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Table of Content

1. Production of Biodegradable Straw from Banana Peel 1
I Putu Karang Adisurya, Mohammad Affan Fajar Falah

2. Fried Chicken Consumer's Preference and Purchase Decision Analysis During Covid 19 Pandemic Era 13
Febrianisa Yulia Sandita, Ibnu Wahid Fakhrudin Aziz, Mirwan Ushada

3. Analysis of Consumers' Preferences for Melon Using the Conjoint Method 22
Tiara Tannesha Hartono, Nafis Khuriyati, Ibnu Wahid Fakhrudin Aziz

4. **Potential Risk of Work Accident in The Production Process of Gudeg Chicken using The Failure Mode and Effect Analysis (FMEA) Method..... 31**
Tasyarafa Shelia Khairani, Rosa Amalia

5. Frozen Tilapia Fillets Business Process Analysis Using Integration Definition for Function Modelling..... 43
Sintia Putri Pradita, Nindya Laksita Laras

Production of Biodegradable Straw from Banana Peel

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Abstract

This study aims to determine the effect of enhancement in stirring temperature (75°C, 80°C, 85°C) and type of plasticizer (glycerol and sorbitol) on the characteristics of biodegradable straw from ambon banana peel waste and to compare them with the characteristics of conventional boba's straws. Methods used in this study were tensile strength, elongation, biodegradation, and water uptake tests. The result showed enhancement of stirring temperature and type of plasticizer did not significantly affect the characteristics of biodegradable straws from ambon banana peel waste ($p > 0.05$). Enhancement of stirring temperature will increase the tensile strength and water resistance value, but decreased elongation and biodegradation value because enhancement of stirring temperature will decrease the water content and increase the molecular density. In addition, plasticizer will increase elongation value and level of biodegradation, but decrease tensile strength and water resistance values. Plasticizer has the ability to increase the elasticity of polymers, as well as increase water absorption because it has hydrophilic hydroxyl groups. Biodegradable straw that have been developed has a colour of black, being rigid, with a length of 13 cm and an external diameter of 1.2 cm. The colour and external diameter of biodegradable boba's straw looks similar with conventional boba's straw but shorter in length. Therefore, ambon banana peel waste was promising to be used as an alternative material for biodegradable straw in the future.

Keywords: *Ambon banana peel waste; biodegradable straw; plasticizer; starch; stirring temperature*

1. INTRODUCTION

Plastic products are becoming a global environmental issue, according to Plastics Europe (2020), global plastic production in 2019 was 368 million tons. The Directorate General of Waste, Waste and B3 Management, Ministry of Environment and Forestry of the Republic of Indonesia (2020) released data that the composition of plastic waste in Indonesia in 2020 reached 5.6 million tons or 17.1% of the total waste production. One of the most common types of plastic waste is plastics straw. Data compiled by Divers Clean Action in Fatia & Sugandi (2019) shows that in Indonesia at least 93 million plastic straws are used by the public in one day. This number causes Indonesia to be ranked 4th in the world in terms of producing plastic straw waste.

One of the uses of plastic straws is for *boba* drinks, where *boba* drinks are tea-based drinks mixed with fruit or milk flavors, as well as the addition of a topping of chewy balls made of tapioca flour and sugar (Veronica dan Ilmi, 2020). *Boba* drink must be consumed using a straw with a large hole to be able to suck the *boba* from the bottom of the glass and cannot be replaced by other objects (Nerissa, 2020). Conventional *boba's* straw has different characteristics from other plastic straws, namely, it is stiffer, thicker, and has a larger hole of diameter. Therefore, there is a potential for development of *boba's* straws that are more environmentally friendly using biodegradable plastics from natural waste.

On the other hand, banana production in Indonesia in 2020 reached 8.18 million tons, increased by 11.02% from banana production in 2019 which only reached 7.28 million tons (Central Agency on Statistics, 2020). One type of banana is the ambon banana. The Agency for Agricultural Research and Development (2007) explained that ambon banana are often used as consumption fruit, or processed into chips, juice, and "*salé pisang*". The utilization of ambon banana produces banana peel which is generally discarded and usually was throw away as waste in garbage production.

Ambon banana is known to have a starch content of 29.37%, while banana peel waste

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(especially green ones) contains ± 15% starch (Musita, 2012; Hassan *et al.*, 2018). The starch content is possible and potential to be used as a material for making biodegradable straws. Regarding to the production of biodegradable straws, this study has objectives to know the characteristic of biodegradable straw from ambon banana peel waste based on enhancement of stirring temperature (75^{o}C, 80^{o}C, and 85^{o}C) and different types of plasticizers (glycerol and sorbitol).

2. MATERIAL AND METHODS

This research was conducted in September-December 2021 in Agroindustrial Process Engineering Laboratory, Vocational College, Universitas Gadjah Mada, and Process Engineering Laboratory, Faculty of Agricultural Technology, Universitas Gadjah Mada.

2.1 Materials

The materials used in this study were ambon banana peel waste, water, distilled water, glycerol, sorbitol, chitosan, 1% acetic acid solution, and conventional *boba's* straws (as control variables) (Adisurya, 2022).

2.2 Methods

2.2.1 Experimental Design

The treatment in this study was enhancement of stirring temperature with a variation of 75^{o}C, 80^{o}C, and 85^{o}C and different types of plasticizers, namely glycerol and sorbitol. The replication of experiment is 4 times which calculated using Federer formula based on the number of group treatments (Wahyuningrum & Probosari, 2012). Each sample uses 3 g of ambon banana peel starch, 3 g of chitosan, and 1 ml of plasticizer. Data were analyzed using a two-tailed test. If there is a significantly difference, then data analysis is continued with duncan test. The experimental design listed in Table 1 (Adisurya, 2022).

Table 1. Experimental Design of Production of Biodegradable Straw

Starch	Chitosan	Plasticizer	Stirring Temperature	Sample Code
Conventional Boba Straw				Control
3 g	3 g	Glycerol (1 ml)	75^{o}C	GT_1
			80^{o}C	GT_2
			85^{o}C	GT_3
		Sorbitol (1 ml)	75^{o}C	ST_1
			80^{o}C	ST_2
			85^{o}C	ST_3

Sources: (Sari, 2016; Melani, Putri dan Robiah, 2019; Azzahra, 2020)

2.2.2 Starch Extraction

The ambon banana peel cut into pieces until it reaches a weight of 500 g, afterward added 1 liter of water and mash it using a blender. After that filter it using a filter cloth. The solution was precipitated for 12 hours, then the water was removed to obtain wet starch. The wet starch was dried in the oven at 70^{o}C for ± 12-24 hours, then mashed using a blender and sieved through a 100-mesh sieve (Made Heni Epriyanti, Admadi Harsojuwono dan Wayan Arnata, 2016; Melani, Putri dan Robiah, 2019; Azzahra, 2020).

2.2.3 Production of Biodegradable Straw

The starch solution for 1 sample of biodegradable straw was made by weighing 3 g of starch, then dissolved it in 20 ml of distilled water and stirred for 30 minutes at 80^{o}C. On the other hand, 3 g of chitosan was dissolved in 100 ml of 1% acetic acid and stirred for 30 minutes without heating to obtain chitosan solution. Put the chitosan solution into the starch solution and stirred until homogeneous by heating at various stirring temperatures of 75^{o}C, 80^{o}C, and 85^{o}C using digital oven—temperature was controlled by manage the number of samples heated in 1 batch and also carry out periodic checks every 1 hour. After that, add 1 ml of plasticizer according to

treatment (glycerol or sorbitol), then stirred for 1 hour using a magnetic stirrer. The solution was then poured on an acrylic plate and dried in the oven at 70°C for 5 hours. Biodegradable film was rolled using an acrylic rod with a diameter of 1 cm and then dried again in the oven at 70°C for 5 hours (Nurfauzy dan Farhah, 2017; Azzahra, 2020)

2.2.4 Sample Testing

Tensile strength, elongation, biodegradation, and water uptake test was conducted to measure the properties of the straw. Tensile strength is the test used to determine how much force that sample can withstand until it breaks, while elongation test to find out the elongation created on the sample from the initial condition to broken off (Safitri et al., 2016 & Suparno et al., 2013). Both of tests using universal testing machine with a speed of 10 mm/min (Rosid et al., 2019). Moreover, biodegradation test is the test to determine level of degradation by looking at the percentage loss of sample mass (Rahmawati, 2018). The technique used was a soil burial test, sample with a long of 4 cm was weighted its initial mass, then planted in humus soil at a depth of 2 cm for 7 days at the room conditions. The moisture content of sample is not be calculated in this study, percentage loss of mass focused on alteration of sample mass. The percentage loss of mass is calculated using the formula in notation 1 (Rifaldi et al., 2017).

$$\%W = \frac{W_0 - W}{W_0} x\ 100\% \quad (1)$$

Explanation:
%W : percentage loss of mass (%)
W_0 : initial mass (g)
W : final mass (g)

The level of resistance of biodegradable straws to water determined using water uptake test. The higher of water absorption capacity, the lower level of its resistance to water (Wahyuni, 2018). Sample with a long of 4 cm was weighted its initial mass, then soaked in distilled water for 30 minutes. After that, sample was weighted its final mass. The percentage of water uptake is calculated using the formula in notation 2 (Rifaldi et al., 2017).

$$\%WU = \frac{W - W_0}{W_0} x\ 100\% \quad (2)$$

Explanation:
%WU : percentage of water uptake (%)
W_0 : initial mass (g)
W : final mass (g)

3. RESULTS AND DISCUSSION

Prototype of biodegradable straw from ambon banana peel waste and conventional *boba's* straw as control variable are attached as below. Biodegradable straw has a length of 13 cm and an external diameter of 1.2 cm.

(a) (b) (c)

Figure 1. Prototype of Biodegradable Straw form Ambon Banana Peel Waste: (a) Front View; (b) Above View; (c) Conventional *Boba*'s Straw

3.1.1. Tensile Strength

Tensile strength test using universal testing machine with a speed of 10 mm/min. The data that presented as a graphic below is an average of tensile strength value of each treatment from 4 times of replication.

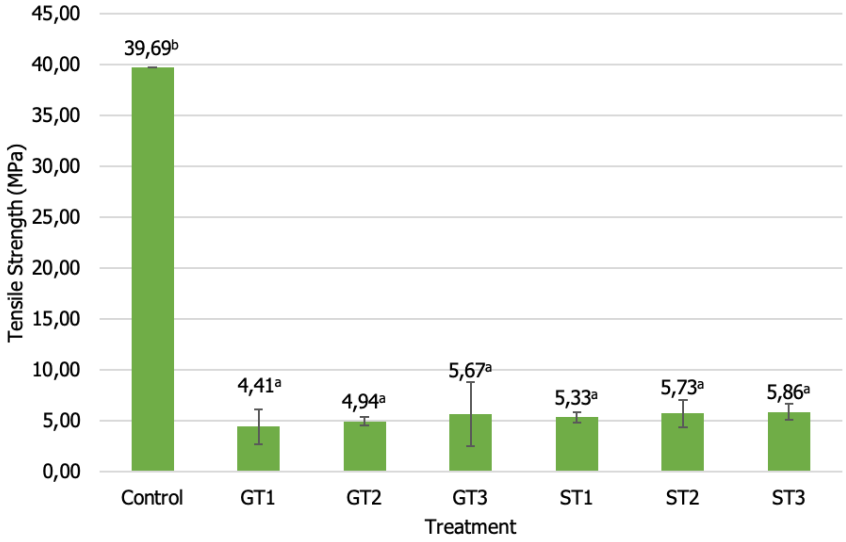

Figure 2. Results of Tensile Strength Test

Explanation:
Control : Conventional *boba's* straws
GT_1 : Biodegradable straws with glycerol as plasticizer and stirring temperature at 75°C.
GT_2 : Biodegradable straws with glycerol as plasticizer and stirring temperature at 80°C.
GT_3 : Biodegradable straws with glycerol as plasticizer and stirring temperature at 85°C.
ST_1 : Biodegradable straws with sorbitol as plasticizer and stirring temperature at 75°C.
ST_2 : Biodegradable straws with sorbitol as plasticizer and stirring temperature at 80°C.
ST_3 : Biodegradable straws with sorbitol as plasticizer and stirring temperature at 85°C.

Based on Fig.2, the control sample has the highest tensile strength value (39.69 MPa), while the GT_1 sample has the lowest tensile strength value (4.41 MPa). In terms of the type of plasticizer, biodegradable straws with sorbitol as plasticizer were generally have a higher tensile strength value than biodegradable straws with glycerol as plasticizer. Sorbitol has a larger molecular weight than glycerol which results in stronger intermolecular bonds that inhibit water penetration, so the resulting of biodegradable straws become tougher (Azizaturrohmah, 2019; Cheng et al., 2006).

Besides that, the enhancement of stirring temperature increased the tensile strength values. The enhancement of stirring temperature causes water content in the biodegradable film solution to decrease, therefore the molecular structure is getting closer which results in enhancement of the tensile strength values (Hartatik, 2014). Futhermore, the process of heating the solution causes starch gelatinization and affect the amylose bonds which it is getting close together one another so that it will increase the tensile strength (Ginting et al., 2014).

Based on two-tailed test, the enhancement of stirring temperature and different type of plasticizers did not affect the tensile strength value of biodegradable straws from ambon banana peel waste ($p > 0.05$). Otherwise, comparison test results showed that the tensile strength value of biodegradable straws was significantly different against of conventional *boba's* straw ($p < 0.05$), so it needs to proceed with duncan test The results of duncan test showed that the tensile strength value of all biodegradable straw samples was significantly different to the conventional *boba's* straw It can be said that the tensile strength value of all the biodegradable straw samples are not close to conventional *boba's* straw.

3.1.2. Elongation

Elongation test also using universal testing machine with a speed of 10 mm/min. The graphic below is an average of elongation value of each treatment from 4 times of replication.

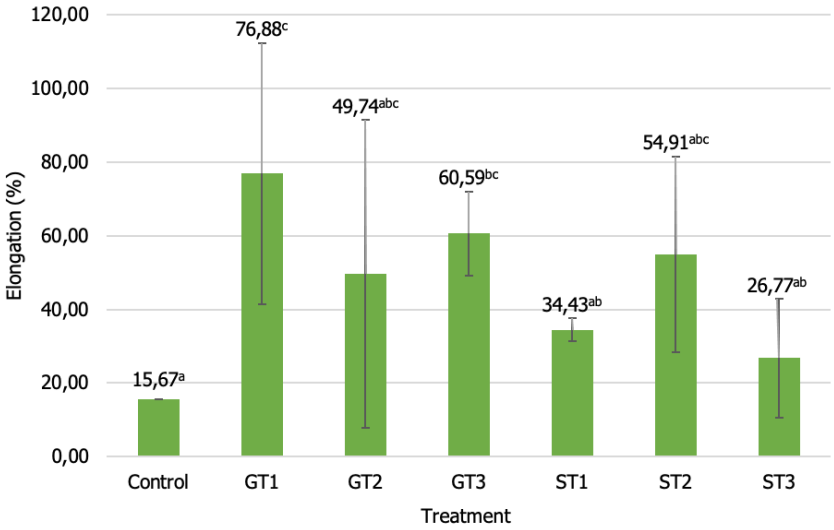

Figure 3. Results of Elongation Test

Explanation:
Control : Conventional *boba's* straws
GT_1 : Biodegradable straws with glycerol as plasticizer and stirring temperature at 75°C.
GT_2 : Biodegradable straws with glycerol as plasticizer and stirring temperature at 80°C.
GT_3 : Biodegradable straws with glycerol as plasticizer and stirring temperature at 85°C.
ST_1 : Biodegradable straws with sorbitol as plasticizer and stirring temperature at 75°C.
ST_2 : Biodegradable straws with sorbitol as plasticizer and stirring temperature at 80°C.
ST_3 : Biodegradable straws with sorbitol as plasticizer and stirring temperature at 85°C.

The elongation test results that represented on Fig.3 showed the GT_1 sample has the highest elongation value (76.88%), while the control sample has the lowest elongation value (15.67%). Elongation has a value that inversely proportional against to tensile strength value (Muhammad et al., 2020). This is caused by the enhancement of stirring temperature will reduce the water content in the biodegradable film solution so that the molecular structure is more homogeneous and closer which results in a decrease in elongation value (Hartatik, 2014).

In terms of the type of plasticizer, biodegradable straws with glycerol as plasticizer were generally have a higher elongation value than biodegradable straws with sorbitol as plasticizer. Glycerol is known to have a higher molecular mobility and solubility compared to sorbitol so it can be distributed more evenly in the solution which causes a higher elongation value (Nuriyah et al., 2018; Sinaga et al., 2014). Besides that, starch which is heated at the gelatinization temperature causes the amylose bonds to come closer together so that their elongation will decrease (Ginting et al., 2014).

Theoretically, the elongation value should decrease as the stirring temperature increases, but the test results showed the opposite and tend to fluctuate value (Epriyanti et al., 2016). High deviation of elongation value result is thought to be caused by the stirring and rolling process. Manual stirring was also carried out using a stir rod because the viscosity of solution was quite high. This made it possible for some samples have an uneven in stirring process which caused in a less homogeneous of starch and plasticizers, and also an uneven distribution of chitosan that caused the elongation value is fluctuate (Nafiyanto, 2019; Tamiogy et al., 2019). Rolling process by manually also thought for this case because the density of sample sheet when it is rolled is not controlled.

The two-tailed test showed the enhancement of stirring temperature and different type of plasticizers did not affect the elongation value of biodegradable straws from ambon banana peel waste ($p > 0.05$). Conversely, the comparison test showed that the elongation value of biodegradable straws was significantly different against of conventional *boba's* straw ($p < 0.05$). Therefore, duncan test was conducted which showed that the GT_3 sample was significantly different to the control sample, while the GT1 sample was very significantly different to the control sample. The elongation values of the GT_2, ST_1, ST_2, and ST_3 samples can be said to be close to the control samples because they are in the same subset.

3.1.3. Biodegradation

The graphic below is the average of biodegradation level from 4 times of replication. The samples of all treatment were planted in humus soil at a depth of 2 cm for 7 days at the room conditions.

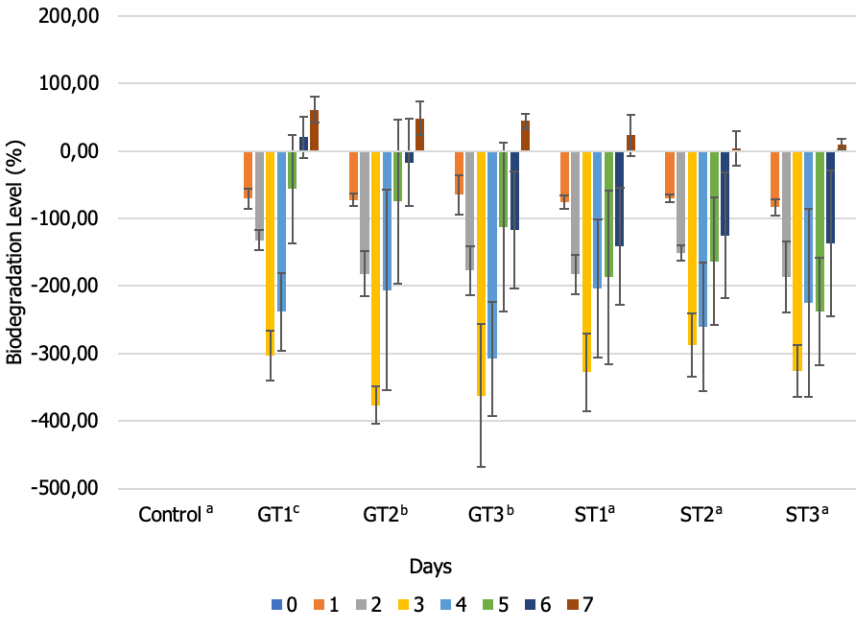

Figure 4. Results of Biodegradation Test

Explanation:
Control : Conventional *boba's* straws
GT_1 : Biodegradable straws with glycerol as plasticizer and stirring temperature at 75°C.
GT_2 : Biodegradable straws with glycerol as plasticizer and stirring temperature at 80°C.
GT_3 : Biodegradable straws with glycerol as plasticizer and stirring temperature at 85°C.
ST_1 : Biodegradable straws with sorbitol as plasticizer and stirring temperature at 75°C.
ST_2 : Biodegradable straws with sorbitol as plasticizer and stirring temperature at 80°C.
ST_3 : Biodegradable straws with sorbitol as plasticizer and stirring temperature at 85°C.

Based on Fig.4, it showed that the control samples did not show a degradation process, on the other hand, biodegradable straws have shown a degradation process. On the 7th day, the GT_1 sample has the highest biodegradation level (66.33%), meanwhile the control sample has a lowest biodegradation level (-0.12%). As a disclaimer, in terms of mass measurement, there are refracting factor in which the soil is attached to the sample and the sample fragments are already fused with the soil. That affects the results of mass measurement and also biodegradation level.

On the 1st to 3rd day, the sample showed an increase in mass due to the water absorption process which is the initial stage before the biodegradation occurs which results in an increase in mass (swelling process) (Nur et al., 2020). After 7 days, the biodegradable straws with glycerol as

plasticizer showed a higher biodegradation level than biodegradable straws with sorbitol as plasticizer. According to Lusiana et al (2019), glycerol has a higher ability than sorbitol to absorb water so that glycerol is more hydrophilic compared to sorbitol. It cause sample with glycrol as plasticizer have a better value in biodegradation level.

Glycerol is also known to be more hydrophilic than sorbitol plasticizer, so it can absorb more water which results in a faster of biodegradation level. Glycerol is known to have 3 hydroxyl groups, more than sorbitol which has 2 hydroxyl groups (Faust et al., 2021; Lee et al., 2018; Prasetyo et al., 2012). Beside that, enhancement of stirring temperature will reduce the water content in the biodegradable film solution which caused the molecular structure will be closer. Therefore, the water molecules will be difficult to penetrate into biodegradable straws (Hartatik, 2014). Furthermore, Pradipa & Mawarani (2012) stated that an increase of stirring temperature causes greater evaporation so the space of plasticizer is larger which results in reduce of water absorption. These condition can be cause a slowing of biodegradation level.

After data is processed using two-tailed test, it can be known that the enhancement of stirring temperature and different type of plasticizers did not affect the biodegradation level of biodegradable straws from ambon banana peel waste ($p > 0.05$). Related to the comparison test, the biodegradation level of biodegradable straws was significantly different against of conventional *boba's* straw ($p < 0.05$). Thus, duncan test was carried out which showed the GT_2 and GT_3 samples were significantly different to the control sample, while the GT_1 sample was very significantly different to the control sample. ST_1, ST_2, and ST_3 samples can be said to be close against of the control samples because they are in the same subset.

3.1.4. Water Uptake

Water uptake test was carried out to determine the percentage of water that can be absorbed by the sample for 30 minutes. The results that showed by graphic below is an average of water uptake percentage from 4 times of replication.

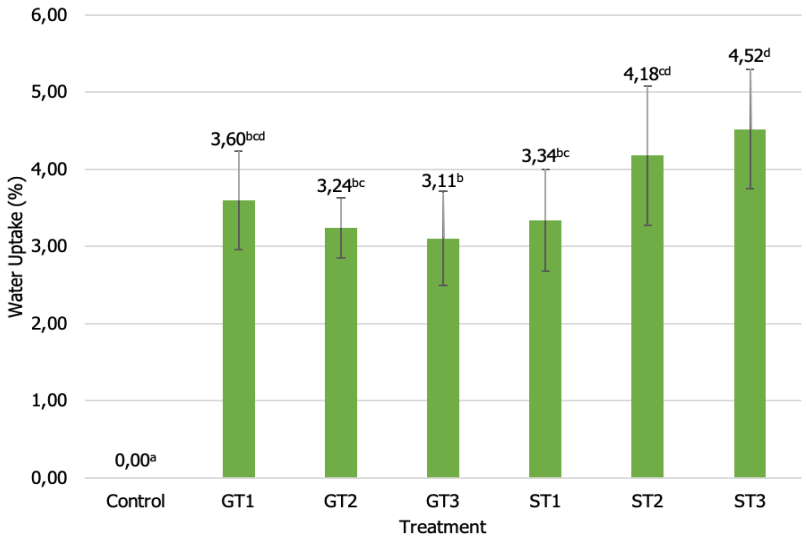

Figure 5. Results of Water Uptake Test

Explanation:
Control : Conventional *boba's* straws
GT_1 : Biodegradable straws with glycerol as plasticizer and stirring temperature at 75°C.
GT_2 : Biodegradable straws with glycerol as plasticizer and stirring temperature at 80°C.
GT_3 : Biodegradable straws with glycerol as plasticizer and stirring temperature at 85°C.
ST_1 : Biodegradable straws with sorbitol as plasticizer and stirring temperature at 75°C.
ST_2 : Biodegradable straws with sorbitol as plasticizer and stirring temperature at 80°C.
ST_3 : Biodegradable straws with sorbitol as plasticizer and stirring temperature at 85°C.

Data that represented on Fig.5 showed the ST_3 sample has the highest water uptake value (4.52%), while the control sample has the lowest water uptake value (0.00%). The use of plasticizer causes water uptake in biodegradable straws to be high. Plasticizers have hydrophilic characteristic so the material will easily absorb the water (Putra et al., 2017). The enhancement of stirring temperature will also reduce the water content in the biodegradable film solution so that the molecular structure is more homogeneous and closer which results in a decrease in water uptake value (Hartatik, 2014). This is supported by Pradipa & Mawarani (2012) that stated an increase of stirring temperature causes greater evaporation so the space of plasticizer is larger which results in reduce of water absorption.

Theoretically, the water uptake of biodegradable straws with sorbitol as plasticizer should be lower than glycerol. This caused by sorbitol is known to have a larger molecular weight than glycerol which will strengthen intermolecular bonds so that water is more difficult to penetrate (Azizaturrohmah, 2019; Hartatik, 2014). Moreover, glycerol has a higher ability than sorbitol to absorb water so that glycerol is more hydrophilic compared to sorbitol (Lusiana et al (2019). However, the data from water uptake test showed the opposite. According to Nur et al., (2020), the water uptake value is also influenced by the thickness of biodegradable film. That is thought to causing the biodegradable straws with sorbitol as plasticizer to show an increasing trend of water absorption even though the stirring temperature has increased. When the samples were to be rolled, there were 2 samples of ST_2 and ST_3 respectively were too dry on one side. These sample must trim out which influenced the thickness of the samples and thought caused an increase in water uptake value even though the stirring temperature has increased.

The two-tailed test results showed that the enhancement of stirring temperature and different type of plasticizers did not affect the water uptake value of biodegradable straws from ambon banana peel waste ($p > 0.05$). On the other hand, the comparison test showed that the water uptake value of biodegradable straws was significantly different against of conventional *boba's* straw ($p < 0.05$). From the duncan test results, it can be shown that the GT_1, GT_2, GT_3, and ST_1 samples were significantly different from to control samples. Besides that, the ST_2 sample showed a very significant difference to the control sample and the ST_3 sample showed a highly significant difference to the control sample.

Compared with another study, Putri & Falah (2020) have developed biodegradable straw using combination of unused rice and rice bran. The study showed that biodegradable straw that made by unused rice and rice brand has a higher value in water uptake and biodegradation value, but lower in elongation value compared with biodegradable straw from ambon banana peel waste. Moreover, biodegradable straw from unused rice and rice brand has water update value of 100% and completely degraded in 4 days. This is presumably because the unused rice and rice brand have more hydrophilic properties than ambon banana peel waste. Nevertheless, the characteristic of both biodegradable straws statistically are not close to conventional straw which is used as a control variable in each study, but more environmentally friendly because it can be degraded in a matter of days.

The availability of ambon bananas in Indonesia is quite abundant. Ambon banana are often used as a consumption fruit or processed into chips, juice, and "*salé pisang*". So, it can be said that there are good prospects related to the sustainable development of biodegradable straw from ambon banana peel waste, especially in Indonesia. The procurement of ambon banana peel waste can be carried out with a cooperation scheme with industry/small and medium enterprise so as to facilitate the procurement of raw materials while preventing the wasting of ambon banana peel waste into the environment which can cause contamination. In addition, biodegradable straw products, especially those intended for *boba* drinks, have not yet been widely developed. Therefore, there are good prospects for conducting further research and development related to the functional aspects of biodegradable straw from ambon banana peel waste that expected to be mass produced in the future as an environmentally friendly *boba's* straw.

4. CONCLUSIONS

The development of biodegradabl *boba's* straw from ambon banana peel waste is an innovation to produce *boba's* straws that are more environmentally friendly and has the potential to replace the use of plastic straw in the future. Biodegradable *boba's* straw that have been developed has a colour of black, being rigid, with a length of 13 cm and an external diameter of 1.2 cm. The colour and external diameter of biodegradable *boba's* straw looks similar with conventional *boba's* straw but shorter in length. Based on sample testing, the enhancement of stirring temperature and different type of plasticizer did not significantly affect the characteristics of biodegradable straw from ambon banana peel waste ($p > 0.05$).

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Fried Chicken Consumer's Preference and Purchase Decision Analysis During Covid 19 Pandemic Era

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Abstract

This study aims to observe the decision-making process on fried chicken purchases, and identify the most considered attribute, and combination of attributes based on consumer preference in the Covid-19 pandemic era. The pandemic has altered consumer behavior and consumption patterns, leading to changes in the food industry. Understanding how consumer preferences have shifted can help businesses adapt their strategies to better serve their customers. The data were collected using the questionnaire method through the Google Form platform with respondent criteria being fried chicken consumers who had purchased fried chicken at least twice in the last six months with the number of respondents being 135. The questionnaire consisted of two parts, the first part is about the consumer's purchase decision-making process and the second one is about the consumer's preference for fried chicken. Price, serving, purchase state, and packaging are the attributes chosen to identify consumer preferences using the conjoint analysis method. This study shows consumer habits in the decision-making process of buying fried chicken and consumers' preferences toward the price, serving, purchase state, and packaging of fried chicken. Product attributes were the most considered based on importance level Price (40.73%), Purchase state (33.57%), Serving (16.99%), and Packaging (8.70%). The combination of fried chicken product attributes that are preferred by consumers according to the utility value of each level attribute is less than 15.000 IDR of price, served with rice/fried chicken and vegetables, purchased in ready-to-eat (takeaway/delivery) form and using paper box packaging.

Keywords: *Conjoint analysis, Covid-19 Pandemic Era, Fried chicken, Preference, Purchase decision.*

1. INTRODUCTION

Chicken meat is one of the animal-based protein sources that is commonly consumed by Indonesian people. Besides the delicious taste, chicken meat is also quite easy to obtain and the price is affordable. People can find chicken meat sellers in traditional markets, supermarkets, and even chicken sellers on the roadside.

Table 1. Production of Chicken and Beef in Daerah Istimewa Yogyakarta (Ton)

Commodity	Production (Ton)		
	2019	2020	2021
Chicken	56,504.35	56,977.21	61,379.79
Beef	7,835.21	7,355.13	7,645.34

Source: Badan Pusat Statistik (2022)

Table 1 presents the production of chicken and beef in Daerah Istimewa Yogyakarta (DIY) from 2019 to 2021. The data shows that the production of chicken in the province increased steadily over the three years, starting from 56,504.35 tons in 2019 to 61,379.79 tons in 2021. On the other hand, the production of beef remained relatively stable, with some fluctuations. In 2019, the province produced 7,835.21 tons of beef, which decreased to 7,355.13 tons in 2020 and increased to 7,645.34 tons in 2021. Overall, the data suggests that there has been a significant increase in chicken production in DIY over the three years, while the production of beef has remained relatively stable. Chicken meat production is much higher compared to beef production. The data shows that chicken meat is easier to reach the community. Chicken meat can be processed in many forms such as fried chicken, nuggets, sausages, etc. We can assume that there are opportunities for processed chicken meat businesses to expand their marketing. One of the forms of processed chicken meat that is commonly found is crispy battered fried chicken, which is chicken meat that is coated in seasoned batter rather than being cooked by deep-frying it into hot oil.

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A product's attribute is the signature of a product that makes a difference between similar products that are offered by several companies. Knowing the attributes that become consumers' preference in purchasing fried chicken is very important for business owners who offer fried chicken in making decisions on marketing strategies for their products and maintaining their business in the market. Knowing a consumer's preference also helps the company to assess their product and if it already fulfills the consumer's needs and wants so the company could improve their products. One of the methods that can be used to determine consumer preference is conjoint analysis. Through this method, we can identify the most considered attribute and the attribute combination based on consumers' liking of fried chicken purchases.

In this study, we would be evaluating consumers' preferences in fried chicken product attributes during the pandemic. In this study, the data is collected during 2nd level of Pemberlakuan Pembatasan Kegiatan Masyarakat (PPKM)/*Community Activities Restrictions Enforcement* that is applied by the DIY government according to *Instruksi Gubernur (INGUB)* about 2nd level of PPKM status in DIY. In this 2nd level of PPKM, the health protocols are being widely adhered to in public sectors albeit with little enforcement.

According to Fuad et al. (2019), marketing is a way to identify and profitably fulfill human and social needs. The marketing concept maintains that the essence of marketing consists of satisfying consumers' needs, creating value, and retaining customers. It maintains that companies must produce only those goods that they have already determined that consumers would buy (Schiffman & Wisenblit, 2015). The American Marketing Association defines marketing as a functional organization and a series of processes to create, communicate, and give value to customers and maintain relationships with customers profitably.

(Kotler & Keller, 2012) stated that consumers typically pass through five stages when deciding to purchase a product, there are (a) problem recognition when consumer recognize their problem and their needs. (b) Information search when consumers are making effort to gather as much information from various sources (c) Evaluation alternatives, from information that had gathered, consumers could develop their beliefs in certain products they will buy (d) Purchase decision, where consumers are sure about their choice and deciding to purchase that product. (e) Post-purchase behavior, consumers can evaluate the product that they purchased based on so many aspects and use them as a reference in a future purchase. Research in consumer behavior is important for business owners to control consumption and maintain market stability, in other words, is to help to maximize the efficiency of resource usage in marketing and helps to solve marketing problems in an effective way (Khuong & Duyen, 2016)

According to Guleria & Parmar (2015), consumer preference is described as "individual subjective taste that is stated in utility value on a series of product attributes". Consumers can sort a set of attributes based on the level of benefits obtained. Consumer preference is consumer satisfaction with a particular brand when comparing price and quality with other products makes them choose that brand (Thomas & Rajendran., 2020).

Conjoint analysis is one of the methods to evaluate objects such as products, services, or new ideas. A direct example of a conjoint analysis application is designing a new product and developing new services. Conjoint analysis can be used to evaluate a complex product just by assessing some product's profile which is a combination of product levels, the researcher also be able to assess the importance level of each attribute (Hair et al., 2019). Conjoint analysis can be used to understand the consumer preference towards certain products to measure the utility value and importance of each attribute. The objection of conjoint analysis is to find someone's impression of some object that contains many parts. The last result of conjoint analysis is a form of product design consisting of the attributes desired by most respondents (Widyawati et al., 2014). This study aims to (a) analyze the decision-making process on fried chicken purchases, (b) identify the most considered attribute, and (c) identify the combination of attributes based on consumer preference in the Covid-19 pandemic era.

2. MATERIAL AND METHODS

The object of this study is fried chicken. The survey was conducted using a questionnaire through the Google Form platform, the questionnaire was blasted on social media with the intended respondents being fried chicken consumers who had purchased fried chicken at least twice in a month. Sample determination is done by non-probability sampling with purposive

sampling type. The total population in this study is not known with certainty so the number of samples is determined using the formula by Lemeshow et al. (1990) and the target respondent is 97 respondents.

$$n = \frac{z^2\, p(1-p)}{d^2} \quad (1)$$

$$n = \frac{(1.96)^2\, 0.5(1-0.5)}{(0.1)^2} = 97$$

n = number of sample
z = standard value = 1.96
p = maximum estimation = 50% = 0.5
d = sampling error = 10%

The questionnaire was divided into two parts, the first part was a multi-choice question about the consumer's buying decision process and the other part was about consumer preference on certain attributes that were rated using the Likert scale. The validity of the questionnaire was conducted using Pearson-Product-Moment by comparing the *r*-table value and the Corrected Item-Total Correlation value while the reliability of the questionnaire was conducted using Cronbach's Alpha value. Based on the validity test, the value of the Corrected Item-Total Correlation on each question is more than the table value, and based on the reliability test shows that Cronbach's Alpha value was more than >0.60. Therefore, the questionnaire was valid and reliable.

The descriptive percentage was used to evaluate the consumer's buying decision process including problem recognition, information search, evaluation alternatives, purchase decision, and post-purchase behavior while the consumer's preference for fried chicken was processed using conjoint analysis. Conjoint analysis is one of the models in the Statistical Package for the Social Sciences (SPSS) that can be used to identify the most desired attributes combination and importance level of attribute on a certain product (Witono & Nurmalinda, 2012). The stages of conjoint analysis in this study are stated below:

a Determining attributes and level
Each attribute contains a couple of levels which later would form a stimulus. The attributes that were used in this study were price, serving, purchase state and packaging.

b Determining the stimulus (attribute and level combination)
Stimulus consisted of a combination of levels of attributes; there are 11 levels from 4 attributes. The stimulus was conducted using an orthogonal design array in SPSS software and resulted in 9 stimuli.

c Collecting respondent evaluation
Research data was collected through online questionnaires using Google Form, respondents are expected to rate every stimulus using Likert scale in a scale 1 to 5. Score 1 for the least desired stimulus and score 5 for the most desired stimulus with following symbol:

Table 2. Likert scale symbol

Score	Response categories
5	Strongly agree
4	Agree
3	Neither agree/disagree
2	Disagree
1	Strongly disagree

d Conjoint analysis
Conjoint analysis was conducted using Syntax Conjoint Plan on SPSS software. The base of the conjoint analysis model study was formulated as following equation:

$$Pref\ (X) = \sum_{i=1}^{m} \quad \sum_{j=1}^{k} \quad a_{ij} x_{ij} \quad (2)$$

Pref (x) = all utilities of one alternative
a_{ij} = utility j and attribute I
k_i = number of attribute level i

m = number of attributes
x_{ij} = is 1 if attribute *i* and attribute level *j* exist and 0 if attribute *i* and level

In conjoint analysis is also resulted relative importance level of each attribute against another attribute that formulated below:

$$W_i = \frac{I_i}{\sum_{i=1}^{m} I_i} \quad (3)$$

W_i = Importance of *i* attribute
I_i = [max (a_{ij}) − min (a_{ij})]
m = number of attributes

The validity of measurement can be conducted from Pearson's and Kendall's Tau values, if both values are more than 0.5 then the measurement has high accuracy. Significance values are used to determine the correlation between the estimated values and actual values, if the significance values are below 0.05 then it could be concluded there is a strong correlation. Hypotheses are stated as below:

H_0 = there is no correlation between the estimated value and actual value
H_1 = there is a correlation between the estimated value and actual value

If the significance value is > 0.05 then H_0 can't be rejected, if the significance value is <0,05 then H_0 is rejected.

3. RESULTS AND DISCUSSION

3.1 Respondent's Profile

This study aims to observe the process of buying decision-making and to know the priority attribute along with the most desired attribute combination of fried chicken. The survey was conducted using an online questionnaire with the number of respondents being 135. The profiles of entire respondent are stated in Table 3:

Table 3. Respondent's Profile

Categories	Frequency	Percentage (%)
Age		
<18 years old	6	4.44
18-24 years old	115	85.18
25-31 years old	13	9.63
>31 years old	1	0.74
Gender		
Female	99	73.33
Male	36	26.67
Education		
Junior High School	2	1.48
Senior High School	67	49.63
Bachelor/Diploma	63	46.67
Other	7	2.22
Occupation		
Student	85	62.96
Private employee	27	20.00
Civil servant	1	0.74
Freelance	4	2.96

Categories	Frequency	Percentage (%)
Earnings		
<IDR 500,000.00	60	44.44
IDR 500,000.00 - IDR 1,500,000.00	39	28.89
IDR 1,500,001.00 - IDR 2,000,000	11	8.15
> IDR 2,000,000,00	25	18.52

Respondents are dominated by the age of 18-24 years old (85.85%), the gender of female (73.33%), the education level of Senior High School (49.63%), occupation of student (62.96%) and the range of earnings is below 500,000 IDR (44.44%).

3.2 Buying Decision Process

This study was observed the buying decision process by John Dewey (1910) on fried chicken products including: problem recognition, information search, evaluation alternative, purchase decision, and post-purchase behavior. Respondents are expected to choose one answer of a multi-choice question that suits them or their liking.

3.2.1 Problem Recognition

In this stage were observed about their purchase reason, the perfect time to consume, purchase frequency (in a month), and what triggers the purchase. Problem recognition stage are stated in Table 4.

Table 4. Problem Recognition

Problem Recognition	
Reason	Taste good
Consumption time	Afternoon
Purchase frequency	1-4 times
Purchase trigger	Hunger

3.2.2 Information Search

Information search was observed based on four indicators which are the personal source, commercial source, experiential source, and main attention of the purchase which stated in Table 5.

Table 5. Information Search

Information Search	
Personal source	Recommendation from relatives
Commercial source	Social media advertisement
Experiential source	Found by themselves
Main attention	Product Quality

3.2.3 Evaluation Alternative

The third stage in the buying decision process is evaluation alternatives, the stage where consumers compare several products and brands to know which product meets their preferences and needs which stated in Table 6.

Table 6. Evaluation Alternative

Evaluation Alternative	
How do they choose purchase place	By rating/review
Purchase method	Dine in
Cost incurred	15,000 IDR – 25,000 IDR
Considered attribute	Taste
Considered hygiene factor	Health protocol for employees and customer

3.2.4 Purchase Decision

The purchase decision is the 4th stage of the buying decision process. In the evaluation, alternative stage consumers developed their preference from many options, in this stage their choice becomes conical. Consumers are faced with 2 or more alternative choices and the choice to buy or not to buy. The purchase decision stage in the fried chicken purchase is stated in Table 7

Table 7. Purchase Decision

Purchase Decision	
Purchase place	Permanent outlet
When to buy	Depending on needs
Influence factor	Themselves
Promotion method	Discount

3.2.5 Post-Purchase Behavior

Post-purchase behavior is the last stage of the buying decision process. After they purchased the product, consumers would assess that product from many aspects, they would decide if they are satisfied or not with the product. Their assessment could affect the future purchase. Consumer's post-purchase decision stages are stated in Table 8.

Table 8. Post-Purchase behavior

Post-Purchase behavior	
Repeat buying	Yes
Consumers respond to many brands	Interested to try some brand
How consumers show their satisfaction	Recommending to their relatives
If their desired product is not available	Find substitution product

3.3 Conjoint Analysis

3.3.1 Attribute and Level

The first stage of finding out consumers' preferences using conjoint analysis is determining the stimulus which is a combination of attribute and level. This study is using 4 attributes related to a consumer behavior pattern that changes during the pandemic, there are how many cost incurred every fried chicken purchase (price), how fried chicken served related to nutritional balance (serving), product condition when buying (purchase state) and product packaging for take away purchase that is assumed to maintain the quality and keep the product clean.

Table 9. Attribute and Level

Attribute	Level
Price	less than 15,000 IDR
	15,000 IDR - 25,000 IDR
	more than 25,000 IDR
Serving	Fried chicken only
	With rice/fries
	With rice/fries and salad
Purchase state	Fresh (dine in)
	Ready to eat (takeaway/delivery)
	Ready to cook (frozen food)
Packaging	Paper box
	Thin wall sealed pack

3.3.2 Stimulus

Stimulus are arranged based on a combination of each attribute and level. Stimulus were stated using a full-profile approach in which respondents are shown a separate profile of all attributes in a form of a profile card. From attributes and levels based on Table 8 resulted in $3 \times 3 \times 3 \times 2=54$ combinations, that number of combinations is too many for respondents to assess, hence the combinations are reduced using an orthogonal design array in SPSS. The arrangement of stimuli is achieved through fractional factorial design, utilizing the orthogonal array design technique and SPSS software, by inputting data in the form of product levels and attributes and resulting in 9 stimulus as the following table.

Table 10. Stimulus

Price (IDR)	Serving	Purchase state	Packaging
more than 25,000	with rice/fries	fresh (dine in)	thin wall-sealed pack
15,000-25,000	with rice/fries and salad	fresh (dine in)	paper box
less than 15,000	fried chicken only	fresh (dine in)	paper box
more than 25,000	with rice/fries and salad	ready to cook (frozen food)	paper box
15,000-25,000	with rice/fries	ready to eat (takeaway/delivery)	paper box
15,000-25,000	fried chicken only	ready to cook (frozen food)	thin wall-sealed pack
less than 15,000	with rice/fries	ready to cook (frozen food)	paper box
less than 15,000	with rice/fries and salad	ready to eat (takeaway/delivery)	thin wall sealed pack
more than 25,000	fried chicken only	ready to eat (takeaway/delivery)	paper box

3.3.3 Data Analysis

Questionnaire data that is stated in the Likert scale then shall be processed through conjoint analysis using SPSS software Version 25 with Syntax Conjoint Plan. Data processing using conjoint analysis resulted utility value, relative importance level value and correlation value.

a. Utility Value

Table 11. Utility value

Attribute	Level	Utility
Price (IDR Rp)	less than 15,000 IDR	0.224
	15,000 IDR - 25,000 IDR	0.105
	more than 25,000 IDR	-0.329
Serving	Fried chicken only	-0.034
	With rice/fries	-0.098
	With rice/fries and salad	0.132
Purchase state	Fresh (dine in)	0.063
	Ready to eat (takeaway/delivery)	0.196
	Ready to cook (frozen food)	-0.259
Packaging	Paper box	0.059
	Thinwall sealed pack	-0.059
(Constant)		3.548

Utility value in conjoint analysis shows consumers satisfaction on each attribute level; it shows which level is the most desired by the respondent by seeing the highest utility value. Based on Table 11 the combination of attribute levels that respondents prefer over fried chicken producers are price <15,000.00 IDR, served with rice/fries and vegetables, purchased on ready-to-eat form (by takeaway or delivery), and packed with paper box.

The study found that the majority of the respondents were students aged 18-24 years old, and for this group, a price of <15,000.00 IDR was considered reasonable and affordable. Many outlets in Sleman Regency sell fried chicken for under this price, including some that include rice in the serving. However, this poses a challenge for marketers or potential marketers as the cost of basic materials tends to increase over time. Diversity in a meal is crucial to maintain a balanced nutritional intake. Fried chicken flour, being a fried food, may contain high levels of cholesterol, but serving it with vegetables can provide significant benefits to the body, including a source of vitamins, minerals, and fiber. Vegetables can also help to reduce cholesterol levels and the risk of heart disease and digestion issues. The daily recommended vegetable consumption is 150 to 200 grams (Widyayunita, 2019). The use of application features that provide food delivery services can provide a convenient option for consumers to order food and beverages from a wide selection of restaurants without physically visiting them. Online food delivery services also offer convenience for MSMEs to develop their businesses and improve marketing without incurring high costs associated with product registration on such platforms (Az-zahra, 2021). Packaging using paper boxes has a higher utility value compared to plastic sealed packaging. Paper-based packaging is biodegradable and recyclable. Besides, paper packaging has less impact on the environment compared to other materials. Hence, paper is considered an environmentally friendly material (Oloyede, 2021).

b. Relative Importance Value

Table 12. Importance value

Attribute	Importance value
Price	40.73%
Serving	16.99%
Purchase state	33.57%
Packaging	8.70%

Table 12 shows the importance level of an attribute, that is the most preferred attribute by the overall respondent when purchasing fried chicken which was Price (40.73%) and followed by purchase state attribute (33.57%), serving attribute (16.99%) and packaging attribute (8.70%).

c. Correlation Value

Table 13. Correlation value

	Value	Sig.
Pearson's R	0.992	0.000
Kendall's tau	0.994	0.000

Pearson's R and Kendall's Tau values in the conjoint analysis show the accuracy of conjoint analysis measurement, if both values are more than 0.5 then the measurement is accurate. In this study Parson's R and Kendall's Tau values were close to 1 hence can be concluded that this measurement has a strong accuracy. The significance value in conjoint analysis shows a correlation between the estimated values and actual values. This value was less than the recommended significance level of 0.05. This means that there was a strong correlation between estimation and actual condition.

4. CONCLUSION

In this study, consumers' habit in purchasing fried chicken based on the 5 stages of buying decision process are identified. The most considered attribute in purchasing fried chicken among price, serving, purchase state and packaging based on the result of conjoint analysis is price. The most preferred attribute level combination is price less than 15,000 IDR, served with rice/fries and salad, purchased on the ready-to-eat form (by takeaway or delivery), and packed in paper box. Since the majority of respondents were students, the future research entailed the respondents of professional and households.

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Analysis of Consumers' Preferences for Melon Using the Conjoint Method

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Abstract

Melon (Cucumis melo L.) is a fruit widely known by the people of Indonesia, including Yogyakarta Province, which has several variants such as C. melo var reticulatus, C. melo var. inodorus, and C. melo var. catalupensis. These variants have different characteristics that can be distinguished by color, aroma, peel texture, as well as their respective markets. To find out consumers' preferences for melon, the conjoint analysis method is used. The results showed that consumers in traditional retail preferred melons with small size, orange flesh, strong aroma, very sweet taste, slightly meshy peel texture, and crunchy flesh texture. Meanwhile, in modern retail, they prefer variants with a large size, green flesh, strong aroma, very sweet taste, non-meshy peel texture, and crunchy flesh texture. Sky Rocket, Glamor, Golden Langkawi, and Mai 119 variants are suitable for traditional and modern retail. There are also other suitable variants for traditional retail, namely Cantaloupe and Roc Melon, while Honey Globe and Action 434 are suitable for modern retail.

Keywords: *conjoint analysis; consumers' preferences; melon*

1. INTRODUCTION

Melon is one of the fruit commodities in Indonesia, known and quite popular because of its sweet taste and rich nutrients (Luo et al., 2022). This fruit has quite a variety of characteristics which can be distinguished by shape, size, peel color, fruit flesh, peel texture, and aroma (Huda et al., 2018). There are several variants, and the most popular in Indonesia are *C. melo var. reticulatus, C. melo var. inodorus, and C. melo var. cantalupensis* (Huda et al., 2018). These various variants have different levels of sweetness, fruit color, and size, hence, consumers have individual preferences. In this study, consumers' preferences for melon were analyzed based on traditional and modern retail.

In Yogyakarta Province, melon can be found in markets or retails. Generally, a retailer can be defined as someone who sells products directly to end users and is divided into two categories, namely traditional and modern retail. Melons in Yogyakarta are not only produced by local farmers, but also by outside farmers, such as Central Java. Then the melon was brought by collectors and sold to sellers in various markets and retailers, according to demand from the market. Consumer behavior is a study of how consumers choose, buy, and use a product or service (Kotler & Keller, 2016). Region is one of the factors influencing consumers' behavior, hence, there can be differences in the characteristics of the preferred melon in each region. In this study, an analysis of consumers' preferences for the quality attributes of melon in Yogyakarta was carried out and the results are expected to become a reference for fruit farmers, suppliers, and sellers regarding the variants preferred by the people.

Meanwhile, conjoint analysis is a statistical method for measuring the combination of correlations between variables on a non-metric scale. The results can be used to design a product based on consumers' preferences for the attributes (Sudaryono, 2016). It is also used to determine the importance level of each attribute for consumers' preferences and a design can be made for the evaluation of a product (Leonardo, 2017). In Yogyakarta melon can easily found, either in traditional retail or traditional retail. This study used conjoint analysis to determine the attributes of consumer-preferred melon in traditional and modern retail. From these results, an analysis of melon variants was carried out according to consumers' preferences in each retail. The attributes analyzed were size, flesh color, peel texture, aroma, taste, and melon flesh. The study was conducted using a questionnaire distributed to end users aged at least 18 years who had bought and consumed melon in modern or traditional retail in Yogyakarta Province more than once but sensory tests were not performed.

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2. MATERIAL AND METHODS

2.1 Materials and Tools

The materials used were data from questionnaires distributed to 100 respondents, with 50 in each retail and the data were in the form of respondent profiles, purchasing location, quality ranking, and combination quality.

The tools used were questionnaires, hardware, and software, the questionnaire was shared to collect the necessary data from the respondents. The hardware used was a laptop to store, process, search for supporting data, as well as compile and write results. The software used included IBM SPSS Statistic 25 to perform data processing using the conjoint method, Microsoft Word to write notes and reports, and Microsoft Excel to process questionnaire data before using IBM SPSS Statisctic 25.

2.2 Study Method

2.2.1 Population and Sample

a. Population

The population is the entire subject in the form of people, objects, or others with certain characteristics determined according to Siyoto & Sodik, (2015). In this study, the population were end users who had bought and consumed melon more than once and currently live in Yogyakarta, as well as consumers who were at least 18 years old. In the first purchase, consumers might only want to try to find out about the product and in the second, they were assumed to have a preference for the fruit products. The end consumers were assumed to be those who make purchases for consumption, hence the selection was assumed to be following their preferences.

b. Sample

The sample is part of the entire population taken with a certain procedure hence, it represents the population (Siyoto & Sodik, 2015). This study used a probability sampling method, namely simple random sampling because the questionnaire was distributed and given to respondents randomly within a population (Budiastuti & Agustinus, 2018).

According to Nurrahmah et al.,(2021), in determining the sample, a cross-sectional sample formula can be used, namely binomunal proportion. When the number of population (N) is known, then the sample search can be done using the formula:

$$n = \frac{Z^2_{1-\frac{\alpha}{2}} p(1-p)N}{d^2(N-1) + Z^2_{1-\frac{\alpha}{2}} p(1-p)} \quad (1)$$

When the number of population (N) is not known or $\frac{N-n}{N-1} = 1$, then the sample search can be done using the formula:

$$n = \frac{Z^2_{\propto} pq}{d^2} = \frac{Z^2 p(1-p)}{d^2} \quad (2)$$

Description:

n = minimum number of samples required
Z = degree of confidence
p = probability of a representative sample of the population
q = (1-p) = probability of the sample that is not representative of the population
d = error value tolerance

The confidence level was determined at 95%, hence, the value was Z = 1.96. Since the sample population was unknown, p = 50% and q = 50%, while the error value or d was determined by 10%. From these values, the minimum number of samples required is determined using the formula:

$$n = \frac{(1{,}96)^2 \times 0.5 \times 0.5}{(0{,}1)^2} = 96{,}04 \quad (3)$$

Based on the calculation, the minimum number of samples required (n) was 96.04, which can be rounded up to 97. Therefore, the number of respondents used was approximately 100 with a distribution of 50 samples in each retail.

2.2.2 Data Analysis

a. Validity Test

A measuring instrument should meet the validity and reliability requirements, to prevent the conclusions from being biased. Validity refers to the power of measuring accuracy, which can be measured using the formula:

$$r_{xy} = \frac{n\sum XY - (\sum X)(\sum Y)}{\sqrt{[n\sum X^2 - (\sum X^2)][n\sum Y^2 - (\sum Y^2)]}} \quad (4)$$

Description:
rxy = correlation coefficient
∑X = number of item scores (respondents' answers)
∑Y = total score
N = number of samples (respondents)

The validity coefficient ranged from -1.00 to +1.00. The higher the validity coefficient, the better the instrument. A valid instrument has $r_{count} > r_{table}$ (Yusup, 2018).

b. Reliability Test

Reliability can be interpreted as the accuracy and precision produced by a measuring instrument in making a measurement (Siyoto & Sodik, 2015). Measuring tools in the form of essays or questionnaires can be tested for reliability using the Alpha Cronbach test with the formula (Yusup, 2018):

$$r_i = \frac{k}{(k-1)}\left\{1 - \frac{\sum s_i^2}{s_t^2}\right\} \quad (5)$$

Description:
r_1 = Cronbach alpha reliability coefficient
k = number of question items
$\sum s_i^2$ = number of variance scores for each item
s_t^2 = total variance

Item and total variances can be found using the formula (Yusup, 2018):

$$s_i^2 = \frac{JKi}{n} - \frac{JKs}{n^2} \quad (6)$$

$$s_t^2 = \frac{\sum X_t^2}{n} - \frac{(\sum X_t)^2}{n^2} \quad (7)$$

Description:
s_i^2 = variant for each item
JKi = the number of the squares of all item scores
JKs = the number of the squares of the subjects
n = number of respondents
s_t^2 = total variance
X_t = total score

According to Dewi & Sudaryanto (2020), a reliable instrument has a Cronbach Alpha coefficient > 0.60 (Rosita et al., 2021).

c. Conjoint Analysis

Conjoint analysis was used to analyze consumers' preferences for melon in traditional and modern retail based on the following formula (Malhotra, 2004):

$$U(X) = \sum_{i=1}^{mi} \sum_{j=1}^{ki} \beta ij\ Xij \quad (9)$$

Description:

U(X) = total utility

β_{ij} = part worth or useful value of the i-th attribute (i, i=1, 2, …, m) j-th level (j, j=1, 2, …, k)

ki = the j-th level of the i-th attribute

mi = number of i-th attribute

X_{ij} = i-th dummy variable attribute level j (1=level appears; 0=does not appear)

Furthermore, a search for the value of relative importance was carried out as the basis for the interpretation of the results. The relative importance can be determined by the following formula (Malhotra, 2004):

$$Wi = \frac{Ii}{\sum_{i=1}^{m} Ii} \times 100\% \quad (10)$$

Description:

I_i = (max (β_{ij}) – min (β_{ij}), for each i-th attribute

M = the number of attributes

Table 1. Attributes and their levels

Attribute	Attribute Level
Size (per piece)	Small (< 1.5 kg) Medium (1.5 – 2.5 kg) Large (> 2.5 kg)
Flesh color	Green Orange White
Aroma	Strong Medium Not aromatic
Sweetness	Very sweet (>12· brix) Medium sweet (10-12· brix) Less sweet (8-10· brix)
Peel texture	Meshy Slightly Meshy Not Meshy
Flesh texture	Crunchy Not Crunchy

Based on Table 1, 6 quality attributes were analyzed in melon, then a conjoint analysis house-based approach was used (Widayat, 2018). The quality attributes in this study included fruit size, flesh color, aroma, sweetness, peel texture, and flesh texture. The size attribute has small < 1.5 kg, medium

1.5 – 2.5 kg, and large > 2.5 kg levels based on the Indonesian National Standard No. 7783:2013, regarding melon. The flesh color attribute has green, orange, and white attribute levels according to the color of the popular melon variant in Indonesia. Furthermore, the fruit aroma attribute has strong, medium, and non-aromatic levels with the selection referring to the color of the popular melon variant which is popular in Indonesia. The fruit sweetness has very, medium, and less sweet attribute levels, while the selection referred to melon fruit Brix with 8°brix (poor), 10°brix (average), 12°brix (good), 14°brix (very good), hence, 8-10°brix is less sweet, 10-12°brix is medium sweet, and >12°brix is very sweet (Alqoria & Utaminingrum, 2021). The peel texture attribute also has levels of meshy, slightly, and non-meshy based on the color of the popular melon variant in Indonesia. Additionally, the flesh texture attribute has crunchy and non-crunchy levels.

From the table, many possible combinations of attributes were made by multiplying all the number of attribute levels. After multiplying 3x3x3x3x3x2, a combination of attributes that allow a total of 486 stimuli was obtained. The number of combinations can make it difficult for consumers to make preferences, hence, it is necessary to reduce the number by using orthogonal arrays or designs. The orthogonal array creates attribute combinations that control the main influence, thereby reducing the number of combinations formed. This was accomplished using the SPSS software (Sugiharti et al., 2021) which produced about 18 attribute combinations.

3. RESULTS AND DISCUSSION

3.1 Validity and Reliability Tests

To determine the appropriateness of the questionnaire used in this study, validity, and reliability tests were carried out. The previous questionnaire was distributed to 30 respondents according to Singarimbun & Effendi (1995) which stated that the minimum number of samples for conducting questionnaire testing is 30 samples to make the distribution of values approach the normal curve. An instrument is considered valid when $r_{count} > r_{table}$ (Yusup, 2018), a r_{table} value of 0.361 was obtained with a sample size (n) of 30 and a significance level of 5% (0.05).

Table 2. Validity test results

No	Statement	r_{count}	r_{table}	Description
1	Combination 1	0.553	0.361	Valid
2	Combination 2	0.626	0.361	Valid
3	Combination 3	0.279	0.361	Invalid
4	Combination 4	0.216	0.361	Invalid
5	Combination 5	0.157	0.361	Invalid
6	Combination 6	0.477	0.361	Valid
7	Combination 7	0.622	0.361	Valid
8	Combination 8	0.397	0.361	Valid
9	Combination 9	0.609	0.361	Valid
10	Combination 10	0.469	0.361	Valid
11	Combination 11	0.388	0.361	Valid
12	Combination 12	0.602	0.361	Valid
13	Combination 13	0.511	0.361	Valid
14	Combination 14	0.493	0.361	Valid
15	Combination 15	0.502	0.361	Valid
16	Combination 16	0.542	0.361	Valid
17	Combination 17	0.694	0.361	Valid
18	Combination 18	0.635	0.361	Valid

Table 2 shows 15 valid and 3 invalid statements which were combinations 3, 4, and 5, the invalid statements were not used in the questionnaire, because the combinations used in this study were obtained using orthogonal arrays.

An instrument is considered reliable when it has a Cronbach's Alpha coefficient > 0.60 according to Rosita et al., (2021). After the reliability test was carried out, Cronbach's alpha result was 0.83 which is greater than 0.60, hence, the questionnaire used can be considered reliable.

3.2 Conjoint Analysis

Analysis of consumer preferences is done by using conjoint analysis. The conjoint analysis perspective is effective in revealing realistic decisions made by consumers regarding the attributes of a product and allows consumers to evaluate a series of alternative combinations of a product's attributes (Wang et al., 2022).

Table 3. Attribute importance level

Attribute	Traditional Retail	Modern Retail
Size (per piece)	16.521	15.287
Flesh Color	19.084	16.346
Aroma	12.124	12.757
Sweetness	29.042	34.245
Peel Texture	11.707	11.367
Flesh Texture	11.522	9.998

Table 3 shows that traditional and modern retail have the same attribute importance order, namely fruit sweetness, flesh color, size, aroma, peel, and flesh texture.

Table 4. Attribute utility value

Attribute	Attribute Level	Traditional Retail		Modern Retail	
		Utility Estimate	*Std. Error*	*Utility Estimate*	*Std. Error*
Size (per piece)	Small (< 1.5 kg)	**0.041**	0.026	-0.102	0.015
	Medium (1.5 – 2.5 kg)	0.032	0.022	0.035	0.013
	Large (> 2.5kg)	-0.074	0.033	**0.067**	0.019
Flesh Color	Green	-0.003	0.042	**0.098**	0.025
	Orange	**0.128**	0.026	0.038	0.015
	White	-0.125	0.026	-0.136	0.015
Aroma	Strong	**0.093**	0.020	**0.122**	0.012
	Medium	0.006	0.022	-0.038	0.013
	Not aromatic	-0.099	0.021	-0.084	0.012
Sweetness	Very sweet (>12· brix)	**0.295**	0.036	**0.294**	0.015
	Medium sweet (10-12· brix)	0.133	0.033	0.177	0.019
	Less sweet (8-10· brix)	-0.428	0.022	-0.471	0.013
Peel Texture	Meshy	-0.019	0.021	0.003	0.012
	Slightly Meshy	**0.021**	0.026	-0.036	0.015
	Non-Meshy	-0.003	0.025	**0.033**	0.015
Flesh Texture	Crunchy	**0.091**	0.020	**0.050**	0.012
	Not Crunchy	-0.091	0.020	-0.050	0.012
Constant		2.492	0.027	2.599	0.016

Based on Table 4, consumers in traditional retail prefer melon that is small in size, has orange flesh, a strong aroma, a very sweet taste, a slightly meshy texture, and a crunchy flesh texture. Meanwhile, in modern retail, melon with large size, green flesh, strong aroma, very sweet taste, non-meshy peel, and crunchy flesh texture was more preferred.

In general, people prefers melon with a sweet taste, crunchy flesh texture, strong aroma, and meshy peel texture (Makful et al., 2017). This is directly proportional to the consumers' preferences in both traditional and modern retail, namely melon with a sweet taste, crunchy flesh texture, and a strong aroma. However, the attributes of meshy peel texture are inversely proportional to consumers' preferences in both traditional and modern retail. In traditional retail, consumers prefer a slightly meshy

peel texture, while in modern retail, they tend to prefer a non-meshy peel texture. This can be caused by flexible consumers' preferences, in general, the melon preferred by people has a high weight and sugar content (Saputra et al., 2021). This is consistent with the results in modern retail which showed that consumers prefer large melon with a very sweet taste. According to Saputra et al., consumers generally prefer melon with a very sweet taste, but in traditional retail, they prefer small varieties. This is presumably because they want fruit that can be consumed immediately after peeling without the need to store any leftovers.

Melon in a retail store does not only consist of one variant but there are several variants with different characteristics because not all consumers have the same preference. Several variants suitable for traditional retail are presented in Table 5, while modern retail is shown in Table 6.

Table 5. Suitable melon variant for traditional retail

Melon Figure	Melon Variant	Quality Attribute					
		Sweetness (^{O}brix)	Flesh Color	Size (kg/piece)	Aroma	Peel Texture	Flesh Texture
	Sky Rocket	9-12	Green	1,5-3	**Strong**	Meshy	**Crunchy**
	Glamour (Japanese Melon)	**14-15**	**Orange**	**1-4**	**Strong**	Meshy	**Crunchy**
	Blewah (Cantaloupe)	8-10	**Orange**	**0,5-2**	**Strong**	**Slightly Meshy**	**Crunchy**
	Golden Langkawi	**16-17**	White	**1-2**	Not Aromatic	Non-Meshy	**Crunchy**
	Rock Melon	**14-16**	**Orange**	± 1,5	**Strong**	**Slightly Meshy**	Non-Crunchy
	Mai 119	**14**	**Jingga**	**1,3-2,5**	**Strong**	**Slightly Meshy**	**Crunchy**

(*) Bold: melon quality attributes according to the analysis of consumers' preferences

Table 6. Suitable melon variant for modern retail

Melon Figure	Melon Variant	Quality Attribute					
		Sweetness (^{O}brix)	Flesh Color	Size (kg/piece)	Aroma	Peel Texture	Flesh Texture
	Sky Rocket	9-12	**Green**	**1,5-3**	**Strong**	Meshy	**Crunchy**
	Honey Globe	**14-17**	**Green**	**2,5-3**	Medium	**Non-Meshy**	**Crunchy**

Melon Figure	Melon Variant	Quality Attribute					
		Sweetness (^{O}brix)	Flesh Color	Size (kg/piece)	Aroma	Peel Texture	Flesh Texture
	Action 434	**14**	**Green**	**± 2,5**	Medium	Meshy	**Crunchy**
	Glamour (Japanese Melon)	**14-15**	Orange	**1-4**	**Strong**	Meshy	**Crunchy**
	Golden Langkawi	**16-17**	White	1-2	Not Aromatic	**Non-Meshy**	**Crunchy**
	Mai 119	**14**	Orange	1,3-2,5	**Strong**	Slightly Meshy	**Crunchy**

(*) Bold: melon quality attributes according to the analysis of consumers' preferences

Sky Rocket Variant is suitable for traditional retail because it has a strong aroma and crunchy flesh texture. Moreover, the green flesh color and medium fruit size are also quite preferred by consumers in traditional retail. The glamor variant is suitable for traditional retail because it has a very sweet taste, orange flesh color, small size, strong aroma, and crunchy flesh texture, while cantaloupe has orange flesh color, small size, strong aroma, slightly meshy peel texture, and crunchy flesh texture. Furthermore, Golden Langkawi is preferred for traditional retail because it has a very sweet taste, small size, and crunchy meat texture, while Rock Melon has a very sweet taste, orange flesh color, strong aroma, and slightly meshy peel texture. Medium fruit size is also quite preferred by consumers in traditional retail, for example, Mai 119 is suitable because it has a very sweet taste, strong aroma, and crunchy flesh texture. Moreover, the orange flesh color and medium size are also quite suitable for consumers in traditional retail.

Sky Rocket is suitable for modern retail because it has green flesh color, large fruit size, strong aroma, crunchy flesh texture, and meshy peel. Honey Globe is suitable for modern retail because it has a very sweet taste, green flesh color, large size, non-meshy peel texture, and crunchy flesh texture, while Action 434 has a very sweet taste, green flesh color, large size, and crunchy flesh texture. Furthermore, Golden Langkawi is good for modern retail because it has a very sweet taste, a non-meshy peel texture, a crunchy flesh texture, and a medium size. Glamor is suitable for modern retail because it has a very sweet taste, large size, strong aroma, crunchy flesh texture, and orange flesh, while Mai 119 has a very sweet taste, strong aroma, and crunchy flesh texture with orange color and medium size.

4. CONCLUSIONS

In traditional retail, consumers in Yogyakarta prefer melon with small size, orange flesh, strong aroma, very sweet taste, slightly meshy peel texture, and crunchy flesh texture. Meanwhile, in modern retail, they prefer melon with a large size, green flesh, strong aroma, very sweet taste, non-meshy peel texture, and crunchy flesh texture. Based on the results, Sky Rocket, Glamor, Golden Langkawi, and Mai 119 variants are suitable for both retail. Furthermore, Cantaloupe and Rock Melon are good for traditional retail, while Honey Globe and Action 434 are suitable for modern retail.From atributte importance level and atributte utility value, the seller, both in traditional or modern retail, can provide melons according to consumer preferences. Besides, melon farmers, especially farmers that sell their melon to Yogyakarta Province, can determine which retail they want to focus, so they can choose the melon seeds and treat them wisely in order to get melons that are liked by consumers in Yogyakarta Province. To fulfill consumers' wants, seed developers or melon researches, can develop varieties of

melon seeds that suit consumer preferences in both traditional and modern retail in Yogyakarta Province.

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Potential Risk of Work Accident in The Production Process of Gudeg Chicken using The Failure Mode and Effect Analysis (FMEA) Method

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Abstract

Every agricultural industry has a potential risk of work accidents, one of which is at the Micro, Small and Medium Enterprises (MSMEs) level in Yogyakarta. Gudeg producers as one of the MSMEs in the traditional culinary also have various types of work accident risks in their production process, including in the process of producing Gudeg Chicken. Overall, the process of producing Gudeg Chicken includes sorting, washing, cooking, and distribution. The results of the initial observations indicated that workers in sorting division had the complaints of back pain and several work accidents have occurred in the production division of Gudeg Chicken. Hence, it is deemed necessary to analyze the risk of work accidents occurred. The analysis of work accident risks was done using the Failure Mode and Effect Analysis (FMEA) method by considering severity, occurrence, and detection values to obtain a Risk Priority Number (RPN). The results were then analyzed using a Pareto diagram to determine the work accident with the highest risk. Recommendations for improvement were given using the Hazard Identification Risk Assessment and Risk Control (HIRARC). The results showed that the highest risk of work accidents was related to the position of sitting that is not ergonomic in the process of sorting Gudeg Chicken. The elimination of these risks does not need to be carried out, but it needs to do substitution of production areas, engineering controls with modifications towards the tables or chairs of employees, administrative controls, and the use of Personal Protective Equipment.

Keywords: *Gudeg Chicken, FMEA, HIRARC, work accident*

1. INTRODUCTION

Micro, Small and Medium Enterprises (MSMEs) becomes one of the growing businesses, as found in agricultural sector including culinary. In Special Region of Yogyakarta, the number of MSMEs in agricultural sector reached 1,249 units in 2021 (Office of Cooperatives and MSMEs of Special Region of Yogyakarta, 2022). One of the growing MSMEs in the Special Region of Yogyakarta that has received considerable concern and is highly favored by tourists is *Gudeg* - a typical culinary heritage made from young jackfruit and cooked in coconut milk. *Gudeg* is usually consumed with other foods as the complement to side dishes. Side dishes such as eggs, chicken, *Krecek* chilli sauce, cassava leaves, tempeh and tofu were served as the complementary with the *gudeg* (Kurniawati and Marta, 2021). The combination of *gudeg* and the side dishes became a unique and value-added dish (Saputra et al., 2021). Thus, chicken is one of the popular main menus at various *Gudeg* outlets.

In a MSME of *Gudeg*, *Gudeg* Chicken is produced through a number of production process until the product is served to the consumer. *Gudeg* Chicken is produced in two separated kitchens in which the process starts from washing the chicken, cutting the chicken, squeezing the grated coconut, cooking and stirring the coconut milk, adding the spices and *areh,* stirring, placing the chicken into the distribution pan, placing the pans into van, distributing the products to restaurant, sorting the cooked products, heating the product, and distributing the product to service. Though it is still at the level of MSMEs, the process of producing *Gudeg* Chicken is not apart from the work accident. From the initial observation and historical data, it was found that it is potential for the workers to suffer an injury to their hand during the process of washing and cutting the chicken, there was a risk of back pain during the sorting process and suffer from the sore eyes caused by the smoke coming from cookstoves (Buruck et al., 2019; Lin et al., 2022).

In agricultural industry, the risk of work accidents has become a concern. The identification of work accidents aims to minimize the risk of workers in conducting the production

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activities. Even though the frequency of work accidents might still be low, the occupational safety and health system needs to be evaluated to achieve a zero accident rate (Bhastary and Suwardi, 2018), one of the ways is by conducting a research on the risks of work accidents in industry. To identify and analyze the work accidents, the Failure Mode And Effect Analysis (FMEA) method is used. Risk assessment can be analysed using the FMEA method, the objective of is to determine the level of risk of accidents in the workplace (Yanda et al., 2020); thus, it can be used as an early detection method for the analysis of occupational safety and health in industry. Recommendations for the improvement priorities were analyzed using Hazard Identification Risk Assessment and Risk Control (HIRARC) considering that this method can overcome and minimize the possibility of the risk of work accidents for workers (Ihsan et al., 2016).

Research related to work accidents in the production process of *Gudeg* chicken is still very rare; hence, it is deemed necessary to know the risks that might occur during the production process. This study, in turn, aims to: 1) analyze the types of work accidents existing in the production line of *Gudeg* Chicken to determine the improvement priorities based upon the risk of work accidents with the highest risk value; and 2) provide recommendations for improvements to this type of work accident.

2. MATERIAL AND METHODS

This research was conducted at one of the *Gudeg* MSMEs in Yogyakarta City, Special Region of Yogyakarta. The MSMEs produced *gudeg* with unripe jackfruit as the raw material, which is processed at around 200kg per day. In addition, the MSMEs processed 100 chickens per day, especially on holidays or peak season, it could be up to 300 kg per day. To process the food, the MSMEs needs 25 workers in the production area and the restaurant.

Work accidents were identified on the division of *Gudeg* Chicken production. The risk of work accidents in *Gudeg* chicken production division was determined based upon the results of observations in the production room and interviews with a number of operational managers. This study used FMEA as a methodology to evaluate any failures occurred in a system, design, process, or service (Stamatis, 2003). This research used FMEA process to identify any potential failure modes, potential effects of failure, potential causes, severity, occurrence, and detection. In FMEA, every possible failure occurred is assessed for making the handling priority (Andiyanto et al., 2017). The risk of failure mode in the FMEA method is estimated by calculating the Risk Priority Number (RPN).

Observations were made for a month in the production room of *Gudeg* chicken, including two *Gudeg* kitchens to determine the risk of work accidents occurred during the production process. The observation was focused on the *gudeg* chicken production. The procedure of processing the *gudeg* chicken can be shown in Figure 1.

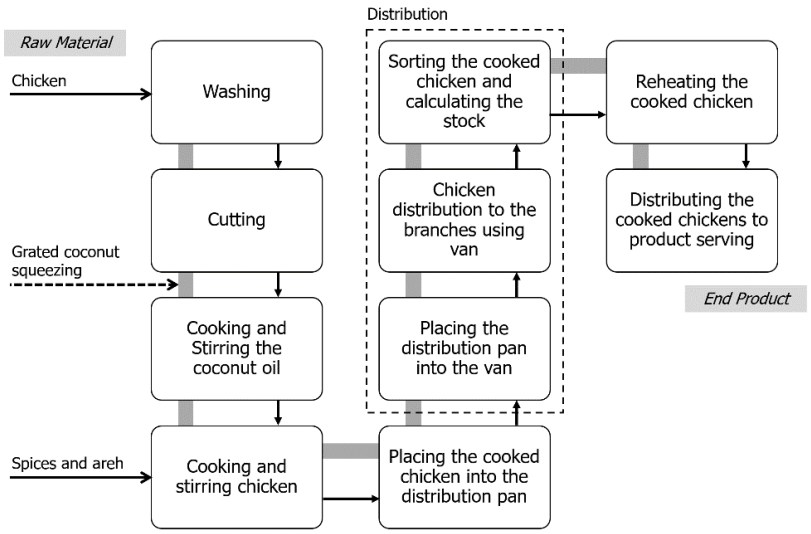

Figure 1. The Procedure of *Gudeg* Chicken Processing

In-depth interview was conducted to verify the results of observations and to obtain a list of risks of other work accidents that have been experienced by workers. The list of verified work accident risks was then made in the form of questionnaire that was used to find out the value of the severity, occurrence, and detection categories for each work accident risk. The verified questionnaire consisted of 20 questions for each category; in other words, there were 60 questions that must be filled in by each respondent. The questionnaires were distributed to six respondents consisting of operational manager, supervisor, quality control and production staff that have been selected by considering that they are the experts in this field and considered competent to provide an assessment in accordance with the condition in field.

The value of severity, occurrence, and detection obtained for each work accident risk was then averaged using the geometric mean, an average paying attention to all variables, not just a flat average and used to measure the rate of change of a variable according to time (Wahyono, 2010). The geometric mean of N units from the data population was calculated by Equation 1 (Perdana, 2018).

$$G = \sqrt[N]{X_1 . X_2 \dots X_n} \quad (1)$$

Description:
G = geometric mean
N = number of respondents
X = value of the n^{th} respondent

The geometric mean value of severity, occurrence, and detection for each work accident risk was then used as data to calculate the RPN values. Equation 2 was used to calculate the RPN values.

$$RPN = S \; x \; O \; x \; D \quad (2)$$

Remarks:
S = Severity
O = Occurrence
D = Detection

The RPN values were analyzed using a pareto diagram to determine the highest risk of work accidents in production process of *Gudeg* chicken.The pareto diagram is a data histogram that sorts from the highest to the smallest frequency (Evan and Lindsay, 2007). The RPN values obtained will be sorted from the highest to the lowest RPN, indicating that the higher the RPN order, the higher the risk of work accidents. Furthermore, the risk of work accidents with the highest RPN value based on the results of the Pareto diagram, was given recommendations for improvement using the Hazard Identification Risk Assessment and Risk Control (HIRARC) related to efforts to prevent and control hazards in the Occupational Safety and Health (K3) management system (Desianna and Yushananta, 2020). Risk control in HIRARC consists of several levels, including elimination, substitution, engineering controls, administrative controls, and Personal Protective Equipment (PPE).

3. RESULTS AND DISCUSSION

3.1 Identification of Work Accident Risk

The risks of work accidents identified consisted of 20 types of work accidents originating from 12 stages of production and distribution in the kitchen of the *Gudeg* chicken production center. Table 1 shows the results of calculating the RPN values from the identified work accident risks. The risk of work accidents in the process of producing *Gudeg* chicken were found varied. These risks might come from the production process, workers, and environmental condition. The risks coming from the production process included the exposure to smoke coming from the chicken being cooked, splashed with hot spices, and flakes of firewood. Workers here became a source of risk, i.e. when sitting in an unergonomic position and during production activities carried out manually. As a consequence, it can pose a risk of work accidents (Table 1). Environmental condition also became a source of potential risk where there were many product wastes left in the production room such as coconut milk liquid and puddle in the production room. These risks

were identified as the potential to cause work accidents in the *Gudeg* chicken production process (Table 2).

Table 1. The Potential of Work Accident Risks on *Gudeg* Chicken Processing

Code	Work Accident Risk	Process
FM 1	Manual work of chicken-washing	Chicken washing
FM 2	Heat source derived from the process of rolling the chicken intestines into the chicken gizzard	
FM 3	Puddle in the cleaning area	
FM 4	Chicken cutting is manually done using knife	Chicken cutting
FM 5	Cocunut oil on the floor	Grated coconut squeezing
FM 6	Squeezing is done manually	
FM 7	A lot of smoke and hot temperature	Cooking and Stirring the coconut oil
FM 8	Flakes of firewood	
FM 9	Pouring the cocunut milk manually	
FM 10	Splashes of hot seasoning	Adding the spices and *areh*
FM 11	Manual stirring	
FM 12	Manually inserting the chicken	
FM 13	Stirring and changing the position of chicken manually	Cooking by stirring and changing the position of chicken
FM 14	Heat and smoke from the freshly cooked chicken	Placing the cooked chicken into the distribution pan
FM 15	Lifting the pan manually	Placing the distribution pan into the van
FM 16	Uncertain and inadequate traffic condition (traffic jam or bad weather)	Chicken distribution to the branches using van

Code	Work Accident Risk	Process
FM 17	Unergonomic sitting position	Sorting the cooked chicken and calculating the stock
FM 18	Hot temperature in certain condition	Reheating the cooked chicken
FM 19	Manually moving the container of stocked cooked chickens	Distributing the cooked chickens to product serving
FM 20	The container is in hot condition	

Table 2. Results of the Calculation of RPN Value

Code	Potential Effect	S	Potential Causes	O	Process Controls	D	RPN
FM 1	Injuring the labor's arm	2.33	Chicken giblets that were difficult to wash out with the tools	1.85	PPE was available, such as gloves	5.72	24.64
FM 2	Heat and burning sensation on labor's arm	5.31	Contents of liver and chicken's intestines	5.48	PPE was available, such as gloves	4.88	142.01
FM 3	Labors may slip and fall on the ground	1.82	Congestion in the drains due to the usage of non-production standard waterway system	2.15	The availability of drainage channel with regular maintenance	7.48	29.3
FM 4	Injuring the labor's arm	6.60	Lack of specialised tools and mats chicken cutter	5.16	The availability of a spesific area for cutting and the availability of PPE, such as gloves	3.96	134.6
FM 5	Labors may slip and fall on the ground	1.59	Coconut milk spillage	2.00	Regular cleaning	8.16	25.91
FM 6	Injuring the labor's arm	1.70	Lack of coconut squeezer	2.70	Safety stock for coconut milk	7.42	33.97
FM 7	Stinging eyes of the labor and discomfort in work	5.90	Air circulation is limited	4.74	Regular building maintenance to reduce heat absorption on the production area	3.68	102.95

Code	Potential Effect	S	Potential Causes	O	Process Controls	D	RPN
FM 8	Injuring the labor's hand	3.73	Firewood had a hard and rough texture	4.06	Cloth usage to put the wood	5.79	87.84
FM 9	Injuring the labor's arm	2.62	Lack of specialised tools to pour the coconut milk into the pot	2.59	PPE was available, such as gloves	6.78	45.94
FM 10	Mild blistering on the labor's body	3.67	The procedure was done manually without tools	3.24	The availability of pan lid	7.44	88.3
FM 11	Injuring the labor's arm and causing a backpain	4.60	No stirring machine due to excessive quantity of mixed ingredients and thick texture	3.66	Stirring was regularly carried out and using multiple pans	4.02	67.58
FM 12	Injuring the labor's arm	3.87	The chicken had to be put into the pot one by one and in the order of cooking process	2.71	PPE was available, such as gloves	6.34	66.63
FM 13	Pain in the arms, back, and labor's legs	4.48	The position of the pot was above the worker's waist, the quantity of cooking was large, and it had to be done regularly to maintain the quality	5.97	The availability of chairs and footrests	4.84	129.44
FM 14	Stinging eyes of the labor	5.58	Material transfer should be done immediately after ripening to maintain quality	4.14	PPE was available, such as gloves	5.37	124.13
FM 15	Pain in the waist, arms, and labor's legs	6.65	Lack of tools to transfer the pan to the box car	2.14	Short distance from the kitchen to the box car parking area	6.76	96.16
FM 16	Fatigue of the driver	3.23	Long distribution distances and divided into several branches	1.70	Rest period for every branch	6.56	35.95
FM 17	Pain in the labor's waist	7.80	The basin position was lower than the labor and the process was carried out for a long time	6.16	The availability of spacious sortation area	3.36	161.43

Code	Potential Effect	S	Potential Causes	O	Process Controls	D	RPN
FM 18	Discomfort in work	5.03	Hot weather due to the use of galvalume roof	4.30	Multiple vents and fans	5.16	111.57
FM 19	Injuring the labor's arm and causing a backpain	4.60	There was a ladder barrier that prevented the trolley from delivering the chicken stock to the serving area.	3.14	The availability of trolleys	7.27	105.05
FM 20	Stinging and burning sensation on labor's arm	4.60	Basin material made of aluminium or stainless steel which were conductors	3.38	Cloth usage when transferring basin	7.63	118.72

S = Severity; O = Occurrence; D = Detection

3.2 Improvement Priority

The analysis of improvement priority was done by processing the data using the Pareto diagram orderly indicating the level of improvement prioroties. In making the pareto diagram, it required the data of the work accident risks, the RPN values, RPN percentage values, and the cummulative percentage values of RPN. Figure 2 shows the work accident risks in the process of producing the *Gudeg* chicken sequentially.

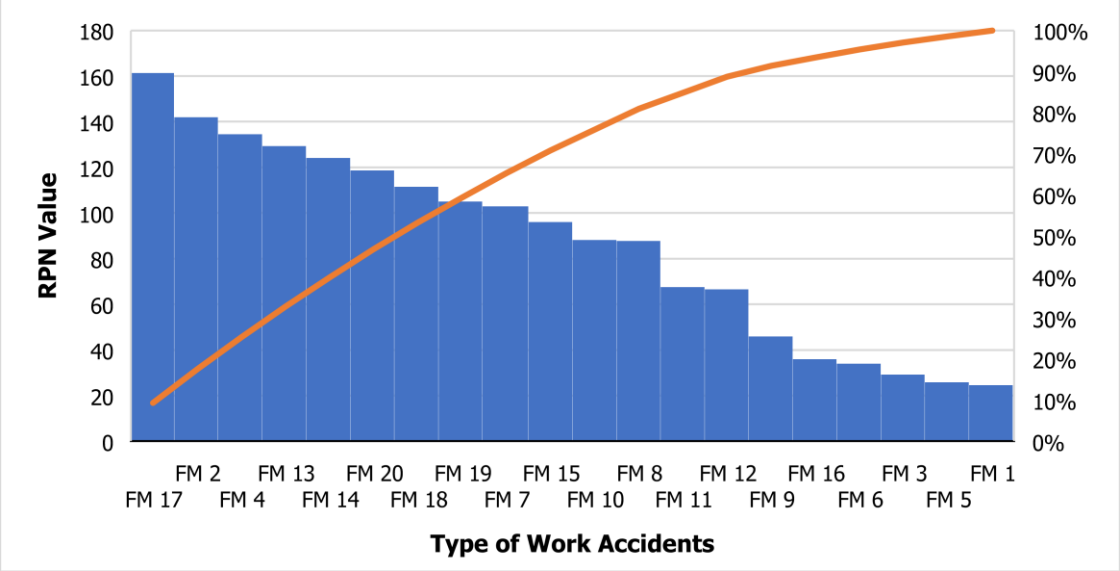

Figure 2. Pareto Diagram of Work Accident Risk in the *Gudeg* Chicken Production Process

As shown in the Pareto diagram, it was found that the types of work accidents were based on the level of risk from the largest level, i.e. the risk of work accidents with code of FM 17 or unergonomic sitting position in the process of sorting and calculating the stock of cooked *Gudeg* chicken. At the risk of work accidents with code of FM 17, the highest RPN value was 161.43 or 9.32% of the total RPN obtained. According to Knowlson (2022), the Pareto principle states that 80% of output comes from 20% of input, meaning that FM 17 can be the main cause of the risk of work accidents in the *gudeg* chicken production process. Working posture that is not in normal condition is the one needs to be a concern. Figure 3 shows the posture of worker in the sorting the cooked *Gudeg* chicken.

FM 17 had a severity value of 7.8 indicating that the work accident totally disrupted the work of the system. The sitting position of workers in the process of sorting and calculating the cooked *Gudeg* chicken stock was seen unergonomic since the chairs used were found higher than the sorting table. This then made the working position in a hunched state or even the worker must stand during working hours and this caused the backpain for the worker. This is consistent with research on ergonomic sitting posture stating that the most contributing factor to low back pain is an unfavorable position during activities. This causes disturbances in the musculoskeletal system and puts considerable pressure on the intervertebral discs; hence, it can cause lower back pain and in the long term it also can cause hunchback in the body (Wahyuni et al., 2020).

Figure 3. The posture of the worker in sorting the cooked *Gudeg* chicken

The occurrence value obtained was 6.16 indicating that the risk of this work accident had quite high probability of work accident occurrence with an occurrence rate of 1 time occurreed within 3 to 4 days. The high rate of occurrence is related to the the process carried out every day and for a long time.

The detection value obtained was 3.36 indicating that the control had a significant effect where the detection had a quite high probability to detect the type and cause of work accidents. The control for this work accident refers to the availability of a large work area enabling the workers to adjust their work position to get more comfortable working condition. However, this area was found not properly utilized by workers and there were no work facilities such as ergonomic desks and chairs. This control is carried out to create an ergonomic sitting posture while working where an ergonomic posture can reduce the work of the extensor muscles to fight against the load transmitted to the spine. By so doing, the possibility of spasm or strain on these muscles can be prevented (Wahyuni et al., 2020), including at the waist of the workers.

3.3 Improvement Recommendation

Based on the pareto diagram, it was found that the type of work accident with the highest value of RPN in the chicken production and distribution process that needs to be prioritized for improvement was FM 17 (unergonomic sitting position) with an RPN value of 161.43. The recommendation for improvement was analyzed using HIRARC to determine the control measures purposely to minimize the risk level and to prevent any work accidents (Urrohmah and Riandadari, 2019). Figure 4 shows risk control and recommendations using HIRARC.

The potential risks based on the results of existing hazard identification indicated that the type of work accident in an unergonomic sitting position was included in the high risk rating, meaning that senior management must pay more attention. The determination of the risk level based on the severity of this risk was at level 3 (moderate) because workers needed a medical treatment, causing the loss of working hours of more than 24 hours, and high financial losses and the likelihood of this risk was at level B (Likely) in view of the possibility of frequent occurrence within a week. The risk control hierarchy is byb using PPE in the form of gloves. Administrative control refers to the provision of SOPs related to the work environment allowed to carry out production processes and safety induction, making work schedules adjusted to workload, and monitoring the work environment on a

regular basis. Engineering control refers to the modification of the table used to make it higher than the chair or the modification of the chair to make it lower than the table. Also, it can be done through substitution by changing the sorting work area to another available area that has a good table and chair size for the work position. In this type of work accident, elimination cannot be done for risk control.

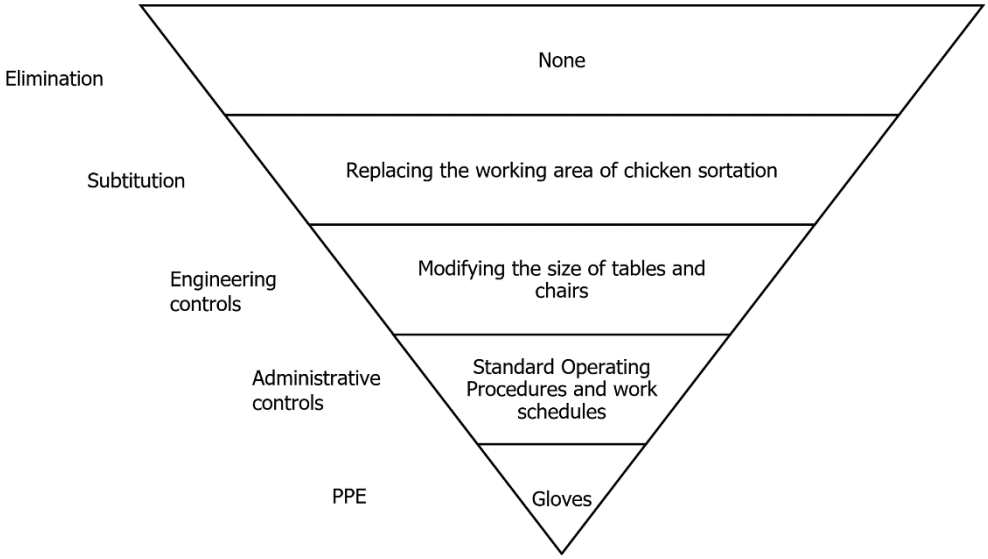

Figure 4. Recommendation of improvement based upon HIRARC

The risk control hierarchy for the risk of work accidents in the form of unergonomic work positions in the sorting process is by using PPE in the form of gloves, doing an administrative control by making SOPs related to the work environment to carry out production and safety induction processes and making work schedules adjusted to workload, engineering control by modifying the table used to make its height exceeding the chair or modifying the chair to make it lower than the table, substitution by changing the sorting work area to another available area that has a good size table and chair for the work position. However, in such work accident risk, elimimation cannot be done for the risk control.

4. CONCLUSIONS

Gudeg Chicken was prepared in two separate kitchens, along with the process initially from washing the chicken, cutting the chicken, squeezing the grated coconut, cooking and stirring the coconut milk, adding the spices and *areh,* stirring, and distributing the end product to the restaurant. The risk of work accidents in the *Gudeg* chicken production division as the priority for improvement was the risk of work accidents with the highest RPN value, i.e. FM 17 (an unergonomic sitting position in the process of sorting and calculating the stock of cooked *Gudeg* chickens). The RPN value for this work accident risk was 161.43 with a severity value of 7.8, an occurrence value of 6.16, and a detection value of 3.36. Recommendations for improvement that can be given are by providing PPE in the form of gloves, administrative control by making SOPs and making work schedules with the adjustment of workload, engineering control by modifying the height of workers' tables or chairs, shifting by changing the sorting work area, and here elimination of the production process for risk control cannot be done.

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Frozen Tilapia Fillets Business Process Analysis Using Integration Definition for Function Modelling

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Abstract

Aquaculture products in Indonesia have great potential in line with population growth. The demand for frozen tilapia fillets is increasing both in Indonesia and globally. Our objectives are to identify the current business process activities of a frozen tilapia fillet product, analyse problems and provide improvement strategies. In-depth interviews and observations were conducted with stakeholders. The business processes were analyzed using an Integration Definition for Function Modelling (IDEF0) to identify the activities and problems at the organizational level, the production plant level and the production department level. The results at the production plant level showed that there was a lack of strategic forecasting and inventory management in the planning activity. In the sourcing activity, the limited number of suppliers and inconsistent fish quality were the main problems. The lack of implementation of a good material handling and production system was a concern in the making activity. The problem in the delivering activity was the lack of product tracking which results in product returns due to defects. The researchers' recommendations, based on several literature reviews, are expected to improve the supply chain of frozen tilapia fillets in Yogyakarta and Central Java to increase its competitive advantage.

Keywords: *Aquaculture*, *Frozen Tilapia Fillets, IDEF0*

1. INTRODUCTION

According to Food and Agriculture Organization (FAO) 2022, global aquaculture foods consumption increased at an average annual rate of 3 percent from 1961 to 2019, a rate almost twice of annual world population growth. Research showed that aquaculture production is positively related to the consumption of aquatic food in 163 countries (Garlock et al., 2022). Indonesia's aquaculture is expected to continue growing to meet fish consumption demand (Tran et al., 2017). Tilapia had the highest production at 1.4 million tonnes in 2019, according to data on aquaculture production in Indonesia by major commodity (Central Bureau of Statistics (Indonesia), 2019). Tilapia trade and forecasts have received considerable attention in recent years, particularly in the US market, which accounts for 70% of the global tilapia market (El-Sayed, 2020). Indonesia, followed by China and Colombia, is the third largest exporter of tilapia to the US market. Indonesia's supply of frozen tilapia fillets is a leading exported product that has seen steady growth in the US market over the past 20 years. However, tilapia products from China and Indonesia have been unable to meet the demands of US consumers. Tilapia products from Indonesia were greatly preferred by American consumers, despite having a higher price compared products from China. This indicates that the tilapia industry in China is growing much faster than in Indonesia (Dai et al., 2020).

In contrast, perception of value, product packaging and consumer lifestyle have a significant impact on the purchase value of frozen food during the pandemic in Indonesia (Chianardi and Permatasari, 2020). Frozen tilapia fillets have a high demand regarding the categories of frozen food consumed during covid-19 pandemic (Janssen et al., 2021). Since the pandemic, the cold chain system in Indonesia has grown, particularly for the supply of agro-industrial products. The cold supply chain for aquaculture in Central Java is implemented to maintain quality (Guritno and Ryanjani Tanuputri, 2017). The cold chain system has several advantages for fisheries products to minimize physical, microbial, and chemical degradation of food quality (Kitinoja, 2014). An analysis of the current cold supply chain in Indonesia, focusing on the business processes of third-party logistics providers, revealed that it is still poorly implemented and inefficient (Pradita and Ongkunaruk, 2019). Integrated inventory management, databases, and traceability systems are also required in the cold supply chain of frozen products. Although the cold chain is appropriate for handling fishery products, its application faces

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several challenges (Arista et al., 2022). In addition, frozen tilapia products have good development potential according to consumer demand in both local and export markets. Therefore, business process analysis of frozen tilapia fillets was conducted in this study to identify problems, then improvement strategies were provided to improve product competitiveness.

2. MATERIAL AND METHODS

The qualitative method involved observation and in-depth interviews with stakeholders in the frozen tilapia fillet supply chain in Yogyakarta and Central Java, using a questionnaire as a tool to obtain data for analysis. In the downstream process, each level of the supply chain was represented by three respondents. In the upstream process, the production plant and the 3PLs were each represented by one respondent in a managerial position who was considered to have a better understanding of the business process. The exporter and customer levels were represented by two respondents each. This research is more specifically focused on data collection at the production plant by conducting in-depth interviews with the production manager of one of the frozen food manufacturers. Respondents are responsible for gathering required information about activities and problems on each tier of the frozen tilapia fillet supply chain. Then, the business process has been identified by using Integration Definition for Function Modelling (IDEF0) level 0 for all stakeholders, level 1 for the company level and level 2 for the production department. The higher level indicates activity in a more detailed business model. IDEF0 is used to model and analyze complex systems, study the functioning and interrelationships of systems, and the activities present in the company's business model. IDEF0 for the development of strategic plans is carried out in micro, small and medium enterprises (Waissi et al., 2015). The advantage of IDEF0 modelling technique is that it permits the user to specify a complete system design to as complete level of detail as desired. The main components in IDEF0 are the functional boxes that represent the activities of each process and four arrow functions including input, output, control and mechanism of each activity (Tangkham and Ongkunaruk, 2019). The left arrow entered in the box shows the input, which is the factor that drives the activity. The right arrow leaving the box shows the output that is the result of performing the activity. The arrow from the top into the activity box shows the control such as standards, regulations or activity requirements. The arrow that enters the box from the bottom shows the mechanism implying resources such as humans and equipment or machines in carrying out activities. The solid line shows current activity and the dashed line offers recommendations for improvement in tilapia fillet frozen supply chain. Furthermore, researchers provide recommendations based on several literature reviews according to the problems encountered.

3. RESULTS AND DISCUSSION

3.1 A frozen tilapia fillet supply chain

The supply chain of frozen tilapia fillets starts from the breeder as the first tier to the end consumer as the last tier. The breeder breeds the fish untul the larvae emerge for about 20 days. Then the fry are cared for by the spreader, the third tier, for approximately 60 days. The next tier is the enlarger, which is carried out for 3-4 months until the fish reaches consumption size. Collection centers collect the consumable fish from the enlarger and resell them to prpduction plants, retailers and end consumers. Breeders, spreaders, enlargers, and collection centers are located in Sleman, Yogyakarta and Klaten, Central Java. In addition, the tilapia for consumption will be sent by the collection center to the production plant in Semarang, Central Java, a distance of approximately 110 km with a travel time of 2-3 hours. After the fish is processed, the frozen tilapia fillet will be delivered to Tanjung Mas using refrigerated containers from third party logistics providers (3PLs). The products are exported from the Tanjung Emas port using a cold chain system. Central Java Province exported tilapia products to six countries in 2020 with a volume share of destination countries (%) to Australia by 2.6%, Germany by 3.8%, Thailand by 4.59%, Canada by 6.72%, Netherlands by 23.54% and United States by 58.75% (Suhana, 2022). The consumers of these products are business-to-business (BTB) such as retail supermarkets and horeca (hotels, restaurants, cafes) and end consumers.

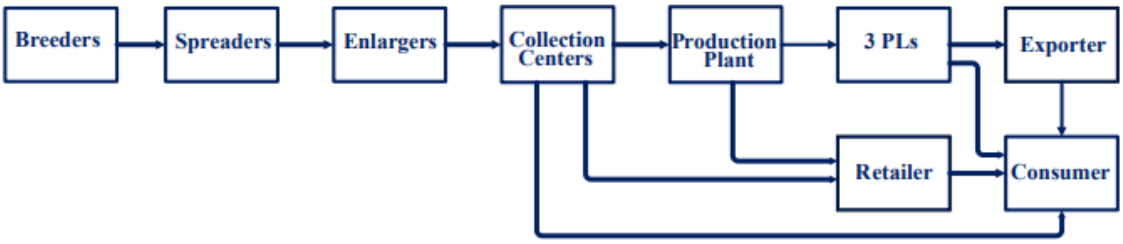

Figure 1. A frozen tilapia fillet supply chain

3.2 Business process analysis of a frozen tilapia fillet

3.2.1. The business process of frozen tilapia fillets at the organizational level (IDEF0 Level 0)

The organizational level of the stakeholders is drawn in IDEF0 Level 0, which is shown in Figure 2. For this figure, the relationship between the stakeholders in the business process can be identified and analyzed. Previously, the collection centers only used experience-based forecasting without considering seasonal and historical data. The lack of forecasting management leads to stock shortages that cannot meet consumer demand, or even overstocking due to poor handling during the harvest season. In the collection centers, there is a suggestion in the input to make strategic forecasts. Therefore, to improve accurate forecasting, an appropriate forecasting strategy is needed through quantitative and qualitative with the required mechanism is a spreadsheet (Fildes et al., 2019). The spreadsheets are required because, previously, collectors only used manual records, which were not well organised. The delivery of fresh fish by the collectors is usually by means of box trucks that have oxygen added for live fish, or ice for dead fish. However, some fish die before they are delivered, and collectors generally sell them to end consumers at low prices as their quality declines. Therefore, a freezer is needed in the collector to preserve the dead fish before shipment, so that the quality remains good and can be sold at a high price.

In the production plant, there should also be improvements in the input section to use a more accurate strategic forecast as in the collector that uses quantitative forecast to realise the data history and qualitative forecast such as forecasting weather conditions. A qualitative forecast is very important to do because the product handled is a very sensitive aquaculture product to weather changes. Production plants have a greater demand than the existing supply, but the capacity within the company is not met or has a lack of capacity. Labour is the capacity in this case because almost the entire process of producing frozen tilapia fillets is done manually. Therefore, when demand is high, it would be better for the company to increase its capacity by outsourcing labour (Francas et al., 2011).

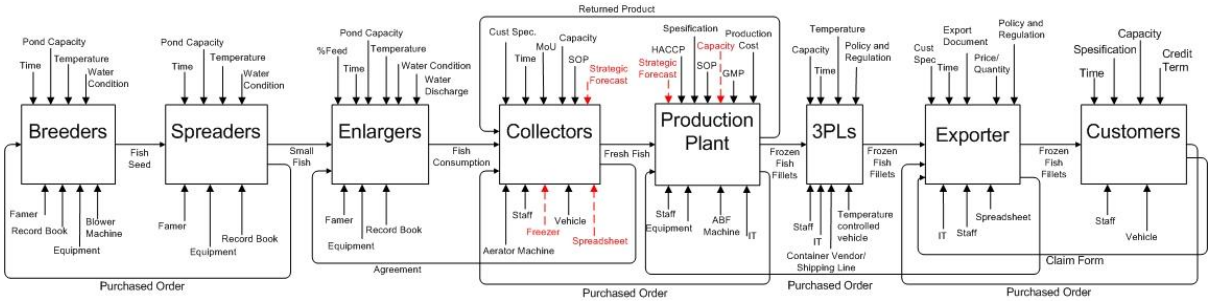

Figure 2. IDEF0 level 0 (organizational level)

3.2.2. The business process of frozen tilapia fillets at the production plant level (IDEF0 Level 1)

In IDEF0 level 1, all activities that occur in the production plant are categorised as plan, source, make, deliver and return. Figure 3 shows the business process of the frozen tilapia fillet production plant. The solid line represents the current situation and the dashed line represents the proposal offered in this production plant. In the planned activity, the given suggestion is strategic forecasting and inventory management. Inventory management is necessary because sometimes when there are a lot of raw materials, raw materials are stored together with finished products. Therefore, there must be

good inventory management to maintain the quality of the products (Wild, 2017). In the source activity, the company uses suppliers from Sleman, Yogyakarta and Klaten, Central Java, so the production only depends on suppliers from both areas. Therefore, the company should add suppliers from other regions in Central Java. Routine supplier evaluation should also be done because there is no evaluation for suppliers.

In the make activity, the company must add a percentage of productivity as a key performance index (KPI). Productivity is the ability of the industry to produce the finished product(Gidwani and Dangayach, 2017). The company uses the services of a third party logistics provider for the delivery of the finished product, which is delivered using a refrigerated truck that is actually equipped with a thermo-logger. However, the company does not regularly check the temperature during transport. Therefore, it needs real-time control of the input and also a KPI in the form of delivery lead time, as currently the company only uses the estimated time. Real-time monitoring is very important when transporting perishable goods. Transported goods are monitored during transport and mitigation plans are implemented when deviations from optimal transport conditions occur and there is a risk of damage to goods or deterioration in product quality. Optimizing a cold chain system that provides optimum refrigeration during transport requires complete sytem integration, not just specific processes (Lailossa, 2015). For the return activity, the KPI required a percentage of defects to be measured by the company. Exporters can return products if the products do not meet the pre-export qualifications. The percentage of product defects that appear as a reference for the application of various methods to eliminate defects and thereby reduce product returns (Przystupa, 2019).

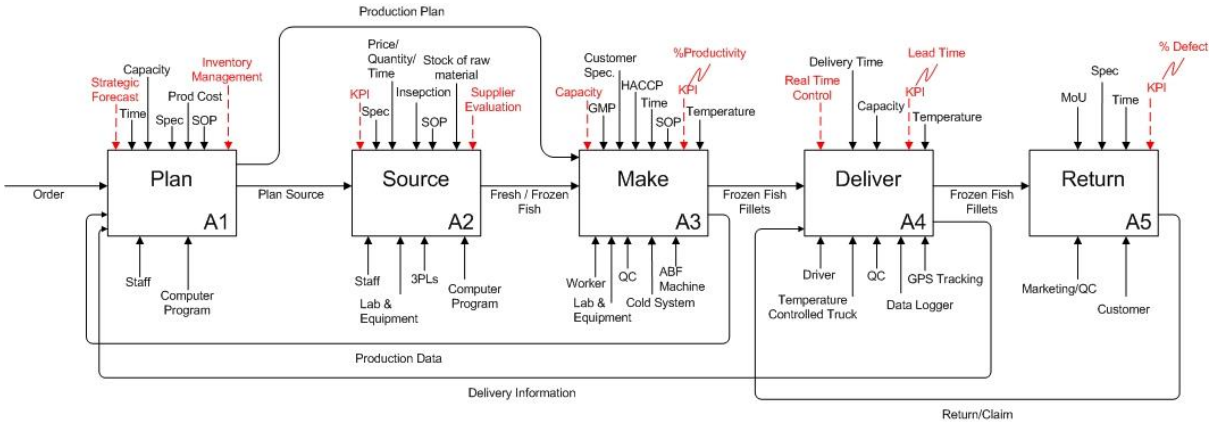

Figure 3. IDEF0 level 1 (production plant level)

3.2.3. The business process of frozen tilapia fillets at the make activity in the production department (IDEF0 Level 2)

In IDEF0 level 2, all the activities that occur in the production department (A3 in level 1) are categorised as receiving, processing, freezing, packing and storing. Figure 4 shows the business process in the production department. In the receiving activity, quality checks are performed by quality control staff based on existing operating procedure standards. However, the checks usually depend on the experience of the staff working in this section, so there will be quality differences with other staff. Therefore, the quality standard in the receiving process needs to be of the same quality. The quality of fresh fish as a raw material affects the final product. The longer the storage period prior to freezing, the more likely the quality of the frozen fish will deteriorate (Watanabe et al., 2020).

There is a bottleneck in the vacuum station because it has less capacity than the previous station. Therefore, it is necessary to increase the capacity of the vacuum machine to overcome the bottleneck. In the production department, all processes are under temperature control, but not well implemented. The company should have an ice crusher for the production of ice so that the temperature can be under control. In the processing section, the capacity is also limited due to limited labour. Actually, the Air Blast Freezer (ABF) machine has a capacity of 5 tonnes / batch, but sometimes it is not fulfilled. Product defects often occur in packing activities due to poor handling from workers. Therefore, inspection by supervisors is required in this process. To improve production results, a

number of quality and human resource management techniques, methods or tools can be applied to increase production capacity, volume of products manufactured and production quality (Blaga, 2020). In the storage activity, inventory management is currently carried out using simple spreadsheets and an inventory policy has not been properly implemented. The recommendation that can be made is that there is a need for a stricter inventory policy in order to maintain the availability of products in accordance with the required cold storage temperature.

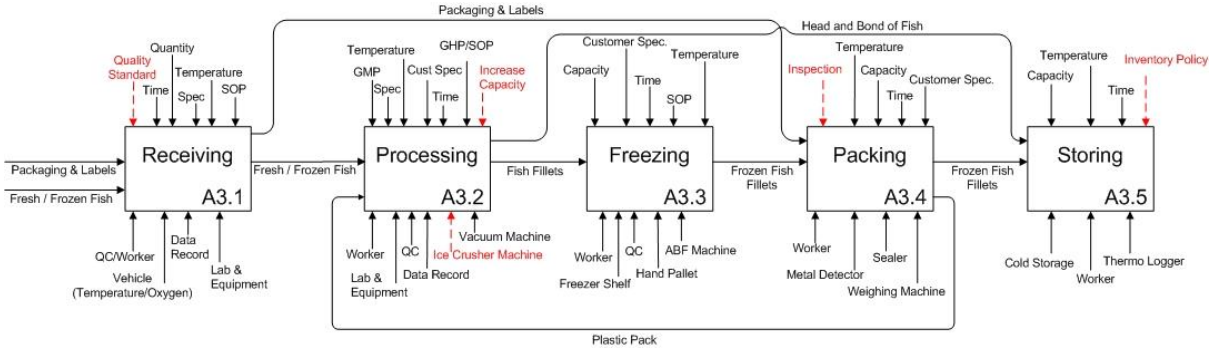

Figure 4. IDEF0 level 2 (make/production department)

3.3 Suggestion for improvement

A summary of current problems and suggestions for improvement at the organizational level can be seen in Table 1:

Table 1. Current problems and suggestions for improvement at the organizational level

Stakeholder	Problem	Improvement
Collection Centers	Product quality decrease during storing	Implement the cold storage management by using freezer
	Lack of traceability at farm level	Implement database and traceability system
	Product defect during delivery process	Checking the amount of oxygen and temperature in routine
All Stakeholders	Lack of coordination and information	Sharing information for all stakeholders
	High error of forecasting	Centralized demand forecast

A summary of current problems and suggestions for improvement at the production plant level can be seen in Table 2:

Table 2. Current problems and suggestions for improvement at the production plant level

Activities	Problem	Improvement
Plan	Lack of strategic forecast	Long term demand forecast Use qualitative and quantitative forecast analysis
	Short shortage during rainy season	Improve the inventory management stock
Source	Minimum number of supplier (only from Sleman and Klaten)	Finding another supplier who able to supply fish with good quality in Central Java
	Lack of consistency of fish quality from collection center	Check quality 3 times (harvesting, in the collection center, and before deliver to production plant) Use some KPI to evaluate supplier performance

Activities	Problem	Improvement
Make	Minimum productivity	Increase the capacity by using outsourcing worker
	Lack of worker commitment	Strengthening personal commitment to following SOP and use inspection (in packaging department)
	Imbalance production line (bottleneck in vacuum process)	Increase the capacity of vacuum machine
	Product defect because of improper handling	Training the outsourcing worker and improve the inventory policy in cold storage department
Deliver	Lack of real time tracking and coordination between driver and staff	Check the temperature product by using thermo data logger in routine
	Long lead time for delivery	Collaborate with 3 PLs who has a good performance
Return	No indicator of product defects returned	Use key performance indicators

A summary of current problems and suggestions for improvement at the make activity in the production departement can be seen in Table 3:

Table 3. Current problems and suggestions for improvement at the make activity in the production departement

Activities	Problem	Improvement
Receiving	Quality standards based solely on staff experience	Maintaining quality through quality standards
Processing	Low capacity of machines	Increase the capacity of the vacuum machine
	Product temperature is not well maintained	Adding ice crusher machine
Packing	Product defects often occur due to poor handling from workers	Inspection by supervisors
Storing	Inventory management has not been implemented properly	Implement a stricter inventory policy

4. CONCLUSIONS

The current supply chain of frozen tilapia fillets was investigated. In this frozen tilapia fillet supply chain, breeders, spreaders, enlargers and collection centres are located in Sleman, Yogyakarta and Klaten, Central Java. Tilapia of consumption size is sent from the collection centre to the production plant in Semarang, Central Java. The products are exported to USA, Europe and some Asian countries using cold chain system. The business process of frozen tilapia fillets is analysed based on IDEF0 level 0 as the organisational level, level 1 as the production plant level and level 2 as the make activity in the production department. We identified the problems that occurred in the main activities and gave the recommendations for improvement. The main problem at the collection centre at the organizational level is the lack of technology in storage and transportation, so it is recommended for the implementation of cold supply chain. There is a lack of coordination between all stakeholders and forecasting has a high error rate, so it is necessary to share information and use appropriate forecasting techniques. The results at the production plant level showed that there was a lack of strategic forecasting and inventory management in the planning activity. In the sourcing activity, the limited

number of suppliers and inconsistent fish quality were the main problems. The lack of implementation of a good material handling and production system was a concern in the making activity. The problem in the delivering activity was the lack of product tracking which results in product returns due to defects. Recommendations for improvement were made for each of the problems in the Activity. At the production department level, quality standards are needed in the receiving process to have the same quality, increasing the capacity of the vacuum machine to overcome the bottleneck, using an ice crusher to produce ice, carrying out inspections to reduce defective products, applying inventory policies to maintain product availability. In this study, there are limitations in collecting some sensitive information due to company confidentiality. We hope that our guidelines can be applied by stakeholders in a frozen tilapia fillet supply chain. Further research can be conducted to identify the problem in more detail and provide an appropriate solution.

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