative by presenting the side of the measurement constraints, both technical and logical. Among the 32 parameters, there are 9 parameters discussed in the constraints in the implementation of the measurement. Measurement parameters which are the main constraints in measuring company performance are recording data and information. This parameter is also a source of constraints for measurement of other parameters. Based on the 9 parameters discussed, there are a number of measurement parameters that still need to be reviewed or need to be replaced, namely: number of trained employees, number of work accidents, and number of employee recruitment. whereas those that need rearrangement of the equations used are: number of complaints and compliments, number of defective products, and number of employee recruitment. other parameters that still need to be used are: additional number of market area, number of direct customer interactions, and recording of data and information, because the constraints in measurement are caused by the company's inability to fulfill its performance.

**Keywords:** Constraint in Measurement; Measurement Parameter; Performance Measurement; SME Performance

---

## 1. Introduction

It is very important to measure the performance of a company to be a benchmark for achieving the goals and objectives of the company, as well as to improve and maintain the quality of the company. Performance measurement is a measurement action against various activities within the value chain of a company. Performance measurement is a process of measuring the efficiency and effectiveness of the company [1].



Many studies of performance measurement with the aim of obtaining measurement effectiveness especially in small and medium industries (SMEs). Several studies have been conducted with a focus on determining the exact measurement parameters and in accordance with the characteristics of the SME [1-5].

Performance measurements are many and more easily performed on large industries due to the availability, completeness and accuracy of the data required in measurement, but not when it is applied to SMEs. The performance measurements of SMEs differ from performance measures in large industries due to their different characteristics. Performance measurement approaches are generally designed for large industries, and are often not applicable to SMEs especially in developing countries, because: (1) SMEs are not well structured and correct, and (2) SME's often does not collect the information required for measurement complex performance [2]. Therefore, measuring the performance of IKM needs to be adjusted to the characteristics of SMEs [2].

Performance measurement systems (PMS) enable enterprises to evaluate the extent to which their goals are being met and the efficiency of their decisions by means of a set of indicators. Nevertheless their implementation in small and medium-sized enterprises (SMEs) is scarce. One of the reasons for this is the lack of suitable methodologies to guide the implementation of a PMS focused on the specific needs of SMEs [5].

Author [6] stated that performance measurement methods that are widely used to measure company performance are Balanced Scorecard (BSC) and Performance Prism (PP). The Balanced Scorecard (BSC) method consists of four perspectives, namely financial (Financial), customer (Customer), internal business processes (Internal Processes), and learning and growth (Learning and Growth). From these four perspectives an IKM strategic objective will be designed. BSC consists of three functions, namely as a measurement system, strategic management system, and as a communication tool [7].

Author [3] conducted a study of SME performance measurements in the UK using the Balanced Scorecard (BSC) Method which concluded that there is a gap between performance measurement theory and its implementation in SME scale companies. Author [8] argue the need for a general approach to the examination of performance measurement in organisations, a perspective that addresses the key questions identified by managers and how they deal with the design, implementation, and usage of performance measurement in real-time settings.

Author [6] conducted a study that produced performance measurement parameters based on Balanced Score Card (BSC). Although performance parameters have been found, the accuracy and suitability still needs to be evaluated. This is based on the validation of a number of parameters in the process of measuring the performance of two small producers of snack foods as case studies. When applied there are some obstacles, where there are parameters that are difficult or even impossible to calculate for various reasons. Moreover, even measurement parameters are considered less precise to be used.

It is therefore necessary to discuss some of the constraints that arise when those parameters are used to measure the performance of SMEs as well as the reasons why they are considered less precise. This discussion can be used as a material to improve the parameters so as to obtain a better performance measurement package for SMEs in food business. Benefits to be gained is the improvement of performance measurement more simple but precise and appropriate.

## 2. Materials and Methods

This research is descriptive, using the object of research that is the parameter of performance measurement for SME in food which is the result of research conducted by Pujianto et al (2016) [6]. The study begins with a study of the results of the research object above. The study included: (1) identification of measurement parameters (Key Performance Indicators) along with a number of variables needed to determine the measurement results, (2) compiling a number of questions as a discussion guide to answer the need for measurement parameters to be used and the reasons for the variables used to measure them. The variables are either quantitative or qualitative, (3) arranging for

possible grouping of constraint types, both on the level of measurement parameters and the variables they need.

Furthermore, a field study was conducted in the form of in-depth discussions with a number of business actors and or managers in CV. X and Y related to each performance measurement parameter. Each measurement parameter from each perspective within the BSC framework and from each strategic objective is discussed. The method of analysis is qualitative by presenting the side of the measurement constraints as well as the guidance of assessments, both technical and logical. The technical nature in question is that which concerns the availability of variable data needed in the measurement. The logic in question is the logic of the absence of possible measurement parameters applied. This process is done through a small group discussion in which the discussion member is a research team involved in the assessment process.

### 3. Results and Discussion

The measurement parameters evaluated to discuss various obstacles in their application are performance measurement parameters with BSC perspective as shown in Table 1.

**Table 1.** Performance Measurement Parameters with BSC Perspective

Perspective	Strategic Objectives	Parameters
Financial	Long-term Financial Success	Return On Investment (ROI) Return On Equity (ROE) Total Asset Turn Over (TATO) Return On Asset (ROA)
	Short-term Financial Success	Profit Margin Sales Growth
Customer	Increase customer satisfaction	Number of complaints and compliments On time delivery
	Increase market share	Sales volume Number of market areas Market segments
	Management of customer needs	Number of direct interactions with customers Customer retention
	Development of new products	Number of new variants Number of new products
Internal Business Process	Increase production capacity	Technology changes Managerial change
	Risk and crisis management	Amount of equipment damage Hazard analysis
	Performance Evaluation System	Raw material efficiency Listing Ordering
	Quality Control	Number of defective products
Growth and Learning	Employee capability	Number of trained employees The level of education Employee retention
	Increase a conducive working atmosphere	Number of work accidents Employee Presentation
	Increase the number of reliable employees	Recruitment of employees Staff Reliability
	Increase employee productivity	Level of productivity Employee satisfaction Reward and punishment programs

In the process of analyzing, it is necessary to distinguish between the inability of a company to meet the measured parameter values because of the company's performance with deficiencies or weaknesses or incompatibility. This is due to the reason that the parameters are not directly related to the performance of the measurement object (can be due to the type of company or its level).

The number of parameters is 32. One by one parameter is discussed with the actors involved in the company. The subject matter is the logical side of the parameter, the relationship between parameter and the interests of the company, the ability to be measured, the availability of quantitative data, the ability to provide qualitative data, and the constraints in terms of facilitating the measurement.

Overall, the discussion of parameter is actually logical as a parameter to measure company performance and is closely related to the type of business. However, when quantitative data is required, the company finds it difficult to provide records that can represent the required data. The types of difficulties are: (1) no records at all, (2) there is little data but not complete either in terms of time, or from the side of variables that need to be recorded, (3) there is data that needs to be processed first but still require data additional. This problem begins with the assumption that recording requires extra time and effort, while the results are not considered so important by the owner of the company.

When the measurement process is done by trying one by one parameters, most parameters obtained data results for later used to calculate the score. However, among the parameters found there are 9 parameters whose measurement results obtained a score of zero (0). This zero score does not indicate that the parameter is incorrectly used as a measuring tool, but rather means that the company does not have performance related parameters, whereas the type of business that runs has the potential to grow when the company takes into account that aspect.

The discussion of the constraints on parameter measurement is more focused on the parameters that result in zero score components, to see whether the zero score is indeed systemic (all SME types will produce the same score) or the zero score does show the actual company performance (other company may be generate non-zero score). The nine parameters are as shown in Table 2.

**Table 2.** Parameter Measurement Whose Measurement Results Have a Zero Score

Perspective	Strategic Objectives	Parameters
Customer	Increase customer satisfaction	Number of complaints and compliments
	Increase market share	Additional number of market areas
	Management of customer needs	Number of direct interactions with customers
Internal Business Process	Performance Evaluation System	Recording of data and information
	Quality Control	Number of defective products
Growth and Learning	Employee capability	Number of trained employees
	Increase a conducive working atmosphere	Number of work accidents
	Increase the number of reliable employees	Recruitment of employees
	Increase employee productivity	Level of productivity

The following describes each of the problems in the use of the parameters listed in Table 2 when used in measuring company performance.

### 3.1. Number of Complaints and Compliments

The firm did not have a specific target for the number of complaints and compliment from customers, but it is very important to measure the extent to which customer satisfaction on SME products and can also be an evaluation of the company.

This parameter is difficult to measure as a parameter. Although it can be measured quantitatively in the form of the number of complaints and compliments, but will find difficulty when setting the value. Ideally the company hopes there is no complaint at all, and expect compliments much. The size

of the amount of compliment is difficult to determine absolutely how much it is scored 100%. On the contrary it will also be easy to determine a complaint score to be 100% when no complaints are made at all, but it is difficult to give a score of 0% that is equivalent to how much the complaint counts.

In addition to this, it still needs to be defined and standardized regarding the quality of complaints and compliments. This requires a separate study of the types of complaints and compliment from customers.

### *3.2. Additional Number of Market Area*

Likewise, in the number of areas, the company did not have a specific target how many cities that are targeted sales of SMEs, so that the spread of SME products just happened, without knowing exactly how many cities routinely supplied by the firm. This indicates that the firm has not yet thought about expanding the marketing area.

In most SME, the expansion of market areas is still not a concern. But companies will grow if turnover increases. Additional sales turnover can be obtained through the expansion of market areas that provide additional consumer opportunities. Based on this, the parameters of increasing the number of market areas are so relevant that they need to remain as performance measurement parameters. The company selected as a case study has a business field that logically enables the expansion of the market area and the distance factor determines the success of the sale.

### *3.3. Number of Direct Customers Interactions*

The third parameter is the number of direct interactions with customers, company do not have specific targets how much the number of direct interactions that are desired., this can be a good evaluation for SME's, because we can know directly complaints or inputs of customers towards SME's products, even this direct interaction can be a way of further introducing SME products.

Today, SMEs tend to find it much easier to interact with customers, because of the social media platform on the internet that is so easy to use. Society is relatively so common with various facilities available on the internet. Many customers use social media and online communication channels to meet their needs. Expectations, comments, and feedback from customers to producers or sellers are very easy to obtain. Because of that reality, corporate interaction with customers becomes very important as a performance measurement parameter. The existence of such interactions can always maintain its performance in terms of fulfillment of customer expectations of the product, even to the service and positive image of the company.

This does not mean that if the company has not planned to interact either directly physically or through electronic media and the internet, then this parameter is not considered necessary. If the company has not done, then the company's performance alone becomes lessened by the customer relationship factor. SME food sector where the product is the final product that is directly enjoyed by the end consumer, then the interaction with the customer is needed. As with the SME that produces goods as industrial raw materials, even for this case can also be debated whether or not the parameters of measurement of interaction with consumers.

### *3.4. Recording of data and information*

Recording of data and information also becomes very weak in the company which is used as an object of case studies. The production process goes just like that without recording the amount of incoming raw materials and the number of final products that meet the standards or the defective ones, let alone record the activities during the process. In the company there is also no record of capital expenditures and the amount of income per period, even though this recording is very useful for the process of evaluating company performance. With the recording, control and monitoring of the company's performance will be much easier.

This recording is a major factor in measuring company performance. This is a major obstacle. The company itself is unable to know exactly and objectively about the company's problems so that it will encounter difficulties when the company wants to improve itself. The weakness of the company is on

the administrative management side. Therefore, the order parameter of administrative registration is absolutely necessary because it is the main source of performance measurement.

### 3.5. *Number of defective products*

Performance measurement related to this defective product is also experiencing problems because the company does not record and even estimates are difficult. In addition, the company does not have a maximum defect product target. The company should have wished that the final product would not be defective. This parameter is still needed to see how far the achievement of the business process is in the production stage.

The problem of measuring parameters for the number of defective products is also the same as some other parameters which are perfect if there are no events, such as the number of work accidents, and the number of consumer complaints. Parameters such as this need to be reviewed in relation to the lowest value limit.

### 3.6. *Number of Trained Employees*

The companies that were subjected to the case study found it difficult to identify the question of whether the employee had been trained or not formally. This parameter is approximated by the level of employee education. The results of in-depth interviews on the parameters of employee education measurement, firms do not have targeted number of employees at a certain level of education, employees are not given education level limits, the SMEs only require employees to work properly and diligently.

However, for the advancement of SMEs this is worth noting, the level of employee education can indicate the level of knowledge and work skills of an employee, by forging, training and giving the same experience to the graduate of elementary and high school graduate employees will be different, really payed attention.

Based on the discussion and referring to the enactment of the Indonesian National Qualification Framework (INQF/in bahasa = KKNI), the measurement parameter of "education level" is better if replaced with a qualification level indicating one's competence. In KKNI, it shows the equivalence of the competencies that are gained through the path: (1) academic education, (2) experience and self learning, (3) professional and professional sertification, and (4) work in industry, so that a person is considered to have an equal qualification even if the competencies are obtained from different paths.

More detailed references are the Indonesian National Work Competency Standards (in bahasa SKKNI). The definition of SKKNI is a formulation of work capability that covers aspects of knowledge, skills and / or skills and attitude that are relevant to the implementation of duties and job requirements that are determined in accordance with the provisions of the prevailing laws and regulations [9].

Scores of this measurement component are not based on the number of highly educated employees, but rather are based on the suitability of competence and availability needs and account for the amount.

### 3.7. *Number of work accidents*

Furthermore, in the parameters of the number of workplace accidents, where the company is used as a case study, work accidents rarely occur, where in one year only 2-3 accidents. However, when viewed from the perceived good performance on the parameters of workplace accidents, it can be said to be less good, because of good performance if there is no work accident or zero accident. This relates to the company's attention to employee safety, and employee attention to hazards in the work environment.

The number of workplace accidents is measured as a strategic goal approach Increase a conducive working atmosphere. Although in fact the work atmosphere is not only a matter of the number of work accidents. The occurrence of psychological barriers caused by the physical condition of the environment or collegial relations between employees, mental pressure by the need to achieve work targets also affect the conducive work atmosphere. However, all of these causes are difficult to measure.

The other approach proposed is to use the average employee working period. This is based on the assumption that if the average working period of all employees is long enough, then it shows that in the company there is a conducive working atmosphere. It's just that a measure of perfection for this objective strategy needs to be clearly defined. It is very difficult to determine the employee's working period that reflects a conducive work atmosphere in the company.

### 3.8. *The number of employee recruitment*

The parameter of the number of employee recruitment is to represent the strategic goals of increasing employee reliability. This means that the recruitment of employees is carried out to meet the level of needs so that there is an adequate number of employees according to the production plan. The recruitment target is important for the company because with the target the company can regulate and predict the amount of production that can be done. The company can also forecast expenses for the salaries of all its employees.

However, this is a waste if there are many incidents of employees going in and out, so the frequency is high. As if high frequency shows good performance. Though the reason for hiring employees is detected not only because it meets the availability of the number of employees associated with the production plan. Employee recruitment can be due to other things.

This frequency number becomes invalid to represent employee reliability. This does not mean that companies that do not recruit employees are considered unreliable. Therefore, this employee recruitment parameter needs to be reviewed if it is used as an indicator of strategic objectives of employee reliability.

### 3.9. *Employee productivity*

The measurement of employee productivity parameters is actually very significant to be used as a component of the company's performance measurement. The main problem in small companies that are used as case studies is the absence of quantitative recording of the performance or products produced by each employee. The company is only able to deliver data qualitatively whose accuracy is doubtful because of inadequate supporting data from other perspectives. But this can actually be designed to be measured in groups according to certain processes that are carried out by a group of employees. The data used can be in the form of records of results of each process in a certain time interval compared to the number of employees in the group being reviewed. So the point is that this parameter is still needed in measuring the company's performance, but needs to be supported by the recording performance by the company.

## 4. **Conclusions**

Among the 32 parameters, there are 9 parameters discussed in the constraints in the implementation of the measurement. Measurement parameters which are the main constraints in measuring company performance are recording data and information. This was acknowledged by the company regarding the lack of properly recorded data and information. This parameter is also a source of constraints for measurement of other parameters. Of the 9 parameters discussed, there are a number of measurement parameters that still need to be reviewed or need to be replaced, namely: (1) Number of Trained Employees, (2) Number of work accidents, and (3) The number of employee recruitment. Whereas those that need rearrangement of the equations used are: (1) Number of Complaints and Compliments, (2) Number of defective products, and (3) The number of Employee Recruitment. Other parameters that still need to be used are: (1) Additional Number of Market Area, (2) Number of Direct Customers Interactions, and (3) Recording of data and information, because the constraints in measurement are caused by the company's inability to fulfill its performance.

**Acknowledgments.** I express my gratitude to: (1) Roni Kastaman, Irfan Ardiansah, Devi Maulida Rahmah, Haikal Amin, who have taken the time to discuss topics on performance measurement; (2) the owners and managers of four companies (classified as small industries) who have also taken the time to discuss and provide information in order to discuss the measurement of performance parameters for small and medium industries; and (3) Faculty of Agro-Industrial Technology, Padjadjaran University, which gave me the opportunity to conduct this research.

## References

1. A. Neely, J. Mills, K. Platts, M. Gregory, dan H. Richards, "Performance measurement system design: Should process based approaches be adopted?," *International Journal of Production Economics*, vol. 46–47, hlm. 423–431, Des 1996.
2. M. Hudson, J. Lean, dan P. A. Smart, "Improving control through effective performance measurement in SMEs," *Production Planning & Control*, vol. 12, no. 8, hlm. 804–813, Jan 2001.
3. S. Sousa dan E. Aspinwall, "Development of a performance measurement framework for SMEs," *Total Quality Management & Business Excellence*, vol. 21, no. 5, hlm. 475–501, Mei 2010.
4. M. Alles dan M. Gupta, "The impact of uncertainty and ambiguity when implementing the Balanced Scorecard," *Asia-Pacific Journal of Accounting & Economics*, vol. 9, no. 2, hlm. 235–262, Des 2002.
5. R. Chalmers, S. Palomero, dan M. Matilla, "Methodology to develop a performance measurement system in small and medium-sized enterprises," *International Journal of Computer Integrated Manufacturing*, vol. 25, no. 8, hlm. 716–740, Agu 2012.
6. T. Pujianto, I. Ardiansah, dan H. Amin, *Optimalisasi Ukuran Kinerja Industri Kecil Menengah Sektor Agro-Food Menggunakan Kerangka Balanced Scorecard (BSC)*, 1 ed., vol. 1, 1 vol. Jember: UPT Penerbitan UNEJ, 2016.
7. S. J. Simon, "Balanced Scorecard: A Tool to Improve IS Department Planning and Evaluation," *Journal of Information Technology Case and Application Research*, vol. 7, no. 4, hlm. 7–29, Okt 2005.
8. M. Elg dan B. Kollberg, "Alternative arguments and directions for studying performance measurement," *Total Quality Management & Business Excellence*, vol. 20, no. 4, hlm. 409–421, Apr 2009.
9. Kementerian Perindustrian Republik Indonesia, "Standar Kompetensi Kerja Nasional Indonesia (SKKNI)." Kementerian Perindustrian Republik Indonesia, 2016.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-EPS-003-ID010

# Trust as a Human Factor for Sustainable Ergonomics Application in Agro-industry

Mirwan Ushada <sup>1,\*</sup>, Titis Wijayanto <sup>2</sup> and Fitri Trapsilawati <sup>2,\*</sup>

<sup>1</sup> Universitas Gadjah Mada, Department of Agro-industrial Technology; mirwan\_ushada@ugm.ac.id

<sup>2</sup> Universitas Gadjah Mada, Department of Mechanical and Industrial Engineering; twijaya@ugm.ac.id; fitri.trapsilawati@gmail.com

\* Correspondence: mirwan\_ushada@ugm.ac.id; Tel./Fax: +62-274-551219

Received: 8 July 2018; Accepted: 28 August 2019; Published: 6 January 2020

**Abstract:** Ergonomics application is not yet fully concerned in agro-industry due to the gap between ergonomics and welfare benefit. The welfare benefits such as wages, incentives, and other financial support have gained more interest than the ergonomics benefits as a comfortable workplace environment, work methods and workload. This study proposes trust as a human factor for sustainable ergonomics application. Trust can be defined as a user affective state that will guide individual and social decision in a work system characterized by uncertainty and vulnerability. The study objective is to analyze the trust-building process to the ergonomics application in agro-industry. The samples were previous research review from 38 food SMEs in Yogyakarta Special Region. The result indicated that building trust should consider skill, workplace environment, financial, multi-tasking, misuse and disuse of ergonomic application. Study result concluded trust could be used as a human factor in ergonomic work system of agro-industry.

**Keywords:** ergonomics benefit; individual decision; local work culture; social decision; welfare benefit

---

## 1. Introduction

Most of agroindustrial work system in Indonesia is typical of manual task [1]. Ergonomic has been defined as fitting the task to the human factors of the involved user in agro-industrial production system. Ergonomics application is not yet fully concerned in agro-industry due to the gap between ergonomics and welfare benefit. The welfare benefits such as wages, incentives, and other financial support have gained more interest than the ergonomics benefits as a comfortable workplace environment, work methods and workload. This study proposes trust as a human factor for sustainable ergonomics application. Trust can be defined as a user affective state that will guide individual and social decision in a work system characterized by uncertainty and vulnerability [2]. The objective of this study is to analyze the trust-building process to the ergonomics application in agro-industry. The expected advantage is to highlight the importance to quantify the abstractive parameters of trust for fourth industrial revolution 4.0 in the agro-industry. Quantification of trust could enable the data interchange in big data system to support decision and policy for agro-industrial competitiveness.

## 2. Materials and Methods

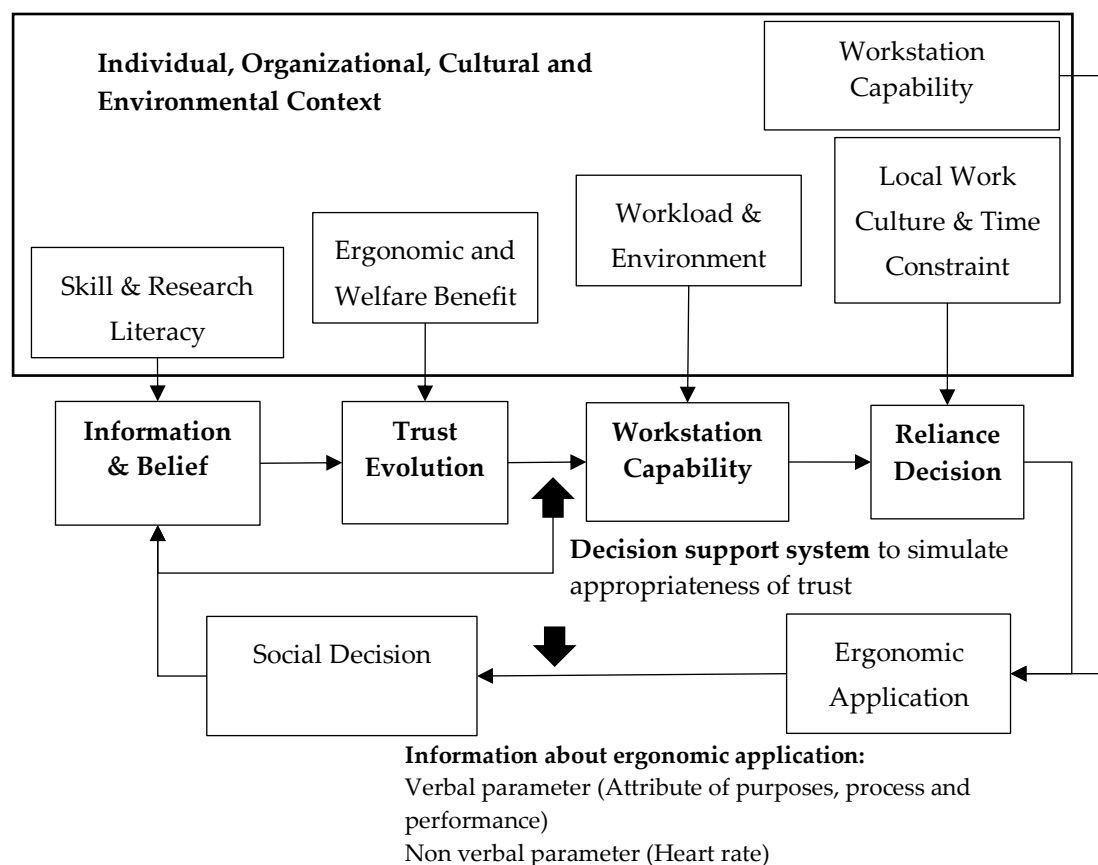
The analysis of trust was reviewed from our previous observation researches. The samples were 38 food SMEs in Yogyakarta Special Region, which was reviewed from author [3] and author [1]. The respondent were 30 sample members from Sleman Regional Businessmens Association for Food and Beverages [3]. Author [1] indicated the Six (6) SMEs of different food products were as crackers, nuggets, fish chips, bakpia, tempe and herbal instant beverages. Two (2) additional reviews from bakery and tobacco agroindustries.



### 3. Results

Recently, trust has gained more attention as human factors in several field of application. Author [4] have explored the trust analysis in multitasking workspace. Author [5] have utilized the trust in instrument of medical technology. Author [6] have recommended trust as a human factor in assesing risk in area Internet of Things (IoT). Author [7] have defined the relationship between trust and human resources in project management of spacecraft. Author [3] have identified the priority of user attribute needs as response to the introduction of KESAN (Kansei Engineering-based Sensor for Agroindustry) as a new ergonomic tool in SMEs. The highest attribute importance of this research was the willingness to use to Information Technology (IT) to implement the ergonomic application. It indicated the SMEs were familiar with the benefit of information technology to support the production system. This findings highlighted the importance of IT to support the sustainable application of ergonomic in agro-industry.

The other interesting research result by Author [1] indicated the affective condition from Six (6) SMEs of different food products as crackers, nuggets, fish chips, bakpia, tempe and herbal instant beverages. The evaluation indicated 51,3% worker in affective and 48,7% in non-affective condition. The other interesting research result by Author [8] indicated that 84,4% of worker are recommended to receive incentive and 15,6% not to receive incentive.



**Figure 1.** A conceptual model for dynamic process of ergonomic application trust in agro-industry (Adapted from author [2])

## 4. Discussion

### 4.1. Conceptual Model of Trust

Figure 1 indicated the conceptual model to implement trust as a human factors for sustainable ergonomic application in agroindustry. The conceptual model was adapted from author [2] and adjusted based on the needs to achieve the sustainable ergonomic application in agro-industry.

Reliance decision is influenced by local work culture and time constraint. Local work culture is considered as one of significant challenges in sustainable ergonomic application in agro-industry. Trust could be influenced by the local work culture in association with the work system and methods. Time constraint influenced by delay time, normal and standard time. Delay time could be minimized using the deviation between buffer and standard time. A buffer time is proposed as a solution to support the bottleneck among the work station in a production system [9]. Buffer time is determined by deviation between worker capacity and integrated workload using Drum-Buffer-Rope algorithm [9]. The workload was classified into normal, capacity constrained worker and bottleneck [9]. The constraint of personal needs and unavoidable delays could become bias for the local work culture. Standard time is determined by adding to normal time for personal worker needs, unavoidable work breakdown or bottleneck, and physical or mental worker fatigue.

Workstation capability is influenced by the interaction between worker, tool, workplace environment and material capabilities [1]. Author [9] indicated that more upstream the process, then the less ergonomic condition of worker in a workstation.

Trust evolution was influenced by trade-offs between ergonomic and welfare benefit. It could be solved by using the optimization method. This trade off to the trust could make trust as a complex computation problems. Individual and social decision influence the attractiveness of ergonomic to the owner of SMEs as individual and cluster of SMEs as the collective. Individual trust to sustainable ergonomic application could be solved using the formula by author [10] using prominence and interpretation. The basic method for this formula is using the questionnaire to collect the data. The possibility of bias is usually high eventough the test of validity and reliability is pursued for the quality control. The alternative method of optimization and computation using artificial intelligence is highly required. The abstractive communication between 1 (one) individual owner of SMEs and other partners in same community/group for the social decision is possible to be simulated in the artificial intelligence-based research.

Ergonomic benefit could be defined as one example is by author [3] from the side of comfortable display colour, compact size, form, informative, keypad, colour, size, font and the availability of manual procedure. The other example of ergonomic benefit is the interaction between workload and environment [1]. Heart rate could be suggested as one of indicator for trade off between ergonomic and welfare benefit for the SMEs. It is fit the work characteristics of food SMEs which most of them is manual, labour incentive and influenced by environmental ergonomics.

Misuse of ergonomic indirectly indicated the existence of capacity constrained worker which could work several times from its capacity in workstation of agroindustry [9]. Disuse of ergonomics application could be indicated the significant amount of less workload worker in agroindustry which could be indicated by by our previous research [9].

The social decision is accomodating the collective opinion from the user to help them to select the appropriate ergonomic technology to accept the technology. The social decision generate the belief and information which support the sustainability of ergonomic application for the agroindustry. Information and belief generate the several alternative technology as: 1) Technology innovation; 2) Technology application; 3) Technology dissemination; 4) Adoption; 5) Revitalization; 6) Upgrade; 7) Downgrade; 8) Difussion; 9) Shared technology.

### 4.2. Building the Trust

Figure 1 concluded that building the trust should consider skill and ergonomic literacy, workplace environment, financial, multi-tasking, misuse and disuse of ergonomic application. Skill could be

analyzed based on national standard qualification. Ergonomic literacy could be implemented by the action research of the university students who pursue the thesis in SMEs. The interaction between agroindustry and student will increase the ergonomic literacy. Providing ergonomic workplace environment will contribute to tradeoff between welfare benefit and ergonomic benefit. The example of welfare benefit is proposed using the wages based on heart rate parameters as shown in our previous results [8]. The example of ergonomic benefit was indicated by author [1] that setting the temperature control  $29.1 \pm 1.8$  °C could save more energy in food SMEs, if it is implemented using air conditioner. Multi-tasking is indicated by no distinct differentiation between one workstation and other workstation. Overtrust may direct to misuse and distrust to disuse [2]. Misuse of ergonomic application refers to the failures that occur when owner of SMS in advertently violate critical assumptions and rely on ergonomic inappropriately. Disuse of ergonomic indicate failures that occur when SMEs reject the capabilities of ergonomic. Considering the complex fact of building trust, it required the methods to quantify it.

#### 4.3. Quantification of Trust

Trust must be quantified to support the decision for sustainable ergonomic application in agro-industry. The next challenge is to find the method for quantifying the trust as the human factors as the perspective from the individual and social decision. There are several ways to implement trust as a human factor for sustainable ergonomic application in agroindustry as follow:

##### 4.3.1. Questionnaire attribute

Questionnaire attribute could be used to quantify the trust based on the dimension of trust as purpose, performance and reliability. Questionnaire attribute is the easiest way of verbal parameters in Kansei Engineering to identify the user needs. The application was confirmed by author [10]. Besides, author [2] recommended the three bases of trust that is competency (performance), reliability (performance), openness (process), and concern (purpose). The dimensions of purpose, process, and performance provide a set of attributes for questionnaire that describe the basis of trust across a wide range of application domains include ergonomic application.

##### 4.3.2. Heart rate

Heart rate is non verbal parameter which could be used to quantify the workload. The application was confirmed by author [1,8]. Heart rate is recommended for manual work type in agroindustry which is influenced by the workplace environment.

##### 4.3.3. SWA Index

SMEs worker affective index could be used to determine the trust based on the comparison between standard and measured heart rate. The application was confirmed by author [8].

##### 4.3.4. Collective intelligence

Collective intelligence could be used to model the trust based on the complexity of the involved verbal and non verbal parameter. The application was confirmed by author [1-8].

## 5. Conclusions

The result concluded that building trust should consider skill, workplace environment, financial, multi-tasking, misuse and disuse of ergonomic application. Study result concluded trust could be used as a human factor in ergonomic work system of agro-industry. Kansei Engineering framework could be used to identify and analyze the conceptual model of trust. The questionnaire attribute, heart rate, index and collective intelligence could be used as a method to quantify the trust as human factors in agro-industry.

**Acknowledgments:** Authors wishing to acknowledge financial support from Ministry of Research, Technology and Higher Education of the Republic of Indonesia by 2018 Research Grants: ‘Penelitian Terapan Unggulan Perguruan Tinggi Tahun 2018’ No: 1877/UN1/DITLIT/DIT-LIT/LT/2018.

## References

1. Ushada M., Okayama M., T.; Khuriyati N.; Suyantohadi A. 2017. Affective Temperature Control in Food SMEs using Artificial Neural Network. *App. Art. Intell.* 31 (7-8): 555-567.
2. Lee, J.D. dan See K.A. Trust in Automation: Designing for Appropriate Reliance. *Human Factors* 2014. 46(1), 50-80,doi: [10.1518/hfes.46.1.50\\_30392](https://doi.org/10.1518/hfes.46.1.50_30392)
3. Agassi, T. A.; Ushada M.; and Suyantohadi A. “User Needs Analysis for Industrial Design of Kansei Engineering-based Sensor for Agroindustry (KESAN)”, *International Conference of Science and Technology*, 7-8 Agustus 2018, Universitas Gadjah Mada
4. Karpinsky N.D.; Chancey E.T.; Palmer D.B.; Yamani Y. Automation trust and attention allocation in multitasking workspace. *Applied Ergonomics* 2018. 70, 194-201,doi: [10.1016/j.apergo.2018.03.008](https://doi.org/10.1016/j.apergo.2018.03.008)
5. Montague E. Validation of a trust in medical technology instrument. *Applied Ergonomics* 2010. 41, 812-821, doi: [10.1016/j.apergo.2010.01.009](https://doi.org/10.1016/j.apergo.2010.01.009)
6. Henshel D.; Cains M.G.; Hoffman B.; Kelley T. Trust as a human factor in holistic cyber security risk assesment. *Procedia Manufacturing* 2015. 3, 1117-1124 doi: [10.1016/j.promfg.2015.07.186](https://doi.org/10.1016/j.promfg.2015.07.186).
7. Niu J.;Geng H.; Zhang Y.; Du X. Relationship between automation trust and operator performance for the novice and expert in spacecraft rendezvous and docking (RVD). *Applied Ergonomics* 2018. 71,1-8, doi: [10.1016/j.apergo.2018.03.014](https://doi.org/10.1016/j.apergo.2018.03.014).
8. Ushada M.; Aji M., G. K.; Okayama T.; Khidir M. "SME Worker Affective (SWA) Index based on Environmental Ergonomics". Conference Proceeding of The International Conference on Industrial and System Engineering (ICONISE), 29-31 Agustus 2017: IOP Conference Series: *Material Science and Engineering.*, 337 (2018).
9. Ushada, M.; Mulyati G. T.; Guritno A. D.; Murase H. Combining Drum-Buffer-Rope Algorithm and Kansei Engineering to Control Capacity Constrained Worker in a Bioproduction System. *IFAC Proceedings Volumes* 2013. 46(4),384-389,doi: [10.3182/20130327-3-JP-3017.00085](https://doi.org/10.3182/20130327-3-JP-3017.00085)
10. Xu, J.; Le G. K.; Deitermann A.; Montague E. How different types of users develop trust in technology: A qualitative analysis of the antecedents of active and passive user trust in a shared technology. *Applied Ergonomics Volumes* 2014. 45(4),1495-1503,doi: <https://doi.org/10.1016/j.apergo.2014.04.012>



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-EPS-005-ID006

# Cost Analysis for Sugarcane Transporting Improvement from Loading Station to Sugar mill

Kris Promsiri<sup>1</sup> and Jumpol Vorasayan<sup>2,\*</sup>

<sup>1</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand;

<sup>2</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand.

\* Correspondence: [jumpol.v@ku.th](mailto:jumpol.v@ku.th); Tel.: +66-2562-5093 Ext. 5372

Received: 7 July 2018; Accepted: 20 December 2018; Published: 6 January 2020

**Abstract:** The transportation of sugarcane is one of major costs of sugar production. Large vehicles such as 22-wheel full trailer and semi-trailer are used for long-distance transportation because it incurs less transportation cost per ton. The objective of this research is to compare annual cost and benefit analysis model for two sugarcane transportation protocols single-loop and double-loop. In situation where the process is continuous and deterministic, the results showed that, the double-loop protocol had higher cost than single-loop protocol.

**Keywords:** cost analysis; transportation; sugar mill; loading station

---

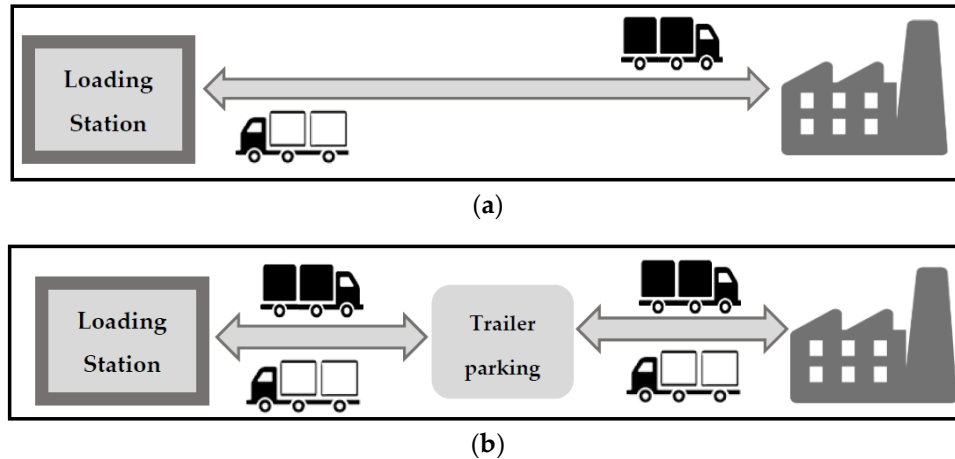
## 1. Introduction

Sugarcane is a perennial agricultural crop that is mainly grown for its expressed juices, which used to produce raw sugar that is later refined into sugar. [1] In 2016, sugar accounted for over 80% of all sweeteners consumed globally, with products such as sugar, high-intensity sweetener (HIS), an artificial sweetener. Approximately 85% of all sugar produced globally come from sugarcane, which grows in equatorial regions such as Brazil and parts of Asia-Pacific. The remaining 15% comes from beetroot, which is grown in Europe, parts of the United States, Canada, and China. In 2016, combined global production came to 175 million tonnes (of raw sugar) and the most important producers were Brazil (22.9% of global production), India (12.8%), the European Union (9.7%), Thailand (5.9%) and China (5.6%). [2] The logistic and production cost plays a major role to gain competitive advantages during periods where the price of sugarcane is low. The logistics cost of the sugar industry in Thailand is apparently high compared with other major sugar export countries such as Brazil, Australia etc. Reasons include the increasing labor costs, inefficient use of machinery due to small farm size, improper system support, and lack of integration between farmer, transport companies, and sugar mill. [3] Thus, the transportation of sugarcane is the major cost of sugar production. All sugarcane in Thailand is transported by road vehicles. Large vehicles such as trailer and semi-trailer are increasingly used to reduce the transportation cost per ton. However, in order to achieve the low cost per ton, the careful operational plan is required to maximize efficiency. The purpose of this research is to developed cost and profit model as a tool to properly manage the number of vehicles for two sugarcane transportation protocols: single-loop and double-loop transportation protocols. The obtained result could assist sugar mill and transport company to understand the benefits of the redesigned system and it could be applied to improve sugarcane logistic efficiency.

## 2. Materials and Methods

The methodology started from collecting the data of fixed and variable cost in sugarcane transportation and other data that related to sugarcane transportation from loading station to sugar mill including transportation processes and the route in yard into sugar mill. These data were collected from the in-depth interview on sugarcane transportation stakeholders such as manager, officers, staffs

and 3rd-party logistic provider in north eastern part of Thailand. [4] This research used cost and benefit analysis model for the sugarcane transportation protocol which considers two protocols: single-loop and double-loop. The first protocol the truck will pick up sugarcane from the loading stations to sugar mill in the order to unload sugarcane. Consequently, this truck go back to the loading station to repeat the loading process. On the other hand, the second protocol used two sets of semi-trailers. Semi-trailers in the first set carry trailer between the loading stations and parking area of the sugar mill. The trailer is released from the tractor in parking area. The tractors Semi-trailers in the second set carry the trailer between parking area and sugar mill in the order to unload sugarcane. The difference of single-loop and double-loop transportation protocols are depicted in Figure 1.



**Figure 1.** Comparison of sugarcane transportations (a) single - loop; (b) double - loop

### 2.1. Formulation of Mathematical Model

In this study, mathematical models about cost and profit of sugarcane transportation which considers two protocols: single-loop and double-loop transportation protocols that were adapted and modified from the mathematical model presented in the study of Jumpol Vorasayan (2014) [5], Watcharachan Sukcharoenvipharat (2012) [6] and W.khamjan, S.Khamjan, S.Pathumnakul (2013) [7]. The model is formulated under assumptions that activity time is deterministic and the transportations are performed continuously with unlimited supply of sugarcane.

#### 2.1.1. Subscript and Set

$i$  = a loading station index,  $I$  = set of loading stations =  $\{1,2,3\}$   
 $j$  = a sugar mill index,  $J$  = set of sugar mill =  $\{1\}$

#### 2.1.2 Notations

The notations for proposed cost and profit model are as follows;

- Notations for cost and revenue of sugarcane transportation
  - $D$  = Distance between the loading stations to sugar mill (kilometer)
  - $T_c$  = Truck cost (baht /truck)
  - $H$  = Tractor cost (baht/tractor)  $H$
  - $T$  = Trailer cost (baht /trailer)
  - $Y$  = Years of useful life whole vehicle (year)
  - $S$  = Salvage Value (baht)
  - $t$  = Vehicle tax (baht /year)
  - $IN$  = Third class insurance expenses (baht /year)
  - $L_f$  = Nonrenewable fuel rate when leave for sugar mill (liter/ kilometer)
  - $R_f$  = Nonrenewable fuel rate when return to the 88 loading stations (liter/kilometer)
  - $F_c$  = Fuel cost (baht /liter)

- $Tr$  = Useful nonrenewable tires and rims rate (baht /kilometer)
  - $Mr$  = Useful nonrenewable motor oil and oil fitter rate (baht /kilometer)
  - $w$  = Wage rate when vehicle driver in sugar mill (baht /kilometer)
  - $Sw$  = Full-time vehicle driver salary (baht /month)
  - $Re$  = Transport Revenue in each the loading stations (baht /tons)
  - $\ell$  = Loan rate for vehicle (percentage/year)
  - Notations for duration of sugarcane transportation
    - $\alpha$  = Period of waiting dumping time in each the loading station (minutes)
    - $\beta$  = Period of dumping time in each the loading stations (minutes)
    - $\gamma$  = Period of time assembly trailer in each the loading stations (minutes)
    - $\delta$  = Period of arrive time to sugar mill in each the loading stations (minutes)
    - $\varepsilon$  = Period of leave time to sugar mill in each the loading stations (minutes)
    - $\zeta$  = Period of unloading time in each the loading stations (minutes)
  - Notations for managed sugarcane transportation from loading station to sugar mill
    - $AV$  = Arrive sugar mill average velocity (kilometer)
    - $LV$  = Leave sugar mill average velocity (kilometer)
    - $CF$  = Frequency of cycle (minute)
    - $CW$  = Frequency of work cycle (minute)
    - $CL$  = One cycle time (minute)
    - $V$  = Vehicle size (ton)
    - $G$  = Sugarcane weight (cycle/ton)
    - $DF$  = Driver in one cycle time (minutes)
    - $WT$  = Weight sugarcane target (ton)
- The model is formulated as follows;
- 5) Number of queue card for truck and semi-trailers in each the loading stations:  $Q_i$  (queue)

$$Q_i = \frac{WT_i}{V \times CF} \quad (1)$$

- 6) Number of queue card of tractors for semi-trailers in sugar mill:  $Q_j$  (queue)

$$Q_j = \sum_{i=1}^3 Q_i \quad (2)$$

- 7) Period of per cycle time for trucks and semi-trailers in each the loading stations:  $C_i$  (minutes)

$$C_i = \alpha_i + 2\beta_i + \gamma_i + \delta_i + \varepsilon_i + \zeta_i \quad (3)$$

- 8) Period of per cycle time of tractors for semi-trailers in sugar mill:  $C_j$  (minutes)

$$C_j = \alpha_j + 2\beta_j + \gamma_j + \delta_j + \varepsilon_j + \zeta_j \quad (4)$$

- 9) Number of tractors for trucks and semi-trailers in each the loading stations:  $T_i$  (unit/tractor)

$$T_i = \frac{Q_i}{\frac{CL}{C_i}}; T_i < U_i \text{ where } U_i = \frac{C_i}{\zeta_i} \quad (5)$$

Let  $U_i$  is the number of tractors that makes the loading stations take trucks and semi-trailers continuously all the time.

- 10) Number of tractors for semi-trailers in sugar mill:  $M_j$  (unit/tractor)

$$M_j = \frac{Q_j}{\frac{CL}{C_j}}; M_j < X_j \text{ where } X_j = \frac{C_j}{\beta_j} \quad (6)$$

Let  $X_i$  is the number of tractor that makes the dumper unloading sugarcane with semi-trailer continuously all the time.

- 11) Number of trailer for semi-trailers in each the loading stations:  $L_i$  (unit/trailer)

$$L_i = T_i + E \quad (7)$$

Let  $E$  is Number of trailer that need to get the tractors not waiting the trailers in sugar mill, from simulation model assume about  $1 \leq E \leq 5$ .

- 12) Number of trailers for semi-trailers in sugar mill:  $N_j$  (unit/trailer)

$$N_j = M_j \quad (8)$$

- 13) Deprecation of truck:  $DT_c$  (baht/year)

$$DT_c = \frac{T_c - \frac{S}{(1+\ell)^Y}}{1 - \frac{1}{(1+\ell)^Y}} \times \frac{1}{\ell} \quad (9)$$

- 14) Deprecation of tractor for semi-trailers:  $DH$  (baht/year)

$$DH = \frac{H - \frac{S}{(1+\ell)^Y}}{1 - \frac{1}{(1+\ell)^Y}} \times \frac{1}{\ell} \quad (10)$$

- 15) Deprecation of trailer for semi-trailers:  $DT$  (baht/year)

$$DT = \frac{T - \frac{S}{(1+\ell)^Y}}{1 - \frac{1}{(1+\ell)^Y}} \times \frac{1}{\ell} \quad (11)$$

- 16) Deprecation of added trailers for semi-trailers in sugar mill:  $DT_a$  (baht/year)

$$DT_a = \frac{T - \frac{S}{(1+\ell)^Y}}{1 - \frac{1}{(1+\ell)^Y}} \times \frac{1}{\ell} \quad (12)$$

Note: The trailer in the loading stations and in sugar mill are the same price.

- 17) Usage fuel cost for trucks and semi-trailers in each the loading stations:  $FV_i$  (baht/month)

$$FV_i = D_i \times (Lf + Af) \times Fc \times Q_i \quad (13)$$



- 18) Usage fuel cost of tractors for semi-trailers in sugar mill:  $FV_j$  (baht/month)

$$FV_j = D_j \times (Lf + Af) \times Fc \times Q_j \quad (14)$$

- 19) Usage tires and rims cost for trucks and semi-trailers in each the loading stations:  $RV_i$  (baht/month)

$$RV_i = D_i \times 2 \times Tr \times Q_i \quad (15)$$

- 20) Usage tires and rims cost of tractors for semi-trailers in sugar mill:  $RV_j$  (baht/month)

$$RV_j = D_j \times 2 \times Tr \times Q_j \quad (16)$$

- 21) Usage motor oil and oil fitter cost for trucks and semi-trailers in each the loading stations:  $MV_i$  (baht/month)

$$MV_i = D_i \times 2 \times Mr \times Q_i \quad (17)$$

- 22) Usage motor oil and oil fitter cost of tractors for semi-trailers in sugar mill:  $MV_j$  (baht/month)

$$MV_j = D_j \times 2 \times Mr \times Q_j \quad (18)$$

- 23) Wage and salary cost for trucks and semi-trailers in each the loading stations:  $SV_i$  (baht/month)

$$SV_i = DW \times SW \times G \times Q_i \quad (19)$$

- 24) Wage and salary cost of tractors for semi-trailers in sugar mill:  $SV_j$  (baht/month)

$$SV_j = \frac{CL}{1440} \times \frac{CL}{DF} \times M_j \times \frac{Sw}{30} \quad (20)$$

- 25) Usage tractors for trucks cost in each the loading stations:  $\Omega_i$  (baht/month)

$$\Omega_i = T_i \times \left( \frac{DTc + t + IN}{CW} \right) \quad (21)$$

- 26) Usage tractors for semi-trailers cost in each the loading stations:  $\Psi_i$  (baht/month)

$$\Psi_i = T_i \times \left( \frac{DH + t + IN}{CW} \right) \quad (22)$$

- 27) Usage trailers for semi-trailers cost in each the loading stations:  $\Phi_i$  (baht/month)

$$\Phi_i = L_i \times \left( \frac{DH}{CW} \right) \quad (23)$$

- 28) Usage tractors for semi-trailers cost in sugar mill:  $HS_j$  (baht/month)

$$HS_j = M_j \times \left( \frac{DH + t}{CW} \right) \quad (24)$$

- 29) Usage trailers for semi-trailers cost in sugar mill:  $TS_j$  (baht/month)

$$TS_j = \left( N_j \times \frac{DT}{CW} \right) + \left( A \times \frac{DTa}{CW} \right) \quad (25)$$

Let A is number of added trailers of sugar mill, in this case we determine to 2 per unit

30) Cost per ton for trucks in each the loading stations:  $CT_i$  (baht/ton)

$$CT_i = \frac{\left( \frac{Q_i + FV_i + RV_i + MV_i + SV_i}{Q_i} \right)}{G} \quad (26)$$

31) Cost per ton for semi-trailers in each the loading stations:  $CS_i$  (baht/ton)

$$CS_i = \frac{\left( \frac{\Psi_i + FV_i + RV_i + MV_i + SV_i}{Q_i} \right)}{G} \quad (27)$$

32) Cost per ton of tractors for semi-trailers in sugar mill:  $CS_j$  (baht/ton)

$$CS_j = \frac{\left( \frac{HS_j + TS_j + FV_j + RV_j + MV_j + SV_j}{Q_j} \right)}{G} \quad (28)$$

33) Total cost of trucks in each the loading stations:  $TC_i$  (baht)

$$TC_i = CT_i \times WT_i \quad (29)$$

34) Total cost of semi-trailer in each the loading stations:  $TCs_i$  (baht/year)

$$TCs_i = CS_i \times WT_i \quad (30)$$

35) Total cost of tractors for semi-trailers in sugar mill:  $TC_j$  (baht)

$$TC_j = CS_j \times WT_j \quad (31)$$

36) Total revenue for trucks and semi-trailers in each the loading stations:  $TR_i$  (baht)

$$TR_i = Re \times WT_i \quad (32)$$

37) Profit per ton for truck in each the loading stations:  $PS_i$  (baht/ton)

$$PT_i = Re - CT_i \quad (33)$$

38) Profit per ton for semi-trailers in each the loading stations:  $PS_i$  (baht/ton)

$$PS_i = Re - CS_i \quad (34)$$

39) Total profit for trucks in each the loading stations:  $ZT_i$  (baht)

$$ZT_i = PT_i \times WT_i \quad (35)$$

40) Total profit for semi-trailers in each the loading stations:  $ZS_i$  (baht)

$$ZS_i = PS_i \times WT_i \quad (36)$$

With data collected from the participant on sugarcane transportation in the production year 2017/2018, the estimate values of the model parameter as shown in Table 1 used in this case study.

**Table 1** Model parameters of the case study sugar mill in the production year 2017/2018.

Parameter	Values	Parameter	Values
$Tc$	$3.75 \times 10^6$ baht <sup>1</sup>	$CW$	160
$H$	$3.05 \times 10^6$ baht	$Lf$	0.6
$T$	700,000 baht	$Af$	0.4
$\gamma$	15 year	$Fc$	27 baht
$S$	500,000 baht	$Tr$	1.50
$\tau$	10,000 baht	$Mr$	0.50
$IN$	20,000 baht	$w$	0.1
$CF$	100	$Sw$	15,000 baht /month
$\ell$	5% <sup>2</sup> and 7% <sup>3</sup>		

<sup>1</sup> Thai Baht: 1 Baht  $\approx$  0.0304956 USD.

<sup>2</sup> For calculated to depreciation added trailer in sugar mill.

<sup>3</sup> For calculated to depreciation truck, tractor and trailer in each the loading stations.

### 3. Results

#### 3.1. Sugarcane Transportation Cost With Two Protocol

In our analysis, we determine the loan rate for the vehicle. In fact, sugar mill takes on a loan agreement to the transport company in the order to the purchased vehicle. In this section, we have shown the result of the sugarcane transportation cost and profit in the loading stations are as shown in Table 2 to Table 4. In this case study, we required to carry weight sugarcane around 35 tons that calculated the cost and profit in two protocols are specific compared to the loading stations number 1, 2 and 3 respectively which these are located around northeastern part of Thailand. We selected these stations because the transport company with sugar mill used these stations to carry sugarcane. In single - loop protocol has total cost about 26,570,718.8 baht/year, which the loading station number 3 has got cost more than other stations about 11,985,109.0 baht/year. And total revenue about 31,728,045.0 baht/year, which the loading station number 3 has got revenue more than other stations about 14,310,000.0 baht/year, so a total profit in this protocol is 5,157,326.3 baht/year which the loading station number 3 has got profit more than other stations about 2,324,891.0 baht/year. Next, in double - loop protocol, we combined the results of tractors in the parking of area sugar mill also, so it has total cost about 27,582,420.9 baht/year, which the loading station number 3 has got cost more than other stations about 11,629,216.0 baht/year. And total revenue about 31,728,045.0 baht/year, which the loading station number 3 has got revenue more than other stations about 14,310,000.0 baht/year, so a total profit in this protocol is 4,145,624.1 baht/year which the loading station number 3 has got profit more than other stations about 2,680,784.1 baht/year.

**Table 2.** Transportation cost and profit for trucks of single - loop protocol in each the loading stations.

$i$	$Q_i$	$C_{hi}$	$T_{hi}$	$\Omega_i$	$FV_{hi}$	$RV_{hi}$	$MV_{hi}$	$SV_{hi}$	$CT_{hi}$	$TC$	$TR$	$PT_i$	$Z_{hi}$
1	5.1	857.3	2.4	6,432.9	21,024.2	2,336.0	778.6	4,356.9	194.8	3,492,883.3	4,356,990.0	48.0	864,106.7
2	14.0	956.3	7.5	19,725.1	68,058.3	7,562.0	2,520.6	13,061.0	225.0	11,092,726.4	13,061,055.0	40.0	1,968,328.6
3	15.4	945.3	8.1	21,362.8	73,316.5	8,146.2	2,715.4	14,310.0	221.9	11,985,109.0	14,310,000.0	43.0	2,324,891.0

**Table 3.** Transportation cost and profit of tractors for semi-trailers of double - loop protocol in sugar mill.

$j$	$Q_j$	$C_j$	$M_j$	$N_j$	$HS_j$	$TS_j$	$FV_j$	$RV_j$	$MV_j$	$SV_j$	$CS_j$	$TC$	$R$	$PS_j$	$Z_j$
1	34.6	213.6	4.1	4.1	8,350.1	2,817.7	935.1	103.9	34.6	5,138.9	14.3	1,738,040.3	-	-	-

**Table 4.** Transportation cost and profit for semi-trailers of double - loop protocol in each the loading stations.

$i$	$Q_i$	$C_{hi}$	$T_{hi}$	$L_i$	$\psi_i$	$\phi_i$	$FV_{hi}$	$RV_{hi}$	$MV_{hi}$	$SV_{hi}$	$CS_i$	$TC$	$TR$	$PS_i$	$Z_{hi}$
1	5.1	657.3	1.9	3.9	4,033.6	1,859.3	21,024.2	2,336.0	778.6	4,356.9	191.8	3,438,885.0	4,356,990	51.2	918,104.9
2	14.0	756.3	5.9	7.9	12,757.7	3,802.9	68,058.3	7,562.0	2,520.6	13,061.0	228.6	10,776,279.6	13,061,055	46.3	2,284,775.3
3	15.4	745.3	6.4	8.4	13,774.4	4,0269.4	73,316.5	8,146.2	2,715.4	14,310.0	215.3	11,629,215.9	14,310,000.0	49.6	2,680,784.1

### 3.2. Number of Vehicle in Sugarcane Transportation

In this case study, the sugar mill used queue system that determine sugarcane volume line up into mill nearly with capacity of press sugarcane. This queue separate to one period consist of 5 quarter which it is 6 hour in each quarter. Addition the season of sugarcane harvest could transport into sugar mill about 100 cycle. And the farmers will received queue card that can dumping sugarcane under determine sugarcane volume and vehicle size. For example, a farmer has sugarcane about 30,000 ton and a truck size 15 ton. Thus, a farmer will gets queue card about 2 cards. It is meaning they will send sugarcane to 2 time in cycle. The queue system need to sugarcane transport, so we developed queue

system formula is  $Q_i = \frac{WT_i}{V \times CF}$ . For example, the loading station number 20 has a weight target ( $WT_2$ )

about 54,000 ton, a truck size ( $V$ ) 35 ton and frequency of cycle ( $CF$ ) about 100, so that number of queue card in the loading station number 2 is 5.1 queue. Next, when we have queue card already result to we can get calculated number of vehicle on two protocols are as shown in Table 2 to Table 4. In single - loop protocol, the loading stations number 1 to 3 used number of tractors ( $T_{1i}$ ) of truck about 3, 8 and 9 per a tractor respectively. A part of double- loop, used number of tractors of semi-trailer ( $T_{2i}$ ) about 2, 6 and 7 per unit respectively. And it has number of trailers of semi-trailer ( $L_i$ ) about 4, 8 and 9 per unit respectively. In addition double - protocol need to tractors and trailers for transported into sugar mill also that the tractors and trailers are as equally. Thus, there are number of tractors and trailers for semi-trailer ( $M_i$ ) and ( $N_i$ ) are about 5 per unit which the tractors of semi-tractor in sugar mill, are sharing with all the loading stations.

## 4. Discussion

The result showed that the cost and benefit compared two sugarcane transportation protocols, single-loop, and double-loop sugarcane transportations. For the same amount of delivered sugarcane, the double-loop has supplementary fixed costs other than the single-loop. We can reduce the fixed cost of double-loop by using tractors, which low capacity and efficiency because the transportation distance is within reach between the parking area and sugar mill. In part of single-loop, if this protocol incurred uncertainty scenarios concerning the time variance or machine is out of order, it will put the break on transportation. But the double - loop, will put the break on the first loop only, between the loading stations and parking area of the sugar mill then, the second loop it works perfectly now. In addition, the system of the double loop will be efficiency and worthwhileness if the number of tractors and trailers that are appropriate with sugarcane transportation.

## 5. Conclusions

To summarize, we have shown with the mathematical model for cost and benefit of two sugarcane transportation protocols, single-loop and double-loop higher cost in double-loop is accounted for the higher fixed cost of the vehicle and the waiting time incurred by double handling of two sets of tractors. For the same amount of delivered sugarcane, the double-loop has supplementary fixed costs other than the single-loop. In addition, the number of tractors needs to balance in each periods which reduced the waiting time of transportations. This provides, in long-term investment, the sugar mill owner and 3rd-party logistic will be able to use the double-loop transportation for a worthwhile investment. In the future, this model might be compared the efficiency of two protocols when other factors such as uncertainty scenarios by using situation analysis.

**Acknowledgments:** The work was supported by The Thailand Research Fund under grant RDG60T0167. The researchers would like to sincerely thank the sugar mill and transport company who provide information.

## References

1. Salassi, M.E., Breaux, J.B., Naquin, C.J. Modeling within-season sugarcane growth for optimal harvest system selection. *Agric. Syst.* 73, 2002; pp. 261-278.

2. Krungsri Research. Industry outlook 2018-2020: Sugar Industry. Available online: [https://www.krungsri.com/bank/getmedia/64a1559a-2938-4f48-b5afc601e52f660c/IO\\_Sugar\\_2018\\_EN.aspx](https://www.krungsri.com/bank/getmedia/64a1559a-2938-4f48-b5afc601e52f660c/IO_Sugar_2018_EN.aspx) (Accessed on 26th August 2018).
3. Jumpol Vorasayan. A simulation to compare single-loop and double-loop transportation protocols for sugarcane industry. Industrial Technology and Management (ICITM), 2018 7th International Conference on IEEE. 2017; pp. 309-313.
4. Ongkunaruk, P. and Ongkunaruk, W. Coconut sap pick up problem with time windows: a case study. International Food Research Journal. 22.5: 2088. 2015.
5. Vorasayan, J., and S. Pathumnakul. Optimal logistics system for sugarcane mechanical harvesting in Thailand. Journal of Applied Science and Agriculture. 2014; pp. 28-35.
6. Watcharachan Sukcharoenvipharat. A study on potential of tractor-towed for transportation sugarcane Muster Thesis, Kasetsart University, Bangkok, Thailand, 2012.
7. W.khamjan, S.Khamjan, S.Pathumnakul. Determination of the locations and capacities of sugarcane loading stations in Thailand. Computers & Industrial Engineering 66.4. 2013; pp.663-674.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-EPS-006-ID020

# A Concept of Engineering Education Program to Improve the Competitiveness of Human Resources in Agroindustry

Elisa Anggraeni <sup>1,\*</sup>, Muhammad Romli<sup>2</sup> and Suprihatin Suprihatin<sup>3</sup>

<sup>1</sup> Department of Agroindustrial Technology, Bogor Agricultural University; e-mail: elisa.anggraeni@gmail.com

<sup>2</sup> Department of Agroindustrial Technology, Bogor Agricultural University; e-mail: mromli@hotmail.com

<sup>3</sup> Department of Agroindustrial Technology, Bogor Agricultural University; e-mail: suprihatin167@gmail.com

\* Correspondence: elisa.anggraeni@gmail.com; Tel.: ++251 8621 974

Received: 9 July 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** The current globalization has led to intense competition among countries, both in the provision of goods, services and professionals. At the regional level, the ASEAN countries have agreed on the implementation of free market in the ASEAN region. The establishment of a free market termed as the ASEAN Economic Community (AEC) enables one country to sell goods and services easily to other countries throughout Southeast Asia. AEC not only opens the flow of trade in goods or services, but also the professional labor market, including professional in field of agroindustry. The AEC requires the abolition of rules that previously hindered the recruitment of foreign workers, especially in the professional workforce sector, resulting in a more intense professional labor competition. This paper presents the concept of academic and professional education programs for the field of agro-industrial engineering applied at IPB, in an effort to improve the quality and competitiveness of its graduates. The analysis and discussions include background, relevance, needs of agroindustry engineers, and the concept of education program paths along with graduate profiles, learning outcomes, and curriculum to meet the objectives.

**Keywords:** agroindustrial engineer, global competition, professional program

---

## 1. Background

### 1.1. Challenges to Improve Competitiveness of Human Resources in Agroindustry

The agricultural sector plays an important role in Indonesia's economic development as it contributes to 13% of national GDP and exhibits 85% of SMEs in Indonesia (Wijono, 2005) that is proven to survive during economic crisis (Pakpahan et al., 2005). Improvements in this sector will lead to an increase in Indonesia's GDP. Improvements can be made by increasing the added value of agricultural commodities, which is the main role of agro-industry. At present, the agro-industry in Indonesia is dominated by small and medium-sized businesses with 49% operating in agriculture, livestock, forestry, fisheries and 6% operating in processing. To increase GDP, it is necessary to increase economies of scale, and more importantly, increase competitiveness through the use of knowledge and technology. Thus, this effort needs to be supported by human resources who are able to provide solutions to the problems of SMEs such as limited access to capital, markets, raw materials, technology and innovation. (Radnor dan Barnes, 2007; Hadiyati 2010; Eravia *et al.*, 2014). The availability of competitive human resources is a must if we want to improve the performance of agro-industry and this is the main task of higher education.

Higher education is obliged to provide graduates that are capable of designing, managing and improving the competitiveness of agroindustry. To be able to provide this much needed human resources in agro-industry, higher education faces two main challenges. The first challenge is related to external pressure, namely the global community, and the second is related to the internal education system.

The current process of globalization causes very tight competition among countries in the supply of goods, services and professionals. At the regional level, ASEAN countries have agreed on the implementation of free markets in the ASEAN region. This is done to improve ASEAN's competitiveness and to attract foreign investment for increasing employment and community welfare in the region. The establishment of a free market that is termed as the ASEAN Economic Community (AEC) allows one country to sell goods and services easily to other countries throughout Southeast Asia. AEC not only opens the flow of trade of goods or services, but also the professional workforce market. EAC requires the elimination of rules that previously prevented the recruitment of foreign works forces especially in the professional works forces. In the era of cross-country works force mobility, the need for providing competitive engineering professionals at the international level is increasingly urgent [1,2].

Internal challenges are related to the ability to meet the demands of agroindustry human resources both in quantity and quality. As reported by PII (2011) there is a shortage in the number of engineers which is estimated to be around 15.000 per year. PII (2011) projected that the demand of agroindustrial engineers is 4.438 in 2015, 6.968 in 2020 and 10.040 in 2025. In the education sector, the projected demand of engineers is 588 in 2015, 922 in 2020, dan 1.750 in 2026. This number is quite high and if the higher education cannot provide the needed engineers, they would be fulfilled by professional engineers from abroad.

Besides, quality of human resources in agroindustry is of another concern. The free mobility of human resources across countries, demands those with a comparable competence at the international level. International standard of engineering education and profession is important to consider. The main competencies that are considered important for agro-industries need to be acquired, such as the ability in information technology, motivation to excel, lifelong learning, creativity to provide solutions, and teamwork. Based on a survey conducted by PII, improvements need to be made on several competencies, especially in the ability to work in teams, problem solving, oral and written communication, and professional commitment. It can be concluded that in addition to knowledge, there are two important dimensions of competence needed, namely skills (hard and soft skills) and attitudes. These three dimensions are needed for graduates to properly function in societies [3].

Improving the competitiveness of human resources in agroindustry, thus, requires improvement on engineering knowledge competences, skills, and attitudes. Engineering knowledge competences requires students to master their abilities to apply mathematics, science, and engineering principles to solve complex engineering problems. This knowledge to be complemented with skills to apply knowledge to problem analysis and formulation, conduct investigation and experiment, as well as skills to creatively design and develop solutions to engineering problems (IEA, 2014; SNPT, 2015). Considering the complexity of the engineering problems, students need to improve their collaboration and communication skills. These knowledge and skills are initial assets that need to be nurtured by themselves to tackle future challenges. To be able to continuously develop their knowledge and skills, they need to have professional attitudes, ethics and responsibilities and empathetic to societal and environmental values, and shows motivation to excel and the important of lifelong learning.

### *1.2. Agroindustry Higher Education*

Agroindustry Higher Education in Indonesia began in 1981, marked by the establishment of the Department of Agroindustrial Technology, Faculty of Agricultural Technology, Bogor Agricultural University (IPB). The rationale for its establishment is to support and enhance the role of the agricultural sector in advancing national development through increasing the added value of agricultural products by providing input on process technology and industrial system engineering. The difference from similar study programs, such as the Agricultural Product Processing Study Program - which has been there before, mainly lies in educational goals and learning outcomes, as well as orientation and approaches to achieving the objectives of the study program. The Agroindustrial Technology Study Program is oriented towards industrial businesses using an industrial system engineering approach and process engineering in increasing the added value of agricultural resources or biological resources in a sustainable manner.



The specificity of the agro-industry study program curriculum is to prepare graduates with the ability to design, develop, implement, control, evaluate and improve the performance of sustainable agro-industrial systems, through an integrated approach to aspects of process technology, system engineering, industrial management, and the environment to increase added value agricultural / biological resources and derivatives (Communication Forum for Indonesian Agroindustry Study Programs, 2018).

In accordance with the Decree of the Minister of Research, Technology and Higher Education No. 257 / M / KPT / 2017 concerning the Nomenclature of Study Programs in Higher Education, Agro-Industrial Technology and Agro-Industrial Engineering study programs are included in the engineering study category. Graduates of these study programs have a Bachelor of Engineering (ST) (Indonesian National Qualification Framework / level 6 KKNI) that can proceed to postgraduate (master and doctoral) programs (Level 8 and 9 KKNI) or continue their studies into engineering professional education programs (KKNI Level 7) with the title of Engineer (Ir.). In professional societies, engineers play a role primarily in design and development, while technologists and technicians play more roles in manufacturing and production lines [4].

The agroindustry study programs continue to experience growth, seen from the number of study programs, lecturers, students, and levels of education degrees (Table 1). Student body for undergraduate program (S1) reaches 6335 students. Not only nationally, higher education in agro-industry is also increasingly found abroad. Table 2 shows the agroindustry engineering study program abroad.

**Table 1.** Agroindustrial study program, number of faculties, and number of students at various levels

<b>Educational level</b>	<b>Number of study program</b>	<b>Number of permanent faculties</b>	<b>Number of active students</b>
D3	7	50	741
D4	3	32	549
S1 (undergraduate program)	31	287	6,335
S2 (magister program)	10	56	258
S3 (doctoral program)	2	10	87
<b>Total</b>	<b>53</b>	<b>435</b>	<b>7,970</b>

\* Source: Higher education data base, report year 2017/2018

**Table 2.** Agroindustrial engineering study programs in some countries

<b>No</b>	<b>Agroindustry Higher Education</b>
1	American Andragogy University, Hawaii, United States ( <a href="https://www.aauniv.com/">https://www.aauniv.com/</a> )
2	ASSUMPTION UNIVERSITY OF THAILAND, Thailand ( <a href="http://www.au.edu/index.php/">http://www.au.edu/index.php/</a> )
3	Chiang Mai University, Thailand ( <a href="https://www.cmu.ac.th">https://www.cmu.ac.th</a> )
4	College of Higher Study AQUINAS, Sri Lanka <a href="http://www.aquinas.lk/degree-programs/bsc-hons-in-agro-industry-management/">http://www.aquinas.lk/degree-programs/bsc-hons-in-agro-industry-management/</a>
5	Kasesart University, Thailand ( <a href="http://www.agro.ku.ac.th">http://www.agro.ku.ac.th</a> )
6	King Mongkut's University of Technology, North Bangkok, Thailand ( <a href="https://sites.google.com/a/sci.kmutnb.ac.th/bachelor-of-science-agro-industrial-technology/">https://sites.google.com/a/sci.kmutnb.ac.th/bachelor-of-science-agro-industrial-technology/</a> )
7	National University of La Rioja, Argentina, <a href="http://studyargentina.com/agro-industrial-engineer-national-university-la-rioja.html">http://studyargentina.com/agro-industrial-engineer-national-university-la-rioja.html</a>
8	Salliman University, Philippine ( <a href="https://su.edu.ph/schools-colleges/school-of-agro-industrial-and-technical-education/">https://su.edu.ph/schools-colleges/school-of-agro-industrial-and-technical-education/</a> )
9	The College of Engineering and Agro-Industrial Technology (CEAT), UPLB, Philippine ( <a href="http://uplb.edu.ph/academics/college-of-engineering-and-agro-industrial-technology-ceat/">http://uplb.edu.ph/academics/college-of-engineering-and-agro-industrial-technology-ceat/</a> )

**Table 2.** Agroindustrial engineering study programs in some countries (continued)

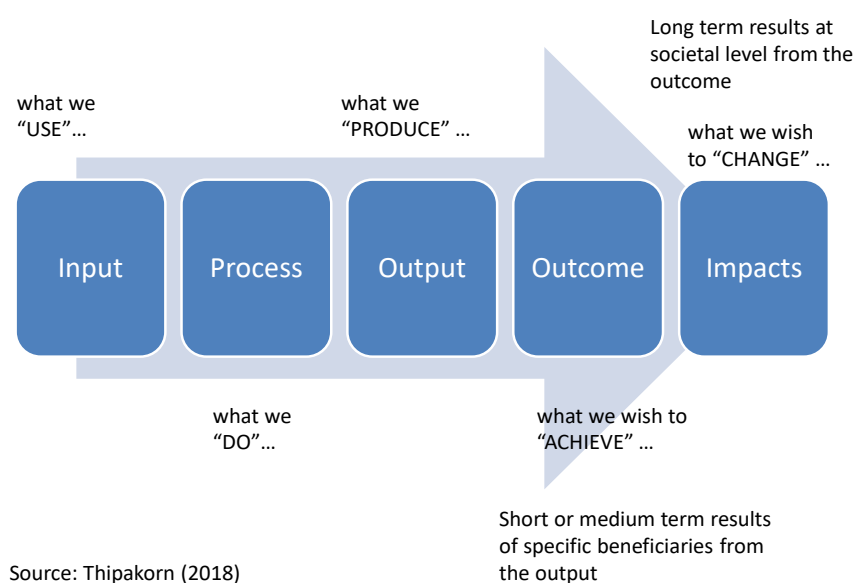
No	Agroindustry Higher Education
10	The University of Guanajuato, Mexico ( <a href="http://www.ugto.mx">http://www.ugto.mx</a> )
11	Universidad de la Costa, CUC, Colombia ( <a href="https://www.cuc.edu.co/en/">https://www.cuc.edu.co/en/</a> )
12	Universidad San Ignacio de Loyola (USIL), Peru ( <a href="http://www.usil.edu.pe/en/about-us/universidad-san-ignacio-de-loyola">http://www.usil.edu.pe/en/about-us/universidad-san-ignacio-de-loyola</a> )
13	Universidade Nova de Lisboa, Portugal ( <a href="https://www.fct.unl.pt">https://www.fct.unl.pt</a> )
14	University Niccolò Cusano, Italy ( <a href="https://www.unicusano.it">https://www.unicusano.it</a> )

Various changes in the external (national, international) and internal environment of the university have been and are happening. These include globalization, MEA, industrial era 4.0, knowledge-based competition, international standards of education and professional competence, implementation of national standards (Higher Education Standards, Indonesian National Qualifications Framework / KKNi, Study Program Nomenclature), government policies on increasing agro-industry competitiveness and added value of agricultural products, changes in stakeholder needs (21st century competencies), and changes in university vision. Considering the rapid changes in the external and internal environment, universities must adjust their study programs and graduate profiles to have the ability to adapt to these conditions. This adaptation ability must be cultivated and sharpened through various learning strategies to improve knowledge, skills and attitudes which are three important components of competence, so that graduates can function in society significantly [3].

Based on the above rationale, this paper presents and discusses the concept of developing the pathway of academic and professional education programs in agro-industry implemented at IPB, which is expected to be useful as a reference for study programs in the field of agroindustrial engineering or similar study programs in improving the competence of their students..

## 2. The role of Higher Education and Paradigm Shift in Higher Education

Responding to the demand for competitive human resources in the field of agro-industry, universities should improve their education quality and accountability. They have to shift from focus on input and process towards outcomes so that can be recognized by and clearly benefit stakeholders, namely professional community, users, and society in general. Universities should also move from the old orientation of producing job seekers towards the new paradigm of generating technopreneurs.



Source: Thipakorn (2018)

**Figure 1.** Outcome-based education system

In the Outcome-Based Education (OBE) system, the focus of attention is given to the outcomes or even to the impacts of education so as to ensure the accountability. The OBE system focuses on learning (not teaching), students (not faculties), and outcomes (not input and capacity). In the OBE system, it is important that "It's not only what you have but what you do with it". Figure 1 shows an illustration of the OBE system. Outcomes may be the results or changes due to educational efforts, relating to changes in knowledge, skills, concerns, attitudes, behavior, opinions, aspirations, decision making, social action, conditions or status. Outcomes can be short-term, medium-term or long-term. Outcomes may be expected or unexpected; positive or negative. The OBE system is a platform that allows study programs to be accountable to guarantee the learning process [5]. Quality and accountability can be assessed through an accreditation program.

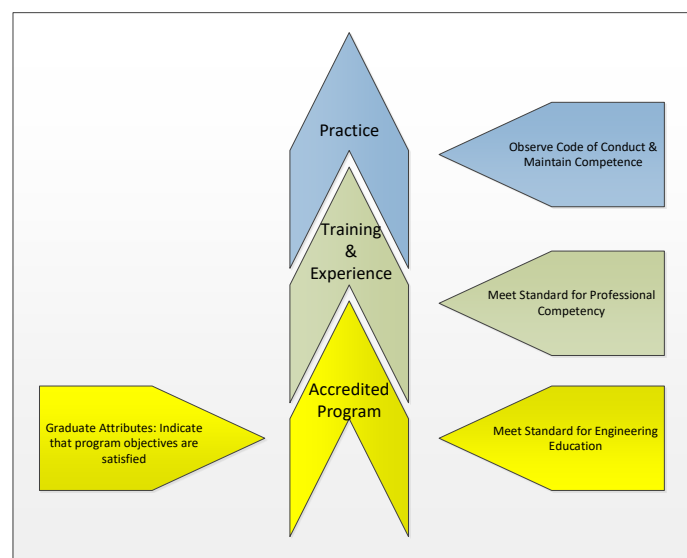
### 3. A concept of Engineering Education for Agroindustry

In the context of global competition, Indonesia's readiness to provide professional workforce is a crucial theme in the development of higher education. Author [6] entitled "Putting Higher Education to Work" identifies the existence of typical weaknesses in the form of unconnected in the education system, namely (a) the unconnected relation between the characteristics of higher education institutions (curriculum, and degree) and the expertise required by the user (employment provider); (b) Weak linkages between higher education institutions and industry as end users from the results of education and research; (c) Unconnected relation between higher education institutions and research institutions; (d) Weak coordination and integration between higher education institutions and between higher education institutions and training providers; and (e) Unconnected vertical relation between higher education with junior and senior high schools.

This situation has caused the relatively low competitiveness of university graduates in Indonesia compared to graduates from other countries. The alternative to overcome the above mentioned conditions and to improve the quality and competitiveness of graduates is the effort to provide a pathway that improves the quality and accountability of undergraduate study programs and professional education programs that meet international standards.

#### 3.1. Curriculum Development

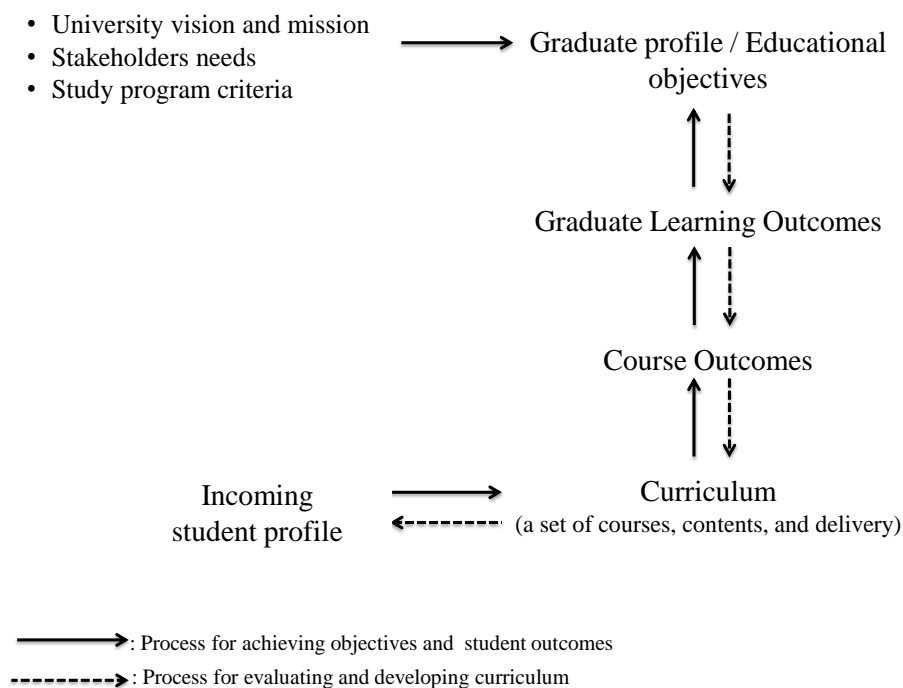
The path towards professional engineers that are capable of providing their engineering services to the improvement of agroindustry competitiveness start with accredited engineering education programs as shown in Figure 2. Graduating from accredited programs, graduates may improve their competences through training and experiences which will help them to meet standard for professional competencies.



**Figure 2.** First steps to professional engineers in agroindustry

Based on the above path, education process that meet engineering education standard is a must. The education process to produce graduates as a whole person certainly requires the involvement of various stakeholders [7] and needs to consider various factors in the development of curriculum [8]. Author [9] introduce an integrated approach for curriculum development which includes graduate competency factors, external and internal environmental variables, pedagogical strategies (student-centered and teacher centered) and leadership of educational institutions. Therefore, the curriculum needs to be developed systematically. The logic flow behind the design of professional engineer education program curriculum in relation to the program objectives, achievement of student learning outcomes, and student input is schematically shown in Figure 3.

The curriculum is developed in accordance with the institution vision, mission and needs of constituents, the education objectives (graduate profiles) and student learning outcomes (SLO) of the engineer professional education program. Furthermore, based on the program educational objectives and the graduate learning outcomes that will be achieved by the program, the curriculum of the program is formulated. The curriculum is a set of guidelines in planning and setting strategies to achieve the student learning outcomes, and thus the education objectives. The curriculum includes the structure of courses, learning materials, learning processes, assessments, monitoring and evaluation.



**Figure 3.** A schematic diagram of curriculum design

In accordance with the intended SLO, the curriculum of the engineer professional education program is emphasized on providing the experience of engineering practices in agro-industry in addition to strengthening the content of professionalism, ethics and work health and safety. The role of professional communities is important. Professional community is an important partner in the development and implementation of the engineer professional education program. In the development and implementation of the agroindustrial engineer professional education program, the Agroindustry Chapter of the Institution Engineers Indonesia is collaborating synergistically with the Communication Forum of Indonesian Agroindustrial Study Programs (FKPSIP), Indonesian Agroindustry Association (AGRIN), Agroindustrial Technology Professional Association (APTA), Forum of Engineer Profession Program Organizer (FPPPI), Indonesian Accreditation Board for Engineering Education (IABEE) and other Chapters of the Institution of Engineers Indonesia. The Agroindutry Chapter of the Institution of Engineers Indonesia carries out engineering service activities to support the government and other parties in the development of agroindustrial sector and other relevant sectors, supporting the

implementation of the agroindustrial engineer professional education program, Engineer Registration Certificate and Professional Engineer Certification, Continuous Professional Development, development of Standard of Engineer Services; consultation, community empowerment, Training, Focus Group Discussion (FGD); and National and International Seminars organization.

Quality and accountability of the program is assured through the implementation of Internal Quality Assurance System (SPMI) and External Quality Assurance System (SPME) as mandated by the Law No. 22/2012 on Higher Education. These quality assurance systems are tools to improve the quality of higher education and accountability to the constituents by applying outcome-based education. SPMI is developed, monitored and evaluated by the university. SPME is done through accreditation. National accreditation is done by National Accreditation Board for Higher Education (BAN PTBAN-PT developed the 2018 version of the Study Program Accreditation Instrument (IAPS), which was briefly written as IAPS 4.0. IAPS 4.0 is more focused on aspects of the process, output and outcome, while the previous instrument measured more aspects of input. External quality assurance can also be done according to international standard. For Engineering Education, this accreditation can be done in accordance to Washington Accord for Engineering Education, Sidney Accord for Engineering Technology, and Dublin Accord for Technician. The international accreditation body in Indonesia for engineering education is Indonesian Accreditation Board for Engineering Education (IABEE).

### 3.2. Agroindustrial Engineering Education Program (AEEP)

Agroindustrial Engineering Education Program (AEEP) is designed to provide graduates that will directly contribute as change maker in agroindustry sectors. The scope of competencies of agroindustry profession is as follow:

“Able to design, develop, implement, control, evaluate and improve performance of sustainable agroindustry through integrated approach of process, system, industrial management, and environmental aspects to increase the added value of agricultural resources and its derivatives” (Communication Forum of Indonesian Agroindustrial Study Programs, 2017)

Referring to this definition and scope of agroindustrial competencies as well as the inputs from the professional communities, the professional profile of agroindustrial graduates is as follow:

“After several (3-5) years in a professional career, graduates of agroindustrial engineering program are able to apply their knowledge from their academic program to:

- 41) Solve agroindustrial engineering problems, as quality engineers, productive and sensitive to the ethical and professional consequences of their works.
- 42) Develop themselves through postgraduate studies
- 43) Become a technopreneur
- 44) Play a role and communicate effectively as individual and in multidisciplinary team, and
- 45) Continue lifelong learning activities”

In order to achieve these graduate profiles, the curriculum should be formulated so that students will achieve student learning outcomes as shown in Table 3.

**Table 3.** Student Learning Outcomes of Agroindustrial Engineering Program

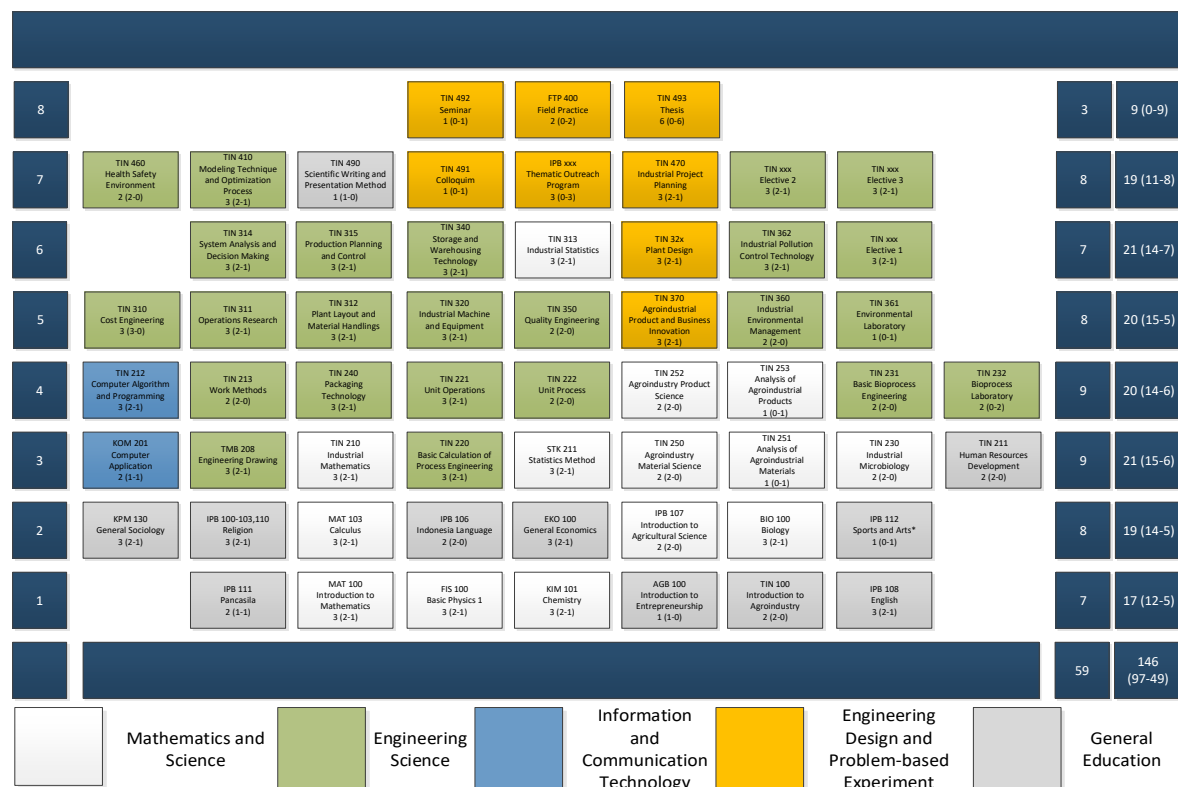
NO	STUDENT LEARNING OUTCOMES
1	Able to identify, analyze and solve problems in agroindustry that cover aspects of process technology, industrial management, systems engineering, and environmental engineering and management by applying knowledge of mathematics, science, engineering and information technology using modern engineering tools.
2	Able to design an agroindustrial system/component, process and product to meet the desired needs within realistic constraints
3	Able to design and conduct scientific and engineering experiments and analyze and interpret the resulting data
4	Able to recognize the needs and have the ability to be involved in lifelong learning

**Tabel 3.** Student Learning Outcomes of Agroindustrial Engineering Program (continued)

NO	STUDENT LEARNING OUTCOMES
5	Able to communicate in writing and oral effectively
6	Able to function effectively within multidisciplinary and multicultural teams
7	Able to understand the application of ethics and professionalism in solving engineering problems of agroindustry in the economic, environmental and societal contexts as well as other contemporary issues
8	Able to transform science and technology-based ideas into the concept of agroindustry business (technopreneurship)

The above student learning outcomes (SLO) consists of 8 graduate attributes that includes knowledge, skills and attitudes and referring to the international standard of bachelor engineering education [10] and considering the suitability to the national standard of higher education.

The SLOs are achieved through a sequence of courses. In the first year students will improve their knowledge of Mathematics, Science and General Knowledge. In the second year, students will follow basic engineering principles and information communication technology. The third and fourth year are designed to improve student's ability to apply and use their mathematics, science, engineering, and general knowledge to solve engineering problems. The structure of the courses is shown in Figure 4.

**Figure 4.** Course structure of Agroindustrial Engineering Program

The total credit for this curriculum is 146 units consisting of 137 units obligatory courses and 9 units of elective courses. This composition complies with the requirement of international standard of engineering education program as shown in Table 4.

**Tabel 4.** Mapping of courses according to the accreditation criteria of Indonesian Accreditation Body for Engineering Education (IABEE)

No.	Discipline	Required Load	Number of Courses	Load (units)	Load (%)	Remarks
1	Mathematics and Science	Min. 20%	14	34	23	Comply
2	Engineering Science and Technology	Min. 40%	24	63	43	Comply
3	Information technology and communication		2	5	3	Comply
4	Engineering design and problem-based experiments		7	22	15	Comply
5	General education	Max. 30%	11	22	15	Comply

### 3.3. Agroindustrial Engineer Professional Education Program (AEPEP)

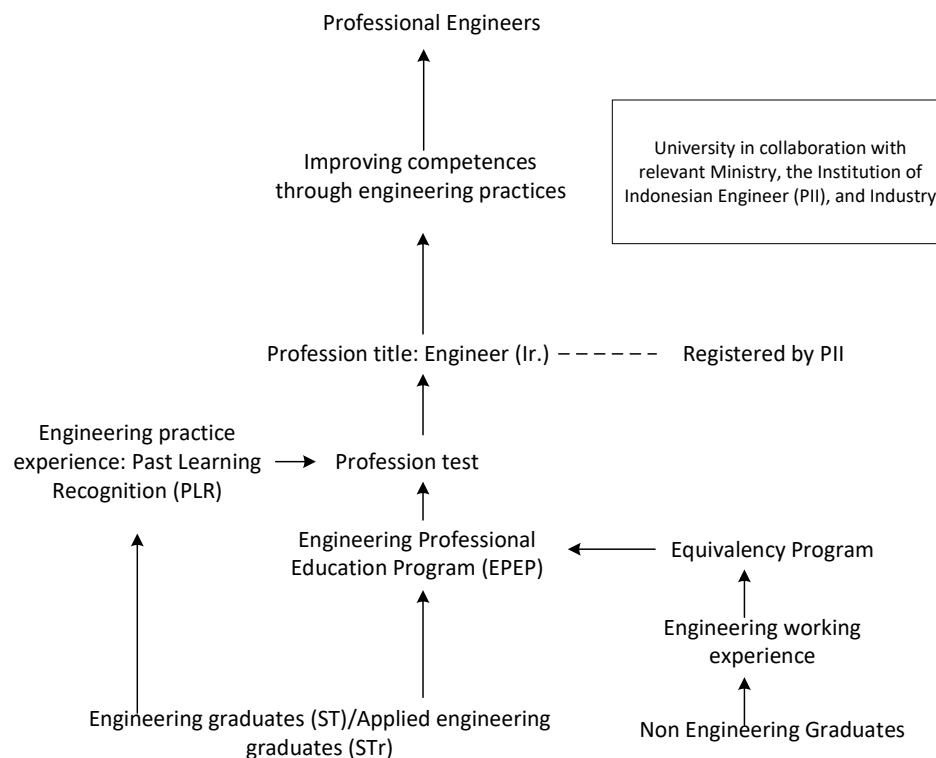
Having completed the undergraduate program, graduates might continue improving their attributes through training and experiences. An engineer professional education program is designed to serve this need. This education program is designed to respond to the demands of global competition while fulfilling the mandate of the Engineering Law No. 11/2014. The law gives mandate to university to carry out engineer professional education which is defined as a higher education after an undergraduate program that prepares students for work with special skill requirements. The law also regulates the obligation of a professional engineer to register in Indonesia (including foreign engineers) so as to provide legal certainty for providers of engineering services, and legal protection for engineers and service users. As a realization of the implementation of the Engineering Law, the Government of Indonesia via the Ministry of Research, Technology and Higher Education (Kemenristekdikti), through a Decree of the Director General of Science, Technology and Higher Education Institutions (SK Ditjen Iptek dan Dikti) No. 682 / C.C4 / KL / 2016 has given a mandate to 40 universities which are considered meeting the requirements for carrying out the Engineer Professional Program.

The Engineer Professional Education Program (EPEP) is a higher education program after an undergraduate program to establish engineering competence. The program is held in collaboration with relevant ministries (whose duties, principal, and functions are related to engineering services), non-ministry state institution (*Lembaga Negara Non Kementerian/LNNK*), the Institution of Engineers Indonesian (*Persatuan Insinyur Indonesia/PII*), relevant industry, and/or professional organizations responsible for the quality of engineering professional services. The university that organizes the EPEP can provide an engineer degree (abbreviated as Ir.) for individuals who have passed all the requirements according to the established standards. The EPEP standard was set by the Minister of Research, Technology and Higher Education, which was formulated based on the recommendations of the higher education institutions in cooperation with ministers fostering the relevant engineering services and the Indonesian Engineers Council.

Figure 5 shows the position of the professional engineer program in producing professional engineers. EPEP graduates hold an engineer degree (Ir.) according to the Law No. 11/2014, Article 7 and 9 are expected to develop themselves continuously through further engineering practices in their career, so that they can practice as professional engineers (PE) who bear responsibility to community safety / security and environmental sustainability.

In the context of producing competitive human resources in agroindustry, the role of engineer profession program in agroindustry is very strategic. The Engineering Professional Education Program (EPEP) is developed to facilitate graduates of undergraduate programs (S1) in developing themselves to work as engineers. The missions of EPEP in IPB are (1) To carry out engineer professional education to produce competent, integrity and highly competitive engineers in the field of agriculture in a broad sense to advance civilization and community welfare, protect the interests of the community, and realize sustainable development, (2) to encourage technological development to increase added value,

usability of agriculture-based resources, and (3) to disseminate technological developments to accelerate and expand the application of good engineering practices in agriculture in the broadest sense. The objectives are: (1) to produce competent, integrity and highly competitive engineers in the field of agriculture in the broadest sense, (2) to develop technology so as to increase added value, usability of agricultural resources for the welfare of society, and (3) to spread of technology and good engineering practices in the agricultural sector in the broadest sense.



**Figure 5.** Position of Professional Engineer Education Program in producing professional engineers  
(Source: Extracted from the Law No. 11/2014)

For those graduated from agroindustrial study program or similarly name of engineering program, they may choose to develop their professional competencies in the scope of agroindustrial engineering services. These services cover the following areas (1) development of process technology and agroindustrial products, (2) Management of the agroindustry, (3) Agroindustrial system engineering, and (4) Industrial environmental engineering and management.

The graduate learning outcomes (GLO) in EPEP is designed to produce engineers who have the ability to:

- 46) Perform engineering planning by utilizing resources and conducting engineering evaluation in agroindustry comprehensively by utilizing science and technology,
- 47) Resolve engineering problems in agroindustry,
- 48) Design and conduct scientific and engineering-based investigation for strategic decision making in accordance with professional ethics and engineering standards, and
- 49) Implement sustainable development of professionalism through lifelong learning.

The curriculum is designed to fulfill graduate learning outcomes that cover knowledge, skill, and attitude required to perform engineering services as a professional engineer. It is prepared by considering the obligations of engineers according to the Engineering Law No. 11/2014, graduate attributes of engineering education from the International Engineering Alliance (IEA), and alignments with national interests. The course subjects are listed in Table 5. Each course subject is designed to contribute directly to one or more the GLOs. It has a total credit of 24 credits, consisting of 70% of industrial practices under the apprenticeship supervisor, and 30% of the theoretical content.



**Table 5.** Course subjects of EPEP IPB

No.	Course subject	Credit	
1	Code of ethics and engineering ethics	2	(1-1)
2	Professionalism	2	(1-1)
3	Work health & safety, and environment	2	(1-1)
4	Engineering practice	12	(2-10)
5	Case Study	4	(1-3)
6	Seminar	2	(1-1)
Total		24	

EPEP curriculum can be grouped into knowledge of engineering ethics, professional competence, and work health & safety and environment; practical engineering skills and problem solving case studies; and soft skills which include communication, collaboration, leadership and management. Tables 6 and 7 are matrices that map the relationship between subjects and competencies to ensure that all learning outcomes can be met.

**Table 6.** Relative contributions of courses to aspects of student knowledge, skills and behavior

No	Course subject	Learning domain		
		Knowledge	Skills	Attitude
1	Code of ethics and engineering ethics	●	●	●●●
2	Professionalism	●	●●	●●●
3	Work health&safety and environment	●●	●●●	●●●
4	Seminar	●	●●●	●●
5	Engineering practice	●●	●●●	●●●
6	Case study	●●	●●●	●●●

Remarks: ●: medium contribution, ●●: high contribution, ●●●: very high contribution

**Table 7.** Relative contributions of courses in the graduate learning outcomes

No	Course subject	Graduate learning outcomes (GLO)*			
		1	2	3	4
1	Code of ethics and engineering ethics	●●	●●	●●●	●●
2	Professionalism	●●●	●●●	●●●	●●●
3	Work health&safety and environment	●●	●●	●●●	●●
4	Seminar	●	●●	●●	●●●
5	Engineering practice	●●●	●●●	●●●	●●●
6	Case study	●●●	●●●	●●●	●●

●: medium contribution, ●●: high contribution, ●●●: very high contribution

The program is conducted in two learning modes, namely the Regular Program and the Past Learning Recognition program (*Rekognisi Pembelajaran Lampau/RPL*). In principle, regular program is intended for practitioners who have not had sufficient experience in engineering practice, whereas the RPL program is for practitioners who have had sufficient engineering practice experience. Learning process in the regular program is carried out within 2 semesters that consists of face-to-face meetings, tutorials, focus group discussions, assignments, role plays, pre- and post-tests implementation of independent individual tasks and group assignments (eg. project / problem-based learning, and collaborative-based learning), involvement in scientific meetings, proposal writing and engineering project reporting, and oral presentations.

The RPL is an acknowledgment of learning outcomes obtained from formal, non-formal, informal, and/or work experience in the education sector and other sectors. It is opened for engineering or

applied engineering graduates who are considered to have sufficient engineering practice experience (more than 2 years) or for science graduates and engineering education graduates who have fulfilled the equivalency requirements (equivalent to 3 years engineering practice) and possessed adequate engineering practice experience (more than 2 years). RPL is carried out through assessment and recognition of participant portfolios against the requirements of semester credit units (SKS). Credit shortages are then fulfilled through the implementation of the program's curriculum. Learning in the RPL program is carried out within 1 semester. The learning process, assessment and graduation requirements are basically similar as the processes and requirements in a regular program.

#### 4. Concluding Remarks

The increasing number of qualified professional engineers through engineer professional education programs can reduce dependence on foreign engineers. As we all know, foreign investment is very encouraged. The availability of qualified Indonesian professional engineers will improve our nation's bargaining position on the use of foreign workers, especially in economic activities financed by foreign investment. The implementation of the 2015 ASEAN Economic Community (AEC) challenges Indonesian industry and workers. This challenge must be answered immediately by higher education by producing more graduates and professionals who have high quality. Global labor mobility also demands a quality and competitive workforce and is recognized globally. Engineering services are one area that will face very tight competition. This requires a level of competence that is equivalent to global standards. For this reason, improving the quality of technical education programs is considered an effective way to prepare the necessary workforce.

The path of academic education and the agro-industrial engineering profession described in this paper is one of the efforts of higher education to contribute in providing competitive human resources in the field of agro-industry. A quality and accountable education system that involves stakeholders and in accordance with national and international standards is expected to produce an adaptive workforce to develop sustainable agro-industries. Graduates of the academic education pathway are expected to have the competence to be able to design, develop, implement, control, evaluate and improve the performance of sustainable agroindustry integrated systems, covering aspects of the transformation process, system engineering, industrial management, and the environment, and able to work as professionals or technopreneurs through increased knowledge and ability in line with the development of agro-industry.

Graduates who continue on the engineering profession program are expected to meet the standards of professional engineer competence in the field of agro-industry. These professional agro-industry engineers are needed to improve the competitiveness of national agro-industries. They are eagerly awaited to take part in increasing the added value of tropical agricultural commodities, developing the capacity of knowledge and technology and providing innovative solutions in the community. As a university that focuses on providing human resources and science and technology in the field of agriculture in a broad sense, IPB is required to have a proactive role to produce agricultural engineers who are able to contribute in realizing the provision of food, energy and industrial products in a sustainable manner.

**Acknowledgments:** The Authors thank to all Preparation Team member of IPB's engineer profession education program, faculties of ATSP, and resource persons from alumni, the Communication Forum of Indonesian Agroindustrial Study Programs, The Institution of Engineers Indonesia, Professional Associations / Organizations, and governmental organizations who have been actively involved at various stages of preparation of the program.

#### References

1. Luekitinan, W. 2014. Employability and Job Mobility: Critical Skills for New Graduates in ASEAN. *Gloval Journal of Business Research*. Vol.106: 292-299
2. Fukunaga, Y. 2015. Assessing the Progress of ASEAN MRAs on Professional Services. *ERIA Discussion Paper Series*

3. Rugarcia, A., Felder, R.M, Woods, D.R., dan Stice, J.E. 2000. The Future of Engineering Education: A vision for a new century. Chemical Engineering Education, Vol. 34 (1), 6-25
4. Cheshier, S. R. 1998. Studying Engineering Technology: A Blue Print for Success. Discovery Press.
5. Thipakorn, B. 2018. Outcome Based Education: An Education Framework to Ensure Performance-Based Accountability Regime of Higher Education Institution in High Quality of Learning. Paper Presentations of International Conference on Outcome-based International Quality Assurance System 2018, in Pekanbaru, Riau, Indonesia, 8-9 August 2018. Available online: <http://spmi.ristekdikti.go.id/publikasi/5b6a69b167e91c071f4ffe26>
6. World Bank. 2012. Putting Higher Education to Work Skills and Research for Growth in East Asia. World Bank East Asia and Pacific Regional Report. Available online: <http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/> (accessed on September 15, 2018)
7. Malkki, H dan Paatero, J.V. 2015 Curriculum Planning in Energy Engineering Education. Journal of Cleaner Production. Vol. 18: 652-658
8. Jackson, D. 2010. An international profile of industry-relevant competencies and skill gaps in modern graduates. International Journal of Management Education Vol. 8: 29-58
9. Khan, M.A., dan Law, L.A. 2015. An Integrative Approach to Curriculum Development in Higher Education in the USA: A theoretical framework. International Education Studies. Vol. 8 (3): 66-76
10. IEA (International Engineering Alliance). 2014. 25 Years of Washington Accords 1989-2014: Celebrating international engineering education standards and recognition. International Engineering Alliance Secretariat. New Zealand. Available online: <http://www.ieagrements.org/accords/washington/> (accessed on July 15, 2018)



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-SA-010-ID014

# Quality and Packaging Analysis of Fresh Strawberry (*Fragaria* Sp) During Storage in Controlled Environment

Agustina R.P. Andam Dewi<sup>1</sup>, Pujo Saroyo<sup>2</sup> and Mohammad Affan Fajar Falah<sup>2,\*</sup>

<sup>1</sup> Student at Departement of Agroindustrial Technology, Fac.of Agricultural Technology, Universitas Gadjah Mada; e-mail@e-mail.com

<sup>2</sup> Department of Agroindustrial Technology, Fac.of Agricultural Technology, Universitas Gadjah Mada Jl. Flora No.1, Bulaksumur, Sleman, Yogyakarta 55281; e-mail@e-mail.com

\* Correspondence: affan\_tip@ugm.ac.id; Tel.: +62-274-551-219

Received: 8 July 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** Strawberry fruit (*Fragaria* sp) is highly perishable fruit fast deteriorate of their quality in tropical conditions and common technique to delay their senescence process was stored in controlled environment. Strawberry fruit in Indonesia generally packaged using plastic to easy handling of strawberry fruit and also to maintain their quality from physical damage. However, the effect of this plastic packaging on quality of the strawberry fruit is often neglected. The strawberry from supermarket in Yogyakarta was chosen from the first day, then continue to store in controlled environment using temperature at 4°C and 10°C with RH varied between 85-95% in a laboratory. Quality parameters of the strawberry were measured, such as water content, pH as acidity indicator, texture of the skin, color of the skin, and total plate count test. Taguchi Method was applied to determine the most appropriate plastics packaging that used for maintaining quality of fresh strawberry. Our results showed, strawberry fruit have shelf-life around 7 days at controlled environment. Water content, acidity and texture of the strawberry can be maintained their quality during storage in controlled temperature conditions. Best combination using Taguchi Methods in plastics packaging of strawberry with plastic are using 10 cm<sup>2</sup> plastic holes, none of the use of carton paperboard, not to wash strawberry before being pack, using plastic packaging size (15,8 x10x3,8) cm<sup>3</sup>, 18 strawberry fruits per packaging, 4°C showcase temperature and tight packaging conditions.

**Keywords:** controlled environment, packaging, quality, strawberry, tropical conditions

## 1. Introduction

Strawberry (*Fragaria* sp) is non-climacteric fruit which has an attractive appearance due to its conical shape fruit and striking red colour. Strawberry has a potential prospect to develop as a fresh or processed food in Indonesia because many consumers like this kind of fruit and there are so many foods which use strawberry as its ingredients. Strawberries grown in Indonesia have many varieties such as Sweet Charlie (from the United States), Oso Grande (from California), Tristar (West America), Nyoho (from Japan and South Korea), Hokowaze (Northern Japanese), Rosa Linda (from Florida), Chandler (from California). Those varieties have been cultivated in Indonesia especially in the plateau areas as Lembang, Cianjur, Cipanas and Sukabumi (West Java), Batu and Situbondo (East Java), Magelang and Purbalingga (Central Java), Bedugul (Bali), and Brastagi (North Sumatra, also with other varieties of Osogrande in Purbalingga, Central Java, Selva in Karanganyar, Earlibrite (Holibert) in Garut and Bandung Ciwidey, Rosa Linda, Sweet Charlie, Aerut and Camarosa in Bedugul Bali, Dorit, Lokal Brastagi and California in Brastagi, Chandler in Bondowoso PTPN XII, Lokal Batu in Batu, Malang [1].

However, development strawberries in Indonesia still have some problems, especially during the post-harvest handling from farmer or wholesaler during distribution, which can lead into faster decay of strawberries and become rotten. Post-harvest handling of strawberry fruit must be done properly

and should not be arbitrary because it has different characteristics to another fruit. Several parameters of strawberry are important to maintain their quality during their postharvest handling. According to [2] water content is the largest part in strawberry fruit which is for about 92 g water per 100 g strawberry, and other substantial content of strawberries are protein, total lipids, carbohydrates, fiber, and ash. [3] shown that there are two notions of maturity of fruits and vegetables which are physiologically mature and commercially mature. Physiologically mature means that fruit has reached exact levels of growth and development. Meanwhile, commercially mature is the current state of the commodity which reach desired quality of the market. Quality parameters that can be used as a basis for determining the maturity of fruit [4]. Previous experiment for storage of local strawberry from West Java Indonesia as a tropical conditions in were strongly recommended to store in controlled environments with lower temperature conditions, to extend their shelf life and maintain their quality [5].

Tropical storage conditions greatly affected shelf life of strawberries during postharvest, storage, distribution or display in the modern supermarket or traditional market. In addition, the condition of packaging also affected strawberries shelf life because packaging material will have direct contact to the fruit. In retail market of Indonesia, strawberries is packed using plastic from polyethylene terephthalate (PET). Packaging is useful to facilitate the handling of fresh strawberries that have been harvested. Packaging can help and prevent or reduce damage and protect the inner materials from pollution and physical disturbance like friction, shock, or vibration and also their used to simplify the process of handling fresh strawberries. In terms of marketing view and promotional objective, packaging may serves as an incentive or attraction to the buyers [6]. However, the influence of packaging on the physical, chemical, and biological conditions of fresh strawberries have less attention especially effects on quality of strawberry during their display and storage in the market.

Furthermore, Taguchi method was used to determine the most appropriate setting of the PET strawberries packaging based on principled on quality improvement by reducing variations without eliminating the cause. Taguchi Method suitable to be applied in this research because it is one of the tool for a quality improvement with principle to minimize the effect of variation without eliminating its cause. It can be obtained through the optimization of the design of products and processes to make the performance robust to various causes of variation in a process called parameters design [7] Taguchi method is a methodology for engineers or improve productivity during the research and development so that high quality products can be produced quickly and at low cost.

Objectives of this research was to determine the effect of packaging on the quality of fresh strawberries in accordance with storage temperature in controlled environment and the best setting of the combination between several types of packaging which is storage in tropical environmental conditions.

## 2. Materials and Methods

### 2.1 Plant Materials

Local fresh strawberry (*Fragaria, sp* cv Holibert) were obtained from a local farm in Dusun Barudua, Malangbong District, Garut Regency, West Java Province, and fruits were transported under ambient temperature conditions (25-30 °C) within 12 h after harvest to reseller or fruit distributor in Yogyakarta using train. In fruit distributor, these fruits were divided into two groups, first group for traditional market and second group for modern market in Yogyakarta, usually based on their size. Strawberry were wrapped with 0.7 mm plastic polyethylene terephthalate (PET).

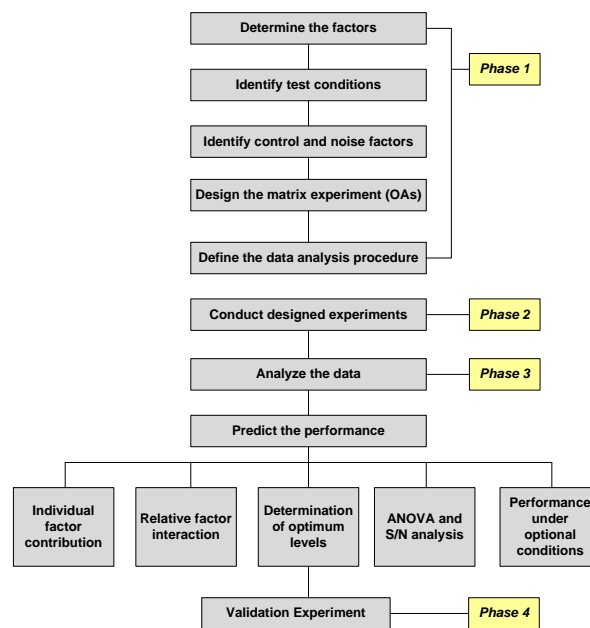
### 2.2. Measurement Quality Parameter of Strawberry

Quality evaluation of fresh strawberry fruit were measured based on their physical and nutritional characteristics. For physical evaluation, , texture of skin strawberry fruit as a fruit firmness was determined using a texture analyzer (UTM, Model Zwick Tipe DO FB0 5TS, Germany) and then color of strawberry fruit (fruit surface color) was measured using a chromameter (Minolta, CR-400, Japan)

and expressed on L-a-b value (dark to light, on a scale of 0–100). All of physical measurements were evaluated and the average data from 7 samples for each measurement were used with triplicates. For nutritional evaluation, water content was evaluated using a thermogravimetric method, acidity of fruits was measured using value of pH, then simple microbial evaluation was also measured using Total Plate Count (TPC) method. All of nutritional measurements were evaluated and the average data from 7 samples for each measurement were used with triplicates. Data obtained from the experiment results were tabulated and calculated using Microsoft Excel 2007 (Microsoft Corporation). Further statistical analysis utilized SPSS version 14.0 (SPSS Incorporation) to obtain optimum treatments and significance of the obtained results through analysis of variance (ANOVA) and LSD interpretations.

### 2.3. Taguchi Method Application

In this experiment, Taguchi Method was chosen because of its excellence and more structured than the conventional statistical methods. This method has several steps, where several quality parameters of the process or product related to the control factors and noise were analyzed. Principle design strategy of the design parameters were determined through the best value of control factor, which is able to minimize the sensitive function process for all noise factors [7-8]. The following are the common steps of Taguchi Method using four phases (Figure 1).



**Figure 1.** Steps of Taguchi Method Approach [9]

In this experiment, we use similar phase, firstly determination the factors, as show in the table 1, then next step is determine Signal to Noise Ratio (SNR). There are three types of Signal to Noise Ratio according to the parameter used to define strawberry quality characteristic, smaller the better, nominal the best and larger the better. In this research orthogonal array  $L_8(2^7)$  is used because of its ability to reduce the number of experiments significantly and a large number of decision variable can be learned through the minimum experiments so that it become more effective. Then, two-way analysis of variance (ANOVA) is used to able for outline and calculate the total variance into factor variance so the contribution of each factor to the total variance will be known. The last step is analysis of multi-response characteristic with validation of experiment.

**Table 1.** Controlled Factors and Levels of Taguchi Method Approach

Controlled Factors		Level	
		1	2
A	The width of the air holes surface of the packaging	10 cm <sup>2</sup>	2 cm <sup>2</sup>
B	Temperature of showcase	4°C	10°C
C	Tightness of packaging	Not tight	Tight
D	The numbers of strawberries/package	15 fruits	18 fruits
E	Pretreatment fruit storage	Fruit do not need to be washed	Fruit need to be washed
F	PET packaging size	(15,8x10x3,8) cm	(13,8x7,5x) cm
G	The use of bottom cardboard	In use	Not in use

In this experiment, it can define and conduct eight different experiment based on the controlled factor and level using taguchi method for orthogonal array. This orthogonal array for the experiment can be found in the table 2.

Tabel 2. Orthogonal Array of controlled factors and experiments for Taguchi Methods

Controlled factors	Experiment Number							
	1	2	3	4	5	6	7	8
A The width of the air holes surface of the packaging	10 cm <sup>2</sup>	10 cm <sup>2</sup>	10 cm <sup>2</sup>	10 cm <sup>2</sup>	2 cm <sup>2</sup>	2 cm <sup>2</sup>	2 cm <sup>2</sup>	2 cm <sup>2</sup>
B Temperature of showcase	4°C	4°C	10°C	10°C	4°C	4°C	10°C	10°C
C Tightness of packaging	Not Tight	Not Tight	Tight	Tight	Tight	Tight	Not Tight	Not Tight
D The numbers of strawberries/package	15	18	15	18	15	18	15	18
E Pretreatment fruit storage	Fruit do not need to be washed	Fruit need to be washed	Fruit do not need to be washed	Fruit need to be washed	Fruit need to be washed	Fruit do not need to be washed	Fruit need to be washed	Fruit do not need to be washed
F PET packaging size	(15x8x3) cm	(12x8x3) cm	(12x8x3) cm	(15x8x3) cm	(15x8x3) cm	(12x8x3) cm	(12x8x3) cm	(15x8x3) cm
G The use of bottom cardboard	In use	Not in use	Not in use	In use	Not in use	In use	In use	Not in use



According to author [10], the optimal storage temperature for fresh strawberries is 0°C with relative humidity or RH of 90-95%, they will be able to survive for 5-7 days of storage. Strawberries for daily consumption were stored at a temperature of 2-3°C, and the recommended temperature for storage of strawberries on showcase maximum is 4.4°C. However, if it is stored in the large number of the best temperature is below 4.4°C or temperature ranges between 2-3°C. Unfortunately, the survey showed that storage temperature for fresh strawberries supermarkets in Yogyakarta Indonesia, showcase in the range of 0°C to 10°C that was used to display strawberry in the modern market and without temperature controlled for traditional market with ambient temperature in the range of 26-30°C.

### *3.1. Quality Parameters of Fresh Strawberry in Controlled Temperature Storage*

In the this study, the storage temperature was used is 4°C according to modern market temperature and 10°C according to fresh fruit seller in the street. During temperature at 4°C, strawberries have a longer shelf life than the temperature of 10°C and several microbes like fungus or mold will be slower to grow at 4°C. According author [11] when the fruit storage temperature increased from 0°C to 10°C, the fruit will rot faster 2 to 4 fold, it means that the strawberries were stored at a temperature of 20°C only has a ¼ or ½ life of fruit stored at 0°C and if stored at a temperature of 30°C berries will last only a few hours so it only has a short shelf life. In this experiments strawberry's shelf life is 3 days at ambient room temperature (26-30°C) and it will extended to 7 days in lower temperature storage conditions.

Table 3 show the average value of the quality characteristics of strawberry fruit during storage for 7 days. We can find that water content, the experimental results showed that the water content has a downward trend, with average about 91-92%, and similar with author [2] which said that the water content of strawberries is 92% as common. pH value of strawberries ranged 3,4 – 3,8, this indicated that the local fresh strawberry have a high acidity value. At 100 grams dry weight of oranges contained 32 mg of vitamin C, while the strawberries contained 53 mg of vitamin C [12].

Table 3. Quality Parameter of Fresh Strawberry Using Plastics Packaging for 7 Days

No.	Quality Parameter	Exp 1	Exp 2	Exp 5	Exp 6	Ex K4	Exp 3	Exp 4	Exp 7	Exp 8	Exp K10
1.	Water Content (%)	91,1 ± 0,9	91,2 ± 1,2	91,5 ± 0,5	91,2 ± 0,9	91,4 ± 0,7	91,0 ± 0,8	90,3 ± 0,8	91,0 ± 0,7	91,3 ± 0,7	90,8 ± 0,9
2.	pH	3,57 ± 0,09	3,61 ± 0,06	3,67 ± 0,11	3,71 ± 0,12	3,71 ± 0,11	3,65 ± 0,08	3,66 ± 0,09	3,70 ± 0,15	3,72 ± 0,13	3,47 ± 0,1
3.	Texture (N)	16,61 ± 2,2	17,53 ± 2,4	17,44 ± 4,3	17,34 ± 3,4	17,14 ± 3,2	18,74 ± 3,3	18,36 ± 3,6	17,59 ± 2,8	18,57 ± 3,5	18,43 ± 2,6
4.	Color (L)	27,27 ± 2,1	27,32 ± 2,5	26,71 ± 3,0	28,95 ± 1,8	28,09 ± 2,1	28,60 ± 1,1	27,21 ± 0,9	26,73 ± 1,6	27,48 ± 1,9	28,75 ± 2,1
5.	Color (a)	23,21 ± 3,9	21,79 ± 2,7	22,66 ± 4,8	24,66 ± 2,7	24,61 ± 2,8	23,11 ± 1,5	22,54 ± 2,6	21,79 ± 1,6	23,32 ± 3,1	24,41 ± 2,3
6.	Color (b)	12,06 ± 1,8	12,43 ± 2,5	12,11 ± 2,7	13,65 ± 1,5	12,96 ± 1,3	12,98 ± 0,9	11,83 ± 1,3	11,49 ± 1,1	11,97 ± 1,5	13,19 ± 1,7
7.	TPC (x 10 <sup>-3</sup> cfu/g)	101	59	103	124	46	80	75	118	69	5

Texture of the skin of strawberry that storage at lower temperature were changed gradually and appeared to be dried and wrinkle due to the ripening and senescence process. Lightness (L), Redness (a), and Yellowness (b) as a color indicator of the strawberries skin were also changed. TPC which measure the number of living microbes in the fruit at the 7<sup>th</sup> day after storage were varied depend on the treatments. Diseases that often attacks strawberry fruit are gray mold caused by the fungus *Botrytis cinerea*, rotten fruit by the fungus *Colletotrichum fragariae*, white fungal mycelium infection caused by the spores of the fungus *Rhizopus stolonifer* black [13]. In this study a lot of decay caused by *Rhizopus* sp. and *Botrytis cinerea* that was appeared on 8<sup>th</sup> day then this indicated that the strawberries can not be eaten.

### 3.2. Taguchi Method Approach for Selection of Packaging Strawberry

#### 3.2.1. Result of MEAN and SNR Calculation

Data mean shows the mean response for each sample strawberries experiment of each quality attribute parameter. Data for the calculation of mean taken from the last day of the experiment which was the 7<sup>th</sup> day. The reason why the data taken at the 7<sup>th</sup> was due on the day which began to be found indications of rotten strawberries and also the fungus began to grow on the surface of a strawberry fruit at the 7<sup>th</sup> day so it did not proper to be saved anymore. Showcase strawberries at 4°C looked fresher than strawberries at a temperature of 10 °C. Decreasing value in fruit quality due to decay processes that occur was mentioned in the table 1 above. Decreasing water content causes strawberries to shrivel due to water loss. Strawberries pH difference was not much different from the first day, but showed an upward trend in the past seven days of storage. Strawberry fruit texture textured tight at the beginning of storage, but then became mushy and the texture increasingly diminished because of the bumping or shaking when strawberries were transported or moved into another storage. Another quality attributes such as color brightness or lightness (L) went down because the skin color of strawberry fruit was getting dark. Similarly happened to attribute redness (a) and yellowness (b) that were getting decline every day. For the quality attribute change of the color ( $\Delta E$ ) showed an increasing trend due to the differences that became more visible from the first day of strawberries until the last day when the strawberries were stored.

In addition, each quality parameters of strawberries Mean and the SNR calculation of the strawberries were water content, pH, texture, color (L, a, b,  $\Delta E$ ). Then the value of calculation for Mean and SNR can be known through the Mean and SNR predetermined formula which was larger the better, nominal the best, or the smaller the better. Furthermore, also can be known the value of the factor effects from the calculation of the formula given.

#### 3.2.2. Analysis of MEAN Factor Effect and SNR Factor Effect

Analysis of MEAN Factor Effect and SNR Factor Effect are used to calculate how much each factor that has been determined before influenced the quality parameters. In the analysis of taguchi effect factor with taguchi L8 orthogonal matrix will be known effect of seven factors that shown in the table 4.

Table 4 show analysis of MEAN Factor Effect and SNR Factor Effect. It can be seen that the effects of factors that most influence the MEAN of fresh strawberries water content was G factor with difference value or effect factor value of 0,50152. Based on the calculation it can be seen that the best combination of water for MEAN's calculation was G1, A2, D1, E2, B1, F2, C2. Meanwhile, the best combination for SNR's calculation of water content was G1, D1, E1, F1, A2, B1, and C1. Then, Taguchi's quality characteristics response used is nominal the best for water content. pH of the strawberry can be identified as acidity level of the strawberry product that influence quality of fresh strawberries. From the Figure known that the best combination for the calculation of MEAN factor effect was E1, D2, F1, A2, G1, C1, and B2. For SNR factor effect, the best combination was E1, D2, F1, A2, G1, C1, and B2. Taguchi's quality characteristics response used is larger the better for pH. Other quality parameter is a texture of the skin of strawberry. For skin texture the most influential factor was G factor with difference

2,80250 for MEAN factor effect and SNR factor effect can be discovered that the most influential or the biggest influence come from G factor with difference value of 0,19030 and the least value come from C factor with difference value of 0,06222. The best combination for MEAN factor effect of texture quality parameter for fresh strawberries was G2, D2, E2, A2, F2, C2, and B2 while the best combination for SNR factor effect was G2, D2, E2, A2, B2, F2, and C2, based on the calculation skin texture of the strawberry used is larger the better.

The next quality parameter is color and the first color parameter attribute is lightness (L), redness (a) and yellowness (b). Taguchi's quality characteristics response used is larger the better for lightness (L), redness (a) and yellowness (b). Another color response observed was change of color ( $\Delta E$ ) which is the combination of the previous three color attribute (L, a, b). The figure showed that the biggest MEAN factor effect was 12,45651 reached by G factor. Besides, the smallest MEAN factor effect was 0,64273 reached by F factor. This difference was bigger rather than another quality response. Meanwhile, for SNR factor effect G factor reached the biggest difference value which was 0,89829. The smallest effect for SNR was D factor with difference value of 0,04800. Graph illustration showed that the best combination for quality parameter change of color ( $\Delta E$ ) in MEAN factor effect was G2, B2, E2, C2, A1, D2, and F2 while best combination for SNR factor effect was G2, B2, A1, C2, E2, F2, and D2. Taguchi's quality characteristics response used is smaller the better which is the opposite of L, a, b color attribute because  $\Delta E$  is combined parameter.

Total Plate Count or TPC is the last quality parameter for this research. From the figure can be known that the most dominant MEAN factor effect was reached by G factor while the least effect comes from E factor, with difference value of 26,5 and 4,66667 respectively. Those two values had wide range because of the big difference of colony forming unit for microbes in petridish in the 0-day until 7-day. Moreover, the best combination for SNR factor effect was G2, D2, A1, B2, C1, E2, and F1 and Taguchi's quality characteristics response used is smaller the better.

**Table 4.** Analysis of MEAN Factor Effect and SNR Factor Effect

No.	Quality Parameter	MEAN Factor Effect		SNR Factor Effect		Best Combination (Mean, SNR)
		Max	Min	Max	Min	
1.	Water Content	G: 0,50152	C: 0,00099	G: 0,30227	C: 0,04213	G1,A2,D1,E2,B1,F2,C2 G1,D1,E1,F1,A2,B1,C1
2.	pH	E: 0,04167	B: 0,02167	E: 0,00988	C: 0,00553	E1,D2,F1,A2,G1,C1,B2 E1,D2,F1,A2,G1,C1,B2
3.	Texture	G: 2,80250	B: 0,89417	G: 0,19030	C: 0,06222	G2,D2,E2,A2,F2,C2,B2 G2,D2,E2,A2, B2,F2,C2
4.	Color (L)	C: 2,00333	D: 0,35	C: 0,06694	B: 0,01069	C2,G2,F2,A2,E2, B1,D2 C2,G2,F2,A2,E2,D2,B1
5.	Color (a)	E: 3,93333	D: 0,84667	E: 0,15950	D: 0,01587	E2,A2,F2,G2,C2,B1,D1 E2,F2,A2,C2,G2,B1,D1
6.	Color (b)	C: 1,57500	D: 0,09833	C: 0,11850	D: 0,00409	C2,G2,F2,B1,A2,E2,D1 C2,F2,G2,B1,A2,E2,D1
7.	Color ( $\Delta E$ )	G: 12,45651	F: 0,64273	G: 0,89829	D: 0,04800	G2,B2,E2,C2,A1,D2,F2 G2,B2,A1,C2,E2,F2,D2
8.	TPC	G: 26,5	E: 4,66667	G: 0,26528	F: 0,03707	G2,A1,D2,B2,C1,F1,E2 G2,D2,A1,B2,C1,E2,F1

Based on the calculation of the effect of these factors can be seen the best combination of factors and levels from every quality parameter of fresh strawberries experiments that have been done. The greater the value of effect factors indicate the greater influence to the sample. Best combination showed that between mean and SNR level have factors sequence which almost identical on every quality attribute of parameter.

### 3.3. Result Comparison of Each Parameter Analysis

The order of best combination of factors and level can be known for every fresh strawberry fruit quality parameters which is water content, pH, texture, color (L, a and b), and TPC were compare each other. Calculation results indicate that the effect of factors and levels of factors that affect the quality of each parameter mostly have the same level between the analysis of factor effect for Mean and SNR. However, there are differences in sequence between one factor to another. This sequence shows that there are differences in the influence of the average (mean) and also the influence of signal to noise ratio.

### 3.4. Analysis of Variance (ANOVA)

Based on the calculation using analysis of variance, to determine which is the large contributions of the factor for each quality parameter. The largest contribution of fresh strawberries for water content quality parameter was the factor G with contribution of 7,432%. Greatest contribution for the fruit pH quality parameter was factor E which was with value of 24,462% and texture quality parameters indicated by factor G had value of 19,238%. For parameter of fruit brightness or lightness the biggest contribution was the factor C with contribution of 29,126%. The largest contribution for the redness (a) color parameter was the E factor with value of 20,783%. Contribution of yellowness (b) color parameter and change of color ( $\Delta E$ ) was factor C 18,472% and factor G by 7,003% respectively. Meanwhile, the last but not least quality parameter TPC had the largest contribution by factor G with percentage as much as 13,157%.

### 3.5. Multi Response Characteristic Analysis

**Table 5.** Priority Factor for Fresh Strawberry Fruits According to Multi Response's Calculation

	Controlled Factors	Level 1	Level 2	Difference	Rank
A	Width of the air holes surface of packaging	-2,01021	-2,16714	0,15693	1
B	Temperature of showcase	-2,04553	-2,13181	0,08628	6
C	Tightness of packaging	-2,13161	-2,04573	0,08588	7
D	The numbers of strawberries/package	-2,13713	-2,04021	0,09692	5
E	Pretreatment fruit storage	-2,02317	-2,15417	0,13099	3
F	PET packaging size	-2,02318	-2,15416	0,13098	4
G	The use of bottom cardboard	-2,15802	-2,01932	0,13870	2

From the table above can be known the sequence of most influential factors in the cold storage of fresh strawberries which is factor A, G, E, F, D, B, and C. The bigger the effect, the wider also the line that represent each factor:

**Table 6.** Factor Effect of Multi Response SNR

	A	B	C	D	E	F	G
Level 1	-2,01021	-2,04553	-2,13161	-2,13713	-2,02317	-2,02318	-2,15802
Level 2	-2,16714	-2,13181	-2,04573	-2,04021	-2,15417	-2,15416	-2,01932
Difference	0,15693	0,08628	-0,08588	-0,09692	0,13099	0,13098	-0,13870
Rank	1	6	7	5	3	4	2

SNR calculations factors using multi-response were resulted and determined the priority ranking difference factor that specify the best condition for strawberries storage . It is known that the difference or the biggest effect factor found in the factor A 0.15693, which is followed by factor G, E, F, D, B, and

C in accordance with factor's order priority for fresh strawberries storage. Meanwhile, levels that affected each factor are A1, B1, C2, D2, E1, F1, and G2. Thus, the order priority for factors and levels final combination of fresh strawberry fruit storage is A1, G2, E1, F1, D2, B1, and C2.

#### 4. Discussion

##### *The Relationship Between Fresh Strawberry Fruit's Quality During Cold Storage and Its Parameter Response with Taguchi Method Approach*

Fresh strawberries cultivar Holibert (Earlibrite) continues for metabolic process after picked up from the field until storage through postharvest handling. Storage at cold temperatures is one way to inhibit the metabolic processes and it could be identified that fresh strawberries which were stored at 4°C has better physical condition than those which were at the temperature of 10°C. This is a match corresponding with statement [10] who says that for daily storage strawberries are best stored at a temperature of 2-3°C. Moreover, recommended cold storage temperature for strawberries on showcase or refrigerator maximum is 4.4°C. This is also indicated by the storage conditions of fresh strawberries with Taguchi Method with combination level 1 at temperature of 4°C which was better than level 2 at temperature of 10°C. Similarly to other factors for instance air holes, tightness of packaging, synchronization of the quantity of strawberries fruits per packaging PET plastic's size, treatment before storage, and the use of the bottom cardboard base. Cardboard base that directly contacted with the strawberry fruit can be accelerate growth of the microbes through the water condensation which resulted from fruit surface and plastics packaging. The condensation on the inner film surface was especially influenced by the flow conditions, the external temperature amplitude and the inner air volume, furthermore condensation processes on fruit surfaces were caused primarily by temperature amplitude and cycle time [14]. Microbes that often arise in cold storage in this showcase are fungus of *Rhizopus* and *Botrytis cinerea*, both of them cause an infection in strawberry fruit and accelerate the damage of fruit so that the decay became faster. *Rhizopus* cause watery fruit, rotten fruit, because of the fungus' mycelium evolve on the surface of strawberries fruit. Meanwhile, *Botrytis cinerea* caused dry rot strawberries with a brownish color.

Taguchi Method helps to determine the combination of controllable factors for the method of strawberries storage using PET plastic packaging. From this would be known the steps of packaging in strawberries fruit using PET plastics the most appropriate packaging can be obtained. With the combination of these step of packaging can be obtained the relationship between water content, pH, texture, color, and TPC of fresh strawberries' cold storage. Using ANOVA calculation known that water content was influenced by G factor (the use of bottom cardboard base) with the percentage of 7.432%. Strawberry fruit's pH was affected by E factor (treatment before storage which is washing fruit) in the amount of 24.462%. The texture of fruit was affected by G factor (the use of bottom cardboard base) as much as 19.238%. Color of fruit including fruit color lightness (L) was influenced by the C factor (tightness of packaging) with percentage of 29.126%. Redness (a) color index influenced by E factor (treatment before storage which is washing fruit) of 20.783%. Another color index which is yellowness (b) contributed by C factor (tightness of packaging) of 18.472%. Change of color ( $\Delta E$ ) and TPC influenced by E factor (treatment before storage which is washing fruit) respectively 7.003% and 13.157%.

Through the Taguchi Method can be known the proper way for packaging fresh strawberries using PET packaging at its optimum way. Surface air holes is 10 cm<sup>2</sup> wide with plastic package volume size (15,8 x 10 x 3,8) cm<sup>3</sup>. With this PET packaging size the best number to fill with strawberries fruit was 18 pieces of strawberries. PET plastic packaging also set with not too much air circulation and to minimize its scotch tape on each side of the packaging was applied. Storage temperature was 2-3°C or 4°C for maximum in cold storage showcase to prevent rapid decay. Temperatures above 4°C causes fruit to rot faster several times higher than the initial conditions. This is consistent with the statement from [11,15] that when the fruit storage temperature increased from 0°C to 10°C, the fruit will rot faster 2 to 4 times. Before it is stored into the showcase strawberries do not need to be washed because it will add moisture to the fruit so as to accelerate the occurrence of fruit rot. In addition, the water attached to the fruit will

invite microorganisms to grow faster. If there is fungus or mold that grows on the surface of a strawberry fruit must be separated with other fruits because the fungus will very easily spread into the other fruits. If this happens then the decay on strawberries fruit in the cold storage can occur more quickly.

## 5. Conclusions

- 1) Local fresh strawberries type Holibrite (Earlibrite) in the cold storage have a shelf life for about approximately  $\pm 7$  days as indicated by the declining quality characteristics include moisture content, pH, texture, color (lightness, redness, yellowness, color change ( $\Delta E$ ), and the number of microbes counted in total plate count (TPC).
- 2) Combination of design factors and levels that influence the storage of fresh strawberries is A1, G2, E1, F1, D2, B1, and C2, namely:
  - A1 = The width of the air holes surface packing 10 cm<sup>2</sup>
  - G2 = Do not use the bottom cardboard base
  - E1 = Pretreatment storage of fruits do not need to be washed
  - F1 = The type of PET plastic packaging size is (15,8 x10x3,8) cm<sup>3</sup>
  - D2 = The number of strawberries/packaging is as much as 18 pieces
  - B1 = Temperature of cooling box/showcase is 4°C
  - C2 = Tightness of packaging is tight
- 3) Taguchi's quality characteristics response are used for parameter quality of strawberry are Water Content is nominal the best; Texture and Color index (L, a, b) are larger the better and Change of Color ( $\Delta E$ ) and Total Plate Count are smaller the better

**Acknowledgments:** The corresponding authors want to thank all their colleagues and students for their assistance in the research, Gadjah Mada University and Ministry of Education and Culture Republic of Indonesia for supporting through their grant no : LPPM-UGM/1333/LIT/2013 for research and research dissemination using their grant : No 1979/UNI/DITLIT/DIT-LIT/LT/2018.

## References

1. Rukmana, H.R. 1998. *Stroberi Budidaya dan Pascapanen*. Yogyakarta: Penerbit Kanisius.
2. Nunes, M. Cecilia N., Jean Pierre Emond, Mary Rauth, Sharon Dea, Khe V. Chau. 2009. Environmental conditions encountered during typical consumer retail display affect fruit and vegetable quality and waste. *Postharvest Biology and Technology*, 51, 2 : 232-241
3. Kader, A. A. 1990. *Quality and its maintenance to the postharvest physiology of strawberry*. In A. Dale, & J. J. Luby (Eds.), *The Strawberry Into The 21st Century*. Dalam *Jurnal Effect of Storage Temperatures on Antioxidant Capacity and Aroma Compounds in Strawberry Fruit*. Elsevier. *Lebensm.-Wiss. u.-Technol.* 37 (2004) 687–695
4. Winarno, F.G. 2002. *Codex dan SNI dalam Perdagangan Pangan Global*. Bogor: M-Brio Press.
5. Falah, M.A.F.F, Hurriin ,H., A.R.P.A. Dewi., Jumeri. (2016). Quality evaluation of fresh strawberry (*Fragaria* sp. cv. Earlybrite) during storage in a tropical environment. *AIP Conference Proceedings* 1755, 130003 <http://doi.org/10.1063/1.4958547>
6. Rahayu, E. Dan Widajati, E., 2007. *Pengaruh Kemasan, Kondisi Ruang Simpan dan Periode Simpan terhadap Viabilitas Benih Caisin*. *Jurnal Penelitian Pertanian. Buletin Agron.* (35) (3) 191 – 196 (2007). [2] Anonim 2. 2012. *Budidaya Pertanian: Stroberi. Menristek*. Jakarta: Bidang Pendayagunaan dan Pemasyarakatan Ilmu Pengetahuan dan Teknologi.
7. Roy, R. (1990). *A primer on the Taguchi method*. New York: Van Nostrand Reinhold.
8. Roy, R. (2001). *Design of experiments using the Taguchi approach: 16 steps to product and process improvement* (pp. 52–53). New York: John Wiley & Sons.
9. Vuchkov, I.N. and Boyadjieva, L.N. 2008. *Quality Improvement with Design of Experiments: A Response Surface Approach*. Kluwer Academic Publishers. Dordrecht
10. US Department of Agriculture, Agriculture Research Service. USDA national nutrient for standard references, release 23. Fruits and fruit juices; 2010, pp. 785–7. Available at: <http://www.ars.usda.gov/Services/docs.html.docid=8964>. Accessed on September 20, 2014

11. Omafra, 2013. *Cooling and Temperature Management for Strawberries*. Ontario Ministry of Agriculture and Food. Ontario.
12. Nurchasanah, 2008. *What is in your food: Rahasia Di Balik Makanan*. Bandung: Hayati Qualita.
13. Yulianah, Nurfitri. 2013. Beberapa Penyakit yang Menyerang Tanaman Stroberi. Diakses dari <http://yusufandriana.com/tag/penyakit-pada-tanaman-stroberi/>. Hari Senin, 3 Juni 2013 pukul 14.47 WIB.
14. Linke, Manfred and Martin Geyer. 2013. Condensation dynamics in plastic film packaging of fruit and vegetables. *Journal of Food Engineering* 116 (2013) 144–154.<http://dx.doi.org/10.1016/j.jfoodeng.2012.11.026>
15. Paull, R. E. , Effect of temperature and relative humidity on fresh commodity Quality. *Postharvest Biology and Technology*. 1999.15 : 263–277.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).



FP-SCM-012-ID071

# Supply Chain Analysis of Local Beef in Malang, Indonesia

Retno Astuti <sup>1,\*</sup>, Sucipto <sup>1,2</sup> and Titik Prastiani <sup>1</sup>

<sup>1</sup> Department of Agroindustrial Technology, Faculty of Agricultural Technology, University of Brawijaya, Malang, Indonesia; retno\_astuti@ub.ac.id

<sup>2</sup> Halal-Qualified Industry Development, Malang, Indonesia; Ciptotip@ub.ac.id

\* Correspondence: retno\_astuti@ub.ac.id; Tel.: +62-812-3311-042

Received: 12 August 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** The price of beef at retailers and end consumers tend to rise due to a lot of members are involved in its supply chain. Several aspects that may affect the distribution process to the final consumer such as product flow, information flow, and financial flows should be considered for beef supply chain management. This study aimed to determine the supply chain map, function, and relationship between members in the supply chain of beef in Malang, Indonesia. The respondents in this study were three butchers with all their supply chain members. Descriptive analysis of the value chain was conducted using the six-step approach of value chain analysis with mapping of supply chain analysis using SCOR Level 2 method. The value chain analysis approach in this study was only conducted in 4 steps, i.e. engaging the chain, understanding the market, mapping the flows, and the identification of opportunities and challenges. The results showed that the speed of the supply chain in providing products to consumers and the agility of producers in responding to demand changes were perfect. The butchers should cooperate with cattle suppliers to improve the performance of the supply chain.

**Keywords:** beef; butcher; slaughterhouse; supply chain

---

## 1. Introduction

The Indonesian population is increasing almost in all region. The population of Malang City increased from 828,491 in 2011 to 851,298 people in 2015 [1]. The demand of products for the fulfillment of nutrition is also increasing along improvement of the living standard and the development of the Indonesian population. One of increasing food demand was beef as a source of animal protein [2]. National Socio-Economic Survey of the Ministry of Agriculture of the Republic of Indonesia (2016) showed that beef consumption per capita per year was fluctuating, but it tent to increase from 2010 to 2015. Beef consumption in Malang also contributed to the behavior of national beef consumption. Beef production in Malang had fluctuated from 2011 to 2015. Beef production declined from 4,165,767 kg in 2011 to 3,305,767 kg in 2015, meanwhile the prices tent to increase [3]. National Socio-Economic Survey of the Ministry of Agriculture of the Republic of Indonesia (2016) showed the price of beef feom 2011 to 2015 tent to increase by 9.58% from IDR 69,642 to IDR 104,326.

The highest of prices at retail and end-consumer levels due to the cost of adding value, transaction costs, actors' profits, shrinkage value, retribution, illegal fees, transportation costs and distribution channel efficiency. The arrangement of beef distribution channels is important due to a lot of stakeholders are involved in the beef supply chain [4]. The supply chain of beef needs to pay attention to several aspects affecting the beef distribution to the end consumer such as product flow, information flow and financial flow [5]. Therefore, the analysis of beef supply chain in Malang should be carried out.

Some researches of beef supply chain in Indonesia had been carried out with different aims. Author [6] analyzed value added analysis of beef cattle supply chain actors micro-scale community farm based on Regional Enterprise Slaughterhouse Makassar (RESM). Author [7,8] investigated how

beef producers can increase supply chain performance (SCP) flexibility by improving supply chain practices. Author [9] analyzed the supply chain of beef industry and the factors affecting meat prices in Indonesia. Author [10] improved the beef supply chain with the support of simulation model to assess the existing system and to develop some scenarios to improve the system performance. Author [11] improved the quality of beef in traditional markets by proposing a supply chain model that involves the schemes of investment and government incentive for improving the distribution system. Author [12] planned actions to control probability of halal risk in Indonesian beef supply chain. Author [13] described the supply chain management of imported frozen beef from Australia to Indonesia then determined the strategy of it based on the strengths, weaknesses, opportunities, and threats for the frozen meat distributor and analyzed alternatives of cooperation between imported frozen beef distribution with local beef distribution chain. Author [14] identified risk issues in Indonesian fresh meat supply chain from the farm until to the “plate”. All those researches had not considered the value chain.

A responsive value chain provides high service levels, short lead times, and a range of innovative products and quantities, whereas an efficient supply chain produces and supplies a smaller range of products at the lowest possible cost [15]. A value chain is focused on identifying and satisfying well-defined customer demands, whilst a supply chain is focused on logistical efficiency which is one component of value chain formation. The purpose of the value chain analysis is improving supply chain performance. The understanding of the product flows, information flows, as well as management and control in the value chain are required in this analysis [16]. Therefore, this research aimed to get the value chain map, function, and relationship between the members in beef supply chain in Malang.

## 2. Materials and Methods

The research was only focused on local beef. It was conducted at slaughter house of Malang Regional Company and traditional market of Malang. Survey was carried out related to the function and relationship between the value chain members and the number of members of supply chain, i.e. cattle ranchers as suppliers, butchers as processors, slaughter house of Malang Regional Company as service provider of processors, retailers, and consumers.

### 2.1. Value Chain Analysis

Author [17] developed value chain approach from six steps reported in the literature as follows:

1. Engaging the chain  
The first and fundamental step of engaging the chain determines the way the chain members interact throughout the value chain analysis process.
2. Understanding the market  
The importance of the end-user is recognized in the value chain analysis process by the inclusion of “understanding the market” as an early step. It is necessary for the industry to understand what it is that consumers value in the products and services they create and modify the business accordingly
3. Mapping the current state of the chain  
The step of mapping the chain is a fundamental component of value chain analysis. The three elements that mapping covers are the flow of products, information and relationships [16]. Product flow requires the mapping of the physical flow of goods through the value chain. Information flow is a two-way process in the value chain. Information regarding the end-user (e.g. preferences, demand specifications and quality) can be transferred back along the chain to the producers, where the producers can then notify the market of supply and quality issues [17]. Relationship flow describes the way chain members relate to each other. The supply chain mapping process in this study used the Supply Chain Operations Reference (SCOR) Model level 2. Beef supply chain activities can be seen through the AS-IS Phase which is the current state of the chain. AS-IS modeling maps the current state of the plan, source, make, and deliver processes. Financial flows in the supply chain are also considered in this research.

#### 4. Identification of opportunities and challenges

Identification of opportunities for improvement at different stages was carried out through an analysis of product flows, information flows and relationships. Identification of such opportunities then can be an effective catalyst for change.

#### 5. Implementation

Once the opportunities and challenges have been identified, the chain members will need to select the areas that they would like to implement to achieve greater value. The actors of the chain must accept full responsibility for the implementation to ensure the commitment of the chain to the improvement process.

#### 6. Evaluation

The final step in the value chain analysis approach is an evaluation of the implemented opportunity, as well as an overall performance evaluation of the value chain approach by the value chain actors. This step has been included to provide feedback as a method for continuous improvement and also a measure of the value to the stakeholders of undertaking such a process.

Implementation and evaluation steps of value chain analysis were not carried out in this research due to limited time of research.

### 2.2. Performance Measurement

The identification of opportunities and challenges in value chain analysis was also supported with performance measurement which was done by referring to performance metrics of SCOR as follows [18]:

#### 1. Perfect Order Fulfillment

Perfect Order Fulfillment is the percentage of orders meeting delivery performance with complete and accurate documentation and no delivery damage or defects

#### 2. Order Fulfilment Cycle Time

Order Fulfilment Cycle Time is a continuous measurement defined as the amount of time from customer authorization of a sales order to the customer receipt of product.

#### 3. Upside Supply Chain Adaptability

Upside Supply Chain Adaptability is the maximum sustainable percentage increase in quantity delivered that can be achieved in 30 days

#### 4. Downside Supply Chain Adaptability

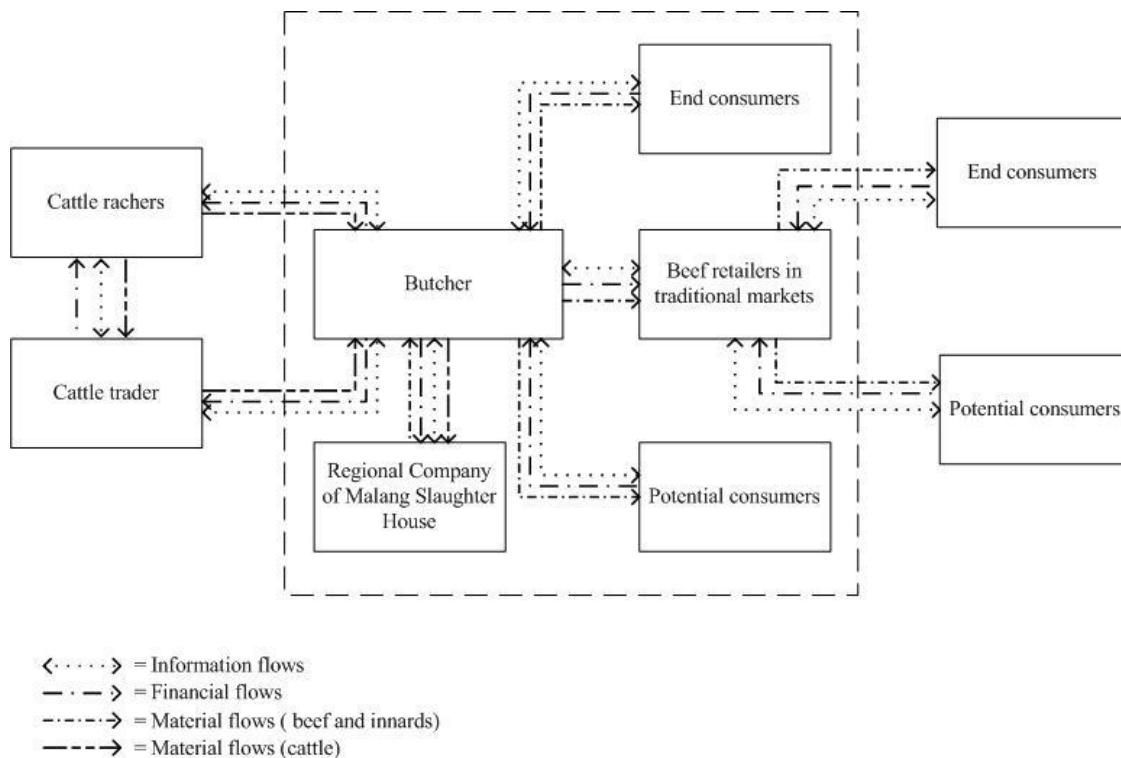
Downside Supply Chain Adaptability is the maximum percentage reduction in quantities ordered that can be sustained at 30 days prior to delivery with no inventory or cost penalties.

## 3. Results and Discussion

### 3.1. Supply Chain Structure

Supply chain structure is the composition of the activities or network of procurement of goods or services that work together and related to each other to create and distribute physical and non-physical products [19]. A supply chain consist of primary members who are directly involved with the products, secondary member who are not directly involved with the flow of product [20], and those who facilitate the activities of the supply chain in providing the raw materials required [21]. The primary members of the local beef supply chain in Malang are cattle ranchers and cattle sellers in traditional markets as cattle suppliers, butchers as suppliers of beef and its side products, beef retailers in the traditional markets of Malang, potential consumers (food sellers which use beef as raw materials of their products) and end consumers. The secondary member of the supply chain is slaughter house of Malang Regional Company as provider of animal slaughtering service. Some consumers buy the beef directly from the butchers and the others buy the beef at traditional market in Malang. The relationship between consumers and the sellers is only transactional relationship. Meanwhile, contractual relationship in this chain are between the butchers and the beef sellers in traditional markets as well as between the

butchers and the cattle sellers or cattle ranchers. The structure of supply chain of local beef in Malang is shown in Figure 1.



**Figure 1.** Structure of local beef supply chain in Malang.

This research only took 3 respondents of butchers who slaughtered animals at slaughter house of Malang Regional Company and sell beef in Malang. The respondents' identities in this study are shown in Table 1.

**Table 1.** The respondents of butchers

Type of service	Butcher 1	Butcher 2	Butcher 3
Gender	Man	Man	Man
Age	35 years	29 years	27 years
Last education	Primary school	Primary school	Bachelor degree
Main job	Butcher	Butcher	Butcher
Trading experience	17 years	8 year	4 year

Slaughter house of Malang Regional Company is a public company which provides animal slaughtering service in Malang. An animal should be examined for its health (ante mortem) by the animal farm officer from the Livestock Farming Service before being slaughtered. The cost of service in slaughter house of Malang Regional Company is shown in Table 2.

**Table 2.** The cost of cattle slaughter and cattle breeding in slaughter house of Malang Regional Company.

Type of service	Cost
The slaughter of cattle	IDR 49,500 / cattle
The slaughter of cattle at out of service hour (forced / emergency)	IDR 60,500 / cattle
Rent a cattle barn	IDR 10,000 / plot per day

The procedure of cattle slaughter in slaughter house of Malang Regional Company is justified according to Islamic Shari 'a. Implementation of cattle is done to create a SAFE, HEALTHY, WHOLE,

and HALAL beef so the slaughter is carried out by adopting Islamic law and supervised by a veterinarian or *keurmaster* officer. Supervision and execution of inspection is carried out before and after the slaughter then the beef is stamped with "GOOD city of Malang". The implementation of cattle slaughter is separated from the implementation of pig slaughter. It is also executed using different place, labor, and tools. Products of cattle slaughtered are separated into some categories, i.e. quality 1, beef quality 2, beef quality 3, side products, skin, legs, head and muzzle cattle. Physical quality of beef is based on National Standardization institutions on quality of carcass and beef [21].

### 3.2. Local Beef Value Chain Analysis in Malang

The value chain is all the activity to distribute the product or service from the starting point, through several stages of production, involving transformation activities and various service inputs, then delivering the product to the end consumer [22]. Value chain analysis is generally conducted to identify improvements in product quality and design that enable producers to gain more value on the product [23]. Analysis of the value chain model or condition is one of the first steps in conducting supply chain management analysis [24].

#### 3.2.1 Engaging the Chain

Members involved in supply chain 1 are a cattle seller as a cattle supplier, butcher 1 as a beef producer, and beef retailers in traditional markets. Members involved in supply chain 2 are a cattle seller as a cattle supplier, butcher 2 as a beef producer, beef retailers in traditional markets, potential consumers and end consumers. Members involved in supply chain 3 are a cattle rancher as a cattle supplier, butcher 3 as a beef producer, and beef retailers in traditional markets. The relationship between butcher 1 and butcher 2 with cattle sellers in the market is only a transactional relationship, meanwhile butcher 3 has contractual relationship with a cattle rancher. Transactional relationship occurs when a price agreement is established, then transactions are made and products move from producer to consumer [22]. The linkages between actors in the value chain can be formal and informal rules. Informal rules are without any written contract between actors. The agreement is based on trust, reliability and long-term relationships [23].

#### 3.2.2 Understanding the Market

Consumers are the central point of attention in the process of marketing a product. Understanding of consumer demand will lead producers to appropriate and efficient marketing policies. The consumers of beef and side product of slaughtered cattle are beef retailers in traditional markets, potential consumers and end consumers. Most potential consumers are meatball sellers. Consumers, products sold, the prices offered from each butcher is shown in Table 3.

**Table 3.** The consumers and products of the butcher.

Butcher	Consumers	Products	Price
1	Beef retailers in traditional markets	Beef quality 1	IDR 105,000/kg
		Beef quality 2	IDR 90,000 / kg
		Beef quality 3	IDR 85,000 / kg
		Cowhide	IDR 14,000 /kg
		Innards	IDR 32,000 / kg
		Head, legs, and muzzle	IDR 28,000 / kg
2	Beef retailers in traditional markets	Beef quality 1	IDR 105,000/kg
	Potential consumers	Beef quality 2	IDR 95,000 / kg
	End consumers	Beef quality 3	IDR 60,000 / kg
		Cowhide	IDR 15,000 / kg

**Table 3.** The consumers and products of the butcher (continued).

Butcher	Consumers	Products	Price
2	End consumers	Innards, head, legs, and muzzle	IDR 2,820,000 / cattle
3	Beef retailers in traditional markets	Beef	IDR 105,000 / kg
		Cowhide	IDR 13,500 / kg
		Innards, head, legs, and muzzle	IDR 4,380,000 / cattle

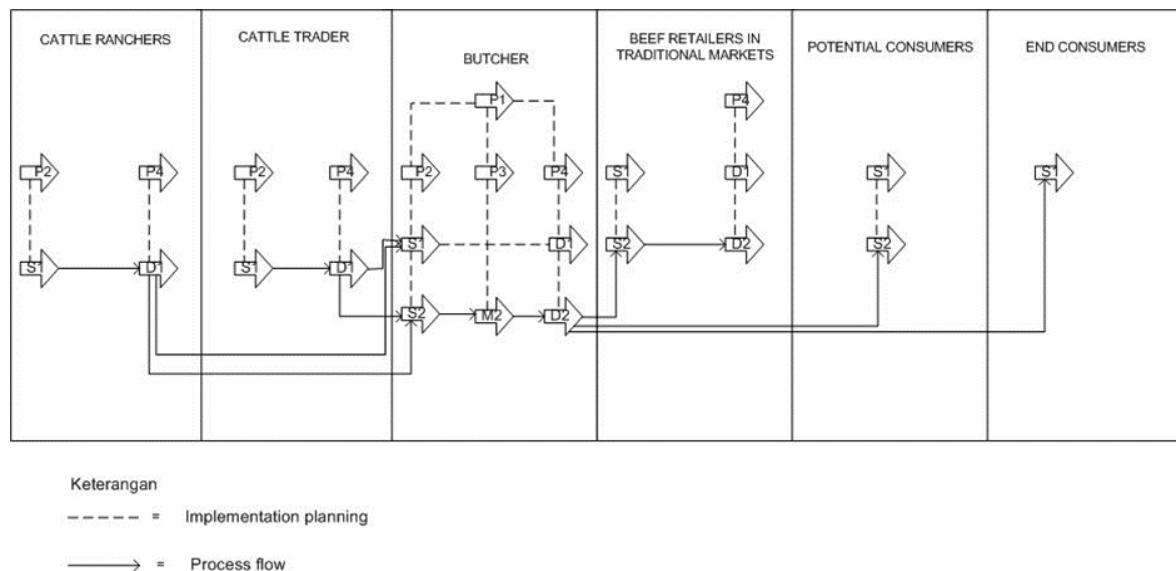
The types of products offered from the three butchers are different. Butcher 1 and 2 sell beef with different qualities, i.e. quality 1, quality 2 and quality 3. Prices offered are also slightly different. This is because the characteristics of beef sold are different although the definition of quality is the same. Quality 3 meat on butcher 1 is meat that still has more fat than quality 1 and 2, while beef quality 3 on butcher 2 is meat for soup. The target consumers of butcher 1 and 2 are also different so the prices for the same quality are also different.

### 3.2.3 Mapping the Flows

In the supply chain there are members directly or indirectly involved. The supply chain structure describes the related parties and their job as well as the flow of information, products and finances [25]. The flow of information relates to production capacity, delivery status and the number of raw material orders, and the number of product orders distributed to the market. The flow of information begins from the butchers that provides information about the needs of the cattle to be ordered. Supplier of cattle will provide information to the butcher related to the number, type of cattle, gender, weight and the price of cattle per kilogram or per cattle.

Information flows between the butcher and the part of slaughter house of Malang Regional Company begins when the butcher gives information to the slaughter house of Malang Regional Company that will entrust animals, will do the slaughtering of animals, and information related to the number of animals to be slaughtered and entrusted in slaughter house of Malang Regional Company. Slaughter house of Malang Regional Company will provide information regarding the availability of barn to rent, the fees to rent the barn, and the fees for slaughtering. Information flow between butchers and beef retailers in traditional markets begins from retailers providing information on the beef requirements to be ordered. Butcher provides information regarding the amount of beef available, the quality and price of beef. The buyer of cowhide provides information to the butcher related the cowhide needs to be ordered. Butcher provides information regarding the amount (in kg) of cowhide and the price per kg. Potential consumers inform the slaughter of the amount of beef to be ordered and the time for beef to be ready. Butcher will provide information regarding the amount of beef available, the price of meat and the time of order fulfillment. The end consumer informs to the butcher of the amount to be ordered and the time for the beef to be ready. Butcher provides information regarding the amount of beef available, the price of beef and the beef fulfillment time.

Material flow is the main raw material flow of cattle to the end consumers of beef. This will produce a product flow map, identifying each activity involved in the production, and where and how much inventory is held (Bonney and Fearn, 2009). Design of AS IS flow material based on data obtained from survey results and in depth interview can be seen in Figure 2.



**Figure 2.** Material flow of AS-IS condition

Financial flow is the movement of money between the members of beef supply chain. Financial flow in the beef supply chain in Malang is from downstream to upstream. The money flows from the butchers to the ranchers. The payment system is carried out in cash. The transaction will occur if there is an agreement and conformity of the cattle between ranchers and the butchers. The price per kilogram of cattle is determined by weighing the cattle directly in the ranchers' place. This also happen in the financial flows between cattle sellers and butchers where prices are determined by estimating the weight of cattle directly in the animal market. The money also flow from the butchers to slaughter house of Malang Regional Company as slaughter service provider. The butchers pay slaughter house of Malang Regional Company officer in cash for slaughtering and renting a barn (for butchers who do not have their own ranch at home). The butchers will get money from the beef retailers the day after the beef pickup from the butcher, meanwhile the butcher will get money from cowhide buyers in cash based on their agreement. Cash payment system is also done by potential consumers and end consumers when they buy beef from the butchers.

### 3.2.4 Identify Opportunities and Challenges

A complete mapping of a chain can put out many problems and opportunities for improvement. The flow value mapping model directly leads to the classification of problems related to physical flows and information flows [26]. Problems relating to material flows are the transactional relationship between cattle suppliers and butchers (on butchers 1 and 2) which makes the uncertain availability of cattle, uncertain demand (at slaughter 1, 2 and 3), and uncertain availability of beef due to unscheduled cattle slaughtering process. Problems relating to financial flows are uncertain profit and loss of the butchers due to the bulk purchase system of innards, the high cost of product sale, and uncertain cash flow due to the delayed payment system from beef retailers to the butchers. Problems related to the flow of information are the butchers have never forecasted their demand which makes problem in controlling the availability of the beef, the butchers have never made financial statements for controlling the cash flow, and unavailability of information about the demand of the consumers.

The improvement of the chain is also based on the performance measurement of the chain. Measurement of beef supply chain performance was done using SCOR Level 1 method. In SCOR model, performance attribute function determines supply chain characteristic and to describe supply chain strategy [27]. The metrics used to measure the chain performance are perfect order fulfillment, order fulfillment cycle-time, upside supply chain adaptability and downside supply chain adaptability. The performance of the butcher in local beef supply chain in Malang is showed in Table 4.

**Table 4.** Butcher performance

SCOR Metrics	Actual		
	Butcher 1	Butcher 2	Butcher 3
Perfect Order Fulfillment	100%	100%	100%
Order Fulfillment Cycle Time	1 day / 247,8 kg	1 day/200,7 kg	1 day / 363,3 kg
Upside Supply Chain Adaptability	100%	100%	100%
Downside Supply Chain Adaptability	100%	100%	100%

All butchers have the same performance for perfect order fulfillment, upside supply chain adaptability and downside supply chain adaptability. Butcher 3 has the highest performance for order fulfillment cycle time because butcher 3 has a contractual relationship with beef retailers in traditional market which makes butcher 3 has more predictable demand.

Overall, contractual relationship should be carried out by all butchers for improving the chain of their business, Contractual relationship between with the cattle ranchers and the butchers will guarantee the availability of cattle, meanwhile contractual relationship between the butchers and the consumers (especially the beef retailers in traditional market) will help the butchers to predict the demand of their products. The butchers also should not sell the side products in bulk which makes uncertain income for the butchers, meanwhile slaughtered cattle has a large part of side products which needs high cost to handle them. Selling product based on the quality grade per unit weight will be better both for the sellers and the buyers regarding the quality and the price. Cash payment system and managing the financial by recording the cash flow also should be considered by the members of the chain to improve their performance.

#### 4. Conclusion

Based on the results of the research, performance of local beef supply chain in Malang can be improved for improving their value chain. Clear and complete information is needed in communication between suppliers and butchers as well as between butchers and their consumers. The butchers as consumers of the cattle sellers / cattle ranchers should have information about the availability of cattle, types of cattle, cattle's weight, cattle's sex and cattle's physical condition from suppliers regularly. The butchers as suppliers also need regular information from retailers regarding the quantity and quality of beef and the side products. Meanwhile, regular information from the butchers to their consumers is necessary regarding availability, price, payment method and delivery method of beef and the side products. This strategies will help the members of the chain to decrease the unsold products due to miss-information between the members of the chain.

Cooperation or partnership between the members of the chain should be done to improve the performance of supply chain and value chain. Some scenarios of the coordination and partnership model can be analyzed in further research by simulating the local beef supply chain system in Malang using system dynamics.

#### References

1. East Java Statistical Centre, 2016, <https://jatim.bps.go.id/statictable/2016/04/29/330/jumlah-penduduk-dan-laju-pertumbuhan-penduduk-menurut-kabupaten-kota-di-provinsi-jawa-timur-2010-2014-dan-2015.html>
2. Ministry of Agriculture. Kementrian Pertanian Republik Indonesia. 2016. Basis Data Konsumsi Pangan Tahun 2010 2015. [https://aplikasi2.pertanian.go.id/konsumsi/tampil\\_susenas\\_kom2\\_th.php](https://aplikasi2.pertanian.go.id/konsumsi/tampil_susenas_kom2_th.php).) [15 Agustus 2016].
3. Animal Husbandry Office of East Java. (2016). Data Produksi Ternak Kabupaten/Kota di Jawa Timur. (<http://disnak.jatimprov.go.id/web/layananpublik/datastatistik> ) [17 Agustus 2016].
4. Sutardi, S.; Endang, B. Sediakan dan Hitung Stock Agar Tak Kehilangan Konsumen. Jakarta: Elex Media Komputndo, Jakarta, Indonesia, 2007.
5. Emhar A.; Joni, M.M.A.; Titin, A. (2014). Analisis Rantai Pasokan (Supplay Chain) Daging Sapi di Kabupaten Jember. Berkala Ilmiah Pertanian, 1(3), 53-61.



6. Hastang; Sirajuddin, S, N.; Mappangaja, A, R.; Darma, R.; Sudirman, I. Value Added Analysis Of Beef Cattle Supply Chain Actors Micro-Scale Community Farm Based. *American-Eurasian Journal Of Sustainable Agriculture* 2015, 9(7), 7-12.
7. Mappigau, P.; Hastang, Asnawi, A; Kadir, S. Improving Collaboration of Bali Cattle Supply Chain and Its Impact on Cattle Farmer Income in South Sulawesi, Indonesia. *Arabian J Bus Manag Review*, 2015 5(150)
8. Jie, F.; Parton, K. A.; Mustafid. Supply chain performance flexibility in the Australian beef industry, 2016. *International Journal of Logistics Research and Applications A Leading Journal of Supply Chain Management* 19 (4), <https://doi.org/10.1080/13675567.2015.1075477>
9. Setiaji, B.; Susila, I.; Wahyudi, H, D. Supply Chain of the Beef Market in Indonesia. *Expert Journal of Business and Management* 2017, 5(2), 129-135.
10. Suryani, E.; Hendrawan, R, A.; Muhandhis, I.; Dewi, L. P. Dynamic Simulation Model Of Beef Supply Chain To Fulfill National Demand. *Jurnal Teknologi*, 2016, 78:(9) 169–177
11. Lupita, A.; Rangkuti, S, H.; Sutopo, W.; Hisjam, M. A supply chain model to improve the beef quality distribution using investment analysis: A case study. *AIP Conference Proceedings* 1902, 020003 (2017); <https://doi.org/10.1063/1.5010620>
12. Maman, U.; Mahbubi, A.; Jie, F.; Strategic Planning to Control Halal Risk in Indonesian Beef Supply Chain. *International Business Management* 2017, 11, 1246-1253 doi: 10.3923/ibm.2017.1246.1253
13. Rakhmat, S.; Zaiul, A.; Yusri, A. Supply Chain Management of Imported Frozen Beef: An Alternative To Integrate With Local Beef Supply Chain Management. *RJOAS*, 2017, 12(72), 260-267, doi <https://doi.org/10.18551/rjoas.2017-12.36>
14. Wahyuni, H, C.; Vanany, I.; Ciptomulyono, U. Identifying risk event in Indonesian fresh meat supply chain. *International Conference on Industrial and System Engineering (IConISE)*, 2017, 1-6 doi:10.1088/1757-899X/337/1/012031 2017
15. Chopra, S.; Meindl, P., *Supply Chain Management: Strategy, Planning and Operations*, 5th ed. Pearson Education Inc., Upper Saddle River, New Jersey, USA, 2013.
16. Fearn. 2009. *The Fearn Report: Sustainable Food and Wine Value Chains – Opportunity or Imperative for Australian Agrifood and Wine?* Government of South Australia, Adelaide
17. Howieson, J; Lawley, M; Hastings, K. (2016). Value Chain Analysis: An Iterative and Relational Approach for Agri-Food Chains. *Supply Chain Management an International Journal* 2016, 21 (3), 352-362, <tps://doi.org/10.1108/SCM-06-2015-0220>
18. APICS, 2017 [https://www.apics.org/docs/default-source/scc-non-research/apicsscc\\_scor\\_quick\\_reference\\_guide.pdf](https://www.apics.org/docs/default-source/scc-non-research/apicsscc_scor_quick_reference_guide.pdf)
19. Maulani, F.; Akhmad, S.; Bambang, I. Analisis Struktur Rantai Pasok Konstruksi pada Pekerjaan Jembatan. *Jurnal Rekayasa Sipil* 2014, 10(2), 1-8, <https://doi.org/10.25077/jrs.10.2.1-8.2014>.
20. Rizqiyah, I.A.; Imam, S. Risiko Rantai Pasok Agroindustri Salak Menggunakan Fuzzy FMEA. *Jurnal Manajemen dan Agribisnis*, 2017, 14(1), 1-11, <http://dx.doi.org/10.17358/jma.14.1.1>.
21. National Standardization Institution. (2008). Mutu Karkas dan Daging Sapi. SNI:3932:2008.
22. Yoga, S.I.W.G.; Dewa, A.A.Y. Karakteristik Rantai Nilai Rumput Laut di Kabupaten Klungkung. *Jurnal Ilmiah Teknologi Pertanian* 2016, 1(1), 28-31.
23. Rosales, R.M.; Pomeroy, R.; Calabio, I.J.; Batong, M.; Cedo, K.; Escara, N.; Facunla, V.; Gulayan, A.; Narvadez, M.; Sarahadil, M.; Sobrevega, M.A. Value chain analysis and small-scale fisheries management, *Marine Policy*, 2017, 83, 11-21, <http://dx.doi.org/10.1016/j.marpol.2017.05.023>
24. Jannah, Z.R.; Hariadi, S.; Hari, R. Optimalisasi Kinerja Rantai Pasokan Dan Rantai Nilai Tembakau Kasturi (Voor Oogst) di Kabupaten Jember. *Jurnal Teknologi Pertanian* 2015, 16 (1), 51-64.
25. Astuti R.; Marimin, M.; Roedy, P.; Machfud, M. Kebutuhan dan Struktur Kelembagaan Rantai Pasok Buah Manggis Studi Kasus Rantai Pasok Di Kabupaten. *Business Management Journal* 2012, 3(1), 99-112.
26. Taylor, H.D. Value Chain Analysis: an Approach to Supply Chain Improvement in Agri-Food Chains. *International Journal of Physical Distribution and Logistic Management* 2005, 35(10), 744-761, <https://doi.org/10.1108/09600030510634599>
27. Medzona, P.A.J. Analytical Hierarchy Process And SCOR Model To Support Supply Chain Re-Design. *International Journal of Information Management* 2014, 34(5), 634-638, <https://doi.org/10.1016/j.ijinfomgt.2014.06.002>



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-SCM-006-ID040

# Analysis of Supply Chain Institutions to the Performance and Competitiveness of Tempeh Chips SMEs Cluster in Sanan, Malang

Siti Asmaul Mustaniroh<sup>1\*</sup>, Rizky LR Silalahi<sup>2</sup> and Adinda Wardhani<sup>3</sup>

<sup>1</sup> Universitas Brawijaya; [asmaul\\_m@yahoo.com](mailto:asmaul_m@yahoo.com)

<sup>2</sup> Universitas Brawijaya; [rizkyrls@ub.ac.id](mailto:rizkyrls@ub.ac.id)

<sup>3</sup> Alumnae Universitas Brawijaya; [wardhanidr@gmail.com](mailto:wardhanidr@gmail.com)

\* Correspondence: [asmaul\\_m@yahoo.com](mailto:asmaul_m@yahoo.com); Tel.: +62-815-557-279-88

Received: 4 August 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** Tempe Chips SMEs in Sanan is one of featured culinary destination in Malang. Currently performance of Tempe Chips SMEs in Sanan has not been optimized. The first obstacle is the absence of proper raw material control and limited market access that causes SMEs have low performance and competitiveness. Therefore, there needs to be an active role of supply chain institutions to improve the performance and competitiveness of SMEs. The purposes of this study are to determine the linkage (influence) of supply chain institutions on the performance and competitiveness of SMEs and the linkage (influence) of performance on the competitiveness of SMEs. The approach used to analyze is GSCA (Generalized Structured Component Analysis) by purposive sampling method for 34 respondents. The variables object are supply chain institutions, business performance and competitiveness. The result shows that there is significance influence of supply chain institutions to performance of SMEs, the relationship between supply chain institutions to the competitiveness of SMEs, business performance with competitiveness of SMEs. There's partial influence of performance on mediating relationship between supply chains institutions and competitiveness. The improvement of innovation is needed for SMEs to high competitiveness.

**Keywords:** Supply Chain Institution, Performance, Competitiveness

---

## 1. Introduction

Micro, Small and Medium Enterprises (SMEs) have a key role as a safeguard for the national economy, this can be seen from the contribution of SMEs to the national Gross Domestic Product (GDP) of 60.34% while the rest is contributed by large business sectors. The data from the Ministry of Cooperatives and SMEs also shows that growth of SMEs in 2013 increased by 2.41% while large-scale businesses only experienced an increase of 1.97% [1]. About 70% of the concentration of SMEs in Java is in the provinces of Central Java, West Java and East Java. Based on the data from [2], Central Java has the highest number of SMEs around 33.76%, followed by West Java having around 20.62%, then East Java with 17.55% of SMEs. The high number of SMEs is in line with the economic growth in these regions [3].

Malang is one of the cities in East Java which has the potential to become a broad market share, based on the data from [4] of Malang City showing a figure of 38.05% in the sector of purchasing goods and services by households. Malang City is an area in the East Java region having several agroindustry products, among of which the one which is superior is tempeh(bean cake) chips. One of the SMEs known as tempehchips producer is located in the center of Sanan tempeh industry. Based on the data from the Department of Industry [5] of Malang City, there are 72 SMEs which produce tempeh chips in Sanan, but currently there are 18 SMEs actively operating. When viewed from the business scale, tempeh industry center in Sanan is dominated by micro-scale businesses, productive businesses owned by individuals and operated individually. This causes in SMEs performance to be less optimal;

therefore, in the previous research the cluster formation was formed to develop strategies which match the characteristics of each cluster based on several indicator considerations: production capacity per month, length of operation, average monthly sales, investment value and the number of workers [6].

Cluster formation alone is not enough to optimize the potential of SMEs if they are not supported by good supply chain management. At present, the performance of Sanan tempeh chips producers is not optimal due to several constraints. One of the obstacles challenged by SME chips producers in Sanan is the absence of good control of raw materials; hence, when raw materials are difficult to obtain, the owners of SMEs must pay more to meet production needs. This condition causes decreasing turnover of tempeh chips SMEs in Sanan by an average of 40% [7]. Limited market access becomes another problem causing tempeh chips SMEs in Sanan to only be able to distribute the final product with the same distribution area from year to year. This condition shows that supply chain management, especially for SMEs, is very necessary for business survival because of the increasingly competitive demands of competition [8]. These problems can be overcome, by activating the role of supply chain institutionalization as one of the solutions.

Supply chain institutions are a form of continuous existing interaction in a supply chain management. Supply chain institutions essentially analyze the relationship of vertical interactions between actors in the supply chain [9]. Supply chain institutions consist of governments, suppliers and retailers. The form of institutional support which can be provided can be in the form of providing loan assistance programs, training and trade shows. If supply chain institutions work optimally, the performance of SME is also expected to increase [10]. Increased performance will increase the business capability of a company in the industry to deal with various conditions in its environment. This ability is called competitiveness which is very important for MSMEs in order to strengthen market share [11].

A chosen method which can be used to analyze the factors influencing the performance and competitiveness of tempeh chips producers in Sanan is Generalized Structured Component Analysis (GSCA) method. GSCA is one analysis of component-based structural equation models using the least squares method. GSCA is a powerful analytical method because it is not based on many assumptions, the data does not have to be normally distributed, the sample does not have to be in large quantities, and can be used to explain the relationship between latent variables [12]. The advantage of the GSCA method compared to the Partial Least Square (PLS) method suggests this method equipped with the overall least square optimization criteria and still maintains local optimization procedures [13]. The purpose of this study is to analyze the influence of supply chain institutions on business performance and competitiveness, the effect of performance on business competitiveness and the effect of performance in mediating the relationship between supply chain institutions and business competitiveness.

## 2. Materials and Methods

This research was carried out at tempeh SMEs center in Sanan, Malang City. The sample in this study consists of 9 SMEs with a total of 34 respondents consisting of SMEs owners and employees who were selected by purposive sampling method. The criteria for selecting respondents are a minimum of 2 years of service. The variables used in this study are exogenous variables namely supply chain institutions (X) and endogenous variables namely performance ( $Y_1$ ) and the competitiveness of SMEs ( $Y_2$ ).

The indicators of supply chain institutions include trust, commitment, communication and partnership. The indicators of performance cover production capacity, production sales and profits. The indicators of competitiveness comprise of human resources, product innovation and market access.

Data analysis in this study consists of descriptive analysis namely validity test, reliability test, and linearity test. The data which has been collected will be analyzed utilizing of GSCA software.

### 3. Results and Discussion

#### 3.1. General Description of Sanan Tempeh Chips MSME sCluster

Malang City is one of the cities in East Java province with the relatively good development of business units. Business units in Malang City are dominated by micro, small and medium enterprises (SMEs) [14]. Based on the data obtained from the Department of Industry of Malang City, the number of SMEs in Malang City in 2014 was 249 SMEs. One of the biggest SMEs centers in Malang City is Sanan Center for tempeh chips SMEs. Until 2013, there were 46 tempeh chips craftsmen involving 210 workers, but currently there are only 18 tempeh chips producers.

**Table 1.** Profile of Sanan for SMEs Tempeh Chips

SMEs	Capacity of production (Kg/month)	Time of production (year)	Amount of Labor
Purnama	3500	28	6
Deny	2700	19	9
Amangtiwi	1000	11	3
Amel	3000	13	11
Sri Bawon	2500	32	6
Arin	3000	6	7
Karina	3000	20	5
Putra	3900	17	12
Ridho			
Delima	900	17	4

Source : Analysis Data (2017)

In the study conducted by [6], a grouping of 9 tempeh chips SMEs in Sanan, Malang was conducted using the K-means clustering method into 2 SMEs clusters based on the variable production capacity, the duration of establishment of SMEs, average sales, initial investment and the number of workers. Cluster 1 is a tempeh chips SMEs which belong to the classification of micro businesses with members from Amangtiwi and Delima SMEs. Cluster 2 is a tempeh chips SMEs which belong to the classification of small businesses consisting members of Purnama, Deny, Amel, Sri Bawon, Arin, Karina and Putra Ridho SMEs. After clustering based on production capacity, duration of operation, the number of workers and initial investment, 9 SMEs have been utilized as objects of research presented in Table 1. The production process in the Sanan SMEs tempeh chips center is still considered as conventional by relying on manual production tools. The production capacity of most tempeh chips SMEs in Sanan is fluctuating by relying on customer driven sales, showing dependency on consumer demand. The micro-scale business can be seen from capital funding sources, most of which come from personal funds and the number of human resources which are not more than 20 people per SMEs.

#### 3.2. Testing Results of Research Instruments

An item is declared as valid if meeting the criteria for testing validity, having Pearson correlation coefficient value  $> r_{table}$ . The test results show that the correlation of the indicators of each variable has a value above the  $r_{table}$  value of 0.339 so that all indicators examined can be affirmed as valid. The instrument has good reliability if the value of Cronbach's Alpha  $> 0.6$ . The test results show the value of Cronbach's Alpha  $> 0.6$ , it can be said that the research instrument has good reliability. Two variables have a linearity relationship if the value of deviation from linearity is  $> 0.05$ . Linearity test results show that the deviation from linearity value has met the requirements; hence, it can be said that all variables have a linear relationship.

A mathematical measurement model presenting the relationship between the variables and indicators studied is as follows:

50) Structural Model Equation:

$$Y_1 = 0,824X$$

$$Y_2 = 0,382X + 0,634Y_1$$

51) Variable of Supply Chain Institution (X)

- Indicator of Trust ( $X_1$ )

$$X_{11} = 0,526X_1 + 0,247$$

$$X_{12} = 0,344X_1 + 0,265$$

- Indicator of Commitment ( $X_2$ )

$$X_{21} = 0,046X_1 + 0,150$$

$$X_{22} = 0,368X_1 + 0,227$$

- Indicator of Communication ( $X_3$ )

$$X_{31} = 0,294X_1 + 0,197$$

$$X_{32} = 0,180X_1 + 0,293$$

- Indicator of Relationship ( $X_4$ )

$$X_{41} = 0,296X_1 + 0,235$$

$$X_{42} = 0,194X_1 + 0,179$$

52) Variable of Business Performance ( $Y_1$ )

- Indicator of production capacity ( $Y_{11}$ )

$$Y_{111} = 0,745Y_1 + 0,107$$

$$Y_{112} = 0,802Y_1 + 0,080$$

- Indicator of product sales ( $Y_{12}$ )

$$Y_{121} = 0,674Y_1 + 0,137$$

$$Y_{122} = 0,800Y_1 + 0,066$$

- Indicator of profit ( $Y_{13}$ )

$$Y_{131} = 0,833Y_1 + 0,103$$

$$Y_{132} = 0,729Y_1 + 0,125$$

53) Variable of Competitiveness ( $Y_2$ )

- Indicator of labor ( $Y_{21}$ )

$$Y_{21} = 0,780Y_2 + 0,097$$

- Indicator of product innovation ( $Y_{22}$ )

$$Y_{221} = 0,834Y_2 + 0,074$$

$$Y_{222} = 0,855Y_2 + 0,089$$

- Indicator of market share ( $Y_{23}$ )

$$Y_{23} = 0,668Y_2 + 0,139$$

54) Variable of business performance ( $Y_1$ ) as mediator variable

$$Y_2 = 0,382X + 0,884Y_1.$$

In mathematical model, the estimation value shows the relationship between variables. Estimation value with a positive sign states that the relationship is directly proportional (Ristiano, 2016), which means that the higher the X variable, the higher the Y variable and vice versa for the value with a negative sign. In the mathematical model, it can be seen that the supply chain institution variable (X) has a positive value on performance ( $Y_1$ ) and competitiveness ( $Y_2$ ) as well as the performance variable ( $Y_1$ ) on competitiveness ( $Y_2$ ).

This study employs a measurement model which is reflective and formative. Measure of Fit in the reflective indicator model is based on the value of loading estimate, while the formative indicator model is based on the value of weight estimate. Formative indicators are said to be valid if significant at 5% [12]. Therefore, if the formative construct indicator has a CR value of > 1.96, then the indicator is valid.

1) Supply Chain Institution (X)

Supply chain institutional variables are formative variables. Formative variables are based on the value of weight estimate. The results of output measurement model of institution variables are presented in Table 2.

**Table 2.** Measurement Results of Supply Chain Institution Variable Models

Symbol	Weight Estimate	Average
<b>X</b>	<b>AVE = 0.000, Alpha =0.838</b>	
<b>X<sub>11</sub></b>	<b>0,526</b>	4
<b>X<sub>12</sub></b>	0,344	4.03
<b>X<sub>21</sub></b>	0,046	3.65
<b>X<sub>22</sub></b>	0,368	3.12
<b>X<sub>31</sub></b>	0,294	3,24
<b>X<sub>32</sub></b>	0,180	3.18
<b>X<sub>41</sub></b>	0,296	3.24
<b>X<sub>42</sub></b>	0,194	<b>4.06</b>

Source : Analysis Data (2017)

Based on Table 2 that X<sub>11</sub> is most described for support supply chain institutions with value 0,526. The responden assesment that X<sub>42</sub> is suitable for explain and influence in supply chain institution. it must integration to optimize and effectivity supply chain intitutions. Real conditions in SMEs show that in certain seasons SMEs still need to find other suppliers because the partner suppliers are unable to meet their production needs. This condition often occurs during the rainy season because tempe suppliers experience problems in producing tempeh due to humidity in the rainy season. Problems faced by tempe suppliers caused constrained supply of raw materials, so that MSMEs were forced to look for other tempe suppliers. The trust of SMEs towards retailers has been established well because all this time retailers have been very helpful to MSMEs in marketing tempe chips. According to Marimin and Maghfiroh (2010)[35] trust building built in the supply chain can create a strong supply chain. Kwon and Taewon (2004)[36] also mentioned that success in supply chain comes from the high value of strong trust between partners in the supply chain.

In the result of outer model for the commitment indicator (X<sub>2</sub>), the statement X<sub>22</sub> item obtains the largest weigh estimate value of 0.368, so that X<sub>22</sub> item becomes the most influential item on the commitment indicator. The respondents' responses showed a mismatch, X<sub>21</sub> item obtained a greater average of 3.65. The actual conditions in the field indicate that the tempeh supplier has made a commitment to do so by making timely deliveries, providing inter-service delivery and procuring a return policy. The higher the commitment which can be built by both suppliers and distributors will strengthen the cooperative relationship built [15].

In the communication indicator (X<sub>3</sub>), X<sub>31</sub> item obtained the largest weight estimate value of 0.294 so that X<sub>31</sub> item becomes the most contributing item to X<sub>3</sub> indicator. This has been in accordance with the responses of respondents seen from the mean value of 3.24. The real conditions in the field, the communication between SMEs and suppliers is connected directly or indirectly (short messages and telephone). Direct communication is carried out every day because tempeh purchaseactivity is carried outin daily basis. The existence of good communication indicates the smooth flow of information between SMEs and tempeh suppliers. According to [16], partners in the supply chain can maintain sustainable relationships and reduce uncertainty in a collaboration system.

## 2) Business Performance (Y<sub>1</sub>)

Business performance variables are reflective variables. Formative variables are based on the value of loading estimate. The results of output measurement model of institution variables are presented in Table 3.

**Table 3.** Measurement Results of Variable Model of SMEs Performance

Symbol	Loading Estimate	Average
<b>Y<sub>1</sub></b>	<b>AVE = 0,586 Alpha = 0,857</b>	
Y <sub>111</sub>	0,745	3,38
Y <sub>112</sub>	0,802	3,47
Y <sub>121</sub>	0,674	3,56
Y <sub>122</sub>	0,800	<b>3,79</b>
Y <sub>131</sub>	<b>0,833</b>	3,50
Y <sub>132</sub>	0,729	3,56

Source : Analysis Data (2017)

Based on the outer model in Table 3, the largest loading estimate value in the production capacity indicator (Y<sub>11</sub>) obtained by Y<sub>112</sub> item is 0.802. These results indicate that Y<sub>112</sub> item becomes the most describing item to production capacity indicator; thus, the production capacity is able to describe the business performance of 0.802. This value is in accordance with the respondent's response when viewed from the mean gain of 3.47. Based on the respondents' responses, the monthly production capacity increased due to good retailer performance. This result is supported by Avery's research [17] stating that institutional relations have a significant effect on improving the company's operating performance both as a provider of physical and information goods.

In the product sales indicator (Y<sub>12</sub>) the largest loading estimate value is obtained by Y<sub>12</sub> item of 0.800. therefore, Y<sub>12</sub> item is the most describing item to product sales indicator. These results indicate that product sales are able to describe the business performance of 0.800. This value is supported by the respondent's response of 3.79. The respondents' responses stated that product sales increased due to the performance of retailers. Kotler [18] stated that sales performance depends on good relations among various parties including retailers in providing the best values for the target customers. This is common because retailers function as marketing tools owned by SMEs, so product sales depend on the performance of retailers as market access holders.

Table 3 presents the highest acquisition of loading estimate value obtained by Y<sub>131</sub> item. Y<sub>131</sub> item illustrates the effect of raw material supplier performance on increasing profits. The estimate item value is the biggest of all items, accounted by 0.833. These results indicate that item Y<sub>131</sub> is the most appropriate descriptor to business performance variables, according to the opinion of [19] which states profit growth becoming one of indicators of performance measurement. Profit growth is the end result of increasing sales value, sales growth and market share [20]. The mean value that is owned by Y<sub>131</sub> item based on the results of the questionnaire is 3.5. The acquisition of the mean value of Y<sub>131</sub> indicates that the increase in profitability is adequate but needs improvement. SMEs stated that the constraints faced by suppliers today are the instability of raw material supply both in terms of quantity and quality. If one supplier still cannot meet the production needs of SMEs, it is necessary to add suppliers to ensure the stability of raw material supply.

### 3) Competitiveness (Y<sub>2</sub>)

Competitiveness variables are reflective variables. Formative variables are based on the loading estimate value. The results of output measurement model of competitiveness variables can be seen in Table 4.

**Table 4.** Measurement Results of Variable Models of SMEs Competitiveness

Symbol	Loading Estimate	Average
<b>Y<sub>2</sub></b>	<b>AVE = 0,628 Alpha = 0,800</b>	
Y <sub>21</sub>	0,780	3,09
Y <sub>221</sub>	0,834	3,53
Y <sub>222</sub>	<b>0,855</b>	3,50
Y <sub>23</sub>	0,668	<b>3,56</b>

Source : Analysis Data (2017)



Table 4 suggests that  $Y_{222}$  item is the best descriptor to business competitiveness variable, this is proven by the loading estimate value of  $Y_{222}$  being equal to 0.855. Based on these values, it can be interpreted that innovation in the production process is an item in improving business competitiveness. In actual conditions,  $Y_{222}$  item has an average value of 3.5, this value is low compared to the average value of other items. tempeh chips SMEs in Sanando not maximize in conducting innovating especially in the production process. This is in line with Tambunan's [21] statement which states that almost all factors of production in Indonesia's SMEs are currently saturated, so there is a need for innovation for the development of SMEs centers in the future. MSMEs can increase innovation in terms of production with the help of public-private partnerships. Based on the publication by Bank Indonesia [22], public-private partnership (private and public - government cooperation) is needed to encourage and assist the development of SMEs competitiveness.

The goodness of fit value of the model is examined through the FIT and AFIT values. Fit describes the diversity of the total variables which can be explained by all variables in the overall model. The results of the fit model test are presented in Table 5.

**Table 5.** Structural Fit Models

Criteria	Model of Structural
FIT	0,589
AFIT	0,567
NPAR	31

Based on these outputs, the FIT value obtained is equal to 0.589. FIT and AFIT values range from 0 to 1, the closer to 1 then the value is considered to be good [23]. This value means that the model formed can explain 58.9% variation of data, so that it can be said that this research has a good model accuracy. This study employs only one model so that the AFIT value functions identical with FIT value. The AFIT value in this study is 0.567. This value means that the model formed can explain 56.7% variation of data. NPAR (Number of Free Parameters Estimate) shows the number of load parameters used in this study. In this model, there are 31 estimated parameters.

### 3.3. Results of Hypothesis Testing

Hypothesis testing is completed with examining the value in the path coefficients in the structural model. Hypothesis testing is based on the measure of fit model by looking at the significance of the Critical Ratio (CR) value. The completed results are presented in Table 6.

**Table 6.** Structural Model of Measure of Fit

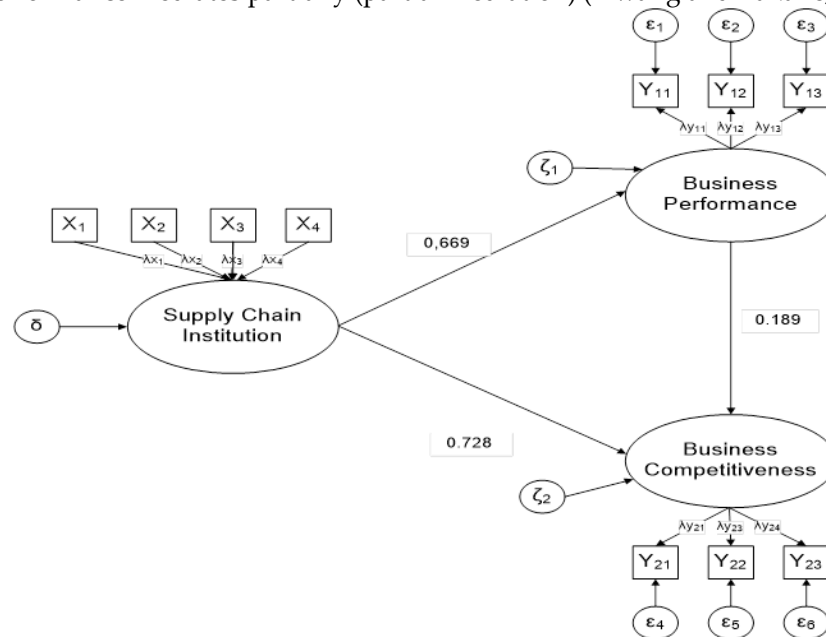
	Path Coefficient		
	Estimate	SE	CR
Supply Chain Institution -> Business Performance	0,824	0,04	19,1*
Supply Chain Institution -> Competitiveness	0,382	0,114	3,36*
Business Performance -> Competitiveness	0,634	0,116	5,46*

Source : Analysis Data (2017)

**Table 7.** Hypothesis Table of Indirect Influence

	Indirect Influence	Patch Coefficient			Amount
		X->Y <sub>1</sub> (a)	Y <sub>1</sub> ->Y <sub>2</sub> (b)	X->Y <sub>2</sub> (c)	c + (axb)
H4	X->Y <sub>1</sub> ->Y <sub>2</sub>	0,824	0,634	0,362	0,884

The test results prove that the direct influence of supply chain (X) on competitiveness (Y<sub>2</sub>) is significant with a path coefficient value of 0.362, while the influence of supply chain (X) on competitiveness (Y<sub>2</sub>) through performance (Y<sub>1</sub>) is also significant with the path coefficient of 0.884. The supply chain institutional path coefficient (X) on competitiveness (Y<sub>2</sub>) through performance (Y<sub>1</sub>) has a greater value than the direct influence, so hypothesis 4 is accepted. The results of this greater total value indicate that performance mediates partially (partial mediation) (Hwang and Takane, 2004).



**Figure 1.** Path Coefficient Value of Structural Model

#### 1) Effect of Supply Chain Institutionalization on SME Performance

Based on the results of data processing, the supply chain institutional path coefficient value for business performance is 0.824 and the CR (Critical Ratio) value is 19.1. This value is stated to be significant at 0.05. Rejection of  $H_0$  causes acceptance of alternative hypotheses which means that supply chain institutions have a significant influence on business performance. This result is supported by Avery's research [17] which states that institutional relations have a significant effect on improving the company's operating performance both as a provider of physical and information goods. Pradabwong et al. [24] also stated that supply chain institutions have an influence on the company's performance with partnership mediation. Tempeh chips SMEs in Sanan have a good relationship of trust to their raw material suppliers, tempeh suppliers; however, based on the observations in the field, tempeh suppliers have not worked optimally hampering the performance of MSMEs. The MSMEs stated that one of the obstacles faced was uncertainty in raw material acquisition during rainy season. Tempeh suppliers claimed that it was difficult to meet the needs of SMEs during rainy season driven by low quality of tempeh produced, even the weather may force tempeh producers to stop production temporarily. Yusniaji and Erni [25] argue that the constraints in raw material inventory would disrupt production activities and would have an impact on the decline in company performance; therefore, decisions regarding the supply of raw materials are very important to do.

Good raw material planning requires sufficient managerial skills. SMEs can obtain managerial skills by participating in programs held by the government. Examples of existing recent programs are financial bookkeeping training programs, collaborative programs between government agencies and educational institutions in order to improve the quality of human resources in SMEs. Research by Abdullahi et al., [26] also said that there was a positive and significant influence of training on SMEs business performance. Through training, SMEs owners and SMEs employees can add knowledge, skills and experience to improve the overall performance of SMEs.

## 2) Effect of Supply Chain Institutionalization on SMEs Competitiveness

The path coefficient value of the supply chain institutions on business competitiveness is 0.382. Moreover, the CR value of 3.36 indicates a significant influence on the 95% significance level. Based on these results, it can be interpreted that supply chain institutions have a significant influence on business competitiveness. The results of testing these hypotheses are in accordance with research conducted by Jakfar et al [27] stating that cooperation activities between institutions in the supply chain will be a sustainable competitive advantage for all organizations in the supply chain. Institutions in the supply chain system determine the volume of supply, profits and added value formed. The results of testing hypotheses are also strengthened by [28] research stating that there is a clear relationship between companies and suppliers as part of the supply chain in determining the position of companies in market competition. Based on the results of field observations and previous data processing, it is known that tempeh chips SMEs in Sanan have good trust in their raw material suppliers, tempeh suppliers. This is a good indication because according to Sumarwan et al. [29] trust between supply chain institutions are two dominant aspects underlying the emergence of cooperation, competitiveness and guarantee of financial benefits. Although the results of field observations show a good relationship between tempeh suppliers and tempeh chips, there were still several other aspects that could be optimized to improve the competitiveness of tempeh chips.

In real condition, most SMEs stated that they only work with one retailer, even some SMEs said they do not use the services of retailers and only rely on orders from end consumers. Moreover, their awareness to cooperate with government agencies is still relatively low. This is very unfortunate, because by cooperating with the right institutions such as government, SMEs can participate in coaching and exhibition programs as provisions to access a wider market. The participation of SMEs in coaching and training programs can also improve the overall performance of SMEs. According to [30], if the performance of SMEs including technical and operational capabilities has reached multinational standards, SMEs can be involved in Global Value Chain (GVC). GVC is basically a system facilitating collaboration between SMEs actors and multinational companies which generally have much better market access, technology and information networks. The lack of SMEs production scale, high transaction costs and limited information and technology networks as obstacles to the growth of SMEs competitiveness can be eliminated by involving SMEs [31].

## 3) Effect of Relationship between Business Performance on Competitiveness

Based on the results of hypothesis testing, it can be seen that the path coefficient of business performance on competitiveness is 0.634, having CR value of 5.46 > 1.96 meaning that the value is significantly positive at 0.05. This value indicates that business performance has a significant influence on business competitiveness. The results of testing this hypothesis are similar to the results of Handriani's [32] study stating that there is a positive influence on the performance variables on the competitiveness of SMEs in Semarang Regency, so that increased competitiveness of SMEs depends on how well performance in SMEs.

In real conditions, tempeh chips SMEs in Sanan said that they still encounter several obstacles hampering overall business performance. These obstacles include limited access to capital and access to information. Limited access to capital hinders SMEs to invest in innovations in both products and production processes. The innovations which can be carried out are only limited to the form of packaging and concoction, there is no innovation in terms of the production process. The innovation for truly new products is considered to be expensive and high risk, so that in general micro-scale businesses cannot perform major innovation. The form of the program which is currently running in the city of Malang is credit assistance for MSME owners.

## 4) Effect of Mediating Performance on the Relationship between Supply Chain Institutions and Competitiveness

The test results show that direct influence of supply chain (X) on competitiveness (Y<sub>2</sub>) is significant with a path coefficient of 0.362, while the influence of supply chain (X) on competitiveness (Y<sub>2</sub>) through performance (Y<sub>1</sub>) is also significant with the path coefficient of 0.884. The path coefficient (X) of supply chain institutions on competitiveness (Y<sub>2</sub>) through performance (Y<sub>1</sub>) has a greater value than the direct influence, so hypothesis 4 is accepted. The result of this greater total value indicates its partial

mediation. These results indicate that supply chain institutions can improve business competitiveness better if considering business performance. This statement is reinforced by [33] which states that companies with high competitiveness tend to have good business performance, resulted from integration between supply chain actors.

The stronger the relationship between supply chain actors, the higher overall performance of members in a supply chain network. Improved business performance according to [34] has a positive influence on increasing business competitiveness. This causes supply chain institutions to indirectly influence the competitiveness of SMEs by mediating business performance variables. Yuhua and Bayhaqi [30] also argue that the higher the value possessed by a business, the greater the opportunity for the business to be involved in a larger scale supply chain. Based on this statement, it can be said that with the help of supply chain institutions, the value of the company will increase implying an increase in the ability of businesses to compete in the market.

#### 4. Conclusions

- Supply chain institutions have a significant influence on SMEs performance of 0.824. Tempeh suppliers are the most influential component in increasing the benefits of SMEs.
- Supply chain institutions have an influence on the competitiveness of SMEs businesses by 0.382. Process innovation is an important component to improve the competitiveness of SMEs. Government become one of the parties in supply chain institutions which can support SMEs in improving process through the provision of training and information regarding access to capital and markets.
- Business performance has a significant influence on the business competitiveness of SMEs by 0.634. The performance of SMEs, especially in process innovation, is an important component to improve the competitiveness of SMEs.
- Business performance has a partial influence in mediating the relationship between supply chain institutions and business capacity statistically at 0.884.

#### References

11. Zebua, M. 2016. *Inspirasi Pengembangan Pariwisata Daerah*. Deepublish Publisher. Yogyakarta.
12. Badan Pusat Statistik. 2015. Persentase UMKM Menurut Wilayah. Dilihat 5 Maret 2017. <<http://www.bps.go.id/linkTabelStatis/view/id/513>>
13. Kuncoro, M. 2008. *Manajemen Usaha Skala Kecil dan Menengah*. BPFE. Yogyakarta
14. Badan Pusat Statistik Kota Malang. 2014. Pengeluaran Rata-rata Perkapita Sebulan Menurut Kelompok Barang dan Jasa. Dilihat 5 Maret 2017. <<http://www.malangkota.bps.go.id/linkTabelStatis/view/id/522>>
15. Dinas Perindustrian Kota Malang. 2012. *Data UMKM Keripik Tempe Kota Malang*. Dinas Perindustrian Kota Malang. Malang.
16. Trisnaningtyas, K. 2017. *Strategi Pengembangan Klaster Usaha Kecil dan Menengah Keripik Tempe dengan Metode K-Means Clustering dan FAHP (Studi Kasus di UKM Keripik Tempe Sanan, Kota Malang)*. Laporan. Teknologi Industri Pertanian. Fakultas Teknologi Pertanian Universitas Brawijaya.
17. Rusno. 2014. Analisis Posisi Bersaing untuk Menentukan Strategi Pemasaran Industri Kripik Tempe di Kota Malang. *Modernisasi*. 10(3)
18. Ariani, D dan Bambang M.D. 2013. Analisis Pengaruh *Supply Chain Management* Terhadap Kinerja Perusahaan (Studi Pada Industri Kecil Menengah Makanan Khas Olahan Padang Sumatra Barat. *Diponegoro Journal of Management*. 2(3).
19. Sejati, W.K. 2011. Analisis Kelembagaan Rantai Pasok Telur Ayam Ras Peternakan Rakyat di Jawa Barat. *Jurnal Analisis Kebijakan Pertanian*. 9(2): 183-198.
20. Ardiana I., Brahmayanti I.A, dan Subaedi. 2010. Kompetensi SDM UKM dan Pengaruhnya Terhadap Kinerja UKM di Surabaya. *Jurnal Manajemen dan Kewirausahaan*. 12(10): 42-55.
21. Meliala, A.S, Nazaruddin M dan Rahmi M. 2014. Strategi Peningkatan Daya Saing Usaha Kecil dan

- Menengah (UKM) Berbasis Kaizen. *Jurnal Optimasi Sistem Industri*. 13(2): 641-664.
22. Kusumadewi KA dan Ghozali I. 2013. *Generalized Structured Component Analysis (GSCA): Model Persamaan Struktural Berbasis Komponen*. Badan Penerbit UNDIP. Semarang.
  23. Hwang, H and Takane Y. 2004. *Generalized Structured Component Analysis*. Psychometrica. 69. 81-99.
  24. Sa'adah, M, Imam S dan Siti A.M. 2015. Analisis Efektivitas Kinerja dalam Klaster Agroindustri Makanan Ringan di Kota Malang. *Jurnal Habitat*. 26(3).
  25. Munizu, Musran. 2010. Pengaruh Faktor-Faktor Eksternal dan Internal Terhadap Kinerja Usaha Mikro dan Kecil (UMK) di Sulawesi Selatan. *Jurnal Manajemen dan Kewirausahaan*. 12: 33-41.
  26. Mamad, M dan Chahdi F. 2013. *The Factors of The Collaboration between the Upstream Supply Chain Actors: Case of The Automotive Sector in Morocco*. *International Business Research*. 6(11).
  27. Avery, S.L. 2009. *Social Capital Impact on Service Supply Chains*. *Journal of Service Science*. 2(2).
  28. Kotler, P. 2007. *Prinsip-Prinsip Pemasaran*. Erlangga. Jakarta.
  29. Pelham, A. 2007. *A Longitudinal Study of the Impact of Market Structure, Firm Structure, Strategy and Market Orientation Culture on Dimensions of Small Firm Performance*. *Journal of The Academy of Marketing*. 24(3).
  30. Ferdinand, A.T. 2000. *Manajemen Pemasaran: Sebuah Pendekatan Strategis*. Badan Penerbit Universitas Diponegoro. Semarang. *Journal of Business & Industrial Marketing*. 27(2).
  31. Tambunan, T. 2000. *Development of Small-Scale Industries During the New Order Government in Indonesia*. Ashgate Publishing. Jakarta.
  32. Bank Indonesia. 2015. Pemetaan dan Strategi Peningkatan Daya Saing UMKM dalam Menghadapi MEA 2015 dan Pasca Mea 2025 / WP BI No 9. Bank Indonesia. Jakarta.
  33. Ristianto, A.D dan Irma F. 2016. Hubungan Profesionalisme, Motivasi dan Gaya Kepemimpinan Partisipatif Terhadap Produktivitas Kerja Dosen Menggunakan Metode *Generalized Structured Component Analysis*(SEM-GSCA). *Jurnal LOG!K@*. 6(2): 112-130.
  34. Pradabwong, J., Christos B., James T., and Kulwant S. 2017. *Business Process Management and Supply Chain Collaboration: Effects on Performance and Competitiveness*. *International Journal of Supply Chain Management*. 22(2).
  35. Yusniaji F dan Erni W. 2013. Analisis Penentuan Persediaan Bahan Baku Kedelai yang Optimal dengan Menggunakan Metode *Stockhastic* Pada PT. Lombok Gandaria. *Jurnal Ekonomi dan Kewirausahaan*. 13(2).
  36. Abdullah, S dan Taufik E. 2015. *Statistik Tanpa Stres*. Transmedia. Jakarta. Hal 259-265.
  37. Jakfar, F., Romano dan Nurcholis. *Pengelolaan Rantai Pasok dan Daya Saing Kelapa Sawit di Aceh*. *Jurnal Agraris*. 1(2)
  38. Prior, D.D. 2012. *The Effects of Buyer-Supplier Relationships on Buyer Competitiveness*. *Journal of Business & Industrial Marketing*. 27(2).
  39. Sumarwan, U., Agus M., dan Muchlis A. 2012. *Key Success Values in Relationship Marketing of Agriculture Products*. *Jurnal Manajemen & Agribisnis*. 9(2).
  40. Yuhua, Z and Bayhaqi, A. 2013. *SME's Participation in Global Production Chains*. APEC Policy Support Unit Paper. Issues Paper No 3.
  41. Asian Bank Development. *Integrating SMEs into Global Value Chains: Challenges and Policy Actions in Asia*. Asian Development Bank Institute. Manila. Hal 4-5.
  42. Handriani, E. 2011. Pengaruh Faktor Internl Eksternal, *Entrepreneurial Skill*, Strategi da Kinerja terhadap Daya Saing UKM di Kabupaten Semarang. *Dinamika Sosial Ekonomi*. 7(1).
  43. Dung, L.T. 2015. *Factors Affecting the Collaboration in Supply Chain of Mechanical Enterprises in Vietnam*. *Journal of Managing Value and Supply Chains*. 6(4).
  44. Handriani, E. 2011. Pengaruh Faktor Internl Eksternal, *Entrepreneurial Skill*, Strategi da Kinerja terhadap Daya Saing UKM di Kabupaten Semarang. *Dinamika Sosial Ekonomi*. 7(1).
  45. Marimin dan Maghfiroh. 2010. *Aplikasi Teknik Pengambilan Keputusan dalam Manajemen Rantai Pasok*. IPB Press. Bogor.
  46. Kwon, I dan Taewon S. 2004. Factors Affecting the Level of Trust and Commitment in Supply Chain Relationships. *Journal of Supply Chain Management*. 40(4).



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license

(<http://creativecommons.org/licenses/by/4.0/>).

## General Chair Greeting

The development of agro-industry is something that should be augmented and reinforced as this sector has been regarded to have a significant contribution to economic growth. The agro-industrial sector provides plenty of opportunities for transforming its comparative advantages into competitive ones because of its linkages to both upstream and downstream industries. Nevertheless, there are some aspects in agro-industry that should be strengthened and improved particularly to enter the current era of industry 4.0.

Industry 4.0 was marked by a rapid pace of transformation in which the aspect of technological mastery become the key determinants of competitiveness. Some technologies especially digital ones such as Artificial Intelligence, Big Data, and Internet of Things (IoT) have become the main technology that supports the implementation of industry 4.0. In the agro-industrial sector, the digital transformation will bring many changes with all the consequences. The integration between digitalization and agro-industry (Agro-industry 4.0) is projected to further maximize the potential development of business and innovation, as well as to improve the process and delivery of its value. This opportunity is also expected to potentially allow agro-industry to be more sustainable and conserved its presence.

Trying to enrich the synergy development of agro-industry 4.0, the Department of Agro-industrial Technology, Universitas Gadjah Mada, Indonesia is initiating a contribution to the development of agro-industry that is capable to meet changing market requirement, both nationally and globally. Supported in a fund by Tetra Pak, Rajawali Nusantara Indonesia, Aneka Tambang, and Gruene Punkt, we proudly hold the 5<sup>th</sup> International Conference on Agro-Industry (ICoA) 2018: Agro-industry 4.0 – Digital Transformation on Agro-food Value Chains. This event is well joined by our distinguished colleagues from Udayana University, Ehime University, De La Salle Araneta University, Kasetsart University and International University of Japan. The ICoA 2018 had invited academics, professionals and researchers to presented and discussed the most recent developments and future trends in agro-industry from various aspects. Thus, we hope that the ICoA 2018 will immensely benefits for the development of agro-industrial sector.

Finally, we would like to express our sincere gratitude to the editors, guest editors, scientific committee, and organizing committee for the valuable contribution upon the publication of this international proceedings.

Yogyakarta, September 2019

General Chair of ICoA

Dr. Adi Djoko Guritno

## Keynote Speaker Profile



### Speaker 1 – Prof. Dr. Yu Pin Lin

Department of Bioenvironmental Systems Engineering,  
National Taiwan University

Education:

- Ph.D. in Civil and Environmental Engineering, Georgia Institute of Technology, USA
- M.S. in Civil and Environmental Engineering, Georgia Institute of Technology, USA

Academic Experience:

- Department Chair, Department of Bioenvironmental Systems Engineering, National Taiwan University, 2015/8~2018/7
- Convener, Sustainable Development Division, Ministry of Science and Technology, Taiwan, 2013/1~2015/12

Honors:

- Ministry of Science and Technology, Outstanding Research Award, 2016
- Ministry of Science and Technology, Advisor of Undergraduate Student Research Creation Award 2016



### Speaker 2 – Prof. Dr. Moch. Maksum

Department of Agroindustrial Technology,  
Universitas Gadjah Mada

Education:

- M.S. in Agricultural Engineering (Crop Post-Harvest Engineering and Technology) University of the Philippines at Los Baños
- Ph.D Agricultural Economics University of the Philippines at los Baños, Philippines

Expertise:

- Agroindustrial Economics
- International Trade
- Industrial Policy



### Speaker 3 – Bjorn Santos

De La Salle Araneta University, Philippines

Education:

- Bachelor of Science (bs), Agricultural Engineering University of Philippines
- Master, Biological and Agricultural Engineering Texas A&M University
- PhD Biological and Agricultural Engineering

Experience:

- President De La Salle University Octo 2016-present
- Vice Chancellor for Academic and Research 2014-2016



#### **Speaker 4 – Helmut Schmidt**

Director Communication-Public Affairs  
Gruene Punkt, Germany



#### **Speaker 5 – Reza Andreanto**

Environment Manager Tetra Pak Indonesia

Education:

- Undergraduate, Computer Science Gadjah Mada University
- MBA Business Administration and Management Swiss German University

Career Experience:

- Business Development and Marketing Specialist DUPONT
- Key Account Manager Trimitra Cikarang
- Senior Sales Representative Trimitra Swadaya



#### **Speaker 6 – B. Didik Prasetyo**

President Director of PT Rajawali Nusantara Indonesia (Persero)

Education:

- Undergraduate. Forestry Management Bogor Agricultural Institute
- Ms. Economic Law University of Indonesia

Career Experience:

- Deputy Assistant to the Ministry of Energy, Mining, Printing and Tourism Business Affairs
- Commissioner Rajawali Nusantara Indonesia 2008-2013



## Invited Speaker Profile



### **Speaker 1 – Dr. Adi Djoko Guritno**

Department of Agroindustrial Technology  
Faculty of Agricultural Technology, Universitas Gadjah Mada

#### Education:

M.T Bandung Institute of Technology  
Dr. Ehime University, Japan

#### Expertise:

- Supply chain management
- Risk management
- Operation management



### **Speaker 2 – Prof. I Ketut Satriawan**

Faculty of Agricultural Technology, Udayana University

#### Education:

M.T Bogor Agricultural Institute  
Dr. Bogor Agricultural Institute

#### Expertise:

- Productivity analysis
- Engineering Economic Analysis
- Production Planning and Inventory Control



### **Speaker 3 – Prof. Sugahara, Takuya**

Graduate School of Agriculture Department of Bioscience, Ehime University

#### Academic & Professional Experience:

- 2016, Graduate School of Agriculture, Ehime University, Department of Bioscience, Professor
- 2007, Ehime University
- 2006 - 2007, Ehime University
- 2002, University of Texas Health Center at Tyler
- 1994 - 2006, Ehime University

#### Research Areas:

- Agricultural Chemistry, Food science
- Process/Chemical engineering, Biofunction/Bioprocess
- Society medicine, Hygiene and public health



#### **Speaker 4 – Kiwi Aliwarga**

Chief Executive Officer and Co-Owner UMG Myanmar

##### Education:

- Master's degree, Engineering Asian Institute of Technology
- S2, System Dynamics Massachusetts Institute of Technology-Sloan School of Management

##### Experience:

- CEO UMG MYANMAR
- GENERAL MANAGER Win Progress Co.Ltd
- Manager PT. Astra International



#### **Speaker 5 – Prof Hiroki Oue**

Science and Technology for Biological Resources And Environment, Ehime University

##### Education:

- 1989 Kyoto University Graduate School, Division of Agriculture
- 1987 Kyoto University Graduate School, Division of Agriculture
- 1985 Kyoto University Faculty of Agriculture

##### Research Areas:

- Earth and planetary science,
- Meteorology/Physical
- oceanography/Hydrology

##### Research Interest:

- Micrometeorology, Hydrology, Irrigation, and drainage, Oceanography and Hydrology

## Table of Contents

Editorial Preface .....	iii
General Chairman Greeting .....	iv
Keynote Speaker Profile .....	vii
Invited Speaker Profile .....	x
 <b>Preparation of Standard Operating Procedures (SOP) of Broccoli Handling at PT. X Bandung</b>	
Totok Pujianto, Arif Rahman and Irfan Ardiansah .....	1
<b>Consumer's Awareness and Adoption for QR Payment at Traditional Trade in Bangkok</b>	
Passaraporn Thongtha and Ajchara Kessuvan .....	13
<b>Discriminant Analysis of Consumer Intention to Use Green Packaging in Thailand</b>	
Boonsita Vichienvanitchkul, Apichaya Lilavanichakul .....	19
<b>Designing Herbal Cosmetics Marketing Channel</b>	
Preuk Petsophonsakul and Chutima Waisarayutt.....	26
<b>Purwaceng Coffee Formulation Based on Consumers Preference</b>	
Julianisa, D.S., Aziz, I.W.F and Jumeri .....	35
<b>Development Marketing Strategy of Salak Pondoh (<i>Sallaca Zalazza</i> (Gaert.) Voss.) Based on Marketing Mix</b>	
Pitaloka Ayustina, Novita Erma Kristanti, Suharno.....	41
<b>Black Rice Agroindustry in Sleman, Yogyakarta: Early Analysis</b>	
Dyah Ismoyowati, Anisah Riyadi, Ardhan Rifai, Endy Suwondo and Tririni Nuringtyas....	51
<b>Analysis of Consumers Perceptions of the Important Factors in Soygurt Products and Marketing Strategies</b>	
Atris Suyantohadi, Mirwan Ushada and Dody Kastono .....	55
<b>The Effectiveness of Instagram Use in Florist Marketing</b>	
Geraldo Herawan, Suharno and Nafis Khuriyati .....	64
<b>Analysis of Consumer Preference Towards Organic Products at Istana Sayur Grocery Shop Malang City Indonesia</b>	
Ika Atsari Dewi, Panji Deoranto, and Diannisa Hadianiti.....	77
<b>Nursery Garden Development Strategy as Educational Tourism Using Swot Analysis and Multi-Attribute Utility Theory (MAUT) (Case Study On Kebun Bibit Kediri)</b>	
Panji Deoranto, Septiana Rosari and Rizky L.R Silalahi .....	84
<b>Immature Black Vinegar Extract Activates Macrophages</b>	
Eri Ishii, Kosuke Nishi, Momoko Ishida, Masanobu Nagano, Kazunori Hashiguchi, Akira Fujii and Takuya Sugahara .....	92

<b>Anti-Inflammatory Effect of Placenta Water-Soluble Extract on Macrophages</b>	
Miyuki Yokotani, Kosuke Nishi, Yoshiharu Sasaki and Takuya Sugahara.....	98
<b>Anti-Allergic Effect of Clove</b>	
Ange Murielle DjidjouTagne, Momoko Ishida, Hiroyuki Onda, Kosuke Nishi and Takuya Sugahara .....	104
<b>Anti-Inflammatory Effect of Aqueous Extract from Kawachi-Bankan Peel on Lipopolysaccharide-Induced Inflammatory Responses in RAW264.7 Cells</b>	
Momoko Ishida, Chihiro Takekuni, Kosuke Nishi and Takuya Sugahara .....	110
<b>Anti-Inflammatory Effect of Lysozyme</b>	
Ayuka Tagashira, Kosuke Nishi, Shinya Matsumoto and Takuya Sugahara .....	115
<b>Inhibitory Effect of Caffeine on Degranulation of RBL-2H3 Cells</b>	
Arita Dewi Nugrahini, Momoko Ishida, Kosuke Nishi and Takuya Sugahara .....	123
<b>Constraints in The Use of Balanced Scorecard Performance Measurement Parameters on Small-Medium Enterprises (Case Study on The Application of SMEs Performance Measurement at CV. X and Y)</b>	
Totok Pujianto .....	128
<b>Trust as a Human Factor for Sustainable Ergonomics Application in Agro-industry</b>	
Mirwan Ushada, Titis Wijayanto and Fitri Trapsilawati .....	136
<b>Cost Analysis for Sugarcane Transporting Improvement from Loading Station to Sugar mill</b>	
Kris Promsiri and Jumpol Vorasayan.....	141
<b>A Concept of Engineering Education Program to Improve the Competitiveness of Human Resources in Agroindustry</b>	
Elisa Anggraeni, Muhammad Romli and Suprihatin Suprihatin .....	151
<b>Quality and Packaging Analysis of Fresh Strawberry (<i>Fragaria</i> Sp) During Storage in Controlled Environment</b>	
Agustina R.P. Andam Dewi, Pujo Saroyo and Mohammad Affan Fajar Falah.....	164
<b>Supply Chain Analysis of Local Beef in Malang, Indonesia</b>	
Retno Astuti, Sucipto and Titik Prastiani.....	177
<b>Analysis of Supply Chain Institutions to the Performance and Competitiveness of Tempeh Chips SMEs Cluster in Sanan, Malang</b>	
Siti Asmaul Mustaniroh, Rizky LR Silalahi and Adinda Wardhani.....	187

FP-SCM-014-ID073

# Preparation of Standard Operating Procedures (SOP) of Broccoli Handling at PT. X Bandung

Totok Pujianto<sup>1,\*</sup>, Arif Rahman<sup>1</sup> and Irfan Ardiansah<sup>1</sup>

<sup>1</sup> Dept. of Agroindustrial Technology; totok.pujianto@unpad.ac.id

\* Correspondence: totok.pujianto@unpad.ac.id; Tel.: +62-856-212-6252

Received: 14 August 2018; Accepted: 25 August 2019; Published: 6 January 2020

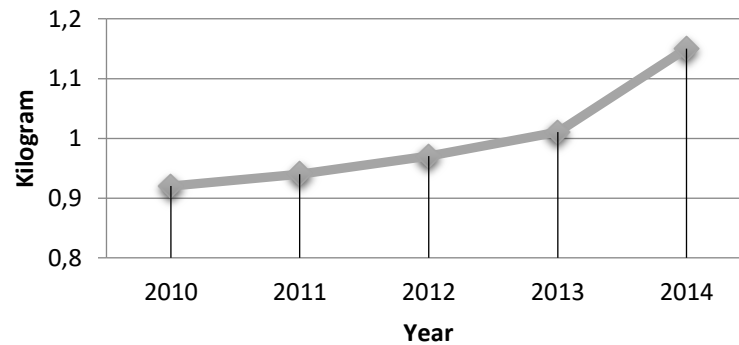
**Abstract:** PT. X is a company that is classified as an agroindustry, especially in the field of post-harvest handling of vegetables and fruits. Some supermarkets in the Jakarta, West Java and Banten regions are consumers of the company, of which broccoli is one of the vegetable commodities that have high demand and high selling prices. Until now PT. X has not followed the standard of good vegetable handling activities in handling broccoli, which raises several problems, including: (1) excessive use of packaging materials, (2) various handling times, and a decrease in quality. This study aims to develop a Standard Operating Procedure (SOP) for handling broccoli at PT. X, as an effort to improve broccoli handling activities. Standards that are structured are useful for handling broccoli in similar companies. Standards are made to consider the rules of SOP compilation according to SNI and Good Handling Practice according to the Minister of Agriculture Regulation No: 73/Permentan/OT.140/7/2013, with research stages: (1) in-depth observation of handling activities, in-depth interviews, data collection on quantities operating time for each process and identification of technical problems, (2) literature study related to observations and problems found, aimed at improving procedures and problem solving, (3) preparation of SOPs and (4) verification to experts and companies. Through this study, SOPs were prepared which resulted in improvements of 39% items. The important points of improvement are: (1) employee self-sanitation, (2) sanitation of equipment and work tools, (3) controlled and recorded packaging usage, (4) the determination of standard operating time, and (5) work instructions for each process successfully arranged.

**Keywords:** standard operating procedures, broccoli, good handling practice, process and product quality

---

## 1. Introduction

Broccoli is a prospective agricultural commodity to be developed as an agro-industrial activity in Indonesia. Broccoli has high economic value and benefits. Broccoli production in Indonesia is still low, both in quality and quantity. This broccoli production area is dominated by highland areas where broccoli is able to adapt well, such as Lembang (West Java), Brastagi (North Sumatra), Malang (East Java), and Bedugul (Bali) [1]. In Indonesia, broccoli consumption in Indonesia tends to increase every year. The prospect of domestic demand for vegetables tends to increase. This is in line with the increase in population, increasing community income, as well as the development of urban, industrial and tourism. Data from the Central Bureau of Statistics regarding consumption that has increased every year is directly proportional to the increasing market demand, as shown in Figure 1 [2]. This increase in demand needs to be balanced with a good supply of broccoli in terms of quality. Presenting quality broccoli requires special treatment starting from the upstream to downstream sub-systems so that product quality is maintained until the end consumer.



**Figure 1.** Broccoli consumption in Indonesia per capita in 2010-2014

PT. X, is a company engaged in post-harvest handling of 127 types of fruits and vegetables, packing and then supplying it to supermarkets located in DKI Jakarta, West Java and Banten, namely DC Carrefour (District Central), Hypermart, Lottemart, Market City, Hero, Ramayana and Aeon. Broccoli is one of the vegetable commodities which has a high demand (170-200 Kg) and has a high selling value. It is unfortunate that PT X has not implemented a standard post-harvest handling of broccoli properly, thus causing problems such as excessive use of packaging materials, length of handling that is still not standard, and lack of self-sanitation activities. These problems have an impact on inefficiency and low quality of handling, such as broccoli stems broken, broccoli packed withered.

Pursuant to the regulation of the Minister of Agriculture of the Republic of Indonesia Number 73/Permentan/OT.140/7/2013 concerning Good Handling Practice (GHP) which requires business actors to follow a food safety program by compiling a Standard Operating Procedure (SOP), then PT. X needs to prepare a SOP for post-harvest handling of broccoli [3]. The application of SOP is motivated by consumer demand for products that are more better from the aspect of quality, and quantity to timeliness of acceptance [4].

PT. X in carrying out its activities only has one SOP not written and generally applicable. While the written SOP for each vegetable commodity have not been compiled. This is a weakness in post-harvest handling activities, given that each vegetable commodity has different characteristics. Therefore, it is very necessary to develop special SOPs regarding post-harvest handling of broccoli

This study aims to compile SOPs for broccoli post-harvest handling to increase productivity, efficiency and as an effort to maintain product quality. In addition, SOP is expected to be able to be used as a SOP specifically in post-harvest handling of broccoli by similar companies.

The scope of the research is the preparation of SOPs related to employees as operators, production tools used, standard handling time and Work Instructions (IK) from broccoli post-harvest handling activities starting with receiving, sorting, trimming, grading, packaging, labeling, checking / TLM, and product distribution. All of these activities are carried out by PT. X.

## 2. Materials and Methods

This research is classified as applied research that is an attempt to get a solution to the problem through engineering methods to compile SOP for handling post-harvest broccoli at PT. X. The preparation of the SOP refers to the regulation of the Minister of Agriculture of the Republic of Indonesia No: 73/Permentan/OT.140/7/2013, and ISO/TR 10013 namely "guidelines for quality management system documentations" [3,5].

This research was carried out with the following steps: (1) in-depth observation of handling activities, in-depth interviews, data collection on quantities operating time for each process and identification of technical problems, (2) literature study related to observations and problems found, aimed at improving procedures and problem solving, (3) preparation of SOPs and (4) verification to experts and companies.

In steps no (1) and (2) the topic is understanding each type of broccoli post-harvest handling process. Searching for each process includes the objectives, scope, main and supporting materials, work procedures, equipment used, operators and other related employees, related work guidelines, work environment, and the time needed to complete the process. Especially regarding the completion time of a process, the cycle time is measured to then set the normal time, then the standard time of the process is determined. The normal time of a process is the cycle time multiplied by the rating factor (using Westinghouse System of Rating), while the standard time of a process is the normal time added to the allowance factor. Standard time determination of a process in this research refers to the rules of determining "standard time" for work that has a cycle [6,7] .

The results in steps no (1) and (2) are used to compile the SOP for each process. The preparation of the SOP substance (step number (3)) refers to the regulation of the Minister of Agriculture of the Republic of Indonesia Number 73 / Permentan / OT. 140/7/2013 concerning Good Handling Practice (GHP), while the writing guide refers to ISO / TR 10013 is modified. The compiled SOP is then verified by the expert and the company to evaluate the possibility of its application which includes comprehensiveness, completeness of SOP material, and logical work procedures. If the evaluation results of the SOP draft are declared as not fulfilling all three of these, then the SOP design is corrected. After verification activities, a trial of the implementation of SOP was conducted as a form of validation of the draft SOP.

### 3. Results and Discussion

#### 3.1. Series of Broccoli Post-Harvest Handling Processes

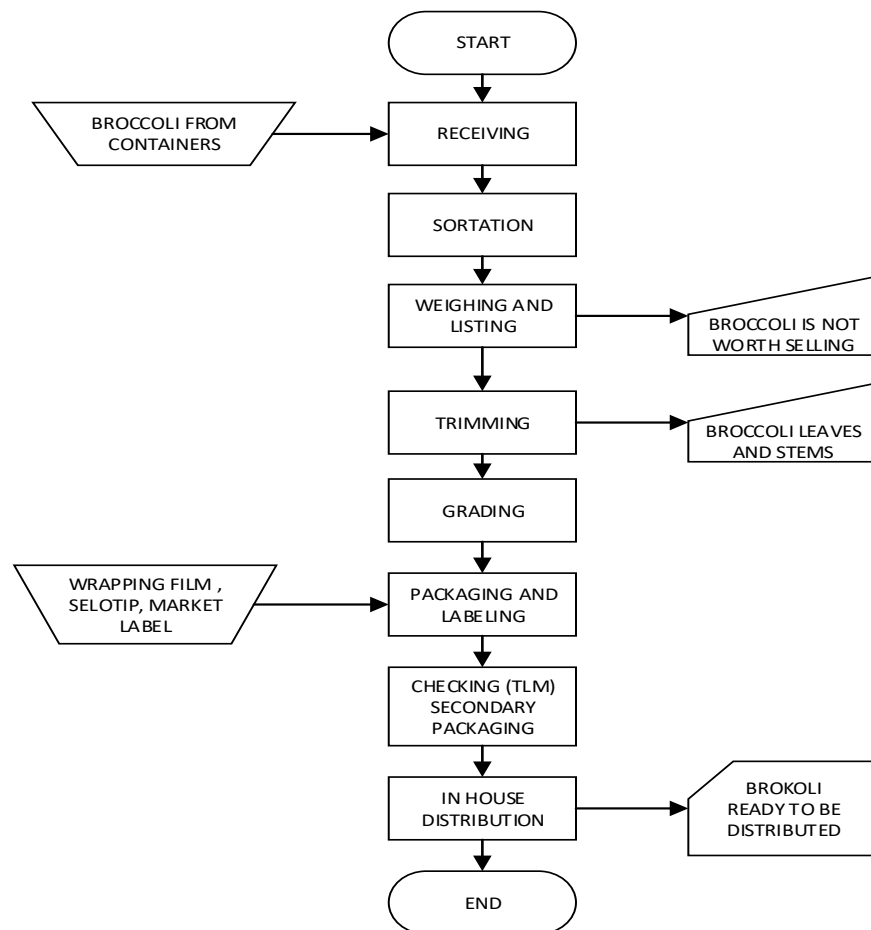
Description of the results of an in-depth understanding of the broccoli post-harvest handling system that occurred at PT. X is based on the work process framework from upstream to downstream. The series of work processes (upstream to downstream) starts from the availability of raw materials (ie the arrival of harvested broccoli in a basket transported by a box car parked in front of the workshop door) until broccoli is packed with secondary packaging ready to be distributed to each supermarket (first buyer). A series of broccoli post-harvest handling processes are presented in Figure 2.

##### 3.1.1. Receiving and Sortation

Broccoli from supplier received by PT. X is in a plastic container, it is clean from leaves, the size of weight and physical condition varies, for example there are black or yellow spots on the part of broccoli flowers. Therefore, the sorting process is carried out.

The sorting process aims to get good quality broccoli based on the diameter of the flower, stalk length, weight and color. The sorting process is carried out manually by the operator through checking the diameter of the flower, the length of the stalk and the color of the broccoli flower. Broccoli is held by the operator without using gloves. This has the potential to accelerate the decay of broccoli due to exposure to contaminants from the hands of employees [3]. The sorting process takes place in a workshop with 2 sides of an open wall, so it has good lighting because it is always carried out during the day. There are at least 3 containers as a container to separate broccoli that passes sorting with broccoli which does not pass sorting.

Broccoli, which is of good quality in containers, is weighed at the same time to find out the amount of payment to suppliers. Broccoli in containers as temporary storage is pushed on the floor (to reduce the operator's workload due to the relatively heavy weight of broccoli (30 kg) per container) towards the trimming process. Broccoli passes sorting can be seen in Figure 3. The characteristics of broccoli set by the company to pass the sorting process can be seen in Table 1.



**Figure 2.** Operating Process Chart for Broccoli Post Harvest Handling at PT. X



**Figure 3.** Physical appearance of broccoli that passes sorting; Source: Research team, 2018

**Table 1.** Characteristic requirements of broccoli that pass sorting

No	Attribute	Specification
1	Flower diameter	9 cm – 15 cm
2	Stem length	9 cm – 10 cm
3	Weight	250 gram – 350 gram
4	Color	Flowers are dark green and have no black or yellow spots.

Source: Processed data research, 2018

### 3.1.2. Trimming and Grading

In the process of trimming and grading, broccoli is examined against the presence of pests and diseases such as caterpillars and black spots, then the stem is removed from the bulge by cutting using a knife. Broccoli is held using the left, and the knife is on the right hand, because the right hand is



considered to have a better balance. Broccoli stems that have been cleaned are cut to a maximum length of 10 cm, to meet the standards set by the market, and avoid packaging damage in distribution activities. The remaining cutting stems are weighed and recorded at the receiving part as a factor to reduce overall broccoli weight to adjust the amount of payment to suppliers.

Trimming tools used in this activity are knives, sorting tables and containers that are prepared in a clean condition, but sometimes used in a dirty state. This is because companies that have not set hygiene standards for trimming activities, in this activity employees do not use gloves. This can endanger operator safety, considering the use of knives as trimming tools. Workers who do not use completeness can be seen in Figure 4.



**Figure 4.** The process of trimming broccoli; Source: Research team, 2018

Broccoli is transferred to the grading operator which is located on the right side of the trimming operator for grading. Broccoli is classified into 2 grades (grades A and B), stored in different container containers. The classification of broccoli in this company is determined by the shape, color, texture and size of the flower. The criteria for each broccoli grade can be seen in Table 2.

**Table 2.** Characteristic requirements of broccoli that pass so

Quality Criteria	Grade A	Grade B
Diameter	9-15 cm	9-15 cm
Stem length	Max 10 cm	Max 10 cm
Weight	200-450 g/ piece	200-450 g/ piece
Color and shape of flowers	Even dark green, round like umbrellas, fresh flowers and stalks, free of disease, relatively the same size	Even dark green, round like an umbrella, fresh flowers and stems, free of disease, size varies greatly
Surface	Seamless, non-defective, non-contaminant	Seamless, slightly defective, non-contaminant
Packaging	<i>Wrapping</i>	<i>Wrapping</i>
Quality	Equally	Varies
Shelf life	One day	One day
Customer	<i>Medium &amp; high income</i>	<i>Low income</i>

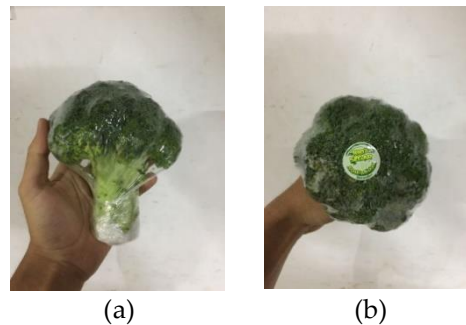
Source: PT. X, 2018

### 3.1.3. Packaging and Labelling

The packaging process begins by arranging the hand wrapper machine to turn on and showing the heat scale at number 3. The packaging used is wrapping Polyvinyl chloride-based film, has a width of 30 cm in an effort to reduce the level of mechanical and biological damage to broccoli. The packaging process is carried out in the afternoon until the evening, carried out on a work table made of aluminum with a height of 90 cm, lighting coming from outside the room because the iron curtain is converted as a wall in the packing room, while at night the lighting comes from fluorescent lamps colored white. Adhesive material in the form of transparent masking tape to avoid damage due to wrapping of films

that do not stick well. The company has not set a maximum standard for using adhesive tape. Here the problem arises in the form of careless use of masking tape and tends to be excessive.

The next process is labeling using a sticker that contains information about the company name. The stickers are placed on the outside of the packaging right in the middle of the broccoli flower. Sticker design differs according to the purpose of delivery. Broccoli that has been labeled can be seen in Figure 5.



**Figure 5.** (a) Broccoli that has been packaged; (b) labeled

Packaged broccoli is then stored in containers that have been coated with scrap paper, to minimize damage to the packaging and bruising on broccoli, which is caused by collision and friction with the cavity of the container that has a hollow surface and has some sharp parts. The use of used paper is intended to reduce the amount of company expenditure.

#### 3.1.4. Total Loss Management (TLM) and Secondary Packaging

Next is the process of Total Loss Management (TLM) which is weighing broccoli using a sitting scale, broccoli weight data recorded and adjusted to the order amount by the admin. The operator in this process is at least 2 people, one is assigned as an admin who enters broccoli data on the computer, and another weighs. Broccoli is then moved to the distribution section, to be included in each container according to their respective order quantities, while checking the quality of the packaging. If damage occurs, it will be repackaged by the packaging section. Admin checks the order data on the computer, then weighs broccoli according to the number of orders and the destination of delivery, with excess tolerance of 1 broccoli or about 350 grams for each shipping destination. This addition is to anticipate the differences in scales used between PT. X with the ordering party. Broccoli is packaged using cardboard boxes with a length of 50 cm, 30 cm wide and 40 cm high.

#### 3.1.5. In House Distribution and Shipping

There are different treatments in the distribution process. This is based on an agreement between the company and the buyer, including the determination of the selling price. The purpose of shipping to DC Carrefour is the main priority of shipping, because it provides greater benefits compared to other shipping destinations. Broccoli sent to DC Carrefour is classified as grade A, stored temporarily on wooden beams. As for shipping to Ramayana, Aeon, Lotte and Hero, broccoli which is classified as grade B is put into containers along with other commodities.

Broccoli shipped at 01:00 AM using a box car without cooling, the selection of the delivery time aims to avoid congestion on the highway, and avoid high temperatures so that the quality of broccoli is maintained in the course of 140 km.

### 3.2. Identification of Problems and Improvements to Broccoli Post Harvest Handling Systems

In-depth analysis was carried out on every work process related to the work system that actually happened compared to the Good Handling Practice guidelines. Analysis material refers to aspects of the objectives, scope, main and supporting materials, work procedures, equipment used, operators and other related employees, related work guidelines, work environment, and the time needed to complete the process. In the analysis include discussing the problems that occur in each process and or event

between processes. The overall results of the problem analysis are presented in Appendix A Table 1. Improvements were made as much as 39%, in the form of SOP preparation, preparation of work instructions, determination of standard time, recording of container materials used, as well as determining the maximum limit for the use of container materials.

### *3.3. Preparation of Work Instructions*

Work instruction is a work mechanism document that regulates in detail and clearly the sequence of activities which only involves one function as a support for quality procedures. Procedures usually involve several parts and describe the process or activity in general, in contrast to work instructions that describe a particular process, carried out by certain parts, and contain a detailed mechanism [5]. General work instructions consist of: (1) Description of the equipment needed; (2) The main material and supporting materials used; (3) Work activities, including preparation activities to implementation; (4) Parties involved in every job; (5) Job tolerance; and (6) Examination. Work instructions are prepared for each process in the post-harvest broccoli handling activities. The preparation of instructions follows the rules as stated above.

### *3.4. Employee Self Sanitation and Use of Work Completeness*

The employee's self-sanitation activities are one of the important factors in the implementation of agricultural production activities, these activities prevent agricultural products contaminated by pathogenic microbes carried by human hands. Employee self-sanitation activities can be carried out with hand-washing activities before and after handling agricultural products, proper hand washing includes the use of soap, rubbing the palms together to produce foam, alternately washing the back of the hand, rubbing between fingers and inside nail, then rinse using clean running water [8].

Apart from hand washing activities, the use of employee work completeness is an effort to protect agricultural products from contamination from human hands, one of which is the use of gloves. There are two types of gloves commonly used, namely thick rubber gloves that can be used repeatedly and disposable gloves [8].

The use of gloves recommended in handling post-harvest vegetables is thick rubber gloves that have a thickness between 0.3 mm to 0.6 mm, because they are considered to have better resistance compared to disposable gloves, considering the use of pesticides (chemicals) in aquaculture who can irritate the hands of employees. Included can be used many times, thereby reducing the cost of purchasing production equipment. Gloves must be washed and replaced regularly to ensure hygiene and do not cause contamination of the product. In addition, the use of gloves is useful as a protective tool for employees if the implementation of activities using sharp tools such as knives [9].

### *3.5. Recording and Determining the Maximum Use of Packing Materials*

The purpose of recording and determining the maximum limit for the use of raw materials is to improve production efficiency, encourage compliance with company policies, and as an effort to check the use of container materials. Recording method can be done by recording continuously about incoming and used items, so that every item used in each activity can be known at any time [10].

Recording at PT. X can be done by weighing the roll wrapping film, then recorded in a special book that contains the recording of the use of goods or packaging materials used every day, with a writing format that shows the number of packaged broccoli, the initial weight of packing material, the final weight of the packing material after use and the reduction results between the initial weight and the final weight of the packing material.

Determination of the maximum limit for the use of containerized materials is done by measuring the length of masking tape when employees carry out packaging activities. The masking tape length can be seen in Table 3.

**Table 3.** Tape length for packaging activities

No	Tape Length (cm)						
	Employee						
	1	2	3	4	5	6	7
1	6,0	4,3	3,0	4,5	4,5	3,0	4,0
2	4,5	5,1	4,5	3,0	5,0	4,0	5,0
3	5,0	5,0	5,0	3,5	5,3	4,0	3,5
4	4,5	5,5	4,0	3,5	4,8	5,0	4,0
5	5,0	5,0	5,5	6,0	4,0	3,5	6,0
<b>Average</b>							4,5

Source: Processed data research, 2018

Suggestions for improvement regarding the determination of the maximum limit for the use of masking tape for packaging activities are carried out by measuring each of the first joints of the right hand thumbs of the employees. Employees are expected to do tape withdrawal activities limited to the first joint joints. Data from the first joint segment measurement of the employee's right thumb can be seen in Table 4.

**Table 4.** Employee's first thumb length

Employee	1	2	3	4	5	6	7	Average
First thumb length (cm)	3,0	2,9	3,1	3,1	2,8	2,7	3,2	3,0

Source: Processed data research, 2018

From each of the data obtained, it can be seen that the average use of 4.5 cm masking tape and improvement advice given based on the first right hand length of the thumb is 3 cm, so that the suggested improvement can save as much as 1.5 cm of tape for every packaged broccoli or 33.3%.

### 3.6. Determination of The Standard Time for Each Process

In determining the standard time of each process, the first step is to measure the cycle time, then calculating the normal time using the Westinghouse adjustment factor, then by adding the allowance time then the standard time is obtained. Calculation data can be seen in Table 5. There is a difference between the standard time and the average cycle time of the measurement results. Standard time is relatively longer than the cycle time. This is due to the calculation of standard time included with the value of adjustments and concessions, which take into account several aspects, namely the type of activities, skills, working conditions, and employee consistency.

**Table 5.** Time Measurement (in seconds)

No	Process	Cyclic time	Rating factor	Allow- ance factor	Normal time	Standard time
1	Sortation	5,4	0,14	14	4,7	5,5
2	Weighing	10,0	0,12	29	8,6	10,3
3	Trimming & Grading	8,4	0,13	27	7,3	9,7
4	Packaging	17,9	0,09	27	16,2	21,4
5	Compile a Packaging Cardboard	183,2	0,12	28	161,2	214,4
6	Weighing for distribution	4,0	0,12	21	3,4	4,1
7	Stepping speed in distributing (10 m)	8,5	0,12	21	7,3	8,7

Source: Processed data research, 2018

Allowance factors are given for three reasons, namely personal needs such as urinating, relieving fatigue, as well as disturbances that may occur and cannot be avoided by employees, such as having to sharpen cutting equipment. Adjustments are given to assess how far the employee's irregularities are

caused by working without seriousness, very fast as if time is hunted, employees encounter difficulties such as poor room conditions, and the appropriateness of the assessors who are lacking because they are not experienced in the type of work being measured [6].

#### **4. Conclusion**

The results of this study are the composition of standard operating procedures (SOP) post-broccoli handling at PT. X. The results of the analysis showed that the required improvements as much as 39% of the entire process in handling broccoli post-harvest activities at PT. X. These improvements are in the form of preparing work instructions, determining employee self-sanitation, determining the use of completeness of employee work, determining the standard time of activities, and determining the maximum limit for the use of container materials.

#### **5. Patent**

The Standard Operational Procedure for post-harvest handling of broccoli that has been successfully compiled is currently being completed in accordance with the requirements for obtaining the proposed patent in order to obtain its patent rights through the patent service institute of Padjadjaran University. Therefore this SOP cannot be included in this paper.

## Appendix A

Activities	Good Handling Practice (GHP)	Real Condition	Suit-ability	Details
Receiving	The existence of calibrated scale.	1	Yes	
	Using a proper and clean transport container	1	Yes	
	The existence of loading dock shelter	1	Yes	
	The existence of receiving work instruction	0	No	The work instruction is designed as a guideline for activity
	Weighing the container and its content	1	Yes	
	Hiring skilled and trained workers	1	Yes	
Sorting	The workers do self-sanitation	0	No	The workers are required to do self-sanitation and use hand gloves before the activity begin
	Weighing and recording correctly	1	Yes	
	Separating products that qualified and not qualified	1	Yes	
	The existence of sorting work instruction	0	No	The work instruction is designed as a guideline for activity
Trimming	A clean place for sorting	1	Yes	
	Hiring skilled and trained workers	1	Yes	
	The workers do self-sanitation	0	No	The workers are required to do self-sanitation before the activity begin
	Transferring the products that have been trimmed well	0	No	The workers are required to transfer the products slowly and carefully
	The existence of trimming work instruction	0	No	The work instruction is designed as a guideline for activity
	Using a proper tools for trimming	1	Yes	
	Using a clean tools	0	No	The workers are required to clean the equipment before use
	The workers are using work equipment	0	No	The workers are required to use work equipment
Grading	Hiring skilled and trained workers	1	Yes	
	Classifying product based on specified quality	1	Yes	
	Putting product on a container based on its quality	1	Yes	
	The existence of grading working instruction	0	No	The work instruction is designed as a guideline for activity
	Using a good and clean tools or machine	0	No	The workers are required to clean the equipment before use

Activities	Good Handling Practice (GHP)	Real Condition	Suit-ability	Details
	The workers are using work equipment	0	No	The workers are required to use work equipment
	The existence of packaging work instruction	0	No	The work instruction is designed as a guideline for activity
	Preparing tools and materials for packaging	1	Yes	
	A sign on package	1	Yes	
Packaging	A temporary storage and additional protective material	1	Yes	
Labelling	The workers listing the amount of used packaging materials	0	No	The workers are required to record the amount of packaging that used
	Preparing product and label that will be used	1	Yes	
	Preparing a strong product label /persistent	1	Yes	
	The existence of labelling work instruction	0	No	The work instruction is designed as a guideline for activity
	Using informative label	1	Yes	
	The existence of calibrated scale	1	Yes	
Total Loss Management (TLM)	The existence of TLM work instruction	0	No	The work instruction is designed as a guideline for activity
	Using a good and clean container	1	Yes	
	Recording the amount of products	1	Yes	
	Preparing tools and materials for packaging	1	Yes	
	The existence of TLM work instruction	0	No	A guideline for broccoli packaging is designed
	A sign on package	1	Yes	
In House Distributing	Preparing a temporary storage	1	Yes	
	Using a good and clean container	1	Yes	
	The existence of distribution work instruction	0	No	The work instruction is designed as a guideline for activity
	Recording the amount of products	1	Yes	
	1 =	27	61%	
	0 =	17	39%	

## References

1. Nuringtyas, T. R. & Ismoyowati, D. 2016. *Development of Pigmented Rice for The Rural Community*. SEARCA Seed Fund For Research and Training (SFRT) Program, Vol 8, No 6.
2. Kristantini, Taryono, P. Basunanda, R, H. Murti, dan Supriyanta. 2012. *Morphological of Genetic Relationships among Black Rice Landraces from Yogyakarta and Surrounding Areas*. *ARPN Journal of Agricultural and Viological Science*. 7(12) : 982-989.
3. Wuryadani, Shafira. Arita, N. Dyah, I. 2016. *STP Analysis on Marketing Pigmented Rice as Functional Food*. *ICoA Conference Proceeding*.
4. Yawadio, R., S. Sanimori and N. Morita. 2007. *Identification Of Phenolic Coumpound Isolated From Pigmented Rice And Their Aldose Reductase Inhibitory Activities*. *Food Chem*. 1001(4): 1616-162.
5. Chaudhary, R.C. 2003. *Speciality rice of the world : Effect of WTIO and IPR on its production trend and marketing*. *J. Food Agric. Env*. 1 (2) : 34 – 41.
6. Anindita, K. P. Dyah, I. Endy, S. (2016) (Unpublished). *Analisis Rantai Nilai Beras Berwarna: Studi Kasus di Kabupaten Sleman D.I Yogyakarta*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.
7. Riyadi, A. Dyah, I. Kuncoro H. W. 2018 (Unpublished). *Strategi Pengembangan Kinerja Rantai Pasok Beras Hitam di Kabupaten Sleman, D.I Yogyakarta*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.
8. Chopra, S., and Meindl, P. 2013. *Supply Chain Management: Strategy, Planning & Operations Third Edition*. Pearson Prentice Hall. New Jersey.
9. Rifai, A. Dyah, I. M. Affan F.F. 2018 (Unpublished). *Analisis Preferensi Konsumen Terhadap Warna Beras Hitam di D.I Yogyakarta*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.
10. Mutmainnah, D. H. Dyah, I. Anggoro C. S. 2017 (Unpublished). *Analisis Pengaruh Perilaku Terhadap Loyalitas Pelanggan Bisnis untuk Perumusan Strategi Pemasaran Beras Berwarna*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).



FP-MCI-002-ID005

# Consumer's Awareness and Adoption for QR Payment at Traditional Trade in Bangkok

Passaraporn Thongtha<sup>1</sup> and Ajchara Kessuvan <sup>2,\*</sup>

<sup>1</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand; passaraporn.th@ku.th

<sup>2</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand; Ajchara.ke@ku.ac.th

\* Correspondence: Ajchara.ke@ku.ac.th; Tel.: +66-2562-5091; Fax: +66-2562-5092

Received: 6 July 2018; Accepted: 20 December 2018; Published: 6 January 2020

**Abstract:** e-Payment is now becoming a significant mean of business transaction in Thailand since the government has set up a national e-Payment master plan for enhancing Thai economy. In marketing aspect, the research on consumer's adoption for QR payment to reveal the application environment has limited. This research aims to investigate the awareness and adoption of consumers and other stakeholders toward the QR payment service in Bangkok. The depth interviews and survey research are conducted at the traditional trade including flea market, weekend market, grocery stores and street food shops based on Technology Acceptance Model (TAM). The data is analyzed using mix methods including qualitative and quantitative approach. The result indicates that consumer's knowledge, perceived ease of use and perceived trust are main factors affecting consumer's adoption of QR payment. The implications of the research will provide the deep understanding and guideline for the relevant stakeholders and extend the body of marketing research.

**Keywords:** awareness; adoption; QR payment; traditional trade; TAM

---

## 1. Introduction

The human lifestyle has changed according to the advancement of technology that has developed consistently to seek for more comfort in life [1]. Technology changes play a vital role in financial transactions from time to time. Commercial banks need to adapt to digital economy to create a competitive advantage by using different technologies to service their customer [2]. Since the customers prefer convenient services, they would not rather to spend more time to do financial transactions. While commercial banks want to expand their businesses, they need to invest large amount of budget to propose other new alternatives to customers [3]. Regarding to Thailand, one of the financial transaction services have evolved to become popular and growing continuously is electronic payment system or e-Payment [4]. The financial transaction statistical of the Bank of Thailand during 2010-2015 indicated that both of volumes and value of electronic payments were growing continuously, especially in 2015, up to 34.9% over the previous year. The proportion of electronic payment through financial institutions and non-financial institutions accounted for 64.1% and 35.9%, respectively [4].

e-Payment is a part of the national e-Payment master plan that Thai government is currently encouraging. This policy was set up for creating consumer's awareness to reduce cash usage and to prevent counterfeit banknotes [5]. In 2017, Thailand has launched a new financial transaction service known as QR code payment or QR payment. The users will be able to use banking application through smartphone to scan QR code at the point of purchase for paying [6]. Currently, there are eight banks in Thailand which are licensed by the Bank of Thailand to launch QR payment service [7]. As a result, QR payment service has been adopted by many traditional trades as well as modern trades in Bangkok. However, on the consumer side, the number of users are limited due to lack of trust in financial transaction service. Therefore, most consumer still rely on the traditional payment system. This research aims to investigate the awareness and adoption of consumers and other stakeholders toward

the QR payment service in traditional trades in Bangkok. Understanding the awareness and adoption of consumers would help the relevant stakeholders of QR payment to develop the guidelines that easy to understand and proper for consumer's payment behaviors for increasing financial transaction.

## 2. Materials and methods

### 2.1 Qualitative approach

The depth interviews were conducted with relevant stakeholders including eight financial service providers or commercial banks and ten merchandisers in the traditional trade. The 54 information from depth interviews were analyzed by content analysis method. Several key factors affecting consumer's adoption of QR payment was explored.

### 2.2 Quantitative approach

The survey research using structural questionnaire was conducted by face to face interviews. The questionnaire was developed from content analysis result as a guideline based on Technology Acceptance Model: TAM [8]. The questionnaire was divided into four parts; demographic information, consumer's payment behavior, consumer's awareness and consumer's adoption of QR payment. The third and fourth part of questionnaire applied a five-point likert scale. The consumer survey was conducted at flea market, weekend market, grocery stores and street food shops in Bangkok. The demographic was analyzed by descriptive statistics. The relationship between payment behavior and consumer's adoption was analyzed by one-way ANOVA. Finally, logistics regression analysis was conducted to investigate the factors affecting the consumer's adoption of QR payment.

## 3. Results

### 3.1 Descriptive analysis

A total of 358 completed questionnaires are collected. All respondents are aware of QR payment. Among total respondents, 53% are QR payment adopters and 47% are non-adopters. The demographic information of adopters and non-adopters are slightly differences in all attributes. About 67% of total respondents are female and 33% are male. In addition, 35% of female and 18% of male are non-adopters, while 32% of female and 15% of male are adopters. Half of respondents (49%) are generation Y who are between 23 and 40 years old [9], in which 25% are non-adopters and 24% are adopters. The majority of respondents (68%) have obtained the bachelor degree, in which 37% are non-adopters and 31% are adopters. Most respondents (43%) are graduate students, while the percentage of adopters is equal to non-adopters (21.5%). Monthly income shows that respondents mostly earn less than 10,000 Baht per month, in which 17% are non-adopters and 14% are adopters.

Table 1 describes the consumer's payment behavior in details. All respondents who have indicated their payment behaviors are QR payment adopters. Siam commercial bank (SCB) was the most preferable for financial transaction service by majority of adopters (35%). The reason for using QR payment about 63% was convenience, while 20% was cash reduction. Over a half of the adopters (57%) indicated that the influencer encouraging them to use QR payment was themselves, followed by merchandiser (23%), friend (8%) and bank staff (7%). The majority of adopters (32%) used QR payment at the flea market or weekend market, which was slightly higher than modern trade and restaurant. Most adopters (51%) used QR payment when purchased foods or beverages, followed by clothes. The highest proportion of adopters (84%) revealed that they were loyalty customer with only one bank. In term of the frequency of using QR payment, most of customers (73%) used QR payment 1-2 times per month.

**Table 1.** The payment behaviors of QR payment adopters

Payment behaviors		Proportion (%)
1. Most preferable bank of QR payment	Siam Commercial Bank	35.3
	Kasikorn Bank	22.4
	Bangkok Bank	15.9
	Krungthai Bank	15.3
	Thai Military Bank	7.6
	Others	3.5
2. The reason for using QR payment	Convenience	63.5
	Cash reduction	20
	Modern	10.6
	Promotion	5.9
3. QR payment influencer	Themselves	56.5
	Merchandiser	22.9
	Friend	8.2
	Bank staff	7.1
	Others (family, boyfriend/girlfriend)	5.3
4. Channel of QR payment	Flea market/weekend market	32.3
	Others (modern trade, restaurant)	28.8
	Grocery	21.8
	Street food shop	15.9
	Fresh-food market	1.2
5. Product purchased by QR payment	Food/beverage	51.2
	Clothes	32.3
	Others (cosmetics, accessories)	16.5
6. QR payment style	Use only 1 bank	83.5
	Change to use other banks when they launched new promotion	14.1
	Use multiple bank	2.4
7. Frequency of using QR payment	1-2 times/month	73
	3-5 times/month	18.8
	More than 10 times/month	8.2

### 3.2 The relationship between payment behavior and consumer's adoption of QR payment

The relationship between payment behavior and consumer's adoption was explored by one-way ANOVA. The independent variables were seven payment behaviors which were most preferable bank of QR payment, the reason for using QR payment, QR payment influencer, channel of QR payment, product purchased by QR payment, QR payment style and frequency of using QR payment. The dependent variable was consumer's adoption of QR payment. The result of the relationship between payment behavior and consumer's adoption was shown in table 2. The reason for using QR payment and product purchased by QR payment had significantly effected on consumer's adoption.

However, the result from one-way ANOVA would not be able to provide the detailed information on the differences among the study groups. The test of the differences among each variable using post hoc multiple comparison [10] must be conducted to understand the group differences as a result of ANOVA. According to four groups of the reason for using QR payment, the results showed that there were the significant differences among the consumers who used QR payment because of promotion and the consumers who used QR payment because of modern, convenience and cash reduction.

Considering the average of adoption score, it was found that the consumers who had the reason for modern, convenience and cash reduction tended to adopt QR payment more than the influence by promotion. In addition, the result of the types of product purchased by QR payment showed the significant differences either. The consumers who purchased food or beverage by QR payment had adoption behavior which differentiated from the consumers who purchased other products which were cosmetics and accessories. The average adoption score of the consumers who purchased cosmetics and accessories was relatively higher, therefore they tended to be a QR payment adopter more than the consumers who purchased clothes and food or beverage.

**Table 2.** The results of testing the relationship between payment behaviors and adoption score

Payment behaviors	Sig	The average of adoption score
1. The reason of using QR payment	0.001*	
1) Modern		4.06 <sup>a</sup>
2) Convenience		4.00 <sup>a</sup>
3) Cash reduction		3.88 <sup>a</sup>
4) Promotion		3.20 <sup>b</sup>
2. Product purchased by QR payment	0.044*	
1) Other products		4.17 <sup>a</sup>
2) Clothes		3.96 <sup>ab</sup>
3) Food/beverage		3.83 <sup>b</sup>

Note: \*p-value  $\leq 0.05$ ; <sup>a,b</sup> different letters show significantly difference in adoption score

### 3.3 Factors affecting the consumer's adoption of QR payment

The logistic regression model was used to examine factors affecting the consumer's adoption. The independent variables included consumer's knowledge, communication strategy, perceived ease of use, perceived usefulness and perceived trust. The dependent variable was consumer's adoption. The consumer's adoption of QR payment was measured by binary choices of respondents where 1 was adopted and 0 was non-adopted. The results from binary logistics regression was shown in table 3. The predictive efficiency was 70.1%. Therefore, this model was accuracy classification. Consumer's knowledge, perceived ease of use and perceived trust significantly affected on the consumer's adoption of QR payment.

More specifically, the odd ratio or odds could interpret the probability of interesting event [11]. The results of odds or Exp(B) of consumer's knowledge, perceived ease of use and perceived trust were greater than one, as a result these three factors had positive effect on the adoption of QR payment. This mean that when these factors increased then the adoption of QR payment increased. For example, the odds of consumer's knowledge was 2.079. Therefore, when the consumer's knowledge increased by 1 unit, the consumer's adoption increased 2.079 times, regardless of other factors. Other factors could be described as the same pattern as consumer's knowledge.

**Table 3.** Logistics regression analysis of consumer's adoption of QR payment

Factors	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Knowledge	.732	.214	11.726	1	.001*	2.079	1.367	3.160
Communication	-.012	.172	.005	1	.945	.988	.706	1.384
Ease of use	.484	.232	4.338	1	.037*	1.622	1.029	2.556
Usefulness	.168	.214	.616	1	.432	1.183	.777	1.801
Trust	.664	.203	10.713	1	.001*	1.942	1.305	2.890
Constant	-7.563	.972	60.592	1	.000	.001		

Note: \*p-value  $\leq 0.05$

## 4. Discussion

The relationship between payment behavior and consumer's adoption indicated that the reason for using QR payment had significantly impact on consumer's adoption as shown in the process of adoption [12] which was the decision process to accept or reject the innovation. In this regard, there were five stages; awareness, interest, evaluation, trial and adoption stage. In evaluation stage, people who would like to try innovative product will consider about advantage and disadvantage by comparing the new product with the traditional one. Therefore, product information would be considered as a reason to adopt it. In trial stage, consumers would try the innovative product/service if they perceived that the benefit was higher, then they decided to adopt it.

Moreover, the type of product purchased by QR payment had significantly effected on consumer's adoption. The analysis of payment behaviors showed that most adopters used QR payment to purchase food or beverage and clothes because the main product selling in traditional trade was consumer goods as food and clothes [13]. Since the consumer goods was easy to find, consumers were familiar with QR payment, that may caused the consumer adopted QR payment. Furthermore, the consumers tended to use QR payment at the channel with large number of adopted merchandiser. Currently, QR payment service in Thailand was widespread in modern trade and traditional trade including grocery store, flea market, weekend market and street food shop [14]. Therefore, it was convenient for consumers to purchase food and consumer goods by using QR payment in several traditional markets.

The result of logistics regression analysis revealed that perceived ease of use and perceived trust were significantly effect on consumer's adoption of QR payment. It was obviously understand that consumers often welcome and quickly adopted new innovative product/service which were beneficial and not too complicated to use [15], as proposed in previous research. Author [16] found that perceived ease of use became the most significant factor affecting the adoption of Internet banking in Mauritius. Furthermore, author [17] revealed that there was a positive relationship between perceived ease of use and acceptance of e-banking by customers. In addition, perceived trust was the important factor for financial transactional service. The results from this study was consistent with author [18] who identified that online services needed the trust element, since trust was one of the main factors influencing the electronic setting. It was implied that the consumers had concerned about safety of banking service. Trust in electronic channels was very important because of some risks involved in using electronic media for financial transaction [19]. As security was the main concern in online transactions, commitments and promises such as keeping private information and transactions safe and secure must be fulfilled [19]. If consumers had a trust in banking service, they would be willing to adopt it.

Consumer's knowledge was one of the awareness factors. This research found that the knowledge had significantly impact on consumer's adoption of QR payment. The same effect was found in the work of author [20] who showed that awareness was positively related to the adoption and usage of online services in Oman. According to author [12] which explained about process of adoption in awareness stage that was often accidental perception. The consumer may need to learn more because the product/service may solve the weakness of traditional product. Therefore, awareness was leaded to adopt or non-adopt for innovative product.

## 5. Conclusions

This study aimed to investigate the awareness and adoption of consumers toward the QR payment service in Bangkok. The depth interviews and consumer survey were conducted at the traditional trade including flea market, weekend market, grocery stores and street food shops. Regarding the relationship between payment behavior and consumer's adoption of QR payment, the result revealed that the reason for using QR payment and the type of product purchased by QR payment had significantly related to consumer's adoption. For factors affecting the consumer's adoption, the logistics regression analysis indicated that consumer's knowledge, perceived ease of use and perceived trust had significantly effected on consumer's adoption of QR payment.

As limitations, since QR payment service was launched in Thailand in 2017, this service was widespread in Bangkok but not much popular in other provinces. This study is only focus on the sample group who live in Bangkok metropolitan. Therefore, further research suggests if the sample should be

cover consumers who live in other provinces, particularly main provinces of each regional Thailand. The result will lead to more understandings of Thai consumers' QR payment adoption behavior throughout the country. Finally, it might be interesting for future investigation of consumer adoption of QR payment across the different categories of the product as well as considering other aspects regarding the lifestyle or psychological variables which could be influence the consumer's adoption behavior.

## References

1. Saetang, A. Attitudes and Behavior of Consumers towards Using Services of Mobile Banking in Bangkok Area. Master Thesis, Srinakharinwirot University, Bangkok, Thailand, 2011.
2. Kongjaroen, W. Acceptance of Innovation Factors Affecting the Satisfaction of Mobile Banking Users in Bangkok Metropolitan Area. Master Thesis, Bangkok University, Pathumthani, Thailand, 2015.
3. Thedsawatwong, A. Attitudes and Behavior in Using Mobile Financial Service of Consumer in Bangkok Metropolitan Area. Master Thesis, Srinakharinwirot University, Bangkok, Thailand, 2010.
4. Financial institution in digital society. Available online: [https://www.gsb.or.th/getattachment/8d7a5d95-b808-49b4-a871-7f985f1f7d38/2IN\\_hotissue\\_Digital\\_bank\\_detail.aspx](https://www.gsb.or.th/getattachment/8d7a5d95-b808-49b4-a871-7f985f1f7d38/2IN_hotissue_Digital_bank_detail.aspx) (accessed on 16 August 2018).
5. Electronic payment system. Available online: <http://www.epayment.go.th/home/app/> (accessed on 1 August 2018).
6. Bank of Thailand launches 'QR Code Standard' to transform Thailand into a cashless society. Available online: <https://thestandard.co/standardqrcode/> (accessed on 16 August 2018).
7. Trend of QR payment. Available online: <http://www.thansettakij.com/index.php/content/246538> (accessed on 16 August 2018).
8. Venkatesh, V.; Davis, F.D. A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science* 2000, 46, 186–204.
9. Gray, R.; Pattaravanich, U.; Lucktong, A. *Quality of Life among Employed Population by Generations*, 1st ed.; October printing Co., Ltd., Bangkok, Thailand, 2016; pp.11, ISBN 978–616–279–950–1.
10. McHugh, M.L. Multiple comparison analysis testing in ANOVA. *The journal of Croatian Society of Medical Biochemistry and Laboratory Medicine* 2011, 21(3), 203–209.
11. Kaiyawan, Y. Principle and Using Logistics Regression Analysis for research. *RMUTSV Research Journal* 2012, 4(1), 1–12.
12. Roger, E.M.; Shoemaker, F.F. *Communication of Innovation: A Cross-Cultural Approach*. The free press 1971, New York.
13. Tiplerlerd, P. Factors Influencing Consumers' Purchasing Decision from Traditional Trade on the Bangkok Metropolitan Area. Master Thesis, Thammasat University, Patumthani, Thailand, 2015.
14. QR payment strategy battle. Available online: <https://www.marketingoops.com/news/biz-news/> (accessed on 16 August 2018).
15. Lin, C.; Nguyen, C. Exploring e-Payment Adoption in Vietnam and Taiwan. *The Journal of Computer Information Systems* 2011, 51, 41–52.
16. Padachi, K.; Rojid, S.; Seetanah, B. Analyzing the Factors that Influence the Adoption of Internet Banking in Mauritius. *Proceedings of the 2007 Computer Science and IT Education Conference*.
17. Odumeru, J. The Acceptance of e-banking by Customers in Nigeria. *World Review of Business Research* 2012, 2, 62–74.
18. Nor, K.M.; Shanab, E.A.; Pearson, J.M. Internet Banking Acceptance in Malaysia Based on the Theory of Reasoned Action. *Journal of Information Systems and Technology Management* 2008, 5, 3–14.
19. Fo, O. Factors Influencing Intention to Adopt Internet Banking by Postgraduate Student of the University of Ibadan, Nigeria. *Journal of Internet Banking Commerce* 2015, 20:123.
20. Shatat, A. Factors Affecting the Adoption and Usage of Online Services in Qman. *Journal of Internet Banking Commerce* 2017, 22, S7:020.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license

(<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-003-ID008

# Discriminant Analysis of Consumer Intention to Use Green Packaging in Thailand

Boonsita Vichienvanitchkul<sup>1</sup>, Apichaya Lilavanichakul<sup>2,\*</sup>

<sup>1</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand; boon.boonsita@gmail.com

<sup>2</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand; apichaya.l@ku.ac.th

\* Correspondence: apichaya.l@ku.ac.th; Tel.: +66-2562-5000 ext 5374

Received: 8 July 2018; Accepted: 26 December 2018; Published: 6 January 2020

**Abstract:** Plastic pollution and waste management, especially single used plastic from food consumption has become one of serious issues in Thailand. Green packaging has been developed for alleviating plastic problems, but it is unacquainted for Thai consumers. This research aims to analyze factors segmenting consumer intention to use green packaging by using discriminant analysis technique. Empirical results from 281 Thai consumers reveals a significant relationship between consumer intention to use green packaging and the factors based on consumer attitudes, value for money and consumption values. Findings show that consumer perceive in term of added cost on green packaging is the most influential in segmenting consumer intention to use green packaging followed by the social value, consumer attitude toward environmental concern, and the conditional value. The classification result show that overall 80.1% were correctly classified. For marketing implication, marketing communications on environmental costs and perceived value, building a positive image for green packaging, and offering environmental campaigns are mainly suggested to influencing consumers to use green packaging.

**Keywords:** discriminant analysis; green packaging; consumer behavior; Thailand

---

## 1. Introduction

The numbers of plastic packaging consumption have been increasing in Thailand, especially single used plastic from food consumption with the expected growth around 8-10 percent annually. Food plastic packaging is divided into several types where one type that causes disposed waste is single used plastic including plastic food pan, spoon, fork and knife plastic, plastic bag, plastic grass, and plastic straw. With a high demand for convenient, inexpensive, and time-efficient foods, the quick service restaurant (QSR) and a high number of convenience stores are the main channel for single used plastic [1,2]. Furthermore, a rapid growth of food delivery service and food events in Thailand reach to 1 Billion USD in 2018 [3]. Incorrect use of plastic packaging affects not only environment pollution and waste management problems, but also hygiene issue. According to report on waste disposal sites in Thailand, the amount of garbage is about 27.37 million tons and can divided into 43 percent for properly disposed, 31 percent for recycle garbage, and 26 percent for incorrect disposed [4]. The percentage of plastic garbage is 12 percent of incorrect disposed waste or 339,400 tons/year [5]. In 2015, Thailand is one of the top five countries in the world with plastic waste in the ocean [6].

Nowadays, several alternative eco-friendly choices are applied to cope the environment challenge such as cloth bag, substituting materials (e.g. paper). Bioplastic packaging or green packaging is one of alternative way for alleviating plastic problems. Currently, compostable bioplastic packaging has been applied in the past 10 years, but the application uses are limited with a small market. One reason is that the production cost of bioplastic is high when compared with the regular plastic. Another reason is Thai consumers are unacquainted with bioplastic due to technology adoption. Moreover, consumer awareness of environmental needs is uncertain. Previous literatures on segmenting consumer intention

to use green packaging have been studied in various countries, but a few researches have been done in Thailand. Study on factors affecting to use bioplastic packaging in Bangkok by author [7] found that environmental exposure factors, environment concern factor, perceived consumer effectiveness factor, impact of using plastic factor, participation in environmental protection factor and environment knowledges have positive effect to choose green packaging, while author [8] found that green marketing communications, green product attitude, environment concern, trust in the green product, green brand, environmental knowledge affect to green products purchasing behavior of the consumer. Author [9] studied about segmentation consumer into active green activists and passive green activists by using discriminant analysis. Author [10] mainly focused on classifying environmental concerned segment and found that environmental knowledge is the greatest value for classifying consumer followed by perceived consumer effectiveness, environmentally friendly buying behavior, recycling, environmental activism, resource saving, economic factor, environmental concern and skepticism towards environmental claims. A consumer loyalty in green perspective based on consumption value was studied by author [11] and the result showed that functional value, economic value, emotional value and social value have a significant on consumer perspective.

The objective of this research is to analyze factors segmenting consumer intention to use green packaging by using discriminant analysis technique. The results will become a guideline of consumer study for food service business and marketer to encourage consumers to use green packaging products instead of plastic packaging.

## 2. Materials and Methods

Both primary and secondary data were conducted in this study. In-depth interview was conducted with an expert on green plastic packaging. The preliminary data related to green packaging knowledges and property of green packaging was collected from the discussion and developed in the questionnaire. The questionnaires were divided into 3 sections: (1.) respondents' general demographic information (2.) The consumer attitude toward environment concern and value for money (3.) Consumption values on buy or not buy a green packaging including emotional value, functional value, social value, conditional value and epistemic value regarding to the theory of consumption value [12]. These data were conducted by using 5-point Likert Scale which are 1 = strongly disagree and 5 = strongly agree. Surveys on consumer intention to use green packaging was conducted during April to July 2018 by face to face interview. The cluster random sampling method was applied by collecting data from Thai consumers who over 20 years old in Bangkok. The data were analyzed by using descriptive statistics and discriminant analysis.

### 2.1. Discriminant Analysis

This technique is appropriate statistic when independent variable is categorical and the independent variables are quantitative. This method is used to predict group membership from a set of metric predictors (independent variable,  $x$ ). The model is composed of a discriminant function based on linear combinations of predictor variables as called "Linear Discriminant Analysis (LDA)" [13]. The model is derived as follows:

$$D = v_1x_1 + v_2x_2 + \dots + v_ix_i + a \quad (1)$$

where  $D$  = discriminant function

$v$  = discriminant coefficient

$x_i$  = independent variable

$a$  = a constant

$i$  = the number of predictor variables

In this study, two distinct groups were defined to intention to use green packaging ( $D=1$ ) and do not use green packaging ( $D=0$ ). The independent variables included three type of factors: consumer attitude toward environment concern ( $x_1$ -  $x_3$ ), value for money ( $x_4$ ), and consumption value ( $x_5$ - $x_{12}$ ) where the definition of each variable was presented in Table 2. The stepwise method was selected for



discriminant analysis because this technique is suitable for the model that contains several predators and selects the best model by entering the predators at each step based on F to Enter value that exceeds the entry criteria value [14].

### 3. Results

#### 3.1. Descriptive

Total number of respondents were 281 as presented in Table 1. The majority of respondents are female (71.5%). Most respondents are 20 to 30 years old accounted for 61.6% and 74.4% of sample respondents have education level on graduate. Almost half of respondents have income lower than 20,000 Baht/month. In addition, private employee represent majority with 42.0% followed by student accounted for 25.3% and government service accounted for 14.9%.

**Table 1.** Sample Descriptive

Variable	Range	Frequency	Percentage
Gender	Male	80	28.5
	Female	201	71.5
Age	20-30 years old	173	61.6
	31-40 years old	52	18.5
	41-50 years old	39	13.9
	51-60 years old	12	4.3
	Over 60 years old	5	1.8
Education	Undergraduate	17	6
	Graduate	209	74.4
	Post graduate	55	19.6
Occupation	Private employee	118	42
	Student	71	25.3
	Government service	42	14.9
	Business	20	7.1
	Contractors	13	4.6
	Unemployed	8	2.8
	Other	4	1.4
Income	less than 10,000 Baht/month	65	23.1
	10,001-20,000 Baht/month	69	24.6
	20,001-30,000 Baht/month	67	23.8
	30,001-40,000 Baht/month	28	10
	40,001-50,000 Baht/month	14	5
	Over 50,000 Baht/month	38	13.5

#### 3.2. Reliability Statistics of Measure

Reliability test is the degree of consistency or dependability with which an instrument measures the attribute [15]. The reliability coefficient between 0.70 to 0.90 is considered as acceptable range with the reliability of items [16]. As presented in Table 2, Cronbach's alpha was computed to be 0.830 with item-to-total reliability of all twelve statements (X1-X12), interpreting that the statements have relatively high internal consistency.

**Table 2.** Reliability Statistics of dependent variable

Factors	Variable name	Statement	Item-to-total Cronbach's	
			reliability	Alpha
Consumer attitude toward environment concern	Reduce Plastic (x <sub>1</sub> )	You want to reduce using plastic packaging to save the world.	0.818	0.830
	Long term Solve (x <sub>2</sub> )	Green packaging can alleviate long term environment problem.	0.814	
	Laws (x <sub>3</sub> )	Laws have helped propel the use of green packaging.	0.838	
Value for money	Accept Added Cost (x <sub>4</sub> )	You accept the added cost of using green products.	0.811	
Emotional value	Unique (x <sub>5</sub> )	The unique characteristic of green products makes you feel good to green products.	0.807	
	Biodegradable Word (x <sub>6</sub> )	"Biodegradable 100%" on the products make you trust in green products.	0.804	
Functional value	Heat Resistant (x <sub>7</sub> )	You concern about heat resistant of packaging product.	0.831	
Social value	Social (x <sub>8</sub> )	Using green packaging impact on society and well-being.	0.812	
	Be Accepted (x <sub>9</sub> )	Using green product make you feel be accepted and have a good image.	0.821	
Condition value	Shop Provide (x <sub>10</sub> )	If the restaurants provide green packaging option, you will choose it.	0.808	
	Campaign (x <sub>11</sub> )	If environment campaign is promoted, you will choose green products.	0.804	
Epistemic value	Try New Thing (x <sub>12</sub> )	You want to try new green packaging which you have never used it before.	0.832	

### 3.3 Discriminant Analysis

The summarized results of the stepwise discriminant analysis were shown in Table 3. Most variables preformed statistically significant canonical functions at alpha 0.01 level, excepting one variable: Laws (x<sub>3</sub>). The Wilks' lambda value explains a spread between the clusters' mean, which Laws variable (x<sub>3</sub>) had the highest value that could be interpreted as a larger spread between the clusters' mean or the least of membership of the group. F-test presents the test of mean of each variable among the groups. If the value is significant, it indicated that the mean of the variable in intention to use green packaging group is significantly different from the mean of that variable in intention to do not use green packaging group [17].

**Table 3.** Tests of Equality of Group Means

Variable	Wilks' lambda	F
Reduce Plastic (x <sub>1</sub> )	0.829	57.428***
Long term Solve (x <sub>2</sub> )	0.931	20.742***
Laws (x <sub>3</sub> )	0.989	3.158*
Accept Added Cost (x <sub>4</sub> )	0.784	77.039***
Unique (x <sub>5</sub> )	0.874	40.269***
Biodegradable Word (x <sub>6</sub> )	0.856	47.001***

**Table 3.** Tests of Equality of Group Means (continued)

Variable	Wilks' lambda	F
Heat Resistant (x <sub>7</sub> )	0.972	8.003***
Social (x <sub>8</sub> )	0.913	26.727***
Be Accepted (x <sub>9</sub> )	0.864	43.772***
Shop Provide (x <sub>10</sub> )	0.894	33.080***
Campaign (x <sub>11</sub> )	0.853	48.173***
Try New Thing (x <sub>12</sub> )	0.964	10.435***

Note: \* significant at 0.10 level; \*\* significant at 0.05 level; \*\*\* significant at 0.01 level

In Table 4, the stepwise discriminant analysis performed the best 4 variables for classify group: Accept added cost (x<sub>4</sub>), Be accepted (x<sub>9</sub>), Reduce plastic (x<sub>1</sub>) and Campaign (x<sub>11</sub>) with an acceptable tolerance value. Note that a variable with low tolerance value (< 0.20) suggests that little information contributed to the model, thus it is removed from the model [18].

**Table 4.** Variable in the analysis

Variable	Tolerance	F to enter
Accept added cost (x <sub>4</sub> )	0.863	21.644
Be accepted (x <sub>9</sub> )	0.942	12.123
Reduce plastic (x <sub>1</sub> )	0.842	8.691
Campaign (x <sub>11</sub> )	0.872	7.597

After the discriminant function was derived with 4 variables (Table 5.), the performance of the model was explained by the statistical test. The eigenvalue of 0.481 and the canonical relation of 0.570 demonstrated a function is quite strong and discriminates well. Moreover, Wilks' lambda indicated the significance of the discriminant function at alpha 0.01 level [17].

The interpretation of discriminant coefficients was explained by the important of each predictor as higher value as more important [17]. Results of discriminant function indicated that the accept added cost (x<sub>4</sub>) variable was strongest predictor to classify the group of consumers intention to use green packaging followed by Be accepted (x<sub>9</sub>), Reduce plastic (x<sub>1</sub>) and Campaign (x<sub>11</sub>), respectively. All variables presented the positive correlation with the intention to use green packaging, given the insight into the marketing potential of green consumers.

**Table 5.** Standardized canonical discriminant function's coefficients

Variable	Coefficients
Reduce Plastic (x <sub>1</sub> )	0.334
Accept added cost (x <sub>4</sub> )	0.509
Campaign (x <sub>11</sub> )	0.307
Be accepted (x <sub>9</sub> )	0.371
<b>Eigenvalue</b>	<b>0.481</b>
<b>Canonical Relation</b>	<b>0.570</b>
<b>Wilks' lambda</b>	<b>0.675***</b>

Note: \*\*\* significant at 0.01 level

After the discriminant function was derived, the test on the correction rate was shown in Table 6. The result indicated that the model was correctly classified at 80.1%. The class 'Intention to use green packaging group' can predict correctly at the correction rate of 88.5%, while the class 'Intention to do not use green packaging group' can forecast properly at the correction rate of 66.4%.

Table 6. Classification result

Real Group	Predicted Group		Total	Correction rate
	Intention to use green packaging	Intention to do not use green packaging		
Intention to use green packaging	154	20	174	88.5%
Intention to do not use green packaging	36	71	107	66.4%
<b>Overall</b>	190	91	281	<b>80.1%</b>

#### 4. Discussion

The results showed that several dimensions of variables were the key element to determine the intention to use of green packaging. The value for money carried the most influential factor. According to value for money literature, consumers choose products what satisfied them as per usage and as per the money spent on it [19]. In this study, the value for money is interpreted as consumers' willingness to accept added cost of green packaging. Therefore, the retailers and food service business should focus on the pricing of green packaging products including the way to communicate benefit and cost of green packaging in order to encourage consumers using environmentally friendly products. In addition, social value was one of driven factors to use green packaging because the use of eco-friendly products may build a personal positive image and be accepted from the society. Author [11] stated that perceived social value is one of the most important for green consumers.

Intention to reduce using plastic is one of attitude toward environmental concerns, thus consumers who have viewpoint of decrease the use of plastic packaging are more likely to use the eco-friendly packaging. Studies by author [20] and [21] indicated that having a positive attitude and green perceived value toward green products affected to intention of customers to buy green products. Lastly, consumers perceived on condition value in the aspect of environmental campaign. If environmental campaign is promoted heavily and it can acknowledge consumer understanding of green products including change their attitudes toward environment and accumulate consumers' confidence on green products, consumers tend to use environmentally friendly products [22]. This condition value related to media exposure of consumer which may motivate the attitude or habits of consumers. Media exposure of environment campaign through social media, poster, exhibition and influencers has a positive impact to intention to use green products [7]. Hence, building a positive image for green packaging and offering environmental campaigns are mainly suggested to influencing consumers to use green packaging.

#### 5. Conclusions

As green packaging has been implemented as one of eco-friendly choices, technology adoption of Thai consumers can be a challenge to reduce environmental pollution problems. According to discriminant analysis, added cost, be accepted, reduce plastic, and campaign were considered as predictor whether Thai consumer intention to use green packaging or not. The cross validated classification showed that the classifying model performed at the correction rate of 80.1%. Four key factors are mainly suggested to food service business and the marketer to encourage consumers to have pro-environmental behavior and decide to use green packaging. Moreover, the outcome can be used as the guideline to create the position of the business and launch the marketing campaign.

**Acknowledgments:** This project has received funding from National Research Council of Thailand (NRCT) and National Science and Technology Development Agency (NSTDA) in the project of Formulation Development and Marketing Feasibility Study of Thermoplastic Starch-Based Blends.

## References

1. Sirikeratikul, S. (United States Department of Agriculture, Bangkok,Thailand). Food Service - Hotel Restaurant Institutional, 2017.
2. Ngamprasertkit, S. (United States Department of Agriculture, Bangkok,Thailand). Retail Foods, 2018.
3. 3. Foodpanda and Line Are Fighting to Feed Bangkok: <https://www.bloomberg.com/news/articles/2018-03-19/foodpanda-uber-take-meal-apps-battle-to-bangkok-s-food-paradise> (accessed on 26 August 2018).
4. Pollution Control Department. (Ministry of Natural Resources and Environment, Bangkok, Thailand). Situation Report of Community Waste Disposal in Thailand in 2017, 2018.
5. 5. Simachaya, V. (Ministry of Natural Resources and Environment, Bangkok,Thailand). Waste situation in Thailand, 2018.
6. Stemming the Tide: Land-based strategies for a plastic- free ocean: <https://oceanconservancy.org/wp-content/uploads/2017/04/full-report-stemming-the.pdf>(accessed on 26 August 2018).
7. Preechanaruechitkul, S. Factors affecting the Using on Bioplastic Packaging of Working people in Bangkok Metropolis. Master's Degree, Thammasat University, Bangkok, Thailand, 17 April 2011.
8. Nisaisuk, N. Factor Affecting Green Products Purchasing Behavior of Consumer. Master's Degree, Suranaree University of Technology, Nakhon Ratchasima, Thailand, 2013.
9. Modi, A.G.; Patel, J.D. Classifying Consumers Based Upon Their Proenvironmental Behaviour: An Empirical Investigation. *Asian Academy of Management Journal* 2013, 18, 85-104.
10. Paco, A.M.F.; Raposo, M.L.B.; Filho, W.L. Identifying the green consumer:A segmentation study. *Journal of Targeting, Measurement and Analysis for Marketing* 2009, 17,17-25, DOI 10.1057/jt.2008.28.
11. Koller, M.; Floh, A.; Zauner, A. Further Insights into Perceived Value and Consumer Loyalty: A "Green" Perspective. *Psychology & Marketing* 2011, 28(2), DOI 1154-1176, 10.1002/mar.20432.
12. Sheth, J.N.; Newman, B.I.; Gross, B.L. Why We Buy What We Buy: A Theory of Consumption Values. *Journal of Business Research* 1991, 22, 150-170, DOI 10.1016/0148-2963(91)90050-8.
13. Balakrishnama,S. (Mississippi State University, Mississippi State, the United States); Ganapathiraju, A. (Mississippi State University, Mississippi State, the United States). *Linear Discriminant Analysis-A Brief Tutorial*, 1998.
14. Stepwise Discriminant Analysis:
15. [https://www.ibm.com/support/knowledgecenter/SS3RA7\\_sub/modeler\\_tutorial\\_ddita/spss/tutorials/discrim\\_telco\\_stepwise.html](https://www.ibm.com/support/knowledgecenter/SS3RA7_sub/modeler_tutorial_ddita/spss/tutorials/discrim_telco_stepwise.html)(accessed on 25 August 2018).
16. Chonbach, L.J. Coefficient Alpha and the Internal Structure of Test. *Psychometrika* 1951, 16, 297-334.
17. Tavakol, M.; Dennick, R. Making sense of Cronbach's alpha. *International Journal of Medical Education* 2011, 2, 53-55, DOI: 10.5116/ijme.4dfb.8dfd.
18. Banerjee, S.; Pawar, S. Predicting Consumer Purchase Intention: A Discriminant Analysis Approach. *NMIMS Management Review* 2013, 13, 113-129.
19. 18. Mernald, S. *Applied Logistic Regression Analysis*, 2nd edition; Sage Publication, Inc: Thousand Oaks, The United States, 2002; pp. 41-63, ISBN 0-7619-2208-3.
20. Glendinning, R. The Concept of Value for Money. *International Journal of Public Sector Management* 1988, 1, 42-50.
21. Vazifehdoust, H.; Taleghani, M.; Esmailpour, F.; Nazari, K.; Khadang, M. Purchasing green to become greener: Factors influence consumers' green purchasing behavior. *Management Science Letters* 2013, 3, 2489-2500, DOI 10.5267/j.msl.2013.08.013.
22. Grob, A. A structural model of environmental attitudes and behavior. *Journal of Environmental Psychology* 1995, 15, 209-220, DOI 10.1016/0272-4944(95)90004-7.
23. Chen,S.C.; Hung, C.W. Elucidating the Factors Influencing the Acceptance of Green Products: An Extension of Theory of Planned Behavior. *Technological Forecasting & Social Change* (Elsevier Inc, Accepted 24 August 2016; in press).



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-005-ID036

# Designing Herbal Cosmetics Marketing Channel

Preuk Petsophonsakul<sup>1</sup> and Chutima Waisarayutt<sup>2,\*</sup>

<sup>1</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand; preuk.p@gmail.com

<sup>2</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand; chutima.w@ku.ac.th

\* Correspondence: chutima.w@ku.ac.th; Tel.: +66-2562-5093

Received: 4 August 2018; Accepted: 26 December 2018; Published: 6 January 2020

**Abstract:** Nowadays, the demand of herbal cosmetics has been growing in Thailand because Trend of health and wellness. Consumer would prefer the natural or herbal based products. There are a many products on the market from the global and local manufacturers which affects to high competition in term of products quality, price and marketing channels. Therefore, the competitive advantage from competitors depends on brand strategy. This research aims to examine consumer in both generation X and Y, their behaviors, life styles on market channel, design and develop appropriate market channels that deliver value of cosmetic products and develop business strategy by experiment using oral herbal product as a case. The business research included in-depth interview, market survey research, segmenting consumer life style by using cluster analysis technique. The result indicate that either customer in generation X or Y, both generations interested products made from natural and prefer originality. Consumer's life style, and product knowledge are key factors affecting the marketing channel preference. The implication of the research will provide the deep understanding, create channels that respond consumer needs and herbal cosmetics business growth.

**Keywords:** herbal cosmetic; channel design; business research; Thailand

---

## 1. Introduction

Thailand has a potential for herbal based production because Thailand locate in the tropical area with high biodiversity; [1] consequently, there are many natural herbal materials with high production capacity and growth rate ranked number 8th in the world. Herbal used as many type of products including medicine, used as food ingredients, supplements and cosmetic base. The utility of herbal base substitute chemical and support from the expansion of related industries affect the growth of herbal in country. [2] Market overview in 2016 herbal and traditional products is worth almost US\$ 37 billion about 17% of global consumer health industry.

The Herbal cosmetic products about 70% used ingredients form herbs [3] in year 2015 products sale volume is 5.5 hundred thousand tons and expandable about 2.2 % form year 2014. The amount of value opportunity, many major and minor manufacturers had come to this market with competitive technologies process and ingredients for herbal cosmetics. Affects to high competition in term of products quality and price war. Therefore, the competitive advantage from business sector depends on marketing strategy.

Most studies focus only on factors affecting decision on herbal product. In additional most segmentation studies of market channel have been conducted in the United States [4] despite cultural differences among countries. Only a few studies on market channel in Thailand, mainly studies on online channel.

The relevant decision for consumer segmentation, is consumer 's life style. [5] The individuals with similar socio-demographic characteristics can have different behaviors. [6] Only socio-demographic characteristics are not sufficient for the analysis of consumer behavior. [7] Lifestyle are psychographic variables that distinguish patterns of personal or social beliefs or even characteristics represented by a

set of particular activities and [8] lifestyle are variables that refer to the perception of life, attitudes, opinions, hobbies or interests.

Therefore, the main objective of this study is to perform a segmentation to identify groups of herbal oral cosmetic consumers in each generation in terms of Demographic and lifestyle. This important factor to use to design market channel for consumer Generation and Generation Y.

The following hypotheses are proposed.

- H1. Consumer's generation has affect to heterogeneous among their life style according to herbal oral cosmetic.
- H2. Consumer's life style of cluster in each generation are heterogeneous.

## 2. Materials and Methods

### 2.1. Sampling and fieldwork

A questionnaire was developed based on a literature review on market channel and consumer behavior and in-depth interview. The target is [9] consumers generation X, age 38-53 years old and generation Y, age 18-37 years old who use oral herbal products. Data were collected by face-to-face interview, this study the data were use to segment consumer lifestyle in each generation. The questionnaire consisted of five parts. The first part captured the demographic profile data of respondents, including gender, age, educational level, occupation, income per month and hobby. The second part captured the consumer's behavior on the herbal oral product including product type, recommended information, purchase frequency, the market channel used. The third examined consumer's lifestyle by five points Likert scale; respondents were asked to indicate their agreement/disagreement (from 1 indicating strongly disagree to 4 indicating strongly agree and 0 indicating disagree). The forth examined factors influencing on buying decision towards oral herbal products by five points scale; respondents were asked to indicate their affected / not affected (from 1 indicating strongly not affected to 4 indicating strongly affected and 0 not affected). The fifth examined problems from the consumer on each market channel; the market channel includes internet or online channel, pharmacy store, trade show, herbal store, dental clinic, shopping center, agent or direct sale, supermarket, and convenience store. The descriptive analysis of the data is shown in Table 1.

**Table 1.** Herbal oral cosmetics consumer demographic' profile

Variable	Categories	Percentage
Gender	Men	27.7%
	Women	72.3%
Age	Generation Y (18-37)	50.0%
	Generation X (38-53)	50.0%
Marital status	Single	61.4%
	Married, no child	9.1%
	Married with child	29.5%
Educational level	High school	37.3%
	High Vocational Certificate	6.4%
	B.A. (Bachelor of Arts)	45.9%
	Over Bachelor of Arts	10.5%
Employment status	Student	43.2%
	Government officer	7.1%
	Company employee	12.4%
	Business owner	11.3%
	Employee	14.6%
	Retired	11.4%

**Table 1.** Herbal oral cosmetics consumer demographic' profile (continued)

Variable	Categories	Percentage
Household income per month	Under 10,000 baht	42.3%
	10,000 – 20,000 baht	25.5%
	20,000 – 30,000 baht	20.5%
	Over 30,000 baht	11.8%

The target population in this survey shows that herbal oral cosmetic consumer is mainly female, although there was different from men about 44.6 % more women than men. Furthermore, we separate the sample into to Generation Y (18-37 years of age) 50% and Generation X (38-53 year of age) 50%. The group was mainly single (61.4%). In terms of educational attainment, the majority of the group had a Bachelor of Arts (45.9% of the sample) and 43.2% of the sample was the student. Income per month, mainly under 10,000 baht (42.3%) of the population.

## 2.2. Technique and research variables

The population from a survey questionnaire, 220 respondent we test the hypothesis by using statistic ANOVA. First, we test hypothesis H1 to confirm that consumer's generation affects to heterogeneous among their lifestyle. Then after segmentation consumer generation, we test the hypothesis H2 to confirms cluster differentiate.

Two-step cluster analysis was used to determine the number of segment and segment result. The cluster analysis examines the relationships among variables to establish a grouping of individuals. This research used the quantitative data, consumer's demographics including gender, age, educational level and Household income per month and qualitative data, consumer's lifestyle to identify segment. The method used to measure distance is Log likelihood and determine the number of the cluster by determining automatically.

## 3. Results

### 3.1. Segmenting customer

To examine hypothesis H1, in which Consumer's generation has affected to heterogeneous among their lifestyle according to herbal oral cosmetic. In the ANOVA test, generation of customer affects to their lifestyle which was statistically significant ( $p=0.000$ ), as indicated by the ANOVA results. It can be concluded that hypothesis H1 can be accepted, which means that generation of consumer affects to heterogeneous among their lifestyle according to herbal oral cosmetic.

The segmented of consumer' generation base on demographic and lifestyle who use oral herbal cosmetics. The mean scores on a scale 0 – 4 for each of variable and groups included in the analysis were calculated to find the main differences between segments. By using a two-step cluster analysis, there are four clusters and each generation has two clusters. The result shows that the cluster quality is good for generation Y and X. We use ANOVA test to confirm that two clusters in each generation, it can be concluded that hypothesis H2 can be accepted how that consumer's lifestyle of Cluster in each generation are heterogeneous were statistically significant ( $p=0.000$ ). The clusters result (Table 2) generation Y, cluster Y-2 was the largest, representing 47.2% of the sample, and generation X, cluster X-1 was the largest, representing 77.3% of the sample.



**Table 2.** Segmentation of consumer's life style base on demographic and life style

Life style	Generation Y		Generation X	
	Cluster Y-1	Cluster Y-2	Cluster X-1	Cluster X-2
	-47.20%	-52.80%	-77.30%	-22.70%
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD
Nature	2.83 <sub>a</sub> $\pm$ 0.66	3.62 <sub>b</sub> $\pm$ 0.42	3.27 <sub>c</sub> $\pm$ 0.52	2.26 <sub>d</sub> $\pm$ 0.56
Innovative	1.92 <sub>a</sub> $\pm$ 0.42	2.55 <sub>b</sub> $\pm$ 0.55	2.43 <sub>b</sub> $\pm$ 0.56	1.62 <sub>c</sub> $\pm$ 0.49
Conservative	2.73 <sub>a</sub> $\pm$ 0.37	3.08 <sub>b</sub> $\pm$ 0.29	2.97 <sub>b</sub> $\pm$ 0.31	1.90 <sub>c</sub> $\pm$ 0.36
Healthy herbal	1.65 <sub>a</sub> $\pm$ 0.57	2.41 <sub>b</sub> $\pm$ 0.54	2.21 <sub>b</sub> $\pm$ 0.52	1.30 <sub>c</sub> $\pm$ 0.48

Note: a b c the mean difference is significant at the .05 level.

From table 2, consumer's lifestyle was divided into four categories including Nature (consumer who prefer natural products which fewer additives and chemical ingredient), Innovative; a group of consumer who interested in product that has new innovation and/or gimmick, Conservative is a category of conservatism consumer and prefer biodegradable packaging, and the last category is Healthy herbal (consumer who like to go to herbal shop and search and/or attend about herbal's news).

- **Cluster Y-1:** The consumer's lifestyle score in this generation are lowest all of category, the lowest score is *healthy herbal*. It's mean that consumer's lifestyle in this cluster had few unconcerned herbal products but they more concerned in nature category. In term of socio-demographic, this group the main consumer are female (80.8%), single (96.2%). For education level is high school (75.0%), they are a student (88.5%) and household income per month are under 10,000 baht (73.1%).
- **Cluster Y-2:** The consumer's lifestyle score in this generation are highest all of category, with the highest score is *nature*. Cluster member in this group mainly member are female (87.9%), most of them are single (96.6%) and enrolled in high school (60.3%). They are a student (84.5%) and household income per month are under 10,000 baht (69.0%).
- **Cluster X-1:** The largest cluster member in generation X with lifestyle core are highest all of category including *nature*, *innovative*, *conservative* and *herbal*. The highest score is *nature* similarity cluster Y-2 but the score is below than cluster Y-2. The cluster profile mainly is female (60.0%) and married with child (51.8%). Educational level mainly are Bachelor of Arts, work for employee (25.9%) and household income per month are 20,000 - 30,000 baht (37.6%)
- **Cluster X-2:** The smallest cluster member consist with lower consumer's lifestyle score all of the categories, the lowest score is *healthy herbal* and high score is *nature* similarity cluster Y-1. The most member are female (60.0%), married with child (72.0%) and had an education level Bachelor of Arts (52.0%). Mainly member worked on business owner and employee (24.0%) and household income per month are 10,000 - 20,000 baht (40.0%).

Overall, generation Y, consumer's lifestyle in cluster Y-1 and Y-2 all category has significantly different with a high score in cluster Y-2, Generation X, both cluster has significantly different with the highest score in cluster X-1. It's mean consumer in cluster Y-2 and X-1 matches on this lifestyle including nature, innovative, conservative and healthy herbal. In both generations, all categories in cluster Y-2 and X-1 are on significantly different except for nature category is significantly different.

**Table 3.** Segmentation of the different cluster according to socio - demographic variable.

Variable	Categories	Generation Y (n=110)		Generation X (n=110)	
		Cluster Y-1	Cluster Y-2	Cluster X-1	Cluster X-2
		47.2%	52.8%	77.3%	22.7%
Gender (chi-square: 3.828; sig = 0.148)	Male	19.2	12.1	40.0	40.0
	Female	80.8	87.9	60.0	60.0

**Table 3.** Segmentation of the different cluster according to socio - demographic variable (continued)

Variable	Categories	Generation Y (n=110)		Generation X (n=110)	
		Cluster	Cluster	Cluster	Cluster
		Y-1	Y-2	X-1	X-2
		47.2%	52.8%	77.3%	22.7%
Marital status (chi-square: 12.404; sig = 0.002)	Single	96.2	96.6	27.1	24.0
	Married, no child	0.0	1.7	21.2	4.0
	Married with child	3.8	1.7	51.8	72.0
Educational level (chi-square: 8.216; sig = 0.042)	High school	75.0	60.3	3.5	20.0
	High Vocational Certificate	0.0	0.0	12.9	12.0
	B.A. (Bachelor of Arts)	19.2	31.0	70.7	52.0
	Over Bachelor of Arts	5.8	8.6	12.9	16.0
Employment status (chi-square: 19.057; sig = 0.008)	Student	88.5	84.5	0.0	0.0
	Government officer	3.8	1.7	11.8	16.0
	Company employee	0.0	8.6	15.3	20.0
	Business owner	1.9	0.0	23.5	24.0
	Employee	3.8	0.0	25.9	24.0
	Retired	1.9	0	23.5	16
Household income per month (chi-square: 10.883; sig = 0.012)	Under 10,000 baht	73.1	69	12.9	16
	10,000 – 20,000 baht	21.2	22.4	25.9	40
	20,000 – 30,000 baht	5.8	5.2	37.6	28
	Over 30,000 baht	0	3.4	23.5	16

After the segmentation consumer's generation was identified according to their lifestyle. And, the socio-demographic variables (gender, marital status, education level, employment status, and household income per month) is used to examine the relationship between socio-demographic and cluster by using the chi-square statistic test (table 3). The result shows that only gender variable has no relationship with clusters.

**Table 4.** Segmentation of the different cluster according to consumer's behavior variable.

Variable	Categories	Generation Y (n=110)		Generation X (n=110)	
		Cluster	Cluster	Cluster	Cluster
		Y-1	Y-2	X-1	X-2
Product type	Herbal toothpaste	73.8	77.5	75.2	79.3
	Herbal mouth wash	15.4	15.5	10.5	10.3
	Herbal mouth spray	6.2	5.6	3.8	3.4
	Herbal Tooth polishing powder	4.6	1.4	10.5	6.9
Product brand	Salz - herbal + salt	16.7	13.9	14.9	16.9
	Colgate	24.7	20.3	21.3	28.6
	Systema } herbal + Fluoride	11.8	12.7	11.2	7.8
	Darlie	9.7	11.6	15.5	10.4

**Table 4.** Segmentation of the different cluster according to consumer's behavior variable (continued).

Variable	Categories	Generation Y (n=110)		Generation X (n=110)	
		Cluster	Cluster	Cluster	Cluster
		Y-1	Y-2	X-1	X-2
With Fluoride	Dentiste	10.2	13.9	7.9	7.8
	Twin lotus	10.8	9.2	14.9	19.5
	Abhaiherb	3.8	2.8	2.1	0
	Bamboo	0	0.8	0.3	1.3
	Viset-Niyom	2.7	3.2	3.3	0
	Tepthai	3.2	3.2	4	2.6
	Kok-liang	1.6	2.4	0.9	1.3
	Kolbadent	2.2	1.6	1.2	1.3
	Tip-Niyom	1.6	1.2	1.5	0
	Other	1.1	3.2	0.9	2.6
Acknowledge information	Internet	31.2	30.4	13.3	15
	Trade show	6.5	10.4	14.7	15
	Media	36.6	30.4	48	52.5
	Herbal store	3.2	11.2	10	5
	Family / Friend	21.5	14.4	10.7	7.5
	Other	1.1	3.2	3.3	5
Purchase frequency	Every week	5.8	1.7	2.4	4
	Every 2 week	11.5	6.9	17.6	12
	1 time per month	53.8	67.2	60	72
	2-3 time per month	28.8	24.1	20	12
When purchasing products	Monday - Friday	32.7	29.3	60	72
	Saturday - Sunday	51.9	67.2	31.8	24
	Holiday – Festival	15.4	3.4	8.2	4
Purchasing behavior	Purchase used brand	47.3	42.9	50.7	58.3
	Purchase when promotion	35.2	26.7	22	22.2
	Purchase when new product available	3.3	10.5	6	2.8
	Purchase when trail product	9.9	10.5	13.3	11.1
	Unconditional purchase	3.3	6.7	5.3	5.6
	Other	1.1	2.9	2.7	0
Payment	Cash	78.1	83.8	79.2	92.6
	Credit / Debit card	20.3	13.2	19.8	7.4
	E-payment	1.6	2.9	10	0
Marketing channels used	Internet	3.3	2.4	2	1.4
	Pharmacy	11.3	15.1	6.9	2.9
	Herbal store	2.7	7.8	3.2	5.7
	Dental Clinic	1.3	1.8	0.4	1.4
	Department store / Shopping mall	29.3	28.3	26.2	0
	Agent / Direct sale	3.3	2.4	2	32.9
	Hypermarket / Supermarket	20	16.3	20.2	4.3

**Table 4.** Segmentation of the different cluster according to consumer's behavior variable (continued).

Variable	Categories	Generation Y (n=110)		Generation X (n=110)	
		Cluster	Cluster	Cluster	Cluster
		Y-1	Y-2	X-1	X-2
Marketing channels used	Convenient store	22.7	21.7	25.8	12.9
	Trade show	2.7	2.4	6	27.1

Note: blue color: highest percentage in each variable

**Table 5.** Segmentation of the different cluster according to consumer's behavior variable by ranking.

Variable		Generation Y (n=110)		Generation X (n=110)	
		Cluster Y-1	Cluster Y-2	Cluster X-1	Cluster X-2
The most channels used	No.1	Convenient store	Convenient store	Convenient store	Convenient store
	No.2	Hypermarket	Hypermarket	Hypermarket	Department store
	No.3	Department store	Department store	Department store	Hypermarket
Reasons to purchase	No.1	Product features	Product features	Product features	Product features
	No.2	Reasonable price	Reasonable price	Necessary product	Necessary product
	No.3	Standard certification	Necessary product	Standard certification	Reasonable price

The consumer behavior in a different cluster (table 4). Cluster Y-1, the most consumer in this cluster used herbal toothpaste (73.8%) with Colgate brand (24.7%). They acknowledge from media channel such as television, brochure (36.6%), purchasing every month for 1 time (53.8%) and mainly purchasing on Saturday – Sunday (51.9%). For purchasing behavior, purchase used brand or brand royalty (47.3%), payment by cash (78.1%), they use market channel majority are Department store or shopping mall (29.3%). Cluster Y-2 this cluster consumer's behavior profile quite similar cluster Y-1 except for acknowledging information, they attend on media and internet (30.4%). Cluster X-1 majority consumer used herbal toothpaste (75.2%) with Colgate brand (20.3%). They acknowledge from media channel such as television, brochure (48.0%), purchasing every month for 1 time (60.0%) and mainly purchasing on Monday – Friday (60.0%). Purchasing behavior includes purchase used brand or brand royalty (50.7%), payment by cash (79.2%), they use market channel majority are Department store or shopping mall (26.2%). And cluster X-2 this cluster consumer's behavior profile quite similar cluster X-1 except for they use marketing channel on an agent or direct sale (32.9%). The suggestion of marketer, consumer generation Y and X, their usually purchase herbal toothpaste more than another, the majority they use the herbal product that mix fluoride, can connect information with them by internet and media, most of them had brand loyalty marketer should find the way to retain customers.

In table 5, the first variable is the most channels used. The result shows that the most channels used of cluster Y-1, Y-2, and X-1 are the same which No.1 is a convenient store, No. 2 is hypermarket, and No.3 is the department store. For, Cluster X-2 consumer selected convenient store in first ranked follow by the department store and hypermarket. Overall in the market channel, can be said that the marketer can launch the product on three channels including the convenience store, hypermarket, and department store. In term of reasons to purchase herbal oral cosmetic all of cluster selected by product feature in the first rank but another rank are the different reasons. In the second rank, both generations are different. Generation Y both clusters are reasonable price only cluster Y-1 has two reasons in similar rank. For generation X, the main reason that both clusters purchase the product because it is a necessary product. From the above information, the marketer or developer should focus on the product feature, however, the main reason that consumer purchases the product because it is the necessary product.

#### 4. Discussion

This research uses the data from each cluster to determination and/or design the suitable market channel to deliver herbal oral cosmetics which had interested point below.

- Two clusters of generation Y were no significantly different due to consumer in this generation has knowledge and understand about herbal. the interesting of herbal and natural products was medium level which related with previous research; [10] studied about herbal knowledge and understanding of consumer and majority of population (67.5%) had age range between 20 to 35 years old (generation Y), the result indicated average of consumer who had knowledge and understand about herbal at 62.25% in addition new generation consumer has high variation of products that sell in different market channel while generation X consumer show significantly different on different clusters by the cluster who interesting in herbal products had 70% follow up the new information about herbal because most of they familiar with herbal and often used herbal oral cosmetics related with [11] studied about consumer's attitude and usage-purchasing behavior toward the herbal toothpaste.
- The studied about market channel, both generation selected convenient store as 1st rank which major of population was female related with research of [12] studied about the market channel on a convenience store. Place and conveniences such as has car parking or easy to reach were a factors that effect to making a decision of consumer.
- For determination and/or design market channel, [13] said business that has varied market channel was enhance competitive opportunity and can reach consumer more than single market channel due to the increasing of convenience to reach consumer needed goods.
- Consumer buying behavior on herbal oral cosmetic, majority consumer consider on products feature and buying the same brand that they use before or brand loyalty related with [14] studied about multi-channel shopping found that service quality and product quality are the most significant determinants affecting loyalty.

#### 5. Conclusions

Consumer indicated that age is the important factor that affects to consumer's lifestyle which divided in to 2 generations; generation Y (age 18-37) and generation X (age 38-54) then the generation were segmented, both of generations had 2 significantly different clusters which divided by different score of herbal interesting (Y-1 and X-2 were low levels while Y-2 and X-1 were high levels of herbal interesting). Now we know the consumer target from socio-demographic (table 3), understand what they concern/unconcern and can create content to connect the consumer target by their lifestyle (table 2), how to approach them and which channel should be select (table 5). This data will be used for determination and/or design market channel for sale herbal oral cosmetics and it also benefit for the marketer, developer or entrepreneur, guideline the optimal solution helps them get opportunities for competition and sustainable business.

#### References

1. Busakorn P. Thai Herbs Wisdom to the World Market. Bangkokbiznews, available online: <http://www.bangkokbiznews.com/news/detail/772552>. August 25, 2018.
2. Sureeporn Sahawat. Thai Herbs on Threshold of a New Economy. Thai herb innobiz network, 2017.
3. Department of Industry Promotion (DIP), Ministry of Industry of Thailand 2017. Industry Trends and 230 Market Size of Herbal Businesses. Available online: <https://bsid.dip.go.th/download-content/quality-control/qs-trensherbsproduct>. August 25, 2018.
4. Ruiz, J.P., Chebat, J.C., Hansen, P., 2004. Another trip to the mall: a segmentation study of customers based on their activities. *Journal of Retail. Consumer. Serv.* 11 (6), 333–350.
5. González, A.M., Bello, L., Muñoz, N., 2000. Orientación de la empresa turística del s. XXI a los valores personales y los estilos de vida de los turistas. *Cuad. Cienc. Econ. Empresa.* 39, 59–86.
6. Du Preez, R., Visser, E.E., Zietsman, L., 2007. Profiling male apparel consumers: life style, shopping orientation, patronage behaviour and shopping mall behavior. *Manag. Dyn.* 16 (1), 2–19.

7. Green, G.T., Gordell, H.K., Betz, G.J., 2006. Construction and validation of the national survey on recreation and the environment's lifestyles scale. *J. Leis. Res.* 38 (4),513–535.
8. Valentine, D.B., Powers, T.L., 2013. Generation Y values and lifestyle segments. *J. Consum. Mark.* 30 (7), 597–606.
9. Novak, J. 2012. The six living generations in America. Available Source: <http://www.marketingteacher.com/the-six-living-generations-in-america/> , March 4, 2017.
10. Reungtorsang C. Factor Affectig Herbal Cosmetic Consumption Behaviors. Master's degree Thesis, Master of public administration Burapha University, Chonburi, 2015.
11. Thitinart J., The effect of marketing communication exposure on the Bangkok metropolitan consumer's attitude and usage-purchasing behavior toward the herbal toothpaste. Master's degree Thesis, Master of Marketing Communication University of the Thai Chamber of Commerce, Bangkok, 2006
12. Wantana R., Market channel analysis on convenient store in Changmai province. Master's degree Thesis, Master of Economics changmai university, Changmai, 2005.
13. Snoenbachler, D.D. and Gordon, G.L. (2002). Multi – channel shopping: Understanding what drives channel choice. *Journal of Consumer marketing* 19(1): 42 – 53.
14. Chummanond N. and Rotchanakitumnuai S. 2010. Determining the Online Purchasing Loyalty for Thai Herbal Products. *Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering.* 228 4 (4), 393-396.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-006-ID042

# Purwaceng Coffee Formulation Based on Consumers Preference

Julianisa, D.S.<sup>1</sup>, Aziz, I.W.F.<sup>2</sup>, and Jumeri<sup>2,\*</sup>

<sup>1</sup> Student of Agroindustrial Technology Department, Faculty of Agriculture Technology, Universitas Gadjah Mada, Yogyakarta, Indonesia; dyas.selvi@gmail.com

<sup>2</sup> Lecturer of Agroindustrial Technology Department, Faculty of Agricultural Technology, Universitas Gadjah Mada, Yogyakarta, Indonesia; ibnu.wahid@gmail.com

\* Correspondence: jumerimw@ugm.ac.id; Tel. : +62 812 1549 5571

Received: 5 August 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** Purwaceng (*Pimpinella pruatjan* Molk.) is one of Indonesian herb used to improve stamina and blood circulation, therefore, it has potential to be functional food. As functional food component, it could be blend with other material such as coffee which improve customers acceptance. The aim of the research is to identify the quality attributes of purwaceng coffee beverage desired by consumers and to develop the concept of purwaceng coffee beverage in accordance to consumer preferences. Value Engineering approach was used to formulate purwaceng coffee, which consists of three phases: information phase, creative phase, and analysis phase. Information phase consists of in-depth interview and gathering information using questionnaire. Creative phase consists of creating FAST diagram and obtaining product concepts using Fully Randomized Design. Analysis phase consists of sensory analysis to obtain product performance and value. According to the research, there are 4 preferable attributes which considered on purwaceng coffee formulation: health benefit, aroma, taste, and intensity. The best concept was composed of robusta coffee powder (7.5 g), full cream milk powder (2.5 g), sugar (15 g), and purwaceng powder (0.35 g). Compared with market product as competitors, the selected concept has advantages on the aroma, taste, intensity, and the performance.

**Keywords:** coffee, functional food, purwaceng, quality attributes, value engineering

---

## 1. Introduction

Food Supplements are found both in the form of beverage products and of tablets or pills. Many people consume this supplement food to stay their healthy and to improve their stamina. However, long term consumption of food supplement have implicated on human health because of their side effects [1]. The best way to improve the quality of life is having a healthy diet. The functional compounds contained in foods or beverages has a positive effect on one's physical and spiritual health in addition to its nutritional content and taste.

Purwaceng is herb used for ingredient in the functional food which allegedly could increase human stamina. Purwaceng can be used as a medicine or as an additive for any kind of beverages, such as coffee. It has a bitter taste, which was almost similar to that of coffee, let to combined both of them into a healthy coffee drinks. However, the research concerning consumer preference on purwaceng coffee products was not so far available. Therefore, it is necessary to optimize the purwaceng coffee formula by exploring their quality attributes according to consumer preferences. In this study, purwaceng coffee products were developed using value engineering methods approach. The value in value engineering is determined by the lowest cost to fulfill the functions or services needed in the certain time and place with basic quality [2]. The aim of this study is to identify the quality attributes of purwaceng coffee products desired by consumers, to develop the concept of purwaceng coffee products in accordance with consumer preferences and to determine the level of consumer preference for the products developed.

## 2. Materials and Methods

The main material used in this research were robusta coffee from Gunung Kelir, Semarang, Central Java and purwaceng (*Pimpinella pruatjan* Molk) harvested from Dieng, Wonosobo, Central Java. Both of these were then formulated with additional substances to be herb coffee regarding on customer preferences.

Formulation of purwaceng coffee was performed by value engineering using the steps as follow:

### 2.1. Information phase.

Information phase in this study aims to find out customer desires toward the product being developed. Information phase consists of product quality attributes data collection and importance level determination. In this study, product quality attributes collected by in-depth interview and questionnaire. Then, the priority order of product quality attributes was measured by calculating importance level and weight. Importance level is the average of importance of each quality product attribute. Importance level was measured by Formula 1.

$$\text{Importance level} = \frac{\text{the importance value number of each quality product attribute}}{\text{the number of respondents}}, \quad (1)$$

Importance weight is the percentage of importance level of each quality product attribute compared to total importance level. Importance weight was measured by Formula 2.

$$\text{Importance weight} = \frac{\text{the importance level of each quality product attribute}}{\text{total importance level}} \times 100\%, \quad (2)$$

### 2.2. Creative phase.

The aim of creative phase is to develop alternatives to fulfill its main function. This phase consists of creating FAST diagram, determination of product specification, developing concept and creating purwaceng coffee prototype. FAST diagram is used to create product specification which obtained by the translation of customer desires become a technical requirement. Product specification obtained was then used to develop product concepts. In this study, product concepts developed by using Completely Randomized Design. Product concepts were then made into prototype for further analyzed in the next phase.

### 2.3. Analysis phase.

In this phase, purwaceng coffee prototypes were analyzed by using organoleptic test to get the number of performance and value. The chosen concept will be compared to the similar commercialized product. Organoleptic tests was carried out on the prototype through giving scores to the product quality attributes by at least 30 responses [3]. The result of organoleptic test is used to calculate performance using Formula 3.

$$\text{Performance} = \text{quality attribute weight} \times \text{the number of respondent rating} \quad (3)$$

Furthermore, value was then calculated to determine which concept will be selected as the best concept. The selected concept has highest value among the other. The value was calculated using Formula 4.

$$\text{Value} = \frac{\text{Performance}}{\text{Cost}}, \quad (4)$$



### 3. Results

#### 3.1. Product Quality Attributes and Importance Level Determination

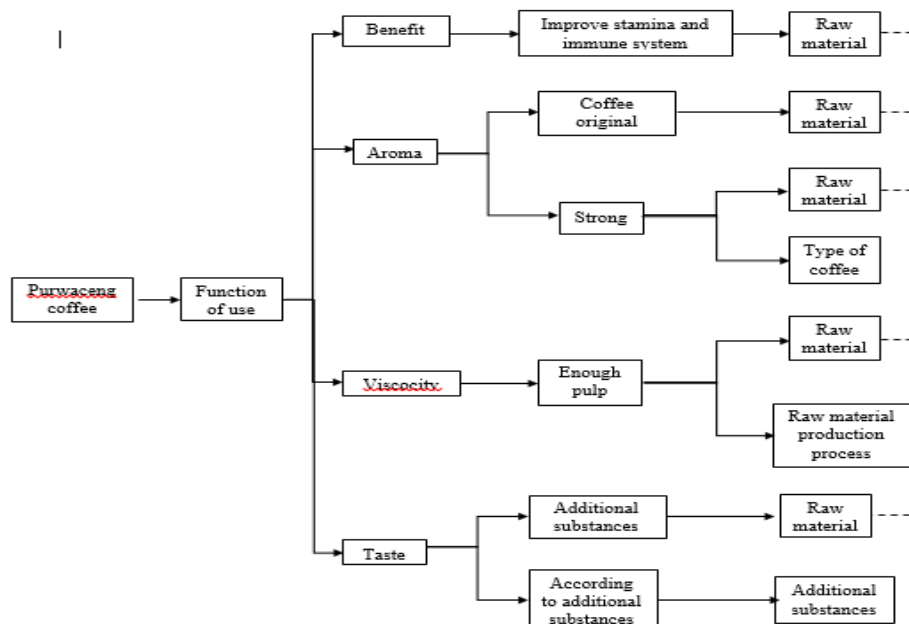
In this study, product quality attribute was obtained by in-depth interview and questionnaire. The result showed that customer have consider on their taste, viscosity, aroma, and benefit. Importance level and weight of product quality attribute was described in Table 1.

**Table 1.** Importance level and weight of product quality attribute

Primary Attributes	Secondary Attributes	Importance Level	Importance Weight (%)	Rank
Benefit	Improve stamina and immune system	3.63	16.26	1
Aroma	Original coffee	3.35	15.01	2
Taste	Balance	3.35	15.01	3
Aroma	Strong	3.10	13.89	4
Viscosity	Enough pulp	3.09	13.84	5
Taste	Contain additional substances	3.00	13.44	6
Aroma	According to additional substances	2.80	12.54	7
Total		22.32	100.00	

#### 3.2. Product Concept Creation

Product quality attributes were identified and analyzed in order to find the factors influencing product quality attributes. Correlation between factors was presented on FAST diagram. Purwaceng coffee FAST diagram was shown in Figure 1. Based on FAST diagram, purwaceng coffee specification consists of robusta coffee powder as the main substance, purwaceng plant was in the form of simplicia, sugar used as sweetener, and milk used as additional substances. According to [4], maximum dose of purwaceng simplicia without any healthy risk was 500 mg.



**Figure 1.** Purwaceng coffee FAST diagram

Drafting of purwaceng coffee concept refers to product specification. It was created by Factorial Completely Randomized Design. There were four factors used to create the concepts, i.e. the amount of robusta coffee powder, full cream milk powder, sugar and purwaceng powder as presented in Tabel 2. Each factors consists of three levels. Product specification created into 9 concepts which was presented in Table 3.

**Table 2.** Variation of purwaceng coffee composition

Factors		Level		
		1	2	3
A	The amount of robusta coffee powder (g)	5	7,5	10
B	The amount of full cream milk powder (g)	7,5	5	2,5
C	The amount of sugar (g)	10	12,5	15
D	The amount of purwaceng powder (g)	0,2	0,35	0,5

**Table 3.** Purwaceng coffee concept

Concepts	Factors (gram)			
	The amount of robusta coffee powder	The amount of full cream milk powder	The amount of sugar	The amount of purwaceng powder
A	5	7,5	10	0,2
B	5	5	12,5	0,35
C	5	2,5	15	0,5
D	7,5	7,5	12,5	0,5
E	7,5	5	10	0,2
F	7,5	2,5	15	0,35
G	10	7,5	15	0,35
H	10	5	10	0,5
I	10	2,5	12,5	0,2

Organoleptic test was used to analyze and identify these 9 prototypes to get the best concept. Quality product attributes which consists of taste, aroma, and viscosity were used as judgment parameter in this test. The result of organoleptic test showed that concept F has the highest value on taste, aroma and viscosity.

### 3.3. Product Performance Analysis

The result of organoleptic test and product quality attribute influence the amount of product performance [5]. The result of product performance calculation was shown in Table 4.

**Table 4.** The result of prototype analysis

Concepts	Product Quality Attribute			Performance	Cost	Value
	Taste	Aroma	Viscosity			
A	110	137	133	127	1,550.00	0.0819
B	130	133	127	130	1,518.75	0.0856
C	132	132	125	130	1,487.50	0.0872
D	131	136	133	133	2,143.75	0.0622
E	123	130	131	128	1,575.00	0.0813
F	150	139	144	144	1,587.50	0.0909
G	139	150	142	144	2,287.50	0.0629

**Table 4.** The result of prototype analysis (continued)

Concepts	Product Quality Attribute			Performance	Cost	Value
	Taste	Aroma	Viscosity			
H	104	126	123	118	2,125.00	0.0555
I	128	137	135	133	1,643.75	0.0812

Each purwaceng coffee concept has different performance. The highest performance obtained by concept F and G, conversely, the lowest performance obtained by concept H.

### 3.4. Cost Analysis

In this study, expenses other than material expenses was ignored. As shown in Table 4, purwaceng coffee concepts has various total cost, possibly caused by the different amount of material and material cost. Total cost of concept G was highest and those of concept B was lowest.

### 3.5. Value Analysis

Value of a product influenced by the amount of performance and cost. The amount of performance has linier comparison to product value. Meanwhile, the amount of total cost has inverse comparison to product value. The best concept of purwaceng coffee was once that has the highest value. Each value of purwaceng coffee concepts showed in Table 4.

According to Table 4, the chosen product was concept F that has the highest value, which supported by the high performance and the low total production cost. Concept F was then compared to the similar product sold in market in order to identify customer level of preference. The comparison between product F and the competitors were shown in Table 5.

**Table 5.** Comparison between selected product and their competitors

Characteristics	Product F	Product X	Product Y	Product Z
Size	25,35 gram	25 gram	7 gram	25 gram
Composition				
Purwaceng	Yes	Yes	Yes	Yes
Coffee	Robusta powder	Powder	Powder	Powder
Sweetener	Sugar	Glucose	No	Sugar
Addition	Milk	No	No	No
Other herbs	No	Ginger	Ginger	No
		Habbatussauda		
		Cinnamon	Habbatussauda	
		Cardamon		

Organoleptic test is used to identify the level of customer preference between selected concept and their competitor. Based on the result, concept F has the highest value on taste, aroma and viscosity. Concept F has the highest performance among the samples. Performance of each sample showed in Table 6.

**Table 6.** Performance of selected product and their competitors

Consept	Quality Product Attribute			Performance
	Taste	Aroma	Viscosity	
F	105	111	104	107
X	96	82	86	88
Y	51	72	77	67
Z	99	94	87	93
Total	351	359	354	

#### 4. Conclusions

The quality attributes of purwaceng coffee considered in the product formulation were the health benefits, aroma, taste, and texture. The F concept was selected from total 9 developed concepts using a Completely Randomized Design. Compared to the competitor product found in the market, the F concept has advantages in terms of taste, aroma, viscosity and performance.

#### References

1. Bjelakovic G.; Nikolova D.; Gluud L.L.; Simonetti R.G.; Gluud C. Mortality in randomized trials of antioxidant supplements for primary and secondary prevention; systematic review and meta-analysis. *Journal of The American Medical Association* 2007, 299 (2), 765 – 766.
2. King, T.R. Value Engineering, Theory and Practice in Industry. The Lawrence D. Miles Value Foundation, Washington DC, 2000.
3. Mehran. Tata Laksana Uji Organoleptik Nasi. Balai Pengkajian Teknologi Pertanian Aceh, Banda Aceh, 2015.
4. Adiguna, B.S. Pengaruh minuman suplemen herbal berenergi purica terhadap peningkatan stamina atlet sepakbola UNY. Skripsi, Fakultas Ilmu Keolahragaan UNY, Yogyakarta, 2013.
5. Umar, H. Riset pemasaran dan perilaku konsumen. PT Gramedia Pustaka Utama, Jakarta, 2005.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-009-ID049

# Development Marketing Strategy of Salak Pondoh (*Sallaca Zalazza (Gaert.) Voss.*) Based on Marketing Mix

Pitaloka Ayustina<sup>1</sup>, Novita Erma Kristanti<sup>2</sup>, Suharno<sup>3,\*</sup>

1 Departement of Agroindustrial Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada , ayustinapitaloka@gmail.com2

2 Departement of Agroindustrial Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada , erma@tip-ugm.org

3 Departement of Agroindustrial Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada , suharnodmx@gmail.com

\* Correspondence: erma@tip-ugm.org ; Tel. : +62 857 1435 9461

Received: 9 August 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** Salak (*Salacca zalacca*) is a species of palm tree (family Arecaceae) native to Java and Sumatra in Indonesia. Salak pondoh (*Sallaca Zalazza (Gaert.) Voss.*) is a local fruit product of Indonesia with the largest production in Central Java province at 39.49%, North Sumatra at 31.64% and Yogyakarta is 6.77%. Production of salak pondoh in Yogyakarta Province are in Sleman Regency with the total production in 2015 of 741,326 quintal and in 2016 amount to 765,340 quintal. The price of salak pondoh fruit is fluctuating, while in the harvest season the price drops. The importance of applying the right marketing strategy for this research so that the goals based on marketing mix attribute consist of product, price, place, and promotion. Marketing strategy is a way of marketing from a business unit to achieve marketing goals. In determining the marketing strategy can be done with a combination of segmentation, targeting, and positioning with the marketing mix to achieve the company's goals. The purpose of this study was to analyze the role of the supply chain of salak pondoh fruit, to identify the segmentation, targeting, and positioning to develop a marketing strategy for salak pondoh fruit based on the marketing mix for the salak pondoh. The result of this research are marketing strategy salak pondoh with improvement quality of salak pondoh to get the better price, improvement promotion to get better price, and improvement place to sell product to increase sale.

**Keywords:** marketing strategy, Analytic Hierarchy Process, consumers

## 1. Introduction

There are three subdistrict that become central production salak in Sleman Regency. The quantity of production salak in three subdistrict and production percentage if compared with total production in Sleman Regency are Turi Subdistrict with production 512,863 quintal or 69.18% in 2015 and 521,882 quintal or 68.19% in 2016; Tempel Subdistrict with production 149,825 quintal or 20.21% in 2015 and 159,192 quintal or 20.80% in 2016; and Pakem Subdistrict with production 61,453 quintal or 8.29% in 2015 and 64,295 quintal or 8.4% in 2016.

The price fluctuation of salak always happen every year. In harvest season the price of salak fruit will drop. Harvest season of salak fruit between December until January. On January until December 2015 the average price of salak Rp 8,283.00/kg while On January until December 2016 the price of salak Rp 4,720.00/kg. The price of salak in 2016 decreased 43% than 2015. The price in 2016 decreased because the quantity of salak pondoh in 2016 increased than 2015. The optimum price of salak pondoh Rp6,000.00/kg with production quantity 755,000 quintal (BPS Kabupaten Sleman, 2017).

Promotion process of salak in Sleman Regency with direct selling of word of mouth. Many supply chain agents of salak in Sleman Regency are not used internet for promotion their product. Promotion process must be improvement to increased the sell with attract customer to buy salak pondoh.

Place that used by supply chain agents to sell the product in Turi Subdistrict for now to reach their local target. Development place to sell salak pondoh with national target and global target must to do because salak have potention in product and price.

Supply of salak pondoh in local area as well as global area will be prove with appropriate supply chain management and marketing. The important supply chain management applied to improved business to reach their success with improvement product quality, revenue, and efisiensy distribution of lead time, cost, inventory, and error forecasting [1]. The important of marketing to introduce salak pondoh to society and attract customer to buy salak pondoh.

Appropriate marketing strategy have improve to in face with competitor. Marketing strategy consider marketing mix of product important to reach goal and target company. The important to applied appropriate marketing strategy is constitute to do this research.

## **2. Materials and Methods**

### *2.1. Market Identification in Supply Chain*

Object of this research used supply chain agents salak pondoh included farmers, collectors, whole salers, and retailers in Turi Subdistrict that become production central of salak pondoh in Sleman Rregency and customer salak pondoh in Yogyakarta City.

### *2.2. Data*

Data that used in this research included primery data and secondary data. Primary data got from indepth interview included salak pondoh distribution, distributor task, and criteria every marketing mix; preliminary questionnaire to know assessment by customer, and core questionnaire to know assessment supply chain agents. Secondary data got from Badan Pusat Statistika included quantity of salak pondoh and price of salak pondoh.

### *2.3. Sampling*

Sampling that used are purposive sampling and snowball sampling. Purposive sampling to determine sample that will used in this research with give appropriate requirement so the sample that used in this research will representative the population. Based on purposive sampling the sample quantity that used 30 sample (Teddlie, 2007). Snowball sampling used to know the flow of product distribution with the related respondents that used in this research [2].

### *2.4. Segmentation, Targeting, and Positioning*

Segmentation to divide market become group of customer into same want, characteristic, or customer attitude [3]. Targeting to determine market segment that will be used to reach company target market [4]. Positioning is used to make company image so company will have special place in the mind of target market [5].

The arrangement of segmentation, targeting, and positioning with cluster analysis and correspondence analysis. Cluster analysis to group respondents in one segment that have same characteristic [6]. Cluster analysis used cluster non – hierarchy with K – Means method. K – Means method clustering used because this method easy and simple to analyse sample, can use to analyse sample in big quantity, and process to found same data in cluster more quick [7]. Correspondence analysis use to connect two variable to determine market target and positioning [8]. Two variable that used are sub criteria of marketing mix and cluster.

## 2.5. Analytic Hierarchy Process

Analytic Hierarchy Process developed by Thomas L. Saaty. This method is framework to make decision of complex problem become simple problem and to make decision process more quick with break the problem into some part, arrange the part or variable in hierarchy, give numeric value in subjective opinion every variable and consider variable that have the biggest priority and have impact for the result [9].

Analytic Hierarchy process used to solve problem in Multi Criteria Decision Making with pair comparison to know the best option that become alternative in criteria [10]. The simple shape to make structure hierarchy in problem decision making of analytic hierarchy process formed into three level are goal, criteria, and alternative [11]. The main strength of Analytic Hierarchy Process to solve problem from subjective opinion and to got quantitative priority in every important alternative [12].

In calculation of Analytic Hierarchy Process used calculating of priority vector to determine the biggest weight from criteria and subcriteria that will become alternative. After that determine eigenvalue from the data to testing consistency. The formula matrix pair comparison, vector priority ( $w_n$ ) and eigenvalue ( $n$ ) can show below [11].

$$\begin{pmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \dots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \dots & \frac{w_2}{w_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \dots & \frac{w_n}{w_n} \end{pmatrix} \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} = n \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} \quad (1)$$

The formula of Consistency Index (CI) and Consistency Ratio (CR) can show below [11].

$$CI = (\lambda_{max} - n) / (n - 1) \quad (2)$$

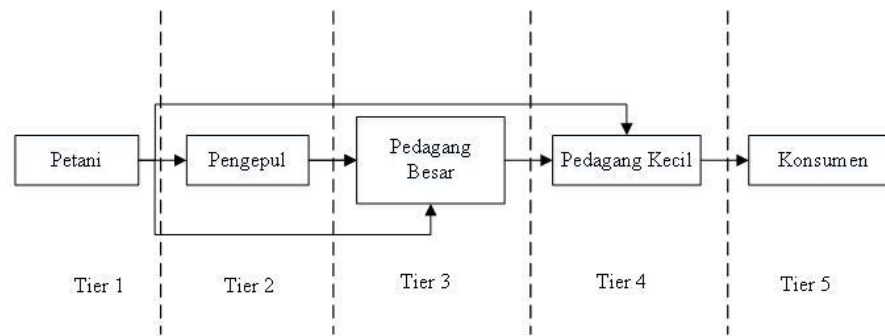
Where eigenvalue ( $\lambda_{max}$ ) and number of row and column ( $n$ )

$$CR = \frac{CI}{RI} \quad (3)$$

## 3. Results

### 3.1. Supply Chain Flow

Supply chain salak pondoh for domestic market in Turi Subdistrict, Sleman Regency is process distribution salak pondoh from producer to customer. Distribution process salak pondoh from producer in Turi Subdistrict that serve domestic market in some area of Java island, Sumatera island, Kalimantan island, Sulawesi island, and Bali island. Distribution process of salak pondoh from four tier of supply chain agents are farmers, collectors, whole salers, and retailers. Picture 1 show flow of supply chain salak pondoh in Turi Subdistrict.



**Figure 1.** Flow Supply Chain Salak Pondoh in Turi Subdistrict

### 3.2. Task of Supply Chain Agents

Farmers have main task to produce salak pondoh. When farmers produced salak pondoh there are some tasks that have to be done by farmers to get the best quality of salak pondoh, starting from choosing seeds that will be planted until controlling salak before harvest.

There are some collector tasks. First, the collector village will collect salak pondoh from farmers. Second, separate salak pondoh based on the condition of salak pondoh that has good quality or all physical conditions of salak pondoh are not rotten. Third, clean salak pondoh from impurities that attach to salak pondoh.

Wholesalers have some tasks as follows. First, collect salak pondoh from farmers and collectors in village and traditional market. Wholesalers in traditional markets are Balerante, Turi, and Prayan. Second, separate salak pondoh based on grade. Wholesalers separate salak pondoh from 3 grade until 7 grade, but most of wholesalers separate into 3 grades (grade A, B, and C). Third, sort or separate salak pondoh based on the quality of salak pondoh that has good condition or salak pondoh are not rotten. Fourth, send salak pondoh to wholesalers in D.I. Yogyakarta Province or out from D. I. Yogyakarta Province.

Retailers in Turi Subdistricts have three tasks. First, separate salak pondoh based on grade. Separate grades of salak pondoh start from 2 grade until 3 grade. Most of retailers separate salak pondoh into 2 grades based on size (big and small). Second, sort salak pondoh based on good quality or salak pondoh are not rotten. Third, sell salak pondoh to end customer.

### 3.3. Segmentation, Targeting, and Positioning Analysis

Content validity is used to test compatibility content from every variable to measure the tool to analyze segmentation, targeting, and positioning and marketing strategy. The formula of Content Validity Ratio can be shown below.

$$CVR = \frac{n_e - (\frac{N}{2})}{(\frac{N}{2})} \quad (4)$$

Explanation :

$n_e$  : Total respondents that answer relevant and important

$N$  : Total respondents that use for research

The minimum value of Content Validity Ratio (CVR) 0,582 when total respondents 8 persons. The value of CVR in table Critical Value for Lawshe's determine with alpha (probability error 0,05 in one – tailed test [13].

Criteria marketing mix that valid then arrange become preliminary questionnaire after that the questionnaire will spread to customer. The result of data preliminary questionnaire will process with cluster analysis and correspondence analysis use SPSS. The table below show final cluster centers that classified criteria in cluster.



**Table 1.** Final Cluster Centers

	<i>Cluster</i>		
	<b>1</b>	<b>2</b>	<b>3</b>
Product salak pondoh have same uniformity (P1)	3,19	1,92	3,80
Product salak pondoh appropriate with customer need (P2)	2,81	1,76	3,73
Product salak pondoh are not defect (P3)	2,19	1,66	3,53
Product salak pondoh in good condition (P4)	2,19	1,75	3,87
Price achievable (H1)	1,85	1,69	3,73
Price influence customer to decision to buy product (H2)	1,96	1,83	3,47
Price competitive (H3)	2,69	2,22	3,13
Price appropriate with quality H4)	2,04	1,80	3,20
Promotion use internet (R1)	4,54	2,64	2,73
Promotion process are appropriate (R2)	3,96	2,36	2,80
Promotion through regional government or other (R3)	3,65	2,78	3,20
Branding salak pondoh (R4)	3,69	2,17	2,80
Good distribution product (T1)	2,85	2,19	3,20
Place for got salak pondoh are easy (T2)	2,35	1,93	3,33
Place easy to reach (T3)	2,62	1,93	3,47
Place for selling the product are strategic (T4)	2,96	2,05	3,60

The highest value of marketing mix criteria in table final cluster centers need to improvement. Based on the result of final cluster centers customer divide into three cluster based on marketing mix criteria to attract customers buy salak pondoh. Cluster 1 (Cluster middle) because customers need improvement in promotion. Cluster 2 (Cluster less aware) because customers are not need improvement in marketing mix. Cluster 3 (Cluster prominence) because customer need to improvement in all criteria of marketing mix.

Based on correspondence analysis the target market that choose is cluster 1 because have the biggest mass value or eigenvalue and cluster 3 have mass value or eigenvalue in second position. The two cluster was choose for targeting because total of respondents in cluster 1 are 26 respondents while total respondents that will analyse used core questionnaire based Analytic Hierarchy Process are 30 respondents so the cluster that choose cluster 1 and cluster 3 with total 41 respondents. Determine minimum total respondents are 30 respondents based on purposive sampling. Criteria P1, H3, R2, and T1 choose to attract customer interest in cluster 1 and criteria P3, H4, and T2 choose to attract customer interest in cluster 3 when buy salak pondoh. Four criteria marketing mix choose because have close distance with cluster 1 and cluster 3 so it indicate that two cluster have same correspondence between cluster and criteria. Targeting cluster 1 and cluster 3 to fulfill customer want with improvement in uniformity of salak pondoh, salak pondoh are not defect, the price competitive, price appropriate with quality, have good distribution process, salak pondoh easy to get, and appropriate promotion. Figure 2 show perceptual map in this research.

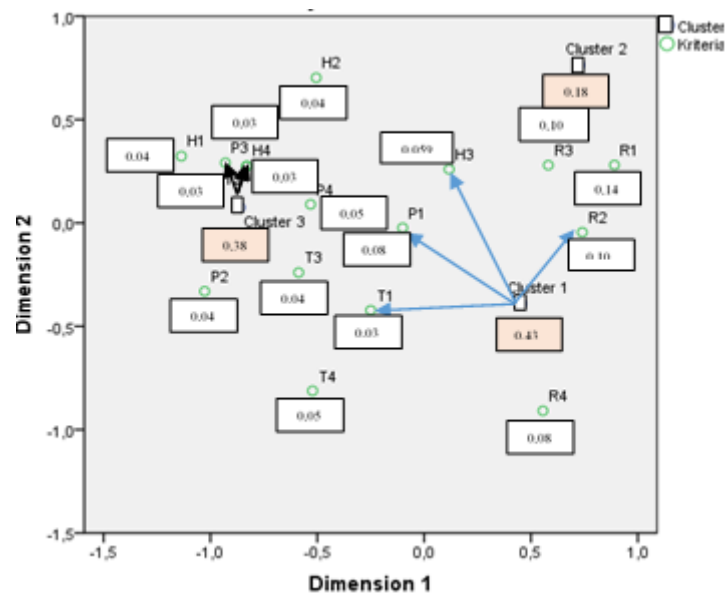


Figure 2. Perceptual Map

Positioning salak pondoh are place product in customer eye so can increased revenue for company. Positioning salak pondoh based on quality, cheap price, availability, and information easy to get. Four positioning salak pondoh place for customer in cluster 1 and cluster 3.

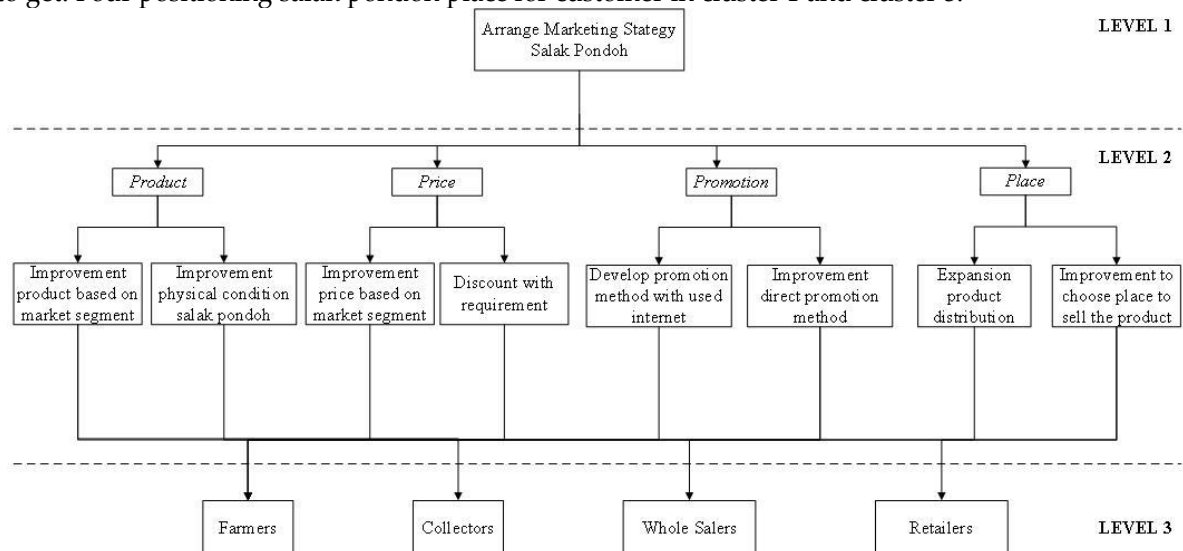


Figure 3. Hierarchy Marketing Strategy of Salak Pondoh

### 3.4. Marketing strategy analysis of supply chain agents salak pondoh

Marketing strategy analysis of supply chain agents salak pondoh used core questionnaire based on analytic hierarchy process. Core questionnaire spread to supply chain agents salak pondoh. Figure 3 show hierarchy in this research.

The recommendation of marketing strategy got after analysis data to determine marketing strategy with used Analytic Hierarchy Process. Marketing strategy in every tier supply chain agents got based on value of global weight in every criteria in marketing mix.

Marketing strategy of salak pondoh for farmers with improvement product because based on calculation of local weight and global weight have the biggest weight. The value can show in table 2. Marketing strategy recommendation product salak pondoh with improvement physical condition of salak pondoh. First, Control plant of salak pondoh from fertilization to make the supply nutrients in soil, supply nutrients balance with growth or blooming of plant, improvement the quality product, and

improvement plant productivity; cut salak pondoh leaves to improve the productivity in maximal condition and stimulate growth sheath female flower; and control Plant Vermin Organism that make decrease the productivity and fruit quality. Second, Decrease the quantity of product in every stalk to got the product that have good quality and optimum quantity. Third, Make food from salak pondoh to decrease the damage physical fresh fruit of salak pondoh.

**Table 2.** Local Weight and Global Weight Marketing Strategy Farmers

Criteria (Local weight)		Sub Criteria (Local weight)		Global weight
Farmer s		Farmers		Farmers
Product	0,48	Improvement product based on market segment	0,21	0,10
		Improvement physical condition salak pondoh	0,79	0,38
Price	0,22	Improvement price based on market segment	0,6	0,13
		Discount with requirement	0,4	0,09
Promotion	0,05	Develop promotion method with used internet	0,22	0,01
		Improvement direct promotion method	0,78	0,04
Place	0,25	Expansion product distribution	0,6	0,15
		Improvement to choose place to sell the product	0,4	0,10

Marketing strategy salak pondoh in collector do with improvement product because based on calculation of local weight and global weight have the biggest weight. The value can show in table 3. Marketing strategy recommendation product for collector with separate salak pondoh that have small size to increase sales, separate salak pondoh from salak pondoh that have defect condition to increase the sales, and separate salak pondoh from the highest ripe level to offer salak pondoh that have best quality to customer.

**Table 3.** Local Weight and Global Weight Marketing Strategy Collectors

Criteria (Local weight)		Sub Criteria (Local weight)		Global weight
Collectors		Collectors		Collectors
Product	0,50	Improvement product based on market segment	0,11	0,05
		Improvement physical condition salak pondoh	0,89	0,44
Price	0,23	Improvement price based on market segment	0,84	0,19
		Discount with requirement	0,16	0,04
Promotion	0,05	Develop promotion method with used internet	0,29	0,01
		Improvement direct promotion method	0,71	0,04
Place	0,22	Expansion product distribution	0,86	0,19
		Improvement to choose place to sell the product	0,14	0,03

Marketing strategy salak pondoh for whole salers do with improvement every criteria in marketing mix because have the close related with end customer and cluster that choose need to improvement in every criteria. Whole salers have the biggest value of local weight and global weight. The value can show in table 4. Marketing strategy product salak pondoh are improvement the physical condition salak pondoh based on supply of salak pondoh appropriate with demand, time for send salak immediately, improvement packaging process, and separate salak pondoh based on ripe level. Recommendation price of salak pondoh in whole salers are improvement price appropriate with market segmen that determine based on grade. Recommendation place on tier whole salers are improvement place for sell with choose place that strategic. Promotion recomendation with develop direct promotion method and develop promotion method with use internet. Develop direct promotion method with offer salak pondoh to other salers; supermarket; and exporter, spread leaflet to supplier salak pondoh in other region through expedition driver that distribute fruit to out D.I.Yogyakarta Province , attace label in packaging "Salak Pondoh Sleman", and join expo that held by regional goverment or other. Develop internet to promotion used website and social media.

**Table 4.** Local Weight and Global Weight Marketing Strategy Whole Salers

Criteria (Local weight)		Sub Criteria (Local weight)	Global weight	
	Whole Salers		Whole Salers	Whole Salers
Product	0,55	Improvement product based on market segment	0,50	0,28
		Improvement physical condition salak pondoh	0,50	0,28
Price	0,23	Improvement price based on market segment	0,73	0,17
		Discount with requirement	0,27	0,06
Promotion	0,06	Develop promotion method with used internet	0,58	0,03
		Improvement direct promotion method	0,42	0,03
Place	0,17	Expansion product distribution	0,30	0,05
		Improvement to choose place to sell the product	0,7	0,12

Marketing strategy salak pondoh for retailer do with improvement every criteria in marketing mix because have close relation with end customer and cluster that choose need to improvement in every criteria. Retailers have the biggest value of local weight and global weight. The value can show in table 5. Recommendation place for retailer with improvement to choose place for sell salak pondoh that strategic in slow lane and serve place to park. Price for retailers used with improvement price appropriate with market segment are separate salak pondoh based on the defect to increase sale salak pondoh and separate salak pondoh base on ripe level. Recommendation product salak pondoh for retailers with improve physical condition salak pondoh. It can do with separate salak pondoh from small size, separate salak pondoh from defect condition (peel the skin), and separate salak pondoh from roppen condition. Improvement promotion of salak pondoh with develop direct promotion method and develop promotion method with internet. Direct promotion method used with attach panflet of salak pondoh and the benefit. Promotion through internet with use website and sosial media (twitter, facebook, instagram, etc) to attract customer interest buy salak pondoh.

**Table 5.** Local Weight and Global Weight Marketing Strategy Retailers

Criteria (Local Weight)		Sub Criteria (Local Weight)	Global Weight	
	Retailers		Retailers	Retailers
Product	0,3	Improvement product based on market segment	0,28	0,08
		Improvement physical condition salak pondoh	0,72	0,22
Price	0,32	Improvement price based on market segment	0,76	0,24
		Discount with requirement	0,24	0,08
Promotion	0,06	Develop promotion method with used internet	0,43	0,03
		Improvement direct promotion method	0,57	0,03
Place	0,32	Expansion product distribution	0,22	0,07
		Improvement to choose place to sell the product	0,78	0,25

#### 4. Discussion

The results showed that the marketing activities of salak pondoh still needed to improve packaging for the upper middle segment with the aim of increasing the value of the product. In addition, processed salak pondoh for product can be an alternative to increasing profit in business salak pondoh fruit.

#### 5. Conclusions

The result of this research are marketing strategy salak pondoh with improvement quality of salak pondoh to get the better price, improvement promotion to get better price, and improvement place to sell product to increase sale.

#### References

1. Siahaya, Willem. 2016. *Sukses Supply Chain Management Akses Demand Chain Management*. Bogor : IN MEDIA.
2. Etikan, Ilker, Rukayya Alkassim, dan Sulaiman Abubakar. 2016. Comparision of Snowball Sampling and Sequential Sampling Technique. *Journal of Biometrics and Biostatistics International*, Vol. 3, No.1 : 55 – 56.
3. Tania, Debby dan Diah Dharmayanti. 2014. Market Segmentation, Targeting, dan Brand Positioning dari Winston Premier Surabaya. *Jurnal Manajemen Pemasaran Petra*, Vol. 2, No. 1 : 1 – 7.
4. Yudelston, Jerry. 2006. *Marketing Green Buildings Guide for Engineering, Construction, and Architecture*. The Fairmont Press, Inc. United States of America
5. Kotler, Philip dan Kevin Lane Keller. 2009. *Manajemen Pemasaran Edisi 13 Jilid 1*. Yogyakarta : Erlangga.
6. Romesburg, H. Charles. 2004. *Cluster Analysis for Researchers*. Lulu Press. United States of America.
7. Oyelade, O. J., O. O. Oladipupo, dan I.C. Obagbuwo. 2010. Application of k-Means Clustering algorithm for prediction of Students' Academic Performance. *International Journal of Computer Science and Information Security*, Vol. 7, No.1 : 292 – 295.
8. Li, Guohui, Song Lu, Heping Zhang, dan Siuming Lo. 2013. Correspondence Analysis on Exploring the Association Between Fire Causes and Influence Factors. *Procedia Engineering*, Vol. X, No. 62 : 581 – 591.
9. Batarius, Patrisius. 2013. Analisis Metode AHP dalam Penentuan Prestasi Gabungan Kelompok Tani. *Seminar Nasional Informasi dan Komunikasi* : 1 – 9.
10. Triantaphyllou, Evangelos. 2000. *Multi – Criteria Decision Making Methods : A Comparative Study*. Kluwer. Netherlands.
11. Saaty, Thomas L. 2000. *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*. McGraw Hill Publishers. New York.

12. Santos, Luiz Felipe se Oliveira Moura, Lauro Osiro, dan Rafael Henrique Palma Lima. 2017. A Model Based on 2 – Tuple Fuzzy Linguistic Representation and Analytic Hierarchy Process for Supplier Segmentation Using Qualitative and Quantitative Criteria. *Journal of Expert Systems with Applications*, Vol. 79, No. X : 53 – 64.
13. Ayre, Colin dan Andrew John Scally.2014. Critical Values for Lawshe's Content Validity Ratio :Revisiting the Original Methods of Calculation. *Jurnal SAGE*, Vol. 47, No. I : 79 -86.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-010-ID056

# Black Rice Agroindustry in Sleman, Yogyakarta: Early Analysis

Dyah Ismoyowati <sup>1,\*</sup>, Anisah Riyadi <sup>1</sup>, Ardhan Rifai <sup>1</sup>, Endy Suwondo<sup>1</sup>, and Tririni Nuringtyas<sup>2</sup>

<sup>1</sup> Faculty of Agricultural Technology, Universitas Gadjah Mada

<sup>2</sup> Faculty of Biology, Universitas Gadjah Mada

\* Correspondence: dyah\_ismoyowati@ugm.ac.id; Tel.: +62811254284

Received: 10 August 2018; Accepted: 28 August 2019; Published: 6 January 2020

**Abstract:** Black rice is getting more acknowledged by consumers for its function as a healthy intake. The demand may be reflected in the more obvious black rice product display on rice retailers shelves. Frequent availability may as well be detected within certain community market that is related to organic produce or health interest base. Sleman, Yogyakarta is a district in the Special Region of Yogyakarta, Indonesia where agriculture is stepping up toward higher value of agroindustry products such as pigmented rice, including black rice particularly. Limited studies on black rice lead us to do this early survey and analysis. The finding suggest that farmers in a small scale had been involved with black rice farming for almost a decade. The farming was not necessarily organic, but in most cases farmers had the idea to be more environment friendly. Local black rice Cultivar Sembada Hitam, used to be known as Pari Ireng should improve the value of this agroindustry in this area. Some marketing channels available and the supply chains exhibited the connection with suppliers from other area nearby. This phenomenon also the case in related with the buyers; Sleman black rice produce also sent to other area including Jakarta, and even to off-Java area. The role of local government in production side might be as important as private sectors in the market side to boost black rice agroindustry development.

**Keywords:** black rice; agroindustry; local cultivar; supply chain; market

---

## 1. Introduction

Increased public awareness on healthy lifestyle had led the consumption growth of healthy food products. Pigmented rice, in particular, facing high demand from consumers who want to be healthier because of the nutritional value is higher compared to white rice [1]. Demand of black rice as one kind of the pigmented rice continues to increase each year as well. Black rice is considered capable of reducing cholesterol levels that trigger the appearance of liquid coronary heart disease and stroke [2]. In Yogyakarta, the pigmented rice demand (including black rice) increased from 900 ton into 1200 ton in the last three years. This statement was supported by the increasing availability of pigmented rice in modern retail in Yogyakarta, which shows that there is a rising demand. In the year 2016 pigmented rice consumption index in Yogyakarta is 1.2 kg/capita/month with the purchase of an average of 3.5 kg/month. Pigmented rice demand is estimated to continue raising along with more awareness food consumption will slide. Most of the pigmented rice consumers has high health-awareness. Most of the consumers believed that consuming rice pigmented can prevent the risk of emergence of diseases [3].

The increased demand has not been in accordance with the availability of sufficient local black rice. In Sleman, Yogyakarta, there are many farmers who plant pigmented rice (black rice in particular). However, information on the production side i.e. number of farmers, planting location, the amount of rice production as well as other information about pigmented rice farming is limited. Whereas this information was very important to gather in order to find out the potency of black rice as healthier food and potency of those area. Based on this situation this paper aims to reveal some basic information and analysis of black rice agroindustry in Sleman, Yogyakarta as a start.

## 2. Object and Methods

The research object is the black rice agroindustry in Sleman District, Special Region of Yogyakarta, Indonesia. The research was started by collecting any information regarding black rice farming and business to the related service officers starting from the provincial, district, sub-district, and village level. The information included the individuals as well as groups of producer (farmer), broker, distributors, retailers, up to the consumers. Field survey has been conducted to gather the information covering the area of development, extents, farming systems, the number of production and productivity. Snowball sampling technique is used to identify black rice supply chain flow. A survey was conducted to find out the information from the side of the consumers. It was conducted using a questionnaire that involved 30 respondents with criteria that consumers ever buying and consuming black rice. The questionnaire was shared online and in interview in some healthy oriented community market.

## 3. Results and Discussion

### 3.1. Black Rice

Pigmented rice is often found in Indonesia included varieties of red rice and black rice. Dark purple of black rice seeds is caused by high anthocyanin content. The anthocyanin are stored in the seed *perikarpium* so the colors being purple toward the black. This increases the potential for black rice as food alternatives [4]. Black color on a rice reserved of compounds formed by anthocyanin in seed *aleurone* layer of rice [5]. Black rice have been long cultivated but not so evolved because it requires a longer growing period and relatively are not resistant to pest attack.

### 3.2. The Local Cultivar Sembada Hitam

Cultivar Sembada Hitam in Sleman, Yogyakarta still needs to be developed. In this district, black rice began to be developed since the year of 2008. In 2010 the planting area was 8,100 m<sup>2</sup> and increased to 9,600 m<sup>2</sup> in 2011. From year of 2012 to 2014, its development continued in area of 12,400, 10,600, and 28,500 m<sup>2</sup>, respectively. Table 1 shows the results of the survey that has been done both to the related local government officers and the farmers as well as the business players directly. In most area the farmer organizations cultivated black rice because of local government programs as an effort to maintain the sustainability of local cultivars so the role of local government in this particular District was significant.

**Table 1.** Black Rice Area in Sleman District

Year	Field Area (m <sup>2</sup> )	Production (kg)	Productivity (ton/Ha)	Annual Increase (%)		
				Field Area	Production	Productivity
2015	36,300	16,162.0	3.42	27%	N/A	N/A
2016	101,500	43,912.5	4.39	180%	172%	28%
2017*	113,300	48,157.5	4.13	12%	10%	-6%
2018*	130,000	60,000.0	4.75	15%	25%	15%

Source: Agricultural Government Office of Sleman District (2017) and Processed Data (2018\*)

### 3.3. The Agroindustry

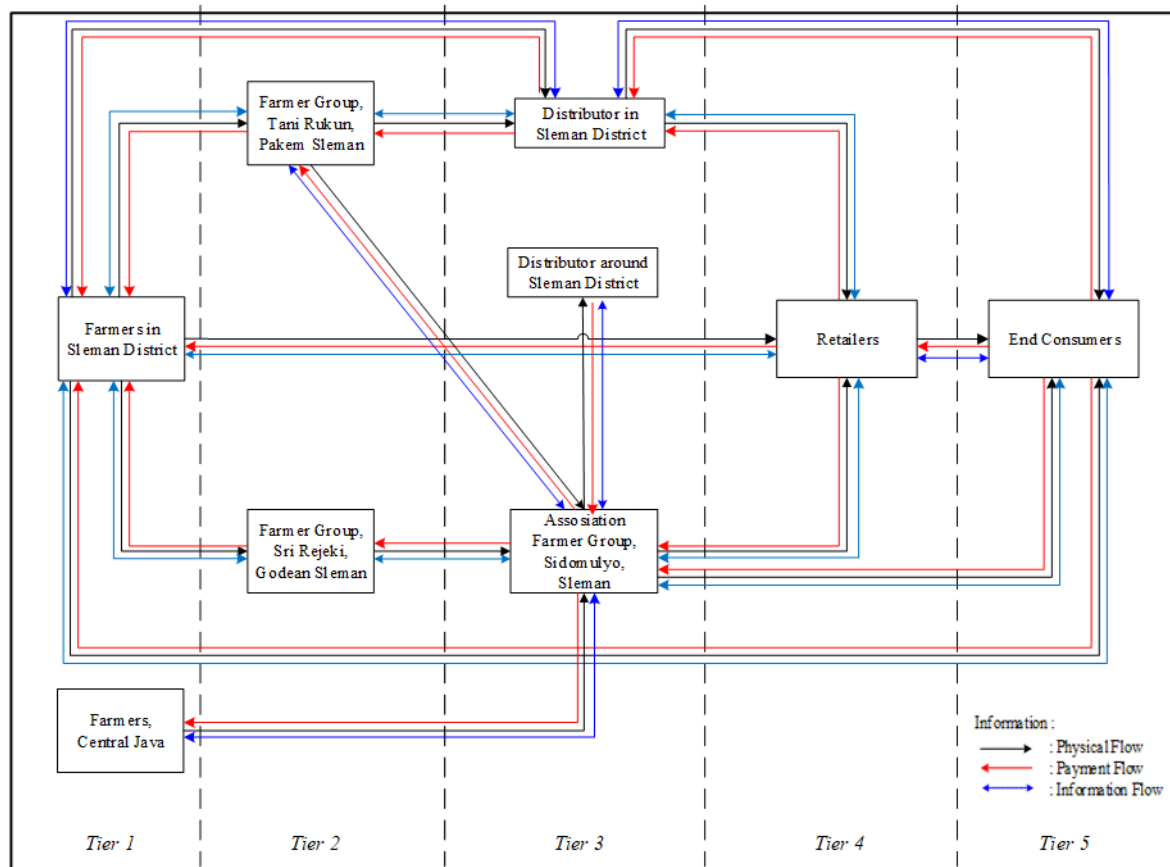
Black rice demand continues to rise as seen in the increasing amount of black rice packages on display in the shelves of rice retailers. It encouraged some farmers to start the business of black rice [6]. The transformation process of the harvested black rice before marketed was beginning with drying, milling, sorting, weighing, and packaging. The sizes adjusted to orders or requests from consumers, both the end consumer as well as business consumers. Before getting into the hands of the end consumer, the majority of the marketing channel flow as: farmers → farmer groups → distributors →



retailer → consumer [7]. Currently the local black rice Cultivar Sembada Hitam has been marketed both inside and outside of Yogyakarta.

### 3.4. The Supply Chain

The supply chain is a network consisting of several parties that is physically involved either directly or indirectly, in creating and submitting a product to the end consumer in the fulfillment of the customer's request [8]. The observed black rice supply chain depicted in Figure 1. The black rice supplied from farmers in Sleman and some parts of Central Java which is supplied in the form of grain. Then, farmer groups (Poktan) and its association of farmer groups (Gapoktan) processed the grain into black rice. Next, the black rice packages were distributed inside and outside of Sleman District such as to Semarang, Jakarta, Kalimantan, Aceh, and other areas in Indonesia.



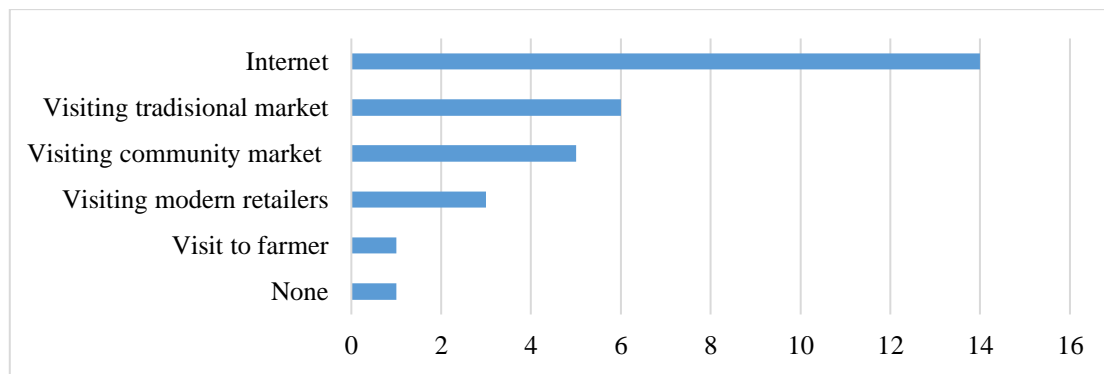
**Figure 1.** The Supply Chain in Sleman and its Surrounding

### 3.5. The Marketing

The marketing of black rice was currently done through various methods both conventional as well as online. Figure 2 shows various way how consumers looking for information about black rice. In the process of information search, the internet was chosen by most consumers (47%) .

According to consumer respondents, black rice appearance observed directly and through the screen of monitor (iPad) did not differ significantly [9]. It indicated that doing a search on the internet or by visiting to the black rice retailers directly was not different.

In addition to the appearance, the consumers were also very attentive to the product that will affect their loyalties [10], so the quality of the products and packaging must be considered in black rice marketing strategy.



**Figure 2.** Sources of consumer information searching

#### 4. Conclusion

The development of black rice in Sleman, Yogyakarta mostly continue to increase each year as shown in the production side. The suppliers must start to engage online marketing to respond many consumers tendency in searching information about black rice before buying. Aside from that, the high produce quality should be combined with proper packaging to fulfill customer's preferences. Government's role in this agroindustry is very important especially to introduce and develop black rice farming to farmers in addition to the role of private sector in the market side.

#### References

1. Nuringtyas, T. R. & Ismoyowati, D. 2016. *Development of Pigmented Rice for The Rural Community*. SEARCA Seed Fund For Research and Training (SFRT) Program, Vol 8, No 6.
2. Kristantini, Taryono, P. Basunanda, R, H. Murti, dan Supriyanta. 2012. *Morphological of Genetic Relationships among Black Rice Landraces from Yogyakarta and Surrounding Areas*. *ARNP Journal of Agricultural and Viological Science*. 7(12) : 982-989.
3. Wuryadani, Shafira. Arita, N. Dyah, I. 2016. *STP Analysis on Marketing Pigmented Rice as Functional Food*. *ICoA Conference Proceeding*.
4. Yawadio, R., S. Sanimori and N. Morita. 2007. *Identification Of Phenolic Coumpound Isolated From Pigmented Rice And Their Aldose Reductase Inhibitory Activities*. *Food Chem*. 1001(4): 1616-162.
5. Chaudhary, R.C. 2003. *Speciality rice of the world : Effect of WTIO and IPR on its production trend and marketing*. *J. Food Agric. Env*. 1 (2) : 34 – 41.
6. Anindita, K. P. Dyah, I. Endy, S. (2016) (Unpublished). *Analisis Rantai Nilai Beras Berwarna: Studi Kasus di Kabupaten Sleman D.I Yogyakarta*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.
7. Riyadi, A. Dyah, I. Kuncoro H. W. 2018 (Unpublished). *Strategi Pengembangan Kinerja Rantai Pasok Beras Hitam di Kabupaten Sleman, D.I Yogyakarta*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.
8. Chopra, S., and Meindl, P. 2013. *Supply Chain Management: Strategy, Planning & Operations Third Edition*. Pearson Prentice Hall. New Jersey.
9. Rifai, A. Dyah, I. M. Affan F.F. 2018 (Unpublished). *Analisis Preferensi Konsumen Terhadap Warna Beras Hitam di D.I Yogyakarta*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.
10. Mutmainnah, D. H. Dyah, I. Anggoro C. S. 2017 (Unpublished). *Analisis Pengaruh Perilaku Terhadap Loyalitas Pelanggan Bisnis untuk Perumusan Strategi Pemasaran Beras Berwarna*. Skripsi Departemen Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Universitas Gadjah Mada: Yogyakarta.



FP-MCI-011-ID074

# Analysis of Consumers Perceptions of the Important Factors in Soygurt Products and Marketing Strategies

Atris Suyantohadi<sup>1,\*</sup>, Mirwan Ushada<sup>1</sup>, Dody Kastono<sup>2</sup>

<sup>1</sup> Agroindustrial Department, Agricultural Technology Faculty, Universitas Gadjah Mada, Jl Flora 1, Bulaksumur, Yogyakarta, Indonesia

<sup>2</sup> Agricultural Faculty, Universitas Gadjah Mada, Jl Flora 2, Bulaksumur, Yogyakarta, Indonesia

\* Correspondence: [atris@ugm.ac.id](mailto:atris@ugm.ac.id)

Received: 14 August 2018; Accepted: 28 August 2019; Published: 6 January 2020

**Abstract:** As a source of protein, soybean is important role in improving the society's nutrition needs. Yogurt products from soy (soygurt) contain high nutrients and vitamins and are a functional food product with low prices for the community. Soygurt product necessary to be produced and disseminated to the community. This study aims to analyze consumer perceptions of soygurt products to be able to determine the priority factors and also to develop a marketing strategy plan. The methodology of consumer perceptions are determined by rating the important factors using the Fuzzy AHP (Fuzzy Analytic Hierarchy Process) method. Fuzzy AHP analyzes the problems related to consumer perceptions of attribute factors. The results of the Fuzzy AHP analysis are used as a basis for determining the internal and external strengths of SMEs by using the SWOT method. The SWOT Method is used to obtain the concept of marketing strategy. Based on Fuzzy AHP analysis, the main criteria for the preference of soygurt product attributes consist of taste, packaging, brand, main raw material and product label. Fuzzy AHP test results show that the taste of adding strawberry and mango is more preferred than the original taste, bottle packaging, and the brand soygurt product. The strategy obtained for soygurt products is a strategy to increase production volume and expand marketing networks, improve product packaging to be more attractive, set prices with cost orientation, expand information dissemination and promotion. Marketing strategies based on SWOT analysis in the results of the study showed the hierarchy that needs by producers so that these products can be accepted by consumers.

**Keywords:** Soygurt, AHP, SWOT, consumer, perception.

---

## 1. Introduction

Soybeans are rich in iron, calcium, complex vitamin B, phosphorus, and fat [1]. With the shift in consumption patterns from animal food ingredients to plant foods, soybeans have a great opportunity to develop. Soy protein has an amino acid composition that is close to the composition of the essential amino acids of milk protein [2]. On the one hand, the diversification of soybean-based food processing is still very limited. Soybean milk also contains fat, carbohydrates, calcium, phosphorus, iron, provitamin A, Vitamin B complex (except B12), and water [3]. However, the level of consumption of soy milk in Indonesia is still relatively low, especially when compared with China, the Philippines or Thailand [4]. Soy milk is soy milk which is processed by destroying soybean seeds in cold or hot water [5]. Soybean milk can be made with simple technology and equipment and does not require special skills [6]. Because of its high protein content, soy milk is the best drink to replace cow's milk products for people who have lactose and casein intolerance [7]. Besides being used as a protein source, soybeans are also processed as functional food products that can prevent the onset of degenerative diseases. One of the soy-based functional food products is yogurt products from soy milk (*Soygurt*) because in this product there are probiotic bacteria *Streptococcus thermophilus* and *Lactobacillus bulgaricus* which can improve the balance of intestinal microflora so that it can accelerate human digestion.

Increasing the economic value of post-harvest results to provide incentives for soybean farmers is important to be done through the development of production centers that process post-harvest results towards the commercialization of products in agro-industries. Supply chain management distribution in the center of soybean production in the region of Grobogan Regency, Central Java [8] has been carried out well from the level of farmers, collectors, wholesalers, and consumers both industrial consumers and community consumers. After harvesting soybean, the rural community agroindustry in processing soybeans is able to increase the economic value of the product which is quite high. The group of community members in the soybean production center in Grobogan Regency has been producing soybean processing in the form of tofu and tempeh products for generations. The development of soybean processing products in addition to tofu and tempeh in the form of industry in the community is very much needed to support the diversification of soybean processed food products in the community. Processing soybeans into *Soygurt* products is one of the alternatives to increase the post-harvest economic value into one of the healthy, nutritious and necessary vegetable food products for the community. Industrialization at the level of community business groups will result in the formulation of *Soygurt* products and their derivatives in accordance with the criteria for perceptions of consumer needs and production cost targets. Soybeans [9,10] are commodities that have very high nutritional value and are very good for fulfilling vegetable protein needs in addition to other health supporting aspects. Soybean [8] is a commodity that has a high protein content which reaches 40% which is the highest content of various other vegetable protein ingredients. In line with the development of food processing technology, soybeans are very good to be processed into healthy functional food products such as soy milk and soy yogurt (*Soygurt*) [11].

The study aims to determine the extent to which consumer perceptions of *Soygurt* products developed by Soybean Production Centers Joint Business Group of Small and Medium Enterprises (UKM KUB) are in accordance with the attributes of the factors needed and the preparation of marketing strategies. Important factors that determine consumer perception of *Soygurt* products produced are used with the Fuzzy AHP (Analytic Hierarchy Process) method. Fuzzy AHP to determine the important factor attributes by rating the priority of product factors that are in accordance with consumer perceptions (Suyatno, 2011). Furthermore, the results of the Fuzzy AHP analysis are used as a basis for determining the internal and external strengths of SMEs which will then be analyzed using the SWOT method to get the right marketing strategy [12].

## 2. Materials and Methods

### 2.1. Research Objects

The product which is the object of this research is *Soygurt* which is produced by Setia Budi SME, Grobogan Regency, Central Java. The research focused on community perceptions by sampling in the Grobogan Regency area for determining product priority ratings. Product priorities are based on consideration of marketing mix elements (Product, Price, Place, and Promotion).

### 2.2. Research Method

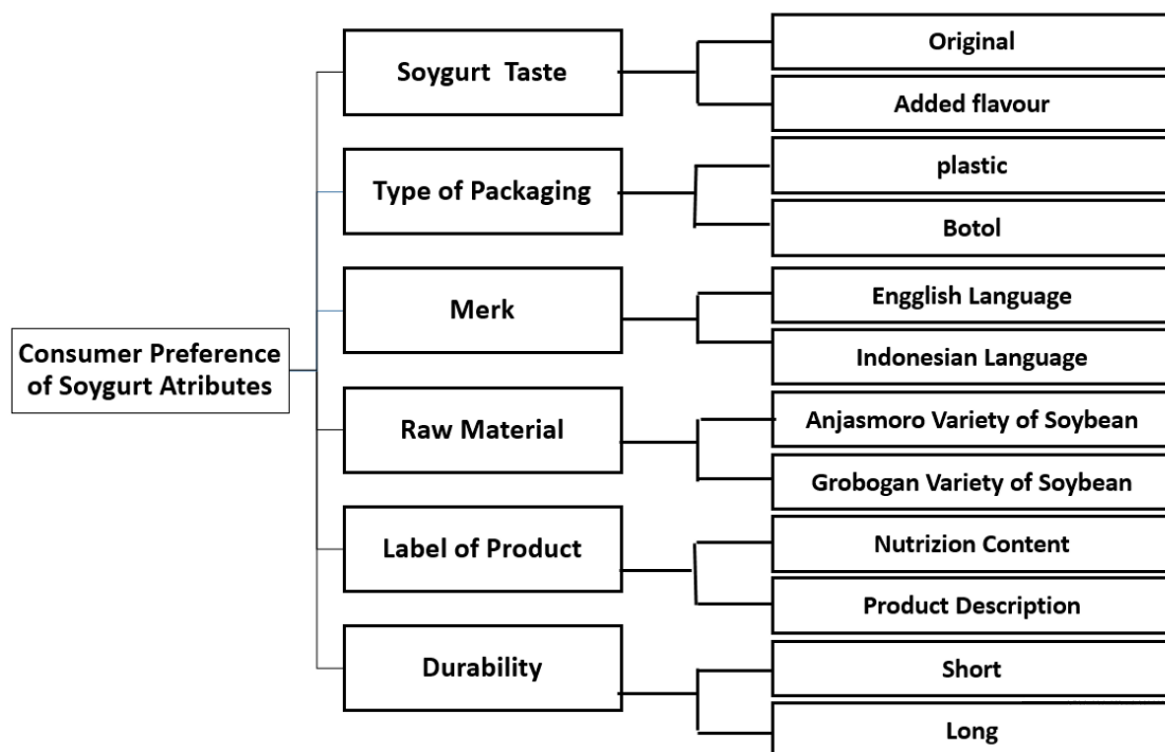
In this research, data collecting technique was done through the interview and questionnaire. The AHP questionnaire aims to determine the priority rating of *Soygurt* products and the SWOT questionnaire is used in the preparation of the strategy. The AHP questionnaire respondents in this study were people who had consumed *Soygurt* in the Grobogan Regency. The sample collecting technique used in this study was nonprobability sampling, which is a sampling technique that gives an unequal opportunity or opportunity for each element or member of the population to be selected as a sample. Furthermore, the method used was purposive sampling, which is the determination of samples for specific purposes only.

### 3. Result and Discussion

#### 3.1. Product Attributes Preference

Products are a set of tangible and intangible attributes [13]. While attributes are specific characteristics or certain characteristics designed in a product or service. Therefore, the product attributes of *Soygurt* are important to be noticed by producers so that their products are preferred by consumers in the market. Consumer preference [14] is a choice that is preferred by consumers compared to other types of choices. Consumers will prefer a *Soygurt* product because it is seen as giving more satisfaction preference to them. One of the consumers' consideration in choosing *Soygurt* products is *Soygurt* product attribute variables to be chosen. Consumers will tend to choose *Soygurt* products that have attributes according to their tastes. The consumer of *Soygurt* products who become respondents will compare a *Soygurt* product attribute with other attributes in the questionnaire with a value scale of 1-9. The results from the questionnaire and the processing were carried out by using Fuzzy AHP method. This method produces a sequence of *Soygurt* product attributes that are more important to consumers so that it can be input for Setia Budi SMEs in increasing marketing and sales activities of *Soygurt*.

The criteria of consumer preference for *Soygurt* products in Fuzzy AHP are the preferred attributes of *Soygurt* products, consisting of the attributes of taste, packaging, brand, main raw material, product shape, and durability. Taste attributes are an important factor in consumer preferences to assess a product [15, 16]. Beauty in packaging is a visual attraction that includes consideration of the use of colors, shapes, brands, or logos, illustrations, letters, layouts or layouts. A brand is a name or term to refer to a product and distinguish it from its competitors [15,17]. *Soygurt* is a yogurt product used with soybean raw materials. The use of several ingredients added more for the purpose of producing the different taste and flavor of *Soygurt* products such as strawberry, mango. Then the criteria are lowered into several sub-criteria. The consumer preference for *Soygurt* product attributes in Fuzzy AHP method as stated in Figure 1.



**Figure 1.** The Hierarchy of Consumer Preference on Soygurt Attributes

### 3.2. Questionnaire Composing

The assessment of consumer preferences through attributes of the factors that are emphasized in *Soygurt* products was done by filling out a questionnaire as a tool for data collection. In the main criteria section, the question comparing one *Soygurt* product attribute with other attributes was calculated in pairs. The questions used in the questionnaire are closed questions with a scale of 1-9.

### 3.3. Fuzzy AHP Testing

Fuzzy AHP that had been compiled was then carried out the testing phase of the results of the results of the calculation of the questionnaire obtained. The results of filling out the questionnaire from consideration of respondents preferences through Fuzzy AHP testing are needed for the sake of analysis of the results obtained. The results of filling in the main criteria and sub-criteria will then be formed into a pairwise comparison matrix. Furthermore, Fuzzy AHP testing is done through fuzzification calculation, ratio consistency, and defuzzification stages.

### 3.4. Main Criteria

The main criteria for *Soygurt* product attribute preferences consist of taste, packaging, brand, local soybean raw material, product shape, and durability of *Soygurt* products. This main criterion is the main consideration of a consumer in choosing *Soygurt* products produced by SMEs.

#### 3.4.1. Consistency Ratio Measurement

Consistency ratio (CR) is calculated to show the ability of respondents to compare the criteria used in pairwise comparisons of the attributes of consumer preferences taken into account. Consistency ratio is used to overcome the inconsistencies of respondents in comparing many criteria. A high CR value illustrates that the respondent's answer is less consistent, while the smaller CR value shows the consistent consistency of answers. A respondent is stated to be consistent if he has a CR value below 0.1. While for respondents who are inconsistent (CR value above 0.1), the results of the assessment of the questionnaire are declared null or not used in the next stage. Table 1 states that the pairwise comparison matrix of the respondents on the attributes given was assessed.

**Table 1.** Paired comparison matrix of respondents

Criteria	Taste	Type of Packaging	Merk	Raw Material	Product Label	Durability
Taste	1	3	5	3	5	1
Type of Packaging	1/3	1	7	1/3	5	1
Merk	1/5	1/7	1	1/5	1/3	1/7
Raw Material	1/3	3	5	1	5	1/5
Product Label	1/5	1/5	3	1/5	1	1/5
Durability	1	1	7	5	5	1

Source: data processing, 2017

Obtained from data processing the CR value obtained is less than 0.1 so it can be concluded that the results of the respondents' questionnaire are consistent for use. Furthermore, the Fuzzy AHP calculation is performed which shows that at this testing stage, the respondent chooses flavor attributes as the main consideration when choosing *Soygurt* products. The next consecutive product attributes that are prioritized by consumers are durability, packaging form, brand, raw material, and finally the *Soygurt* product label.

Taste is the main criterion that is most important for consumers in choosing a *Soygurt* product. Consumers will prefer *Soygurt* if the taste of *Soygurt* products is as expected and able to provide

maximum satisfaction. If the taste of *Soygurt* is not met, then it can be ascertained that consumers will not choose *Soygurt* products or are not interested in repurchasing. The second important criterion is the durability of the product. Good product durability will ensure consumers get the highest quality *Soygurt* products when consuming them. The third important criterion is the type of packaging. Packaging is a consumer attraction when choosing a *Soygurt* product. Unique types of packaging will be more noticed by consumers and have a greater chance of being selected. The fourth important product attribute is the brand. Brands describe a *Soygurt* product briefly and clearly so that a consumer will more easily recognize the product he likes. The fifth and sixth attributes are raw materials and product labels. Consumers do not think too much about these two product attributes as long as they get satisfaction from the *Soygurt* flavor they offer.

### 3.5. Sub Criteria

#### 3.5.1. Consistency Ratio

The measurement of consistency ratio in the sub criteria was done in the same way as in the main criteria. The aim is to ensure that the data processed using Fuzzy AHP comes from respondents who are able to answer questionnaires consistently. Before calculating consistency ratios, answers from respondents were formed into pairwise comparison ratio matrices Table 2 and Table 3.

**Table 2.** Paired comparison matrix of Product Taste

Taste	Original	Adding Flavour
Original	1	1/8
Adding Flavour	8	1

Source: Data Processing, 2017

**Table 3.** The Result of Consistency Rasio (CR)

Taste	Original	Adding Flavour	Weight
Original	1	1/8	0,111
Adding Flavour	8	1	0,889
$\lambda \max = 5,0625$ C.I. = 3,0625 R.I.= 0 C.R. = 0			

The CR value obtained is less than 0.1 so it can be concluded that the results of questionnaire 1 respondents are consistent. Meanwhile, the sub-criteria only compares 2 criteria. For example, the taste criteria only compare the original flavor and the addition of strawberry flavor. This condition makes a person be consistent in making choices. Viewed from the calculation side, in the random index table, the number of criteria 2 has the value of R.I. 0 so that the results of the C.I calculation divided by R.I. will get a CR value of 0 which means consistent. As a result, all respondents who answered the sub-criteria question were stated to be consistent. The results of filling out the sub-criteria questionnaire are then converted into fuzzy forms through the fuzzification process. Table 4.

**Tabel 4.** The Result of Fuzzy AHP on Sub Criteria

Criteria	Sub Criteria	Weight	Rank
Taste	Original	0,457357	2
	Adding Flavour	0,542643	1
Type of	Plastic	0,342199	2
Pacaking	Bottle	0,657801	1
Merk	Indonesia Language	0,394801	2
	English Language	0,605199	1
Raw Material	Anjasmoro Variety of Soybean	0,522052	1

**Table 4.** The Result of Fuzzy AHP on Sub Criteria (continued)

Criteria	Sub Criteria	Weight	Rank
Raw Material	Grobogan Variety of Soybean	0,477948	2
Product Label	Nutriiton Content	0,48797	2
	Product Descriptiont	0,51203	1
Durability	Short	0,372577	2
	Long	0,627423	1

The output of the Fuzzy AHP test shows that the taste of adding strawberries to *Soygurt* is preferable to the original taste. The choice of the flavor of strawberry addition can be affected because it is sweeter and more fragrant in the *Soygurt* that has been made. This choice of taste must be considered well by the manufacturer considering the flavor attribute as the most important attribute of consumers in choosing *Soygurt* products. Second, the type of bottle packaging is preferred by the respondent. This choice can be influenced because in the market *Soygurt* products have not been found with a variety of attractive designs and of course with bottle packaging proved to be able to maintain the quality of the product itself. Third, respondents prefer brands using foreign language terms. Brands with foreign language terms in the market are generally shorter and easier to remember by consumers so that they become more attractive. Fourth, the raw material for pure corn is chosen by the respondents. Fifth, the *Soygurt* product label that is preferred by respondents is displaying nutritional composition and description of *Soygurt* products. This type of consumer assesses that bottle packaging provides a more attractive product appearance. And finally, respondents prefer *Soygurt* products with long-lasting durability. Long durability makes a consumer able to buy large quantities of products for a long period of time so that they can save time and cost of purchase.

### 3.6. Marketing Strategy Analysis with SWOT Matrix

Strengths, weaknesses, opportunities and potential threats of *Soygurt* products are carried out through analysis using the SWOT method. SWOT analysis compares the external factors of opportunities and threats with internal factors of strength (weakness) and weakness (weakness). SWOT analysis systematically identifies various factors to formulate a company strategy. Analysis of internal factors is obtained from interviews and observations which are the identification of the factors that influence the success of the marketing of the instant corn rice industry. This complete internal environmental analysis can be seen in Table 5 and for its external environmental analysis in Table 6.

**Table 5.** Intern Environment Analysis

No	Items	Strength	Weakness
1.	The Advantage of Soygurt Product	√	
2.	Good quality	√	
3.	Good Product Price	√	
4.	Good packaging		√
5.	Soygurt product still needed promotion and communication for marketing		√
6.	Limited budgeting for SME		√
7.	Financial administration is still not done well		√
8.	Traditional Equipment in SME		√
9.	Good Cooperation between sellers and buyers	√	
10.	SMEs needed to improving and developing	√	
11.	SMEs have regular customers	√	



**Table 6.** Eksternal Environment Analysis

No	Items	Opportunity	Threat
1.	<i>Market leader</i>	√	
2.	Product competitor		√
3.	Difficulty for permanent worker		√
4.	The same of raw material used by Industry		√
5.	The development of Information System	√	
6.	Processing Technology Development	√	
7.	High Demand	√	
8.	Goverment Policy for increasing cost of gasoline or diesel raw material		√
9.	Climate Change		√
10.	Broad marketing area	√	

### 3.6.1. Determination of alternative strategies using the SWOT matrix.

This SWOT matrix contains four alternative strategies [12], where each strategy attempts to use strengths and opportunities to overcome weaknesses and threats. Based on the results of the determination of the strategies obtained for *Soygurt* products include:

#### 3.6.1.a. SO (Strengths-Opportunities) Strategy

The SO strategy is to use the power to take advantage of existing opportunities, can be formulated as follows:

- Increasing production volume
- Expanding the marketing network

#### 3.6.1.b WO (Weaknesses-Opportunities) Strategy

The WO strategy is to correct weaknesses to take advantage of existing opportunities, can be formulated as follows:

- Improving the type of product packaging to make it more attractive
- Maximizing promotions and streamlining production
- Improving the system and financial management

#### 3.6.1.c ST (Strengths-Threats) Strategy

The ST strategy is to use the power to anticipate or avoid threats that can be formulated as follows:

- Improving a comfortable working atmosphere in SMEs
- Setting the prices with a cost orientation

#### 3.6.1.d WT (Weaknesses-Threats) Strategy

The WT strategy is to improve weaknesses to overcome existing threats, can be formulated as follows:

- Expanding the information dissemination, promotion, and communication
- Renewing the production system

## 4. Conclusion

The results of the consumer preference that are prioritized on *Soygurt* product attributes in Setia Budi Small and Medium Enterprises have been obtained from research conducted so that these products can be accepted in the market and alternative strategies that need to be done by SMEs so that instant corn rice products are accepted by the market. The main criteria for *Soygurt* product attribute preferences consist of taste, type of packaging, brand, main raw material, product label, and product

durability. Testing the results of Fuzzy AHP shows that the taste of adding strawberries to *Soygurt* is more preferred than the original taste. The choice of preference prefers the type of bottle packaging, the brand uses foreign language terms, Anjasmoro local soybean raw material and instant corn rice products with long-lasting durability. The strategy obtained for *Soygurt* products is SO strategy on increasing production volumes and expanding marketing networks, WO strategy on improving the type of product packaging to be more attractive, maximizing promotion and streamlining production, system improvement, and financial management, ST strategy is carried out on building a comfortable working atmosphere in SMEs and setting prices with cost orientation, and WT's strategy to expand information dissemination, promotion and communication and renew the industrial systems.

## References

1. Radiyati, T. 1992. *Pengolahan Kedelai*. [Soybean Processing], BPTTG Puslitbang Fisika Terapan – LIPI. Subang.
2. Smith, AK., dan S.J. Circle, 1972. *Soybean Chemistry and Technology*, Vol. 1. The AVI Publishing Co. Inc., Westport, Connecticut.
3. Astuti, Dewi Herawati dan Arif, D. Wibawa. 2012. Pengaruh Konsentrasi Susu Skim dan Waktu Fermentasi Terhadap Hasil Pembuatan Soyghurt. [Effect of Skim Milk Concentration and Fermentation Time on Results of Soyghurt Production]. *Jurnal Ilmiah Teknik Lingkungan [Scientific Journal of Environmental Engineering]* Vol. 1 No. 2. Universitas Setia Budi; Surakarta
4. Ginting, Erlina, Satya, Sri Antarlina dan Widiowati, Sri. 2009. Varietas Unggul Kedelai Untuk Bahan Baku Industri Pangan [Superior Soybean Varieties for Food Industry Raw Materials], *Jurnal Litbang Pertanian [Agricultural Research and Development Journal]*, 28(3), 2009. Malang
5. Jumadi. 2009. Pengkajian Teknologi Pengolahan Susu kedelai [Assessment of Processing Technology for Soy Milk], dalam [in] Kartasasmita, Unang G., etal. *Buletin Teknik Pertanian [Agricultural Engineering Bulletin]* (Vol. 14, no. 1, hal. 34-36). Badan Penelitian dan Pengembangan Pertanian [Agricultural Research and Development Institution], Departemen Pertanian [Agricultural Department]: Jakarta.
6. Esti dan Sediadi. 2000. Susu kedelai. [Soybean Milk] Accessed on 26 November 2015, [http://www.warintek.riset.go.id/pangan\\_kesehatan/pangan/piwp/susu\\_kedelai.pdf](http://www.warintek.riset.go.id/pangan_kesehatan/pangan/piwp/susu_kedelai.pdf).
7. Drake, M., Cheng, X., Tamarapu, S. dan Leenanon, B., (2000). Soy protein fortification affects sensory, chemical, and microbiological properties of dairy yogurts. *Journal of Food Science*, 65(7): 1244-1247.
8. Endang, S.R. Kusnandar, J. Sutrisno, 2014, *Analisis Efisiensi Rantai Pasok Kedelai di Kabupaten Grobogan [Efficiency Analysis of Soybean Supply Chain in Grobogan Regency]*. Laporan Penelitian Hibah Pasca Sarjana [Post Graduated Grants Report], Universitas Sebelas Maret, Surakarta
9. Deddy M, 2010, *Kedelai komponen untuk Kesehatan [Soybean Component for Health]*, Penerbit Alfabeta, Jakarta
10. Wisnu C, 2007, *Kedelai Khasiat dan Teknologi [Soybean Benefits and Technology]*, Penerbit Bumi Aksara, Jakarta
11. Suyantohadi, A, 2012, *Desain dan Pengembangan Produk Susu Kedelai Bubuk berdasarkan Kriteria Persepsi Konsumen dan Target Costing dengan Integrasi Metoda Fuzzy Logic dan Value Engineering [Design and Development of Powdered Soy Milk Products based on Criteria for Consumer Perception and Target Costing with Integration of Fuzzy Logic Methods and Value Engineering]*, Laporan Penelitian Sekolah Vokasi D3 Agroindustri [Vocation Departement of Agroindustry], Universitas Gadjah Mada, Yogyakarta
12. Rangkuti, Freddy. 2006. *Analisis SWOT Teknik Membedah Kasus Bisnis, [SWOT Analysis of Business Case Techniques]*, PT Gramedia Pustaa Utama. Jakarta.
13. Shinta, Agustina. 2011. *Manajemen Pemasaran. [Marketing Management]*, Universitas Brawijaya Press. Malang.
14. Kotler, Philip dan Keller, Kevin Lane. 2009. *Manajemen Pemasaran. [Marketing Management]*, Edisi kedua belas, Jilid 1 [12 Edition, Jilid 1], PT Indeks. Jakarta.
15. Jansen, A. 2012. *Pengaruh Atribut Mutu Produk Terhadap Minat Beli Ulang Keripik Maich [The Influence of Product Quality Attributes to Interest in Repurchasing Maich Chips]*. Depok : Universitas Indonesia.
16. Mustafid & Gunawan, A. 2008. Pengaruh Atribut Produk Terhadap Keputusan Pembelian Kripik Pisang "Kenali" [The Effect of Product Attributes on the Decision to Purchase Banana Chips "Kenali"] Pada Pd Asa Wira Perkasa Di Bandar Lampung. *Jurnal Bisnis dan Manajemen*. Vol 4. No. 2, Hal 123-140
17. Stanton, W.J. (1993). *Marketing Management*. Jilid 1, Edisi 7. Jakarta: Erlangga.

© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the



Creative Commons Attribution (CC BY) license  
(<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-012-ID026

# The Effectiveness of Instagram Use in Florist Marketing

Geraldo Herawan <sup>1</sup>, Suharno <sup>2</sup> and Nafis Khuriyati <sup>2,\*</sup>

<sup>1</sup> Alumni of Agro-industrial Technology Department, Faculty of Agricultural Technology, UGM Yogyakarta; [geraldherawanf@gmail.com](mailto:geraldherawanf@gmail.com)

<sup>2</sup> Lecturer of Agro-industrial Technology Department, Faculty of Agricultural Technology UGM Yogyakarta; [suharno@ugm.ac.id](mailto:suharno@ugm.ac.id); [nafis.khuriyati@ugm.ac.id](mailto:nafis.khuriyati@ugm.ac.id)

\* Correspondence: [suharno@ugm.ac.id](mailto:suharno@ugm.ac.id) ; Tel.: +62-815-793-8741

Received: 9 July 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** Instagram is increasingly used by entrepreneurs to market their products. Some flower shops in Yogyakarta have used Instagram to market their products. The effectiveness of Instagram use in marketing has not been much known, so it is necessary to do research to know the effectiveness of Instagram in florist marketing. This study also measures the level of customer satisfaction based on 7P variables. This research positions Atelier Hanabira as the main object, followed by Floweridea and Mekar Florist. This study was conducted with a survey of 241 respondents to measure the effectiveness of Instagram and 255 respondents to measure the level of customer satisfaction. The sampling technique used is purposive sampling. Instagram's effectiveness as a marketing medium uses Customer Response Index (CRI) method and measurement of consumer satisfaction level using Customer Satisfaction Index (CSI) and Importance Performance Analysis (IPA). The results showed that the measurement of CRI Instagram on Atelier Hanabira was quite effective. While the CRI measurements on Floweridea and Mekar Florist are not effective. The value of CSI Atelier Hanabira is 72%, this value belongs to the "satisfied" category. There are 5 variables in the first quadrant of IPA diagram that need to be considered.

**Keywords:** Florist; Effectiveness; Instagram; Consumer satisfaction; AISAS; CRI; CSI; IPA

---

## 1. Introduction

Internet technology is growing rapidly in helping people's daily lives. Sellers and buyers use online applications to offer and shop goods. The purchase process is made easy by the availability of social media applications such as Instagram and Facebook. Digital communication using the internet and social media makes it very easy for customers to get information on the marketed products. Content facilities and conversations on social media are useful as communication media in various marketing activities. There are 700 million Instagram users, around 60 million photos are shared every day and reach 1.6 billion users like [1]. Instagram has great capabilities that can be used by companies to introduce their products to customers. One of Instagram's business users is the cut flower business and flower arrangement services. The development of cut flower business is related to the consumer mindset about beauty and aesthetics. When consumers type "florist Jogja" on the Instagram Search menu, consumers can find around 50 florist accounts in Yogyakarta. Atelier Hanabira is a florist located in Yogyakarta. Atelier Hanabira relies on Instagram for marketing activities and a means to introduce products to the public. This research put Atelier Hanabira as the main object, Floweridea and Mekar Florist as a comparison. These three florists have similarities in managing customers with Instagram. Atelier Hanabira and Floweridea have implemented the Instagram Business while Mekar Florist hasn't. The AISAS concept (Attention–Interest–Search–Action–Sharing) was successfully used to determine the effectiveness of Line as a medium to convey messages in the campaign [2]. The AISAS concept was used to determine the effectiveness of advertisements (promotions) and Line Shopping. The results

showed that the Customer Response Index (CRI) with the AISAS concept was claimed quite effective [3]. Thus, this study was conducted to determine the effectiveness of the use of Instagram as a florist marketing medium by using the Customer Response Index (CRI) method with the AISAS concept. Consumers will make positive recommendations when they are satisfied with the products and services they receive [4]. Therefore, analysis of customer satisfaction needs to be done to determine the level of customer satisfaction and to find out which variables have high priority for improving performance. Customer satisfaction is a function of product performance and consumer expectations. If product performance meets expectations, consumers will be satisfied. Satisfied consumers might repurchase and recommend these products to other consumers. So, it is important to measure the level of customer satisfaction using Instagram as a florist marketing medium. This study aims to (1) measure the effectiveness of Instagram usage as a marketing medium; (2) measure the level of customer satisfaction based on 7P variables (product, price, place, promotion, people, process, and physical evidence).

The florist business is promising and has good business prospects. Florist is a term used to describe the flower trade professionally including flower care and flower arrangement [5]. Social media is becoming popular because people can connect with each other in a variety of Interests including business activities. One most used popular social media is Instagram. Instagram provides space for users to present themselves and communicate to the public using photos and videos, assisted by text to write [6]. Effectiveness is basically related to output, namely the goals or objectives to be achieved [7]. Duriyanto, et al (2003) say that effective advertising makes the message delivered easy to digest and understand. Consumer satisfaction can be known after consumers use products and services. Customer satisfaction is evaluation after comparing what consumers feel with their expectations. Consumer satisfaction is what is felt for the use of products and services, the same or exceeds expectations [8]. Customer satisfaction is a function of views about product performance and consumer expectations. If performance meets expectations, then consumers will be satisfied. Satisfied consumers have the potential to make repeat purchases and recommend others to buy products [4].

Dentsu (2004) explains the use of a new consumer behavior model, namely AISAS (Attention, Interest, Search, Action, and Share). AISAS is the process of a consumer paying Attention to a product (Attention) and an Interest (Interest) arises from the product. Then collect all kinds of information (Search) about the product. After that, consumers make an assessment based on the information previously collected. If consumers are Interested in buying after Searching, the consumer will make a purchase. After the purchase process, consumers will deliver information to others by sending comments and talking in cyberspace (sharing) [9]. AISAS modeling is a nonlinear modeling that can be seen in Figure 1. With the existence of AISAS, companies are advised not to rely on advertising only but also to maintain the relationship between consumers and companies.

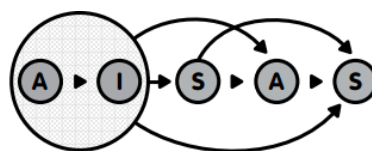


Figure 1. AISAS Model

## 2. Materials and Methods

This research used three florist companies Atelier Hanabira, Floweridea, and Mekar Florist where they all are located at Yogyakarta. All related data were collected from observation, interviews, and questionnaires. Respondents are those who have interacted with the three florists.

Customer Response Index (CRI). CRI is a tool to measure the effectiveness of communication carried out by advertisers. This CRI is the result of a link between awareness (awareness), comprehend (consumer understanding), Interest (Interest), intentions (intent to buy), and Action (purchase Action). CRI displays the purchasing process that starts from the emergence of consumer awareness, until finally consumers make purchase Actions (Duriyanto, 2003). The CRI model shown in Figure 2.

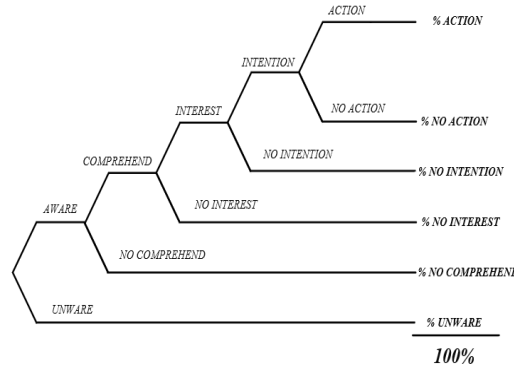


Figure 2. CRI Model

### 2.1. Importance Performance Analysis (IPA).

IPA can be used to analyze customer satisfaction [10]. This method measures the level of customer Interest in relation to what should be done by the company in order to produce high quality products or services. IPA combines measurement of importance and satisfaction levels in two-dimensional graphs. This IPA graph is divided into four quadrants as seen in Figure 3.

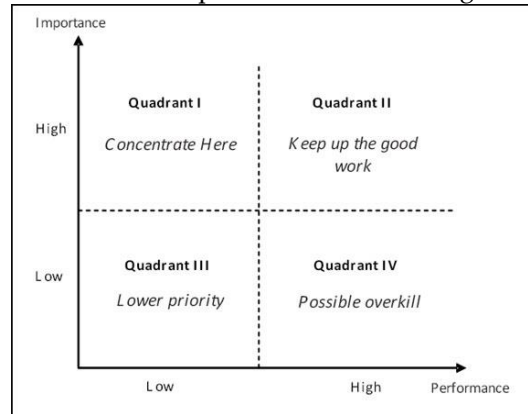


Figure 3. Importance Performance Analysis (IPA)

Quadrant I shows the factors that are considered to have a high level of importance but these factors still cannot satisfy customers. Quadrant II shows the elements of the product or service that the company has successfully carried out. Factors in this area are considered very important and very satisfying to customers. Quadrant III shows the factors that are considered less important to the customer and the implementation is normal. Quadrant IV shows the factors that affect customers are less important but the implementation is excessive.

Customer Satisfaction Index (CSI). CSI analysis is used to determine the level of overall customer satisfaction by considering the level of importance and level of performance of the quality of the attributes of the goods or services tested. Steps below are used in the CSI analysis:

1. Mean Importance Score (MIS) and Mean Satisfaction Score (MSS), Equation 1.

$$MIS = \frac{\sum_{i=1}^n Y_i}{n} \quad \text{and} \quad MSS = \frac{\sum_{i=1}^n X_i}{n} \quad (1)$$

Where:

$Y_i$  = Value of Interest Attribute to  $i^{\text{th}}$

$X_i$  = Value of Attribute Performance to  $i^{\text{th}}$

$N$  = Number of Respondents

2. Weighting Factor (WF), Equation 2.

$$WF = \frac{MIS_i}{Total\ MIS_i} \times 100\% \quad (2)$$

Where:

WF = Weighting Factors

MIS = Mean Important Score

i = Attribute to  $i^{th}$

3. Weighted Score (WS), Equation 3.

$$WS = MSS \times WF \quad (3)$$

Where:

WS = Weighted Score

WF = Weighting Factors

MSS = Mean Satisfaction Score

4. Customer Satisfaction Index (CSI).

CSI value in the form of a percentage that measures the level of customer satisfaction at Atelier Hanabira. Determination of satisfaction by matching the CSI value with the criteria as shown in Table 1. CSI is calculated using Equation 4:

$$CSI = \frac{\sum_{i=1}^p WS_i}{HS} \times 100\% \quad (4)$$

Where:

CSI = Customer Satisfaction Index

WS = Weighted Score

HS = Highest Score

**Table 1.** Customer Satisfaction Index (CSI) Criteria

Index Value (%)	Customer Satisfaction Index Criteria
81,00 – 100,00	Very satisfied
66,00 – 80,99	Satisfied
51,00 – 65,99	Quite satisfied
35,00 – 50,99	Less satisfied
0,00 – 34,99	Not satisfied

This study used Atelier Hanabira as the main object, while Floweridea and Mekar Florist were the comparison objects. This study includes observation, interviews with owners, questionnaires distribution for customers, and data analysis. The population used were consumers who knew Atelier Hanabira, Floweridea, and Mekar Florist from Instagram. Purposive sampling was used where the number of consumers who know the three florists was uncertain. The measurement of the sample size follows author [11] with the appropriate sample size (observation data) between 100-200 respondents, Equation 5.

$$n = 5 \times N \text{ to } 10 \times N \quad (5)$$

Where:

n = Number of samples

N = Number of variables

Variables used were 13 for measuring effectiveness of Instagram usage and 27 for measuring customer satisfaction. Thus, a decent sample size based on the criteria follows Equations 6 and 7:

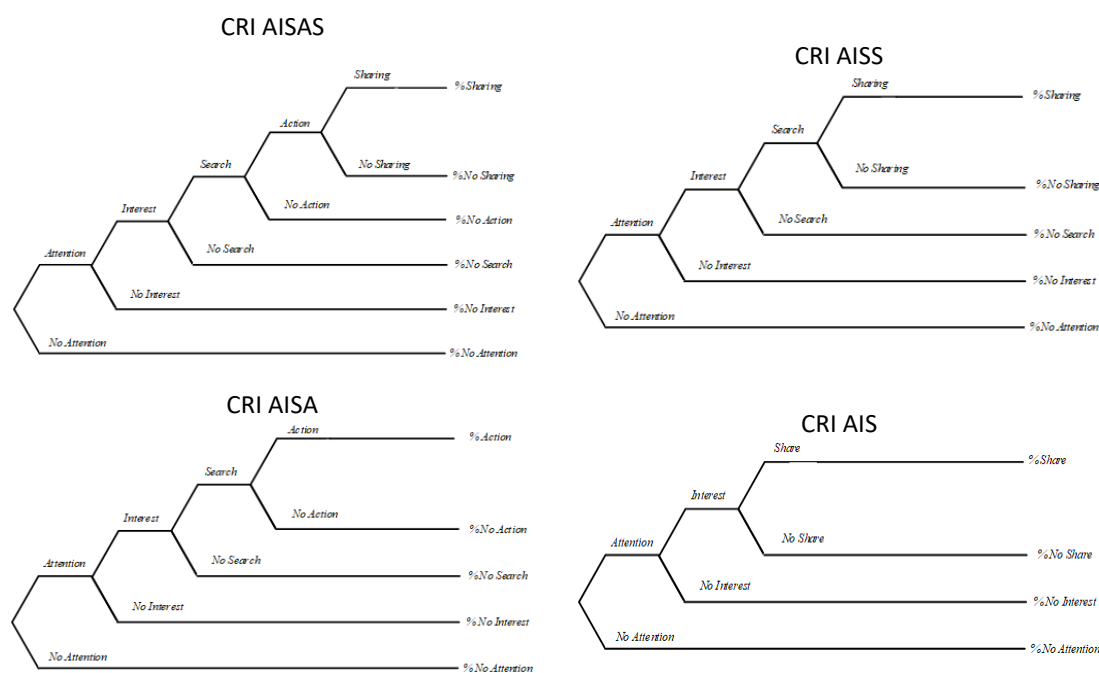
$$n = 5 \times 13 \text{ to } 10 \times 13 = 65 \text{ to } 130 \quad (6)$$

$$n = 5 \times 27 \text{ to } 10 \times 27 = 135 \text{ to } 270 \quad (7)$$

The number of 65 respondents for the effectiveness of Instagram and 135 respondents for the level of satisfaction were considered sufficient. The use of these 13 variables is based on 5 main AISAS variables (3 Attention, 4 Interests, 2 Searches, 2 Actions, and 2 Shares) and 27 variables based on 7 main variables 7P (8 products, 3 prices, 3 promotions, 2 places, 5 people, 5 process, 1 physical evidence).

Calculation of the effectiveness of Instagram social media for marketing Atelier Hanabira using a modified CRI. It consists of awareness (awareness), comprehend (understanding of consumers), Interest (Interest), intentions (intentions to buy), and Actions (purchase Actions) that are modified to AISAS consisting of Attention, Interest, Search, Action, Share. Modified CRI was used because social media is interpersonal which will be effective when customer willing to Share [2].

The AISAS concept is not linear that can be modified into 4 models: CRI AISAS (Attention–Interest–Search–Action–Share), CRI AISS (Attention–Interest–Search–Share), CRI AISA (Attention–Interest–Search–Action), and CRI AIS (Attention–Interest–Share), shown in Figure 4.



**Figure 4.** Four CRI AISAS Models

Formula to calculate CRI (Durianto, 2003):

AISAS CRI = Attention × Interest × Search × Action × Share

CRI AISS = Attention × Interest × Search × Share

CRI AISA = Attention × Interest × Action × Share

CRI AIS = Attention × Interest × Share

### 3. Results and Discussion

#### 3.1. Industrial Profile

Atelier Hanabira is one of the florists in Yogyakarta that has used Instagram as their marketing medium since the company was founded. In the first six months, they only rely on online sales, then they open their offline store. Atelier Hanabira's expertise not only arranges flowers on media buckets but also on various other media such as flower crowns, flower boxes, flower frames, flower jar, artificial flowers, decorations for weddings, and wedding equipment. The segmentation of Atelier Hanabira is middle to upper class society. The target market for this business is young people, especially college



students and socialites. Atelier Hanabira positioned itself as a flower design studio located in Yogyakarta.

### 3.2. CRI at Atelier Hanabira

Before calculating CRI at Atelier Hanabira, it is necessary to know the customer's response from the results of the questionnaire as in Table 2.

**Table 2.** Customer Response Atelier Hanabira

No.	Variable	Customer Response	Portion of Customer Response
1	Attention	Attention	96.92%
		No Attention	3.08%
2	Interest	Interest	93.85%
		No Interest	6.15%
3	Search	Search	70.77%
		No Search	29.23%
4	Action	Action	65.00%
		No Action	35.00%
5	Share	Share	66.92%
		No Share	33.08%

Based on the data in Table 2, the calculations are continued to obtain CRI\_AISAS, CRI\_AISS, CRI\_AISA, and CRI\_AIS

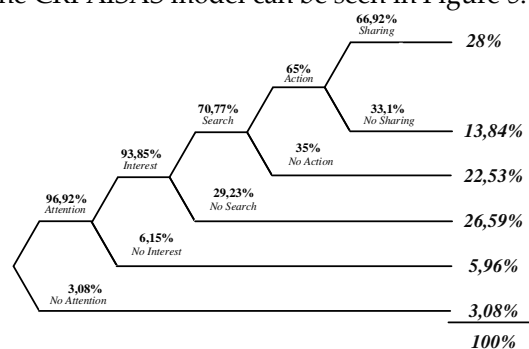
#### 3.2.1. CRI\_AISAS

In addition to calculating the final results of the model, the percentage of consumers who reach the Action stage through the stages of Attention, Interest and Search will also calculate the percentage of consumer number who have No Action, No Search, no Interest, and no Attention. CRI\_AISAS calculation results can be seen in Table 3.

**Table 3.** CRI Calculation for AISAS Model at Atelier Hanabira

No.	Variable	Formula	Calculation	Result
1	AISA	Attention x Interest x Search x Action	$96.92\% \times 93.85\% \times 70.77\% \times 65\%$	41.84%
2	No Action	Attention x Interest x Search x No Action	$96.92\% \times 93.85\% \times 70.77\% \times 35\%$	22.53%
3	No Search	Attention x Interest x No Search	$96.92\% \times 93.85\% \times 29.23\%$	26.59%
4	No Interest	Attention x No Interest	$96.92\% \times 6.15\%$	5.96%
5	No Attention	No Attention	3.08%	3.08%

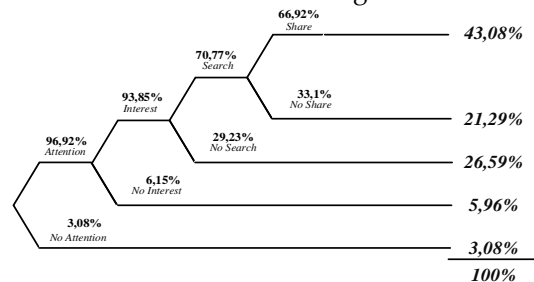
After the above calculation is complete, the calculation results are included in the CRI model structure. The structure of the CRI AISAS model can be seen in Figure 5.



**Figure 5.** CRI AISAS Model at Atelier Hanabira

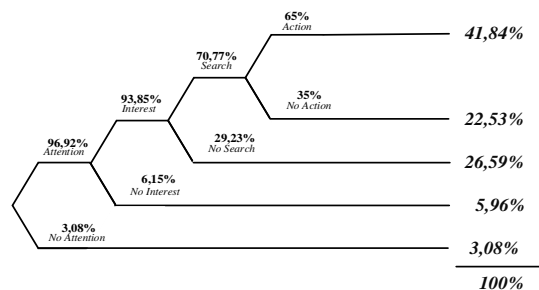
## 3.2.2. CRI\_AISS

In addition to calculating the final model results, the percentage of consumers who reach the stage of sharing through the stages of Attention, Interest, and Search, will also calculate the percentage of consumers who have No Action, No Search, no Interest, and no Attention. The calculation results are included in the CRI model structure that can be seen in Figure 6.

**Figure 6.** CRI AISS Model at Atelier Hanabira

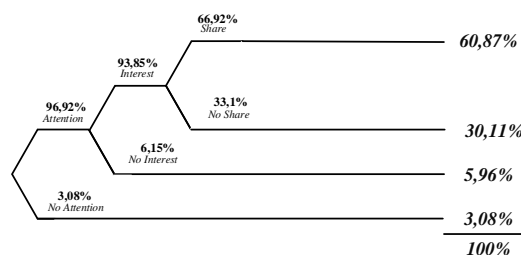
## 3.2.3. CRI\_AISA

Final results of the model, the percentage of consumers who reach the Action stage through the stages of Attention, Interest, and Search. The percentage of consumers with No Action, No Search, no Interest, and no Attention. The calculation results then are included in the CRI model structure shown in Figure 7.

**Figure 7.** CRI AISA Model on Atelier Hanabira

## 3.2.4. CRI\_AIS

In addition to calculating the final model results, the percentage of consumers who reach the stage of sharing through the stages of Attention, Interest, will also calculate the percentage of consumers who no Share, no Interest, and no Attention. The calculation results are included in the CRI model structure as shown in Figure 8.

**Figure 8.** CRI AISS Model on Atelier Hanabira

This research aims to find out the effectiveness of Instagram use as a marketing tool for florist products. It was found that the use of Instagram for florist marketing "Atelier Hanabira" was quite

effective on AISAS, AISS, AISA, and AIS. The percentage of respondents in each model were higher than the no Attention, no Interest, No Search, No Action, and no Share that can be seen in Table 7.

**Table 7.** CRI-AISAS Measurement Results at Atelier Hanabira

	<b>AISAS</b>	<b>AISA</b>	<b>AISS</b>	<b>AIS</b>
	<b>28%</b>	<b>41.84%</b>	<b>43.08%</b>	<b>60.87%</b>
	<b>Higher than</b>			
No Share	13.84%		21,29%	30,11%
No Action	22.53%	22.53%		
No Search	26.59%	26,59%	26,59%	
No Interest	5.96%	5,96%	5,96%	5,96%
No Attention	3.08%	3,08%	3,08%	3,08%

In the measurements of CRI\_AISAS (Attention–Interest–Search–Action–Share), the respondents who reached the Share by Action and Search first of 28.00%, there are still 72.00% respondents who were still able to achieve or who have not Share yet. At CRI\_AISA (Attention–Interest–Search–Action), the respondents who reached the Action stage through the Search phase without the Share of 41.84%, there are still 58.16% respondents who can still be achieved or who have not yet done Search. At CRI\_AISS (Attention–Interest–Search–Share), the respondents are up to the Share without doing the Action but doing a Search of 43.08%, there are still 56.92% respondents who are still able to achieve or who have yet to Share though an Action . In CRI\_AIS, the respondents who only reached the Share without going through the Action and Share of 60.87%, there are still 39.13% respondents who are still able to achieve or who have not yet Share without doing Action and Search. These data show that the use of Instagram as a marketing medium is effective as explained above but the results can still be maximized to see the results of the number of respondents that can still be achieved from every calculation of CRIS AISAS, AISA, AISS, and AIS.

Table 2 shows that the lowest AISAS stage is at the Action stage of 65% and Share of 66.92%. Atelier Hanabira is expected to improve the quality of the product and can adjust the development of consumer desires, so that more consumers make purchases and make recommendations to other potential customers. In addition to improving quality, Atelier Hanabira is expected to maintain the quality and quantity of each product offered. Catalog content with the product produced must be appropriate. While the highest stage is 96.92%, this shows that the Atelier Hanabira Instagram account page and the products offered have attracted the Attention of potential customers. In addition to improving quality, Atelier Hanabira is expected to maintain the quality and quantity of each product offered. Catalog content with the product produced must be appropriate. While the highest achievement was 96.92%, this shows that the Atelier Hanabira Instagram account page and the products offered attract many potential customers.

Before calculating CRI AISAS at Floweridea and Mekar Florist, it was necessary to know the customer response from the results of the questionnaire as summarized in Table 8.

**Table 8.** Floweridea and Mekar Florist Customer Response (CR)

No	Variable	Customer Response	Floweridea CR Portion	Mekar Florist CR Portion
1	Attention	Attention	89.16%	80.36%
		No Attention	10.84%	19.64%
2	Interest	Interest	90.96%	83.93%
		No Interest	9.04%	16.07%
3	Search	Search	62.65%	66.07%
		No Search	37.35%	33.93%
4	Action	Action	59.64%	55.36%
		No Action	40.36%	44.64%
5	Share	Share	51.20%	73.21%

No Share	48.80%	26.79%
----------	--------	--------

After calculating the respondents of Floweridea and Mekar Florist customers, CRI AISAS, AISA, AISS, and AIS were calculated as in the CRI calculation at Atelier Hanabira. The results of these calculations show that the effectiveness of Instagram use on Floweridea and Mekar Florist were not effective as shown in Table 9 for Floweridea and Table 10 for Mekar Florist.

**Table 9.** The results of the AISAS CRI Measurement Model at Floweridea

	<b>AISAS</b> <b>15.52%</b> <b>Lower</b>	<b>AISA</b> <b>30.30%</b> <b>Higher</b>	<b>AISS</b> <b>26.02%</b> <b>Lower</b>	<b>AIS</b> <b>41.53%</b> <b>Higher</b>
No Share	14.79%		24.79%	39.57%
No Action	20.51%	20.51%		
No Search	30.29%	30.29%	30.29%	
No Interest	8.06%	8.06%	8.06%	8.06%
No Attention	10.64%	10.84%	10.84%	10.84%

Data shows that Instagram use at Floweridea was ineffective, CRI's calculation for AISAS, CRI AISAS (15.52%) has a lower percentage of "No Action" (20.51%) and "No Search" (30.29%) and CRI AISS (24.79%) also has a lower percentage of "No Search" (30.29%). The ineffective CRI is CRI AISAS (Attention–Interest–Search–Action–Share) because the CRI AISAS value is lower than the "No Action" and "No Search".

**Table 10.** The results of the AISAS CRI Measurement Model at Mekar Florist

	<b>AISAS</b> <b>18.06%</b> <b>Lower</b>	<b>AISA</b> <b>24.67%</b> <b>Higher</b>	<b>AISS</b> <b>32.62%</b> <b>Higher</b>	<b>AIS</b> <b>41.53%</b> <b>Higher</b>
No Share	6.61%		32.2%	49.38%
No Action	19.89%	19.89%		
No Search	22.88%	22.88%	22.88%	
No Interest	12.91%	12.91%	12.91%	12.91%
No Attention	19.64%	19.64%	19.64%	19.64%

The use of Instagram at Mekar Florist and Floweridea was not so effective where CRI AISAS was 18.06% lower than the "No Action" (19.89%), "No Search" (22.88%), and "no Attention" (19.64%). The CRI AISAS (Attention–Interest–Search–Action–Share) on Atelier Hanabira was quite effective as shown in Table 7, while in Floweridea and Mekar Florist seems ineffective (Table 9 and Table 10). The effective "CRI AISAS" measurement indicates that there were consumers who aware of the existence of a product, who were Interested in the product, then find out more information about the product, then make a purchase, and finally they made recommendations to other potential customers. Instagram usage at Atelier Hanabira was quite effective for marketing tool where 52% of respondents knew Atelier Hanabira through Instagram social media. While at Floweridea 47% of respondents knew that Floweridea from Instagram social media and Mekar Florist was 36%. Atelier Hanabira was more sought after and recommended by consumers because the appearance and photos posted on Instagram are more attractive and have more variety of flower arrangements.

After measuring the level of effectiveness of Instagram use at Atelier Hanabira, then measured the level of customer satisfaction for Atelier Hanabira. Measurement of customer satisfaction was carried out to support the level of effectiveness of Instagram use. Satisfied consumers will share to other potential customers. Analysis of Customer Satisfaction Index (CSI) was used to measure the level of customer satisfaction with the product. CSI results in the form of percentage of customer satisfaction obtained after calculating the average level of expectations and reality, weighting factor, and weighting

score. Consumer satisfaction questionnaires used 7P variables (product, price, promo, place, people, process, and physical evidence). A summary of the results of CSI's analysis on Atelier Hanabira can be seen in Table 11.

**Table 11.** CSI Overall

No	Variable	MIS	MSS	WF	WS	CSI overall
1	Product 1	4.13	3.68	3.85%	0.14	
2	Product 2	4.11	3.64	3.82%	0.14	
3	Product 3	4.09	3.51	3.81%	0.13	
4	Product 4	4.25	4.01	3.96%	0.16	
5	Product 5	4.15	3.55	3.87%	0.14	
6	Product 6	4.26	4.14	3.97%	0.16	
7	Product 7	3.93	3.01	3.66%	0.11	
8	Product 8	4.11	3.87	3.83%	0.15	
9	Price 1	4.02	3.67	3.75%	0.14	
10	Price 2	3.96	3.71	3.69%	0.14	
11	Price 3	3.80	3.34	3.54%	0.12	
12	Promotion 1	4.14	4.06	3.85%	0.16	
13	Promotion 2	3.75	3.06	3.49%	0.11	
14	Promotion 3	3.92	3.43	3.65%	0.13	72.02%
15	Place 1	3.89	3.69	3.62%	0.13	
16	Place 2	3.62	2.71	3.37%	0.09	
17	People 1	3.93	3.58	3.66%	0.13	
18	People 2	3.84	3.34	3.57%	0.12	
19	People 3	3.97	3.75	3.70%	0.14	
20	People 4	3.82	3.49	3.55%	0.12	
21	People 5	3.93	3.70	3.66%	0.14	
22	Process 1	3.93	3.61	3.66%	0.13	
23	Process 2	4.09	3.91	3.81%	0.15	
24	Process 3	4.05	3.85	3.77%	0.15	
25	Process 4	3.98	3.85	3.71%	0.14	
26	Process 5	4.04	3.82	3.77%	0.14	
27	Physical Evidence	3.66	2.94	3.41%	0.10	
	Total	107.35	96.92	100%	3.60	

$$CSI = \frac{\sum_{i=1}^p WS_i}{HS} \times 100\% = \frac{3,60}{5} \times 100\% = 72,02\% \quad (8)$$

CSI value obtained from dividing the total weighting score with the maximum scale used in this study is 5. In Table 11, the total value of WS is 3.60 and the maximum scale is 5, so that CSI is 72.02%. Based on Table 1 about the CSI criteria that CSI is 72.02% into the "satisfied" category. So, it can be interpreted that consumers have felt satisfied overall with Atelier Hanabira. Product, price, promotion, place, people, process, and physical evidence have given satisfaction so that the variables are in accordance with the expectations of consumers. Variable Physical Evidence is a variable that is categorized as quite satisfied, giving information that the convenience of waiting for customers at Atelier Hanabira needs to be improved.

Importance Performance Analysis (IPA) method was used to measure the level of customer satisfaction by measuring the variables of the level of consumer expectations and the level of performance. The results of the IPA measurement shown in Table 12.

**Table 12.** Summary of IPA Measurement Results

No	Variable	Sum		Average	
		Expectation	Performance	Expectation	Performance
1	Product 1	1053	938	4.13	3.68
2	Product 2	1047	929	4.11	3.64
3	Product 3	1042	895	4.09	3.51
4	Product 4	1084	1023	4.25	4.01
5	Product 5	1058	904	4.15	3.55
6	Product 6	1086	1056	4.26	4.14
7	Product 7	1002	768	3.93	3.01
8	Product 8	1048	986	4.11	3.87
9	Price 1	1026	936	4.02	3.67
10	Price 2	1009	945	3.96	3.71
11	Price 3	968	852	3.80	3.34
12	Promo 1	1055	1035	4.14	4.06
13	Promo 2	955	781	3.75	3.06
14	Promo 3	999	875	3.92	3.43
14	Place 1	992	942	3.89	3.69
16	Place 2	922	691	3.62	2.71
17	People 1	1003	914	3.93	3.58
18	People 2	978	852	3.84	3.34
19	People 3	1013	955	3.97	3.75
20	People 4	973	889	3.82	3.49
21	People 5	1003	943	3.93	3.70
22	Process 1	1002	920	3.93	3.61
23	Process 2	1043	998	4.09	3.91
24	Process 3	1033	982	4.05	3.85
25	Process 4	1015	983	3.98	3.85
26	Process 5	1031	974	4.04	3.82
27	P7 Physical Evidence	934	794	3.66	2.94
Total		27374	24715	107.35	96.92

IPA Cartesian Diagram has the X axis and Y axis perpendicular to each other and has four areas: quadrant I, quadrant II, quadrant III, and quadrant IV. The X axis represents the average level of expectation and the Y axis represents the average level of performance. The average value of the level of expectations and the level of performance are used to determine the center line of the IPA Cartesian diagram as shown in Figure 9.

$$\sum \bar{x}_i = 96,92$$

$$\sum \bar{y}_i = 107,35$$

$$k = 27$$

$$\bar{\bar{X}} = \frac{\sum_{i=1}^n \bar{X}_i}{k} \quad (9)$$

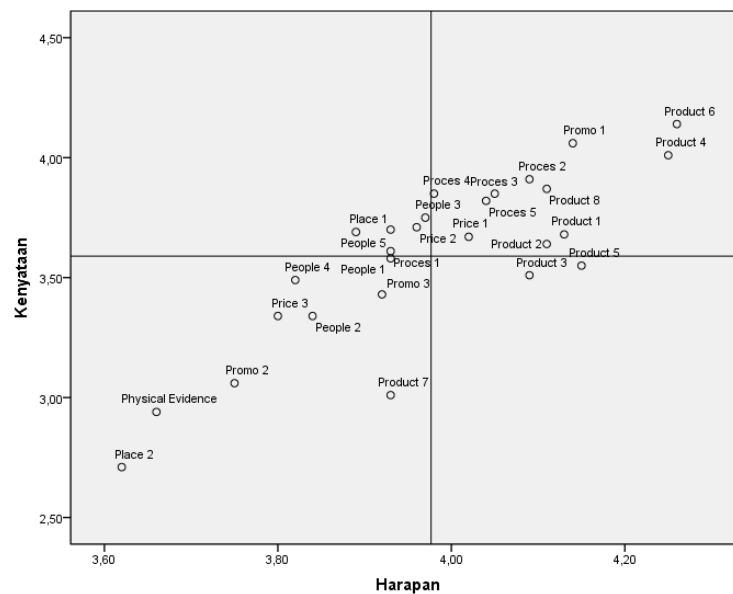
$$\bar{\bar{Y}} = \frac{\sum_{i=1}^n \bar{Y}_i}{k} \quad (10)$$

$$\bar{\bar{X}} = \frac{96,92}{27}$$

$$\bar{\bar{Y}} = \frac{107,35}{27}$$

$$\bar{\bar{X}} = 3,59$$

$$\bar{\bar{Y}} = 3,96$$



**Figure 9.** Importance Performance Analysis (IPA) Cartesian Diagram

**Quadrant I** contains variables that are important for customers but have not fulfill customer expectations yet (*Price 2; Place 1; People 3; People 5 and Process 1*). **Quadrant II** contains variables that are important for customers and have met customer expectations (*Product 1; Product 2; Product 4; Product 6; Product 8; Price 1; Promotion 1; Process 2; Process 3; Process 4 and Process 5*). **Quadrant III** contains variables that are less important for customers and their performance were not too special (*Product 7; Price 3; Promotion 2; Promotion 3; Place 2; People 1; People 2; People 4 and the outlet of Atelier Hanabira is comfortable to wait*). **Quadrant IV** contains variables that are less important for customers and their performance were too excessive (*Product 3 and Product 5*).

#### 4. Conclusions

Based on the research results it can be concluded. **First**, Instagram use at Atelier Hanabira was most effective compared to the use of it at Floweridea and Mekar Florist. CSI value at Atelier Hanabira was 72.02% that can be categorized as "Satisfied" as in the range of 66.00% - 80.99%. **Second**, five attributes that need to be improved by Atelier Hanabira are product prices, store locations, employee professionalism, patience in service, time to complete orders.

#### References

1. Dewaweb. 2018. 12 Tips dan Strategi Marketing Instagram Untuk Bisnis Anda. <https://www.dewaweb.com/blog/tips-dan-strategi-marketing-instagram-untuk-bisnis-anda>. Date 10 April 2018 time 21.00.
2. Faroktarina, F. Anastasia. 2014. "Line Sebagai Media Penyampai Pesan (Studi Deskriptif Mengenai Efektivitas Jejaring Sosial Line sebagai Media Penyampaian Pesan Kampanye WWF "Tiggy Tiger" Berdasarkan Perhitungan Customer Response Index pada Pengguna Line". Skripsi. Fakultas Ilmu Sosial dan Ilmu Politik. Universitas Atmajaya Yogyakarta.
3. Praja, Arya Widya. 2015. "Analisis Persentase Efektivitas Iklan (Promosi) dan Efektivitas Line Shopping Menggunakan Metode Customer Response Index (CRI). Skripsi. Fakultas Ekonomi dan Bisnis. Universitas Telkom Bandung.
4. Kotler, Philip. dan Armstrong, G. 2008. Manajemen Pemasaran. Jakarta: PT Gramedia Pustaka Utama.
5. Puspitasari, Ratna. 2015. "Analisis Kelayakan Usaha Bunga Rangkaian (Florist) Pada Jelita Florist di kota Bekasi". Skripsi. Departemen Agribisnis, Fakultas Ekonomi dan Manajemen, Institute Pertanian Bogor.
6. Ramadhanti, Tatia Ridho. 2016. Fenomena Pemanfaatan Instagram Sebagai Media Personal Branding. Skripsi. Fakultas Ilmu Sosial dan Ilmu Politik. Universitas Diponegoro.
7. Mardiasmo. 2009. Akuntansi Sektor Publik. Andi. Yogyakarta.

8. Yamit, Z. 2015. Manajemen Kualitas Produk dan Jasa-Edisi I. Yogyakarta.
9. Sugiyama, Kotaro, Tim Andree. 2010. The Denstu Way. McGraw-Hill.
10. Rangkuti, Freddy. 2006. Measuring Customer Satisfaction. Jakarta: PT. Gramedia Pustaka Utama
11. Hair, J.R., Anderson, R.E., Tatham, R.L., Black W.C. 2006. Multivariate Data Analysis 3th Edition. New York: Macmillan Publishing Company.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license  
<http://creativecommons.org/licenses/by/4.0/>.



FP-MCI-007-ID043

# Analysis of Consumer Preference Towards Organic Products at Istana Sayur Grocery Shop Malang City Indonesia

Ika Atsari Dewi<sup>1</sup>, Panji Deoranto<sup>1</sup>, and Diannisa Hadiani<sup>1</sup>

<sup>1</sup> Agroindustrial Technology Department Universitas Brawijaya Malang Indonesia

\* Correspondence: ikaatsaridewi@ub.ac.id; Tel.: +6281230968368

Received: 7 August 2018; Accepted: 28 August 2019; Published: 6 January 2020

**Abstract:** The growth of organic products market in Indonesia is seen by the increasing number of organic farmers, retailers and restaurants selling organic products. The main requirement that must be fulfilled by ventures to be successful in the competition is trying to achieve the goal to attract and maintain customers. To find out factors that affect purchasing decisions, investigation was done to determine the factors that construct customer preferences of organic product. The purpose of this study is to determine the effect of product attributes variable on consumer purchase decisions by using consumer preference as mediation variable. The research is conducted at UD Istana Sayur in Malang City Indonesia which sells organic rice and vegetables. Data collection was done by distributing questionnaires to 120 respondents using Likert scale 1-5. The obtained data were then processed using Partial Least Square (PLS). The results of the study indicated that good product attributes and consumer preference variables had certain influence in the increase of consumer purchasing decisions. In addition, consumer preference variable is able to mediate the relationship between product attributes and consumer purchase decisions variables.

**Keywords:** organic products; Partial Least Square (PLS); purchasing decision

---

## 1. Introduction

The government of Indonesia has proclaimed the 2010 Go Organic program to accelerate the realization of environmentally sound agribusiness development. One of its activities is promoting organic farming to consumers, farmers, market players and the community [1]. The growth of organic food market in Indonesia is reflected by the increasing numbers of organic farmers, supermarkets, and restaurants that sell organic products [2]. UD Istana Sayur a store in Malang that sells organic products, such as organic rice and organic vegetables since 2015. To stay competitive and to be able to achieve certain corporate goal, a company should attract and maintain its customers. To enhance customer satisfaction, a company needs to identify factors influencing purchasing decision by analyzing consumer product preferences [3]. Consumer preference refers to a prioritized characteristic of certain product [4]. The attributes of customer preference include quality, price, popularity, and lifestyle. One of factors that determines consumer preferences is product attributes. Product attributes are characteristics that differentiate a product from the others [5]. In this research, product attributes included chemical free status, packaging size, product color, packaging label, and packaging design. Customers' considerations upon product attributes can affect their purchase decision upon certain product. For consumers, purchase decision is an important process since there are sequential steps that take place before customers make decision. Purchase decision is a process of selecting one product among two or more alternative choices [6]. The purpose of this research is to determine the effect of product attributes on consumer purchase decision through consumer preference as the mediating variable.

## 2. Materials and Methods

This research took place in UD Istana Sayur Malang in Jalan Raya Tlogomas No 93 Lowokwaru District, Malang City, East Java Province, Indonesia. The focus of this study was limited to only analyzing vegetable commodities and organic rice sold at UD Istana Sayur Malang. This research started from a preliminary survey, literature study, identification of research problems and formulation and development of structural research models and hypotheses, determination of population and sample, questionnaire preparation, questionnaire distribution and interview, validity test, reliability test, linearity test, and data analysis using SmartPLS. Interviews were done with 120 vegetable and organic rice buyers at UD Istana Sayur Malang which data were then analyzed using PLS method. There were primary and secondary data in this research. Primary data were obtained from questionnaires and interviews. Respondents' responses toward the questionnaires were measured using a Likert scale. Descriptive analysis and inferential analysis were employed to analyze the obtained data. Descriptive analysis was administered to determine respondents' characteristics and the average score of respondents' answers for each item, question, indicator, and variable. This analysis was administered using SPSS 17.0 software. Meanwhile, inferential analysis was conducted to answer the hypothesis in this study using Partial Least Square (PLS) of SmartPLS. Latent variables and observed variables in the study are presented in Table 1. The hypotheses of this research were formulated as follows:

- H1: Product attributes influence consumer preference
- H2: Product attributes influence purchase decision
- H3: Consumer preference influences purchase decision
- H4: Consumer preference mediates the relationship between product attributes and purchase decision

### 3. Results

#### 3.1. Descriptive statistics

There were a total of 120 respondents interviewed consisting of 77 (64.17%) women and 43 (35.83%) men. The majority of respondents were 32-38 years old, working as employees (58.33%), earning an average income of around USD 123.44 up to USD 246.88 per month and had consumed organic products more than 3 times (82.5%).

#### 3.2. Validation of Research Instrument

##### 3.2.1. Validity Test

Validity test was done to ensure that the instrument precisely measured the intended item. The results of the data analysis showed R value for each indicator. Based on the value, the research indicators were considered valid since R value was found greater than R table [4].

##### 3.2.2. Reliability Test

Reliability test was conducted to guarantee the level of consistency of the instrument when it is used in different time. The results of the test showed that all variables used in this research were entirely reliable as the Cronbach's alpha value was found greater than 0.6 [7].

##### 3.2.3. Linearity Test

Linearity test was conducted to determine whether the relationship between independent variables and dependent variables was linear [8]. Reliability test was done using SPSS Statistics 17.0 software. The results of the test showed a value of  $> 0.05$ , indicating that the independent variable and the dependent variables shared a linear relationship.

**Table 1.** The Latent and Observed Variable in the Research

Latent Variable	Observed Variable (Indicator)	Code	Operational Definition
Product Attributes (X <sub>1</sub> )	Chemical-free Status	X <sub>11</sub>	Organic products are free from any chemical substances
	Packaging Size	X <sub>12</sub>	Variants of packaging size match the needs
	Product Color	X <sub>13</sub>	Product color is more interesting than non-organic products
	Packaging Label	X <sub>14</sub>	Packaging label contains complete information
	Packaging Design	X <sub>15</sub>	Packaging design in interesting
Consumer Preference (Y <sub>1</sub> )	Quality	Y <sub>11</sub>	Nutritional value of organic product is higher than the non-organic ones
	Price	Y <sub>12</sub>	Affordable price
	Popularity	Y <sub>13</sub>	Consumption based on trend
	Life Style	Y <sub>14</sub>	Consumption for healthier life
Purchase Decision(Y <sub>2</sub> )	Wants	Y <sub>21</sub>	Consumers want to try something different
	Needs	Y <sub>22</sub>	Products meet consumers' necessities

### 3.3. Path Diagram

The result of PLS model can be seen in Figure 1 which shows that the loading factor values of all research indicators are greater than 0.5. Loading factor is the strength of correlation between research indicator and its latent construct. Indicators with high loading factors have stronger contribution to reflect the latent construct. Conversely, indicators with low loading factors have weak contribution to reflect the latent construct [9].

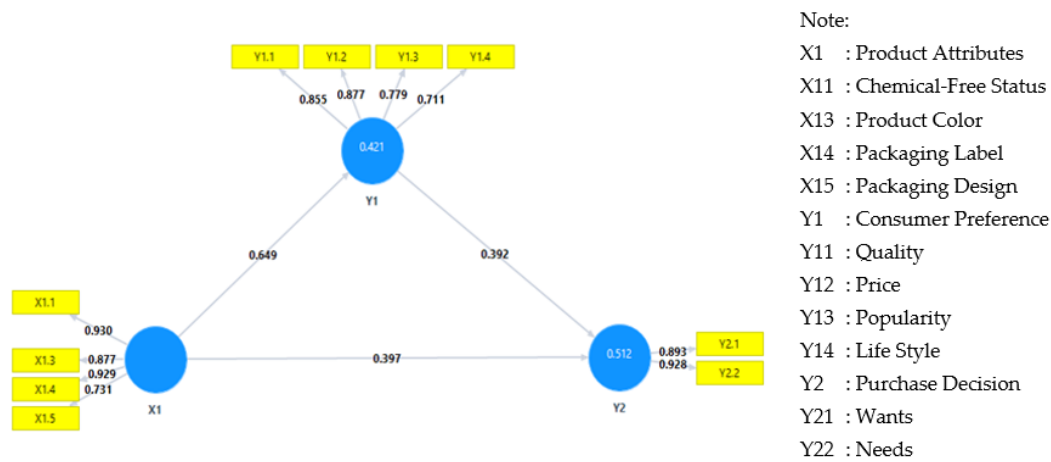
### 3.4. Goodness of Fit Evaluation

#### 3.4.1. Convergent Validity

Convergent validity was measured to determine the correlation across subscales. If theoretically, subscales share close relationship, correlational value will be high and the vice versa [9]. The indicator is said to adequately meet convergent validity if its loading factor ranges from 0.5 to 0.6. As seen in Table 2, all indicators and variables in this research have loading factor values greater than 0.5 that they have met the convergent validity requirements.

#### 3.4.2. Average Variance Extracted (AVE)

AVE value obtained in this research can be seen in Table 3. All research variables have been considered valid because the AVE values are greater than 0.5. The Average Variance Extracted (AVE) is valid if its value is greater than 0.5. AVE value describes the strength of the variant or the diversity of manifest variables that can be possessed by the latent construct. Valid AVE shows that the instrument used in a research has successfully measured the intended items [9].



**Figure 1.** Path Diagram from PLS

### 3.4.3. Cronbach's Alpha and Composite Reliability

Based on the Cronbach's Alpha value obtained in the reliability test, all variables of this research have been considered reliable. The value of Cronbach's alpha can be seen in Table 3. Reliability test was intended to guarantee the level of consistency of research instrument when it is used at different times. The instrument is stated reliable if the value of Cronbach's alpha  $> 0.6$ . All variables of this research have been considered reliable based on the values of composite reliability. The composite reliability values obtained in this research are shown in Table 3. Research variables are considered reliable if composite reliability value is greater than 0.7. If all of the assumptions are fulfilled, the indicator blocks in each construct have high consistency.

**Table 2.** Convergent Validity Results

Variable	Indicator	Loading Factor	Note
Product Attributes (X <sub>1</sub> )	Chemical-Free Status (X <sub>11</sub> )	0.930	Valid
	Product Color (X <sub>13</sub> )	0.877	Valid
	Packaging Label (X <sub>14</sub> )	0.929	Valid
	Packaging Design (X <sub>15</sub> )	0.731	Valid
Consumer Preference (Y <sub>1</sub> )	Quality (Y <sub>11</sub> )	0.855	Valid
	Price (Y <sub>12</sub> )	0.877	Valid
	Popularity (Y <sub>13</sub> )	0.779	Valid
	Life Style (Y <sub>14</sub> )	0.711	Valid
Purchase Decision (Y <sub>2</sub> )	Wants (Y <sub>21</sub> )	0.893	Valid
	Needs (Y <sub>22</sub> )	0.928	Valid

**Table 3.** The Average Values of Average Variance Extracted (AVE), Cronbach's Alpha and Composite Reliability

Variable	AVE	Cronbach's Alpha	Composite Reliability
Product Attributes (X <sub>1</sub> )	0.758	0.890	0.925
Consumer Preference (X <sub>2</sub> )	0.653	0.821	0.882
Purchase Decision (Y <sub>1</sub> )	0.830	0.797	0.907

### 3.5. Evaluation of Structural Model (Inner Model)

The structural model of this research was evaluated from the R-square value (R<sup>2</sup>). R-square value measures how far the model is able to explain the variation of the dependent variable. The R-square for

the innovation variable is 0.23 and the business performance is 0.32. Based on those R-square values, Q2 predictive relevance value can be determined as follows:

$$\begin{aligned} Q^2 &= 1 - (1 - R^2)(1 - R^2) \\ &= 1 - (1 - 0.421)(1 - 0.512) \\ &= 0.717 \text{ (71.7\%)} \end{aligned}$$

Q2 predictive relevance value of 0.717 indicates that the observed value of the structural model has good predictive relevance and is appropriate to be used in a research.

## 4. Discussions

### 4.1. The Results of Direct and Indirect Hypotheses Testing

Path coefficient score for testing hypotheses was done using alpha ( $\alpha$ ) 5% (0.05). The results of direct hypothesis testing can be seen in Table 4. Whilst, the results of the indirect hypothesis testing is shown in Table 5.

#### 4.1.1. The Influence of Product Attributes on Consumer Preference

Hypothesis testing resulted in Product Attribute path coefficient of 0.649 and  $p$  value of 0.000 accepting H1. This results confirm the existence of a significant influence of Product Attribute variable on Consumer Preference variable. This shows that Product Attributes variable affect Consumer Preference. In addition to its significance, the path coefficient value is positive, which indicates that Product Attributes ( $X_1$ ) positively affect Consumer Preference ( $Y_1$ ).

This study shows that the attributes of organic products are able to increase consumer preferences. Currently, UD Istana Sayur Malang has sold organic products which have several advantages such as chemical-free status, attractive product colors, informative packaging labels, and attractive packaging designs. By selling products that have these advantages, consumers will grow their preference to purchase organic products from UD Istana Sayur Malang. This finding supports the results of research conducted by [10] which state that product attributes determine to what extent a product is accepted by consumers. Marketing actors need to understand customers' product attributes expectations. Therefore, consumer preferences can be measured by the level of usefulness and relative importance of each product attribute.

**Table 4.** The Result of Direct Hypothesis Testing

Hypothesis	Statistical Hypothesis	Path Coefficients	T value	T table	P values	Note
H <sub>1</sub>	(X <sub>1</sub> ) → (Y <sub>1</sub> )	0.649	9.2648	1.96	0.000	Significant
H <sub>2</sub>	(X <sub>1</sub> ) → (Y <sub>2</sub> )	0.397	2.4997	1.96	0.015	Significant
H <sub>3</sub>	(Y <sub>1</sub> ) → (Y <sub>2</sub> )	0.392	2.7871	1.96	0.005	Significant

**Table 5.** The Result of Indirect Hypothesis Testing

Variable	Direct Coefficient	Standard of Error	Indirect Coefficient	SE Sobel	T value	P Value
X1 - Y1 - Y2	0.649 0.392	0.074 0.138	0.254	0.094	2.702	0.007

#### 4.1.2. The Influence of Product Attributes on Purchase Decision

The results of the hypothesis testing showed path coefficient value of Product Attribute variable ( $X_1$ ) at 0.397 and  $p$  value of 0.014 to accept H<sub>2</sub>. It can be concluded from those values that a significant influence between Product Attribute variable on Purchase Decision variable exists. In addition to its significance, the positive mark in the path coefficient value also shows that the relationship between Product Attribute variable and Purchase Decision variable ( $Y_2$ ) is within an unidirectional pathway.

The results of this research show that the attributes of organic products are able to increase purchase decisions. It is important to focus on the attributes of organic products that are sold in order to increase consumer purchase decisions. It can be understood that the better the attributes of the products sold, the more interested consumers will be to buy those products. The results of this research reinforce the findings of previous research conducted by [11] which state that product attributes are one of consumers' consideration within purchase decision process. Producers should highlight certain attributes of a their products that strongly drive their consumers to purchase the products.

#### 4.1.3. The Influence of Consumer Preference on Purchase Decision

The path coefficient of Consumer Preferences ( $Y_1$ ) was obtained in the hypothesis testing at 0.392 and  $p$  value of 0.006. Therefore,  $H_3$  is accepted, implying the existence of a significant influence of Consumer Preference variable on Purchase Decision variable. In addition to its significance, a positive path coefficient mark indicates that the relationship between Consumer Preference ( $Y_1$ ) and Purchase Decision ( $Y_2$ ) is within an unidirectional pathway.

This research confirms that consumer preference has certain effect on the increase in purchase decision. Consumers prefer to buy products they like rather than products they dislike. If consumers like a product, the probability of the consumers to buy the product is higher. Consumer preferences can be influenced by several aspects including the nutritional value of organic products, the price of organic products, consumers' lifestyle and the popularity of organic products. The results of this research reinforces the finding of a previous research done by [12] which states that consumer preference is an important aspect that determines the success of product marketing as it is closely related to the success of the company in achieving its corporate goals which includes the purchase decisions based on customer preference.

#### 4.1.4. The Influence of Consumer Preference in Mediating the Relationship between Product Attributes and Purchase Decision

The testing of the fourth hypothesis shows that the relationship between Product Attributes and Purchase Decisions ( $Y_2$ ) through Consumer Preference resulted in indirect path coefficient of 0.254 with  $p$  value (0.007)  $< 0.05$  as presented in Table 3. These results imply that Consumer Preference has a significant influence in mediating the influence of Product Attributes on Purchase Decisions.

A set of tests done in this research has confirmed that product attribute have certain significant influence on purchase decisions mediated by consumer preference. Therefore, in this context, consumer preference acts as a mediating variable (intervening variable). In mediating the relationship, consumer preference partially intervenes the influence of product attributes toward purchase decisions. Product attributes are depicted with chemical-free organic products. Organic products are closely associated with chemical-free status among consumers who have strong awareness of health. Those customers prefer consuming products that are safe for consumption. Furthermore, consumers also prefer cheap products. Thus, the insight related to consumer preference about the preferred product price is expected to help producers improve the rate of consumer purchase decision. The results of this research show that consumers have stronger preference on chemical-free organic products with affordable price. It is expected that this data allows producers to improve their products to meet these preferences in order to increase the purchase decision.

## 5. Conclusions

Regarding to the results of this research done in UD Istana Sayur Malang, conclusions were drawn as follows.

- Product attributes have a positive and significant influence on consumer purchase decision. The attributes of products sold in UD Istana Sayur Malang affect the increase in customer purchase decision.

- Consumer preference is able to significantly and positively affect consumer decision. Thus, consumer preference is an aspect that counts in the improvement of purchase decision in UD Istana Sayur Malang.
- Product attributes share a significant and positive influence on consumer preference. Hence, product attributes are able to affect the improvement of consumer preference upon certain product.
- As a mediating variable, consumer preference shares a significant and positive partial influence in mediating the relationship between product attributes and purchase decision. Therefore, consumer preference should be taken into consideration for higher purchase decision.

**Acknowledgments:** Gratitude is expressed to *Hibah Peneliti Pemula Universitas Brawijaya* that funded this research based on the letter of agreement Number. 731.66 / UN10.C10/PN/2017. Gratitude also goes to the owner and employees of UD Istana Sayur Malang and any related parties that contributed in the completion of this research.

## References

1. Rusma, J; Hubeis, M; Suharjo, B. *Kajian Preferensi Konsumen Rumah Tangga Terhadap Beras Organik di Wilayah Kota Bogor*. Jurnal Ilmu Pertanian **2011**. 8(2), 20-32.
2. Thio, S. *Persepsi Konsumen Terhadap Makanan Organik di Surabaya*. Jurnal Manajemen Perhotelan **2008**. 4(1), 18-27.
3. Pramono dan Prabawani. *Analisis Faktor-Faktor Preferensi Konsumen yang Mempengaruhi Keputusan Pembelian Sayuran Organik*. Jurnal Studi Manajemen **2014**. 4(1), 14-20.
4. Munandar, J.M; Udin, F; Amelia, K. *Analisis Faktor yang Mempengaruhi Preferensi Konsumen Produk Air Minum dalam Kemasan di Bogor*. Jurnal Teknik Industri Pertanian **2014**. 13(3), 97-107.
5. Henly, C.D; Deborah, C.F; Johnson, D.E. *Label Design: Impact on Millenials' Perception of Wine*. Journal of Wine Business Research **2010**. 23(1), 33-40.
6. Schiffman, L.K dan Leslie, L. *Perilaku Konsumen*. Macana Jaya Cemerlang: Jakarta 2008.
7. Rossiter, J.R. *Measurement for the Social Sciences*. Springer: Berlin German. 2011. pp.13-28.
8. Hayes, A.F. *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Reggression – Based Approach*. Journal of Education Measurement **2014**. 51(3), 335-337.
9. Vinzi, E.V; Chin, W.W; Henseler, J; Wang, H. *Handbook of Partial Least Squares*. Springer: Berlin German. 2010.
10. Shivatanuu, B. *Factors Affecting Consumer Preference Towards the Organic Food Purchases*. Indian Journal of Science and Technology **2015**. 8(33), 33-42
11. Magistris, T; Gracia, A. *The Decision to Buy Organic Food Products in Southern Italy*. British Food Journal **2008**. 110(9), 929-947.
12. Yoridoe, E.K; Bonti, S; Martin, R.C. *Comparison of Consumer Perceptions and Preference Toward Organic Versus Conventionally Produced Foods*. Journal Renewable Agriculture and Food System **2008**. 20(4), 193-205.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-MCI-014-ID070

# Nursery Garden Development Strategy as Educational Tourism Using Swot Analysis and Multi-Attribute Utility Theory (MAUT) (Case Study On Kebun Bibit Kediri)

Panji Deoranto<sup>1,\*</sup>, Septiana Rosari<sup>1</sup> and Rizky L.R Silalahi<sup>1</sup>

<sup>1</sup> Department of Agro-Industrial, Faculty of Agricultural Technology, Universitas Brawijaya, Malang 65145

\* Correspondence: [deoranto@ub.ac.id](mailto:deoranto@ub.ac.id)

Received: 12 August 2018; Accepted: 28 August 2019; Published: 6 January 2020

**Abstract:** The purpose of this research are to know internal and external factors of Kebun Bibit Kediri, to determine alternative strategy, and strategic priority. This study, using SWOT analysis and MAUT. The results showed that the most influential internal factors are giving of interactive education with a weight score 0.258 and soft skills labor with a weight score 0.142. The most influential external factors are the change of mindset to prefer the nature-based educational tourism with a weight score 0.616 and competitor's educational facilities with a weight score 0.184. Alternative strategy of Kebun Bibit Kediri development as educational tourism based on SWOT matrix are to improve management of Kebun Bibit Kediri (ST1), development of educational variant (ST2), use of computer technology in work system (ST3), expand market segmentation (ST4), provide training to workers (ST5), increasing number of guide (ST7), enhancing education image of Kebun Bibit Kediri (ST7), improving promotion through advertisement and following the events (ST8), and adding educational tour facility (ST9). The priority of development strategy on Kebun Bibit Kediri as educational tourism based on MAUT are ST1 with total utility value of 0.8945, ST2 with total utility value of 0.871, and ST3 with total utility value of 0.867.

**Keywords:** Nursery Garden, Development, Educational Tourism.

---

## 1. Introduction

In 2016, the area of Kediri Regency is 138,605 Ha. According to the Minister of Agriculture Regulation number 08 / KPTS / RC.110 / J / 01/2017, optimization of land use is carried out by cultivating various types of plants. This development approach is carried out by developing sustainable agriculture to be able to preserve nature. One of the efforts made is to build a nursery. Nursery garden have an important role in providing various types of superior seeds and can also be developed into educational environments based on the natural environment which are attractive to visitors. One of the places that develops its business is a natural environment-based educational tour, namely UD. Alam Tani or better known as the Kebun Bibit Kediri. However, there are problems that become obstacles in the development of its business. This problem is closely related to the non-optimal development strategy at Kebun Bibit Kediri. According to David and Forest (2017), organizations without coherent direction and strategies can accelerate their own fall. In this study, used method analysis of Strength, Weakness, Opportunities, Threats (SWOT) and Multi-Attribute Utility Theory (MAUT). Based on SWOT analysis can determine alternative development strategies and to determine the priority of development strategies using MAUT. MAUT is used to evaluate alternatives by calculating the weight or utility value of each alternative. The utility value shows how well an alternative meets the criteria so that it can produce a better alternative evaluation quality (Ganiardi, 2014). In this study MAUT was chosen because it has the advantage of being able to take into account uncertainty and can combine decision-making preferences (Velasquez and Hester, 2013).



## 2. Materials and Methods

This research in Kebun Bibit Kediri, located on Jalan Raya Papar-Pare, Plemahan, Kediri. The time for research is March 2018 to May 2018. Data processing and analysis was carried out in Computing and System Analysis Laboratory, Department of Agricultural Industrial Technology, Faculty of Agricultural Technology, Brawijaya University Malang. The limitation of the problem in this study are that the attributes used in MAUT include the attributes of costs, time, infrastructure, and opinions of employers or experts and this research is only carried out until the priority stage of determining alternative strategies.

### 2.1. Determination of variables

The variables used in this study are based on internal factors and external factors of the Kebun Bibit Kediri. Determination of these factors and variables is the result of literature studies and preliminary research that has been adjusted to the conditions at the current Kebun Bibit Kediri. In this study using 5 respondents. A list of research variables can be seen in Table 1.

Factors	Variabels	Information
<b>Internal factors</b>		
Management	Planning	A booking system for predicting the number of visitors (S)
	Actuating	Briefing before educational tours begin (S)
Marketing	Product	Nature-based educational tours that are interesting to visit (S)
	Price	Price of educational tours (S)
	Place	Educational tourism is not in one place (W)
	Promotion	Parking area (W)
	Process	Promotional intensity (W)
		Market segmentation (W)
		Interactive education (S)
	Person	Educational tour package services (S)
		Soft skill workforce (W)
	Physical evidence	Number of guides (W)
		Atmosphere where educational tours (S)
Management information system	Software	Website (W)
<b>External factors</b>		
Micro environment	Level of competition	Competitor promotion (T)
	Threat of new entrants	Educational tourism competitor facility (T)
		The emergence of new educational tours (T)
Macro environment	Economy	Rising incomes (O)
	Social	Changes in mindset to prefer nature-based education tours (O)
	Political	Local government support (O)
	Technology	Technology development (O)

### 2.2. Questionnaire preparation

This study uses a questionnaire with three stages in filling out the questionnaire given, namely:

- Questionnaires to determine internal and external factor weights were filled by the owners of Kebun Bibit Kediri, the marketing department of Kebun Bibit Kediri, the Office of Youth and Sports Education of Kediri Regency, the Kediri Regency Tourism and Culture Office, and 1 academic.

- The rating determination questionnaire is filled by the owner of the Kebun Bibit Kediri, the marketing department of the Kebun Bibit Kediri, the Kediri District Youth and Sports Education Office, the Kediri Regency Tourism and Culture Office, and 1 academician.
- The questionnaire to determine the final decision using the MAUT model is filled by the owners of the Kebun Bibit Kediri and the Kediri Regency Tourism and Culture Office.

### 2.3. SWOT analysis

#### 2.3.1. Internal and External Factor Analysis

Analysis of internal factors and external factors is done through weighting and rating each variable by respondents. Weighting with paired comparison methods uses three scales (1 = less important, 2 = equally important, 3 = more important). Rating is done after knowing the weight of each attribute, the scale used is 4 scales including 4 if the strategic factor is the main strength / opportunity that has a large influence up to 1 if the strategic factor is a major weakness / threat that has a big influence. Weighting results and rating values are then multiplied so that we obtain the weight score on the IFE and EFE matrices.

#### 2.3.2. SWOT diagram

The SWOT diagram is used to determine the business position based on the IFE and EFE values which are divided into four quadrants, each quadrant has each strategy.

#### 2.3.3. SWOT matrix

The SWOT matrix is used to develop strategic plans that are expected in the future.

### 2.4. Multi-Attribute Utility Theory (MAUT)

MAUT is an analytical approach that is often used to solve complex problems (Nadeem et al, 2014). MAUT is used to change from several interests into numeric values with a scale of 0-1 with 0 representing the worst and 1 best choices. The final result of the MAUT calculation is the ranking order of alternative evaluations that describe the choices of decision makers. Attributes used in this study include attributes of costs, time, infrastructure, and opinions of entrepreneurs / experts in their fields.

## 3. Results

### 3.1. General Description of Kebun Bibit Kediri

UD. Alam Tani or better known as the Kebun Bibit Kediri is a business entity engaged in the cultivation and sale of plant seeds, especially fruits, organic fertilizers, and gazebos. Kebun Bibit Kediri was officially established by Mr. Agus Joko Susilo in 2013. Currently, the owner also develops his business into a nature-based educational tour and opens a cafe with the concept of a rest area. Visitors to educational tours that often come from schools start from the play group to high school level around Kediri Regency. Within a week there are about 3 times educational tours, with one visit totaling 30-180 people. Kebun Bibit Kediri educational tourism operating hours are from 08.00 WIB to 16.00 WIB.

### 3.2. Input stage

#### 3.2.1. IFE Matrix

IFE Matrix can be known after calculating the factors of strength and weakness. Based on the IFE matrix, it can be seen that the main strength has the biggest weight score and the main weakness that has the smallest score. The IFE matrix in the Kebun Bibit Kediri can be seen in Table 2.

**Table 2.** Matrix IFE

Internal factors	Weight	Rating	Score weight
<b>Strength</b>			
A booking system for predicting the number of visitors	0,048	2,200	0,106
Briefing before educational tours begin	0,071	3,000	0,213
Nature-based educational tours that are interesting to visit	0,070	3,400	0,238
Price of educational tours	0,062	3,200	0,198
Interactive education	0,076	3,400	0,258*
Educational tour package services	0,071	3,400	0,241
Atmosphere where educational tours	0,071	3,000	0,213

Table 2. Matrix IFE

Internal factors	Weight	Rating	Score weight
<b>Weakness</b>			
Educational tourism is not in one place	0,061	2,800	0,171
Parking area	0,064	2,400	0,154
Promotional intensity	0,092	2,000	0,184
Market segmentation	0,082	2,200	0,180
Soft skill workforce	0,089	1,600	0,142*
Number of guides	0,075	2,200	0,165
Website	0,068	2,800	0,190
<b>TOTAL IFE</b>	<b>1,000</b>		<b>2,653</b>

\* Main strengths / weaknesses; Source: Data Processed (2018)

The main strength is interactive education with a weight score of 0.258. Interactive education is the main force because Kebun Bibit Kediri provides educational tourism accompanied by guides so that it is more effective and visitors are not easily bored. In addition, it can practice direct educational activities that are not obtained while in the classroom. The main weakness is soft skill workforce with a score of 0.142. The majority of workers do not have good soft skiing. Whereas to achieve the targets set, workers are required to have good technical and non-technical abilities such as being easy to socialize, be creative, responsive and energetic. The IFE total value is 2,653 which indicates that the internal position in the moderate or average internal position.

### 3.2.2. EFE matrix

EFE Matrix can be known after calculating the opportunity and threat factors. Based on the EFE matrix, we can find the main opportunity that has the biggest weight score and the main threat that has the smallest score score. The EFE matrix in the Kebun Bibit Kediri can be seen in Table 3.

Table 3. Matrix EFE

External factors	Weight	Rating	Score weight
<b>Opportunities</b>			
Rising incomes	0,153	4,000	0,612
Changes in mindset to prefer nature-based education tours	0,171	3,600	0,616*
Local government support	0,188	3,000	0,564
Technology development	0,152	3,600	0,547
<b>Threats</b>			
Competitor promotion	0,117	2,600	0,304
Educational tourism competitor facility	0,102	1,800	0,184*
The emergence of new educational tours	0,117	1,800	0,210

TOTAL EFE	1,000	3,037
-----------	-------	-------

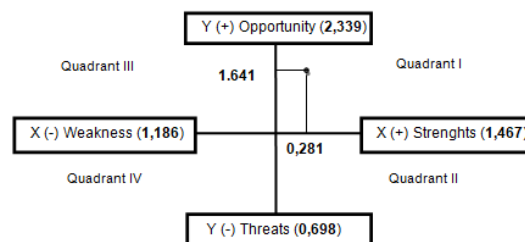
\* Main oportutites / threats; Source: Data Processed (2018)

The main opportunity is the change of mindset to prefer nature-based education tours with a weight score of 0.616. This change in mindset has become a major opportunity because Kebun Bibit Kediri provides educational tourism that have followed the trend of tourism activities in Indonesia. The main threat is competitors' educational tourism facilities with a score of 0.184. Educational tourism competitor facilities become a major threat because facilities are one of the important considerations of visitors. The total EFE value is 3.037 which indicates that the external position is in a strong external position.

### 3.3. Matching Stage

#### 3.3.1. SWOT Diagram

To determine the position of the coordinates of Kebun Bibit Kediri, the difference in scores from the two factors was calculated. The difference in the internal factor is 0.281 while the difference from the external factor is 1.641. The position of the coordinates of Kebun Bibit Kediri can be seen in Figure 1.



**Figure 1.** Position of the coordinates Kebun Bibit Kediri; Source: Data Processed (2018)

#### 3.3.2. SWOT Matrix

The SWOT matrix is a matching tool used to determine the development strategy of Kebun Bibit Kediri as an educational tour. Strategy formulation is carried out by combining internal factors with external factors so that four types of strategies are obtained, namely S-O strategy, W-O strategy, S-T strategy, and W-T strategy. Four types of development strategies in the SWOT matrix can be seen in Figure 2.

<div> <div>Internal</div> <div>External</div> </div>	<b>Strength (S)</b> 1. A booking system for predicting the number of visitors 2. Briefing before educational tours begin 3. Nature-based educational tours that are interesting to visit 4. Price of educational tours 5. Interactive education 6. Educational tour package services 7. Atmosphere where educational tours	<b>Weakness (W)</b> 1. Educational tourism is not in one place 2. Parking area 3. Promotional intensity 4. Market segmentation 5. Soft skill workforce 6. Number of guides 7. Website
	<b>Opportunity (O)</b> 1. Rising incomes  2. Changes in mindset to prefer nature-based education tours 3. Local government support 4. Technology development  <b>Threat (T)</b> 1. Competitor promotion 2. Educational tourism competitor facility 3. The emergence of new educational tours	<b>Strategi S-O</b> • Improve management of the Kebun Bibit Kediri management (ST1) (S1,S2,O3) • Educational variant development (ST2)(S4,S6,O1,O2) • Use of computer technology in work systems (ST3)(S6,O4)  <b>Strategi S-T</b> • Improve the image of Kebun Bibit Kediri education tourism (ST7) (S3, S5, S7,T3)

Figure 2. SWOT Matrix; Source: Data Processed (2018)

### 3.4. Decision Stage

#### 3.4.1. Multi Attribute Utility Theory (MAUT)

Determination of strategic alternative priorities using the MAUT model with several attributes considered, namely cost, time, infrastructure, and the opinions of entrepreneurs or experts in their fields. The MAUT model questionnaire was given to the owner of Kebun Bibit Kediri (R1) and the head of tourism development in the Kediri Regency Tourism Office (R2). Table 4 shows the weight of each attribute in the MAUT model that has been filled by the two respondents.

Table 4. Weight of MAUT Model Attributes

Attribute	R1		R2	
	Total	Weight	Total	Weight
1. Cost	4	0,2353	5	0,2941
2. Time	4	0,2353	3	0,1765
3. Infrastructure	5	0,2941	5	0,2941
4. The opinions of entrepreneurs or experts in their fields	4	0,2353	4	0,2353
Total	17	1,0000	17	1,0000

Source: Data Processed (2018)

If you know the attribute weight, then the respondent is required to assign values to all alternative strategies and determine the utility value of each attribute that will be calculated using the utility function. Then the total utility value is calculated for each alternative strategy using the formula by multiplying the utility value of each attribute with the attribute weight. The order of priority ranking is obtained from the calculation of the average of the two respondents. Table 5 shows the results of the strategic priority ranking of the two respondents.

Table 5. Results of Priority Strategy Ranking

Alternative strategy	Average	Ranking
----------------------	---------	---------

Improve management of the Kebun Bibit Kediri management	0,8945	I
Development of educational variants	0,871	II
Use of computer technology in work systems	0,8525	IV
Expand market segmentation	0,8445	V
Provide training to workers	0,867	III
Increase the number of guides	0,838	VI
Improve the image of Kediri Seed Garden education tourism	0,808	VII
Increase promotions through advertisements and follow certain events	0,7965	VIII
Add educational tourism facilities	0,7182	IX

Source: Data Processed (2018)

#### 4. Discussion

The results showed that the alternatives that occupy the three main priorities of the development strategy of Kebun Bibit Kediri as an educational tourism are improve management of the Kebun Bibit Kediri management (ST1), development of educational variants (ST2), and providing training to workers (ST5). ST1 and ST2 began to be applied but not optimal because they were hampered by the quantity and quality of human resources owned by Kebun Bibit Kediri. While ST5 has not been implemented and is considered by the owner to implement the strategy. ST1 needs to be implemented because all this time the management of poor management, such as the implementation of all activities that are only handled by the owner, will have an impact on workers' confusion and some related parties. The application of ST1 in the Kebun Bibit Kediri can be done by holding regular meetings and forming a clear organizational structure. ST2 began to be applied by the owners of the Kebun Bibit Kediri by innovating to open new tourism, namely a million color education tours in developing educational tourism packages that work with residents. Development of education variants that can be added in Kebun Bibit Kediri, which is the cultivation of plants that are in great demand by visitors. ST5 has not been implemented because currently the owners focus on developing the market and not paying enough attention to the quality of human resources. The application of ST5 is done by holding training, especially soft skills training for workers. This training is expected to be able to increase the knowledge and skills of workers so that they can work optimally.

#### 5. Conclusions

Based on the results of the study, the conclusions include:

- The internal factors that most influence the development of Kebun Bibit Kediri as an educational tourism in terms of strength are the provision of interactive education with a score of 0.258, while in terms of weaknesses, the soft skills of the workforce are 0.142. External factors that most influence in terms of opportunities are changes in mindset to prefer nature-based education tours with a score of 0.616 while in terms of threats, educational tourism competitors with a score of 0.184.
- Alternative development strategy for Kebun Bibit Kediri as an educational tourism based on the SWOT matrix which is improve management of the Kebun Bibit Kediri management (ST1), development of educational variants (ST2), use of computer technology in the work system (ST3), expanding market segmentation (ST4), providing training for workers (ST5), increasing the number of guides (ST7), improving the image of educational tourism Kebun Bibit Kediri (ST7), increasing promotion through advertising and participating in certain events (ST8), add educational tourism facilities (ST9).
- The priority sequence of the development strategy of Kebun Bibit Kediri as an educational tourism based on MAUT is ST1 with a total utility value of 0.8945, ST2 with a total utility value of 0.871, and ST3 with a total utility value of 0.867.

#### References

- 1) David, F.R.; Forest R.D. Strategic Management Concept Issue 15.; Salemba Empat, Jakarta, 2007, ISBN.
- 2) Ganiardi, M.A. The Housing Development Decision System uses the Analytical Hierarchy Process Method-Multi Attribute Utility Theory. Proceedings of the National Conference on Information Technology and Applications, Politeknik Negeri Sriwijaya, Palembang, 2007, pp.81-89.
- 3) Nadeem, A.; Juiping X.; Muhammad N.; Muhammad H.; Muhammad K.J. An Integrated Group Decision-making Process For Supplier Selection and Order Allocation Using Multi-attribute Utility Theory Under Fuzzy Environment. Science IJSBAR, 2014; Volume 14, pp. 205-224, ISBN.
- 4) Velasquez, M and Patrick H. An Analysis of Multi-Criteria Decision Making Methods. Operation Research, 2013; Volume 10, pp.56-66, ISBN.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license <http://creativecommons.org/licenses/by/4.0/>.

FP-FST-006-ID016

# Immature Black Vinegar Extract Activates Macrophages

Eri Ishii<sup>1</sup>, Kosuke Nishi<sup>1,2</sup>, Momoko Ishida<sup>1</sup>, Masanobu Nagano<sup>3</sup>, Kazunori Hashiguchi<sup>3</sup>, Akira Fujii<sup>3</sup> and Takuya Sugahara<sup>1,2,\*</sup>

1 Graduate School of Agriculture, Ehime University, Matsuyama, Ehime 790-8566, Japan

2 Food and Health Sciences Research Center, Ehime University, Matsuyama, Ehime 790-8566, Japan

3 Sakamoto Kurozu Inc., 21-15 Uenosono-cho, Kagoshima 890-0052, Japan

\* Corresponding author: mars95@agr.ehime-u.ac.jp

Received: 9 July 2018; Accepted: 4 December 2018; Published: 6 January 2020

**Abstract:** Black vinegar is a traditional rice vinegar produced in Kagoshima prefecture in Japan. This vinegar is produced by saccharification, fermentation, and aging in one pot. Wakazu is an immature black vinegar collected before aging for 1-3 years. Many researchers are studying on health functions of black vinegar, and various functions have been revealed such as antitumor and antiallergic effects. However, the studies on wakazu have not been done yet. Therefore, in this study, the immunostimulatory effect of wakazu on macrophages was investigated. Acetic acid was removed from wakazu by repeated freeze-drying. After centrifugation to remove insoluble substances, wakazu was dialyzed with a 14 kDa molecular weight cut off dialysis membrane against 10 mM sodium phosphate buffer before use. As a result, wakazu enhanced TNF- $\alpha$  and IL-6 production by mouse macrophage cell line, RAW264.7 cells. In addition, wakazu stimulated gene expression of these cytokines in RAW264.7 cells. Western blot analysis indicated that wakazu enhances translocation of NF- $\kappa$ B to nucleus and MAP kinase signal transduction in RAW264.7 cells. In conclusion, immature black vinegar, wakazu also has a potential as a health-promoting food with the immunostimulatory effect.

**Keywords:** Black vinegar; Macrophage; Cytokine production; IL-6; TNF- $\alpha$

---

## 1. Introduction

Macrophages are versatile cells that play crucial roles in the innate immune system for host defense. Macrophage activation is mediated primarily by recognition of active substances through specific receptors in the initial phase of the immune response. Macrophages bind to the activator via Toll-like receptor (TLR) 4, CD14, complement receptor 3, scavenger receptor, dectin-1, or mannose receptor [1]. This process initiates the activation of intracellular signaling cascades including mitogen-activated protein (MAP) kinases and NF- $\kappa$ B, thereby inducing macrophage activation. The activated macrophages secrete several mediators including inflammatory cytokines such as interleukin (IL)-1, IL-6, and tumor necrosis factor (TNF)- $\alpha$  and release some cytotoxic and inflammatory molecules such as nitric oxide (NO) [2]. These cytokines stimulate the antibody production by plasma cells and the synthesis of other inflammatory mediators that have antitumor and antibacterial activities. Furthermore, macrophages have phagocytosis activity which induces the activation of T cells and B cells and contribute to the activation of the adaptive immune response. Therefore, the activation of macrophages is very important in enhancing the entire immune system both of the innate and adaptive immune responses.

The black vinegar is a traditional vinegar manufactured with three components: steamed unpolished rice, a fermentation starter called koji, and water. Various microorganisms such as *Aspergillus*, yeasts, lactic acid bacteria, and acetic acid bacteria are involved in their process of fermentation and maturation such as saccharification, alcoholic fermentation, and acetic fermentation.



Wakazu is an immature black vinegar collected before aging for 1-3 years, and characterized by a light amber color and sour than black vinegar. Many researchers are studying on health functions of black vinegar, and various functions have been revealed such as antioxidative activity [3] and antiallergy effect [4]. However, the studies on wakazu have not been done yet. Therefore, in this study, the immunostimulatory effect of wakazu on macrophages was investigated.

## 2. Materials and methods

### 2.1. Sample preparation

Wakazu manufactured by Sakamoto Kurozu Inc. (Kagoshima, Japan) was repeatedly freeze-dried to remove acetic acid. It was then centrifuged at  $1,500 \times g$  for 10 min to remove insoluble substances, and the supernatant was collected and dialyzed with a 14,000 molecular weight cut off dialysis membrane (Wako Pure Chemical Industries, Osaka, Japan) against 10 mM sodium phosphate buffer (NaPB) for 24 h at 10°C. The dialyzed supernatant was filtrated through a 0.22  $\mu\text{m}$  membrane, and it was passed through Endo Trap (Hyglos GmbH - a bioMérieux company, Freistaat Bayern, Germany), which is an affinity matrix intended for removal of lipopolysaccharide from biological samples in aqueous solutions. Dry weight of wakazu components was measured after freeze-drying of wakazu preparation.

### 2.2 Cells and cell culture

RAW 264.7 cells, a mouse macrophage-like cell line, were obtained from Japanese Collection of Research Bioresources Cell Bank (Osaka, Japan). RAW264.7 cells were cultured in DMEM supplemented with 100 U/mL of penicillin, 100  $\mu\text{g/mL}$  of streptomycin, and 10% fetal bovine serum (FBS; Sigma-Aldrich, St. Louis, MO, USA) at 37°C under humidified 5%  $\text{CO}_2$ . RAW264.7 cells were detached using phosphate-buffered saline (PBS) containing 0.25% trypsin and 0.02% ethylenediamine-N,N,N',N'-tetraacetic acid (Dojindo Laboratories, Kumamoto, Japan) for the subsequent experiments.

### 2.3. Determination of cytokine levels in culture medium

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 96-well cell culture plate (Corning, Corning, NY, USA) at  $6.0 \times 10^4$  cells/well and cultured for 16 h at 37°C. After washing with PBS, the cells were treated with 200  $\mu\text{L}$  of 10% FBS-DMEM containing various concentrations of wakazu, 10 mM NaPB as negative control, or 100 ng/mL of LPS from *E. coli* O26/B6 (Sigma-Aldrich) as positive control and incubated for 6 h at 37°C. After incubation, the concentrations of IL-6 and TNF- $\alpha$  in the culture media were measured by mouse IL-6 ELISA kit (Bio Legend, San Diego, CA, USA) and Mouse TNF $\alpha$  ELISA kit (eBioscience, San Diego, CA, USA), respectively.

### 2.4. Cell viability

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 96-well cell culture plate at  $6.0 \times 10^4$  cells/well and **cultured for 16 h at 37°C**. After washing with PBS, the cells were treated with 200  $\mu\text{L}$  of 10% FBS-DMEM containing various concentrations of wakazu, 10 mM NaPB as negative control, or 100 ng/mL of LPS as positive control and **incubated for 6 h at 37°C**. After incubation, the cell supernatant was collected for ELISA, and the cells were washed with PBS twice. Cell viability was measured using Cell Count Reagent SF (Nacalai Tesque, Kyoto, Japan).

### 2.5. Real time RT-PCR

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 24-well cell culture plate (BD Falcon, Franklin Lakes, NJ, USA) at  $3.0 \times 10^5$  cells/well and cultured for 16 h. After washing with PBS, the cells were treated with 1 mL of 10% FBS-DMEM containing various concentrations of wakazu, 10 mM NaPB as negative control, or 100 ng/mL of LPS as positive control and incubated for 3 h. Total RNA was isolated from the cells using Sepasol-RNA I Super G (Nacalai Tesque) according to the

manufacturer's instructions and used as a template for cDNA synthesis with MMLV-reverse transcriptase (Promega, Madison, WI, USA) and an oligo-(dT)<sub>20</sub> primer (Toyobo, Osaka, Japan). A real time RT-PCR mixture, with a final volume of 20 µL, consisted of Thunderbird SYBR qPCR Mix (Toyobo), 10 pmol of a forward primer, 10 pmol of a reverse primer, and 0.1 µg of a cDNA sample. Thermal cycling conditions were 20 s at 95°C, followed by 40 cycles of 3 s at 95°C and 30 s at 60°C. PCR products were measured on a StepOnePlus Real-time PCR System (Applied Biosystems, Foster City, CA, USA), and relative gene expression was calculated based on the comparative CT method using StepOne Software v2.1 (Applied Biosystems). Expression of the β-actin gene was used as an endogenous control. Specific oligonucleotide sequences for each gene are as follows. Mouse β-actin: sense, 5'-CATCCGTAAAGACCTCTATGCCAAC-3' and antisense, 5'-ATGGAGCCACCGATCCACA-3'; mouse TNF-α: sense, 5'-CTACTCCCAGGTTCTCTTCAA-3' and antisense, 5'-GCAGAGAGGAGGTTGACTTTC-3'; mouse IL-6: sense, 5'-AAGCCAGAGTCCTTCAGAGAGAT-3' and antisense, 5'-TTGGATGGTCTTGGTCCTTAGC-3'; mouse inducible nitric oxide synthase (iNOS): sense, 5'-CCAAGCCCTCACCTACTTCC-3' and antisense, 5'-CTCTGAGGGCTGACACAAGG-3'.

## 2.6. Griess assay

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 96-well cell culture plate at  $6.0 \times 10^4$  cells/well and cultured for 10 h. After washing with PBS, the cells were treated with 200 µL of 10% FBS-DMEM containing various concentrations of wakazu or 10 mM NaPB as negative control and incubated for 24 h. The concentration of nitric oxide (NO) in the culture media was measured by Griess Reagent System (Promega, Tokyo, Japan) according to the manufacturer's instructions.

## 2.7. Western blot analysis

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 35 mm dish (BD Falcon) at  $6.0 \times 10^5$  cells/dish at 2 mL and cultured for 16 h. After washing with PBS, the cells were treated with 2 mL of 10% FBS-DMEM containing various concentrations of wakazu, 10 mM NaPB as negative control, or 100 ng/mL of LPS as positive control and incubated for 15 min. Cytosolic and nuclear proteins were prepared using a CellLytic NuCLEAR Extraction Kit (Sigma-Aldrich) according to the manufacturer's instructions. The protein concentration of cell lysate was determined using a DC protein assay kit (Bio-Rad Laboratories, Hercules, Calif., U.S.A.) with BSA as a standard. Denatured proteins were then separated using SDS-PAGE and transferred onto a PVDF membrane (Hybond-P; GE Healthcare, Buckinghamshire, UK). Immunoblotting with various antibodies was performed as previously described [5].

## 2.8. Measurement of phagocytosis activity

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 24-well cell culture plate at  $3.0 \times 10^5$  cells/well and cultured for 16 h. After washing with PBS, the cells were treated with 1 mL of 10% FBS-DMEM containing various concentrations of wakazu, 10 mM NaPB as negative control, or 100 ng/mL of LPS as positive control and incubated for 6 h. After washing with PBS, 1 mL of 10% FBS-RPMI 1640 medium containing 40 µg of Texas Red-conjugated Zymosan A (*S. cerevisiae*) BioParticles (Molecular Probes, Eugene, Ore., U.S.A.) was added to each well and incubated for 1 h under a dark condition. After removing the culture medium, the cells were collected and centrifuged at  $160 \times g$  for 5 min at 4°C. The cells pellet was suspended with 1 mL of 2% FBS-PBS, and phagocytotic activity was measured on a flow cytometer (FACSCalibur; BD Biosciences, San Jose, CA, USA).

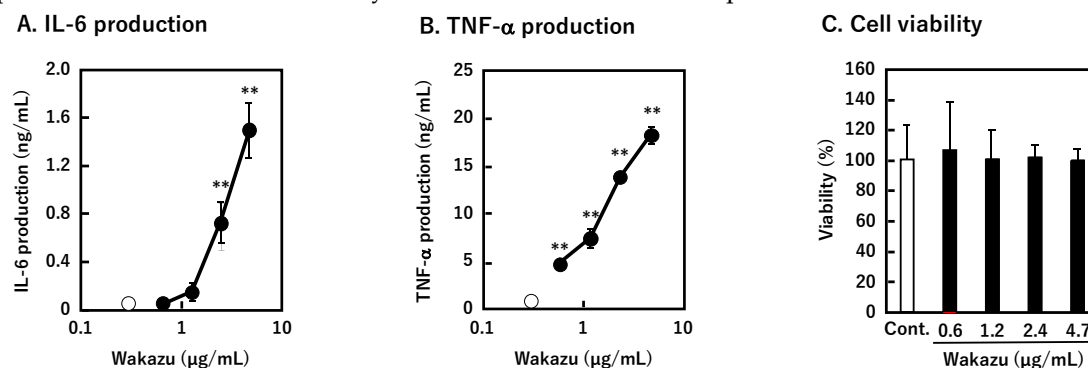
## 2.9. Statistical analysis

Data obtained were expressed as mean ± standard deviation. One way ANOVA followed by Tukey-Kramer test was used to assess the statistical significance of the difference. Values with \* $p < 0.05$  or \*\* $p < 0.01$  were considered statistically significant.

### 3. Results

#### 3.1 Effect of wakazu on cytokine production by RAW264.7 cells

The effect of wakazu on cytokine production by RAW264.7 cells was first examined. Wakazu was added to the culture media at various concentrations, and the cytokine concentration in the medium was measured by ELISA after incubation for 6 h. As shown in Figure 1, wakazu significantly enhanced the production of IL-6 and TNF- $\alpha$  by RAW264.7 cells in a dose-dependent manner.



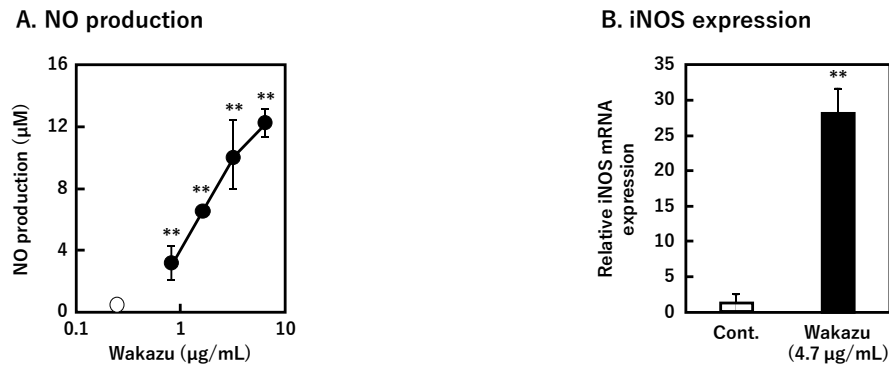
**Figure 1.** Effect of wakazu on cytokine production by RAW264.7 cells. (A, B) RAW264.7 cells were treated with 10% FBS-DMEM containing various concentrations of wakazu (gray circle) or 10 mM NaPB as control (open circle) and incubated for 6 h at 37°C. After incubation, the concentrations of IL-6 and TNF- $\alpha$  in the culture media were measured by ELISA. (C) Cell viability was measured after collecting the culture media from each well for ELISA. Experiments were performed in triplicate, and error bars indicate as the mean  $\pm$  standard deviation. \*\* $p$  < 0.01 against control by Tukey-Kramer test.

#### 3.2 Effect of wakazu on cytokine gene expression levels in RAW264.7 cells

As mentioned above, wakazu stimulated the production on IL-6 and TNF- $\alpha$  by RAW264.7 cells. Hence, the effect of wakazu on mRNA expression levels of these cytokines was evaluated. Wakazu was added to the culture media at various concentrations, and the mRNA expression levels of IL-6 and TNF- $\alpha$  were evaluated by real-time RT-PCR. Wakazu significantly increased the mRNA expression levels of IL-6 and TNF- $\alpha$  in RAW264.7 cells. These results indicated that wakazu stimulates cytokine production by promoting the transcription process.

#### 3.3 Effect of wakazu on NO production and mRNA expression of iNOS in RAW264.7 cells

NO is recognized as one of the most versatile compounds in the immune system, and produced by macrophages which are activated by cytokines and microbial compounds. Therefore, we examined the effect of wakazu on NO produced by RAW264.7 cells. As shown in Figure 2A, wakazu significantly stimulated NO production by RAW264.7 cells. In addition, wakazu also enhanced the mRNA expression of iNOS in RAW264.7 cells (Figure 2B), suggesting that wakazu stimulates NO production by enhancing iNOS gene expression.



**Figure 2.** Effect of wakazu on NO production and mRNA expression of iNOS in RAW264.7 cells. (A) RAW264.7 cells were treated with 10% FBS-DMEM containing various concentrations of wakazu (gray circle) or 10 mM NaPB as control (open circle) and incubated for 24 h at 37°C. After incubation, the concentrations of NO in the culture media were measured by Griess assay. (B) RAW264.7 cells were treated with 10% FBS-DMEM containing 4.7 µg /mL of wakazu or 10 mM NaPB as control and incubated for 3 h. After incubation, mRNA expression levels of iNOS was evaluated by Real time RT-PCR. Experiments were performed in triplicate, and error bars indicate as the mean  $\pm$  standard deviation. \*\* $p < 0.01$  against control by Tukey-Kramer test.

### 3.4. Effect of wakazu on NF- $\kappa$ B and MAP kinase signaling pathways involved in macrophage activation

To examine the involvement of NF- $\kappa$ B and MAP kinase signaling pathways in the regulation of the TNF- $\alpha$  and IL-6 production, RAW264.7 cells were incubated in the medium containing wakazu for 15 min, and the protein levels of signal molecules were evaluated by western blot analysis. The result showed that the degradation of I $\kappa$ B $\alpha$  and the translocation of NF- $\kappa$ B into the nucleus were stimulated by wakazu (data not shown). In addition, the phosphorylation levels of ERK and JNK were increased by wakazu, whereas that of p38 was not affected. These results suggested that wakazu enhances translocation of NF- $\kappa$ B to the nucleus and MAP kinase signal transduction in RAW264.7 cells.

### 3.5. Effect of wakazu on phagocytotic activity of RAW264.7 cells

Phagocytosis occurs in specialized cells such as macrophages, dendritic cells, and neutrophils. It is the first step in triggering host defense and inflammation. Thus, the effect of wakazu on phagocytotic activity of RAW264.7 cells was examined. The phagocytotic activity of RAW264.7 cells was obviously elevated by wakazu (data not shown), suggesting that wakazu stimulates the phagocytotic activity of macrophages.

## 4. Discussion

Black vinegar is produced by saccharification, fermentation, and aging in one pot. Wakazu is an immature black vinegar collected before aging for 1-3 years. Various microorganisms such as *Aspergillus*, yeasts, lactic acid bacteria, and acetic acid bacteria are involved in their process of fermentation and maturation. Since many of the fermenting microorganisms die in this process, wakazu contains many components derived from the microorganisms such as endotoxin which activates macrophages. Therefore, we removed the endotoxin from wakazu before evaluating the activity of wakazu and studied the immunostimulatory effect of wakazu components not derived from endotoxins. Wakazu significantly enhanced the production of IL-6 and TNF- $\alpha$  by RAW264.7 cells. In addition, the expression levels of IL-6 and TNF- $\alpha$  genes in RAW264.7 cells were enhanced in dose-dependent manners. These results suggest that wakazu stimulates cytokine production by upregulating the transcription process of the cytokine genes.

Next, we examined the effect of wakazu on the signaling pathways involved in macrophage activation. The activation of macrophages is caused by NF- $\kappa$ B and MAP kinase cascades. The result showed that the phosphorylation levels of ERK and JNK were increased by treatment with wakazu. Wakazu also helped degradation of I $\kappa$ B $\alpha$  and translocation of NF- $\kappa$ B into the nucleus. These results suggest that wakazu stimulates cytokine production through upregulation of the NF- $\kappa$ B and MAP kinase cascades. In addition, wakazu stimulated NO production and phagocytotic activity of RAW264.7 cells. So far, the NF- $\kappa$ B and MAP kinase cascades have been reported to be involved in NO production and the phagocytosis activity of macrophages [6,7]. Therefore, the wakazu-induced NO production and phagocytosis activity of macrophages are considered to be due to the upregulation of the NF- $\kappa$ B and MAP kinase cascades.

## 5. Conclusions

Although several function of wakazu on human health are known, the immunostimulatory effect of wakazu components on macrophages has not been reported. In this study, we found that endotoxin free-wakazu has an immunostimulatory effect on macrophages. Our findings indicate that not only kurozu, but also wakazu is also expected to be effective on our health as functional food.

## References

1. Gordon, S. Pattern recognition receptors: doubling up for the innate immune respons. *Cell* **2002**, *111*, 927-930, 10.1016/S0092-8674(02)01201-1.
2. Nathan, C.F. Secretory products of macrophages. *J Clin Invest* **1987**, *79*, 319-326, 10.1172/JCI112815.
3. Nishidai, S.; Nakamura, Y.; Torikai, K.; Yamamoto, M.; Ishihara, N.; Mori, H.; Ohigashi, H. Kurozu, a traditional vinegar produced from unpolished rice, suppresses lipid peroxidation *in vitro* and in mouse skin. *Biosci Biotechnol Biochem* **2000**, *64*, 1909-1914, 10.1271/bbb.64.1909.
4. Awane, S.; Nishi, K.; Ishida, M.; Nagano, M.; Hashiguchi, K.; Fujii, A.; Sugahara, T. Inhibitory effect of Japanese black vinegar on IgE-mediated degranulation of RBL-2H3 cells and a murine model of Japanese cedar pollinosis. *Cytotechnology* **2018**, *70*, 961-974, 10.1007/s10616-018-0208-6.
5. Kumalasari, I.D.; Nishi, K.; Putra, A.B.; Sugahara, T. Activation of macrophages stimulated by bengkoang fiber extract through Toll-like receptor-4. *Food Funct* **2014**, *5*, 1403-1408, 10.1039/c3fo60360a.
6. Chen, B.-C.; Chen, Y.-H.; Lin, W.-W. Involvement of p38 mitogen-activated protein kinase in lipopolysaccharide-induced iNOS and COX-2 expression in J774 macrophages. *Immunology* **1999**, *97*, 124-129, 10.1046/j.1365-2567.1999.00747.x.
7. Blander J.M.; Medzhitov, R. Regulation of phagosome maturation by signals from Toll-Like receptors, *Science* **2004**, *304*, 1014-1018, 10.1126/science.1096158.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license

(<http://creativecommons.org/licenses/by/4.0/>).

FP-FST-007-ID017

# Anti-Inflammatory Effect of Placenta Water-Soluble Extract on Macrophages

Miyuki Yokotani<sup>1</sup>, Kosuke Nishi<sup>1,2</sup>, Yoshiharu Sasaki<sup>3</sup>, Takuya Sugahara<sup>1,2,\*</sup>

<sup>1</sup> Graduate School of Agriculture, Ehime University, Matsuyama, Ehime 790-8566, Japan

<sup>2</sup> Food and Health Sciences Research Center, Ehime University, Matsuyama, Ehime 790-8566, Japan

<sup>3</sup> Fine Japan Co., Ltd., Higashiyodogawa-ku, Osaka 533-0021, Japan

\* Corresponding author: mars95@agr.ehime-u.ac.jp; Tel.: +81-89-946-9863

Received: 9 July 2018; Accepted: 4 December 2018; Published: 6 January 2020

**Abstract:** The placenta is an organ attached to the lining of womb during pregnancy. It contains many kinds of substances such as amino acids, lipids, carbohydrates, vitamins, and minerals. It also has various health functions such as anti-allergy and anti-oxidant. We examined the anti-inflammatory effect of placenta water-soluble extract (PE) on lipopolysaccharide (LPS)-stimulated macrophages. PE significantly suppressed interleukin (IL)-6 and tumor necrosis factor (TNF)- $\alpha$  production by LPS-stimulated RAW264.7 cells and LPS-stimulated P-Mac without cytotoxicity. The gene expression levels of inflammatory cytokines in LPS-stimulated macrophages were significantly suppressed by PE. Then, the effect of PE on signal transduction for macrophage activation was evaluated. As a result, phosphorylation levels of ERK, JNK and p38 in MAPK cascade located at downstream of TLR4 signaling were decreased by PE treatment. In addition, heat-treatment of PE did not affect the inflammatory activity, so the active substance in PE is heat stable. As indicated here, our findings suggest that PE suppresses LPS-induced inflammation by inhibiting phosphorylation of MAPK cascade.

**Keywords:** RAW264.7, macrophage, anti-inflammatory, cytokine, MAPK

---

## 1. Introduction

The placenta is an organ attached to the lining of womb during pregnancy. It connects to fetus and provides oxygen and nutrients. In recent years, it is known that placenta has some health function such as anti-oxidant [1] and skin-whitening effects [2].

When infection occurs in the body, macrophages are induced to release inflammatory cytokines such as tumor necrosis factor (TNF)- $\alpha$ , interleukin (IL)-1, IL-12, IL-8, and IL-6. These cytokines activate immune cells [3]. However, the excessive production of these inflammatory cytokines is to trigger many disease such as obesity, Alzheimer's disease, and cancer. It is also reported that many cancers arise from sites of infection, chronic irritation and inflammation. In this study, the anti-inflammatory effect of placenta water-soluble extract (PE) on macrophages was examined.

## 2. Materials and Methods

### 2.1. Preparation of placenta water-soluble extract

Placenta powder was provided by Fine Japan Co., Ltd (Osaka, Japan). Placenta powder was suspended in 10 mM sodium phosphate buffer (NaPB; pH 7.4) at 0.1 g/mL at 10°C for 24 h. After centrifugation at 15,000  $\times$  g at 4°C for 20 min, the supernatant was collected and adjusted to pH 7.4. The supernatant was then filtrated through a 0.22  $\mu$ m membrane and used as PE. The protein concentration of PE was determined using a DC protein assay kit (Bio-Rad Laboratories, Hercules, CA, USA) with bovine serum albumin (BSA) as a standard.

## 2.2. Cells and cell culture

A mouse macrophage-like cell line, RAW264.7 cells were purchased from Japanese Collection of Research Bioresources Cell Bank (Osaka, Japan). RAW264.7 cells were cultured in DMEM supplement with 100 U/mL of penicillin, 100 µg/mL of streptomycin, and 10% FBS at 37°C under humidified 5% CO<sub>2</sub>. RAW264.7 cells were detached using phosphate-buffered saline (PBS) containing 0.25% trypsin and 0.02% ethylenediamine-*N*, *N*, *N'*, *N'*-tetraacetic acid (Dojindo Laboratories, Kumamoto, Japan) for the subsequent experiments.

## 2.3. Preparation of mouse primary peritoneal macrophages

Eight-week-old female BALB/c mice (Japan SLC, Shizuoka, Japan) were injected with 3.0% of thioglycolate medium (2 mL/body) in the peritoneum. Four days after injection, the mice were sacrificed and injected with 3 mL of PBS in the peritoneum to collect thioglycolate-elicited peritoneal macrophages (P-Mac). The collected cells were centrifuged at  $160 \times g$  for 5 min at 4°C, and the cell pellet was washed with PBS and centrifuged again. The cell pellet was suspended in RPMI 1640 medium supplemented with 100 U/mL of penicillin, 100 µg/mL of streptomycin, and 10% FBS. Cells were seeded into a 24-well culture plate (BD Falcon, Franklin Lakes, NJ, USA) at  $1.0 \times 10^6$  cells/well and cultured at 37°C under humidified 5% CO<sub>2</sub>. After cultivation for 1 h, the cells were washed with PBS three times to remove unattached cells such as neutrophils. P-Mac were cultured at 37°C under humidified 5% CO<sub>2</sub> overnight and used for the subsequent experiments.

## 2.4. Determination of cytokine levels in culture medium

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 96-well culture plate (Corning, Corning, NY, USA) at  $6.0 \times 10^4$  cells/well and cultured at 37°C overnight under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 200 µL of 10% FBS-DMEM containing 100 ng/mL of lipopolysaccharides (LPS; Sigma-Aldrich, St. Louis, MO, USA) and various concentrations of PE or 10 mM NaPB as a control and incubated for 6 h. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. P-Mac suspended in 10% FBS-RPMI 1640 medium were seeded into a 24-well culture plate at  $1.0 \times 10^6$  cells/well and cultured at 37°C under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 1.0 mL of 10% FBS-RPMI 1640 medium containing 100 ng/mL of LPS and various concentrations of PE or 10 mM of NaPB as control and incubated for 24 h. Blank cells were treated with 10% FBS-RPMI 1640 medium containing 10 mM NaPB alone. After the incubation, the concentrations of IL-6 and TNF-α in the culture media were measured by enzyme-linked immunosorbent assay (ELISA) using mouse IL-6 ELISA kit (BioLegend, San Diego, CA, USA) and mouse TNF-α ELISA kit (eBioscience, San Diego, CA, USA), respectively, according to the manufacturer's instructions.

## 2.5. Cell viability

Cytotoxicity of PE extract was examined using Cell Count Reagent SF (Nacalai Tesque, Kyoto, Japan) according to manufacturer's instructions after collecting the culture media from each well for ELISA.

## 2.6. Real time RT-PCR

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 48-well culture plate (BD Falcon) at  $1.5 \times 10^5$  cells/well and cultured at 37°C overnight under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 500 µL of 10% FBS-DMEM containing 100 ng/mL of LPS and various concentrations of PE or 10 mM NaPB as control and incubated for 6 h. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. P-Mac suspended in 10% FBS-RPMI 1640 medium was seeded into a 24-well culture plate at  $1.0 \times 10^6$  cells/well and cultured at 37°C under humidified 5% CO<sub>2</sub>. The cells were treated with 1.0 mL of 10% FBS-RPMI 1640 medium containing 100 ng/mL of LPS and various concentrations of PE or 10 mM NaPB as control and incubated for 24 h. Total

RNA was then isolated from the cells using Sepasol-RNA I Super G (Nacalai Tesque) according to the manufacturer's instructions and used as a template for cDNA synthesis with MMLV-reverse transcriptase (Promega, Madison, WI, USA) and an oligo-(dT)<sub>20</sub> primer (Toyobo, Osaka, Japan). A real-time PCR mixture, with a final volume of 20 µL, consisted of Thunderbird SYBR qPCR Mix (Toyobo), 10 pmol of a forward primer, 10 pmol of a reverse primer, and 0.1 µg of a cDNA sample. Thermal cycling conditions were 20 s at 95°C, followed by 40 cycles of 3 s at 95°C and 30 s at 60°C. PCR products were measured on a StepOnePlus Real-time PCR System (Applied Biosystems, Foster City, CA, USA), and relative gene expression was calculated based on the comparative CT method using StepOne Software v2.1 (Applied Biosystems). Expression of the β-actin gene was used as an endogenous control. Specific oligonucleotide sequences for each gene are as follows. Mouse β-actin: sense, 5'-CATCCGTAAAGACCTCTATGCCAAC-3' and antisense, 5'-ATGGAGCCACCGATCCACA-3'; mouse TNF-α: sense, 5'-CTACTCCCAGGTTCTCTTCAA-3' and antisense, 5'-GCAGAGAGGAGGTTGACTTTC-3'; mouse IL-6: sense, 5'-AAGCCAGAGTCCTTCAGAGAGAT-3' and antisense, 5'-TTGGATGGTCTTGGTCCTTAGC-3'; mouse inducible nitric oxide synthase (iNOS): sense, 5'-CCAAGCCCTCACCTACTTCC-3' and antisense, 5'-CTCTGAGGGCTGACACAAGG-3'.

### 2.7. Nitric oxide production assay

RAW264.7 cells suspended in 10% FBS-DMEM were inoculated into a 96-well cell culture plate at  $1.0 \times 10^4$  cells/well and cultured for 12 h. The cells were treated with 200 µL of 10% FBS-DMEM containing 100 ng/mL of LPS and various concentrations of PE or 10 mM NaPB as control and incubated for 24 h. The concentration of nitric oxide (NO) was measured by Griess Reagent System (Promega) according to the manufacturer's instructions.

### 2.8. Immunoblot analysis

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 35 mm dish (BD Falcon) at  $1.0 \times 10^6$  cells/dish and cultured at 37°C for overnight under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 2.0 mL of 10% FBS-DMEM containing 100 ng/mL of LPS and 6200 µg/mL of PE or 10 mM NaPB as control and incubated for 15 min. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. Cytosolic and nuclear proteins were prepared using a CellLytic NuCLEAR Extraction Kit (Sigma-Aldrich) according to the manufacturer's instructions. Denatured proteins were then separated using SDS-PAGE and transferred onto a PVDF membrane (Hybond-P; GE Healthcare, Buckinghamshire, UK). Immunoblotting with various antibodies was performed as previously described [4].

### 2.9. Heat-treatment of PE

To examine the effect of heat-treated PE on cytokine production by LPS-stimulated RAW264.7 cells, PE was heated at 100°C for 20 min and used for assay of activity.

### 2.10. Statistical analysis

Data obtained were expressed as mean ± standard deviation. One way ANOVA followed by Tukey-Kramer test was used to assess the statistical significance of the difference. Values with \* $p < 0.05$ , \*\* $p < 0.01$ , were considered statistically significant.

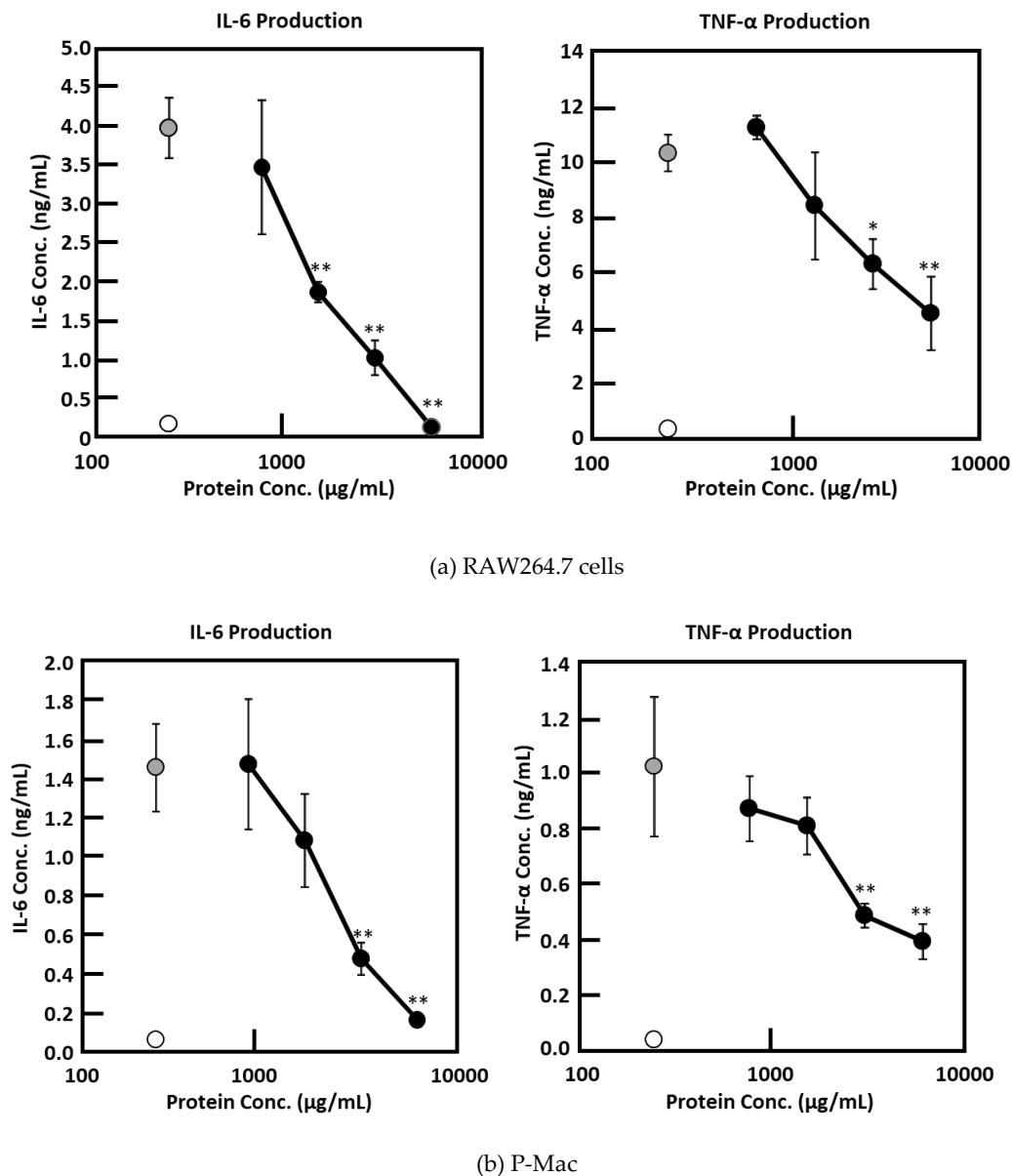
## 3. Results

### 3.1. Effect of PE on cytokine production by RAW264.7 cells and P-Mac

The effect of PE on cytokine production by RAW264.7 cells and P-Mac was first examined. As shown in Figure 1, PE significantly inhibited cytokine production by both RAW264.7 cells and P-Mac in dose-dependent manners. In addition, it showed that PE has no significant cytotoxicity to either cell



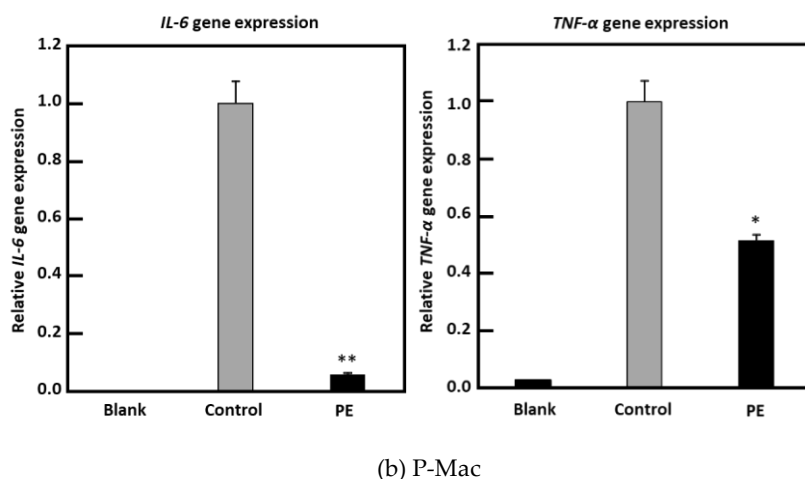
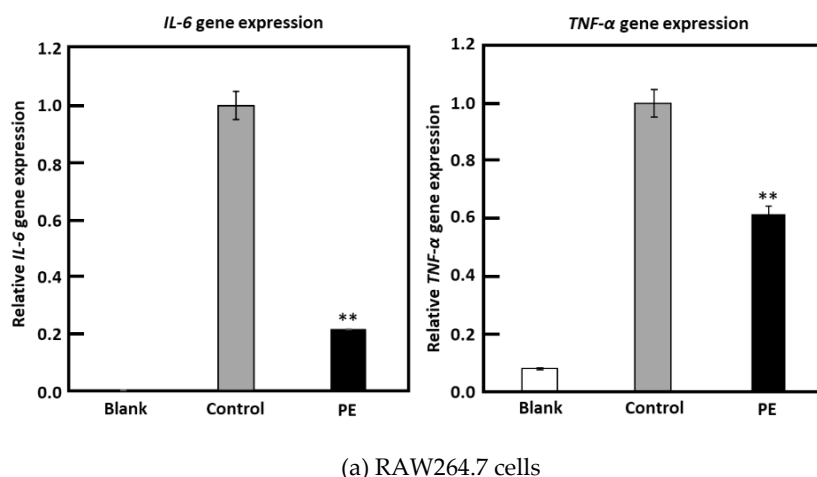
culture within the tested concentrations (data not shown). From these results, further experiments were performed at 6200  $\mu\text{g}$  protein/mL or lower concentrations of PE.



**Figure 1.** Effect of PE on cytokine production by RAW264.7 cells and P-Mac. (a) RAW264.7 cells and (b) P-Mac were incubated with 100 ng/mL of LPS and various concentrations of PE (closed circle) or 10 mM NaPB as control (gray circle). Blank cells (open circle) were treated with 10 mM NaPB alone. After incubation, the concentrations of IL-6 and TNF- $\alpha$  in the culture media were measured by ELISA. Experiments were performed in triplicate, and error bars indicate as the mean  $\pm$  standard deviation. \* $p < 0.05$ , \*\* $p < 0.01$ , against control by Tukey-Kramer test.

### 3.2. Effect of PE on cytokine gene expression levels in RAW264.7 cells and P-Mac

As described above, PE inhibited the production of IL-6 and TNF- $\alpha$  by both RAW264.7 cells and P-Mac. Hence, the effect of PE on mRNA expression levels of these cytokines was examined. As shown in Figure 2, PE significantly inhibited the mRNA expression levels of IL-6 and TNF- $\alpha$  in both RAW264.7 cells and P-Mac. It is suggested that the effect of PE on cytokine production is due to the downregulation of cytokine gene expression.



**Figure 2.** Effect of PE on cytokine gene expression levels by RAW264.7 cells and P-Mac. (a) RAW264.7 cells and (b) P-Mac were incubated with 100 ng/mL of LPS and various concentrations of PE (closed circle) or 10 mM NaPB as control (gray circle). Blank cells (open circle) were treated with 10 mM NaPB alone. After incubation, the gene expression levels of IL-6 and TNF- $\alpha$  were measured by real time RT-PCR. Experiments were performed in duplicate, and error bars indicate as the mean  $\pm$  standard deviation. \* $p < 0.05$ , \*\* $p < 0.01$ , against control by Tukey-Kramer test.

### 3.3. Effect of PE on NO production and mRNA expression of iNOS in RAW264.7 cells

NO is recognized as one of the most versatile compounds in the immune system and produced by macrophages activated by cytokines and microbial compounds. Therefore, we examined the effect of PE on NO production by LPS-stimulated RAW264.7 cells. The result showed that PE significantly inhibited NO production by LPS-stimulated RAW264.7 cells (data not shown). In addition, PE also suppressed the mRNA expression of iNOS in the cells, suggesting that PE inhibits NO production by suppressing iNOS gene expression.

### 3.4. Effect of PE on signaling pathways involved in macrophage activation

To examine the involvement of MAPK and NF- $\kappa$ B signaling pathways in the inhibition of the IL-6 and TNF- $\alpha$  production by treating with PE, the protein levels of signal molecules were evaluated by immunoblot analysis. As a result, the phosphorylation levels of ERK, JNK and p38 were decreased by PE treatment, whereas PE did not affect the translocation of NF- $\kappa$ B into the nucleus in LPS-stimulated RAW264.7 cells (data not shown). These results suggested that PE inhibits inflammatory cytokine production through downregulation of MAPK cascade.

### 3.5. Effect of heat-treated PE on cytokine production by RAW264.7 cells

To investigate whether the active substance in PE is heat-stable or not, PE was heated at 100°C for 20 min. The result showed that the cytokine production-suppressive activity of PE was not affected by heat treatment (data not shown), suggesting that the active substance in PE is heat-stable.

## 4. Discussion

In this study, we firstly measured cytokine concentration in the culture media to assess the anti-inflammatory activity of PE. PE significantly inhibited the production of IL-6 and TNF- $\alpha$  by both RAW264.7 cells and P-Mac in dose-dependent manners. PE also significantly suppressed the gene expression levels of IL-6 and TNF- $\alpha$  in both RAW264.7 cells and P-Mac. These results suggested that PE inhibits the cytokine production by suppressing the transcription process. In addition, PE inhibited NO production by suppressing the mRNA expression of iNOS in LPS-stimulated RAW264.7 cells, suggesting that PE inhibits NO production by suppressing iNOS gene expression.

There are two signaling pathways involved in the production of cytokines and NO by macrophages, namely, MAPK and NF- $\kappa$ B cascades. Therefore, we examined the effect of PE on MAPK and NF- $\kappa$ B cascades. The result showed that the phosphorylation levels of ERK, JNK, and p38 in MAPK cascade located at downstream of TLR4 signaling were decreased by PE treatment. On the other hand, PE did not affect the translocation of NF- $\kappa$ B into the nucleus in the LPS-stimulated cells. These results indicated that the activity of PE is due to the downregulation of MAPK cascade.

Furthermore, we investigated the properties of active substance in PE. The result showed that heat-treated PE has the inhibitory effect on cytokine production by LPS-stimulated RAW264.7 cells, suggesting that the active substance in PE is heat-stable.

## 5. Conclusions

Although macrophages have an important role to release cytokines when inflammation occurs, the excess of producing these cytokines causes diseases. In this study, we found that PE has anti-inflammatory effect on macrophages. In addition, our findings suggested that PE suppresses LPS-induced inflammation by inhibiting the activation of MAPK cascade. Taken together, these data indicate that placenta would be a beneficial functional food with anti-inflammatory effect on macrophages.

## References

1. Togashi, S.; Takahashi, N.; Iwama, M.; Watanabe, S.; Tamagawa, K.; Fukui, T. Antioxidative collagen-derived peptides in human-placenta extract. *Placenta* 2002, 23, 497-502, 10.1053/plac.2002.0833.
2. Yamasaki, M.; Hasegawa, S.; Takahashi, H.; Kobayashi, Y.; Sakai, C.; Ashizawa, Y.; Asai, Y.; Kanzaki, M.; Fukui, T. Placental extracts induce the expression of antioxidant enzyme genes and suppress melanogenesis in B16 melanoma cells. *Nat Prod Res* 2015, 29, 2103-2106, 10.1080/14786419.2014.986660.
3. Arango Duque, G.; Descoteaux, A. Macrophage cytokines: involvement in immunity and infectious diseases. *Front Immunol* 2014, 5, 491, 10.3389/fimmu.2014.00491.
4. Ishida, M.; Nishi, K.; Kunihiro, N.; Onda, H.; Nishimoto, S.; Sugahara, T. Immunostimulatory effect of aqueous extract of *Coriandrum sativum* L. seed on macrophages. *J Sci Food Agric* 2017, 97, 4727-4736, 10.1002/jsfa.8341.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license

(<http://creativecommons.org/licenses/by/4.0/>).

FP-FST-008-ID018

# Anti-Allergic Effect of Clove

Ange Murielle DjidjouTagne<sup>1</sup>, Momoko Ishida <sup>1</sup>, Hiroyuki Onda<sup>2</sup>, Kosuke Nishi <sup>1,3</sup>, Takuya Sugahara<sup>2,\*</sup>

<sup>1</sup> Graduate School of Agriculture, Ehime University, Matsuyama, Ehime 790-8566, Japan

<sup>2</sup> Research and Analysis Center, Research and Product Development Division, S&B FOODS Incorporated, Itabashi-ku, Tokyo 174-8651, Japan

<sup>3</sup> Food and Health Sciences Research Center, Ehime University, Matsuyama, Ehime 790-8566, Japan

\* Corresponding author: [mars95@agr.ehime-u.ac.jp](mailto:mars95@agr.ehime-u.ac.jp); Tel.: +81 89-946-9863

Received: 9 July 2018; Accepted: 4 December 2018; Published: 6 January 2020

**Abstract:** Allergic rhinitis is a common disease which has affected more than 500 million people worldwide over the last 20 years. Though not a severe disease, it has significant impacts on lowering quality of life due to its co-occurring symptoms like headache, asthma and sinusitis. Faced with this problem, scientists all over the world are constantly in search of active substances from natural sources to find the candidates for functional food materials. In this study, we focused on the anti-allergic effect of cloves; one of the spices used worldwide. Clove extract in 70% ethanol suppressed degranulation of rat basophilic leukemia cell line, RBL-2H3 cells. In addition, the elevation of intracellular  $\text{Ca}^{2+}$  concentration induced by antigen stimulation was obviously suppressed by clove extract. Cloves can thus be a good candidate for the food and pharmaceuticals industries.

**Keywords:** clove; anti-allergic effect; degranulation

---

## 1. Introduction

The rapid growth in the prevalence, severity, and complexity of allergic diseases in modern population has been of significant health concern. This is due to the burden they impose on patient's quality of life by displaying various symptoms such as asthma, chronic urticaria, allergic rhinitis, conjunctivitis and angioedema to life-threatening anaphylaxis [1-3]. Allergic rhinitis is a type I allergic disease induced by an immunoglobulin E (IgE) that has affected more than 500 million people worldwide over the last 20 years. Development of the disease commences with sensitisation to allergen, which elicits the predominant production of IgE by B cells [4]. The high-affinity IgE receptor (FcεRI) is expressed on mast cells and basophils. An allergic reaction is provoked by cross-linking of allergens to IgE bound on FcεRI, leading to FcεRI aggregation. Aggregation of FcεRI is followed by a rise in intracellular  $\text{Ca}^{2+}$  concentration and the degranulation of mast cells. Chemical mediators including histamine,  $\beta$ -hexosaminidase and inflammatory mediators such as prostaglandins are released from intracellular granules during mast cell degranulation [1,5]. Released chemical mediators are responsible for the nasal itching, and sneezing symptoms of allergic rhinitis. Thus prevention of degranulation of mast cells and basophils is one of the most effective approaches to attenuate allergic symptoms.

The drugs used to treat allergic diseases are usually, anti-histamine, mast cell stabilizer and leukotriene receptor antagonists. However, anti-histamine drugs have undesirable side effects, most notably drowsiness, dry mouth etc. The use of functional food has become more popular in recent years, a safe and effective management of allergic rhinitis and other atopic diseases through food resources has received much attention [6-8]. Grape seed, jujube fruits, citrus species, passion fruit seeds, mango peels [6,9-12] and many others, have been shown to possess anti-allergic and anti-anaphylactic activities. In addition, many other spices such as rosemary, cinnamon and ingredients such as *Aster yomena* and *Ocimum tenuiflorum* [3,5,13-14], have also been shown to stabilize mast cell and cause inhibition of the allergic markers such as histamine, IL-4, and  $\beta$ -hexosaminidase in IgE-mediated allergic reaction.

Clove (*Syzygium aromaticum*) is a spice widely used to add flavour to food preparations [15]. It is indigenous to east Africa and Asian countries like Indonesia, and it has been reported to have many therapeutic uses. Clove oil has been experimentally shown to have potent antimicrobial activity against dental caries-causing microorganisms promoting their use as antimicrobial agents in dentistry [16]. It is also used to relieve pain, to control nausea and vomiting, stomach distension and gastrointestinal spasm [16-18]. However the anti-allergic effects of cloves have not yet been revealed. This study was therefore aimed at analysing the potentials of clove in suppressing the development of allergic responses in mice cells.

## 2. Materials and Methods

### 2.1. Reagents

Dulbecco's modified Eagle's medium (DMEM), penicillin, streptomycin, bovine serum albumin (BSA), fetal bovine serum (FBS), mouse anti-dinitrophenol (DNP) monoclonal IgE, DNP-human serum albumin (HSA) conjugate, and Triton X-100 were products of Sigma-Aldrich (St. Louis, MO, USA). All other chemicals were purchased from Wako Pure Chemical Industries (Osaka, Japan) or Nacalai Tesque (Kyoto, Japan) unless otherwise noted.

### 2.2. Sample preparation

Clove seed powder was provided by S&B Foods Inc. (Tokyo, Japan). The powder was suspended in 70% ethanol at 0.05g/ml and extracted at 12°C for 24 h. The solution was then centrifuged at 4°C,  $15,000 \times g$  for 20 min to remove insoluble materials. The supernatant was filtered through a 0.22  $\mu$ m membrane filter, and concentrated using an evaporator and a freeze-drier. The final concentration was adjusted to 70mg/mL with 70% ethanol. It was sterilized by filtration through a 0.22  $\mu$ m membrane filter and the ethanol extract of clove (EEC) was used for the experiments described below.

### 2.3. Cell and cell culture

RBL-2H3 cells (rat basophilic leukemia cells) were obtained from American Type Culture Collection (Rockville, MD, USA) and cultured in DMEM supplemented with 100 U/mL of penicillin, 100  $\mu$ g/mL of streptomycin, and 5% FBS at 37°C under humidified 5% CO<sub>2</sub>.

### 2.4. $\beta$ -Hexosaminidase release assay

The assay was performed using the method of Nishi *et al.* and Hwang *et al.* [1,8] with some modifications. RBL-2H3 cells were seeded at  $4.0 \times 10^5$  cells/well into a 96-well plate (Corning, Corning, NY, USA) and sensitized with 50 ng/mL of anti-DNP IgE diluted in 5% FBS-DMEM for 24 h at 37°C. After washing with the modified Tyrode's (MT) buffer (20 mM HEPES, 135 mM NaCl, 5 mM KCl, 1.8 mM CaCl<sub>2</sub>, 1 mM MgCl<sub>2</sub>, 5.6 mM glucose, and 0.05% BSA, pH 7.4), the cells were treated with 120  $\mu$ L of various concentrations of EEC diluted in MT buffer for 10 min at 37°C. The cells were subsequently challenged for 30 min at 37°C by adding 10  $\mu$ L of DNP-HSA diluted in MT buffer at the final concentration of 0.625  $\mu$ g/mL. After the collection of supernatant, cells were sonicated in 130  $\mu$ L of MT buffer containing 0.1% Triton X-100 for 5 sec on ice. Both supernatant and cell lysate were transferred into a new 96-well microplate at 50  $\mu$ L/well and incubated for 5 min at 37°C. Then, 100  $\mu$ L of 3.3 mM 4-nitrophenyl 2-acetamido-2-deoxy- $\beta$ -D-glucopyranoside (Wako Pure Chemical Industries) dissolved in 0.1 M citrate buffer (pH 4.5) was added to each well and incubated at 37°C for 25 min. The enzyme reaction was terminated by the addition of 100  $\mu$ L of 2 M glycine buffer (pH 10.4), and the absorbance was measured at 415 nm using a microplate reader. The  $\beta$ -hexosaminidase release rate was calculated as:

$$100 \times \left[ \frac{OD_{\text{supernatant}} - OD_{\text{blank of supernatant}}}{\{(OD_{\text{supernatant}} - OD_{\text{blank of supernatant}}) + (OD_{\text{cell lysate}} - OD_{\text{blank of cell lysate}})\}} \right] \quad (1)$$

### 2.5. Cell viability assay

The cytotoxicity of EEC to RBL-2H3 cells was examined using Cell Count Reagent SF (Nacalai Tesque). RBL-2H3 cells were seeded, sensitized with anti-DNP IgE, treated with various concentrations of EEC, and challenged with DNP-HSA as described above. After the cells were washed with phosphate-buffered saline (PBS, pH 7.4) once, 100  $\mu$ L of DMEM containing 10  $\mu$ L of WST-8 solution was added to each well of the cell culture plate and incubated for 45 min at 37°C. The absorbance was then measured at 450 nm and 655 nm using a microplate reader.

### 2.6. Measurement of intracellular $\text{Ca}^{2+}$ concentration

The intracellular  $\text{Ca}^{2+}$  concentration ( $[\text{Ca}^{2+}]_i$ ) was measured using a Calcium KitFluo 3 (Dojindo Laboratories, Kumamoto, Japan) as reported by Nishi *et al.* [1], with some modifications. RBL-2H3 cells were seeded in a black 96-well culture plate and sensitized with anti-DNP IgE as described above for  $\beta$ -hexosaminidase assay. After washing with warm PBS twice, the IgE-sensitized cells were incubated with 100  $\mu$ L of Fluo-3 AM for 1 h. The cells were then washed with PBS, and treated with 100  $\mu$ L of various concentrations of EEC for 10 min. Basal reading was taken for 2 sec. Then, the cells were stimulated by the addition of 10  $\mu$ L of DNP-HSA diluted in MT buffer at the final concentration of 0.625  $\mu$ g/mL, and the fluorescence intensity was immediately monitored for the next 120 sec with an excitation wavelength of 485 nm and an emission wavelength of 530 nm using a fluorescence microplate reader.

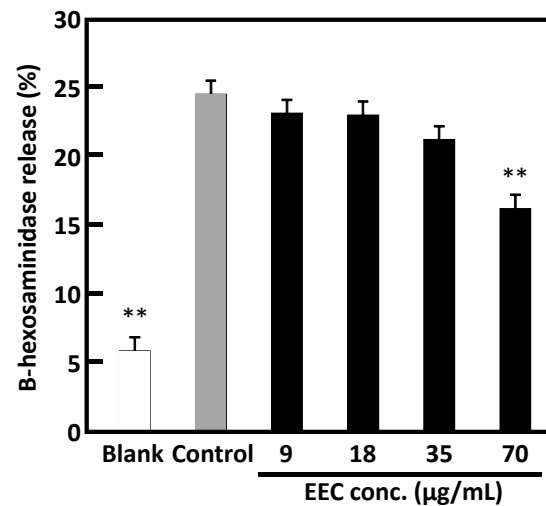
### 2.7. Statistical analysis

Data obtained were expressed as mean  $\pm$  standard deviation. One way ANOVA followed by Tukey-Kramer test as used to assess the statistical significance of the difference. Values with \* $p < 0.05$  or \*\* $p < 0.01$  were considered statistically significant.

## 3. Results

### 3.1. Effect of EEC on the rate of $\beta$ -hexosaminidase released

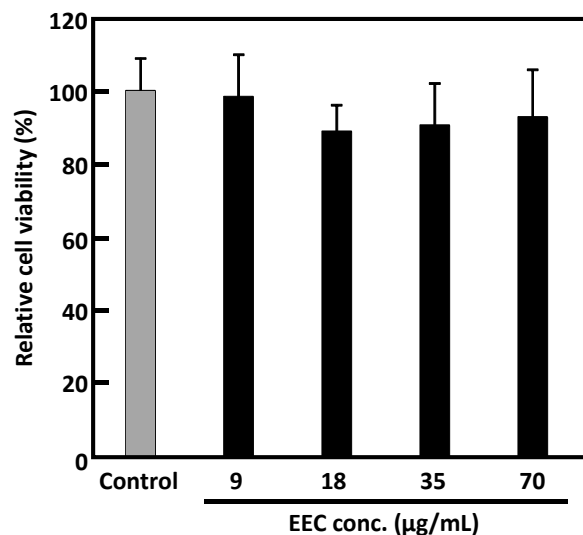
Mast cells are known to undergo degranulation upon sensitization with IgE and activation with allergens. In order to determine the effect of EEC on mast cell degranulation, RBL-2H3 cells were sensitized with anti-DNP IgE and challenged with DNP-HSA. The rate of degranulation was measured by the percentage of  $\beta$ -hexosaminidase release with or without pre-treatment of the cells with different concentrations of EEC. As shown in Figure 1, treatment of RBL-2H3 cells with EEC suppressed the amount of  $\beta$ -hexosaminidase released in a dose dependent manner.



**Figure 1.** Effect of EEC on degranulation of RBL-2H3 cells stimulated with antigen. Anti-DNP IgE-sensitized RBL-2H3 cells were treated with various concentrations of EEC or 0.07% ethanol (blank and control). Degranulation was induced by the addition of DNP-HSA diluted in MT buffer. Blank cells were treated with MT buffer alone. Released  $\beta$ -hexosaminidase was used as a marker of degranulation. Experiments were performed in triplicate, and error bars indicate standard deviation. \*\* $p < 0.01$  against control by Tukey-Kramer test.

### 3.2. Effect of EEC on the cell viability of RBL2H3 cells

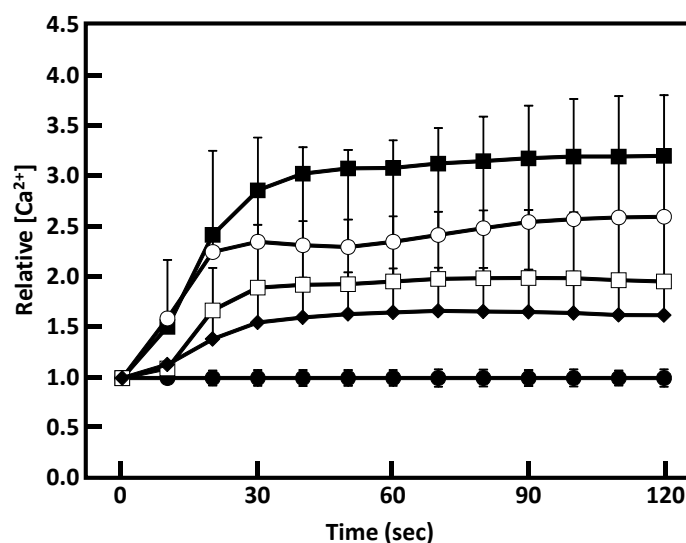
Cell viability assay using the WST-8 kit (Cell Count Reagent SF) revealed that the relative viability of RBL-2H3 cells after pre-treatment with various concentrations of EEC was not significantly different from the control (Figure 2), indicating that EEC was not toxic to the cells.



**Figure 2.** Effect of EEC on  $[Ca^{2+}]_i$  in RBL-2H3 cells stimulated with antigen. Anti-DNP IgE-sensitized RBL-2H3 cells were treated with various concentrations of EEC or 0.07% ethanol (control). Cell viability was measured using a WST-8 kit after stimulation with DNP-HSA. Experiments were performed in triplicate, and error bars indicate standard deviation. Tukey-Kramer test was used to assess the statistical significance of the difference against control.

### 3.3. Effect of EEC on the intracellular $\text{Ca}^{2+}$ concentration

Various cellular responses leading to mast cell degranulation are activated by the increase in intracellular  $\text{Ca}^{2+}$  concentration ( $[\text{Ca}^{2+}]_i$ ). To find out if the suppressive effect of EEC on mast cell degranulation is due to an inhibition of the elevation levels of intracellular  $\text{Ca}^{2+}$ , the  $[\text{Ca}^{2+}]_i$  in RBL-2H3 cells stimulated with antigen was measured using Fluo-3 AM. As shown in Figure 3, EEC inhibited the amount of intracellular  $\text{Ca}^{2+}$  in stimulated RBL-2H3 cells as compared with the control.



**Figure 3.** Effect of EEC on  $[\text{Ca}^{2+}]_i$  in RBL-2H3 cells stimulated with antigen. After anti-DNP IgE-sensitized RBL-2H3 cells were incubated with Fluo-3 AM, the cells were treated with various concentrations of EEC or ethanol as control. Fluorescence intensity was measured immediately after inducing degranulation by treating with DNP-HSA. Closed circle, ethanol-treated cells not stimulated with DNP-HSA; closed square, ethanol-treated cells stimulated with DNP-HSA; open circle, 18  $\mu\text{g/ml}$  of EEC-treated cells stimulated with DNP-HSA; open square, 35  $\mu\text{g/ml}$  of EEC-treated cells stimulated with DNP-HSA; closed diamond, 70  $\mu\text{g/ml}$  of EEC-treated cells stimulated with DNP-HSA. Experiments were performed in triplicate, and error bars indicate standard deviation.

## 4. Discussion

Screening in search of candidates for functional food materials revealed that EEC could have a significant effect in alleviating allergic symptoms. The release of the enzyme  $\beta$ -hexosaminidase which together with histamine is considered a major mediator of the acute inflammation and early hypersensitivity responses in allergic rhinitis was dose-dependently suppressed by EEC. Moreover, the relative viability of RBL-2H3 cells was not affected by all concentrations of EEC tested, indicating that the suppressive effect of EEC on degranulation of RBL-2H3 cells was not caused by cytotoxicity. Amit *et al.* [3], found similar results with the spice cinnamon. Our results also showed that there was a decrease in intracellular calcium concentration after treatment with EEC. It is known that intracellular calcium mobilization precedes mast cell degranulation. Also, the measurement of intracellular calcium serves as an important marker for mast cell activation and it has been shown to be inhibited in many other anti-allergic foodstuffs [1,5].

## 5. Conclusions

This study reveals that EEC inhibits mast cell allergic reactions by suppressing degranulation. However, the effect of EEC on degranulation *in vivo* and its effect on intracellular signaling pathways involved in degranulation process have not yet been clarified. Such experiments will be performed in the future.



## References

1. Nishi, K.; Teranishi, M.; Yasunaga, S.; Iitsuka, M.; Matsumoto, S.; Sugahara, T. The major whey protein  $\beta$ -lactoglobulin inhibits IgE-mediated degranulation of RBL-2H3 cells and passive cutaneous anaphylaxis in mice. *Int Dairy J* **2014**, *39*, 89-95, 10.1016/j.idairyj.2014.05.006.
2. Ren, M.; Tang, Q.; Chen, F.; Xing, X.; Huang, Y.; Tan, X. *MahuangFuZiXixin* decoction attenuates Th1 and Th2 responses in the treatment of ovalbumin-induced allergic inflammation in a rat model of allergic rhinitis. *J Immunol Res* **2017**, *2017*, 1-12, 10.1155/2017/8254324.
3. Kandhare, A.D.; Aswar, U.M.; Mohan, V.; Thakurdesai, P.A. Ameliorative effects of type-A procyanidins polyphenols from cinnamon bark in compound 48/80-induced mast cell degranulation. *Anat Cell Biol* **2017**, *50*, 275-283, 10.5115/acb.2017.50.4.275
4. Galli, S.J.; Tsai, M.; Piliponsky, A.M. The development of allergic inflammation. *Nature* **2008**, *454*, 445-454, 10.1038/nature07204.
5. Prakash, A.; Ebenezer, A.J.; Vasanth, S.; Nagarajan, G.; Elden B.T. Effect of *Ocimumtenuiflorum* Linn extract on histamine mediated allergic inflammation in human mast cells. *JBAPN* **2017**, *7*, 10-17, 10.1080/22311866.2016.1275983.
6. Bernstein, D.I.; Bernstein, C.K.; Deng, C.; Murphy, K.J.; Bernstein, I.L.; Bernstein, J.A.; Shukla, R. Evaluation of the clinical efficacy and safety of grapeseed extract in the treatment of fall seasonal allergic rhinitis; a pilot study. *Ann Allergy Asthma Immunol* **2002**, *88*, 272-278, 10.1016/S1081-1206(10)62008-X.
7. Resnick, E.S.; Bielory, B.P.; Bielory, L. Complementary therapy in allergic rhinitis. *Curr Allergy Asthma Rep* **2008**, *8*, 118-125, 10.1007/s11882-008-0021-y.
8. Hwang, K.-A.; Hwang, Y.-J.; Song, J. Anti-allergic effect of *Aster yomena* on ovalbumin-sensitized mouse and RHL-2H3 cells via Th1/Th2 cytokine balance. *J Funct foods* **2018**, *44*, 1-8, 10.1016/j.jff.2018.02.026
9. Naik, S.R.; Bhagat, S.; Shah, P.D.; Tare, A.A.; Ingawale, D.; Wadekar, R.R. Evaluation of anti-allergic and anti-anaphylactic activity of ethanolic extract of *Zizyphusjuzubafruits* in rodents. *Rev Bras Farmacogn* **2013**, *23*, 811-818, 10.1590/S0102-695X2013000500014.
10. Onishi, S.; Nishi, K.; Yasunaga, S.; Muranaka, A.; Maeyama, K.; Kadota, A.; Sugahara, T. Nobiletin, a polymethoxy flavonoid, exerts anti-allergic effect by suppressing activation of phosphoinositide 3-kinase. *J Funct Foods* **2014**, *6*, 606-614, 10.1016/j.jff.2013.12.005.
11. Mizusaki, A.; Nishi, K.; Nishiwaki, H.; Sugahara, T. Suppressive effect of ethanol extract from passion fruit seeds on IgE production. *J Funct Foods* **2017**, *32*, 176-184, 10.1016/j.jff.2017.02.030.
12. Ishida, M.; Sasaki, T.; Nishi, K.; Tamamoto, T.; Sugahara, T. Suppressive effect of ethanol extract from mango (*Mangifera indica* L.) peel on IgE production *in vitro* and *in vivo*. *Biosci Biotech Bioch* **2018**, *82*, 732-739, 10.1080/09168451.2017.1412250.
13. Osakabe, N.; Takano, H.; Sanbongi, C.; Yasuda, A.; Yanagisawa, R.; Inoue, K.; Yoshikawa, T. Anti-inflammatory and anti-allergic effect of rosmarinic acid (RA); inhibition of seasonal allergic rhinoconjunctivitis (SAR) and its mechanism. *Biofactors* **2004**, *21*, 127-131, 10.1002/biof.552210125.
14. Sim, J.H.; Lee, H.S.; Lee, S.; Park, D.E.; Oh, K.; Hwang, K.-A.; Kang, H.-R.; Ye, S.-K.; Kim, H.-R. Anti-asthmatic activities of an ethanol extract of *Aster yomena* in an ovalbumin-induced murine asthma model. *J Med Food* **2014**, *17*, 606-611, 10.1089/jmf.2013.2939.
15. Bachiega, T.F.; de Sousa, J.P.; Bastos, J.K.; Sforcin, J.M. Clove and eugenol in noncytotoxic concentrations exert immunomodulatory/anti-inflammatory action on cytokine production by murine macrophages. *J Pharm Pharmacol* **2012**, *64*, 610-616, 10.1111/j.2042-7158.2011.01440.x.
16. Xu, J.-S.; Li, Y.; Cao, X.; Cui, Y. The effect of eugenol on the cariogenic properties of *Streptococcus mutans* and dental caries development in rats. *Exp Ther Med* **2013**, *5*, 1667-1670, 10.3892/etm.2013.1066.
17. Sulieman, A.M.E.; Boshra, I.M.O.; El Khalifa, E.A.A. Nutritive value of clove (*Syzygium aromaticum*) and detection of antimicrobial effect of its bud oil. *Res J Microbiol* **2007**, *2*, 266-271, ISSN 1816-4935.
18. Tanko, Y.; Mohammed, A.; Okasha, M.A.; Umar, A.H.; Magaji, R.A. Anti-nociceptive and anti-inflammatory activities of ethanol extract of *Syzygium aromaticum* flower bud in wistar rats and mice. *Afr J Tradit Complement Altern Med* **2008**, *5*, 209-212, 10.4314/ajtcam.v5i2.31275.



FP-FST-009-ID021

# Anti-Inflammatory Effect of Aqueous Extract from Kawachi-Bankan Peel on Lipopolysaccharide-Induced Inflammatory Responses in RAW264.7 Cells

Momoko Ishida<sup>1</sup>, Chihiro Takekuni<sup>1</sup>, Kosuke Nishi<sup>1,2</sup> and Takuya Sugahara<sup>1,2,\*</sup>

<sup>1</sup> Graduate School of Agriculture, Ehime University, Matsuyama, Ehime 790-8566, Japan

<sup>2</sup> Food and Health Sciences Research Center, Ehime University, Matsuyama, Ehime 790-8566, Japan

\* Corresponding author: [mars95@agr.ehime-u.ac.jp](mailto:mars95@agr.ehime-u.ac.jp); Tel.: +81 89-946-9863

Received: 9 July 2018; Accepted: 4 December 2018; Published: 6 January 2020

**Abstract:** Kawachi-bankan (*Citrus maxima*) is one of the citruses produced in Ehime, Japan. Bioactive substances in citrus peel such as flavonoids and carotenoids have been studied very well. However, health functions of water-soluble substances in citrus peel have not been focused. We herein indicated the anti-inflammatory effect of Kawachi-bankan peel aqueous extract (KPE) on mouse macrophage-like RAW264.7 cells. RAW264.7 cells were treated with lipopolysaccharide (LPS) to induce inflammation, and the effect of KPE on LPS-induced hyperinflammatory response in the cells was examined. KPE significantly inhibited the production of inflammatory cytokines such as interleukin (IL)-6 and tumor necrosis factor (TNF)- $\alpha$  by LPS-stimulated RAW264.7 cells without cytotoxicity. KPE also significantly inhibited the mRNA expression levels of IL-6 and TNF- $\alpha$  in the cells, suggesting that KPE inhibits the production of inflammatory cytokines by suppressing the gene expression levels. Immunoblot analysis revealed that KPE suppressed the activation level of p38 MAPK and translocation of NF- $\kappa$ B into nucleus in the LPS-stimulated cells, suggesting that KPE shows an anti-inflammatory effect on macrophages through downregulation of MAPK and NF- $\kappa$ B cascades. Taken together, our findings indicated that KPE contributes to alleviating of a hyperinflammatory response in macrophages.

**Keywords:** Kawachi-bankan; anti-inflammatory effect; macrophages

---

## 1. Introduction

An inflammatory response is a local defense reaction to maintain homeostasis in a living body. The inflammatory response begins with recognition of the infection or injury by immune cells such as macrophages and dendritic cells. Recognition of them by macrophages causes the activation of mitogen-activated protein kinase (MAPK) and nuclear factor- $\kappa$ B (NF- $\kappa$ B) cascades. Eventually, the activated macrophages produce proinflammatory cytokines such as interleukin (IL)-6 and tumor necrosis factor (TNF)- $\alpha$  [1,2]. These actions lead to activation of other immune cells and contribute to the elimination of non-self substances. However, continued inflammatory state caused by excessive production of inflammatory substances leads to autoimmune diseases and chronic inflammatory diseases such as rheumatoid arthritis and Crohn's disease. Thus, the inhibition of excessive or chronic macrophage activation is great importance for the prevention and alleviation of these diseases.

Citrus peel contains abundant flavonoids and carotenoids such as hesperidin, naringin, and  $\beta$ -cryptoxanthin, and various biological functions based on these components have been reported. Kawachi-bankan (*Citrus maxima*) is one of the citruses produced in Ehime, Japan. The peel of Kawachi-bankan contains abundant auraptene, which is a kind of coumarin, as compared with other citrus peels [3]. It has been reported that auraptene has an immunomodulatory effect on lymphocytes [4] and anti-inflammatory effect on macrophages [5]. Although health functions of lipid-soluble substances in citrus peel such as auraptene have been studied very well, those of water-soluble substances in the peel have

not been focused. Therefore, we examined the anti-inflammatory effect of Kawachi-bankan peel aqueous extract (KPE) on mouse macrophage-like RAW264.7 cells.

## 2. Materials and Methods

### 2.1. Reagents

Dulbecco's modified Eagle's medium (DMEM), penicillin, streptomycin, bovine serum albumin (BSA), fetal bovine serum (FBS), and lipopolysaccharides (LPS) from *Escherichia coli* 026/B6 were products of Sigma-Aldrich (St. Louis, MO, USA). Goat anti-actin antibody and horseradish peroxidase-labeled (HRP-labeled) anti-goat IgG antibody were purchased from Santa Cruz Biotechnology (Santa Cruz, CA, USA). HRP-labeled anti-rabbit IgG antibody, HRP-labeled anti-mouse IgG antibody, mouse anti-I $\kappa$ B $\alpha$  antibody, and rabbit antibodies against histone H3, NF- $\kappa$ B p65, extracellular signal-regulated protein kinases (ERK)1/2, phosphorylated ERK1/2, c-Jun N-terminal kinase (JNK), phosphorylated JNK, p38 MAPK, and phosphorylated p38 MAPK were purchased from Cell Signaling Technology (Danvers, MA, USA). All other chemicals were purchased from Wako Pure Chemical Industries (Osaka, Japan) or Nacalai Tesque (Kyoto, Japan) unless otherwise noted.

### 2.2. Sample preparation

Fruits of Kawachi-bankan were harvested in Ehime, Japan. The peels were manually separated from the fresh fruit and freeze-dried. The dried peels were then powdered with a mill mixer (Iwatani, Tokyo, Japan) and used as Kawachi-bankan peel powder. The powder was suspended in 10 mM sodium phosphate buffer (NaPB; pH 7.4) at 0.1 g/mL at 12°C for 20 h. After centrifugation at 15,000  $\times$  g at 4°C for 20 min, the supernatant was collected and centrifuged at 270,000  $\times$  g at 4°C for 20 min. After centrifugation, the supernatant was collected and adjusted to pH 7.4. The supernatant was then filtrated through a 0.22  $\mu$ m membrane and used as Kawachi-bankan peel aqueous extract (KPE). Dry weight of KPE was measured by weighing a portion of freeze-dried samples.

### 2.3. Cells and cell culture

Mouse macrophage-like cell line RAW264.7 cells were obtained from the Japanese Collection of Research Bioresources Cell Bank (Osaka, Japan). RAW264.7 cells were cultured in DMEM supplemented with 100 U/mL of penicillin, 100  $\mu$ g/mL of streptomycin, and 10% FBS at 37°C under humidified 5% CO<sub>2</sub>. RAW264.7 cells were detached using phosphate-buffered saline (PBS) containing 0.25% trypsin and 0.02% ethylenediamine-*N,N,N',N'*-tetraacetic acid (Dojindo Laboratories, Kumamoto, Japan) for the subsequent experiments.

### 2.4. Cytokine production assay

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 96-well culture plate (Corning, Corning, NY, USA) at  $3.0 \times 10^4$  cells/well, and cultured for 12 h at 37°C under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 200  $\mu$ L of 10% FBS-DMEM containing 20 ng of LPS and various concentrations of KPE or 10 mM NaPB as control and incubated for 12 h at 37°C. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. After incubation, the concentrations of TNF- $\alpha$  and IL-6 in the culture media were measured by enzyme-linked immunosorbent assay (ELISA) using Mouse TNF- $\alpha$  ELISA Ready-SET-GO! (eBioscience, San Diego, CA, USA) and Mouse IL-6 ELISA MAX Standard Set (BioLegend, San Diego, CA, USA), respectively, according to the manufacturer's instructions. Cell viability was measured using Cell Count Reagent SF (Nacalai Tesque) after collecting the culture media from each well for ELISA.

### 2.5. Real-time RT-PCR

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 24-well culture plate (BD Falcon, Franklin Lakes, NJ, USA) at  $1.5 \times 10^5$  cells/well and cultured for 12 h at 37°C under humidified

5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 1 mL of 10% FBS-DMEM containing 100 ng of LPS and various concentrations of KPE or 10 mM NaPB as control, and incubated for 12 h at 37°C. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. Total RNA was then isolated from the cells using Sepasol-RNA I Super G (Nacalai Tesque) according to the manufacturer's instructions and used as a template for cDNA synthesis with MMLV-reverse transcriptase (Promega, Madison, WI, USA) and an oligo-(dT)<sub>20</sub> primer (Toyobo, Osaka, Japan). A real-time PCR mixture, with a final volume of 20 µL, consisted of Thunderbird SYBR qPCR Mix (Toyobo), 10 pmol of a forward primer, 10 pmol of a reverse primer, and 0.1 µg of a cDNA sample. Thermal cycling conditions were 20 s at 95°C, followed by 40 cycles of 3 s at 95°C and 30 s at 60°C. PCR products were measured on a StepOnePlus Real-time PCR System (Applied Biosystems, Foster City, CA, USA), and relative gene expression was calculated based on the comparative CT method using StepOne Software v2.1 (Applied Biosystems). Expression of the β-actin gene was used as an endogenous control. Specific oligonucleotide sequences for each gene are as follows. Mouse β-actin: sense, 5'-CATCCGTAAAGACCTCTATGCCAAC-3' and antisense, 5'-ATGGAGCCACCGATCCACA-3'; mouse TNF-α: sense, 5'-CTACTCCCAGGTTCTCTTCAA-3' and antisense, 5'-GCAGAGAGGAGGTTGACTTTC-3'; mouse IL-6: sense, 5'-AAGCCAGAGTCCTTCAGAGAGAT-3' and antisense, 5'-TTGGATGGTCTTGGTCCTTAGC-3'.

## 2.6. Immunoblot analysis

RAW264.7 cells suspended in 10% FBS-DMEM were seeded into a 35 mm dish (BD Falcon) at  $1.0 \times 10^6$  cells/dish and cultured for 12 h at 37°C under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were treated with 2.0 mL of 10% FBS-DMEM containing 200 ng of LPS and 20 mg/mL of KPE or 10 mM NaPB as control and incubated for 15 min. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. Cytosolic and nuclear proteins were prepared using a CellLytic NuCLEAR Extraction Kit (Sigma-Aldrich) according to the manufacturer's instructions. Denatured proteins were then separated using SDS-PAGE and transferred onto a PVDF membrane (Hybond-P; GE Healthcare, Buckinghamshire, UK). Immunoblotting with various antibodies was performed as previously described [6].

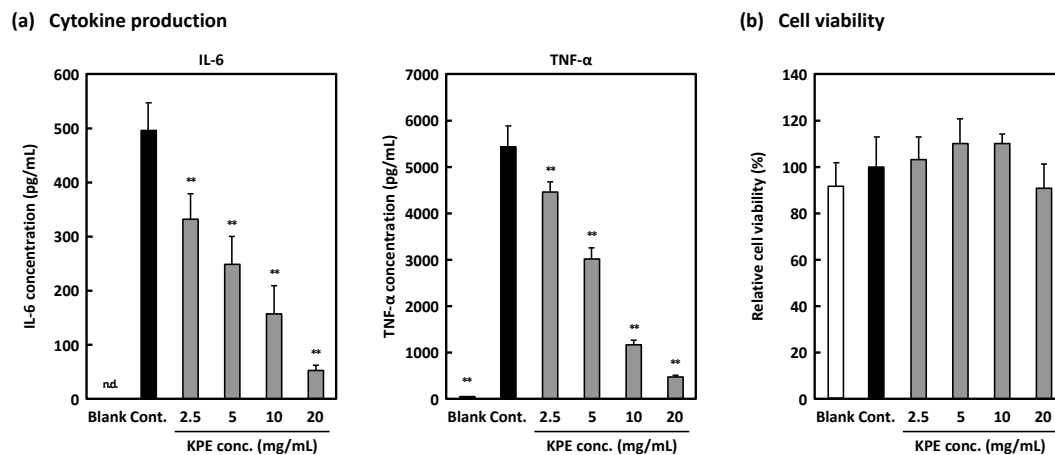
## 2.7. Statistical analysis

Data obtained were expressed as mean ± standard deviation. One way ANOVA followed by Tukey-Kramer test as used to assess the statistical significance of the difference. Values with \* $p < 0.05$  or \*\* $p < 0.01$  were considered statistically significant.

# 3. Results

## 3.1. Effect of KPE on inflammatory cytokine production by LPS-stimulated RAW 264.7 cells

We first examined the effect of KPE on inflammatory cytokine production by LPS-stimulated RAW264.7 cells. As shown in Figure 1a, KPE significantly inhibited the production of IL-6 and TNF-α by LPS-stimulated RAW264.7 cells in a dose-dependent manner. The highest concentration of KPE showed the inhibition rate of approximately 90% for the production of both IL-6 and TNF-α compared to control. Cell viability test showed that KPE was not cytotoxic within the tested concentrations (Figure 1b). Therefore, we performed further experiments at 20 mg/mL or lower concentrations of KPE.



**Figure 1.** Effect of KPE on cytokine production and cell viability of RAW264.7 cells. (a) RAW264.7 cells were treated with 10% FBS-DMEM containing 100 ng/mL of LPS and various concentrations of KPE or 10 mM NaPB as control and incubated for 12 h. Blank cells were treated with 10% FBS-DMEM containing 10 mM NaPB alone. After incubation, the concentrations of TNF- $\alpha$  and IL-6 in the culture media were measured by ELISA. (b) Cell viability was measured after collecting the culture media from each well for ELISA. Experiments were performed in triplicate, and error bars indicate as the mean  $\pm$  standard deviation. \*\* $p < 0.01$  against control by Tukey-Kramer test. n.d. indicates not determined.

### 3.2. Effect of KPE on expression levels of IL-6 and TNF- $\alpha$ genes in RAW264.7 cells

Next, the effect of KPE on gene expression of inflammatory cytokines in LPS-stimulated RAW264.7 cells was examined. The result showed that KPE significantly inhibited the mRNA expression levels of IL-6 in the cells (data not shown). On the other hand, a suppression tendency was observed in the mRNA expression levels of TNF- $\alpha$ , although there was no significant difference. These results suggested that KPE inhibits the production of inflammatory cytokines by suppressing the gene expression levels.

### 3.3. Effect of KPE on the signaling pathways involved in macrophage activation

LPS, a major outer membrane component of gram-negative bacteria, binds to TLR4 on the cell surface of macrophages and leads to macrophage activation through MAPK and NF- $\kappa$ B cascades. Therefore, we examined the effect of KPE on the signal molecules in MAPK and NF- $\kappa$ B cascades. The result showed that the phosphorylation level of p38 MAPK was inhibited by KPE, whereas that of ERK or JNK was not affected (data not shown). In addition, KPE inhibited translocation of NF- $\kappa$ B into the nucleus in the LPS-stimulated cells, suggesting that KPE shows an anti-inflammatory effect on macrophages through downregulation of MAPK and NF- $\kappa$ B cascades.

## 4. Discussion

In this study, we found that KPE inhibits the production of IL-6 and TNF- $\alpha$  by LPS-stimulated RAW264.7 cells without cytotoxicity. KPE also inhibited the mRNA expression levels of IL-6 and TNF- $\alpha$  in the cells. These results suggested that KPE inhibits production of inflammatory cytokines by suppressing the gene expression of cytokines in LPS-stimulated RAW264.7 cells.

MAPK and NF- $\kappa$ B cascades play essential roles in macrophage activation. There are mainly three families of MAPKs: ERK, JNK, and p38 kinases. MAPKs are activated by specific MAPK kinases (MAPKKs) and eventually lead to the synthesis of transcription factors such as c-Jun and c-Fos. These transcription factors form the activator protein (AP)-1 dimers, which bind on DNA after translocating

into the nucleus, and promote the transcriptional activity of target genes. In addition, NF- $\kappa$ B is translocated into the nucleus after activation, and regulates the transcriptional activity as a transcription factor. KPE suppressed the phosphorylation level of p38 MAPK and translocation of NF- $\kappa$ B from cytosol to nucleus in the LPS-stimulated cells. Our data indicated here suggest that KPE suppresses the expression levels of cytokine genes through inhibition of AP-1 activity and NF- $\kappa$ B translocation.

## 5. Conclusions

Although bioactive substances in citrus peel such as flavonoids and carotenoids have been studied very well, health functions of water-soluble substances in citrus peel have not been focused. In this study, we found that KPE inhibits the excessive production of inflammatory cytokines by LPS-stimulated RAW264.7 cells through downregulation of MAPK and NF- $\kappa$ B cascades. Taken together, our findings indicated that KPE contributes to alleviating a hyperinflammatory response in macrophages.

## References

1. Aderem, A.; Ulevitch, R. J. Toll-like receptors in the induction of the innate immune response. *Nature* **2000**, *406*, 782-787, 10.1038/35021228.
2. Takeuchi, O.; Akira, S. Pattern recognition receptors and inflammation. *Cell* **2010**, *140*, 805-820, 10.1016/j.cell.2010.01.022.
3. Amakura, Y.; Yoshimura, M.; Ouchi, K.; Okuyama, S.; Furukawa, Y.; Yoshida, T. Characterization of constituents in the peel of *Citrus kawachiensis* (Kawachibankan). *Biosci Biotechnol Biochem* **2013**, *77*, 1977-1980, 10.1271/bbb.130324.
4. Nishimoto, S.; Muranaka, A.; Nishi, K.; Kadota, A.; Sugahara, T. Immunomodulatory effects of citrus fruit auraptene *in vitro* and *in vivo*. *J Funct foods* **2012**, *4*, 883-890, 10.1016/j.jff.2012.06.005.
5. Lin, S.; Hirai, S.; Goto, T.; Sakamoto, T.; Takahashi, N.; Yano, M.; Sasaki, T.; Yu, R.; Kawada, T. Auraptene suppresses inflammatory responses in activated RAW264 macrophages by inhibiting p38 mitogen-activated protein kinase activation. *Mol Nutr Food Res* **2013**, *57*, 1135-1144, 10.1002/mnfr.201200611.
6. Ishida, M.; Nishi, K.; Kunihiro, N.; Onda, H.; Nishimoto, S.; Sugahara, T. Immunostimulatory effect of aqueous extract of *Coriandrum sativum* L. seed on macrophages. *J Sci food Agric* **2017**, *97*, 4727-4736, 10.1002/jsfa.8341.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-FST-010-ID024

# Anti-Inflammatory Effect of Lysozyme

Ayuka Tagashira <sup>1</sup>, Kosuke Nishi <sup>2,3</sup>, Shinya Matsumoto <sup>2</sup> and Takuya Sugahara <sup>2,3,\*</sup><sup>1</sup> The United Graduate School of Agricultural Sciences, Ehime University, Matsuyama, Ehime 790-8566, Japan<sup>2</sup> Graduate School of Agriculture, Ehime University, Matsuyama, Ehime 790-8566, Japan<sup>3</sup> Food and Health Sciences Research Center, Ehime University, Matsuyama, Ehime 790-8566, Japan

\* Correspondence: mars95@agr.ehime-u.ac.jp; Tel.: +81-89-946-9863

Received: 9 July 2018; Accepted: 4 December 2018; Published: 6 January 2020

**Abstract:** Lysozyme is an antibacterial protein that is widely distributed in nature including egg white, fish, and insects. Lysozyme from hen egg white has been reported to possess an anti-inflammatory effect; however, little is known about its detailed mechanism. We examined the effect of lysozyme on macrophages involved in inflammatory responses and on lipopolysaccharide (LPS)-induced inflammation model mice. Lysozyme significantly suppressed the production of interleukin (IL)-6 and tumor necrosis factor (TNF)- $\alpha$  by mouse peritoneal macrophages (P-mac) in a dose-dependent manner by suppressing their gene expression levels. Zymosan A-mediated phagocytosis activity of P-mac was not affected by lysozyme, suggesting that lysozyme shows the anti-inflammatory effect without affecting the phagocytotic response against microbes. In addition, lysozyme inhibited phosphorylation of c-jun N-terminal kinase (JNK) that is a member of mitogen-activated protein kinase (MAPK) involved in the production of inflammatory cytokines by macrophages. Oral administration of lysozyme at 2,250 mg/kg body weight/day significantly decreased the serum IL-6 and TNF- $\alpha$  levels in LPS-induced inflammation model mice. These findings suggest that lysozyme suppresses the gene expression of inflammatory cytokines by inhibiting MAPK signaling pathway in macrophages, and mitigates the hyperinflammatory condition in vivo.

**Keywords:** Anti-inflammatory effect; Lysozyme; Peritoneal macrophages; Tumor necrosis factor- $\alpha$ ; Interleukin-6; Lipopolysaccharide-induced inflammation model mice

## 1. Introduction

Chronic inflammation closely related to the pathological base of chronic diseases such as cancer and lifestyle-related diseases has garnered attention [1,2]. Inflammation is a defensive reaction, which occurs when individuals are infected with pathogens such as viruses and bacteria. Macrophages involved in inflammation are multifunctional leucocytes related to innate immunity and remove foreign substances such as bacteria and dead cells. In addition, lipopolysaccharide (LPS), a component of the outer membrane of Gram-negative bacteria, is recognized by macrophages and promotes the release of various mediators such as cytokines, chemokines, and prostaglandins. The recognition of LPS by macrophages is caused by binding to Toll-like receptors (TLR) 4 on the cell surface, which activates the cells and promotes the production of inflammatory mediators, such as tumor necrosis factor (TNF)- $\alpha$  and interleukin (IL)-6. On the other hand, the overexpression of these inflammatory cytokine genes causes rheumatoid arthritis, insulin resistance, and arteriosclerosis.

Lysozyme is an antibacterial protein that breaks down bacterial cell walls, and widely distributed in nature including egg white, fish, and insects. Hen egg white lysozyme is a basic protein (pI = 11) composed of a single polypeptide chain with 129 amino acid residues. Previous studies have been reported that hen egg white lysozyme promotes antibody production by lymphocytes [3,4]. In addition, heat-treated lysozyme enhances the anti-bacterial and immunostimulatory activities [5,6]. Heat treatment in the food processing step of hen egg white is considered to enhance the immunostimulatory activity. Thus, we examined the health function of lysozyme derived from hen egg white in the immune system for application to functional foods. Lysozyme is well known to exhibit the anti-inflammatory

effect in addition to anti-bacterial and immunostimulatory activities [7-9]. Lysozyme has also been reported to attenuate inflammation in a porcine model of dextran sodium sulfate-induced colitis [10] and to suppress polyphosphate-mediated vascular inflammatory responses [11]. However, the detailed mechanism of the anti-inflammatory effect of lysozyme is still unknown. Hence, we examined the effect of lysozyme on macrophages involved in inflammatory responses and on LPS-induced inflammation model mice.

## 2. Materials and Methods

### 2.1. Reagents

Lysozyme from chicken egg white ( $\geq 90\%$ ), RPMI 1640 medium, penicillin, streptomycin, fetal bovine serum (FBS), and LPS from *Escherichia coli* 026/B6 were products from Sigma-Aldrich (St. Louis, Mo, USA). Goat anti-actin antibody and anti-goat IgG antibody labeled with horseradish peroxidase (HRP) were purchased from Santa Cruz Biotechnology (Santa Cruz, CA, USA). HRP-labeled anti-rabbit IgG antibody and rabbit antibodies against extracellular signal-regulated protein kinases (ERK) 1/2, phosphorylated ERK1/2, c-Jun N-terminal kinase (JNK), phosphorylated JNK, p38 mitogen-activated protein kinase (MAPK), and phosphorylated p38 MAPK, histone H3, and nuclear factor- $\kappa$ B (NF- $\kappa$ B) p65 were purchased from Cell Signaling Technology (Danvers, MA, USA). All other chemicals were purchased from Fujifilm Wako Pure Chemical (Osaka, Japan) or Nacalai Tesque (Kyoto, Japan) unless otherwise noted.

### 2.2. Animals

BALB/c mice were obtained from Japan SLC (Shizuoka, Japan) and kept in a temperature-controlled facility. All animals were maintained and examined according to the protocol approved by the Animal care and Use Committee of Ehime University.

### 2.3. Peritoneal macrophages

Peritoneal macrophages (P-Mac) were prepared as previously described [12] with some modifications. In brief, 8-week-old female BALB/c mice were injected with 3.0% thioglycolate medium (2 mL/body) into the peritoneum. Four days after injection, mice were sacrificed and injected with 3 mL of RPMI 1640 medium into the peritoneum to harvest thioglycollate-elicited P-Mac. Collected cells were centrifuged at  $160 \times g$  for 5 min at  $4^{\circ}\text{C}$ , and the cell pellet was washed with RPMI 1640 medium and centrifuged again. The cell pellet was then resuspended in RPMI 1640 medium supplemented with 100 U/mL of penicillin, 100  $\mu\text{g/mL}$  of streptomycin, and 10% FBS and cultured in a culture dish (Corning, Corning, NY, USA). After incubation at  $37^{\circ}\text{C}$  for 1 h, the cells were washed with phosphate-buffered saline (PBS; pH 7.4) three times to remove unattached cells such as neutrophils. In the subsequent experiments, P-Mac were detached by pipetting in cold PBS.

### 2.4. Cytokine production assay

Lysozyme was dissolved in 10 mM sodium phosphate buffer (NaPB; pH 7.4) and sterilized by filtration. P-Mac suspended in 10% FBS-RPMI 1640 medium were seeded into a 96-well culture plate (Corning) at  $6.0 \times 10^4$  cells/well and cultured at  $37^{\circ}\text{C}$  overnight under humidified 5%  $\text{CO}_2$ . After washing with PBS, P-Mac were pretreated with 100 ng/mL of LPS in 200  $\mu\text{L}$  of 10% FBS-RPMI 1640 medium at  $37^{\circ}\text{C}$ . After incubation for 1 h, the cells were washed with PBS to remove LPS. P-Mac were then treated with various concentrations of lysozyme in 200  $\mu\text{L}$  of 10% FBS-RPMI 1640 medium at  $37^{\circ}\text{C}$ . After incubation for 11 h, the concentrations of IL-6 and TNF- $\alpha$  in culture media were measured by enzyme-linked immunosorbent assay (ELISA) using mouse IL-6 ELISA MAX Standard (BioLegend, San Diego, CA, USA) and mouse TNF alpha ELISA Ready-SET-Go! (eBioscience, San Diego, CA, USA), respectively, according to the manufacturer's instructions.



## 2.5. Cell viability

Cytotoxicity of lysozyme to P-Mac was examined using a WST-8 assay kit (Nacalai Tesque) according to the manufacturer's instructions. P-Mac suspended in 10% FBS-RPMI 1640 medium were seeded into a 96-well culture plate at  $6.0 \times 10^4$  cells/well and cultured at 37°C overnight under humidified 5% CO<sub>2</sub>. After washing with PBS, P-Mac were pretreated with 100 ng/mL of LPS in 200 µL of 10% FBS-RPMI 1640 medium at 37°C. After incubation for 1 h, P-Mac were washed with PBS and treated with various concentrations of lysozyme in 200 µL of 10% FBS-RPMI 1640 medium at 37°C. After incubation for 11 h, the culture media were removed, and P-Mac were cultured in 100 µL of 10% FBS-RPMI 1640 medium containing 10% WST-8 solution for 40 min at 37°C under dark condition. The absorbance was then measured at 450 nm using a microplate reader.

## 2.6. Real-time RT-PCR

P-Mac suspended in 10% FBS-RPMI 1640 medium were seeded into a 24-well culture plate at  $5.0 \times 10^5$  cells/well and cultured at 37°C overnight under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were pretreated with 100 ng/mL of LPS in 1.0 mL of 10% FBS-RPMI 1640 medium at 37°C. After incubation for 1 h, the cells were washed with PBS and treated with 500 µg/mL of lysozyme in 1.0 mL of 10% FBS-RPMI 1640 medium at 37°C. After incubation for 5 h or 11 h, total RNA was isolated from the cells using Sepasol-RNA I Super G (Nacalai Tesque) according to the manufacturer's instructions and used as a template for cDNA synthesis with MML V-reverse transcriptase (Promega, Madison, WI, USA) and an oligo-(dT)<sub>20</sub> primer (Toyobo, Osaka, Japan). Real-time PCR was performed using Thunderbird SYBR qPCR Mix (Toyobo), 10 pmol of a forward primer, 10 pmol of a reverse primer, and 0.1 µg of a cDNA sample as previously described [13]. Thermal cycling conditions were 20 s at 95°C, and 40 cycles of 3 s at 95°C and 30 s at 60°C. PCR products were measured on a StepOnePlus Real-time PCR System (Applied Biosystems, Foster City, CA, USA), and relative gene expression was calculated based on the comparative CT method using StepOne Software v2.1 (Applied Biosystems). Expression of the β-actin gene was used as an endogenous control. Specific oligonucleotide sequences for each gene are as follows. Mouse β-actin: sense, 5'-CATCCGTAAAGACCTCTATGCCAAC-3' and antisense, 5'-ATGGAGCCACCGATCCACA-3'; mouse IL-6: sense, 5'-AAGCCAGATCCTTCAGAGAGAT-3' and antisense, 5'-TTGGATGGTCTTGGTCCTTAGC-3'; mouse TNF-α: sense, 5'-CTACTCCCAGTTCTCTTCAA-3' and antisense, 5'-GCAGAGAGGAGGTTGACTTTC-3'.

## 2.7. Phagocytosis activity

Phagocytosis activity was measured as previously described [12] with some modifications. P-Mac suspended in 10% FBS-RPMI 1640 medium were seeded into a 48-well culture plate at  $2.5 \times 10^5$  cells/well and cultured at 37°C under humidified 5% CO<sub>2</sub>. After incubation for 3 h, the cells were pretreated with 100 ng/mL of LPS in 0.5 mL of 10% FBS-RPMI 1640 medium. After incubation at 37°C for 1 h, the cells were washed with PBS and treated with 500 µg/mL of lysozyme in 0.5 mL of 10% FBS-RPMI 1640 medium for 5 h or 11 h. After washing with PBS, 0.5 mL of 10% FBS-RPMI 1640 medium containing 500 µg of Texas Red-conjugated zymosan A (*Saccharomyces cerevisiae*) BioParticles (Molecular Probes, Eugene, OR, USA) were added to each well and incubated for 1 h under dark condition. After removing the culture medium, the cells were suspended in PBS and centrifuged at  $160 \times g$  for 5 min at 4°C. The cell pellet was suspended in 1 mL of 2% FBS-PBS, and phagocytosis activity was measured on a flow cytometer (FACSCalibur; BD Biosciences, San Jose, CA, USA).

## 2.8. Immunoblot analysis

P-Mac suspended in 10% FBS-RPMI 1640 medium were seeded into a 35 mm culture dish (Corning) at  $5.0 \times 10^5$  cells/dish and cultured at 37°C overnight under humidified 5% CO<sub>2</sub>. After washing with PBS, the cells were pretreated with 100 ng/mL of LPS in 2 mL of 10% FBS-RPMI 1640 medium at 37°C. After incubation for 15 min, the cells were washed with PBS and treated with 500 µg/mL of lysozyme in 2 mL of 10% FBS-RPMI 1640 medium at 37°C. After incubation for 30 min,

cytosolic proteins were prepared using a CellLytic NuCLEAR Extraction Kit (Sigma-Aldrich) according to the manufacturer's instructions. Denatured proteins were then separated using SDS-PAGE and transferred onto a PVDF membrane (Hybond-P; GE Healthcare, Buckinghamshire, UK). Immunoblotting with various antibodies was performed as previously described [14].

### 2.9. Lipopolysaccharide-induced inflammation model mice

The assay was performed by the method of [15] with some modifications. After acclimatization to their housing environment for 1 week, 8-week-old female BALB/c mice were placed into 5 groups (7 mice per group). On day 0, mice were orally administered using feeding needles (Natsume Seisakusho, Tokyo, Japan) with 200  $\mu$ L of 10 mM NaPB for intact and control groups, 200  $\mu$ L of lysozyme at 4.5 mg/kg body weight/day for the low-dose group, 200  $\mu$ L of lysozyme at 450 mg/kg body weight/day for the middle-dose group, or 200  $\mu$ L of lysozyme at 2,250 mg/kg body weight/day for the high-dose group for seven consecutive days from day 0 to day 6. Two hours after oral administration on day 6, the control, low-dose, middle-dose, and high-dose groups were injected with 20  $\mu$ L of PBS containing LPS (5 mg/kg body weight) into the peritoneum to induce systemic inflammation. In contrast, the intact group was injected with 20  $\mu$ L of PBS alone. Blood was taken by cardiac puncture 2 h after intraperitoneal administration, and sera were collected. The concentrations of IL-6 and TNF- $\alpha$  in the serum were measured by ELISA.

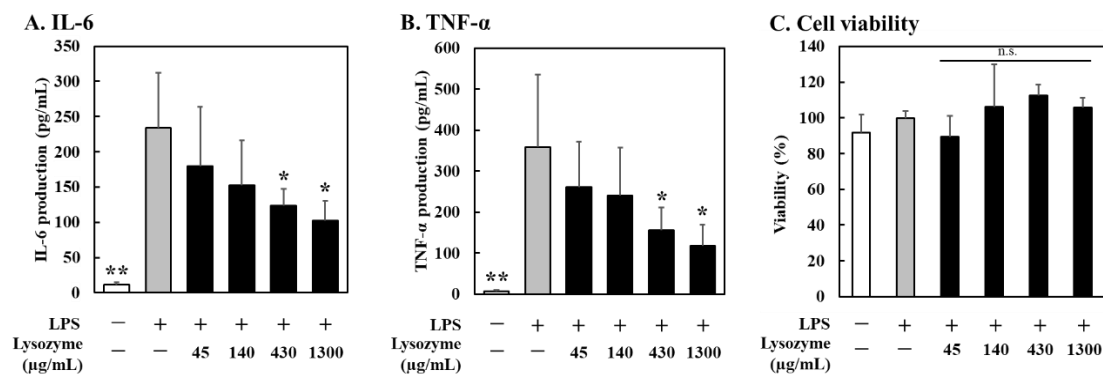
### 2.10. Statistical analysis

Data obtained were expressed as mean  $\pm$  standard deviation. One-way ANOVA followed by Dunnett's test or Tukey-Kramer test was used to assess the statistical significance of the difference. Values with  $*p < 0.05$  or  $**p < 0.01$  were considered statistically significant.

## 3. Results

### 3.1. Effect of lysozyme on inflammatory cytokine production

Firstly, the effect of lysozyme on inflammatory cytokine production by P-Mac was examined. After pretreatment with 100 ng/mL of LPS for 1 h, P-Mac were treated with lysozyme at various concentrations for 11 h, and the cytokine concentration in the medium was measured by ELISA. As shown in Fig. 1A and 1B, lysozyme significantly inhibited the production of IL-6 and TNF- $\alpha$  in dose-dependent manners. When P-Mac were treated with 500  $\mu$ g/mL of lysozyme, the production of IL-6 and TNF- $\alpha$  was suppressed by around 50% compared with control. The cytotoxicity of lysozyme was evaluated using the WST-8 assay. The result showed that lysozyme has no cytotoxicity to P-Mac at 1,000  $\mu$ g/mL (Fig. 1C). From these results, further experiments were performed at 500  $\mu$ g/mL of lysozyme.



**Figure 1.** The effect of lysozyme on inflammatory cytokine production and viability of P-Mac. (A) and (B), for cytokine production assay, P-Mac were pretreated with 100 ng/mL of LPS or 10 mM NaPB. After washing, the cells were treated with various concentrations of lysozyme or with 10 mM NaPB. After incubation for 11 h, the concentrations of IL-6 and TNF- $\alpha$  in the culture medium were measured by ELISA. Data were represented as mean  $\pm$  standard deviations ( $n = 6$ ). \* $p < 0.05$  or \*\* $p < 0.01$  against LPS (+) / Lysozyme (-) by Dunnett's test. (C), for cell viability assay, P-Mac were pretreated with 100 ng/mL of LPS or 10 mM NaPB. After washing, the cells were treated with various concentrations of lysozyme or with 10 mM NaPB. After incubation for 11 h, cell viability was measured using a WST-8 assay kit. Data were represented as mean  $\pm$  standard deviations ( $n = 9$ ). n.s. indicates no statistical significance against LPS (+) / Lysozyme (-) by Dunnett's test.

### 3.2. Effect of lysozyme on cytokine gene expression

As described above, lysozyme inhibited cytokine production by P-Mac without cytotoxicity. Hence, the effect of lysozyme on cytokine gene expression was examined. After pretreatment with 100 ng/mL of LPS for 1 h, P-Mac were treated with lysozyme at 500  $\mu$ g/mL for 5 h or 11 h. After that, the transcription level of the cytokine genes was evaluated by real-time RT-PCR. As a result, the expression of IL-6 and TNF- $\alpha$  genes was significantly inhibited by lysozyme in both treatment time (Data not shown). These results indicated that lysozyme downregulates the expression of IL-6 and TNF- $\alpha$  genes within 5 h after treatment, resulting in suppressed production of IL-6 and TNF- $\alpha$ . Furthermore, it was revealed that the effect of suppressed IL-6 and TNF- $\alpha$  gene expression by lysozyme continues at least for 11 h after treatment.

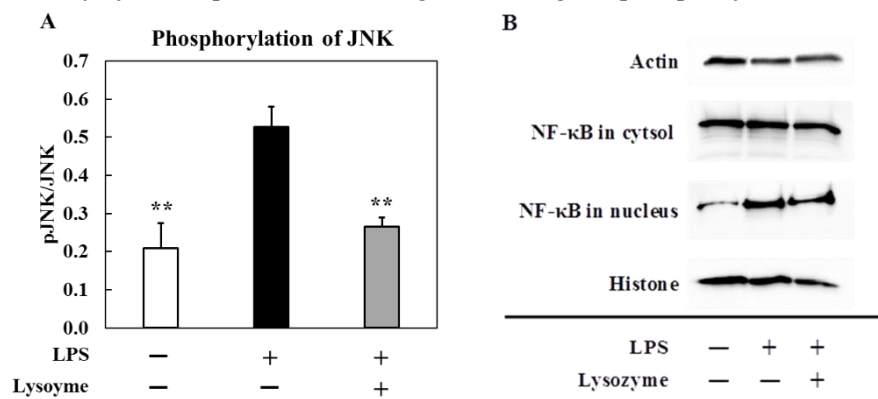
### 3.3. Effect of lysozyme on phagocytotic activity

Macrophages have an important role in innate immunity such as ingesting foreign materials and enhancing immune responses. We thus examined the effect of lysozyme on the phagocytosis activity of P-Mac using Texas Red-labeled zymosan A. P-Mac were treated with 500  $\mu$ g/mL of lysozyme for 5 h or 11 h after pretreatment with 100 ng/mL of LPS for 1 h. The cells were then treated with Texas Red-labeled zymosan A for 1 h. The results showed that the zymosan A-mediated phagocytosis activity of the P-Mac is not affected by lysozyme compared with control. Thus, lysozyme inhibits LPS-induced cytokine production by P-Mac, but does not modulate phagocytotic activity. These results suggested that lysozyme has an anti-inflammatory effect without inhibiting the innate immune response by macrophages.

### 3.4. Effect of lysozyme on the signaling pathways in macrophages

Macrophages are induced the expression of inflammatory cytokine genes by activating the MAPK and the NF- $\kappa$ B signaling pathways. The effect of lysozyme on MAPK and NF- $\kappa$ B signaling was then examined. P-Mac were treated with 500  $\mu$ g/mL of lysozyme for 30 min after pretreatment with 100 ng/mL of LPS for 15 min, and the cytosolic protein levels of the signal molecules were evaluated by immunoblot analysis. As summarized in Fig. 2A, the phosphorylation level of JNK was inhibited by lysozyme whereas those of ERK and p38 were not affected. In addition, lysozyme did not affect the

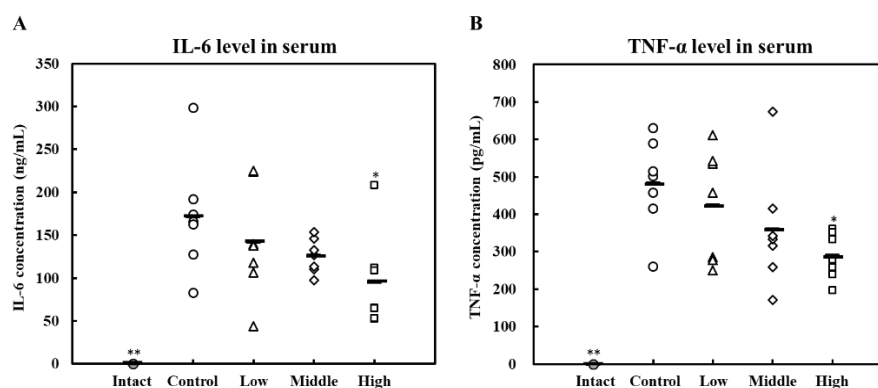
translocation of NF- $\kappa$ B from cytosol to the nucleus (Fig. 2B). These results suggest that lysozyme inhibits inflammatory cytokine production through inhibiting the phosphorylation of JNK.



**Figure 2.** The effect of lysozyme on the signaling pathways of macrophage activation. P-Mac were pretreated with 100 ng/mL of LPS or 10 mM NaPB for 15 min. After washing, the cells were treated with 500  $\mu$ g/mL of lysozyme or 10 mM NaPB for 30 min. (A), The result of densitometric analysis was expressed as the ratio of the amount of phosphorylated protein to that of whole protein. Data were represented as mean  $\pm$  standard deviations of three independent experiments. \*\* $p < 0.01$  against LPS (+) / Lysozyme (-) by Tukey-Kramer test. (B), The protein level of NF- $\kappa$ B was evaluated by immunoblot analysis.

### 3.5. Effect of lysozyme in LPS-induced inflammation model mice

The effect of lysozyme *in vivo* was evaluated by LPS-induced inflammation model mice. Oral administration of lysozyme to mice for 7 consecutive days did not change body weight in all lysozyme-treated groups. In this experiment, systemic inflammation in mice was induced by LPS at 5 mg/kg body weight via intraperitoneal administration. As indicated in Fig. 3, the amounts of IL-6 and TNF- $\alpha$  in sera were significantly decreased in the high-dose group (2,250 mg/kg body weight/day) compared to the control group. Furthermore, the amounts of IL-6 and TNF- $\alpha$  tended to be suppressed in the middle-dose group (450 mg/kg body weight/day). These results suggest that lysozyme alleviates systemic inflammation *in vivo*.



**Figure 3.** The effect of lysozyme on the amounts of inflammatory cytokines in serum. (A), (B), Seven-week-old female BALB/c mice were orally administered with 10 mM NaPB or lysozyme at various concentrations for seven consecutive days from day 0 to day 6. Two hours after oral administration on day 6, LPS (5 mg/kg body weight) in PBS was injected via peritoneum to induce systemic inflammation. In contrast, PBS was injected to intact group. Two hours after intraperitoneal administration, serum was collected. Then, the concentrations of IL-6 and TNF- $\alpha$  in serum were measured by ELISA. Data were represented as mean  $\pm$  standard deviations of three independent experiments. \* $p < 0.05$  or \* $p < 0.01$  against control by Tukey-Kramer test.

#### 4. Discussion

In this study, it was revealed that lysozyme suppresses production of IL-6 and TNF- $\alpha$  by suppressing their gene expression levels. It has been reported that lysozyme binds to LPS to form a complex and inhibits inflammatory reaction [16]. Moreover, several peptides derived from human lysozyme bind to TLR4 to show an antagonistic anti-inflammatory effect [17]. On the other hands, in this study, LPS was washed away with PBS before lysozyme treatment against P-Mac. Then, it is revealed that the suppressive effect of lysozyme on LPS-induced inflammation is not due to its antagonism activity against TLR4. Macrophages have an important role in innate immunity such as destroying microorganisms, ingesting foreign materials, removing dead cells, and enhancing acquired immune responses. As a result of examining the effect of lysozyme on the phagocytic activity of P-Mac, phagocytosis activity of P-Mac was not affected by lysozyme. These results suggested that lysozyme shows an anti-inflammatory effect without inhibiting the innate immune responses by macrophages. Next, the mechanism underlying the inhibition of inflammatory cytokine production by lysozyme was investigated. Macrophages are induced the expression of inflammatory cytokine genes by activating the MAPK and NF- $\kappa$ B cascades. LPS activates MAPK and NF- $\kappa$ B signaling to facilitate inflammatory cytokine production. To reveal how lysozyme affects these cascades, we examined the effect on the signal molecules in MAPK and NF- $\kappa$ B cascade. As summarized in Fig. 2, the phosphorylation level of JNK was significantly inhibited by lysozyme, whereas that of ERK or p38 was not affected, and lysozyme showed no effect on the translocation of NF- $\kappa$ B into the nucleus. These results suggest that lysozyme inhibits inflammatory cytokine production through inhibiting the phosphorylation of JNK. Finally, we investigated the effect of oral administration of lysozyme on LPS-induced inflammation model mice. As a result, oral administration of lysozyme significantly decreased the amounts of IL-6 and TNF- $\alpha$  in sera compared to the control group, suggesting that lysozyme mitigates the hyperinflammatory condition *in vivo*. These data indicate that lysozyme exhibits anti-inflammatory effect *in vitro* and *in vivo* and is expected to be effective as a functional food material.

#### 5. Conclusions

Although lysozyme is well known to exhibit the anti-inflammatory effect, the detailed mechanism of its effect is still unknown. In this study, we found that lysozyme inhibits phosphorylation of JNK to suppress pro-inflammatory cytokines. Moreover, lysozyme suppressed inflammatory cytokine levels in sera from LPS-induced inflammation model mice. Taken together, our data indicate that lysozyme exerts anti-inflammatory effect *in vitro* and *in vivo*.

**Acknowledgments:** This work was supported by a JSPS KAKENHI Grant-in-Aid for Scientific Research C (15K07432). Animal experiments were accomplished at the Division of Genetic Research of the Advanced Research Support Center (ADRES), Ehime University.

#### References

1. Coussens, L.M.; Zitvogel, L.; Palucka, A.K. Neutralizing tumor-promoting chronic inflammation: a magic bullet? *Science* **2013**, *339*, 286-291, 10.1126/science.1232227.
2. Manabe, I. Chronic inflammation links cardiovascular, metabolic and renal diseases. *Circ J*, **2011**, *75*, 2739-2748, 10.1253/circj.CJ-11-1184.
3. Murakami, F.; Sasaki, T.; Sugahara, T. Lysozyme stimulates immunoglobulin production by human-human hybridoma and human peripheral blood lymphocytes. *Cytotechnology* **1997**, *24*, 177-182, 10.1023/A:1007936629501.
4. Sugahara, T.; Murakami, F.; Yamada, Y.; Sasaki, T. The mode of actions of lysozyme as an immunoglobulin production stimulating factor. *Biochim Biophys Acta* **2000**, *1475*, 27-34, 10.1016/S0304-4165(00)00041-6.
5. Sugahara, T.; Yamada, Y.; Yano, S.; Sasaki, T. Heat denaturation enhanced immunoglobulin production stimulating activity of lysozyme from hen egg white. *Biochim Biophys Acta* **2002**, *1572*, 19-24, 10.1016/S0304-4165(02)00272-6.

6. Carrillo, W.; Gracia-Ruiz, A.; Recio, I.; Moreno-Arribas, M.V. Antibacterial activity of hen egg white lysozyme modified by heat and enzymatic treatments against oenological lactic acid bacteria and acetic acid bacteria. *J Food Prot* **2014**, *77*, 1732-1739, 10.4315/0362-028X.JFP-14-009.
7. Ogundele, M.O. A novel anti-inflammatory activity of lysozyme: modulation of serum complement activation. *Mediators Inflamm* **1998**, *7*, 363-365, 10.1080/09629359890893.
8. Lee, W.; Ku, S.K.; Na, D.H.; Bae, J.S. Anti-inflammatory effects of lysozyme against HMGB1 in human endothelial cells and in mice. *Inflammation* **2015**, *38*, 1911-1924, 10.1007/s10753-015-0171-8.
9. Carrillo, W.; Spindola, H.; Ramos, M.; Recio, I.; Carvalho, J.E. Anti-inflammatory and anti-nociceptive activities of native and modified hen egg white lysozyme. *J Med Food* **2016**, *19*, 978-982, 10.1089/jmf.2015.0141.
10. Lee, M.; Kovacs-Nolan, J.; Yang, C.; Archbold, T.; Fan, M.Z.; Mine, Y. Hen egg lysozyme attenuates inflammation and modulates local gene expression in a porcine model of dextran sodium sulfate (DSS)-induced colitis. *J Agric Food Chem* **2009**, *57*, 2233-2240, 10.1021/jf803133b.
11. Chung, J.; Ku, S.K.; Lee, S.; Bae, J.S. Suppressive effects of lysozyme on polyphosphate-mediated vascular inflammatory responses. *Biochem Biophys Res Commun* **2016**, *474*, 715-721, 10.1016/j.bbrc.2016.05.016.
12. Purta, A.B.N.; Morishige, H.; Nishimoto, S.; Nishi, K.; Shiraishi, R.; Doi, M.; Sugahara, T. Effect of collagens from jellyfish and bovine Achilles tendon on the activity of J774.1 and mouse peritoneal macrophages cells. *J Funct Foods* **2012**, *4*, 504-512, 10.1016/j.jff.2012.02.011.
13. Nishi, K.; Kondo, A.; Okamoto, T.; Nakano, H.; Daifuku, M.; Nishimoto, S.; Ochi, K.; Takaoka, T.; Sugahara, T. Immunostimulatory *in vitro* and *in vivo* effects of a water-soluble extract from kale. *Biosci Biotechnol Biochem* **2011**, *75*, 40-46, 10.1271/bbb.100490.
14. Kanda, K.; Nishi, K.; Kadota, A.; Nishimoto, S.; Liu, M.C.; Sugahara, T. Nobiletin suppresses adipocyte differentiation of 3T3-L1 cells by an insulin and IBMX mixture induction. *Biochem Biophys Acta* **2012**, *1820*, 461-468, 10.1016/j.bbagen.2011.11.015.
15. Mendes, S.J.F.; Sousa, F.I.A.B.; Pereira, D.M.S.; Ferro, T.A.F.; Pereira, I.C.P.; Silva, B.L.R.; Pinheiro, A.J.M.C.R.; Mouchrek, A.Q.S.; Monteiro-Neto, V.; Costa, S.K.P.; Nascimento, J.L.M.; Grisotto, M.A.G.; da Costa, R.; Fernandes, E.S. Cinnamaldehyde modulates LPS-induced systemic inflammatory response syndrome through TRPA1-dependent and independent mechanisms. *Int Immunopharmacol* **2016**, *34*, 60-70, 10.1016/j.intimp.2016.02.012.
16. Takada, K.; Ohno, N.; Yadomae, T.; Detoxification of lipopolysaccharide (LPS) by egg white lysozyme. *FEMS Immunol Med Microbiol* **1994**, *9*, 255-263, 10.1111/j.1574-695X.1994.tb00360.x.
17. Ibrahim, H.R.; Hamasaki, K.; Miyata, T. Novel peptide motifs from lysozyme suppress pro-inflammatory cytokines in macrophages by antagonizing toll-like receptor and LPS-scavenging action. *Eur J Pharm Sci* **2017**, *107*, 240-248, 10.1016/j.ejps.2017.07.005.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-FST-013-ID025

# Inhibitory Effect of Caffeine on Degranulation of RBL-2H3 Cells

Arita Dewi Nugrahini <sup>1,2</sup>, Momoko Ishida <sup>3</sup>, Kosuke Nishi <sup>3,4</sup> and Takuya Sugahara <sup>3,4\*</sup>

<sup>1</sup> Faculty of Agricultural Technology, Gadjah Mada University, Yogyakarta 55281, Indonesia

<sup>2</sup> The United Graduate School of Agricultural Sciences, Ehime University, Matsuyama, Ehime 790-8566, Japan

<sup>3</sup> Graduate School of Agriculture, Ehime University, Matsuyama, Ehime 790-8566, Japan

<sup>4</sup> Food and Health Sciences Research Center, Ehime University, Matsuyama, Ehime 790-8566, Japan

\* Correspondence: mars95@agr.ehime-u.ac.jp; Tel.: +81-89-946-9863

Received: 9 July 2018; Accepted: 4 December 2018; Published: 6 January 2020

**Abstract:** It is well known that caffeine can have positive health effects. Caffeine consumption may reduce some of the risks of chronic diseases, diabetes, liver disease, and cancer, as well as improve immune function. Although caffeine has been shown to provide several benefits to human health, there are no reports on anti-allergic activity. In this study, we focused on the inhibitory effect of caffeine on the degranulation of basophils that may indicate the inhibition of type I allergy. Effect of caffeine on antigen-induced degranulation by rat basophil cell line, RBL-2H3 cells was evaluated. As a result, caffeine significantly inhibited the release of  $\beta$ -hexosaminidase from RBL-2H3 cells in a dose-dependent manner without cytotoxicity. Besides, caffeine suppressed the elevation of intracellular  $Ca^{2+}$  concentration induced by antigen.

**Keywords:** caffeine; degranulation; mast cell; anti-allergy

---

## 1. Introduction

Allergic disorders increase dramatically in some developed countries. Allergy is a global healthcare problem that significantly affects daily activities, work productivity, learning, sleep, and quality of life in people of all ages [1]. Allergic reactions represent an immune response to allergens entering into our body from the environment. Allergens may be house dust, pollen, and also foods such as milk, eggs, and wheat [2].

Allergy is classified into four types. Among them, the type I allergy is the most common allergic reaction associated with asthma, hives, hay fever, and allergic dermatitis. During the initiation of type I allergic reaction, the allergen binds to IgE molecules binding to high-affinity IgE receptors (Fc $\epsilon$ RI) on cell surfaces of mast cells and basophils. The cross-linking between the cell-bound IgE–Fc $\epsilon$ RI complex and specific antigen causes the aggregation of Fc $\epsilon$ RI, which induces a variety of cellular responses, including the release of chemical mediators such as histamine,  $\beta$ -hexosaminidase, leukotrienes, prostaglandins, pro-inflammatory cytokines, and chemokines [3–5]. The process of releasing such chemical mediators is defined as degranulation process which induces allergic reactions.

Caffeine (1,3,7-trimethylxanthine, C<sub>8</sub>H<sub>10</sub>N<sub>4</sub>O<sub>2</sub>) is a natural alkaloid or xanthine alkaloid found in coffee beans, tea leaves, cocoa beans, cola nuts, and other plants. It is one of the most widely used pharmacological substances in the world. Caffeine consumption in the world today is quite high. More than eighty percent of the world's population consumes caffeine every day both for stimulants, drug combinations and reducing jetlag [6–10]. This active compound can provide health benefits, such as a source of antioxidants, anti-cancer, anti-bacterial, and anti-inflammatory activities. This study aims to determine the inhibitory effect of caffeine on degranulation of RBL-2H3 cells.

## 2. Materials and Methods

### 2.1. Materials

The equipments used in this study were 15 mL and 50 mL centrifuge tubes, pH-meter, 5 mL syringe, 0.22  $\mu$ m filters, 1.5 mL sample tubes, 50 mL glass beaker, blade grinder, electronic balance, autoclave, rotary mixer, high-speed centrifuge, cell counter, 96-well plates, and plate reader.

While the materials used in this study were caffeine, sterilized distilled water (DW), rat basophilic leukemia RBL-2H3 cells, sterilized phosphate buffered saline (PBS), fetal bovine serum (FBS), Dulbecco's Modified Eagle's medium (DMEM), anti DNP-IgE, DNP-HSA, substrate solution, TritonX-100, trypsin-EDTA (0.25% trypsin-0.02% EDTA-PBS), tyrode's buffer, glycine buffer, loading buffer for blank and sample, loading medium, WST-8 Solution, PVDF membrane, Towbin buffer, running buffer, filter papers, TBS-t (0.1%), 5% skim milk-TBS-t, 1st antibodies, actin, 5% BSA-TBS-t, goat anti-rabbit IgG, HRP-linked antibody, donkey anti-goat IgG, HRP-linked antibody, MeOH, and distilled water (DW).

### 2.2. Methods

#### 2.2.1. Sample preparation

Caffeine was prepared with a concentration of 20 mM. Firstly, caffeine was weighed as much as 19.5 mg. A total of 3 mL of DW was added to dissolve caffeine. The pH of the sample was adjusted to 7.4 ( $\pm 0.1$ ), then DW was added to fill up to 5 mL. The caffeine solution was filtered using a 0.22  $\mu$ m filter, and then it was stored in the freezer.

#### 2.2.2. Cell seeding

RBL-2H3 cells were torn off by sterilized 0.05% EDTA-trypsin, stored in 15 mL centrifuge tube and centrifuged at 1,000 rpm for 5 min. This supernatant was removed, and the precipitated cells were suspended with 10% FBS-DMEM medium, and it was centrifuged at 1,000 rpm for 5 min. This supernatant was removed, and cell density was adjusted to  $2.0 \times 10^5$  cells/mL. Then, 200  $\mu$ L/well of suspension was added to 96-well culture plate and incubated for 18 h.

#### 2.2.3. Degranulation assay

First steps of degranulation assay were conducted on the clean bench. Eleven milliliters of 5% FBS-DMEM medium was prepared in centrifuge tube. One milliliter of the solution was taken out and put into sample tube (for blank). Anti-DNP IgE solution was prepared. Then the 96-well plate seeded with RBL-2H3 cells was washed with 200  $\mu$ L of PBS. After that, 120  $\mu$ L of anti-DNP IgE solution was added to the 96-well plate and incubated for 2 h. The sample solution was prepared. After 2 h, the 96-well plate was observed under a microscope, and anti-DNP IgE was removed from the 96-well plate. The cells were washed twice with 200  $\mu$ L of 1x Tyrode's buffer. Then 120  $\mu$ L of sample solution was added to the 96-well plate and incubated for 10 min. The sample solution was removed, and 120  $\mu$ L of 1x Tyrode's buffer was added to the plate. Then 10  $\mu$ L/well of DNP-HSA solution was added to the 96-well plate and incubated for 30 min. During the incubation, 0.1% TritonX-100 solution and substrate solution were prepared outside the clean bench. After 30 min, the 96-well plate was taken out from the incubator and put on ice for 10 min. The supernatant was moved into the other 96-well plate on ice. Then 130  $\mu$ L/well of 0.1% Triton X-100 solution was added to the cell lysate and crushed it using ultrasonic disintegrator for 5 sec/well on ice. After that, 50  $\mu$ L/well of supernatant and cell lysate were moved into the other 96-well plate. The 96-well plate was incubated at 37°C for 5 min. After the incubation, 100  $\mu$ L/wells of substrate solution and 100  $\mu$ L/ well of 2 M glycine buffer were added to the wells alternately and incubated at 37°C for 25 min. After the incubation, 100  $\mu$ L/well of substrate solution and 2 M glycine buffer were added to the wells on the reverse. Then the solutions in the 96-well plate were measured by optical absorbance at 405 nm.



### 2.2.4. Viability assay

After collection of culture supernatant, wells were washed with PBS. One hundred  $\mu\text{L}$  of 10% FBS-DMEM medium and 10  $\mu\text{L}$  of WST-8 were added to each well and plate was incubated in the dark. The absorbance was measured at 450 nm and the reference at 655 nm by a plate reader.

### 2.2.5. Intracellular $\text{Ca}^{2+}$ assay

Intracellular calcium assay was carried out after the cell seeding was conducted. Anti-DNP IgE was diluted with 10 mL of 5% FBS-DMEM at 10,000 folds. After 18 h of incubation (cell seeding), RBL-2H3 cells were taken out from the incubator, and the medium was removed from each well. The cells were washed with sterilized PBS, and 120  $\mu\text{L}$  of anti-DNP IgE solution was added to each well, then the plate was incubated for 2 h. During the incubation, loading buffers and loading medium were prepared. After the incubation, the cells were taken out from the incubator, and then anti DNP-IgE solution was removed. The cells were washed with PBS twice, and 100  $\mu\text{L}$  loading buffers (for blank and sample) were added to each well, then it was incubated for 1 h. During incubation, DNP-HSA solution was diluted at 16,000 folds. Then loading buffers were removed, and the cells were washed with PBS twice. After that, 100  $\mu\text{L}$  of recording medium was added to each well and then incubated for 10 min. After incubation, the plate was measured by fluorescence plate reader (at 0 min). Ten  $\mu\text{L}$  of DNP-HSA solution was added to each well (outside the clean bench), and then fluorescence intensity was measured by fluorescence plate reader (at 1-30 min).

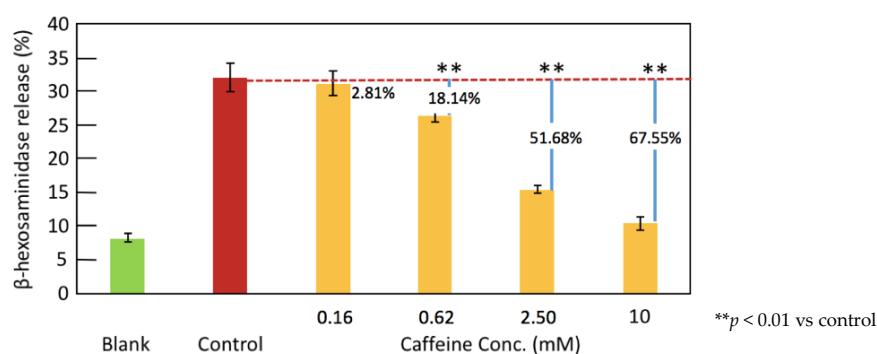
### 2.2.6. Statistical analysis

Data were represented as the mean  $\pm$  SD. Statistical analysis was performed using Dunnett's test to identify significant differences between groups.

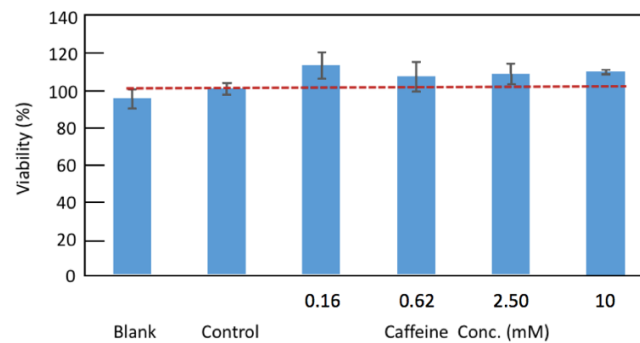
## 3. Results and Discussion

### 3.1. Effects of caffeine on the antigen-mediated degranulation of RBL-2H3 cells

We examined the effects of caffeine on the antigen-mediated degranulation of RBL-2H3 cells. This study was aimed to examine the inhibitory effect of caffeine on  $\beta$ -hexosaminidase release along with degranulation by RBL-2H3 cells. As shown in Fig. 1, caffeine inhibited the release of the  $\beta$ -hexosaminidase from antigen-induced RBL-2H3 cells, suggesting that caffeine can suppress the release of histamine. Caffeine concentrations used in this experiment were 0.16, 0.62, 2.5 and 10 mM, and caffeine at these concentrations inhibited the release of  $\beta$ -hexosaminidase by 2.8%, 18.1%, 51.7%, and 67.6%, respectively. We found that caffeine at higher concentration had a higher inhibitory effect on degranulation. In addition, caffeine had no cytotoxic effects on RBL-2H3 cells (Fig. 2).



**Figure 1.** Effect of caffeine on degranulation by RBL-2H3 cells



**Figure 2.** Cytotoxicity of caffeine on RBL-2H3 cells

### 3.2. Effects of caffeine on $\text{Ca}^{2+}$ concentration in RBL-2H3 cells

To clarify the mechanisms that underlie the inhibitory effects of caffeine on antigen-stimulated degranulation, we determined the degranulation-mediated  $\text{Ca}^{2+}$  influx upstream of degranulation response.  $\text{Ca}^{2+}$  concentration in RBL-2H3 cells is increased by the antigen-antibody induction. In this experiment, we examined the effect of caffeine on antigen-antibody induced increase in  $\text{Ca}^{2+}$  concentration in RBL-2H3 cells. As a result, caffeine suppressed increase in  $\text{Ca}^{2+}$  concentration induced by antigen in a dose-dependent manner.

## 4. Conclusions

Caffeine was found to be capable of inhibiting antigen-stimulated degranulation in RBL-2H3 cells. The inhibitory effects of caffeine on antigen-stimulated degranulation in RBL-2H3 cells were demonstrated, and this effect was related to the suppression of  $\text{Ca}^{2+}$  influx.

**Acknowledgement.** This work was supported by *Lembaga Pengelola Dana Pendidikan (LPDP)*; Indonesian Ministry of Finance; and Indonesian Ministry of Research, Technology and Higher Education.

## References

1. Yamada, T.; Saito, H.; and Fujieda, S. Present state of Japanese cedar pollinosis: the national affliction. *J Allergy Clin Immunol* **2014**, 133(3):632-639.
2. Campbell, D.E.; hILL, d.j.; Kemp, A.S. Enhanced IL-4 but normal interferon-gamma production in children with isolated IgE mediated food hypersensitivity. *Pediatr Allergy Immunol* **1998**, 9:68-72.
3. Broide, D.; Sriramaraio, P. Eosinophil trafficking to sites of allergic inflammation. *Immunol Rev* **2001**, 179:163-72.
4. Srivastava, K.D.; Qu, C.; Zhang, T. Food allergy herbal formula-2 silences peanut-induced anaphylaxis for a prolonged posttreatment period via IFN-gamma-producing CD8+ T cells. *J Allergy Clin Immunol* **2009**, 123:443-51.
5. Kalesnikoff, J.; Galli, S.J. New developments in mast cell biology. *Nat Immunol* **2008**, 9(11):1215-23.
6. Sadock, B.J.; Sadock, V.A. Kaplan & Sadock's Synopsis of Psychiatry: Behavioral Sciences. In *Clinical Psychiatry*, 10<sup>th</sup> ed. Lippincott Williams & Wilkins: New York, 2007; p.413- 7.
7. Norton, T.R.; Lazev, A.B.; Sullivan, M.J. The "Buzz" on caffeine: patterns of caffeine use in a convenience sample of college students. *Journal of Caffeine Research* **2011**, 1(1):35-40.
8. Juliano, L.M.; Griffiths, R.R. A critical review of caffeine withdrawal: empirical validation of symptoms and signs, incidence, severity and associated features. *Psychopharmacology* **2004**, 176: 1-29.
9. Waterhouse, J; Reily, T.; Atkinson, G.; Edwards, B. Jet lag: trends and coping strategies. *Lancet* **2007**, 369:1117-29.
10. Katzung, B.G.; Masters, S.B.; Trevor, A.J. *Basic and Clinical Pharmacology*, 12th ed. McGrawHill Medical: New York, 2012; p:565-80.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-EPS-002-ID047

# Constraints in The Use of Balanced Scorecard Performance Measurement Parameters on Small-Medium Enterprises (Case Study on The Application of SMEs Performance Measurement at CV. X and Y)

Totok Pujianto<sup>1,\*</sup><sup>1</sup> Dept. of Agroindustrial Technology; totok.pujianto@unpad.ac.id

\* Correspondence: totok.pujianto@unpad.ac.id; Tel.: +62-856-212-6252

Received: 8 August 2018; Accepted: 28 August 2019; Published: 6 January 2020

**Abstract:** Performance measurement method that are widely used to measure company performance is Balanced Scorecard (BSC). The BSC method consists of four perspectives, while from these, a company strategic objective will be designed. Pujianto et al (2016) conducted a study that produced performance measurement parameters based on BSC. Although performance parameters have been found, the accuracy and suitability still needs to be evaluated. This is based on the validation of a number of parameters in the process of measuring the performance of two small producers of snack foods as case studies. When applied there are some obstacles, where there are parameters that are difficult or even impossible to calculate for various reasons. Moreover, even measurement parameters are considered less precise to be used. It is therefore necessary to discuss some of the constraints that arise when those parameters are used to measure the performance of SMEs as well as the reasons why they are considered less precise. The study included: identification of measurement parameters along with a number of variables needed, compiling a number of questions as a discussion guide, arranging for possible grouping of constraint types. Field study was conducted in the form of in-depth discussions with a number of business actors and or managers related to each performance measurement parameter. The method of analysis through a small group discussion is qualitative by presenting the side of the measurement constraints, both technical and logical. Among the 32 parameters, there are 9 parameters discussed in the constraints in the implementation of the measurement. Measurement parameters which are the main constraints in measuring company performance are recording data and information. This parameter is also a source of constraints for measurement of other parameters. Based on the 9 parameters discussed, there are a number of measurement parameters that still need to be reviewed or need to be replaced, namely: number of trained employees, number of work accidents, and number of employee recruitment. whereas those that need rearrangement of the equations used are: number of complaints and compliments, number of defective products, and number of employee recruitment. other parameters that still need to be used are: additional number of market area, number of direct customer interactions, and recording of data and information, because the constraints in measurement are caused by the company's inability to fulfill its performance.

**Keywords:** Constraint in Measurement; Measurement Parameter; Performance Measurement; SME Performance

## 1. Introduction

It is very important to measure the performance of a company to be a benchmark for achieving the goals and objectives of the company, as well as to improve and maintain the quality of the company. Performance measurement is a measurement action against various activities within the value chain of a company. Performance measurement is a process of measuring the efficiency and effectiveness of the company [1].

Many studies of performance measurement with the aim of obtaining measurement effectiveness especially in small and medium industries (SMEs). Several studies have been conducted with a focus on determining the exact measurement parameters and in accordance with the characteristics of the SME [1-5].

Performance measurements are many and more easily performed on large industries due to the availability, completeness and accuracy of the data required in measurement, but not when it is applied to SMEs. The performance measurements of SMEs differ from performance measures in large industries due to their different characteristics. Performance measurement approaches are generally designed for large industries, and are often not applicable to SMEs especially in developing countries, because: (1) SMEs are not well structured and correct, and (2) SME's often does not collect the information required for measurement complex performance [2]. Therefore, measuring the performance of IKM needs to be adjusted to the characteristics of SMEs [2].

Performance measurement systems (PMS) enable enterprises to evaluate the extent to which their goals are being met and the efficiency of their decisions by means of a set of indicators. Nevertheless their implementation in small and medium-sized enterprises (SMEs) is scarce. One of the reasons for this is the lack of suitable methodologies to guide the implementation of a PMS focused on the specific needs of SMEs [5].

Author [6] stated that performance measurement methods that are widely used to measure company performance are Balanced Scorecard (BSC) and Performance Prism (PP). The Balanced Scorecard (BSC) method consists of four perspectives, namely financial (Financial), customer (Customer), internal business processes (Internal Processes), and learning and growth (Learning and Growth). From these four perspectives an IKM strategic objective will be designed. BSC consists of three functions, namely as a measurement system, strategic management system, and as a communication tool [7].

Author [3] conducted a study of SME performance measurements in the UK using the Balanced Scorecard (BSC) Method which concluded that there is a gap between performance measurement theory and its implementation in SME scale companies. Author [8] argue the need for a general approach to the examination of performance measurement in organisations, a perspective that addresses the key questions identified by managers and how they deal with the design, implementation, and usage of performance measurement in real-time settings.

Author [6] conducted a study that produced performance measurement parameters based on Balanced Score Card (BSC). Although performance parameters have been found, the accuracy and suitability still needs to be evaluated. This is based on the validation of a number of parameters in the process of measuring the performance of two small producers of snack foods as case studies. When applied there are some obstacles, where there are parameters that are difficult or even impossible to calculate for various reasons. Moreover, even measurement parameters are considered less precise to be used.

It is therefore necessary to discuss some of the constraints that arise when those parameters are used to measure the performance of SMEs as well as the reasons why they are considered less precise. This discussion can be used as a material to improve the parameters so as to obtain a better performance measurement package for SMEs in food business. Benefits to be gained is the improvement of performance measurement more simple but precise and appropriate.

## 2. Materials and Methods

This research is descriptive, using the object of research that is the parameter of performance measurement for SME in food which is the result of research conducted by Pujianto et al (2016) [6]. The study begins with a study of the results of the research object above. The study included: (1) identification of measurement parameters (Key Performance Indicators) along with a number of variables needed to determine the measurement results, (2) compiling a number of questions as a discussion guide to answer the need for measurement parameters to be used and the reasons for the variables used to measure them. The variables are either quantitative or qualitative, (3) arranging for

possible grouping of constraint types, both on the level of measurement parameters and the variables they need.

Furthermore, a field study was conducted in the form of in-depth discussions with a number of business actors and or managers in CV. X and Y related to each performance measurement parameter. Each measurement parameter from each perspective within the BSC framework and from each strategic objective is discussed. The method of analysis is qualitative by presenting the side of the measurement constraints as well as the guidance of assessments, both technical and logical. The technical nature in question is that which concerns the availability of variable data needed in the measurement. The logic in question is the logic of the absence of possible measurement parameters applied. This process is done through a small group discussion in which the discussion member is a research team involved in the assessment process.

### 3. Results and Discussion

The measurement parameters evaluated to discuss various obstacles in their application are performance measurement parameters with BSC perspective as shown in Table 1.

**Table 1.** Performance Measurement Parameters with BSC Perspective

Perspective	Strategic Objectives	Parameters
Financial	Long-term Financial Success	Return On Investment (ROI) Return On Equity (ROE) Total Asset Turn Over (TATO) Return On Asset (ROA)
	Short-term Financial Success	Profit Margin Sales Growth
Customer	Increase customer satisfaction	Number of complaints and compliments On time delivery
	Increase market share	Sales volume Number of market areas Market segments
	Management of customer needs	Number of direct interactions with customers Customer retention
Internal Business Process	Development of new products	Number of new variants Number of new products
	Increase production capacity	Technology changes Managerial change
	Risk and crisis management	Amount of equipment damage Hazard analysis
	Performance Evaluation System	Raw material efficiency Listing Ordering
	Quality Control	Number of defective products
Growth and Learning	Employee capability	Number of trained employees The level of education Employee retention
	Increase a conducive working atmosphere	Number of work accidents Employee Presentation
	Increase the number of reliable employees	Recruitment of employees Staff Reliability
	Increase employee productivity	Level of productivity Employee satisfaction Reward and punishment programs

In the process of analyzing, it is necessary to distinguish between the inability of a company to meet the measured parameter values because of the company's performance with deficiencies or weaknesses or incompatibility. This is due to the reason that the parameters are not directly related to the performance of the measurement object (can be due to the type of company or its level).

The number of parameters is 32. One by one parameter is discussed with the actors involved in the company. The subject matter is the logical side of the parameter, the relationship between parameter and the interests of the company, the ability to be measured, the availability of quantitative data, the ability to provide qualitative data, and the constraints in terms of facilitating the measurement.

Overall, the discussion of parameter is actually logical as a parameter to measure company performance and is closely related to the type of business. However, when quantitative data is required, the company finds it difficult to provide records that can represent the required data. The types of difficulties are: (1) no records at all, (2) there is little data but not complete either in terms of time, or from the side of variables that need to be recorded, (3) there is data that needs to be processed first but still require data additional. This problem begins with the assumption that recording requires extra time and effort, while the results are not considered so important by the owner of the company.

When the measurement process is done by trying one by one parameters, most parameters obtained data results for later used to calculate the score. However, among the parameters found there are 9 parameters whose measurement results obtained a score of zero (0). This zero score does not indicate that the parameter is incorrectly used as a measuring tool, but rather means that the company does not have performance related parameters, whereas the type of business that runs has the potential to grow when the company takes into account that aspect.

The discussion of the constraints on parameter measurement is more focused on the parameters that result in zero score components, to see whether the zero score is indeed systemic (all SME types will produce the same score) or the zero score does show the actual company performance (other company may be generate non-zero score). The nine parameters are as shown in Table 2.

**Table 2.** Parameter Measurement Whose Measurement Results Have a Zero Score

Perspective	Strategic Objectives	Parameters
Customer	Increase customer satisfaction	Number of complaints and compliments
	Increase market share	Additional number of market areas
	Management of customer needs	Number of direct interactions with customers
Internal Business Process	Performance Evaluation System	Recording of data and information
	Quality Control	Number of defective products
Growth and Learning	Employee capability	Number of trained employees
	Increase a conducive working atmosphere	Number of work accidents
	Increase the number of reliable employees	Recruitment of employees
	Increase employee productivity	Level of productivity

The following describes each of the problems in the use of the parameters listed in Table 2 when used in measuring company performance.

### 3.1. Number of Complaints and Compliments

The firm did not have a specific target for the number of complaints and compliment from customers, but it is very important to measure the extent to which customer satisfaction on SME products and can also be an evaluation of the company.

This parameter is difficult to measure as a parameter. Although it can be measured quantitatively in the form of the number of complaints and compliments, but will find difficulty when setting the value. Ideally the company hopes there is no complaint at all, and expect compliments much. The size

of the amount of compliment is difficult to determine absolutely how much it is scored 100%. On the contrary it will also be easy to determine a complaint score to be 100% when no complaints are made at all, but it is difficult to give a score of 0% that is equivalent to how much the complaint counts.

In addition to this, it still needs to be defined and standardized regarding the quality of complaints and compliments. This requires a separate study of the types of complaints and compliment from customers.

### *3.2. Additional Number of Market Area*

Likewise, in the number of areas, the company did not have a specific target how many cities that are targeted sales of SMEs, so that the spread of SME products just happened, without knowing exactly how many cities routinely supplied by the firm. This indicates that the firm has not yet thought about expanding the marketing area.

In most SME, the expansion of market areas is still not a concern. But companies will grow if turnover increases. Additional sales turnover can be obtained through the expansion of market areas that provide additional consumer opportunities. Based on this, the parameters of increasing the number of market areas are so relevant that they need to remain as performance measurement parameters. The company selected as a case study has a business field that logically enables the expansion of the market area and the distance factor determines the success of the sale.

### *3.3. Number of Direct Customers Interactions*

The third parameter is the number of direct interactions with customers, company do not have specific targets how much the number of direct interactions that are desired., this can be a good evaluation for SME's, because we can know directly complaints or inputs of customers towards SME's products, even this direct interaction can be a way of further introducing SME products.

Today, SMEs tend to find it much easier to interact with customers, because of the social media platform on the internet that is so easy to use. Society is relatively so common with various facilities available on the internet. Many customers use social media and online communication channels to meet their needs. Expectations, comments, and feedback from customers to producers or sellers are very easy to obtain. Because of that reality, corporate interaction with customers becomes very important as a performance measurement parameter. The existence of such interactions can always maintain its performance in terms of fulfillment of customer expectations of the product, even to the service and positive image of the company.

This does not mean that if the company has not planned to interact either directly physically or through electronic media and the internet, then this parameter is not considered necessary. If the company has not done, then the company's performance alone becomes lessened by the customer relationship factor. SME food sector where the product is the final product that is directly enjoyed by the end consumer, then the interaction with the customer is needed. As with the SME that produces goods as industrial raw materials, even for this case can also be debated whether or not the parameters of measurement of interaction with consumers.

### *3.4. Recording of data and information*

Recording of data and information also becomes very weak in the company which is used as an object of case studies. The production process goes just like that without recording the amount of incoming raw materials and the number of final products that meet the standards or the defective ones, let alone record the activities during the process. In the company there is also no record of capital expenditures and the amount of income per period, even though this recording is very useful for the process of evaluating company performance. With the recording, control and monitoring of the company's performance will be much easier.

This recording is a major factor in measuring company performance. This is a major obstacle. The company itself is unable to know exactly and objectively about the company's problems so that it will encounter difficulties when the company wants to improve itself. The weakness of the company is on



the administrative management side. Therefore, the order parameter of administrative registration is absolutely necessary because it is the main source of performance measurement.

### 3.5. *Number of defective products*

Performance measurement related to this defective product is also experiencing problems because the company does not record and even estimates are difficult. In addition, the company does not have a maximum defect product target. The company should have wished that the final product would not be defective. This parameter is still needed to see how far the achievement of the business process is in the production stage.

The problem of measuring parameters for the number of defective products is also the same as some other parameters which are perfect if there are no events, such as the number of work accidents, and the number of consumer complaints. Parameters such as this need to be reviewed in relation to the lowest value limit.

### 3.6. *Number of Trained Employees*

The companies that were subjected to the case study found it difficult to identify the question of whether the employee had been trained or not formally. This parameter is approximated by the level of employee education. The results of in-depth interviews on the parameters of employee education measurement, firms do not have targeted number of employees at a certain level of education, employees are not given education level limits, the SMEs only require employees to work properly and diligently.

However, for the advancement of SMEs this is worth noting, the level of employee education can indicate the level of knowledge and work skills of an employee, by forging, training and giving the same experience to the graduate of elementary and high school graduate employees will be different, really payed attention.

Based on the discussion and referring to the enactment of the Indonesian National Qualification Framework (INQF/in bahasa = KKNI), the measurement parameter of "education level" is better if replaced with a qualification level indicating one's competence. In KKNI, it shows the equivalence of the competencies that are gained through the path: (1) academic education, (2) experience and self learning, (3) professional and professional sertification, and (4) work in industry, so that a person is considered to have an equal qualification even if the competencies are obtained from different paths.

More detailed references are the Indonesian National Work Competency Standards (in bahasa SKKNI). The definition of SKKNI is a formulation of work capability that covers aspects of knowledge, skills and / or skills and attitude that are relevant to the implementation of duties and job requirements that are determined in accordance with the provisions of the prevailing laws and regulations [9].

Scores of this measurement component are not based on the number of highly educated employees, but rather are based on the suitability of competence and availability needs and account for the amount.

### 3.7. *Number of work accidents*

Furthermore, in the parameters of the number of workplace accidents, where the company is used as a case study, work accidents rarely occur, where in one year only 2-3 accidents. However, when viewed from the perceived good performance on the parameters of workplace accidents, it can be said to be less good, because of good performance if there is no work accident or zero accident. This relates to the company's attention to employee safety, and employee attention to hazards in the work environment.

The number of workplace accidents is measured as a strategic goal approach Increase a conducive working atmosphere. Although in fact the work atmosphere is not only a matter of the number of work accidents. The occurrence of psychological barriers caused by the physical condition of the environment or collegial relations between employees, mental pressure by the need to achieve work targets also affect the conducive work atmosphere. However, all of these causes are difficult to measure.

The other approach proposed is to use the average employee working period. This is based on the assumption that if the average working period of all employees is long enough, then it shows that in the company there is a conducive working atmosphere. It's just that a measure of perfection for this objective strategy needs to be clearly defined. It is very difficult to determine the employee's working period that reflects a conducive work atmosphere in the company.

### 3.8. *The number of employee recruitment*

The parameter of the number of employee recruitment is to represent the strategic goals of increasing employee reliability. This means that the recruitment of employees is carried out to meet the level of needs so that there is an adequate number of employees according to the production plan. The recruitment target is important for the company because with the target the company can regulate and predict the amount of production that can be done. The company can also forecast expenses for the salaries of all its employees.

However, this is a waste if there are many incidents of employees going in and out, so the frequency is high. As if high frequency shows good performance. Though the reason for hiring employees is detected not only because it meets the availability of the number of employees associated with the production plan. Employee recruitment can be due to other things.

This frequency number becomes invalid to represent employee reliability. This does not mean that companies that do not recruit employees are considered unreliable. Therefore, this employee recruitment parameter needs to be reviewed if it is used as an indicator of strategic objectives of employee reliability.

### 3.9. *Employee productivity*

The measurement of employee productivity parameters is actually very significant to be used as a component of the company's performance measurement. The main problem in small companies that are used as case studies is the absence of quantitative recording of the performance or products produced by each employee. The company is only able to deliver data qualitatively whose accuracy is doubtful because of inadequate supporting data from other perspectives. But this can actually be designed to be measured in groups according to certain processes that are carried out by a group of employees. The data used can be in the form of records of results of each process in a certain time interval compared to the number of employees in the group being reviewed. So the point is that this parameter is still needed in measuring the company's performance, but needs to be supported by the recording performance by the company.

## 4. **Conclusions**

Among the 32 parameters, there are 9 parameters discussed in the constraints in the implementation of the measurement. Measurement parameters which are the main constraints in measuring company performance are recording data and information. This was acknowledged by the company regarding the lack of properly recorded data and information. This parameter is also a source of constraints for measurement of other parameters. Of the 9 parameters discussed, there are a number of measurement parameters that still need to be reviewed or need to be replaced, namely: (1) Number of Trained Employees, (2) Number of work accidents, and (3) The number of employee recruitment. Whereas those that need rearrangement of the equations used are: (1) Number of Complaints and Compliments, (2) Number of defective products, and (3) The number of Employee Recruitment. Other parameters that still need to be used are: (1) Additional Number of Market Area, (2) Number of Direct Customers Interactions, and (3) Recording of data and information, because the constraints in measurement are caused by the company's inability to fulfill its performance.

**Acknowledgments.** I express my gratitude to: (1) Roni Kastaman, Irfan Ardiansah, Devi Maulida Rahmah, Haikal Amin, who have taken the time to discuss topics on performance measurement; (2) the owners and managers of four companies (classified as small industries) who have also taken the time to discuss and provide information in order to discuss the measurement of performance parameters for small and medium industries; and (3) Faculty of Agro-Industrial Technology, Padjadjaran University, which gave me the opportunity to conduct this research.

## References

1. A. Neely, J. Mills, K. Platts, M. Gregory, dan H. Richards, "Performance measurement system design: Should process based approaches be adopted?," *International Journal of Production Economics*, vol. 46–47, hlm. 423–431, Des 1996.
2. M. Hudson, J. Lean, dan P. A. Smart, "Improving control through effective performance measurement in SMEs," *Production Planning & Control*, vol. 12, no. 8, hlm. 804–813, Jan 2001.
3. S. Sousa dan E. Aspinwall, "Development of a performance measurement framework for SMEs," *Total Quality Management & Business Excellence*, vol. 21, no. 5, hlm. 475–501, Mei 2010.
4. M. Alles dan M. Gupta, "The impact of uncertainty and ambiguity when implementing the Balanced Scorecard," *Asia-Pacific Journal of Accounting & Economics*, vol. 9, no. 2, hlm. 235–262, Des 2002.
5. R. Chalmers, S. Palomero, dan M. Matilla, "Methodology to develop a performance measurement system in small and medium-sized enterprises," *International Journal of Computer Integrated Manufacturing*, vol. 25, no. 8, hlm. 716–740, Agu 2012.
6. T. Pujianto, I. Ardiansah, dan H. Amin, *Optimalisasi Ukuran Kinerja Industri Kecil Menengah Sektor Agro-Food Menggunakan Kerangka Balanced Scorecard (BSC)*, 1 ed., vol. 1, 1 vol. Jember: UPT Penerbitan UNEJ, 2016.
7. S. J. Simon, "Balanced Scorecard: A Tool to Improve IS Department Planning and Evaluation," *Journal of Information Technology Case and Application Research*, vol. 7, no. 4, hlm. 7–29, Okt 2005.
8. M. Elg dan B. Kollberg, "Alternative arguments and directions for studying performance measurement," *Total Quality Management & Business Excellence*, vol. 20, no. 4, hlm. 409–421, Apr 2009.
9. Kementerian Perindustrian Republik Indonesia, "Standar Kompetensi Kerja Nasional Indonesia (SKKNI)." Kementerian Perindustrian Republik Indonesia, 2016.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-EPS-003-ID010

# Trust as a Human Factor for Sustainable Ergonomics Application in Agro-industry

Mirwan Ushada <sup>1,\*</sup>, Titis Wijayanto <sup>2</sup> and Fitri Trapsilawati <sup>2,\*</sup>

<sup>1</sup> Universitas Gadjah Mada, Department of Agro-industrial Technology; mirwan\_ushada@ugm.ac.id

<sup>2</sup> Universitas Gadjah Mada, Department of Mechanical and Industrial Engineering; twijaya@ugm.ac.id; fitri.trapsilawati@gmail.com

\* Correspondence: mirwan\_ushada@ugm.ac.id; Tel./Fax: +62-274-551219

Received: 8 July 2018; Accepted: 28 August 2019; Published: 6 January 2020

**Abstract:** Ergonomics application is not yet fully concerned in agro-industry due to the gap between ergonomics and welfare benefit. The welfare benefits such as wages, incentives, and other financial support have gained more interest than the ergonomics benefits as a comfortable workplace environment, work methods and workload. This study proposes trust as a human factor for sustainable ergonomics application. Trust can be defined as a user affective state that will guide individual and social decision in a work system characterized by uncertainty and vulnerability. The study objective is to analyze the trust-building process to the ergonomics application in agro-industry. The samples were previous research review from 38 food SMEs in Yogyakarta Special Region. The result indicated that building trust should consider skill, workplace environment, financial, multi-tasking, misuse and disuse of ergonomic application. Study result concluded trust could be used as a human factor in ergonomic work system of agro-industry.

**Keywords:** ergonomics benefit; individual decision; local work culture; social decision; welfare benefit

---

## 1. Introduction

Most of agroindustrial work system in Indonesia is typical of manual task [1]. Ergonomic has been defined as fitting the task to the human factors of the involved user in agro-industrial production system. Ergonomics application is not yet fully concerned in agro-industry due to the gap between ergonomics and welfare benefit. The welfare benefits such as wages, incentives, and other financial support have gained more interest than the ergonomics benefits as a comfortable workplace environment, work methods and workload. This study proposes trust as a human factor for sustainable ergonomics application. Trust can be defined as a user affective state that will guide individual and social decision in a work system characterized by uncertainty and vulnerability [2]. The objective of this study is to analyze the trust-building process to the ergonomics application in agro-industry. The expected advantage is to highlight the importance to quantify the abstractive parameters of trust for fourth industrial revolution 4.0 in the agro-industry. Quantification of trust could enable the data interchange in big data system to support decision and policy for agro-industrial competitiveness.

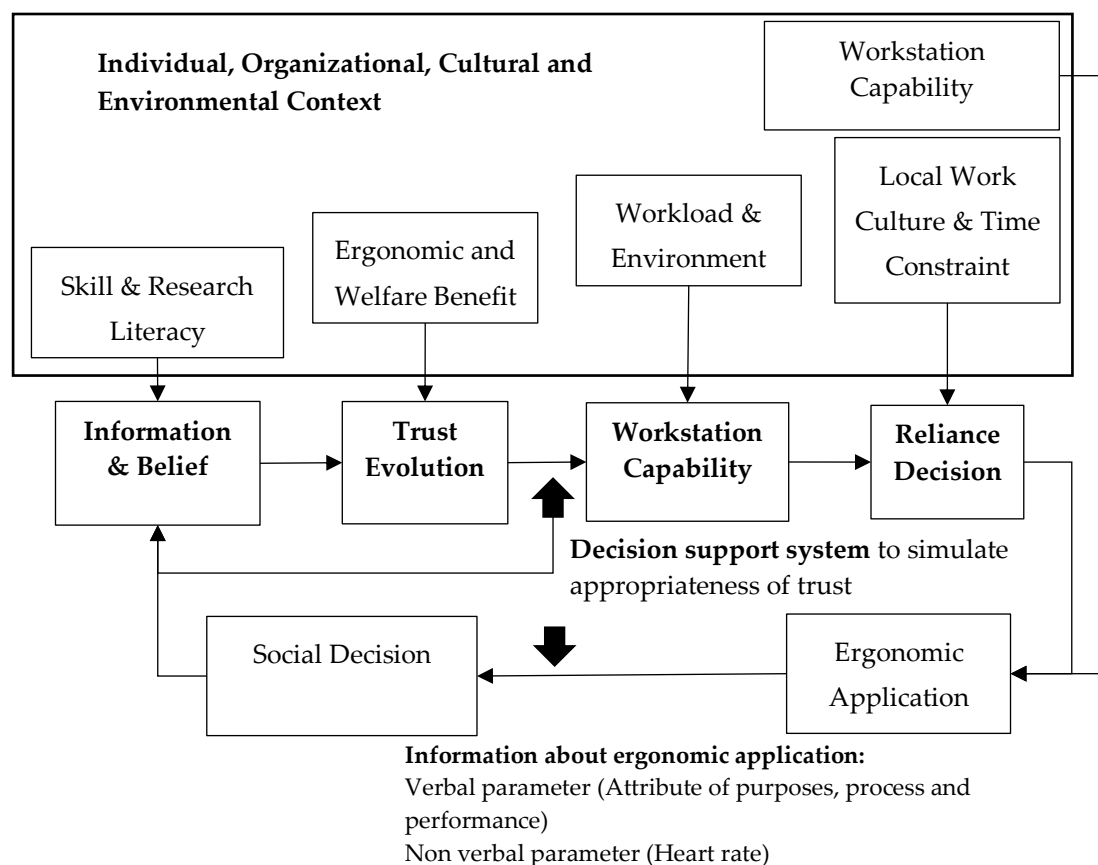
## 2. Materials and Methods

The analysis of trust was reviewed from our previous observation researches. The samples were 38 food SMEs in Yogyakarta Special Region, which was reviewed from author [3] and author [1]. The respondent were 30 sample members from Sleman Regional Businessmens Association for Food and Beverages [3]. Author [1] indicated the Six (6) SMEs of different food products were as crackers, nuggets, fish chips, bakpia, tempe and herbal instant beverages. Two (2) additional reviews from bakery and tobacco agroindustries.

### 3. Results

Recently, trust has gained more attention as human factors in several field of application. Author [4] have explored the trust analysis in multitasking workspace. Author [5] have utilized the trust in instrument of medical technology. Author [6] have recommended trust as a human factor in assesing risk in area Internet of Things (IoT). Author [7] have defined the relationship between trust and human resources in project management of spacecraft. Author [3] have identified the priority of user attribute needs as response to the introduction of KESAN (Kansei Engineering-based Sensor for Agroindustry) as a new ergonomic tool in SMEs. The highest attribute importance of this research was the willingness to use to Information Technology (IT) to implement the ergonomic application. It indicated the SMEs were familiar with the benefit of information technology to support the production system. This findings highlighted the importance of IT to support the sustainable application of ergonomic in agro-industry.

The other interesting research result by Author [1] indicated the affective condition from Six (6) SMEs of different food products as crackers, nuggets, fish chips, bakpia, tempe and herbal instant beverages. The evaluation indicated 51,3% worker in affective and 48,7% in non-affective condition. The other interesting research result by Author [8] indicated that 84,4% of worker are recommended to receive incentive and 15,6% not to receive incentive.



**Figure 1.** A conceptual model for dynamic process of ergonomic application trust in agro-industry (Adapted from author [2])

## 4. Discussion

### 4.1. Conceptual Model of Trust

Figure 1 indicated the conceptual model to implement trust as a human factors for sustainable ergonomic application in agroindustry. The conceptual model was adapted from author [2] and adjusted based on the needs to achieve the sustainable ergonomic application in agro-industry.

Reliance decision is influenced by local work culture and time constraint. Local work culture is considered as one of significant challenges in sustainable ergonomic application in agro-industry. Trust could be influenced by the local work culture in association with the work system and methods. Time constraint influenced by delay time, normal and standard time. Delay time could be minimized using the deviation between buffer and standard time. A buffer time is proposed as a solution to support the bottleneck among the work station in a production system [9]. Buffer time is determined by deviation between worker capacity and integrated workload using Drum-Buffer-Rope algorithm [9]. The workload was classified into normal, capacity constrained worker and bottleneck [9]. The constraint of personal needs and unavoidable delays could become bias for the local work culture. Standard time is determined by adding to normal time for personal worker needs, unavoidable work breakdown or bottleneck, and physical or mental worker fatigue.

Workstation capability is influenced by the interaction between worker, tool, workplace environment and material capabilities [1]. Author [9] indicated that more upstream the process, then the less ergonomic condition of worker in a workstation.

Trust evolution was influenced by trade-offs between ergonomic and welfare benefit. It could be solved by using the optimization method. This trade off to the trust could make trust as a complex computation problems. Individual and social decision influence the attractiveness of ergonomic to the owner of SMEs as individual and cluster of SMEs as the collective. Individual trust to sustainable ergonomic application could be solved using the formula by author [10] using prominence and interpretation. The basic method for this formula is using the questionnaire to collect the data. The possibility of bias is usually high eventough the test of validity and reliability is pursued for the quality control. The alternative method of optimization and computation using artificial intelligence is highly required. The abstractive communication between 1 (one) individual owner of SMEs and other partners in same community/group for the social decision is possible to be simulated in the artificial intelligence-based research.

Ergonomic benefit could be defined as one example is by author [3] from the side of comfortable display colour, compact size, form, informative, keypad, colour, size, font and the availability of manual procedure. The other example of ergonomic benefit is the interaction between workload and environment [1]. Heart rate could be suggested as one of indicator for trade off between ergonomic and welfare benefit for the SMEs. It is fit the work characteristics of food SMEs which most of them is manual, labour incentive and influenced by environmental ergonomics.

Misuse of ergonomic indirectly indicated the existence of capacity constrained worker which could work several times from its capacity in workstation of agroindustry [9]. Disuse of ergonomics application could be indicated the significant amount of less workload worker in agroindustry which could be indicated by by our previous research [9].

The social decision is accomodating the collective opinion from the user to help them to select the appropriate ergonomic technology to accept the technology. The social decision generate the belief and information which support the sustainability of ergonomic application for the agroindustry. Information and belief generate the several alternative technology as: 1) Technology innovation; 2) Technology application; 3) Technology dissemination; 4) Adoption; 5) Revitalization; 6) Upgrade; 7) Downgrade; 8) Difussion; 9) Shared technology.

### 4.2. Building the Trust

Figure 1 concluded that building the trust should consider skill and ergonomic literacy, workplace environment, financial, multi-tasking, misuse and disuse of ergonomic application. Skill could be

analyzed based on national standard qualification. Ergonomic literacy could be implemented by the action research of the university students who pursue the thesis in SMEs. The interaction between agroindustry and student will increase the ergonomic literacy. Providing ergonomic workplace environment will contribute to tradeoff between welfare benefit and ergonomic benefit. The example of welfare benefit is proposed using the wages based on heart rate parameters as shown in our previous results [8]. The example of ergonomic benefit was indicated by author [1] that setting the temperature control  $29.1 \pm 1.8$  °C could save more energy in food SMEs, if it is implemented using air conditioner. Multi-tasking is indicated by no distinct differentiation between one workstation and other workstation. Overtrust may direct to misuse and distrust to disuse [2]. Misuse of ergonomic application refers to the failures that occur when owner of SMS in advertently violate critical assumptions and rely on ergonomic inappropriately. Disuse of ergonomic indicate failures that occur when SMEs reject the capabilities of ergonomic. Considering the complex fact of building trust, it required the methods to quantify it.

#### 4.3. Quantification of Trust

Trust must be quantified to support the decision for sustainable ergonomic application in agro-industry. The next challenge is to find the method for quantifying the trust as the human factors as the perspective from the individual and social decision. There are several ways to implement trust as a human factor for sustainable ergonomic application in agroindustry as follow:

##### 4.3.1. Questionnaire attribute

Questionnaire attribute could be used to quantify the trust based on the dimension of trust as purpose, performance and reliability. Questionnaire attribute is the easiest way of verbal parameters in Kansei Engineering to identify the user needs. The application was confirmed by author [10]. Besides, author [2] recommended the three bases of trust that is competency (performance), reliability (performance), openness (process), and concern (purpose). The dimensions of purpose, process, and performance provide a set of attributes for questionnaire that describe the basis of trust across a wide range of application domains include ergonomic application.

##### 4.3.2. Heart rate

Heart rate is non verbal parameter which could be used to quantify the workload. The application was confirmed by author [1,8]. Heart rate is recommended for manual work type in agroindustry which is influenced by the workplace environment.

##### 4.3.3. SWA Index

SMEs worker affective index could be used to determine the trust based on the comparison between standard and measured heart rate. The application was confirmed by author [8].

##### 4.3.4. Collective intelligence

Collective intelligence could be used to model the trust based on the complexity of the involved verbal and non verbal parameter. The application was confirmed by author [1-8].

## 5. Conclusions

The result concluded that building trust should consider skill, workplace environment, financial, multi-tasking, misuse and disuse of ergonomic application. Study result concluded trust could be used as a human factor in ergonomic work system of agro-industry. Kansei Engineering framework could be used to identify and analyze the conceptual model of trust. The questionnaire attribute, heart rate, index and collective intelligence could be used as a method to quantify the trust as human factors in agro-industry.

**Acknowledgments:** Authors wishing to acknowledge financial support from Ministry of Research, Technology and Higher Education of the Republic of Indonesia by 2018 Research Grants: ‘Penelitian Terapan Unggulan Perguruan Tinggi Tahun 2018’ No: 1877/UN1/DITLIT/DIT-LIT/LT/2018.

## References

1. Ushada M., Okayama M., T.; Khuriyati N.; Suyantohadi A. 2017. Affective Temperature Control in Food SMEs using Artificial Neural Network. *App. Art. Intell.* 31 (7-8): 555-567.
2. Lee, J.D. dan See K.A. Trust in Automation: Designing for Appropriate Reliance. *Human Factors* 2014. 46(1), 50-80,doi: [10.1518/hfes.46.1.50\\_30392](https://doi.org/10.1518/hfes.46.1.50_30392)
3. Agassi, T. A.; Ushada M.; and Suyantohadi A. “User Needs Analysis for Industrial Design of Kansei Engineering-based Sensor for Agroindustry (KESAN)”, *International Conference of Science and Technology*, 7-8 Agustus 2018, Universitas Gadjah Mada
4. Karpinsky N.D.; Chancey E.T.; Palmer D.B.; Yamani Y. Automation trust and attention allocation in multitasking workspace. *Applied Ergonomics* 2018. 70, 194-201,doi: [10.1016/j.apergo.2018.03.008](https://doi.org/10.1016/j.apergo.2018.03.008)
5. Montague E. Validation of a trust in medical technology instrument. *Applied Ergonomics* 2010. 41, 812-821, doi: [10.1016/j.apergo.2010.01.009](https://doi.org/10.1016/j.apergo.2010.01.009)
6. Henshel D.; Cains M.G.; Hoffman B.; Kelley T. Trust as a human factor in holistic cyber security risk assesment. *Procedia Manufacturing* 2015. 3, 1117-1124 doi: [10.1016/j.promfg.2015.07.186](https://doi.org/10.1016/j.promfg.2015.07.186).
7. Niu J.;Geng H.; Zhang Y.; Du X. Relationship between automation trust and operator performance for the novice and expert in spacecraft rendezvous and docking (RVD). *Applied Ergonomics* 2018. 71,1-8, doi: [10.1016/j.apergo.2018.03.014](https://doi.org/10.1016/j.apergo.2018.03.014).
8. Ushada M.; Aji M., G. K.; Okayama T.; Khidir M. "SME Worker Affective (SWA) Index based on Environmental Ergonomics". Conference Proceeding of The International Conference on Industrial and System Engineering (ICONISE), 29-31 Agustus 2017: IOP Conference Series: *Material Science and Engineering.*, 337 (2018).
9. Ushada, M.; Mulyati G. T.; Guritno A. D.; Murase H. Combining Drum-Buffer-Rope Algorithm and Kansei Engineering to Control Capacity Constrained Worker in a Bioproduction System. *IFAC Proceedings Volumes* 2013. 46(4),384-389,doi: [10.3182/20130327-3-JP-3017.00085](https://doi.org/10.3182/20130327-3-JP-3017.00085)
10. Xu, J.; Le G. K.; Deitermann A.; Montague E. How different types of users develop trust in technology: A qualitative analysis of the antecedents of active and passive user trust in a shared technology. *Applied Ergonomics Volumes* 2014. 45(4),1495-1503,doi: <https://doi.org/10.1016/j.apergo.2014.04.012>



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).



FP-EPS-005-ID006

# Cost Analysis for Sugarcane Transporting Improvement from Loading Station to Sugar mill

Kris Promsiri<sup>1</sup> and Jumpol Vorasayan<sup>2,\*</sup>

<sup>1</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand;

<sup>2</sup> Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand.

\* Correspondence: [jumpol.v@ku.th](mailto:jumpol.v@ku.th); Tel.: +66-2562-5093 Ext. 5372

Received: 7 July 2018; Accepted: 20 December 2018; Published: 6 January 2020

**Abstract:** The transportation of sugarcane is one of major costs of sugar production. Large vehicles such as 22-wheel full trailer and semi-trailer are used for long-distance transportation because it incurs less transportation cost per ton. The objective of this research is to compare annual cost and benefit analysis model for two sugarcane transportation protocols single-loop and double-loop. In situation where the process is continuous and deterministic, the results showed that, the double-loop protocol had higher cost than single-loop protocol.

**Keywords:** cost analysis; transportation; sugar mill; loading station

---

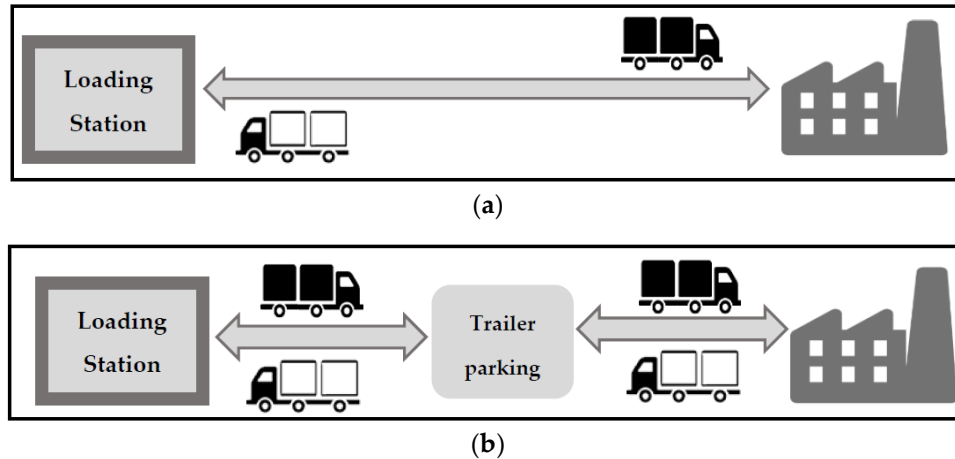
## 1. Introduction

Sugarcane is a perennial agricultural crop that is mainly grown for its expressed juices, which used to produce raw sugar that is later refined into sugar. [1] In 2016, sugar accounted for over 80% of all sweeteners consumed globally, with products such as sugar, high-intensity sweetener (HIS), an artificial sweetener. Approximately 85% of all sugar produced globally come from sugarcane, which grows in equatorial regions such as Brazil and parts of Asia-Pacific. The remaining 15% comes from beetroot, which is grown in Europe, parts of the United States, Canada, and China. In 2016, combined global production came to 175 million tonnes (of raw sugar) and the most important producers were Brazil (22.9% of global production), India (12.8%), the European Union (9.7%), Thailand (5.9%) and China (5.6%). [2] The logistic and production cost plays a major role to gain competitive advantages during periods where the price of sugarcane is low. The logistics cost of the sugar industry in Thailand is apparently high compared with other major sugar export countries such as Brazil, Australia etc. Reasons include the increasing labor costs, inefficient use of machinery due to small farm size, improper system support, and lack of integration between farmer, transport companies, and sugar mill. [3] Thus, the transportation of sugarcane is the major cost of sugar production. All sugarcane in Thailand is transported by road vehicles. Large vehicles such as trailer and semi-trailer are increasingly used to reduce the transportation cost per ton. However, in order to achieve the low cost per ton, the careful operational plan is required to maximize efficiency. The purpose of this research is to developed cost and profit model as a tool to properly manage the number of vehicles for two sugarcane transportation protocols: single-loop and double-loop transportation protocols. The obtained result could assist sugar mill and transport company to understand the benefits of the redesigned system and it could be applied to improve sugarcane logistic efficiency.

## 2. Materials and Methods

The methodology started from collecting the data of fixed and variable cost in sugarcane transportation and other data that related to sugarcane transportation from loading station to sugar mill including transportation processes and the route in yard into sugar mill. These data were collected from the in-depth interview on sugarcane transportation stakeholders such as manager, officers, staffs

and 3rd-party logistic provider in north eastern part of Thailand. [4] This research used cost and benefit analysis model for the sugarcane transportation protocol which considers two protocols: single-loop and double-loop. The first protocol the truck will pick up sugarcane from the loading stations to sugar mill in the order to unload sugarcane. Consequently, this truck go back to the loading station to repeat the loading process. On the other hand, the second protocol used two sets of semi-trailers. Semi-trailers in the first set carry trailer between the loading stations and parking area of the sugar mill. The trailer is released from the tractor in parking area. The tractors Semi-trailers in the second set carry the trailer between parking area and sugar mill in the order to unload sugarcane. The difference of single-loop and double-loop transportation protocols are depicted in Figure 1.



**Figure 1.** Comparison of sugarcane transportations (a) single - loop; (b) double - loop

### 2.1. Formulation of Mathematical Model

In this study, mathematical models about cost and profit of sugarcane transportation which considers two protocols: single-loop and double-loop transportation protocols that were adapted and modified from the mathematical model presented in the study of Jumpol Vorasayan (2014) [5], Watcharachan Sukcharoenvipharat (2012) [6] and W.khamjan, S.Khamjan, S.Pathumnakul (2013) [7]. The model is formulated under assumptions that activity time is deterministic and the transportations are performed continuously with unlimited supply of sugarcane.

#### 2.1.1. Subscript and Set

$i$  = a loading station index,  $I$  = set of loading stations =  $\{1,2,3\}$   
 $j$  = a sugar mill index,  $J$  = set of sugar mill =  $\{1\}$

#### 2.1.2 Notations

The notations for proposed cost and profit model are as follows;

- Notations for cost and revenue of sugarcane transportation
  - $D$  = Distance between the loading stations to sugar mill (kilometer)
  - $T_c$  = Truck cost (baht /truck)
  - $H$  = Tractor cost (baht/tractor)  $H$
  - $T$  = Trailer cost (baht /trailer)
  - $Y$  = Years of useful life whole vehicle (year)
  - $S$  = Salvage Value (baht)
  - $t$  = Vehicle tax (baht /year)
  - $IN$  = Third class insurance expenses (baht /year)
  - $L_f$  = Nonrenewable fuel rate when leave for sugar mill (liter/ kilometer)
  - $R_f$  = Nonrenewable fuel rate when return to the 88 loading stations (liter/kilometer)
  - $F_c$  = Fuel cost (baht /liter)

- $Tr$  = Useful nonrenewable tires and rims rate (baht /kilometer)
  - $Mr$  = Useful nonrenewable motor oil and oil fitter rate (baht /kilometer)
  - $w$  = Wage rate when vehicle driver in sugar mill (baht /kilometer)
  - $Sw$  = Full-time vehicle driver salary (baht /month)
  - $Re$  = Transport Revenue in each the loading stations (baht /tons)
  - $\ell$  = Loan rate for vehicle (percentage/year)
  - Notations for duration of sugarcane transportation
    - $\alpha$  = Period of waiting dumping time in each the loading station (minutes)
    - $\beta$  = Period of dumping time in each the loading stations (minutes)
    - $\gamma$  = Period of time assembly trailer in each the loading stations (minutes)
    - $\delta$  = Period of arrive time to sugar mill in each the loading stations (minutes)
    - $\varepsilon$  = Period of leave time to sugar mill in each the loading stations (minutes)
    - $\zeta$  = Period of unloading time in each the loading stations (minutes)
  - Notations for managed sugarcane transportation from loading station to sugar mill
    - $AV$  = Arrive sugar mill average velocity (kilometer)
    - $LV$  = Leave sugar mill average velocity (kilometer)
    - $CF$  = Frequency of cycle (minute)
    - $CW$  = Frequency of work cycle (minute)
    - $CL$  = One cycle time (minute)
    - $V$  = Vehicle size (ton)
    - $G$  = Sugarcane weight (cycle/ton)
    - $DF$  = Driver in one cycle time (minutes)
    - $WT$  = Weight sugarcane target (ton)
- The model is formulated as follows;
- 5) Number of queue card for truck and semi-trailers in each the loading stations:  $Q_i$  (queue)

$$Q_i = \frac{WT_i}{V \times CF} \quad (1)$$

- 6) Number of queue card of tractors for semi-trailers in sugar mill:  $Q_j$  (queue)

$$Q_j = \sum_{i=1}^3 Q_i \quad (2)$$

- 7) Period of per cycle time for trucks and semi-trailers in each the loading stations:  $C_i$  (minutes)

$$C_i = \alpha_i + 2\beta_i + \gamma_i + \delta_i + \varepsilon_i + \zeta_i \quad (3)$$

- 8) Period of per cycle time of tractors for semi-trailers in sugar mill:  $C_j$  (minutes)

$$C_j = \alpha_j + 2\beta_j + \gamma_j + \delta_j + \varepsilon_j + \zeta_j \quad (4)$$

- 9) Number of tractors for trucks and semi-trailers in each the loading stations:  $T_i$  (unit/tractor)

$$T_i = \frac{Q_i}{\frac{CL}{C_i}}; T_i < U_i \text{ where } U_i = \frac{C_i}{\zeta_i} \quad (5)$$

Let  $U_i$  is the number of tractors that makes the loading stations take trucks and semi-trailers continuously all the time.

- 10) Number of tractors for semi-trailers in sugar mill:  $M_j$  (unit/tractor)

$$M_j = \frac{Q_j}{\frac{CL}{C_j}}; M_j < X_j \text{ where } X_j = \frac{C_j}{\beta_j} \quad (6)$$

Let  $X_i$  is the number of tractor that makes the dumper unloading sugarcane with semi-trailer continuously all the time.

- 11) Number of trailer for semi-trailers in each the loading stations:  $L_i$  (unit/trailer)

$$L_i = T_i + E \quad (7)$$

Let  $E$  is Number of trailer that need to get the tractors not waiting the trailers in sugar mill, from simulation model assume about  $1 \leq E \leq 5$ .

- 12) Number of trailers for semi-trailers in sugar mill:  $N_j$  (unit/trailer)

$$N_j = M_j \quad (8)$$

- 13) Deprecation of truck:  $DT_c$  (baht/year)

$$DT_c = \frac{T_c - \frac{S}{(1+\ell)^Y}}{1 - \frac{1}{(1+\ell)^Y}} \times \frac{1}{\ell} \quad (9)$$

- 14) Deprecation of tractor for semi-trailers:  $DH$  (baht/year)

$$DH = \frac{H - \frac{S}{(1+\ell)^Y}}{1 - \frac{1}{(1+\ell)^Y}} \times \frac{1}{\ell} \quad (10)$$

- 15) Deprecation of trailer for semi-trailers:  $DT$  (baht/year)

$$DT = \frac{T - \frac{S}{(1+\ell)^Y}}{1 - \frac{1}{(1+\ell)^Y}} \times \frac{1}{\ell} \quad (11)$$

- 16) Deprecation of added trailers for semi-trailers in sugar mill:  $DT_a$  (baht/year)

$$DT_a = \frac{T - \frac{S}{(1+\ell)^Y}}{1 - \frac{1}{(1+\ell)^Y}} \times \frac{1}{\ell} \quad (12)$$

Note: The trailer in the loading stations and in sugar mill are the same price.

- 17) Usage fuel cost for trucks and semi-trailers in each the loading stations:  $FV_i$  (baht/month)

$$FV_i = D_i \times (Lf + Af) \times Fc \times Q_i \quad (13)$$

- 18) Usage fuel cost of tractors for semi-trailers in sugar mill:  $FV_j$  (baht/month)

$$FV_j = D_j \times (Lf + Af) \times Fc \times Q_j \quad (14)$$

- 19) Usage tires and rims cost for trucks and semi-trailers in each the loading stations:  $RV_i$  (baht/month)

$$RV_i = D_i \times 2 \times Tr \times Q_i \quad (15)$$

- 20) Usage tires and rims cost of tractors for semi-trailers in sugar mill:  $RV_j$  (baht/month)

$$RV_j = D_j \times 2 \times Tr \times Q_j \quad (16)$$

- 21) Usage motor oil and oil fitter cost for trucks and semi-trailers in each the loading stations:  $MV_i$  (baht/month)

$$MV_i = D_i \times 2 \times Mr \times Q_i \quad (17)$$

- 22) Usage motor oil and oil fitter cost of tractors for semi-trailers in sugar mill:  $MV_j$  (baht/month)

$$MV_j = D_j \times 2 \times Mr \times Q_j \quad (18)$$

- 23) Wage and salary cost for trucks and semi-trailers in each the loading stations:  $SV_i$  (baht/month)

$$SV_i = DW \times SW \times G \times Q_i \quad (19)$$

- 24) Wage and salary cost of tractors for semi-trailers in sugar mill:  $SV_j$  (baht/month)

$$SV_j = \frac{CL}{1440} \times \frac{CL}{DF} \times M_j \times \frac{Sw}{30} \quad (20)$$

- 25) Usage tractors for trucks cost in each the loading stations:  $\Omega_i$  (baht/month)

$$\Omega_i = T_i \times \left( \frac{DTc + t + IN}{CW} \right) \quad (21)$$

- 26) Usage tractors for semi-trailers cost in each the loading stations:  $\Psi_i$  (baht/month)

$$\Psi_i = T_i \times \left( \frac{DH + t + IN}{CW} \right) \quad (22)$$

- 27) Usage trailers for semi-trailers cost in each the loading stations:  $\Phi_i$  (baht/month)

$$\Phi_i = L_i \times \left( \frac{DH}{CW} \right) \quad (23)$$

- 28) Usage tractors for semi-trailers cost in sugar mill:  $HS_j$  (baht/month)

$$HS_j = M_j \times \left( \frac{DH + t}{CW} \right) \quad (24)$$

- 29) Usage trailers for semi-trailers cost in sugar mill:  $TS_j$  (baht/month)

$$TS_j = \left( N_j \times \frac{DT}{CW} \right) + \left( A \times \frac{DTa}{CW} \right) \quad (25)$$

Let A is number of added trailers of sugar mill, in this case we determine to 2 per unit

- 30) Cost per ton for trucks in each the loading stations:  $CT_i$  (baht/ton)

$$CT_i = \frac{\left( \frac{Q_i + FV_i + RV_i + MV_i + SV_i}{Q_i} \right)}{G} \quad (26)$$

- 31) Cost per ton for semi-trailers in each the loading stations:  $CS_i$  (baht/ton)

$$CS_i = \frac{\left( \frac{\Psi_i + FV_i + RV_i + MV_i + SV_i}{Q_i} \right)}{G} \quad (27)$$

- 32) Cost per ton of tractors for semi-trailers in sugar mill:  $CS_j$  (baht/ton)

$$CS_j = \frac{\left( \frac{HS_j + TS_j + FV_j + RV_j + MV_j + SV_j}{Q_j} \right)}{G} \quad (28)$$

- 33) Total cost of trucks in each the loading stations:  $TC_i$  (baht)

$$TC_i = CT_i \times WT_i \quad (29)$$

- 34) Total cost of semi-trailer in each the loading stations:  $TCs_i$  (baht/year)

$$TCs_i = CS_i \times WT_i \quad (30)$$

- 35) Total cost of tractors for semi-trailers in sugar mill:  $TC_j$  (baht)

$$TC_j = CS_j \times WT_j \quad (31)$$

- 36) Total revenue for trucks and semi-trailers in each the loading stations:  $TR_i$  (baht)

$$TR_i = Re \times WT_i \quad (32)$$

- 37) Profit per ton for truck in each the loading stations:  $PS_i$  (baht/ton)

$$PT_i = Re - CT_i \quad (33)$$

- 38) Profit per ton for semi-trailers in each the loading stations:  $PS_i$  (baht/ton)

$$PS_i = Re - CS_i \quad (34)$$

- 39) Total profit for trucks in each the loading stations:  $ZT_i$  (baht)

$$ZT_i = PT_i \times WT_i \quad (35)$$

- 40) Total profit for semi-trailers in each the loading stations:  $ZS_i$  (baht)

$$ZS_i = PS_i \times WT_i \quad (36)$$

With data collected from the participant on sugarcane transportation in the production year 2017/2018, the estimate values of the model parameter as shown in Table 1 used in this case study.

**Table 1** Model parameters of the case study sugar mill in the production year 2017/2018.

Parameter	Values	Parameter	Values
$Tc$	$3.75 \times 10^6$ baht <sup>1</sup>	$CW$	160
$H$	$3.05 \times 10^6$ baht	$Lf$	0.6
$T$	700,000 baht	$Af$	0.4
$\gamma$	15 year	$Fc$	27 baht
$S$	500,000 baht	$Tr$	1.50
$\tau$	10,000 baht	$Mr$	0.50
$IN$	20,000 baht	$w$	0.1
$CF$	100	$Sw$	15,000 baht /month
$\ell$	5% <sup>2</sup> and 7% <sup>3</sup>		

<sup>1</sup> Thai Baht: 1 Baht  $\approx$  0.0304956 USD.

<sup>2</sup> For calculated to depreciation added trailer in sugar mill.

<sup>3</sup> For calculated to depreciation truck, tractor and trailer in each the loading stations.

### 3. Results

#### 3.1. Sugarcane Transportation Cost With Two Protocol

In our analysis, we determine the loan rate for the vehicle. In fact, sugar mill takes on a loan agreement to the transport company in the order to the purchased vehicle. In this section, we have shown the result of the sugarcane transportation cost and profit in the loading stations are as shown in Table 2 to Table 4. In this case study, we required to carry weight sugarcane around 35 tons that calculated the cost and profit in two protocols are specific compared to the loading stations number 1, 2 and 3 respectively which these are located around northeastern part of Thailand. We selected these stations because the transport company with sugar mill used these stations to carry sugarcane. In single - loop protocol has total cost about 26,570,718.8 baht/year, which the loading station number 3 has got cost more than other stations about 11,985,109.0 baht/year. And total revenue about 31,728,045.0 baht/year, which the loading station number 3 has got revenue more than other stations about 14,310,000.0 baht/year, so a total profit in this protocol is 5,157,326.3 baht/year which the loading station number 3 has got profit more than other stations about 2,324,891.0 baht/year. Next, in double - loop protocol, we combined the results of tractors in the parking of area sugar mill also, so it has total cost about 27,582,420.9 baht/year, which the loading station number 3 has got cost more than other stations about 11,629,216.0 baht/year. And total revenue about 31,728,045.0 baht/year, which the loading station number 3 has got revenue more than other stations about 14,310,000.0 baht/year, so a total profit in this protocol is 4,145,624.1 baht/year which the loading station number 3 has got profit more than other stations about 2,680,784.1 baht/year.

**Table 2.** Transportation cost and profit for trucks of single - loop protocol in each the loading stations.

$i$	$Q_i$	$C_{hi}$	$T_{hi}$	$\Omega_i$	$FV_{hi}$	$RV_{hi}$	$MV_{hi}$	$SV_{hi}$	$CT_{hi}$	$TC$	$TR$	$PT_i$	$Z_{hi}$
1	5.1	857.3	2.4	6,432.9	21,024.2	2,336.0	778.6	4,356.9	194.8	3,492,883.3	4,356,990.0	48.0	864,106.7
2	14.0	956.3	7.5	19,725.1	68,058.3	7,562.0	2,520.6	13,061.0	225.0	11,092,726.4	13,061,055.0	40.0	1,968,328.6
3	15.4	945.3	8.1	21,362.8	73,316.5	8,146.2	2,715.4	14,310.0	221.9	11,985,109.0	14,310,000.0	43.0	2,324,891.0

**Table 3.** Transportation cost and profit of tractors for semi-trailers of double - loop protocol in sugar mill.

$j$	$Q_j$	$C_j$	$M_j$	$N_j$	$HS_j$	$TS_j$	$FV_j$	$RV_j$	$MV_j$	$SV_j$	$CS_j$	$TC$	$R$	$PS_j$	$Z_j$
1	34.6	213.6	4.1	4.1	8,350.1	2,817.7	935.1	103.9	34.6	5,138.9	14.3	1,738,040.3	-	-	-

**Table 4.** Transportation cost and profit for semi-trailers of double - loop protocol in each the loading stations.

$i$	$Q_i$	$C_{hi}$	$T_{hi}$	$L_i$	$\psi_i$	$\phi_i$	$FV_{hi}$	$RV_{hi}$	$MV_{hi}$	$SV_{hi}$	$CS_i$	$TC$	$TR$	$PS_i$	$Z_{hi}$
1	5.1	657.3	1.9	3.9	4,033.6	1,859.3	21,024.2	2,336.0	778.6	4,356.9	191.8	3,438,885.0	4,356,990	51.2	918,104.9
2	14.0	756.3	5.9	7.9	12,757.7	3,802.9	68,058.3	7,562.0	2,520.6	13,061.0	228.6	10,776,279.6	13,061,055	46.3	2,284,775.3
3	15.4	745.3	6.4	8.4	13,774.4	4,0269.4	73,316.5	8,146.2	2,715.4	14,310.0	215.3	11,629,215.9	14,310,000.0	49.6	2,680,784.1



### 3.2. Number of Vehicle in Sugarcane Transportation

In this case study, the sugar mill used queue system that determine sugarcane volume line up into mill nearly with capacity of press sugarcane. This queue separate to one period consist of 5 quarter which it is 6 hour in each quarter. Addition the season of sugarcane harvest could transport into sugar mill about 100 cycle. And the farmers will received queue card that can dumping sugarcane under determine sugarcane volume and vehicle size. For example, a farmer has sugarcane about 30,000 ton and a truck size 15 ton. Thus, a farmer will gets queue card about 2 cards. It is meaning they will send sugarcane to 2 time in cycle. The queue system need to sugarcane transport, so we developed queue

system formula is  $Q_i = \frac{WT_i}{V \times CF}$ . For example, the loading station number 20 has a weight target ( $WT_2$ )

about 54,000 ton, a truck size ( $V$ ) 35 ton and frequency of cycle ( $CF$ ) about 100, so that number of queue card in the loading station number 2 is 5.1 queue. Next, when we have queue card already result to we can get calculated number of vehicle on two protocols are as shown in Table 2 to Table 4. In single - loop protocol, the loading stations number 1 to 3 used number of tractors ( $T_{1i}$ ) of truck about 3, 8 and 9 per a tractor respectively. A part of double- loop, used number of tractors of semi-trailer ( $T_{2i}$ ) about 2, 6 and 7 per unit respectively. And it has number of trailers of semi-trailer ( $L_i$ ) about 4, 8 and 9 per unit respectively. In addition double - protocol need to tractors and trailers for transported into sugar mill also that the tractors and trailers are as equally. Thus, there are number of tractors and trailers for semi-trailer ( $M_i$ ) and ( $N_i$ ) are about 5 per unit which the tractors of semi-tractor in sugar mill, are sharing with all the loading stations.

## 4. Discussion

The result showed that the cost and benefit compared two sugarcane transportation protocols, single-loop, and double-loop sugarcane transportations. For the same amount of delivered sugarcane, the double-loop has supplementary fixed costs other than the single-loop. We can reduce the fixed cost of double-loop by using tractors, which low capacity and efficiency because the transportation distance is within reach between the parking area and sugar mill. In part of single-loop, if this protocol incurred uncertainty scenarios concerning the time variance or machine is out of order, it will put the break on transportation. But the double - loop, will put the break on the first loop only, between the loading stations and parking area of the sugar mill then, the second loop it works perfectly now. In addition, the system of the double loop will be efficiency and worthwhileness if the number of tractors and trailers that are appropriate with sugarcane transportation.

## 5. Conclusions

To summarize, we have shown with the mathematical model for cost and benefit of two sugarcane transportation protocols, single-loop and double-loop higher cost in double-loop is accounted for the higher fixed cost of the vehicle and the waiting time incurred by double handling of two sets of tractors. For the same amount of delivered sugarcane, the double-loop has supplementary fixed costs other than the single-loop. In addition, the number of tractors needs to balance in each periods which reduced the waiting time of transportations. This provides, in long-term investment, the sugar mill owner and 3rd-party logistic will be able to use the double-loop transportation for a worthwhile investment. In the future, this model might be compared the efficiency of two protocols when other factors such as uncertainty scenarios by using situation analysis.

**Acknowledgments:** The work was supported by The Thailand Research Fund under grant RDG60T0167. The researchers would like to sincerely thank the sugar mill and transport company who provide information.

## References

1. Salassi, M.E., Breaux, J.B., Naquin, C.J. Modeling within-season sugarcane growth for optimal harvest system selection. *Agric. Syst.* 73, 2002; pp. 261-278.

2. Krungsri Research. Industry outlook 2018-2020: Sugar Industry. Available online: [https://www.krungsri.com/bank/getmedia/64a1559a-2938-4f48-b5afc601e52f660c/IO\\_Sugar\\_2018\\_EN.aspx](https://www.krungsri.com/bank/getmedia/64a1559a-2938-4f48-b5afc601e52f660c/IO_Sugar_2018_EN.aspx) (Accessed on 26th August 2018).
3. Jumpol Vorasayan. A simulation to compare single-loop and double-loop transportation protocols for sugarcane industry. Industrial Technology and Management (ICITM), 2018 7th International Conference on IEEE. 2017; pp. 309-313.
4. Ongkunaruk, P. and Ongkunaruk, W. Coconut sap pick up problem with time windows: a case study. International Food Research Journal. 22.5: 2088. 2015.
5. Vorasayan, J., and S. Pathumnakul. Optimal logistics system for sugarcane mechanical harvesting in Thailand. Journal of Applied Science and Agriculture. 2014; pp. 28-35.
6. Watcharachan Sukcharoenvipharat. A study on potential of tractor-towed for transportation sugarcane Muster Thesis, Kasetsart University, Bangkok, Thailand, 2012.
7. W.khamjan, S.Khamjan, S.Pathumnakul. Determination of the locations and capacities of sugarcane loading stations in Thailand. Computers & Industrial Engineering 66.4. 2013; pp.663-674.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-EPS-006-ID020

# A Concept of Engineering Education Program to Improve the Competitiveness of Human Resources in Agroindustry

Elisa Anggraeni <sup>1,\*</sup>, Muhammad Romli<sup>2</sup> and Suprihatin Suprihatin<sup>3</sup>

<sup>1</sup> Department of Agroindustrial Technology, Bogor Agricultural University; e-mail: elisa.anggraeni@gmail.com

<sup>2</sup> Department of Agroindustrial Technology, Bogor Agricultural University; e-mail: mromli@hotmail.com

<sup>3</sup> Department of Agroindustrial Technology, Bogor Agricultural University; e-mail: suprihatin167@gmail.com

\* Correspondence: elisa.anggraeni@gmail.com; Tel.: ++251 8621 974

Received: 9 July 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** The current globalization has led to intense competition among countries, both in the provision of goods, services and professionals. At the regional level, the ASEAN countries have agreed on the implementation of free market in the ASEAN region. The establishment of a free market termed as the ASEAN Economic Community (AEC) enables one country to sell goods and services easily to other countries throughout Southeast Asia. AEC not only opens the flow of trade in goods or services, but also the professional labor market, including professional in field of agroindustry. The AEC requires the abolition of rules that previously hindered the recruitment of foreign workers, especially in the professional workforce sector, resulting in a more intense professional labor competition. This paper presents the concept of academic and professional education programs for the field of agro-industrial engineering applied at IPB, in an effort to improve the quality and competitiveness of its graduates. The analysis and discussions include background, relevance, needs of agroindustry engineers, and the concept of education program paths along with graduate profiles, learning outcomes, and curriculum to meet the objectives.

**Keywords:** agroindustrial engineer, global competition, professional program

---

## 1. Background

### 1.1. Challenges to Improve Competitiveness of Human Resources in Agroindustry

The agricultural sector plays an important role in Indonesia's economic development as it contributes to 13% of national GDP and exhibits 85% of SMEs in Indonesia (Wijono, 2005) that is proven to survive during economic crisis (Pakpahan et al., 2005). Improvements in this sector will lead to an increase in Indonesia's GDP. Improvements can be made by increasing the added value of agricultural commodities, which is the main role of agro-industry. At present, the agro-industry in Indonesia is dominated by small and medium-sized businesses with 49% operating in agriculture, livestock, forestry, fisheries and 6% operating in processing. To increase GDP, it is necessary to increase economies of scale, and more importantly, increase competitiveness through the use of knowledge and technology. Thus, this effort needs to be supported by human resources who are able to provide solutions to the problems of SMEs such as limited access to capital, markets, raw materials, technology and innovation. (Radnor dan Barnes, 2007; Hadiyati 2010; Eravia *et al.*, 2014). The availability of competitive human resources is a must if we want to improve the performance of agro-industry and this is the main task of higher education.

Higher education is obliged to provide graduates that are capable of designing, managing and improving the competitiveness of agroindustry. To be able to provide this much needed human resources in agro-industry, higher education faces two main challenges. The first challenge is related to external pressure, namely the global community, and the second is related to the internal education system.

The current process of globalization causes very tight competition among countries in the supply of goods, services and professionals. At the regional level, ASEAN countries have agreed on the implementation of free markets in the ASEAN region. This is done to improve ASEAN's competitiveness and to attract foreign investment for increasing employment and community welfare in the region. The establishment of a free market that is termed as the ASEAN Economic Community (AEC) allows one country to sell goods and services easily to other countries throughout Southeast Asia. AEC not only opens the flow of trade of goods or services, but also the professional workforce market. EAC requires the elimination of rules that previously prevented the recruitment of foreign works forces especially in the professional works forces. In the era of cross-country works force mobility, the need for providing competitive engineering professionals at the international level is increasingly urgent [1,2].

Internal challenges are related to the ability to meet the demands of agroindustry human resources both in quantity and quality. As reported by PII (2011) there is a shortage in the number of engineers which is estimated to be around 15.000 per year. PII (2011) projected that the demand of agroindustrial engineers is 4.438 in 2015, 6.968 in 2020 and 10.040 in 2025. In the education sector, the projected demand of engineers is 588 in 2015, 922 in 2020, dan 1.750 in 2026. This number is quite high and if the higher education cannot provide the needed engineers, they would be fulfilled by professional engineers from abroad.

Besides, quality of human resources in agroindustry is of another concern. The free mobility of human resources across countries, demands those with a comparable competence at the international level. International standard of engineering education and profession is important to consider. The main competencies that are considered important for agro-industries need to be acquired, such as the ability in information technology, motivation to excel, lifelong learning, creativity to provide solutions, and teamwork. Based on a survey conducted by PII, improvements need to be made on several competencies, especially in the ability to work in teams, problem solving, oral and written communication, and professional commitment. It can be concluded that in addition to knowledge, there are two important dimensions of competence needed, namely skills (hard and soft skills) and attitudes. These three dimensions are needed for graduates to properly function in societies [3].

Improving the competitiveness of human resources in agroindustry, thus, requires improvement on engineering knowledge competences, skills, and attitudes. Engineering knowledge competences requires students to master their abilities to apply mathematics, science, and engineering principles to solve complex engineering problems. This knowledge to be complemented with skills to apply knowledge to problem analysis and formulation, conduct investigation and experiment, as well as skills to creatively design and develop solutions to engineering problems (IEA, 2014; SNPT, 2015). Considering the complexity of the engineering problems, students need to improve their collaboration and communication skills. These knowledge and skills are initial assets that need to be nurtured by themselves to tackle future challenges. To be able to continuously develop their knowledge and skills, they need to have professional attitudes, ethics and responsibilities and empathetic to societal and environmental values, and shows motivation to excel and the important of lifelong learning.

### *1.2. Agroindustry Higher Education*

Agroindustry Higher Education in Indonesia began in 1981, marked by the establishment of the Department of Agroindustrial Technology, Faculty of Agricultural Technology, Bogor Agricultural University (IPB). The rationale for its establishment is to support and enhance the role of the agricultural sector in advancing national development through increasing the added value of agricultural products by providing input on process technology and industrial system engineering. The difference from similar study programs, such as the Agricultural Product Processing Study Program - which has been there before, mainly lies in educational goals and learning outcomes, as well as orientation and approaches to achieving the objectives of the study program. The Agroindustrial Technology Study Program is oriented towards industrial businesses using an industrial system engineering approach and process engineering in increasing the added value of agricultural resources or biological resources in a sustainable manner.

The specificity of the agro-industry study program curriculum is to prepare graduates with the ability to design, develop, implement, control, evaluate and improve the performance of sustainable agro-industrial systems, through an integrated approach to aspects of process technology, system engineering, industrial management, and the environment to increase added value agricultural / biological resources and derivatives (Communication Forum for Indonesian Agroindustry Study Programs, 2018).

In accordance with the Decree of the Minister of Research, Technology and Higher Education No. 257 / M / KPT / 2017 concerning the Nomenclature of Study Programs in Higher Education, Agro-Industrial Technology and Agro-Industrial Engineering study programs are included in the engineering study category. Graduates of these study programs have a Bachelor of Engineering (ST) (Indonesian National Qualification Framework / level 6 KKNI) that can proceed to postgraduate (master and doctoral) programs (Level 8 and 9 KKNI) or continue their studies into engineering professional education programs (KKNI Level 7) with the title of Engineer (Ir.). In professional societies, engineers play a role primarily in design and development, while technologists and technicians play more roles in manufacturing and production lines [4].

The agroindustry study programs continue to experience growth, seen from the number of study programs, lecturers, students, and levels of education degrees (Table 1). Student body for undergraduate program (S1) reaches 6335 students. Not only nationally, higher education in agro-industry is also increasingly found abroad. Table 2 shows the agroindustry engineering study program abroad.

**Table 1.** Agroindustrial study program, number of faculties, and number of students at various levels

<b>Educational level</b>	<b>Number of study program</b>	<b>Number of permanent faculties</b>	<b>Number of active students</b>
D3	7	50	741
D4	3	32	549
S1 (undergraduate program)	31	287	6,335
S2 (magister program)	10	56	258
S3 (doctoral program)	2	10	87
<b>Total</b>	<b>53</b>	<b>435</b>	<b>7,970</b>

\* Source: Higher education data base, report year 2017/2018

**Table 2.** Agroindustrial engineering study programs in some countries

<b>No</b>	<b>Agroindustry Higher Education</b>
1	American Andragogy University, Hawaii, United States ( <a href="https://www.aauniv.com/">https://www.aauniv.com/</a> )
2	ASSUMPTION UNIVERSITY OF THAILAND, Thailand ( <a href="http://www.au.edu/index.php/">http://www.au.edu/index.php/</a> )
3	Chiang Mai University, Thailand ( <a href="https://www.cmu.ac.th">https://www.cmu.ac.th</a> )
4	College of Higher Study AQUINAS, Sri Lanka <a href="http://www.aquinas.lk/degree-programs/bsc-hons-in-agro-industry-management/">http://www.aquinas.lk/degree-programs/bsc-hons-in-agro-industry-management/</a>
5	Kasesart University, Thailand ( <a href="http://www.agro.ku.ac.th">http://www.agro.ku.ac.th</a> )
6	King Mongkut's University of Technology, North Bangkok, Thailand ( <a href="https://sites.google.com/a/sci.kmutnb.ac.th/bachelor-of-science-agro-industrial-technology/">https://sites.google.com/a/sci.kmutnb.ac.th/bachelor-of-science-agro-industrial-technology/</a> )
7	National University of La Rioja, Argentina, <a href="http://studyargentina.com/agro-industrial-engineer-national-university-la-rioja.html">http://studyargentina.com/agro-industrial-engineer-national-university-la-rioja.html</a>
8	Salliman University, Philippine ( <a href="https://su.edu.ph/schools-colleges/school-of-agro-industrial-and-technical-education/">https://su.edu.ph/schools-colleges/school-of-agro-industrial-and-technical-education/</a> )
9	The College of Engineering and Agro-Industrial Technology (CEAT), UPLB, Philippine ( <a href="http://uplb.edu.ph/academics/college-of-engineering-and-agro-industrial-technology-ceat/">http://uplb.edu.ph/academics/college-of-engineering-and-agro-industrial-technology-ceat/</a> )

**Table 2.** Agroindustrial engineering study programs in some countries (continued)

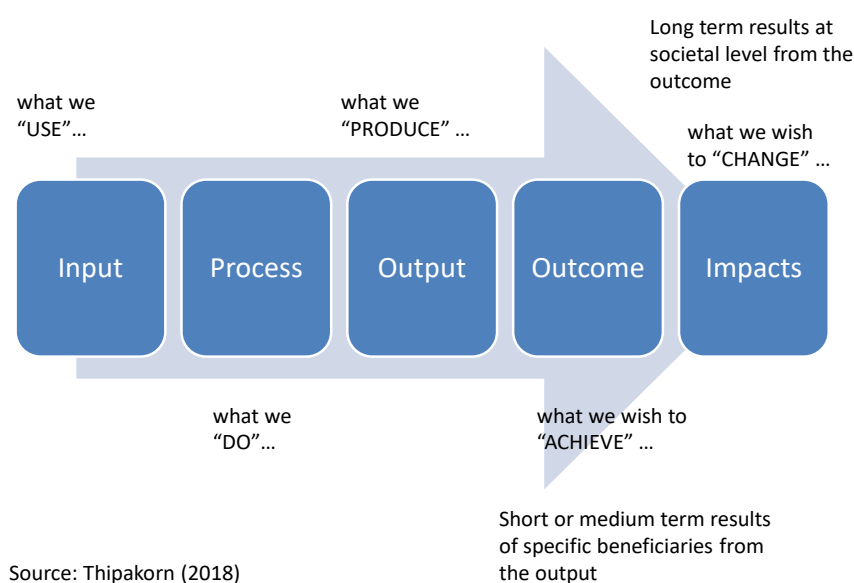
No	Agroindustry Higher Education
10	The University of Guanajuato, Mexico ( <a href="http://www.ugto.mx">http://www.ugto.mx</a> )
11	Universidad de la Costa, CUC, Colombia ( <a href="https://www.cuc.edu.co/en/">https://www.cuc.edu.co/en/</a> )
12	Universidad San Ignacio de Loyola (USIL), Peru ( <a href="http://www.usil.edu.pe/en/about-us/universidad-san-ignacio-de-loyola">http://www.usil.edu.pe/en/about-us/universidad-san-ignacio-de-loyola</a> )
13	Universidade Nova de Lisboa, Portugal ( <a href="https://www.fct.unl.pt">https://www.fct.unl.pt</a> )
14	University Niccolò Cusano, Italy ( <a href="https://www.unicusano.it">https://www.unicusano.it</a> )

Various changes in the external (national, international) and internal environment of the university have been and are happening. These include globalization, MEA, industrial era 4.0, knowledge-based competition, international standards of education and professional competence, implementation of national standards (Higher Education Standards, Indonesian National Qualifications Framework / KKNi, Study Program Nomenclature), government policies on increasing agro-industry competitiveness and added value of agricultural products, changes in stakeholder needs (21st century competencies), and changes in university vision. Considering the rapid changes in the external and internal environment, universities must adjust their study programs and graduate profiles to have the ability to adapt to these conditions. This adaptation ability must be cultivated and sharpened through various learning strategies to improve knowledge, skills and attitudes which are three important components of competence, so that graduates can function in society significantly [3].

Based on the above rationale, this paper presents and discusses the concept of developing the pathway of academic and professional education programs in agro-industry implemented at IPB, which is expected to be useful as a reference for study programs in the field of agroindustrial engineering or similar study programs in improving the competence of their students..

## 2. The role of Higher Education and Paradigm Shift in Higher Education

Responding to the demand for competitive human resources in the field of agro-industry, universities should improve their education quality and accountability. They have to shift from focus on input and process towards outcomes so that can be recognized by and clearly benefit stakeholders, namely professional community, users, and society in general. Universities should also move from the old orientation of producing job seekers towards the new paradigm of generating technopreneurs.



Source: Thipakorn (2018)

**Figure 1.** Outcome-based education system

In the Outcome-Based Education (OBE) system, the focus of attention is given to the outcomes or even to the impacts of education so as to ensure the accountability. The OBE system focuses on learning (not teaching), students (not faculties), and outcomes (not input and capacity). In the OBE system, it is important that "It's not only what you have but what you do with it". Figure 1 shows an illustration of the OBE system. Outcomes may be the results or changes due to educational efforts, relating to changes in knowledge, skills, concerns, attitudes, behavior, opinions, aspirations, decision making, social action, conditions or status. Outcomes can be short-term, medium-term or long-term. Outcomes may be expected or unexpected; positive or negative. The OBE system is a platform that allows study programs to be accountable to guarantee the learning process [5]. Quality and accountability can be assessed through an accreditation program.

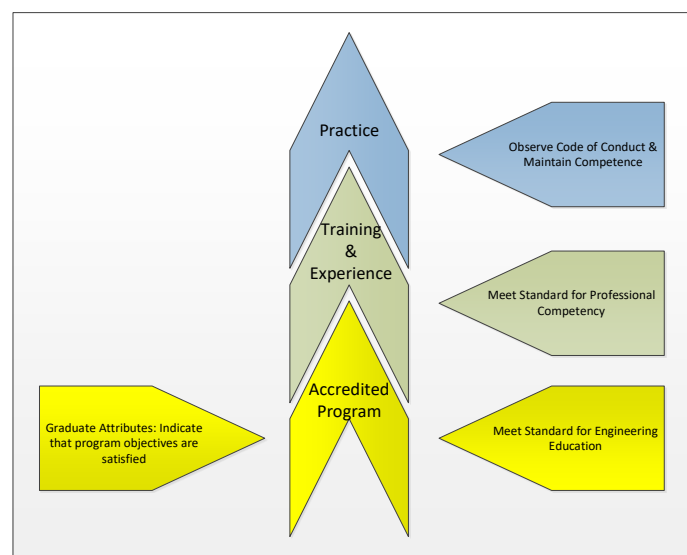
### 3. A concept of Engineering Education for Agroindustry

In the context of global competition, Indonesia's readiness to provide professional workforce is a crucial theme in the development of higher education. Author [6] entitled "Putting Higher Education to Work" identifies the existence of typical weaknesses in the form of unconnected in the education system, namely (a) the unconnected relation between the characteristics of higher education institutions (curriculum, and degree) and the expertise required by the user (employment provider); (b) Weak linkages between higher education institutions and industry as end users from the results of education and research; (c) Unconnected relation between higher education institutions and research institutions; (d) Weak coordination and integration between higher education institutions and between higher education institutions and training providers; and (e) Unconnected vertical relation between higher education with junior and senior high schools.

This situation has caused the relatively low competitiveness of university graduates in Indonesia compared to graduates from other countries. The alternative to overcome the above mentioned conditions and to improve the quality and competitiveness of graduates is the effort to provide a pathway that improves the quality and accountability of undergraduate study programs and professional education programs that meet international standards.

#### 3.1. Curriculum Development

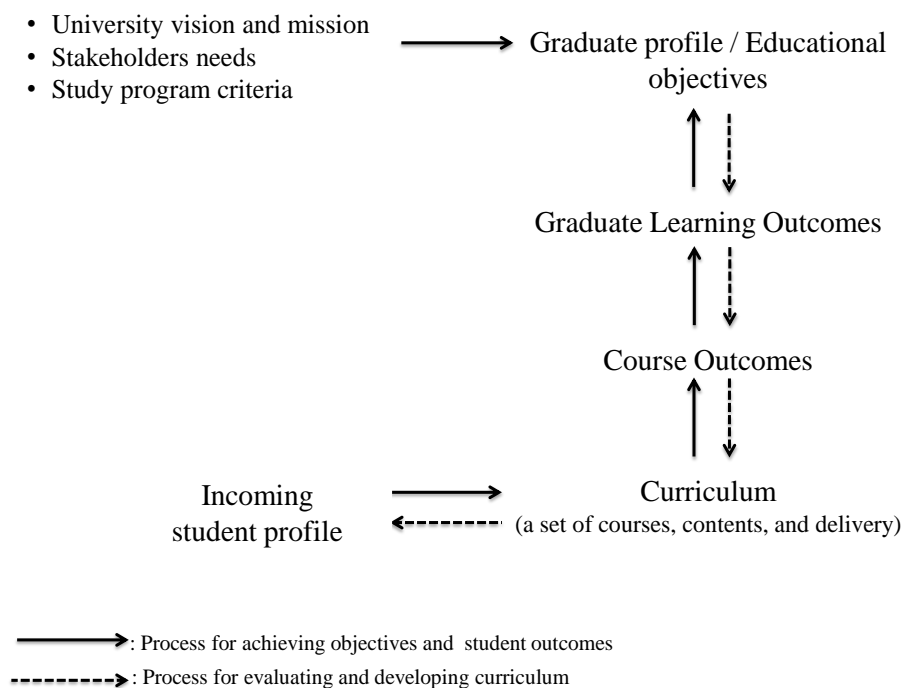
The path towards professional engineers that are capable of providing their engineering services to the improvement of agroindustry competitiveness start with accredited engineering education programs as shown in Figure 2. Graduating from accredited programs, graduates may improve their competences through training and experiences which will help them to meet standard for professional competencies.



**Figure 2.** First steps to professional engineers in agroindustry

Based on the above path, education process that meet engineering education standard is a must. The education process to produce graduates as a whole person certainly requires the involvement of various stakeholders [7] and needs to consider various factors in the development of curriculum [8]. Author [9] introduce an integrated approach for curriculum development which includes graduate competency factors, external and internal environmental variables, pedagogical strategies (student-centered and teacher centered) and leadership of educational institutions. Therefore, the curriculum needs to be developed systematically. The logic flow behind the design of professional engineer education program curriculum in relation to the program objectives, achievement of student learning outcomes, and student input is schematically shown in Figure 3.

The curriculum is developed in accordance with the institution vision, mission and needs of constituents, the education objectives (graduate profiles) and student learning outcomes (SLO) of the engineer professional education program. Furthermore, based on the program educational objectives and the graduate learning outcomes that will be achieved by the program, the curriculum of the program is formulated. The curriculum is a set of guidelines in planning and setting strategies to achieve the student learning outcomes, and thus the education objectives. The curriculum includes the structure of courses, learning materials, learning processes, assessments, monitoring and evaluation.



**Figure 3.** A schematic diagram of curriculum design

In accordance with the intended SLO, the curriculum of the engineer professional education program is emphasized on providing the experience of engineering practices in agro-industry in addition to strengthening the content of professionalism, ethics and work health and safety. The role of professional communities is important. Professional community is an important partner in the development and implementation of the engineer professional education program. In the development and implementation of the agroindustrial engineer professional education program, the Agroindustry Chapter of the Institution Engineers Indonesia is collaborating synergistically with the Communication Forum of Indonesian Agroindustrial Study Programs (FKPSIP), Indonesian Agroindustry Association (AGRIN), Agroindustrial Technology Professional Association (APTA), Forum of Engineer Profession Program Organizer (FPPPI), Indonesian Accreditation Board for Engineering Education (IABEE) and other Chapters of the Institution of Engineers Indonesia. The Agroindutry Chapter of the Institution of Engineers Indonesia carries out engineering service activities to support the government and other parties in the development of agroindustrial sector and other relevant sectors, supporting the



implementation of the agroindustrial engineer professional education program, Engineer Registration Certificate and Professional Engineer Certification, Continuous Professional Development, development of Standard of Engineer Services; consultation, community empowerment, Training, Focus Group Discussion (FGD); and National and International Seminars organization.

Quality and accountability of the program is assured through the implementation of Internal Quality Assurance System (SPMI) and External Quality Assurance System (SPME) as mandated by the Law No. 22/2012 on Higher Education. These quality assurance systems are tools to improve the quality of higher education and accountability to the constituents by applying outcome-based education. SPMI is developed, monitored and evaluated by the university. SPME is done through accreditation. National accreditation is done by National Accreditation Board for Higher Education (BAN-PT) developed the 2018 version of the Study Program Accreditation Instrument (IAPS), which was briefly written as IAPS 4.0. IAPS 4.0 is more focused on aspects of the process, output and outcome, while the previous instrument measured more aspects of input. External quality assurance can also be done according to international standard. For Engineering Education, this accreditation can be done in accordance to Washington Accord for Engineering Education, Sydney Accord for Engineering Technology, and Dublin Accord for Technician. The international accreditation body in Indonesia for engineering education is Indonesian Accreditation Board for Engineering Education (IABEE).

### 3.2. Agroindustrial Engineering Education Program (AEEP)

Agroindustrial Engineering Education Program (AEEP) is designed to provide graduates that will directly contribute as change maker in agroindustry sectors. The scope of competencies of agroindustry profession is as follow:

“Able to design, develop, implement, control, evaluate and improve performance of sustainable agroindustry through integrated approach of process, system, industrial management, and environmental aspects to increase the added value of agricultural resources and its derivatives” (Communication Forum of Indonesian Agroindustrial Study Programs, 2017)

Referring to this definition and scope of agroindustrial competencies as well as the inputs from the professional communities, the professional profile of agroindustrial graduates is as follow:

“After several (3-5) years in a professional career, graduates of agroindustrial engineering program are able to apply their knowledge from their academic program to:

- 41) Solve agroindustrial engineering problems, as quality engineers, productive and sensitive to the ethical and professional consequences of their works.
- 42) Develop themselves through postgraduate studies
- 43) Become a technopreneur
- 44) Play a role and communicate effectively as individual and in multidisciplinary team, and
- 45) Continue lifelong learning activities”

In order to achieve these graduate profiles, the curriculum should be formulated so that students will achieve student learning outcomes as shown in Table 3.

**Table 3.** Student Learning Outcomes of Agroindustrial Engineering Program

NO	STUDENT LEARNING OUTCOMES
1	Able to identify, analyze and solve problems in agroindustry that cover aspects of process technology, industrial management, systems engineering, and environmental engineering and management by applying knowledge of mathematics, science, engineering and information technology using modern engineering tools.
2	Able to design an agroindustrial system/component, process and product to meet the desired needs within realistic constraints
3	Able to design and conduct scientific and engineering experiments and analyze and interpret the resulting data
4	Able to recognize the needs and have the ability to be involved in lifelong learning



**Tabel 4.** Mapping of courses according to the accreditation criteria of Indonesian Accreditation Body for Engineering Education (IABEE)

No.	Discipline	Required Load	Number of Courses	Load (units)	Load (%)	Remarks
1	Mathematics and Science	Min. 20%	14	34	23	Comply
2	Engineering Science and Technology	Min. 40%	24	63	43	Comply
3	Information technology and communication		2	5	3	Comply
4	Engineering design and problem-based experiments		7	22	15	Comply
5	General education	Max. 30%	11	22	15	Comply

### 3.3. Agroindustrial Engineer Professional Education Program (AEPEP)

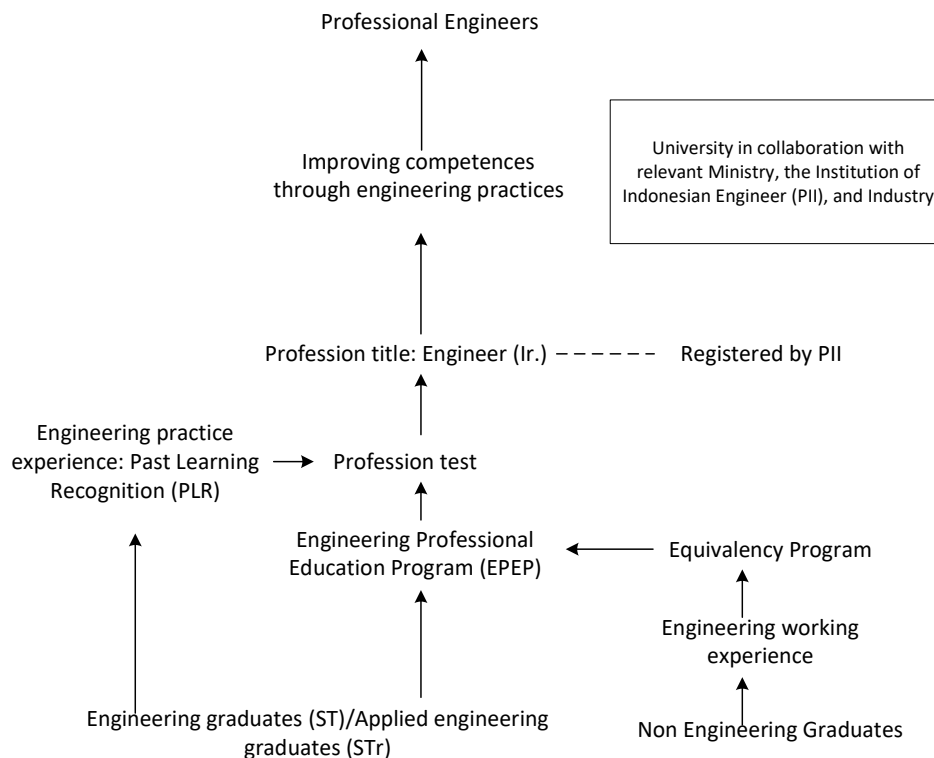
Having completed the undergraduate program, graduates might continue improving their attributes through training and experiences. An engineer professional education program is designed to serve this need. This education program is designed to respond to the demands of global competition while fulfilling the mandate of the Engineering Law No. 11/2014. The law gives mandate to university to carry out engineer professional education which is defined as a higher education after an undergraduate program that prepares students for work with special skill requirements. The law also regulates the obligation of a professional engineer to register in Indonesia (including foreign engineers) so as to provide legal certainty for providers of engineering services, and legal protection for engineers and service users. As a realization of the implementation of the Engineering Law, the Government of Indonesia via the Ministry of Research, Technology and Higher Education (Kemenristekdikti), through a Decree of the Director General of Science, Technology and Higher Education Institutions (SK Ditjen Iptek dan Dikti) No. 682 / C.C4 / KL / 2016 has given a mandate to 40 universities which are considered meeting the requirements for carrying out the Engineer Professional Program.

The Engineer Professional Education Program (EPEP) is a higher education program after an undergraduate program to establish engineering competence. The program is held in collaboration with relevant ministries (whose duties, principal, and functions are related to engineering services), non-ministry state institution (*Lembaga Negara Non Kementerian/LNNK*), the Institution of Engineers Indonesian (*Persatuan Insinyur Indonesia/PII*), relevant industry, and/or professional organizations responsible for the quality of engineering professional services. The university that organizes the EPEP can provide an engineer degree (abbreviated as Ir.) for individuals who have passed all the requirements according to the established standards. The EPEP standard was set by the Minister of Research, Technology and Higher Education, which was formulated based on the recommendations of the higher education institutions in cooperation with ministers fostering the relevant engineering services and the Indonesian Engineers Council.

Figure 5 shows the position of the professional engineer program in producing professional engineers. EPEP graduates hold an engineer degree (Ir.) according to the Law No. 11/2014, Article 7 and 9 are expected to develop themselves continuously through further engineering practices in their career, so that they can practice as professional engineers (PE) who bear responsibility to community safety / security and environmental sustainability.

In the context of producing competitive human resources in agroindustry, the role of engineer profession program in agroindustry is very strategic. The Engineering Professional Education Program (EPEP) is developed to facilitate graduates of undergraduate programs (S1) in developing themselves to work as engineers. The missions of EPEP in IPB are (1) To carry out engineer professional education to produce competent, integrity and highly competitive engineers in the field of agriculture in a broad sense to advance civilization and community welfare, protect the interests of the community, and realize sustainable development, (2) to encourage technological development to increase added value,

usability of agriculture-based resources, and (3) to disseminate technological developments to accelerate and expand the application of good engineering practices in agriculture in the broadest sense. The objectives are: (1) to produce competent, integrity and highly competitive engineers in the field of agriculture in the broadest sense, (2) to develop technology so as to increase added value, usability of agricultural resources for the welfare of society, and (3) to spread of technology and good engineering practices in the agricultural sector in the broadest sense.



**Figure 5.** Position of Professional Engineer Education Program in producing professional engineers  
(Source: Extracted from the Law No. 11/2014)

For those graduated from agroindustrial study program or similarly name of engineering program, they may choose to develop their professional competencies in the scope of agroindustrial engineering services. These services cover the following areas (1) development of process technology and agroindustrial products, (2) Management of the agroindustry, (3) Agroindustrial system engineering, and (4) Industrial environmental engineering and management.

The graduate learning outcomes (GLO) in EPEP is designed to produce engineers who have the ability to:

- 46) Perform engineering planning by utilizing resources and conducting engineering evaluation in agroindustry comprehensively by utilizing science and technology,
- 47) Resolve engineering problems in agroindustry,
- 48) Design and conduct scientific and engineering-based investigation for strategic decision making in accordance with professional ethics and engineering standards, and
- 49) Implement sustainable development of professionalism through lifelong learning.

The curriculum is designed to fulfill graduate learning outcomes that cover knowledge, skill, and attitude required to perform engineering services as a professional engineer. It is prepared by considering the obligations of engineers according to the Engineering Law No. 11/2014, graduate attributes of engineering education from the International Engineering Alliance (IEA), and alignments with national interests. The course subjects are listed in Table 5. Each course subject is designed to contribute directly to one or more the GLOs. It has a total credit of 24 credits, consisting of 70% of industrial practices under the apprenticeship supervisor, and 30% of the theoretical content.

**Table 5.** Course subjects of EPEP IPB

No.	Course subject	Credit	
1	Code of ethics and engineering ethics	2	(1-1)
2	Professionalism	2	(1-1)
3	Work health & safety, and environment	2	(1-1)
4	Engineering practice	12	(2-10)
5	Case Study	4	(1-3)
6	Seminar	2	(1-1)
Total		24	

EPEP curriculum can be grouped into knowledge of engineering ethics, professional competence, and work health & safety and environment; practical engineering skills and problem solving case studies; and soft skills which include communication, collaboration, leadership and management. Tables 6 and 7 are matrices that map the relationship between subjects and competencies to ensure that all learning outcomes can be met.

**Table 6.** Relative contributions of courses to aspects of student knowledge, skills and behavior

No	Course subject	Learning domain		
		Knowledge	Skills	Attitude
1	Code of ethics and engineering ethics	●	●	●●●
2	Professionalism	●	●●	●●●
3	Work health&safety and environment	●●	●●●	●●●
4	Seminar	●	●●●	●●
5	Engineering practice	●●	●●●	●●●
6	Case study	●●	●●●	●●●

Remarks: ●: medium contribution, ●●: high contribution, ●●●: very high contribution

**Table 7.** Relative contributions of courses in the graduate learning outcomes

No	Course subject	Graduate learning outcomes (GLO)*			
		1	2	3	4
1	Code of ethics and engineering ethics	●●	●●	●●●	●●
2	Professionalism	●●●	●●●	●●●	●●●
3	Work health&safety and environment	●●	●●	●●●	●●
4	Seminar	●	●●	●●	●●●
5	Engineering practice	●●●	●●●	●●●	●●●
6	Case study	●●●	●●●	●●●	●●

●: medium contribution, ●●: high contribution, ●●●: very high contribution

The program is conducted in two learning modes, namely the Regular Program and the Past Learning Recognition program (*Rekognisi Pembelajaran Lampau/RPL*). In principle, regular program is intended for practitioners who have not had sufficient experience in engineering practice, whereas the RPL program is for practitioners who have had sufficient engineering practice experience. Learning process in the regular program is carried out within 2 semesters that consists of face-to-face meetings, tutorials, focus group discussions, assignments, role plays, pre- and post-tests implementation of independent individual tasks and group assignments (eg. project / problem-based learning, and collaborative-based learning), involvement in scientific meetings, proposal writing and engineering project reporting, and oral presentations.

The RPL is an acknowledgment of learning outcomes obtained from formal, non-formal, informal, and/or work experience in the education sector and other sectors. It is opened for engineering or

applied engineering graduates who are considered to have sufficient engineering practice experience (more than 2 years) or for science graduates and engineering education graduates who have fulfilled the equivalency requirements (equivalent to 3 years engineering practice) and possessed adequate engineering practice experience (more than 2 years). RPL is carried out through assessment and recognition of participant portfolios against the requirements of semester credit units (SKS). Credit shortages are then fulfilled through the implementation of the program's curriculum. Learning in the RPL program is carried out within 1 semester. The learning process, assessment and graduation requirements are basically similar as the processes and requirements in a regular program.

#### 4. Concluding Remarks

The increasing number of qualified professional engineers through engineer professional education programs can reduce dependence on foreign engineers. As we all know, foreign investment is very encouraged. The availability of qualified Indonesian professional engineers will improve our nation's bargaining position on the use of foreign workers, especially in economic activities financed by foreign investment. The implementation of the 2015 ASEAN Economic Community (AEC) challenges Indonesian industry and workers. This challenge must be answered immediately by higher education by producing more graduates and professionals who have high quality. Global labor mobility also demands a quality and competitive workforce and is recognized globally. Engineering services are one area that will face very tight competition. This requires a level of competence that is equivalent to global standards. For this reason, improving the quality of technical education programs is considered an effective way to prepare the necessary workforce.

The path of academic education and the agro-industrial engineering profession described in this paper is one of the efforts of higher education to contribute in providing competitive human resources in the field of agro-industry. A quality and accountable education system that involves stakeholders and in accordance with national and international standards is expected to produce an adaptive workforce to develop sustainable agro-industries. Graduates of the academic education pathway are expected to have the competence to be able to design, develop, implement, control, evaluate and improve the performance of sustainable agroindustry integrated systems, covering aspects of the transformation process, system engineering, industrial management, and the environment, and able to work as professionals or technopreneurs through increased knowledge and ability in line with the development of agro-industry.

Graduates who continue on the engineering profession program are expected to meet the standards of professional engineer competence in the field of agro-industry. These professional agro-industry engineers are needed to improve the competitiveness of national agro-industries. They are eagerly awaited to take part in increasing the added value of tropical agricultural commodities, developing the capacity of knowledge and technology and providing innovative solutions in the community. As a university that focuses on providing human resources and science and technology in the field of agriculture in a broad sense, IPB is required to have a proactive role to produce agricultural engineers who are able to contribute in realizing the provision of food, energy and industrial products in a sustainable manner.

**Acknowledgments:** The Authors thank to all Preparation Team member of IPB's engineer profession education program, faculties of ATSP, and resource persons from alumni, the Communication Forum of Indonesian Agroindustrial Study Programs, The Institution of Engineers Indonesia, Professional Associations / Organizations, and governmental organizations who have been actively involved at various stages of preparation of the program.

#### References

1. Luekitinan, W. 2014. Employability and Job Mobility: Critical Skills for New Graduates in ASEAN. *Gloval Journal of Business Research*. Vol.106: 292-299
2. Fukunaga, Y. 2015. Assessing the Progress of ASEAN MRAs on Professional Services. *ERIA Discussion Paper Series*

3. Rugarcia, A., Felder, R.M, Woods, D.R., dan Stice, J.E. 2000. The Future of Engineering Education: A vision for a new century. Chemical Engineering Education, Vol. 34 (1), 6-25
4. Cheshier, S. R. 1998. Studying Engineering Technology: A Blue Print for Success. Discovery Press.
5. Thipakorn, B. 2018. Outcome Based Education: An Education Framework to Ensure Performance-Based Accountability Regime of Higher Education Institution in High Quality of Learning. Paper Presentations of International Conference on Outcome-based International Quality Assurance System 2018, in Pekanbaru, Riau, Indonesia, 8-9 August 2018. Available online: <http://spmi.ristekdikti.go.id/publikasi/5b6a69b167e91c071f4ffe26>
6. World Bank. 2012. Putting Higher Education to Work Skills and Research for Growth in East Asia. World Bank East Asia and Pacific Regional Report. Available online: <http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/> (accessed on September 15, 2018)
7. Malkki, H dan Paatero, J.V. 2015 Curriculum Planning in Energy Engineering Education. Journal of Cleaner Production. Vol. 18: 652-658
8. Jackson, D. 2010. An international profile of industry-relevant competencies and skill gaps in modern graduates. International Journal of Management Education Vol. 8: 29-58
9. Khan, M.A., dan Law, L.A. 2015. An Integrative Approach to Curriculum Development in Higher Education in the USA: A theoretical framework. International Education Studies. Vol. 8 (3): 66-76
10. IEA (International Engineering Alliance). 2014. 25 Years of Washington Accords 1989-2014: Celebrating international engineering education standards and recognition. International Engineering Alliance Secretariat. New Zealand. Available online: <http://www.ieagrements.org/accords/washington/> (accessed on July 15, 2018)



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-SA-010-ID014

# Quality and Packaging Analysis of Fresh Strawberry (*Fragaria* Sp) During Storage in Controlled Environment

Agustina R.P. Andam Dewi<sup>1</sup>, Pujo Saroyo<sup>2</sup> and Mohammad Affan Fajar Falah<sup>2,\*</sup>

<sup>1</sup> Student at Departement of Agroindustrial Technology, Fac.of Agricultural Technology, Universitas Gadjah Mada; e-mail@e-mail.com

<sup>2</sup> Department of Agroindustrial Technology, Fac.of Agricultural Technology, Universitas Gadjah Mada Jl. Flora No.1, Bulaksumur, Sleman, Yogyakarta 55281; e-mail@e-mail.com

\* Correspondence: affan\_tip@ugm.ac.id; Tel.: +62-274-551-219

Received: 8 July 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** Strawberry fruit (*Fragaria* sp) is highly perishable fruit fast deteriorate of their quality in tropical conditions and common technique to delay their senescence process was stored in controlled environment. Strawberry fruit in Indonesia generally packaged using plastic to easy handling of strawberry fruit and also to maintain their quality from physical damage. However, the effect of this plastic packaging on quality of the strawberry fruit is often neglected. The strawberry from supermarket in Yogyakarta was chosen from the first day, then continue to store in controlled environment using temperature at 4°C and 10°C with RH varied between 85-95% in a laboratory. Quality parameters of the strawberry were measured, such as water content, pH as acidity indicator, texture of the skin, color of the skin, and total plate count test. Taguchi Method was applied to determine the most appropriate plastics packaging that used for maintaining quality of fresh strawberry. Our results showed, strawberry fruit have shelf-life around 7 days at controlled environment. Water content, acidity and texture of the strawberry can be maintained their quality during storage in controlled temperature conditions. Best combination using Taguchi Methods in plastics packaging of strawberry with plastic are using 10 cm<sup>2</sup> plastic holes, none of the use of carton paperboard, not to wash strawberry before being pack, using plastic packaging size (15,8 x10x3,8) cm<sup>3</sup>, 18 strawberry fruits per packaging, 4°C showcase temperature and tight packaging conditions.

**Keywords:** controlled environment, packaging, quality, strawberry, tropical conditions

## 1. Introduction

Strawberry (*Fragaria* sp) is non-climacteric fruit which has an attractive appearance due to its conical shape fruit and striking red colour. Strawberry has a potential prospect to develop as a fresh or processed food in Indonesia because many consumers like this kind of fruit and there are so many foods which use strawberry as its ingredients. Strawberries grown in Indonesia have many varieties such as Sweet Charlie (from the United States), Oso Grande (from California), Tristar (West America), Nyoho (from Japan and South Korea), Hokowaze (Northern Japanese), Rosa Linda (from Florida), Chandler (from California). Those varieties have been cultivated in Indonesia especially in the plateau areas as Lembang, Cianjur, Cipanas and Sukabumi (West Java), Batu and Situbondo (East Java), Magelang and Purbalingga (Central Java), Bedugul (Bali), and Brastagi (North Sumatra, also with other varieties of Oso Grande in Purbalingga, Central Java, Selva in Karanganyar, Earlibrite (Holibert) in Garut and Bandung Ciwidey, Rosa Linda, Sweet Charlie, Aerut and Camarosa in Bedugul Bali, Dorit, Lokal Brastagi and California in Brastagi, Chandler in Bondowoso PTPN XII, Lokal Batu in Batu, Malang [1].

However, development strawberries in Indonesia still have some problems, especially during the post-harvest handling from farmer or wholesaler during distribution, which can lead into faster decay of strawberries and become rotten. Post-harvest handling of strawberry fruit must be done properly



and should not be arbitrary because it has different characteristics to another fruit. Several parameters of strawberry are important to maintain their quality during their postharvest handling. According to [2] water content is the largest part in strawberry fruit which is for about 92 g water per 100 g strawberry, and other substantial content of strawberries are protein, total lipids, carbohydrates, fiber, and ash. [3] shown that there are two notions of maturity of fruits and vegetables which are physiologically mature and commercially mature. Physiologically mature means that fruit has reached exact levels of growth and development. Meanwhile, commercially mature is the current state of the commodity which reach desired quality of the market. Quality parameters that can be used as a basis for determining the maturity of fruit [4]. Previous experiment for storage of local strawberry from West Java Indonesia as a tropical conditions in were strongly recommended to store in controlled environments with lower temperature conditions, to extend their shelf life and maintain their quality [5].

Tropical storage conditions greatly affected shelf life of strawberries during postharvest, storage, distribution or display in the modern supermarket or traditional market. In addition, the condition of packaging also affected strawberries shelf life because packaging material will have direct contact to the fruit. In retail market of Indonesia, strawberries is packed using plastic from polyethylene terephthalate (PET). Packaging is useful to facilitate the handling of fresh strawberries that have been harvested. Packaging can help and prevent or reduce damage and protect the inner materials from pollution and physical disturbance like friction, shock, or vibration and also their used to simplify the process of handling fresh strawberries. In terms of marketing view and promotional objective, packaging may serves as an incentive or attraction to the buyers [6]. However, the influence of packaging on the physical, chemical, and biological conditions of fresh strawberries have less attention especially effects on quality of strawberry during their display and storage in the market.

Furthermore, Taguchi method was used to determine the most appropriate setting of the PET strawberries packaging based on principled on quality improvement by reducing variations without eliminating the cause. Taguchi Method suitable to be applied in this research because it is one of the tool for a quality improvement with principle to minimize the effect of variation without eliminating its cause. It can be obtained through the optimization of the design of products and processes to make the performance robust to various causes of variation in a process called parameters design [7] Taguchi method is a methodology for engineers or improve productivity during the research and development so that high quality products can be produced quickly and at low cost.

Objectives of this research was to determine the effect of packaging on the quality of fresh strawberries in accordance with storage temperature in controlled environment and the best setting of the combination between several types of packaging which is storage in tropical environmental conditions.

## 2. Materials and Methods

### 2.1 Plant Materials

Local fresh strawberry (*Fragaria, sp* cv Holibert) were obtained from a local farm in Dusun Barudua, Malangbong District, Garut Regency, West Java Province, and fruits were transported under ambient temperature conditions (25-30 °C) within 12 h after harvest to reseller or fruit distributor in Yogyakarta using train. In fruit distributor, these fruits were divided into two groups, first group for traditional market and second group for modern market in Yogyakarta, usually based on their size. Strawberry were wrapped with 0.7 mm plastic polyethylene terephthalate (PET).

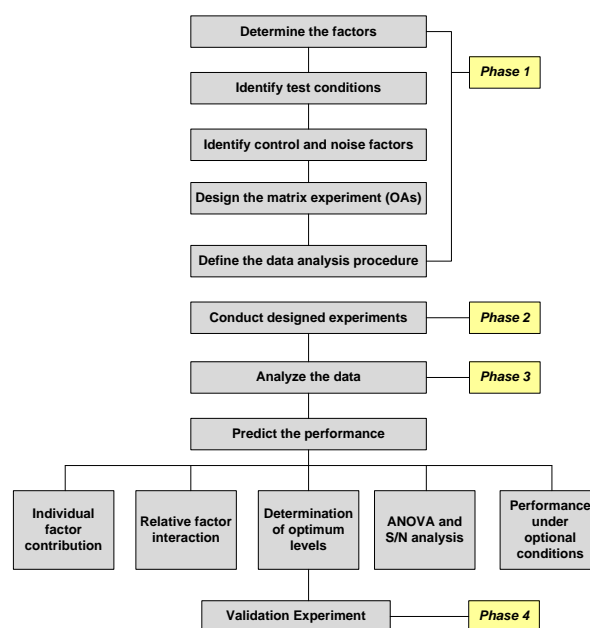
### 2.2. Measurement Quality Parameter of Strawberry

Quality evaluation of fresh strawberry fruit were measured based on their physical and nutritional characteristics. For physical evaluation, , texture of skin strawberry fruit as a fruit firmness was determined using a texture analyzer (UTM, Model Zwick Tipe DO FB0 5TS, Germany) and then color of strawberry fruit (fruit surface color) was measured using a chromameter (Minolta, CR-400, Japan)

and expressed on L-a-b value (dark to light, on a scale of 0–100). All of physical measurements were evaluated and the average data from 7 samples for each measurement were used with triplicates. For nutritional evaluation, water content was evaluated using a thermogravimetric method, acidity of fruits was measured using value of pH, then simple microbial evaluation was also measured using Total Plate Count (TPC) method. All of nutritional measurements were evaluated and the average data from 7 samples for each measurement were used with triplicates. Data obtained from the experiment results were tabulated and calculated using Microsoft Excel 2007 (Microsoft Corporation). Further statistical analysis utilized SPSS version 14.0 (SPSS Incorporation) to obtain optimum treatments and significance of the obtained results through analysis of variance (ANOVA) and LSD interpretations.

### 2.3. Taguchi Method Application

In this experiment, Taguchi Method was chosen because of its excellence and more structured than the conventional statistical methods. This method has several steps, where several quality parameters of the process or product related to the control factors and noise were analyzed. Principle design strategy of the design parameters were determined through the best value of control factor, which is able to minimize the sensitive function process for all noise factors [7-8]. The following are the common steps of Taguchi Method using four phases (Figure 1).



**Figure 1.** Steps of Taguchi Method Approach [9]

In this experiment, we use similar phase, firstly determination the factors, as show in the table 1, then next step is determine Signal to Noise Ratio (SNR). There are three types of Signal to Noise Ratio according to the parameter used to define strawberry quality characteristic, smaller the better, nominal the best and larger the better. In this research orthogonal array  $L_8(2^7)$  is used because of its ability to reduce the number of experiments significantly and a large number of decision variable can be learned through the minimum experiments so that it become more effective. Then, two-way analysis of variance (ANOVA) is used to able for outline and calculate the total variance into factor variance so the contribution of each factor to the total variance will be known. The last step is analysis of multi-response characteristic with validation of experiment.

**Table 1.** Controlled Factors and Levels of Taguchi Method Approach

Controlled Factors		Level	
		1	2
A	The width of the air holes surface of the packaging	10 cm <sup>2</sup>	2 cm <sup>2</sup>
B	Temperature of showcase	4°C	10°C
C	Tightness of packaging	Not tight	Tight
D	The numbers of strawberries/package	15 fruits	18 fruits
E	Pretreatment fruit storage	Fruit do not need to be washed	Fruit need to be washed
F	PET packaging size	(15,8x10x3,8) cm	(13,8x7,5x) cm
G	The use of bottom cardboard	In use	Not in use

In this experiment, it can define and conduct eight different experiment based on the controlled factor and level using taguchi method for orthogonal array. This orthogonal array for the experiment can be found in the table 2.

Tabel 2. Orthogonal Array of controlled factors and experiments for Taguchi Methods

Controlled factors	Experiment Number							
	1	2	3	4	5	6	7	8
A The width of the air holes surface of the packaging	10 cm <sup>2</sup>	10 cm <sup>2</sup>	10 cm <sup>2</sup>	10 cm <sup>2</sup>	2 cm <sup>2</sup>	2 cm <sup>2</sup>	2 cm <sup>2</sup>	2 cm <sup>2</sup>
B Temperature of showcase	4°C	4°C	10°C	10°C	4°C	4°C	10°C	10°C
C Tightness of packaging	Not Tight	Not Tight	Tight	Tight	Tight	Tight	Not Tight	Not Tight
D The numbers of strawberries/package	15	18	15	18	15	18	15	18
E Pretreatment fruit storage	Fruit do not need to be washed	Fruit need to be washed	Fruit do not need to be washed	Fruit need to be washed	Fruit need to be washed	Fruit do not need to be washed	Fruit need to be washed	Fruit do not need to be washed
F PET packaging size	(15x8x3) cm	(12x8x3) cm	(12x8x3) cm	(15x8x3) cm	(15x8x3) cm	(12x8x3) cm	(12x8x3) cm	(15x8x3) cm
G The use of bottom cardboard	In use	Not in use	Not in use	In use	Not in use	In use	In use	Not in use

According to author [10], the optimal storage temperature for fresh strawberries is 0°C with relative humidity or RH of 90-95%, they will be able to survive for 5-7 days of storage. Strawberries for daily consumption were stored at a temperature of 2-3°C, and the recommended temperature for storage of strawberries on showcase maximum is 4.4°C. However, if it is stored in the large number of the best temperature is below 4.4°C or temperature ranges between 2-3°C. Unfortunately, the survey showed that storage temperature for fresh strawberries supermarkets in Yogyakarta Indonesia, showcase in the range of 0°C to 10°C that was used to display strawberry in the modern market and without temperature controlled for traditional market with ambient temperature in the range of 26-30°C.

### *3.1. Quality Parameters of Fresh Strawberry in Controlled Temperature Storage*

In the this study, the storage temperature was used is 4°C according to modern market temperature and 10°C according to fresh fruit seller in the street. During temperature at 4°C, strawberries have a longer shelf life than the temperature of 10°C and several microbes like fungus or mold will be slower to grow at 4°C. According author [11] when the fruit storage temperature increased from 0°C to 10°C, the fruit will rot faster 2 to 4 fold, it means that the strawberries were stored at a temperature of 20°C only has a  $\frac{1}{4}$  or  $\frac{1}{2}$  life of fruit stored at 0°C and if stored at a temperature of 30°C berries will last only a few hours so it only has a short shelf life. In this experiments strawberry's shelf life is 3 days at ambient room temperature (26-30°C) and it will extended to 7 days in lower temperature storage conditions.

Table 3 show the average value of the quality characteristics of strawberry fruit during storage for 7 days. We can find that water content, the experimental results showed that the water content has a downward trend, with average about 91-92%, and similar with author [2] which said that the water content of strawberries is 92% as common. pH value of strawberries ranged 3,4 – 3,8, this indicated that the local fresh strawberry have a high acidity value. At 100 grams dry weight of oranges contained 32 mg of vitamin C, while the strawberries contained 53 mg of vitamin C [12].

Table 3. Quality Parameter of Fresh Strawberry Using Plastics Packaging for 7 Days

No.	Quality Parameter	Exp 1	Exp 2	Exp 5	Exp 6	Ex K4	Exp 3	Exp 4	Exp 7	Exp 8	Exp K10
1.	Water Content (%)	91,1 ± 0,9	91,2 ± 1,2	91,5 ± 0,5	91,2 ± 0,9	91,4 ± 0,7	91,0 ± 0,8	90,3 ± 0,8	91,0 ± 0,7	91,3 ± 0,7	90,8 ± 0,9
2.	pH	3,57 ± 0,09	3,61 ± 0,06	3,67 ± 0,11	3,71 ± 0,12	3,71 ± 0,11	3,65 ± 0,08	3,66 ± 0,09	3,70 ± 0,15	3,72 ± 0,13	3,47 ± 0,1
3.	Texture (N)	16,61 ± 2,2	17,53 ± 2,4	17,44 ± 4,3	17,34 ± 3,4	17,14 ± 3,2	18,74 ± 3,3	18,36 ± 3,6	17,59 ± 2,8	18,57 ± 3,5	18,43 ± 2,6
4.	Color (L)	27,27 ± 2,1	27,32 ± 2,5	26,71 ± 3,0	28,95 ± 1,8	28,09 ± 2,1	28,60 ± 1,1	27,21 ± 0,9	26,73 ± 1,6	27,48 ± 1,9	28,75 ± 2,1
5.	Color (a)	23,21 ± 3,9	21,79 ± 2,7	22,66 ± 4,8	24,66 ± 2,7	24,61 ± 2,8	23,11 ± 1,5	22,54 ± 2,6	21,79 ± 1,6	23,32 ± 3,1	24,41 ± 2,3
6.	Color (b)	12,06 ± 1,8	12,43 ± 2,5	12,11 ± 2,7	13,65 ± 1,5	12,96 ± 1,3	12,98 ± 0,9	11,83 ± 1,3	11,49 ± 1,1	11,97 ± 1,5	13,19 ± 1,7
7.	TPC (x 10 <sup>-3</sup> cfu/g)	101	59	103	124	46	80	75	118	69	5

Texture of the skin of strawberry that storage at lower temperature were changed gradually and appeared to be dried and wrinkle due to the ripening and senescence process. Lightness (L), Redness (a), and Yellowness (b) as a color indicator of the strawberries skin were also changed. TPC which measure the number of living microbes in the fruit at the 7<sup>th</sup> day after storage were varied depend on the treatments. Diseases that often attacks strawberry fruit are gray mold caused by the fungus *Botrytis cinerea*, rotten fruit by the fungus *Colletotrichum fragariae*, white fungal mycelium infection caused by the spores of the fungus *Rhizopus stolonifer* black [13]. In this study a lot of decay caused by *Rhizopus* sp. and *Botrytis cinerea* that was appeared on 8<sup>th</sup> day then this indicated that the strawberries can not be eaten.

### 3.2. Taguchi Method Approach for Selection of Packaging Strawberry

#### 3.2.1. Result of MEAN and SNR Calculation

Data mean shows the mean response for each sample strawberries experiment of each quality attribute parameter. Data for the calculation of mean taken from the last day of the experiment which was the 7<sup>th</sup> day. The reason why the data taken at the 7<sup>th</sup> was due on the day which began to be found indications of rotten strawberries and also the fungus began to grow on the surface of a strawberry fruit at the 7<sup>th</sup> day so it did not proper to be saved anymore. Showcase strawberries at 4°C looked fresher than strawberries at a temperature of 10 °C. Decreasing value in fruit quality due to decay processes that occur was mentioned in the table 1 above. Decreasing water content causes strawberries to shrivel due to water loss. Strawberries pH difference was not much different from the first day, but showed an upward trend in the past seven days of storage. Strawberry fruit texture textured tight at the beginning of storage, but then became mushy and the texture increasingly diminished because of the bumping or shaking when strawberries were transported or moved into another storage. Another quality attributes such as color brightness or lightness (L) went down because the skin color of strawberry fruit was getting dark. Similarly happened to attribute redness (a) and yellowness (b) that were getting decline every day. For the quality attribute change of the color ( $\Delta E$ ) showed an increasing trend due to the differences that became more visible from the first day of strawberries until the last day when the strawberries were stored.

In addition, each quality parameters of strawberries Mean and the SNR calculation of the strawberries were water content, pH, texture, color (L, a, b,  $\Delta E$ ). Then the value of calculation for Mean and SNR can be known through the Mean and SNR predetermined formula which was larger the better, nominal the best, or the smaller the better. Furthermore, also can be known the value of the factor effects from the calculation of the formula given.

#### 3.2.2. Analysis of MEAN Factor Effect and SNR Factor Effect

Analysis of MEAN Factor Effect and SNR Factor Effect are used to calculate how much each factor that has been determined before influenced the quality parameters. In the analysis of taguchi effect factor with taguchi L8 orthogonal matrix will be known effect of seven factors that shown in the table 4.

Table 4 show analysis of MEAN Factor Effect and SNR Factor Effect. It can be seen that the effects of factors that most influence the MEAN of fresh strawberries water content was G factor with difference value or effect factor value of 0,50152. Based on the calculation it can be seen that the best combination of water for MEAN's calculation was G1, A2, D1, E2, B1, F2, C2. Meanwhile, the best combination for SNR's calculation of water content was G1, D1, E1, F1, A2, B1, and C1. Then, Taguchi's quality characteristics response used is nominal the best for water content. pH of the strawberry can be identified as acidity level of the strawberry product that influence quality of fresh strawberries. From the Figure known that the best combination for the calculation of MEAN factor effect was E1, D2, F1, A2, G1, C1, and B2. For SNR factor effect, the best combination was E1, D2, F1, A2, G1, C1, and B2. Taguchi's quality characteristics response used is larger the better for pH. Other quality parameter is a texture of the skin of strawberry. For skin texture the most influential factor was G factor with difference

2,80250 for MEAN factor effect and SNR factor effect can be discovered that the most influential or the biggest influence come from G factor with difference value of 0,19030 and the least value come from C factor with difference value of 0,06222. The best combination for MEAN factor effect of texture quality parameter for fresh strawberries was G2, D2, E2, A2, F2, C2, and B2 while the best combination for SNR factor effect was G2, D2, E2, A2, B2, F2, and C2, based on the calculation skin texture of the strawberry used is larger the better.

The next quality parameter is color and the first color parameter attribute is lightness (L), redness (a) and yellowness (b). Taguchi's quality characteristics response used is larger the better for lightness (L), redness (a) and yellowness (b). Another color response observed was change of color ( $\Delta E$ ) which is the combination of the previous three color attribute (L, a, b). The figure showed that the biggest MEAN factor effect was 12,45651 reached by G factor. Besides, the smallest MEAN factor effect was 0,64273 reached by F factor. This difference was bigger rather than another quality response. Meanwhile, for SNR factor effect G factor reached the biggest difference value which was 0,89829. The smallest effect for SNR was D factor with difference value of 0,04800. Graph illustration showed that the best combination for quality parameter change of color ( $\Delta E$ ) in MEAN factor effect was G2, B2, E2, C2, A1, D2, and F2 while best combination for SNR factor effect was G2, B2, A1, C2, E2, F2, and D2. Taguchi's quality characteristics response used is smaller the better which is the opposite of L, a, b color attribute because  $\Delta E$  is combined parameter.

Total Plate Count or TPC is the last quality parameter for this research. From the figure can be known that the most dominant MEAN factor effect was reached by G factor while the least effect comes from E factor, with difference value of 26,5 and 4,66667 respectively. Those two values had wide range because of the big difference of colony forming unit for microbes in petridish in the 0-day until 7-day. Moreover, the best combination for SNR factor effect was G2, D2, A1, B2, C1, E2, and F1 and Taguchi's quality characteristics response used is smaller the better.

**Table 4.** Analysis of MEAN Factor Effect and SNR Factor Effect

No.	Quality Parameter	MEAN Factor Effect		SNR Factor Effect		Best Combination (Mean, SNR)
		Max	Min	Max	Min	
1.	Water Content	G: 0,50152	C: 0,00099	G: 0,30227	C: 0,04213	G1,A2,D1,E2,B1,F2,C2 G1,D1,E1,F1,A2,B1,C1
2.	pH	E: 0,04167	B: 0,02167	E: 0,00988	C: 0,00553	E1,D2,F1,A2,G1,C1,B2 E1,D2,F1,A2,G1,C1,B2
3.	Texture	G: 2,80250	B: 0,89417	G: 0,19030	C: 0,06222	G2,D2,E2,A2,F2,C2,B2 G2,D2,E2,A2, B2,F2,C2
4.	Color (L)	C: 2,00333	D: 0,35	C: 0,06694	B: 0,01069	C2,G2,F2,A2,E2, B1,D2 C2,G2,F2,A2,E2,D2,B1
5.	Color (a)	E: 3,93333	D: 0,84667	E: 0,15950	D: 0,01587	E2,A2,F2,G2,C2,B1,D1 E2,F2,A2,C2,G2,B1,D1
6.	Color (b)	C: 1,57500	D: 0,09833	C: 0,11850	D: 0,00409	C2,G2,F2,B1,A2,E2,D1 C2,F2,G2,B1,A2,E2,D1
7.	Color ( $\Delta E$ )	G: 12,45651	F: 0,64273	G: 0,89829	D: 0,04800	G2,B2,E2,C2,A1,D2,F2 G2,B2,A1,C2,E2,F2,D2
8.	TPC	G: 26,5	E: 4,66667	G: 0,26528	F: 0,03707	G2,A1,D2,B2,C1,F1,E2 G2,D2,A1,B2,C1,E2,F1

Based on the calculation of the effect of these factors can be seen the best combination of factors and levels from every quality parameter of fresh strawberries experiments that have been done. The greater the value of effect factors indicate the greater influence to the sample. Best combination showed that between mean and SNR level have factors sequence which almost identical on every quality attribute of parameter.



### 3.3. Result Comparison of Each Parameter Analysis

The order of best combination of factors and level can be known for every fresh strawberry fruit quality parameters which is water content, pH, texture, color (L, a and b), and TPC were compare each other. Calculation results indicate that the effect of factors and levels of factors that affect the quality of each parameter mostly have the same level between the analysis of factor effect for Mean and SNR. However, there are differences in sequence between one factor to another. This sequence shows that there are differences in the influence of the average (mean) and also the influence of signal to noise ratio.

### 3.4. Analysis of Variance (ANOVA)

Based on the calculation using analysis of variance, to determine which is the large contributions of the factor for each quality parameter. The largest contribution of fresh strawberries for water content quality parameter was the factor G with contribution of 7,432%. Greatest contribution for the fruit pH quality parameter was factor E which was with value of 24,462% and texture quality parameters indicated by factor G had value of 19,238%. For parameter of fruit brightness or lightness the biggest contribution was the factor C with contribution of 29,126%. The largest contribution for the redness (a) color parameter was the E factor with value of 20,783%. Contribution of yellowness (b) color parameter and change of color ( $\Delta E$ ) was factor C 18,472% and factor G by 7,003% respectively. Meanwhile, the last but not least quality parameter TPC had the largest contribution by factor G with percentage as much as 13,157%.

### 3.5. Multi Response Characteristic Analysis

**Table 5.** Priority Factor for Fresh Strawberry Fruits According to Multi Response's Calculation

	Controlled Factors	Level 1	Level 2	Difference	Rank
A	Width of the air holes surface of packaging	-2,01021	-2,16714	0,15693	1
B	Temperature of showcase	-2,04553	-2,13181	0,08628	6
C	Tightness of packaging	-2,13161	-2,04573	0,08588	7
D	The numbers of strawberries/package	-2,13713	-2,04021	0,09692	5
E	Pretreatment fruit storage	-2,02317	-2,15417	0,13099	3
F	PET packaging size	-2,02318	-2,15416	0,13098	4
G	The use of bottom cardboard	-2,15802	-2,01932	0,13870	2

From the table above can be known the sequence of most influential factors in the cold storage of fresh strawberries which is factor A, G, E, F, D, B, and C. The bigger the effect, the wider also the line that represent each factor:

**Table 6.** Factor Effect of Multi Response SNR

	A	B	C	D	E	F	G
Level 1	-2,01021	-2,04553	-2,13161	-2,13713	-2,02317	-2,02318	-2,15802
Level 2	-2,16714	-2,13181	-2,04573	-2,04021	-2,15417	-2,15416	-2,01932
Difference	0,15693	0,08628	-0,08588	-0,09692	0,13099	0,13098	-0,13870
Rank	1	6	7	5	3	4	2

SNR calculations factors using multi-response were resulted and determined the priority ranking difference factor that specify the best condition for strawberries storage . It is known that the difference or the biggest effect factor found in the factor A 0.15693, which is followed by factor G, E, F, D, B, and

C in accordance with factor's order priority for fresh strawberries storage. Meanwhile, levels that affected each factor are A1, B1, C2, D2, E1, F1, and G2. Thus, the order priority for factors and levels final combination of fresh strawberry fruit storage is A1, G2, E1, F1, D2, B1, and C2.

#### 4. Discussion

##### *The Relationship Between Fresh Strawberry Fruit's Quality During Cold Storage and Its Parameter Response with Taguchi Method Approach*

Fresh strawberries cultivar Holibert (Earlibrite) continues for metabolic process after picked up from the field until storage through postharvest handling. Storage at cold temperatures is one way to inhibit the metabolic processes and it could be identified that fresh strawberries which were stored at 4°C has better physical condition than those which were at the temperature of 10°C. This is a match corresponding with statement [10] who says that for daily storage strawberries are best stored at a temperature of 2-3°C. Moreover, recommended cold storage temperature for strawberries on showcase or refrigerator maximum is 4.4°C. This is also indicated by the storage conditions of fresh strawberries with Taguchi Method with combination level 1 at temperature of 4°C which was better than level 2 at temperature of 10°C. Similarly to other factors for instance air holes, tightness of packaging, synchronization of the quantity of strawberries fruits per packaging PET plastic's size, treatment before storage, and the use of the bottom cardboard base. Cardboard base that directly contacted with the strawberry fruit can be accelerate growth of the microbes through the water condensation which resulted from fruit surface and plastics packaging. The condensation on the inner film surface was especially influenced by the flow conditions, the external temperature amplitude and the inner air volume, furthermore condensation processes on fruit surfaces were caused primarily by temperature amplitude and cycle time [14]. Microbes that often arise in cold storage in this showcase are fungus of *Rhizopus* and *Botrytis cinerea*, both of them cause an infection in strawberry fruit and accelerate the damage of fruit so that the decay became faster. *Rhizopus* cause watery fruit, rotten fruit, because of the fungus' mycelium evolve on the surface of strawberries fruit. Meanwhile, *Botrytis cinerea* caused dry rot strawberries with a brownish color.

Taguchi Method helps to determine the combination of controllable factors for the method of strawberries storage using PET plastic packaging. From this would be known the steps of packaging in strawberries fruit using PET plastics the most appropriate packaging can be obtained. With the combination of these step of packaging can be obtained the relationship between water content, pH, texture, color, and TPC of fresh strawberries' cold storage. Using ANOVA calculation known that water content was influenced by G factor (the use of bottom cardboard base) with the percentage of 7.432%. Strawberry fruit's pH was affected by E factor (treatment before storage which is washing fruit) in the amount of 24.462%. The texture of fruit was affected by G factor (the use of bottom cardboard base) as much as 19.238%. Color of fruit including fruit color lightness (L) was influenced by the C factor (tightness of packaging) with percentage of 29.126%. Redness (a) color index influenced by E factor (treatment before storage which is washing fruit) of 20.783%. Another color index which is yellowness (b) contributed by C factor (tightness of packaging) of 18.472%. Change of color ( $\Delta E$ ) and TPC influenced by E factor (treatment before storage which is washing fruit) respectively 7.003% and 13.157%.

Through the Taguchi Method can be known the proper way for packaging fresh strawberries using PET packaging at its optimum way. Surface air holes is 10 cm<sup>2</sup> wide with plastic package volume size (15,8 x 10 x 3,8) cm<sup>3</sup>. With this PET packaging size the best number to fill with strawberries fruit was 18 pieces of strawberries. PET plastic packaging also set with not too much air circulation and to minimize its scotch tape on each side of the packaging was applied. Storage temperature was 2-3°C or 4°C for maximum in cold storage showcase to prevent rapid decay. Temperatures above 4°C causes fruit to rot faster several times higher than the initial conditions. This is consistent with the statement from [11,15] that when the fruit storage temperature increased from 0°C to 10°C, the fruit will rot faster 2 to 4 times. Before it is stored into the showcase strawberries do not need to be washed because it will add moisture to the fruit so as to accelerate the occurrence of fruit rot. In addition, the water attached to the fruit will

invite microorganisms to grow faster. If there is fungus or mold that grows on the surface of a strawberry fruit must be separated with other fruits because the fungus will very easily spread into the other fruits. If this happens then the decay on strawberries fruit in the cold storage can occur more quickly.

## 5. Conclusions

- 1) Local fresh strawberries type Holibrite (Earlibrite) in the cold storage have a shelf life for about approximately  $\pm 7$  days as indicated by the declining quality characteristics include moisture content, pH, texture, color (lightness, redness, yellowness, color change ( $\Delta E$ ), and the number of microbes counted in total plate count (TPC).
- 2) Combination of design factors and levels that influence the storage of fresh strawberries is A1, G2, E1, F1, D2, B1, and C2, namely:
  - A1 = The width of the air holes surface packing 10 cm<sup>2</sup>
  - G2 = Do not use the bottom cardboard base
  - E1 = Pretreatment storage of fruits do not need to be washed
  - F1 = The type of PET plastic packaging size is (15,8 x10x3,8) cm<sup>3</sup>
  - D2 = The number of strawberries/packaging is as much as 18 pieces
  - B1 = Temperature of cooling box/showcase is 4°C
  - C2 = Tightness of packaging is tight
- 3) Taguchi's quality characteristics response are used for parameter quality of strawberry are Water Content is nominal the best; Texture and Color index (L, a, b) are larger the better and Change of Color ( $\Delta E$ ) and Total Plate Count are smaller the better

**Acknowledgments:** The corresponding authors want to thank all their colleagues and students for their assistance in the research, Gadjah Mada University and Ministry of Education and Culture Republic of Indonesia for supporting through their grant no : LPPM-UGM/1333/LIT/2013 for research and research dissemination using their grant : No 1979/UNI/DITLIT/DIT-LIT/LT/2018.

## References

1. Rukmana, H.R. 1998. *Stroberi Budidaya dan Pascapanen*. Yogyakarta: Penerbit Kanisius.
2. Nunes, M. Cecilia N., Jean Pierre Emond, Mary Rauth, Sharon Dea, Khe V. Chau. 2009. Environmental conditions encountered during typical consumer retail display affect fruit and vegetable quality and waste. *Postharvest Biology and Technology*, 51, 2 : 232-241
3. Kader, A. A. 1990. *Quality and its maintenance to the postharvest physiology of strawberry*. In A. Dale, & J. J. Luby (Eds.), *The Strawberry Into The 21st Century*. Dalam *Jurnal Effect of Storage Temperatures on Antioxidant Capacity and Aroma Compounds in Strawberry Fruit*. Elsevier. Lebensm.-Wiss. u.-Technol. 37 (2004) 687–695
4. Winarno, F.G. 2002. *Codex dan SNI dalam Perdagangan Pangan Global*. Bogor: M-Brio Press.
5. Falah, M.A.F.F, Hurriin ,H., A.R.P.A. Dewi., Jumeri. (2016). Quality evaluation of fresh strawberry (*Fragaria* sp. cv. Earlybrite) during storage in a tropical environment. *AIP Conference Proceedings* 1755, 130003 <http://doi.org/10.1063/1.4958547>
6. Rahayu, E. Dan Widajati, E., 2007. *Pengaruh Kemasan, Kondisi Ruang Simpan dan Periode Simpan terhadap Viabilitas Benih Caisin*. *Jurnal Penelitian Pertanian. Buletin Agron.* (35) (3) 191 – 196 (2007). [2] Anonim 2. 2012. *Budidaya Pertanian: Stroberi. Menristek*. Jakarta: Bidang Pendayagunaan dan Pemasyarakatan Ilmu Pengetahuan dan Teknologi.
7. Roy, R. (1990). *A primer on the Taguchi method*. New York: Van Nostrand Reinhold.
8. Roy, R. (2001). *Design of experiments using the Taguchi approach: 16 steps to product and process improvement* (pp. 52–53). New York: John Wiley & Sons.
9. Vuchkov, I.N. and Boyadjieva, L.N. 2008. *Quality Improvement with Design of Experiments: A Response Surface Approach*. Kluwer Academic Publishers. Dordrecht
10. US Department of Agriculture, Agriculture Research Service. USDA national nutrient for standard references, release 23. Fruits and fruit juices; 2010, pp. 785–7. Available at: <http://www.ars.usda.gov/Services/docs.html.docid=8964>. Accessed on September 20, 2014

11. Omafra, 2013. *Cooling and Temperature Management for Strawberries*. Ontario Ministry of Agriculture and Food. Ontario.
12. Nurchasanah, 2008. *What is in your food: Rahasia Di Balik Makanan*. Bandung: Hayati Qualita.
13. Yulianah, Nurfitri. 2013. Beberapa Penyakit yang Menyerang Tanaman Stroberi. Diakses dari <http://yusufandriana.com/tag/penyakit-pada-tanaman-stroberi/>. Hari Senin, 3 Juni 2013 pukul 14.47 WIB.
14. Linke, Manfred and Martin Geyer. 2013. Condensation dynamics in plastic film packaging of fruit and vegetables. *Journal of Food Engineering* 116 (2013) 144–154.<http://dx.doi.org/10.1016/j.jfoodeng.2012.11.026>
15. Paull, R. E. , Effect of temperature and relative humidity on fresh commodity Quality. *Postharvest Biology and Technology*. 1999.15 : 263–277.



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-SCM-012-ID071

# Supply Chain Analysis of Local Beef in Malang, Indonesia

Retno Astuti <sup>1,\*</sup>, Sucipto <sup>1,2</sup> and Titik Prastiani <sup>1</sup>

<sup>1</sup> Department of Agroindustrial Technology, Faculty of Agricultural Technology, University of Brawijaya, Malang, Indonesia; retno\_astuti@ub.ac.id

<sup>2</sup> Halal-Qualified Industry Development, Malang, Indonesia; Ciptotip@ub.ac.id

\* Correspondence: retno\_astuti@ub.ac.id; Tel.: +62-812-3311-042

Received: 12 August 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** The price of beef at retailers and end consumers tend to rise due to a lot of members are involved in its supply chain. Several aspects that may affect the distribution process to the final consumer such as product flow, information flow, and financial flows should be considered for beef supply chain management. This study aimed to determine the supply chain map, function, and relationship between members in the supply chain of beef in Malang, Indonesia. The respondents in this study were three butchers with all their supply chain members. Descriptive analysis of the value chain was conducted using the six-step approach of value chain analysis with mapping of supply chain analysis using SCOR Level 2 method. The value chain analysis approach in this study was only conducted in 4 steps, i.e. engaging the chain, understanding the market, mapping the flows, and the identification of opportunities and challenges. The results showed that the speed of the supply chain in providing products to consumers and the agility of producers in responding to demand changes were perfect. The butchers should cooperate with cattle suppliers to improve the performance of the supply chain.

**Keywords:** beef; butcher; slaughterhouse; supply chain

---

## 1. Introduction

The Indonesian population is increasing almost in all region. The population of Malang City increased from 828,491 in 2011 to 851,298 people in 2015 [1]. The demand of products for the fulfillment of nutrition is also increasing along improvement of the living standard and the development of the Indonesian population. One of increasing food demand was beef as a source of animal protein [2]. National Socio-Economic Survey of the Ministry of Agriculture of the Republic of Indonesia (2016) showed that beef consumption per capita per year was fluctuating, but it tent to increase from 2010 to 2015. Beef consumption in Malang also contributed to the behavior of national beef consumption. Beef production in Malang had fluctuated from 2011 to 2015. Beef production declined from 4,165,767 kg in 2011 to 3,305,767 kg in 2015, meanwhile the prices tent to increase [3]. National Socio-Economic Survey of the Ministry of Agriculture of the Republic of Indonesia (2016) showed the price of beef feom 2011 to 2015 tent to increase by 9.58% from IDR 69,642 to IDR 104,326.

The highest of prices at retail and end-consumer levels due to the cost of adding value, transaction costs, actors' profits, shrinkage value, retribution, illegal fees, transportation costs and distribution channel efficiency. The arrangement of beef distribution channels is important due to a lot of stakeholders are involved in the beef supply chain [4]. The supply chain of beef needs to pay attention to several aspects affecting the beef distribution to the end consumer such as product flow, information flow and financial flow [5]. Therefore, the analysis of beef supply chain in Malang should be carried out.

Some researches of beef supply chain in Indonesia had been carried out with different aims. Author [6] analyzed value added analysis of beef cattle supply chain actors micro-scale community farm based on Regional Enterprise Slaughterhouse Makassar (RESM). Author [7,8] investigated how

beef producers can increase supply chain performance (SCP) flexibility by improving supply chain practices. Author [9] analyzed the supply chain of beef industry and the factors affecting meat prices in Indonesia. Author [10] improved the beef supply chain with the support of simulation model to assess the existing system and to develop some scenarios to improve the system performance. Author [11] improved the quality of beef in traditional markets by proposing a supply chain model that involves the schemes of investment and government incentive for improving the distribution system. Author [12] planned actions to control probability of halal risk in Indonesian beef supply chain. Author [13] described the supply chain management of imported frozen beef from Australia to Indonesia then determined the strategy of it based on the strengths, weaknesses, opportunities, and threats for the frozen meat distributor and analyzed alternatives of cooperation between imported frozen beef distribution with local beef distribution chain. Author [14] identified risk issues in Indonesian fresh meat supply chain from the farm until to the “plate”. All those researches had not considered the value chain.

A responsive value chain provides high service levels, short lead times, and a range of innovative products and quantities, whereas an efficient supply chain produces and supplies a smaller range of products at the lowest possible cost [15]. A value chain is focused on identifying and satisfying well-defined customer demands, whilst a supply chain is focused on logistical efficiency which is one component of value chain formation. The purpose of the value chain analysis is improving supply chain performance. The understanding of the product flows, information flows, as well as management and control in the value chain are required in this analysis [16]. Therefore, this research aimed to get the value chain map, function, and relationship between the members in beef supply chain in Malang.

## 2. Materials and Methods

The research was only focused on local beef. It was conducted at slaughter house of Malang Regional Company and traditional market of Malang. Survey was carried out related to the function and relationship between the value chain members and the number of members of supply chain, i.e. cattle ranchers as suppliers, butchers as processors, slaughter house of Malang Regional Company as service provider of processors, retailers, and consumers.

### 2.1. Value Chain Analysis

Author [17] developed value chain approach from six steps reported in the literature as follows:

1. Engaging the chain

The first and fundamental step of engaging the chain determines the way the chain members interact throughout the value chain analysis process.

2. Understanding the market

The importance of the end-user is recognized in the value chain analysis process by the inclusion of “understanding the market” as an early step. It is necessary for the industry to understand what it is that consumers value in the products and services they create and modify the business accordingly

3. Mapping the current state of the chain

The step of mapping the chain is a fundamental component of value chain analysis. The three elements that mapping covers are the flow of products, information and relationships [16]. Product flow requires the mapping of the physical flow of goods through the value chain. Information flow is a two-way process in the value chain. Information regarding the end-user (e.g. preferences, demand specifications and quality) can be transferred back along the chain to the producers, where the producers can then notify the market of supply and quality issues [17]. Relationship flow describes the way chain members relate to each other. The supply chain mapping process in this study used the Supply Chain Operations Reference (SCOR) Model level 2. Beef supply chain activities can be seen through the AS-IS Phase which is the current state of the chain. AS-IS modeling maps the current state of the plan, source, make, and deliver processes. Financial flows in the supply chain are also considered in this research.

#### 4. Identification of opportunities and challenges

Identification of opportunities for improvement at different stages was carried out through an analysis of product flows, information flows and relationships. Identification of such opportunities then can be an effective catalyst for change.

#### 5. Implementation

Once the opportunities and challenges have been identified, the chain members will need to select the areas that they would like to implement to achieve greater value. The actors of the chain must accept full responsibility for the implementation to ensure the commitment of the chain to the improvement process.

#### 6. Evaluation

The final step in the value chain analysis approach is an evaluation of the implemented opportunity, as well as an overall performance evaluation of the value chain approach by the value chain actors. This step has been included to provide feedback as a method for continuous improvement and also a measure of the value to the stakeholders of undertaking such a process.

Implementation and evaluation steps of value chain analysis were not carried out in this research due to limited time of research.

### 2.2. Performance Measurement

The identification of opportunities and challenges in value chain analysis was also supported with performance measurement which was done by referring to performance metrics of SCOR as follows [18]:

#### 1. Perfect Order Fulfillment

Perfect Order Fulfillment is the percentage of orders meeting delivery performance with complete and accurate documentation and no delivery damage or defects

#### 2. Order Fulfilment Cycle Time

Order Fulfilment Cycle Time is a continuous measurement defined as the amount of time from customer authorization of a sales order to the customer receipt of product.

#### 3. Upside Supply Chain Adaptability

Upside Supply Chain Adaptability is the maximum sustainable percentage increase in quantity delivered that can be achieved in 30 days

#### 4. Downside Supply Chain Adaptability

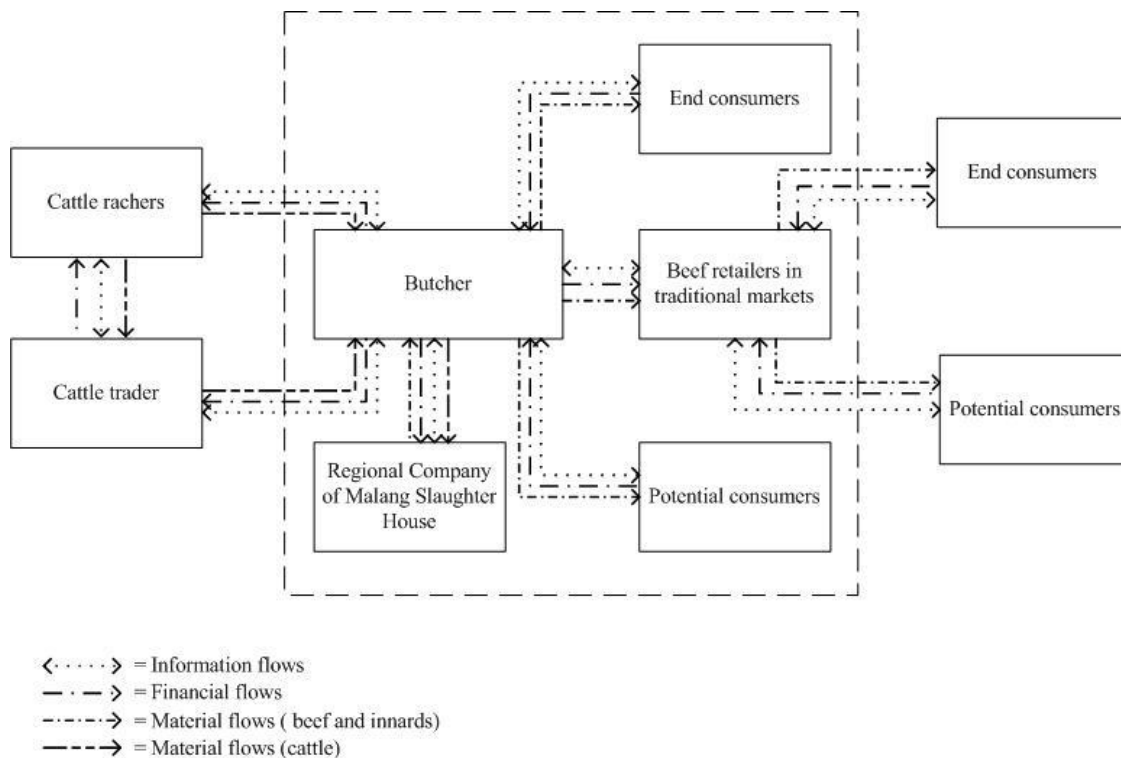
Downside Supply Chain Adaptability is the maximum percentage reduction in quantities ordered that can be sustained at 30 days prior to delivery with no inventory or cost penalties.

## 3. Results and Discussion

### 3.1. Supply Chain Structure

Supply chain structure is the composition of the activities or network of procurement of goods or services that work together and related to each other to create and distribute physical and non-physical products [19]. A supply chain consist of primary members who are directly involved with the products, secondary member who are not directly involved with the flow of product [20], and those who facilitate the activities of the supply chain in providing the raw materials required [21]. The primary members of the local beef supply chain in Malang are cattle ranchers and cattle sellers in traditional markets as cattle suppliers, butchers as suppliers of beef and its side products, beef retailers in the traditional markets of Malang, potential consumers (food sellers which use beef as raw materials of their products) and end consumers. The secondary member of the supply chain is slaughter house of Malang Regional Company as provider of animal slaughtering service. Some consumers buy the beef directly from the butchers and the others buy the beef at traditional market in Malang. The relationship between consumers and the sellers is only transactional relationship. Meanwhile, contractual relationship in this chain are between the butchers and the beef sellers in traditional markets as well as between the

butchers and the cattle sellers or cattle ranchers. The structure of supply chain of local beef in Malang is shown in Figure 1.



**Figure 1.** Structure of local beef supply chain in Malang.

This research only took 3 respondents of butchers who slaughtered animals at slaughter house of Malang Regional Company and sell beef in Malang. The respondents' identities in this study are shown in Table 1.

**Table 1.** The respondents of butchers

Type of service	Butcher 1	Butcher 2	Butcher 3
Gender	Man	Man	Man
Age	35 years	29 years	27 years
Last education	Primary school	Primary school	Bachelor degree
Main job	Butcher	Butcher	Butcher
Trading experience	17 years	8 year	4 year

Slaughter house of Malang Regional Company is a public company which provides animal slaughtering service in Malang. An animal should be examined for its health (ante mortem) by the animal farm officer from the Livestock Farming Service before being slaughtered. The cost of service in slaughter house of Malang Regional Company is shown in Table 2.

**Table 2.** The cost of cattle slaughter and cattle breeding in slaughter house of Malang Regional Company.

Type of service	Cost
The slaughter of cattle	IDR 49,500 / cattle
The slaughter of cattle at out of service hour (forced / emergency)	IDR 60,500 / cattle
Rent a cattle barn	IDR 10,000 / plot per day

The procedure of cattle slaughter in slaughter house of Malang Regional Company is justified according to Islamic Shari 'a. Implementation of cattle is done to create a SAFE, HEALTHY, WHOLE,



and HALAL beef so the slaughter is carried out by adopting Islamic law and supervised by a veterinarian or *keurmaster* officer. Supervision and execution of inspection is carried out before and after the slaughter then the beef is stamped with "GOOD city of Malang". The implementation of cattle slaughter is separated from the implementation of pig slaughter. It is also executed using different place, labor, and tools. Products of cattle slaughtered are separated into some categories, i.e. quality 1, beef quality 2, beef quality 3, side products, skin, legs, head and muzzle cattle. Physical quality of beef is based on National Standardization institutions on quality of carcass and beef [21].

### 3.2. Local Beef Value Chain Analysis in Malang

The value chain is all the activity to distribute the product or service from the starting point, through several stages of production, involving transformation activities and various service inputs, then delivering the product to the end consumer [22]. Value chain analysis is generally conducted to identify improvements in product quality and design that enable producers to gain more value on the product [23]. Analysis of the value chain model or condition is one of the first steps in conducting supply chain management analysis [24].

#### 3.2.1 Engaging the Chain

Members involved in supply chain 1 are a cattle seller as a cattle supplier, butcher 1 as a beef producer, and beef retailers in traditional markets. Members involved in supply chain 2 are a cattle seller as a cattle supplier, butcher 2 as a beef producer, beef retailers in traditional markets, potential consumers and end consumers. Members involved in supply chain 3 are a cattle rancher as a cattle supplier, butcher 3 as a beef producer, and beef retailers in traditional markets. The relationship between butcher 1 and butcher 2 with cattle sellers in the market is only a transactional relationship, meanwhile butcher 3 has contractual relationship with a cattle rancher. Transactional relationship occurs when a price agreement is established, then transactions are made and products move from producer to consumer [22]. The linkages between actors in the value chain can be formal and informal rules. Informal rules are without any written contract between actors. The agreement is based on trust, reliability and long-term relationships [23].

#### 3.2.2 Understanding the Market

Consumers are the central point of attention in the process of marketing a product. Understanding of consumer demand will lead producers to appropriate and efficient marketing policies. The consumers of beef and side product of slaughtered cattle are beef retailers in traditional markets, potential consumers and end consumers. Most potential consumers are meatball sellers. Consumers, products sold, the prices offered from each butcher is shown in Table 3.

**Table 3.** The consumers and products of the butcher.

Butcher	Consumers	Products	Price
1	Beef retailers in traditional markets	Beef quality 1	IDR 105,000/kg
		Beef quality 2	IDR 90,000 / kg
		Beef quality 3	IDR 85,000 / kg
		Cowhide	IDR 14,000 /kg
		Innards	IDR 32,000 / kg
		Head, legs, and muzzle	IDR 28,000 / kg
2	Beef retailers in traditional markets	Beef quality 1	IDR 105,000/kg
	Potential consumers	Beef quality 2	IDR 95,000 / kg
	End consumers	Beef quality 3	IDR 60,000 / kg
		Cowhide	IDR 15,000 / kg

**Table 3.** The consumers and products of the butcher (continued).

Butcher	Consumers	Products	Price
2	End consumers	Innards, head, legs, and muzzle	IDR 2,820,000 / cattle
3	Beef retailers in traditional markets	Beef	IDR 105,000 / kg
		Cowhide	IDR 13,500 / kg
		Innards, head, legs, and muzzle	IDR 4,380,000 / cattle

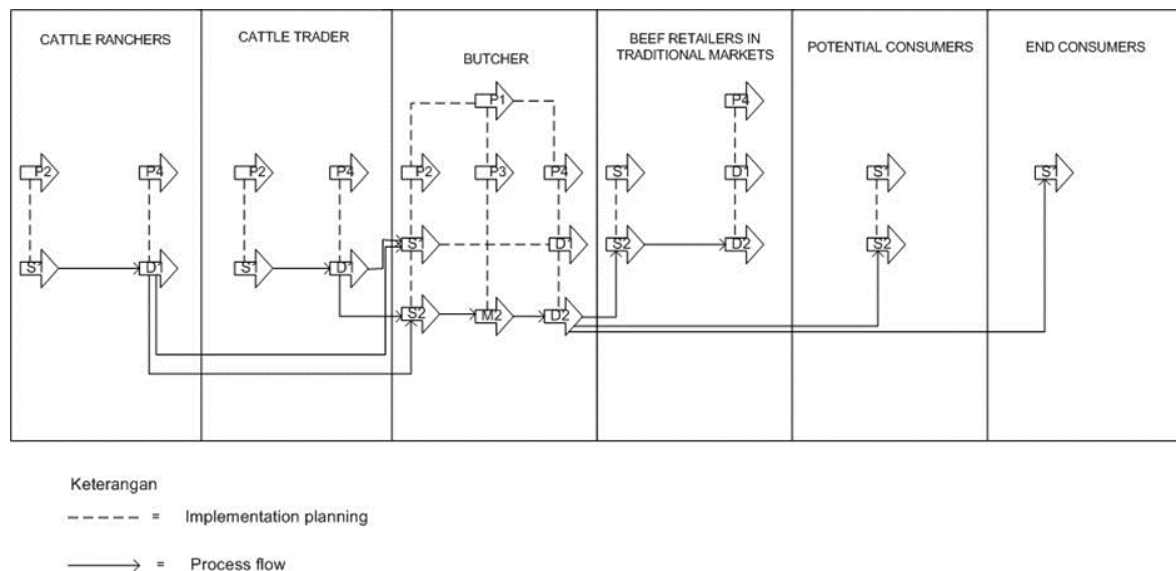
The types of products offered from the three butchers are different. Butcher 1 and 2 sell beef with different qualities, i.e. quality 1, quality 2 and quality 3. Prices offered are also slightly different. This is because the characteristics of beef sold are different although the definition of quality is the same. Quality 3 meat on butcher 1 is meat that still has more fat than quality 1 and 2, while beef quality 3 on butcher 2 is meat for soup. The target consumers of butcher 1 and 2 are also different so the prices for the same quality are also different.

### 3.2.3 Mapping the Flows

In the supply chain there are members directly or indirectly involved. The supply chain structure describes the related parties and their job as well as the flow of information, products and finances [25]. The flow of information relates to production capacity, delivery status and the number of raw material orders, and the number of product orders distributed to the market. The flow of information begins from the butchers that provides information about the needs of the cattle to be ordered. Supplier of cattle will provide information to the butcher related to the number, type of cattle, gender, weight and the price of cattle per kilogram or per cattle.

Information flows between the butcher and the part of slaughter house of Malang Regional Company begins when the butcher gives information to the slaughter house of Malang Regional Company that will entrust animals, will do the slaughtering of animals, and information related to the number of animals to be slaughtered and entrusted in slaughter house of Malang Regional Company. Slaughter house of Malang Regional Company will provide information regarding the availability of barn to rent, the fees to rent the barn, and the fees for slaughtering. Information flow between butchers and beef retailers in traditional markets begins from retailers providing information on the beef requirements to be ordered. Butcher provides information regarding the amount of beef available, the quality and price of beef. The buyer of cowhide provides information to the butcher related the cowhide needs to be ordered. Butcher provides information regarding the amount (in kg) of cowhide and the price per kg. Potential consumers inform the slaughter of the amount of beef to be ordered and the time for beef to be ready. Butcher will provide information regarding the amount of beef available, the price of meat and the time of order fulfillment. The end consumer informs to the butcher of the amount to be ordered and the time for the beef to be ready. Butcher provides information regarding the amount of beef available, the price of beef and the beef fulfillment time.

Material flow is the main raw material flow of cattle to the end consumers of beef. This will produce a product flow map, identifying each activity involved in the production, and where and how much inventory is held (Bonney and Fearn, 2009). Design of AS IS flow material based on data obtained from survey results and in depth interview can be seen in Figure 2.



**Figure 2.** Material flow of AS-IS condition

Financial flow is the movement of money between the members of beef supply chain. Financial flow in the beef supply chain in Malang is from downstream to upstream. The money flows from the butchers to the ranchers. The payment system is carried out in cash. The transaction will occur if there is an agreement and conformity of the cattle between ranchers and the butchers. The price per kilogram of cattle is determined by weighing the cattle directly in the ranchers' place. This also happen in the financial flows between cattle sellers and butchers where prices are determined by estimating the weight of cattle directly in the animal market. The money also flow from the butchers to slaughter house of Malang Regional Company as slaughter service provider. The butchers pay slaughter house of Malang Regional Company officer in cash for slaughtering and renting a barn (for butchers who do not have their own ranch at home). The butchers will get money from the beef retailers the day after the beef pickup from the butcher, meanwhile the butcher will get money from cowhide buyers in cash based on their agreement. Cash payment system is also done by potential consumers and end consumers when they buy beef from the butchers.

### 3.2.4 Identify Opportunities and Challenges

A complete mapping of a chain can put out many problems and opportunities for improvement. The flow value mapping model directly leads to the classification of problems related to physical flows and information flows [26]. Problems relating to material flows are the transactional relationship between cattle suppliers and butchers (on butchers 1 and 2) which makes the uncertain availability of cattle, uncertain demand (at slaughter 1, 2 and 3), and uncertain availability of beef due to unscheduled cattle slaughtering process. Problems relating to financial flows are uncertain profit and loss of the butchers due to the bulk purchase system of innards, the high cost of product sale, and uncertain cash flow due to the delayed payment system from beef retailers to the butchers. Problems related to the flow of information are the butchers have never forecasted their demand which makes problem in controlling the availability of the beef, the butchers have never made financial statements for controlling the cash flow, and unavailability of information about the demand of the consumers.

The improvement of the chain is also based on the performance measurement of the chain. Measurement of beef supply chain performance was done using SCOR Level 1 method. In SCOR model, performance attribute function determines supply chain characteristic and to describe supply chain strategy [27]. The metrics used to measure the chain performance are perfect order fulfillment, order fulfillment cycle-time, upside supply chain adaptability and downside supply chain adaptability. The performance of the butcher in local beef supply chain in Malang is showed in Table 4.

**Table 4.** Butcher performance

SCOR Metrics	Actual		
	Butcher 1	Butcher 2	Butcher 3
Perfect Order Fulfillment	100%	100%	100%
Order Fulfillment Cycle Time	1 day / 247,8 kg	1 day/200,7 kg	1 day / 363,3 kg
Upside Supply Chain Adaptability	100%	100%	100%
Downside Supply Chain Adaptability	100%	100%	100%

All butchers have the same performance for perfect order fulfillment, upside supply chain adaptability and downside supply chain adaptability. Butcher 3 has the highest performance for order fulfillment cycle time because butcher 3 has a contractual relationship with beef retailers in traditional market which makes butcher 3 has more predictable demand.

Overall, contractual relationship should be carried out by all butchers for improving the chain of their business, Contractual relationship between with the cattle ranchers and the butchers will guarantee the availability of cattle, meanwhile contractual relationship between the butchers and the consumers (especially the beef retailers in traditional market) will help the butchers to predict the demand of their products. The butchers also should not sell the side products in bulk which makes uncertain income for the butchers, meanwhile slaughtered cattle has a large part of side products which needs high cost to handle them. Selling product based on the quality grade per unit weight will be better both for the sellers and the buyers regarding the quality and the price. Cash payment system and managing the financial by recording the cash flow also should be considered by the members of the chain to improve their performance.

#### 4. Conclusion

Based on the results of the research, performance of local beef supply chain in Malang can be improved for improving their value chain. Clear and complete information is needed in communication between suppliers and butchers as well as between butchers and their consumers. The butchers as consumers of the cattle sellers / cattle ranchers should have information about the availability of cattle, types of cattle, cattle's weight, cattle's sex and cattle's physical condition from suppliers regularly. The butchers as suppliers also need regular information from retailers regarding the quantity and quality of beef and the side products. Meanwhile, regular information from the butchers to their consumers is necessary regarding availability, price, payment method and delivery method of beef and the side products. This strategies will help the members of the chain to decrease the unsold products due to miss-information between the members of the chain.

Cooperation or partnership between the members of the chain should be done to improve the performance of supply chain and value chain. Some scenarios of the coordination and partnership model can be analyzed in further research by simulating the local beef supply chain system in Malang using system dynamics.

#### References

1. East Java Statistical Centre, 2016, <https://jatim.bps.go.id/statictable/2016/04/29/330/jumlah-penduduk-dan-laju-pertumbuhan-penduduk-menurut-kabupaten-kota-di-provinsi-jawa-timur-2010-2014-dan-2015.html>
2. Ministry of Agriculture. Kementrian Pertanian Republik Indonesia. 2016. Basis Data Konsumsi Pangan Tahun 2010 2015. [https://aplikasi2.pertanian.go.id/konsumsi/tampil\\_susenas\\_kom2\\_th.php](https://aplikasi2.pertanian.go.id/konsumsi/tampil_susenas_kom2_th.php).) [15 Agustus 2016].
3. Animal Husbandry Office of East Java. (2016). Data Produksi Ternak Kabupaten/Kota di Jawa Timur. (<http://disnak.jatimprov.go.id/web/layananpublik/datastatistik> ) [17 Agustus 2016].
4. Sutardi, S.; Endang, B. Sediakan dan Hitung Stock Agar Tak Kehilangan Konsumen. Jakarta: Elex Media Komputndo, Jakarta, Indonesia, 2007.
5. Emhar A.; Joni, M.M.A.; Titin, A. (2014). Analisis Rantai Pasokan (Supplay Chain) Daging Sapi di Kabupaten Jember. Berkala Ilmiah Pertanian, 1(3), 53-61.

6. Hastang; Sirajuddin, S, N.; Mappangaja, A, R.; Darma, R.; Sudirman, I. Value Added Analysis Of Beef Cattle Supply Chain Actors Micro-Scale Community Farm Based. *American-Eurasian Journal Of Sustainable Agriculture* 2015, 9(7), 7-12.
7. Mappigau, P.; Hastang, Asnawi, A; Kadir, S. Improving Collaboration of Bali Cattle Supply Chain and Its Impact on Cattle Farmer Income in South Sulawesi, Indonesia. *Arabian J Bus Manag Review*, 2015 5(150)
8. Jie, F.; Parton, K. A.; Mustafid. Supply chain performance flexibility in the Australian beef industry, 2016. *International Journal of Logistics Research and Applications A Leading Journal of Supply Chain Management* 19 (4), <https://doi.org/10.1080/13675567.2015.1075477>
9. Setiaji, B.; Susila, I.; Wahyudi, H, D. Supply Chain of the Beef Market in Indonesia. *Expert Journal of Business and Management* 2017, 5(2), 129-135.
10. Suryani, E.; Hendrawan, R, A.; Muhandhis, I.; Dewi, L. P. Dynamic Simulation Model Of Beef Supply Chain To Fulfill National Demand. *Jurnal Teknologi*, 2016, 78:(9) 169–177
11. Lupita, A.; Rangkuti, S, H.; Sutopo, W.; Hisjam, M. A supply chain model to improve the beef quality distribution using investment analysis: A case study. *AIP Conference Proceedings* 1902, 020003 (2017); <https://doi.org/10.1063/1.5010620>
12. Maman, U.; Mahbubi, A.; Jie, F.; Strategic Planning to Control Halal Risk in Indonesian Beef Supply Chain. *International Business Management* 2017, 11, 1246-1253 doi: 10.3923/ibm.2017.1246.1253
13. Rakhmat, S.; Zaiul, A.; Yusri, A. Supply Chain Management of Imported Frozen Beef: An Alternative To Integrate With Local Beef Supply Chain Management. *RJOAS*, 2017, 12(72), 260-267, doi <https://doi.org/10.18551/rjoas.2017-12.36>
14. Wahyuni, H, C.; Vanany, I.; Ciptomulyono, U. Identifying risk event in Indonesian fresh meat supply chain. *International Conference on Industrial and System Engineering (IconISE)*, 2017, 1-6 doi:10.1088/1757-899X/337/1/012031 2017
15. Chopra, S.; Meindl, P., *Supply Chain Management: Strategy, Planning and Operations*, 5th ed. Pearson Education Inc., Upper Saddle River, New Jersey, USA, 2013.
16. Fearn. 2009. *The Fearn Report: Sustainable Food and Wine Value Chains – Opportunity or Imperative for Australian Agrifood and Wine?* Government of South Australia, Adelaide
17. Howieson, J; Lawley, M; Hastings, K. (2016). Value Chain Analysis: An Iterative and Relational Approach for Agri-Food Chains. *Supply Chain Management an International Journal* 2016, 21 (3), 352-362, <tps://doi.org/10.1108/SCM-06-2015-0220>
18. APICS, 2017 [https://www.apics.org/docs/default-source/scc-non-research/apicsscc\\_scor\\_quick\\_reference\\_guide.pdf](https://www.apics.org/docs/default-source/scc-non-research/apicsscc_scor_quick_reference_guide.pdf)
19. Maulani, F.; Akhmad, S.; Bambang, I. Analisis Struktur Rantai Pasok Konstruksi pada Pekerjaan Jembatan. *Jurnal Rekayasa Sipil* 2014, 10(2), 1-8, <https://doi.org/10.25077/jrs.10.2.1-8.2014>.
20. Rizqiyah, I.A.; Imam, S. Risiko Rantai Pasok Agroindustri Salak Menggunakan Fuzzy FMEA. *Jurnal Manajemen dan Agribisnis*, 2017, 14(1), 1-11, <http://dx.doi.org/10.17358/jma.14.1.1>.
21. National Standardization Institution. (2008). Mutu Karkas dan Daging Sapi. SNI:3932:2008.
22. Yoga, S.I.W.G.; Dewa, A.A.Y. Karakteristik Rantai Nilai Rumput Laut di Kabupaten Klungkung. *Jurnal Ilmiah Teknologi Pertanian* 2016, 1(1), 28-31.
23. Rosales, R.M.; Pomeroy, R.; Calabio, I.J.; Batong, M.; Cedo, K.; Escara, N.; Facunla, V.; Gulayan, A.; Narvadez, M.; Sarahadil, M.; Sobrevega, M.A. Value chain analysis and small-scale fisheries management, *Marine Policy*, 2017, 83, 11-21, <http://dx.doi.org/10.1016/j.marpol.2017.05.023>
24. Jannah, Z.R.; Hariadi, S.; Hari, R. Optimalisasi Kinerja Rantai Pasokan Dan Rantai Nilai Tembakau Kasturi (Voor Oogst) di Kabupaten Jember. *Jurnal Teknologi Pertanian* 2015, 16 (1), 51-64.
25. Astuti R.; Marimin, M.; Roedy, P.; Machfud, M. Kebutuhan dan Struktur Kelembagaan Rantai Pasok Buah Manggis Studi Kasus Rantai Pasok Di Kabupaten. *Business Management Journal* 2012, 3(1), 99-112.
26. Taylor, H.D. Value Chain Analysis: an Approach to Supply Chain Improvement in Agri-Food Chains. *International Journal of Physical Distribution and Logistic Management* 2005, 35(10), 744-761, <https://doi.org/10.1108/09600030510634599>
27. Medzona, P.A.J. Analytical Hierarchy Process And SCOR Model To Support Supply Chain Re-Design. *International Journal of Information Management* 2014, 34(5), 634-638, <https://doi.org/10.1016/j.ijinfomgt.2014.06.002>



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

FP-SCM-006-ID040

# Analysis of Supply Chain Institutions to the Performance and Competitiveness of Tempeh Chips SMEs Cluster in Sanan, Malang

Siti Asmaul Mustaniroh<sup>1\*</sup>, Rizky LR Silalahi<sup>2</sup> and Adinda Wardhani<sup>3</sup>

<sup>1</sup> Universitas Brawijaya; [asmaul\\_m@yahoo.com](mailto:asmaul_m@yahoo.com)

<sup>2</sup> Universitas Brawijaya; [rizkyrls@ub.ac.id](mailto:rizkyrls@ub.ac.id)

<sup>3</sup> Alumnae Universitas Brawijaya; [wardhanidr@gmail.com](mailto:wardhanidr@gmail.com)

\* Correspondence: [asmaul\\_m@yahoo.com](mailto:asmaul_m@yahoo.com); Tel.: +62-815-557-279-88

Received: 4 August 2018; Accepted: 25 August 2019; Published: 6 January 2020

**Abstract:** Tempe Chips SMEs in Sanan is one of featured culinary destination in Malang. Currently performance of Tempe Chips SMEs in Sanan has not been optimized. The first obstacle is the absence of proper raw material control and limited market access that causes SMEs have low performance and competitiveness. Therefore, there needs to be an active role of supply chain institutions to improve the performance and competitiveness of SMEs. The purposes of this study are to determine the linkage (influence) of supply chain institutions on the performance and competitiveness of SMEs and the linkage (influence) of performance on the competitiveness of SMEs. The approach used to analyze is GSCA (Generalized Structured Component Analysis) by purposive sampling method for 34 respondents. The variables object are supply chain institutions, business performance and competitiveness. The result shows that there is significance influence of supply chain institutions to performance of SMEs, the relationship between supply chain institutions to the competitiveness of SMEs, business performance with competitiveness of SMEs. There's partial influence of performance on mediating relationship between supply chains institutions and competitiveness. The improvement of innovation is needed for SMEs to high competitiveness.

**Keywords:** Supply Chain Institution, Performance, Competitiveness

---

## 1. Introduction

Micro, Small and Medium Enterprises (SMEs) have a key role as a safeguard for the national economy, this can be seen from the contribution of SMEs to the national Gross Domestic Product (GDP) of 60.34% while the rest is contributed by large business sectors. The data from the Ministry of Cooperatives and SMEs also shows that growth of SMEs in 2013 increased by 2.41% while large-scale businesses only experienced an increase of 1.97% [1]. About 70% of the concentration of SMEs in Java is in the provinces of Central Java, West Java and East Java. Based on the data from [2], Central Java has the highest number of SMEs around 33.76%, followed by West Java having around 20.62%, then East Java with 17.55% of SMEs. The high number of SMEs is in line with the economic growth in these regions [3].

Malang is one of the cities in East Java which has the potential to become a broad market share, based on the data from [4] of Malang City showing a figure of 38.05% in the sector of purchasing goods and services by households. Malang City is an area in the East Java region having several agroindustry products, among of which the one which is superior is tempeh(bean cake) chips. One of the SMEs known as tempehchips producer is located in the center of Sanan tempeh industry. Based on the data from the Department of Industry [5] of Malang City, there are 72 SMEs which produce tempeh chips in Sanan, but currently there are 18 SMEs actively operating. When viewed from the business scale, tempeh industry center in Sanan is dominated by micro-scale businesses, productive businesses owned by individuals and operated individually. This causes in SMEs performance to be less optimal;

therefore, in the previous research the cluster formation was formed to develop strategies which match the characteristics of each cluster based on several indicator considerations: production capacity per month, length of operation, average monthly sales, investment value and the number of workers [6].

Cluster formation alone is not enough to optimize the potential of SMEs if they are not supported by good supply chain management. At present, the performance of Sanan tempeh chips producers is not optimal due to several constraints. One of the obstacles challenged by SME chips producers in Sanan is the absence of good control of raw materials; hence, when raw materials are difficult to obtain, the owners of SMEs must pay more to meet production needs. This condition causes decreasing turnover of tempeh chips SMEs in Sanan by an average of 40% [7]. Limited market access becomes another problem causing tempeh chips SMEs in Sanan to only be able to distribute the final product with the same distribution area from year to year. This condition shows that supply chain management, especially for SMEs, is very necessary for business survival because of the increasingly competitive demands of competition [8]. These problems can be overcome, by activating the role of supply chain institutionalization as one of the solutions.

Supply chain institutions are a form of continuous existing interaction in a supply chain management. Supply chain institutions essentially analyze the relationship of vertical interactions between actors in the supply chain [9]. Supply chain institutions consist of governments, suppliers and retailers. The form of institutional support which can be provided can be in the form of providing loan assistance programs, training and trade shows. If supply chain institutions work optimally, the performance of SME is also expected to increase [10]. Increased performance will increase the business capability of a company in the industry to deal with various conditions in its environment. This ability is called competitiveness which is very important for MSMEs in order to strengthen market share [11].

A chosen method which can be used to analyze the factors influencing the performance and competitiveness of tempeh chips producers in Sanan is Generalized Structured Component Analysis (GSCA) method. GSCA is one analysis of component-based structural equation models using the least squares method. GSCA is a powerful analytical method because it is not based on many assumptions, the data does not have to be normally distributed, the sample does not have to be in large quantities, and can be used to explain the relationship between latent variables [12]. The advantage of the GSCA method compared to the Partial Least Square (PLS) method suggests this method equipped with the overall least square optimization criteria and still maintains local optimization procedures [13]. The purpose of this study is to analyze the influence of supply chain institutions on business performance and competitiveness, the effect of performance on business competitiveness and the effect of performance in mediating the relationship between supply chain institutions and business competitiveness.

## 2. Materials and Methods

This research was carried out at tempeh SMEs center in Sanan, Malang City. The sample in this study consists of 9 SMEs with a total of 34 respondents consisting of SMEs owners and employees who were selected by purposive sampling method. The criteria for selecting respondents are a minimum of 2 years of service. The variables used in this study are exogenous variables namely supply chain institutions (X) and endogenous variables namely performance ( $Y_1$ ) and the competitiveness of SMEs ( $Y_2$ ).

The indicators of supply chain institutions include trust, commitment, communication and partnership. The indicators of performance cover production capacity, production sales and profits. The indicators of competitiveness comprise of human resources, product innovation and market access.

Data analysis in this study consists of descriptive analysis namely validity test, reliability test, and linearity test. The data which has been collected will be analyzed utilizing of GSCA software.



### 3. Results and Discussion

#### 3.1. General Description of Sanan Tempeh Chips MSME sCluster

Malang City is one of the cities in East Java province with the relatively good development of business units. Business units in Malang City are dominated by micro, small and medium enterprises (SMEs) [14]. Based on the data obtained from the Department of Industry of Malang City, the number of SMEs in Malang City in 2014 was 249 SMEs. One of the biggest SMEs centers in Malang City is Sanan Center for tempeh chips SMEs. Until 2013, there were 46 tempeh chips craftsmen involving 210 workers, but currently there are only 18 tempeh chips producers.

**Table 1.** Profile of Sanan for SMEs Tempeh Chips

SMEs	Capacity of production (Kg/month)	Time of production (year)	Amount of Labor
Purnama	3500	28	6
Deny	2700	19	9
Amangtiwi	1000	11	3
Amel	3000	13	11
Sri Bawon	2500	32	6
Arin	3000	6	7
Karina	3000	20	5
Putra	3900	17	12
Ridho			
Delima	900	17	4

Source : Analysis Data (2017)

In the study conducted by [6], a grouping of 9 tempeh chips SMEs in Sanan, Malang was conducted using the K-means clustering method into 2 SMEs clusters based on the variable production capacity, the duration of establishment of SMEs, average sales, initial investment and the number of workers. Cluster 1 is a tempeh chips SMEs which belong to the classification of micro businesses with members from Amangtiwi and Delima SMEs. Cluster 2 is a tempeh chips SMEs which belong to the classification of small businesses consisting members of Purnama, Deny, Amel, Sri Bawon, Arin, Karina and Putra Ridho SMEs. After clustering based on production capacity, duration of operation, the number of workers and initial investment, 9 SMEs have been utilized as objects of research presented in Table 1. The production process in the Sanan SMEs tempeh chips center is still considered as conventional by relying on manual production tools. The production capacity of most tempeh chips SMEs in Sanan is fluctuating by relying on customer driven sales, showing dependency on consumer demand. The micro-scale business can be seen from capital funding sources, most of which come from personal funds and the number of human resources which are not more than 20 people per SMEs.

#### 3.2. Testing Results of Research Instruments

An item is declared as valid if meeting the criteria for testing validity, having Pearson correlation coefficient value  $> r_{table}$ . The test results show that the correlation of the indicators of each variable has a value above the  $r_{table}$  value of 0.339 so that all indicators examined can be affirmed as valid. The instrument has good reliability if the value of Cronbach's Alpha  $> 0.6$ . The test results show the value of Cronbach's Alpha  $> 0.6$ , it can be said that the research instrument has good reliability. Two variables have a linearity relationship if the value of deviation from linearity is  $> 0.05$ . Linearity test results show that the deviation from linearity value has met the requirements; hence, it can be said that all variables have a linear relationship.

A mathematical measurement model presenting the relationship between the variables and indicators studied is as follows:

50) Structural Model Equation:

$$Y_1 = 0,824X$$

$$Y_2 = 0,382X + 0,634Y_1$$

51) Variable of Supply Chain Institution (X)

- Indicator of Trust ( $X_1$ )

$$X_{11} = 0,526X_1 + 0,247$$

$$X_{12} = 0,344X_1 + 0,265$$

- Indicator of Commitment ( $X_2$ )

$$X_{21} = 0,046X_1 + 0,150$$

$$X_{22} = 0,368X_1 + 0,227$$

- Indicator of Communication ( $X_3$ )

$$X_{31} = 0,294X_1 + 0,197$$

$$X_{32} = 0,180X_1 + 0,293$$

- Indicator of Relationship ( $X_4$ )

$$X_{41} = 0,296X_1 + 0,235$$

$$X_{42} = 0,194X_1 + 0,179$$

52) Variable of Business Performance ( $Y_1$ )

- Indicator of production capacity ( $Y_{11}$ )

$$Y_{111} = 0,745Y_1 + 0,107$$

$$Y_{112} = 0,802Y_1 + 0,080$$

- Indicator of product sales ( $Y_{12}$ )

$$Y_{121} = 0,674Y_1 + 0,137$$

$$Y_{122} = 0,800Y_1 + 0,066$$

- Indicator of profit ( $Y_{13}$ )

$$Y_{131} = 0,833Y_1 + 0,103$$

$$Y_{132} = 0,729Y_1 + 0,125$$

53) Variable of Competitiveness ( $Y_2$ )

- Indicator of labor ( $Y_{21}$ )

$$Y_{21} = 0,780Y_2 + 0,097$$

- Indicator of product innovation ( $Y_{22}$ )

$$Y_{221} = 0,834Y_2 + 0,074$$

$$Y_{222} = 0,855Y_2 + 0,089$$

- Indicator of market share ( $Y_{23}$ )

$$Y_{23} = 0,668Y_2 + 0,139$$

54) Variable of business performance ( $Y_1$ ) as mediator variable

$$Y_2 = 0,382X + 0,884Y_1.$$

In mathematical model, the estimation value shows the relationship between variables. Estimation value with a positive sign states that the relationship is directly proportional (Ristiano, 2016), which means that the higher the X variable, the higher the Y variable and vice versa for the value with a negative sign. In the mathematical model, it can be seen that the supply chain institution variable (X) has a positive value on performance ( $Y_1$ ) and competitiveness ( $Y_2$ ) as well as the performance variable ( $Y_1$ ) on competitiveness ( $Y_2$ ).

This study employs a measurement model which is reflective and formative. Measure of Fit in the reflective indicator model is based on the value of loading estimate, while the formative indicator model is based on the value of weight estimate. Formative indicators are said to be valid if significant at 5% [12]. Therefore, if the formative construct indicator has a CR value of  $> 1.96$ , then the indicator is valid.

1) Supply Chain Institution (X)

Supply chain institutional variables are formative variables. Formative variables are based on the value of weight estimate. The results of output measurement model of institution variables are presented in Table 2.

**Table 2.** Measurement Results of Supply Chain Institution Variable Models

Symbol	Weight Estimate	Average
<b>X</b>	<b>AVE = 0.000, Alpha =0.838</b>	
<b>X<sub>11</sub></b>	<b>0,526</b>	<b>4</b>
<b>X<sub>12</sub></b>	0,344	4.03
<b>X<sub>21</sub></b>	0,046	3.65
<b>X<sub>22</sub></b>	0,368	3.12
<b>X<sub>31</sub></b>	0,294	3,24
<b>X<sub>32</sub></b>	0,180	3.18
<b>X<sub>41</sub></b>	0,296	3.24
<b>X<sub>42</sub></b>	0,194	<b>4.06</b>

Source : Analysis Data (2017)

Based on Table 2 that X<sub>11</sub> is most described for support supply chain institutions with value 0,526. The responden assesment that X<sub>42</sub> is suitable for explain and influence in supply chain institution. it must integration to optimize and effectivity supply chain intitutions. Real conditions in SMEs show that in certain seasons SMEs still need to find other suppliers because the partner suppliers are unable to meet their production needs. This condition often occurs during the rainy season because tempe suppliers experience problems in producing tempeh due to humidity in the rainy season. Problems faced by tempe suppliers caused constrained supply of raw materials, so that MSMEs were forced to look for other tempe suppliers. The trust of SMEs towards retailers has been established well because all this time retailers have been very helpful to MSMEs in marketing tempe chips. According to Marimin and Maghfiroh (2010)[35] trust building built in the supply chain can create a strong supply chain. Kwon and Taewon (2004)[36] also mentioned that success in supply chain comes from the high value of strong trust between partners in the supply chain.

In the result of outer model for the commitment indicator (X<sub>2</sub>), the statement X<sub>22</sub> item obtains the largest weigh estimate value of 0.368, so that X<sub>22</sub> item becomes the most influential item on the commitment indicator. The respondents' responses showed a mismatch, X<sub>21</sub> item obtained a greater average of 3.65. The actual conditions in the field indicate that the tempeh supplier has made a commitment to do so by making timely deliveries, providing inter-service delivery and procuring a return policy. The higher the commitment which can be built by both suppliers and distributors will strengthen the cooperative relationship built [15].

In the communication indicator (X<sub>3</sub>), X<sub>31</sub> item obtained the largest weight estimate value of 0.294 so that X<sub>31</sub> item becomes the most contributing item to X<sub>3</sub> indicator. This has been in accordance with the responses of respondents seen from the mean value of 3.24. The real conditions in the field, the communication between SMEs and suppliers is connected directly or indirectly (short messages and telephone). Direct communication is carried out every day because tempeh purchaseactivity is carried outin daily basis. The existence of good communication indicates the smooth flow of information between SMEs and tempeh suppliers. According to [16], partners in the supply chain can maintain sustainable relationships and reduce uncertainty in a collaboration system.

## 2) Business Performance (Y<sub>1</sub>)

Business performance variables are reflective variables. Formative variables are based on the value of loading estimate. The results of output measurement model of institution variables are presented in Table 3.

**Table 3.** Measurement Results of Variable Model of SMEs Performance

Symbol	Loading Estimate	Average
<b>Y<sub>1</sub></b>	<b>AVE = 0,586 Alpha = 0,857</b>	
Y <sub>111</sub>	0,745	3,38
Y <sub>112</sub>	0,802	3,47
Y <sub>121</sub>	0,674	3,56
Y <sub>122</sub>	0,800	<b>3,79</b>
Y <sub>131</sub>	<b>0,833</b>	3,50
Y <sub>132</sub>	0,729	3,56

Source : Analysis Data (2017)

Based on the outer model in Table 3, the largest loading estimate value in the production capacity indicator (Y<sub>11</sub>) obtained by Y<sub>112</sub> item is 0.802. These results indicate that Y<sub>112</sub> item becomes the most describing item to production capacity indicator; thus, the production capacity is able to describe the business performance of 0.802. This value is in accordance with the respondent's response when viewed from the mean gain of 3.47. Based on the respondents' responses, the monthly production capacity increased due to good retailer performance. This result is supported by Avery's research [17] stating that institutional relations have a significant effect on improving the company's operating performance both as a provider of physical and information goods.

In the product sales indicator (Y<sub>12</sub>) the largest loading estimate value is obtained by Y<sub>12</sub> item of 0.800. therefore, Y<sub>12</sub> item is the most describing item to product sales indicator. These results indicate that product sales are able to describe the business performance of 0.800. This value is supported by the respondent's response of 3.79. The respondents' responses stated that product sales increased due to the performance of retailers. Kotler [18] stated that sales performance depends on good relations among various parties including retailers in providing the best values for the target customers. This is common because retailers function as marketing tools owned by SMEs, so product sales depend on the performance of retailers as market access holders.

Table 3 presents the highest acquisition of loading estimate value obtained by Y<sub>131</sub> item. Y<sub>131</sub> item illustrates the effect of raw material supplier performance on increasing profits. The estimate item value is the biggest of all items, accounted by 0.833. These results indicate that item Y<sub>131</sub> is the most appropriate descriptor to business performance variables, according to the opinion of [19] which states profit growth becoming one of indicators of performance measurement. Profit growth is the end result of increasing sales value, sales growth and market share [20]. The mean value that is owned by Y<sub>131</sub> item based on the results of the questionnaire is 3.5. The acquisition of the mean value of Y<sub>131</sub> indicates that the increase in profitability is adequate but needs improvement. SMEs stated that the constraints faced by suppliers today are the instability of raw material supply both in terms of quantity and quality. If one supplier still cannot meet the production needs of SMEs, it is necessary to add suppliers to ensure the stability of raw material supply.

### 3) Competitiveness (Y<sub>2</sub>)

Competitiveness variables are reflective variables. Formative variables are based on the loading estimate value. The results of output measurement model of competitiveness variables can be seen in Table 4.

**Table 4.** Measurement Results of Variable Models of SMEs Competitiveness

Symbol	Loading Estimate	Average
<b>Y<sub>2</sub></b>	<b>AVE = 0,628 Alpha = 0,800</b>	
Y <sub>21</sub>	0,780	3,09
Y <sub>221</sub>	0,834	3,53
Y <sub>222</sub>	<b>0,855</b>	3,50
Y <sub>23</sub>	0,668	<b>3,56</b>

Source : Analysis Data (2017)

Table 4 suggests that  $Y_{222}$  item is the best descriptor to business competitiveness variable, this is proven by the loading estimate value of  $Y_{222}$  being equal to 0.855. Based on these values, it can be interpreted that innovation in the production process is an item in improving business competitiveness. In actual conditions,  $Y_{222}$  item has an average value of 3.5, this value is low compared to the average value of other items. tempeh chips SMEs in Sanando not maximize in conducting innovating especially in the production process. This is in line with Tambunan's [21] statement which states that almost all factors of production in Indonesia's SMEs are currently saturated, so there is a need for innovation for the development of SMEs centers in the future. MSMEs can increase innovation in terms of production with the help of public-private partnerships. Based on the publication by Bank Indonesia [22], public-private partnership (private and public - government cooperation) is needed to encourage and assist the development of SMEs competitiveness.

The goodness of fit value of the model is examined through the FIT and AFIT values. Fit describes the diversity of the total variables which can be explained by all variables in the overall model. The results of the fit model test are presented in Table 5.

**Table 5.** Structural Fit Models

Criteria	Model of Structural
FIT	0,589
AFIT	0,567
NPAR	31

Based on these outputs, the FIT value obtained is equal to 0.589. FIT and AFIT values range from 0 to 1, the closer to 1 then the value is considered to be good [23]. This value means that the model formed can explain 58.9% variation of data, so that it can be said that this research has a good model accuracy. This study employs only one model so that the AFIT value functions identical with FIT value. The AFIT value in this study is 0.567. This value means that the model formed can explain 56.7% variation of data. NPAR (Number of Free Parameters Estimate) shows the number of load parameters used in this study. In this model, there are 31 estimated parameters.

### 3.3. Results of Hypothesis Testing

Hypothesis testing is completed with examining the value in the path coefficients in the structural model. Hypothesis testing is based on the measure of fit model by looking at the significance of the Critical Ratio (CR) value. The completed results are presented in Table 6.

**Table 6.** Structural Model of Measure of Fit

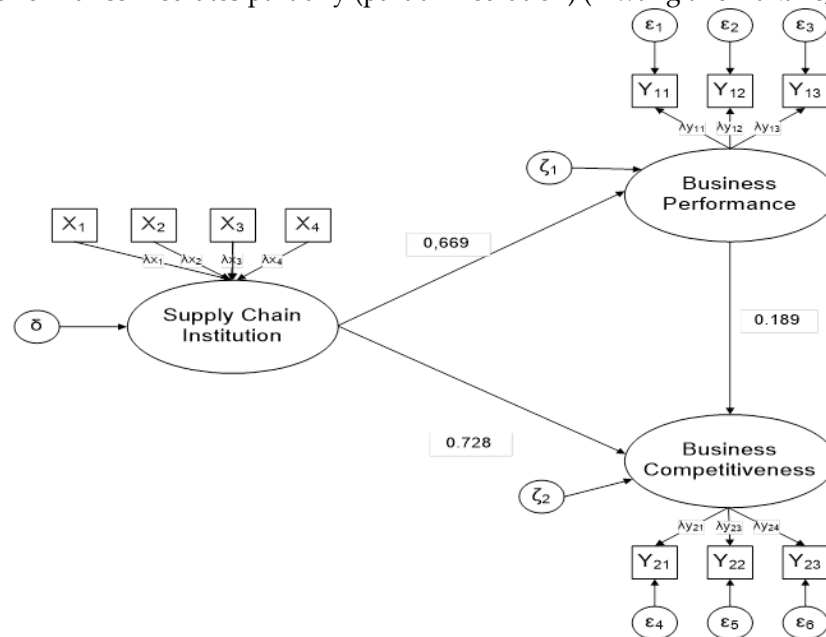
	Path Coefficient		
	Estimate	SE	CR
Supply Chain Institution -> Business Performance	0,824	0,04	19,1*
Supply Chain Institution -> Competitiveness	0,382	0,114	3,36*
Business Performance -> Competitiveness	0,634	0,116	5,46*

Source : Analysis Data (2017)

**Table 7.** Hypothesis Table of Indirect Influence

	Indirect Influence	Patch Coefficient			Amount
		X->Y <sub>1</sub> (a)	Y <sub>1</sub> ->Y <sub>2</sub> (b)	X->Y <sub>2</sub> (c)	c + (axb)
H4	X->Y <sub>1</sub> ->Y <sub>2</sub>	0,824	0,634	0,362	0,884

The test results prove that the direct influence of supply chain (X) on competitiveness ( $Y_2$ ) is significant with a path coefficient value of 0.362, while the influence of supply chain (X) on competitiveness ( $Y_2$ ) through performance ( $Y_1$ ) is also significant with the path coefficient of 0.884. The supply chain institutional path coefficient (X) on competitiveness ( $Y_2$ ) through performance ( $Y_1$ ) has a greater value than the direct influence, so hypothesis 4 is accepted. The results of this greater total value indicate that performance mediates partially (partial mediation) (Hwang and Takane, 2004).



**Figure 1.** Path Coefficient Value of Structural Model

#### 1) Effect of Supply Chain Institutionalization on SME Performance

Based on the results of data processing, the supply chain institutional path coefficient value for business performance is 0.824 and the CR (Critical Ratio) value is 19.1. This value is stated to be significant at 0.05. Rejection of  $H_0$  causes acceptance of alternative hypotheses which means that supply chain institutions have a significant influence on business performance. This result is supported by Avery's research [17] which states that institutional relations have a significant effect on improving the company's operating performance both as a provider of physical and information goods. Pradabwong et al. [24] also stated that supply chain institutions have an influence on the company's performance with partnership mediation. Tempeh chips SMEs in Sanan have a good relationship of trust to their raw material suppliers, tempeh suppliers; however, based on the observations in the field, tempeh suppliers have not worked optimally hampering the performance of MSMEs. The MSMEs stated that one of the obstacles faced was uncertainty in raw material acquisition during rainy season. Tempeh suppliers claimed that it was difficult to meet the needs of SMEs during rainy season driven by low quality of tempeh produced, even the weather may force tempeh producers to stop production temporarily. Yusniaji and Erni [25] argue that the constraints in raw material inventory would disrupt production activities and would have an impact on the decline in company performance; therefore, decisions regarding the supply of raw materials are very important to do.

Good raw material planning requires sufficient managerial skills. SMEs can obtain managerial skills by participating in programs held by the government. Examples of existing recent programs are financial bookkeeping training programs, collaborative programs between government agencies and educational institutions in order to improve the quality of human resources in SMEs. Research by Abdullahi et al., [26] also said that there was a positive and significant influence of training on SMEs business performance. Through training, SMEs owners and SMEs employees can add knowledge, skills and experience to improve the overall performance of SMEs.

## 2) Effect of Supply Chain Institutionalization on SMEs Competitiveness

The path coefficient value of the supply chain institutions on business competitiveness is 0.382. Moreover, the CR value of 3.36 indicates a significant influence on the 95% significance level. Based on these results, it can be interpreted that supply chain institutions have a significant influence on business competitiveness. The results of testing these hypotheses are in accordance with research conducted by Jakfar et al [27] stating that cooperation activities between institutions in the supply chain will be a sustainable competitive advantage for all organizations in the supply chain. Institutions in the supply chain system determine the volume of supply, profits and added value formed. The results of testing hypotheses are also strengthened by [28] research stating that there is a clear relationship between companies and suppliers as part of the supply chain in determining the position of companies in market competition. Based on the results of field observations and previous data processing, it is known that tempeh chips SMEs in Sanan have good trust in their raw material suppliers, tempeh suppliers. This is a good indication because according to Sumarwan et al. [29] trust between supply chain institutions are two dominant aspects underlying the emergence of cooperation, competitiveness and guarantee of financial benefits. Although the results of field observations show a good relationship between tempeh suppliers and tempeh chips, there were still several other aspects that could be optimized to improve the competitiveness of tempeh chips.

In real condition, most SMEs stated that they only work with one retailer, even some SMEs said they do not use the services of retailers and only rely on orders from end consumers. Moreover, their awareness to cooperate with government agencies is still relatively low. This is very unfortunate, because by cooperating with the right institutions such as government, SMEs can participate in coaching and exhibition programs as provisions to access a wider market. The participation of SMEs in coaching and training programs can also improve the overall performance of SMEs. According to [30], if the performance of SMEs including technical and operational capabilities has reached multinational standards, SMEs can be involved in Global Value Chain (GVC). GVC is basically a system facilitating collaboration between SMEs actors and multinational companies which generally have much better market access, technology and information networks. The lack of SMEs production scale, high transaction costs and limited information and technology networks as obstacles to the growth of SMEs competitiveness can be eliminated by involving SMEs [31].

## 3) Effect of Relationship between Business Performance on Competitiveness

Based on the results of hypothesis testing, it can be seen that the path coefficient of business performance on competitiveness is 0.634, having CR value of  $5.46 > 1.96$  meaning that the value is significantly positive at 0.05. This value indicates that business performance has a significant influence on business competitiveness. The results of testing this hypothesis are similar to the results of Handriani's [32] study stating that there is a positive influence on the performance variables on the competitiveness of SMEs in Semarang Regency, so that increased competitiveness of SMEs depends on how well performance in SMEs.

In real conditions, tempeh chips SMEs in Sanan said that they still encounter several obstacles hampering overall business performance. These obstacles include limited access to capital and access to information. Limited access to capital hinders SMEs to invest in innovations in both products and production processes. The innovations which can be carried out are only limited to the form of packaging and concoction, there is no innovation in terms of the production process. The innovation for truly new products is considered to be expensive and high risk, so that in general micro-scale businesses cannot perform major innovation. The form of the program which is currently running in the city of Malang is credit assistance for MSME owners.

## 4) Effect of Mediating Performance on the Relationship between Supply Chain Institutions and Competitiveness

The test results show that direct influence of supply chain (X) on competitiveness (Y<sub>2</sub>) is significant with a path coefficient of 0.362, while the influence of supply chain (X) on competitiveness (Y<sub>2</sub>) through performance (Y<sub>1</sub>) is also significant with the path coefficient of 0.884. The path coefficient (X) of supply chain institutions on competitiveness (Y<sub>2</sub>) through performance (Y<sub>1</sub>) has a greater value than the direct influence, so hypothesis 4 is accepted. The result of this greater total value indicates its partial

mediation. These results indicate that supply chain institutions can improve business competitiveness better if considering business performance. This statement is reinforced by [33] which states that companies with high competitiveness tend to have good business performance, resulted from integration between supply chain actors.

The stronger the relationship between supply chain actors, the higher overall performance of members in a supply chain network. Improved business performance according to [34] has a positive influence on increasing business competitiveness. This causes supply chain institutions to indirectly influence the competitiveness of SMEs by mediating business performance variables. Yuhua and Bayhaqi [30] also argue that the higher the value possessed by a business, the greater the opportunity for the business to be involved in a larger scale supply chain. Based on this statement, it can be said that with the help of supply chain institutions, the value of the company will increase implying an increase in the ability of businesses to compete in the market.

#### 4. Conclusions

- Supply chain institutions have a significant influence on SMEs performance of 0.824. Tempeh suppliers are the most influential component in increasing the benefits of SMEs.
- Supply chain institutions have an influence on the competitiveness of SMEs businesses by 0.382. Process innovation is an important component to improve the competitiveness of SMEs. Government become one of the parties in supply chain institutions which can support SMEs in improving process through the provision of training and information regarding access to capital and markets.
- Business performance has a significant influence on the business competitiveness of SMEs by 0.634. The performance of SMEs, especially in process innovation, is an important component to improve the competitiveness of SMEs.
- Business performance has a partial influence in mediating the relationship between supply chain institutions and business capacity statistically at 0.884.

#### References

11. Zebua, M. 2016. *Inspirasi Pengembangan Pariwisata Daerah*. Deepublish Publisher. Yogyakarta.
12. Badan Pusat Statistik. 2015. *Persentase UMKM Menurut Wilayah*. Dilihat 5 Maret 2017. <<http://www.bps.go.id/linkTabelStatis/view/id/513>>
13. Kuncoro, M. 2008. *Manajemen Usaha Skala Kecil dan Menengah*. BPFE. Yogyakarta
14. Badan Pusat Statistik Kota Malang. 2014. *Pengeluaran Rata-rata Perkapita Sebulan Menurut Kelompok Barang dan Jasa*. Dilihat 5 Maret 2017. <<http://www.malangkota.bps.go.id/linkTabelStatis/view/id/522>>
15. Dinas Perindustrian Kota Malang. 2012. *Data UMKM Keripik Tempe Kota Malang*. Dinas Perindustrian Kota Malang. Malang.
16. Trisnaningtyas, K. 2017. *Strategi Pengembangan Klaster Usaha Kecil dan Menengah Keripik Tempe dengan Metode K-Means Clustering dan FAHP (Studi Kasus di UKM Keripik Tempe Sanan, Kota Malang)*. Laporan. Teknologi Industri Pertanian. Fakultas Teknologi Pertanian Universitas Brawijaya.
17. Rusno. 2014. *Analisis Posisi Bersaing untuk Menentukan Strategi Pemasaran Industri Kripik Tempe di Kota Malang*. Modernisasi. 10(3)
18. Ariani, D dan Bambang M.D. 2013. *Analisis Pengaruh Supply Chain Management Terhadap Kinerja Perusahaan (Studi Pada Industri Kecil Menengah Makanan Khas Olahan Padang Sumatra Barat)*. Diponegoro Journal of Management. 2(3).
19. Sejati, W.K. 2011. *Analisis Kelembagaan Rantai Pasok Telur Ayam Ras Peternakan Rakyat di Jawa Barat*. Jurnal Analisis Kebijakan Pertanian. 9(2): 183-198.
20. Ardiana I., Brahmayanti I.A, dan Subaedi. 2010. *Kompetensi SDM UKM dan Pengaruhnya Terhadap Kinerja UKM di Surabaya*. Jurnal Manajemen dan Kewirausahaan. 12(10): 42-55.
21. Meliala, A.S, Nazaruddin M dan Rahmi M. 2014. *Strategi Peningkatan Daya Saing Usaha Kecil dan*



- Menengah (UKM) Berbasis Kaizen. *Jurnal Optimasi Sistem Industri*. 13(2): 641-664.
22. Kusumadewi KA dan Ghozali I. 2013. *Generalized Structured Component Analysis (GSCA): Model Persamaan Struktural Berbasis Komponen*. Badan Penerbit UNDIP. Semarang.
  23. Hwang, H and Takane Y. 2004. *Generalized Structured Component Analysis*. Psychometrica. 69. 81-99.
  24. Sa'adah, M, Imam S dan Siti A.M. 2015. Analisis Efektivitas Kinerja dalam Klaster Agroindustri Makanan Ringan di Kota Malang. *Jurnal Habitat*. 26(3).
  25. Munizu, Musran. 2010. Pengaruh Faktor-Faktor Eksternal dan Internal Terhadap Kinerja Usaha Mikro dan Kecil (UMK) di Sulawesi Selatan. *Jurnal Manajemen dan Kewirausahaan*. 12: 33-41.
  26. Mamad, M dan Chahdi F. 2013. *The Factors of The Collaboration between the Upstream Supply Chain Actors: Case of The Automotive Sector in Morocco*. *International Business Research*. 6(11).
  27. Avery, S.L. 2009. *Social Capital Impact on Service Supply Chains*. *Journal of Service Science*. 2(2).
  28. Kotler, P. 2007. *Prinsip-Prinsip Pemasaran*. Erlangga. Jakarta.
  29. Pelham, A. 2007. *A Longitudinal Study of the Impact of Market Structure, Firm Structure, Strategy and Market Orientation Culture on Dimensions of Small Firm Performance*. *Journal of The Academy of Marketing*. 24(3).
  30. Ferdinand, A.T. 2000. *Manajemen Pemasaran: Sebuah Pendekatan Strategis*. Badan Penerbit Universitas Diponegoro. Semarang. *Journal of Business & Industrial Marketing*. 27(2).
  31. Tambunan, T. 2000. *Development of Small-Scale Industries During the New Order Government in Indonesia*. Ashgate Publishing. Jakarta.
  32. Bank Indonesia. 2015. Pemetaan dan Strategi Peningkatan Daya Saing UMKM dalam Menghadapi MEA 2015 dan Pasca Mea 2025 / WP BI No 9. Bank Indonesia. Jakarta.
  33. Ristianto, A.D dan Irma F. 2016. Hubungan Profesionalisme, Motivasi dan Gaya Kepemimpinan Partisipatif Terhadap Produktivitas Kerja Dosen Menggunakan Metode *Generalized Structured Component Analysis*(SEM-GSCA). *Jurnal LOG!K@*. 6(2): 112-130.
  34. Pradabwong, J., Christos B., James T., and Kulwant S. 2017. *Business Process Management and Supply Chain Collaboration: Effects on Performance and Competitiveness*. *International Journal of Supply Chain Management*. 22(2).
  35. Yusniaji F dan Erni W. 2013. Analisis Penentuan Persediaan Bahan Baku Kedelai yang Optimal dengan Menggunakan Metode *Stockhastic* Pada PT. Lombok Gandaria. *Jurnal Ekonomi dan Kewirausahaan*. 13(2).
  36. Abdullah, S dan Taufik E. 2015. *Statistik Tanpa Stres*. Transmedia. Jakarta. Hal 259-265.
  37. Jakfar, F., Romano dan Nurcholis. *Pengelolaan Rantai Pasok dan Daya Saing Kelapa Sawit di Aceh*. *Jurnal Agraris*. 1(2)
  38. Prior, D.D. 2012. *The Effects of Buyer-Supplier Relationships on Buyer Competitiveness*. *Journal of Business & Industrial Marketing*. 27(2).
  39. Sumarwan, U., Agus M., dan Muchlis A. 2012. *Key Success Values in Relationship Marketing of Agriculture Products*. *Jurnal Manajemen & Agribisnis*. 9(2).
  40. Yuhua, Z and Bayhaqi, A. 2013. *SME's Participation in Global Production Chains*. APEC Policy Support Unit Paper. Issues Paper No 3.
  41. Asian Bank Development. *Integrating SMEs into Global Value Chains: Challenges and Policy Actions in Asia*. Asian Development Bank Institute. Manila. Hal 4-5.
  42. Handriani, E. 2011. Pengaruh Faktor Internl Eksternal, *Entrepreneurial Skill*, Strategi da Kinerja terhadap Daya Saing UKM di Kabupaten Semarang. *Dinamika Sosial Ekonomi*. 7(1).
  43. Dung, L.T. 2015. *Factors Affecting the Collaboration in Supply Chain of Mechanical Enterprises in Vietnam*. *Journal of Managing Value and Supply Chains*. 6(4).
  44. Handriani, E. 2011. Pengaruh Faktor Internl Eksternal, *Entrepreneurial Skill*, Strategi da Kinerja terhadap Daya Saing UKM di Kabupaten Semarang. *Dinamika Sosial Ekonomi*. 7(1).
  45. Marimin dan Maghfiroh. 2010. *Aplikasi Teknik Pengambilan Keputusan dalam Manajemen Rantai Pasok*. IPB Press. Bogor.
  46. Kwon, I dan Taewon S. 2004. Factors Affecting the Level of Trust and Commitment in Supply Chain Relationships. *Journal of Supply Chain Management*. 40(4).



© 2018 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license

(<http://creativecommons.org/licenses/by/4.0/>).

