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Design and Development of Satay Delivery Packaging Box

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Abstract: Satay is one of Malaysia's popular take away food with various types of packaging. However, it has an issue of food freshness and sustainability. In this paper, the design and development of a new packaging for Satay takeaway and delivery purpose is discussed.This project has redesigned and developed a new packaging for Satay takeaway and delivery purpose. New redesigned Satay packaging was developed using paper-based material. The methodology is based on Quality Function Deployment (QFD) method through customer interview, Voice of Customers (VoC) and questionnaire to observe the consumer requirements and construct the House of Quality (HoQ). After that, followed the design process via developing concepts, concepts selection, determining critical parts, computer aided design (CAD) and producing a visual prototype. Food freshness, food temperature and sensory evaluation were also evaluated on the visual prototype compared to other types of packaging. The results show that the new developed Satay delivery packaging is further complements to customer needs, recyclable and maintains the food freshness.
Keywords: House of Quality, Packaging, Quality Function Deployment, Satay

1. Introduction

Nowadays, online food delivery service has increased rapidly especially in urban areas in Malaysia. The benefits of online food delivery (FD) were evident during the global 2020 COVID-19 outbreak, as it enabled consumer access to prepared meals and allowed food providers to keep operating [1].

Satay is very simple to produce, as it is only important to grill the meat with charcoal and pierce it with bamboo skewers and smear the meat with specially made sauce or seasoning [2]. Satay is also served with slices of red onion and cucumber, in addition to lontong, rice cake or ketupat to make it more delicious. There was an increasing demand of Satay delivery and take away. Therefore, a suitable packaging needs to be developed for Satay delivery applications.

Delivery food always concerns with freshness. Satay serving needs proper ingredients preparation and highly grilling skills to maintain its freshness. Freshness is determined by the package itself where

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less of 'ventilation' would certainly make it less fresh [3]. Hence, the development of Satay delivery packaging that could maintain the temperature and freshness is beneficial.

Packaging flexibility, sustainability, material and price are required by the consumer. Quality Function Deployment (QFD) enables the design process to concentrate on main consumer specifications, which are described as very relevant to the customer [4]. The House of Quality (HoQ) process's production provides an incentive for enterprises to produce goods that fulfill industry requirements [4]. Thus, the new Satay packaging that was designed and developed via QFD method in this project could fulfill the customer requirements. The development of new Satay delivery packaging design could support the increasing demand of food delivery service.

Figure 1 shows the current established Satay delivery packaging style which uses transparent plastic and paper-based lunch box. However, there was still less study on the Satay freshness quality when using these types of packaging. Satay packaging problems: such as in terms of practicality, the incapability to optimally protect the satay, the possibility to eat satay without having to use plates, and the lack of identity on the packaging itself [5]. For the Satay seasoning packaging, consumers need improvement in the packaging aspect such as packaging using clear plastic material, attractive and low prices [2].

Food delivery also concerns about the packaging sustainability in terms of recycling and biodegradability. In addition to maintaining food quality and safety, promoting transport and logistics and allowing connectivity, sustainability has become one of the integral roles of packaging [6]. High levels of waste created especially plastic as a result of online food delivery [1]. Nevertheless, there were still major usage of plastic and polystyrene base packaging for Satay delivery. Therefore, this study is focused on the development of Satay packaging design that could fulfill the customer requirements, maintain the freshness and also be recyclable.

(a) (b) (c) (d) (e)

Figure 1: Current Satay Packaging (a) Satay Cup; (b) paper-based lunch box; (c) paper-based compartment type; (d) plastic container; and (e) plastic bag

The scope of this study cover the survey on customer requirements of satay packaging delivery box, packaging design, the material use to produce the packaging, food quality testing, and customer survey on the new developed packaging delivery box.

2. Materials and Methods

Figure 2 shows the methodology flowchart of this study.

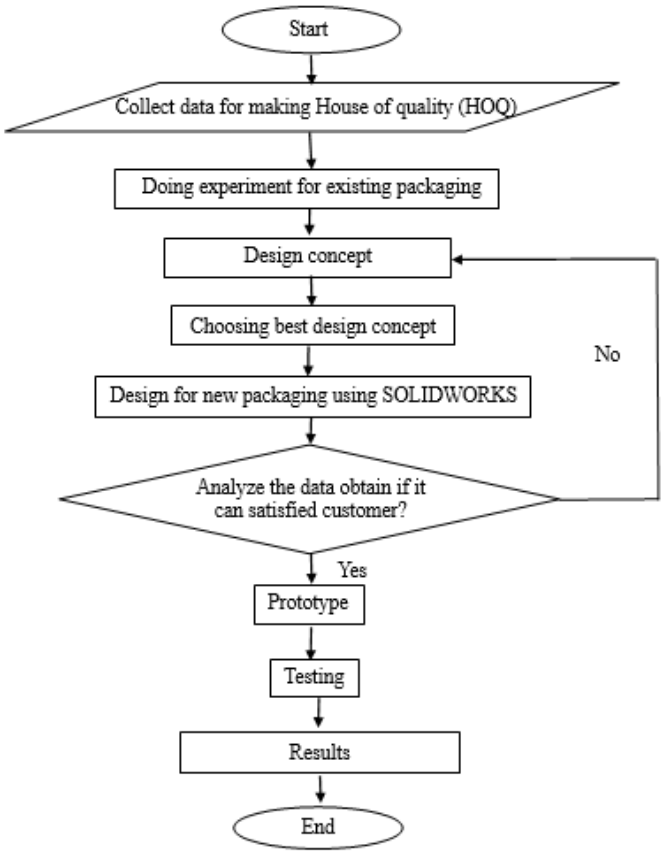


Figure 2: Methodology flow chart

2.1 Material preparation

For this project, disposable paper packaging was used for the material selection. Food contact paper-based material was prepared and taken from Packaging Design and Simulation Laboratory, Universiti Tun Hussein Onn Malaysia in order to produce recyclable Satay delivery packaging box.

2.2 QFD and HoQ

The data rate of consumer interests obtained from 30 respondents' questionnaires, with 8 attributes assessed, based on five levels, namely the interests ranging from strongly disagree (value 1) to strongly agree (score 5).

A conceptual Quality Function Deployment (QFD) model in this research was performed to translate Voice of Customers (VOCs) into the technical requirements [7]. In this phase, technical requirements (also referred to as 'product development', 'HOWs') derived from the calculation of Geometric Mean for accurate data, which will use importance rating [8]. Importance rating (IMP) is the same as level of customer satisfaction (CLS) which is calculated by Eq. 1.

$$CLS = \frac{\Sigma x}{N} \qquad Eq.1$$

Where CLS is level of customer satisfaction, x is the satisfaction value of each customer and N is the number of respondents

Making correlation matrix helps to know the relationship between technical requirements and attributes of consumer needs of satay packaging. The value of the relationship on HOQ was gained through questionnaire and discussions with resource persons. A correlation matrix was developed

containing the relationship between the technical requirements and the attribute of the consumer needs in terms of packaging [9]. Here is the correlation matrix for Satay packaging obtained from questionnaire and discussions [10]. For the top portion, the "roof" of the house, displays potential conflicts between engineering specifications. When the packaging is using disposable paper, the packaging also should be water resistant.

The next step was calculating of important weight of each technical requirement. This step shall be done by Equation 2:

$$IW = \Sigma(RL \times IMP) \qquad Eq.2$$

Where IW is importance weight, RL is relationship level and IMP is importance rating.

The next step was calculating of importance relative weight (% Relative). This step shall be done by Equation 3: [11]

$$\%\, Relative = \frac{IW}{\Sigma IW} \times 100 \qquad Eq.3$$

Where (%) relative is importance relative weight and IW is importance weight.

Finally, the technical requirements were ranking by technical importance relative weight (% Relative) constructed in the HOQ.

2.3 Design and development phase

The concept generation was conducted after the HOQ construction was completed. Three (3) different sketches of Satay packaging delivery box were prepared during the design generation phase. Design selection is conducted using concept scoring methods. Then, the final design die cut drawing was prepared by Adobe Illustrator. The CAD model and drawing was prepared by SolidWorks software. Maximum stress for three (3) different Satay weight impacts on the packaging was analyzed by SolidWorks Simulation. Finally, a prototype of Satay packaging delivery box was produced.

2.4 Freshness, temperature and sensory testing procedure

Freshness is conducted to analyze response to Satay to determine the best type of packaging during storage time of 5,10,15,20.25 and 30 hours. The attributes tested include color, smell and texture. The selected packaging type is applied to the next primary research.

Descriptive sensory tests are often performed to determine the effects of changes in raw material, processing, and packaging on the sensory qualities of products. In all of these cases, multiple attributes on a single set of samples were evaluated and analyzed. Before taste each product, the tester should take a sip of water to remove any lingering tastes in the mouth. Tester was given a serving of the Satay to eat. They must eat at least one-half of the product so that they can form an opinion. Once they are done with the entire questionnaire, there will be a 5-min break and then they will go on to the next product. The same procedures will be followed for the second product. In this study two (2) testers are selected.

2.5 Graphic label design and customer feedback

Graphic design for Satay delivery box is prepared by using Canva. The design of packaging was based on the concept selected. Customer feedback is conducted to one of the potential customers of Satay packaging delivery box.

3. Results and Discussion

3.1 QFD and HoQ findings

Table 1 shows the customer satisfaction rating for each attribute of the consumer needs of the Satay packaging delivery box. The top three (3) ranking are non-toxic packaging, odorless and recyclable.

Table 1: The level of customer satisfaction of Satay packaging

	Attribute Consumer Needs	$\sum$	Level of customer satisfaction	Rating
Packaging	Transparent packaging	131	4.37	4
	Attractive packaging	130	4.33	5
	Cheaper	130	4.33	6
	Not oversize	124	4.13	7
	Smart packaging	120	4.00	8
	Can recycle	145	4.83	3
	Non-toxic	147	4.90	1
	Odorless	146	4.87	2

Table 2 shows the correlation matrix between technical aspects and the customer needs for Satay packaging delivery box. It shows that sustainable packaging is the most concerned followed by safety of food, water resistant, QR code and keep warm respectively.

Table 2: Correlation matrix of Satay packaging HoQ

Technical aspects	Packaging using disposable paper	Keep warm	Has QR code	Safe for food	Water resistant
Transparent materials	9	3			9
Has aesthetic value	1		3		
Price RM 1.00 per box	3			3	
Dimension is 20 cm x 20 cm x 10 cm	9				1
Access to more detail product			9		
Recyclable	9				3
Non-toxic				9	
Do not effect odor or taste to the food	1	3		9	3

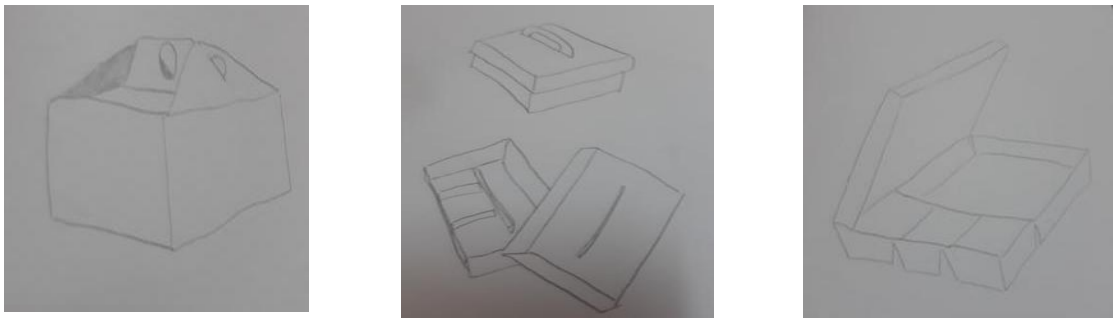
The matrix of HoQ consists of several portions of all the results. Dependent on each component, all data or information from the previous phases is inserted into the HoQ matrix [2]. The purpose of the House of Quality (HoQ) is to directly translate customer requirements into technical requirements or specifications of the product produced [12]. Figure 3 shows the HoQ matrix of the Satay packaging delivery box.

Customer Requirement \ Technical Requirement	IMP	packaging using disposable paper	keep warm	has QR code	safe to eat the food	water resistant
		1	3	9	1	3
Transparent materials	4.37	9	3			9
Has aesthetic value	4.33	1		3		
Price RM1.00 per box	4.33	3			3	
Dimension is 20cm×20cm×10cm	4.13	3				1
Access to more detail product	4.00			9		
Can recycle	4.83	9				3
Non toxic	4.90				9	
Do not effect odor or taste to the food	4.87	1	3		9	3
Importance Weight		117.38	27.72	48.99	100.92	72.77
% Importance Relative Weight		31.92	7.53	13.32	27.44	19.79
Rank		1	5	4	2	3

Figure 3: HoQ matrix of Satay packaging delivery box

3.2 Design, development and prototyping findings

One final design from three designs as shown in Figure 4 is selected by concept scoring method as illustrated in Table 3. The design is chosen by using the highest ranking from strongly disagree (value 1) to strongly agree (value 5). Design 1 has a complicated design to fold and attach it. The best design was the third design because of its more functional features. The design has a compartment to separate between the peanut sauce, rice cake and cucumber for the Satay to long lasting. The first and the second design is rejected, since it consists of many parts. Besides that, the hole part that is used to put the finger might be torn, if the customer put the Satay in a large quantity. Hence, the third design is suitable so that the customer does not worry about the food falling to the ground. This is because customers can place their hand on the bottom of the Satay packaging during eating.



(a) (b) (c)

Figure 4: Design sketches (a) Design 1; (b) Design 2; and (c) Design 3

Table 3: Technical function and characteristics of concept sketching

Sketching	Design Name	Purpose	Easy to fold	Easy to attach	Total
1	House Shape Satay Box	Big in size	2	1	3
2	Present Shape Satay Box	Small in size	4	4	8
3	Satay Delivery Box	Contain compartment	5	4	9

Figure 5 shows the die cut drawing prepared by using Adobe Illustrator software for the base and compartment of Satay packaging delivery box. Die cutting is a processing technique that uses advanced machines and equipment by cutting, shaping, and shearing to convert stock material. To produce distinctive shapes and mark patterns, die-cuts are used in printing. The 'die line' is the outline of where the die will be cut and is commonly seen as a thick colored line in evidence. Based on Figure 5, it shows that the shape of a Satay packaging made of paper is easy to open and assemble. To make assembling the packaging easy, no glue or tape is required. These two side flaps were locked down and locked in beside together and once they're locked in comfortably, it's created a base. Figure 6 also shows the Satay packaging CAD modeling and drawing constructed by Solidworks sheet metal method.

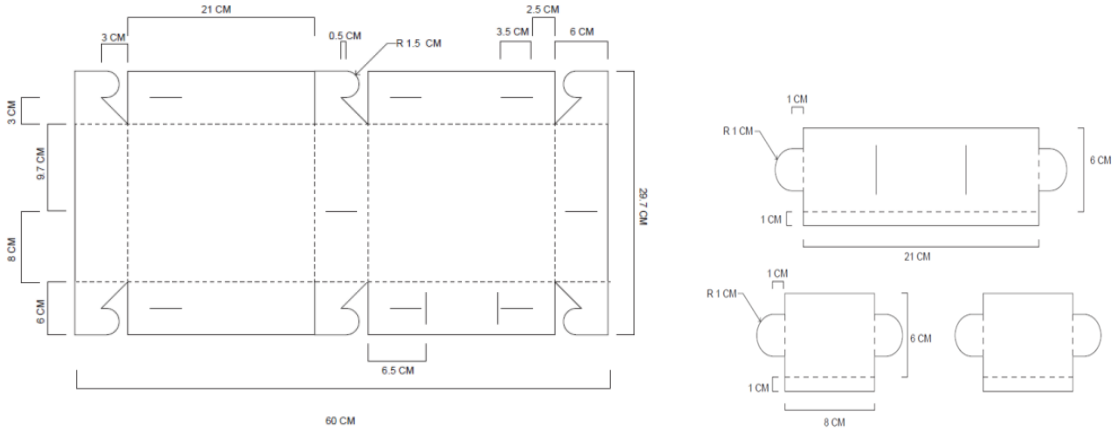


Figure 5: Die cut drawing of Satay packaging delivery box

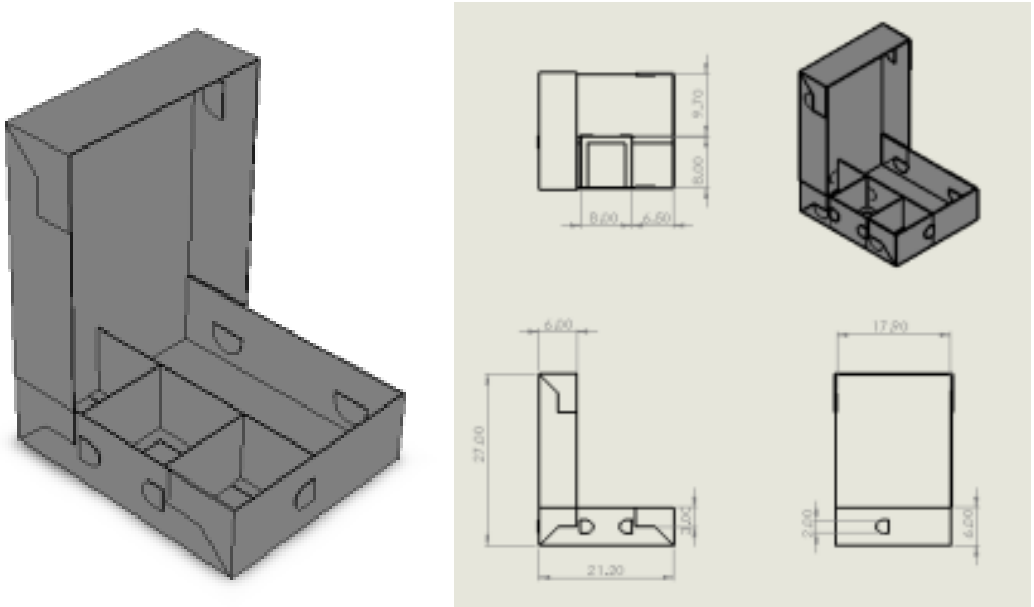


Figure 6: SolidWorks sheet metal drawing of Satay packaging delivery box

The die line of packaging is drawn manually on the paper board as a package template that ensures proper layout for the prototype. The measurement of packaging is based on Figure 5. Since the length of skewers is 20 cm, the length of the Satay packaging should be achieved at a minimum of 20 cm

length. From here, the die line is cut manually. Figure 7 shows the die cut of the prototype Satay packaging delivery box with its compartment.

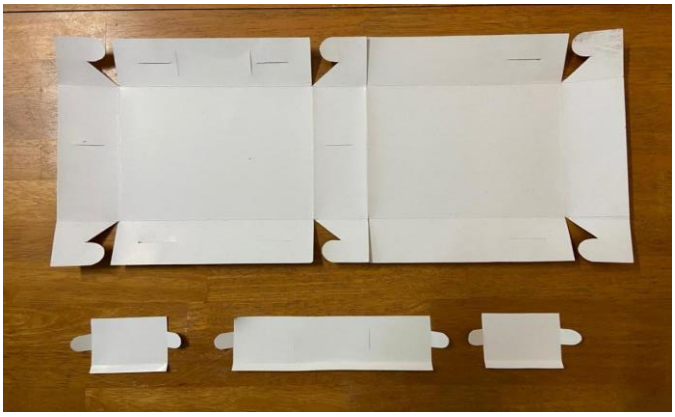


Figure 7: Die cut of prototype Satay packaging box with its compartment

Figure 8 shows the assembly of Satay packaging delivery box with and without the serve of Satay. A compartment made of hard paper was inserted to the Satay packaging to isolate the rice cake, cucumber and peanut sauce. For the peanut sauce a current food grade paper cup with lid is used to prevent the sauce from spill inside the packaging.

Figure 8: Satay packaging delivery box (a) without satay; and (b) with satay and ingredients

3.3 Finite element analysis (FEA) findings

The FEA is needed to know the suitable force of the Satay in the packaging. Figure 9 shows the total equivalent stress of three difference forces that was applied in the simulation which is 1.23 N, 1.47 N and 1.72 N. Figure 9 (a) shows the total equivalent stress of the Satay packaging box with 1.23 N force impact into the base which the maximum equivalent stress observed was 5.961e+0.4 N/m^2. Figure 9 (b) shows the total equivalent stress of the Satay packaging box with 1.47N force impact into the base which the maximum equivalent stress observed was 6.591e+04 N/m^2. Figure 9 (c) shows the total equivalent stress of the Satay packaging box with 1.72 N force impact into the base which the maximum equivalent stress observed was 7.413e+04 N/m^2. Therefore, the suitable force of Satay is 1.23 N or 125 g which is 10 pieces of Satay since it is not very heavy.

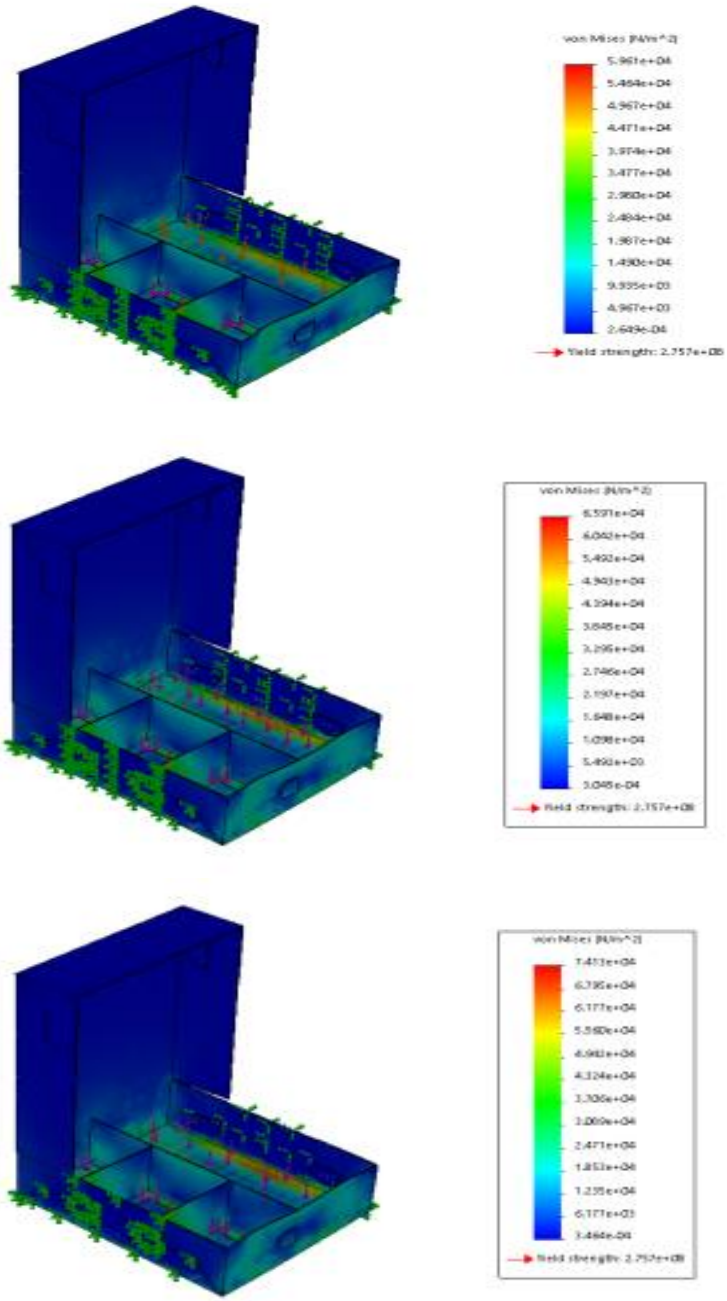


Figure 9: Equivalent stress of satay packaging delivery box

3.3 Freshness and sensory test

The average for the initial food temperature of Satay is about 86.9 ˚C as shown in Table 4. The temperature of Satay in three different packaging is taken for every 10 minutes. From the table below, the Satay in the plastic does not cool down quickly compared to the others packaging. This is because the heat of Satay in plastic is trapped inside the packaging, since that the Satay is sweating more easily. The Satay in the lunch paper box is rapidly cool because the thickness of the paper is very thin compared to the new design which is using white paper board. The grammage for paper lunch box is about 260 gsm while the grammage for white paper board is 350 gsm

The Satay that is put in the plastic packaging is sweating due to the heat trapped inside it. When this happens, the microorganism is easy to grow, and the Satay has a shorter shelf life compared to other

packaging. The most frequently used ones are based on detection of spoilage metabolites through visible color change. Figure 10 and Table 5 show the condition of Satay after 30 hours in the packaging.

Table 4: Result for food temperature

Time taken (min)	Temperature of Satay (˚C)		
	Transparent plastic	Lunch paper box	New design
0	86.9	86.9	86.9
10	61.2	56.4	58.2
20	46.4	42.4	43.9
30	38.8	35.6	36.8
40	34.8	32.4	33.3
50	32.6	31.0	31.6
60	31.3	30.5	30.8

(a) (b) (c)

Figure 10: Satay condition after 30 hours (a) plastic; (b) lunch paper box; and (c) new design

Table 5: Result for Satay freshness in different packaging type

Type of packaging	Observation					
	5 hour	10 hour	15 hour	20 hour	25 hour	30 hour
Plastic	Sweating	Sweating	Sweating	The smell is bad	The smell is bad	The smell is bad
Lunch paper box	Good	Good	Good	Good	The smell is bad	The smell is bad
Current commercial paper cup	Good	Good	Good	Good	Good	The smell is bad
New design	Good	Good	Good	Good	Good	The smell is bad

There are two consumers that volunteer to eat and observe the Satay for three different times. The volunteers were picked from wellness committee members that are experts in Satay taste. The Satay will be eaten after the Satay is left for every 2 hours in the packaging. The consumer said that they like the new design packaging since it is bio-degradable and interesting compared to the current packaging. Besides that, they like the appearance of this product. The color of Satay after 2 hours is much too light, while after 4 hours is just about right and after 6 hours is somewhat too dark.

Overall texture for this product is extremely liked by the consumer. After 2 hours the moistness of the Satay is somewhat too moist, then after 4 hours it is just about right and after 6 hours, the Satay is somewhat too dry. The consumer likes to taste the Satay that was left in the packaging after 2 hours compared to 6 hours. This is because the Satay is still moist and soft. The maximum shelf life after

preparation according to the food regulatory body is 6 hours, but the Satay still can be eaten because there is no smell.

3.4 Visual design for satay packaging and customer feedback

The picture of graphic design of the front cover label is shown on Figure 9, while the packaging with printed label is shown in Figure 11.

Figure 11: Graphic design for front Satay packaging delivery box label

Based on the Satay packaging that has been developed, the customer feedback survey has been made to observe the customer satisfaction and improvement for new design. This survey is given priority by a food seller located in Parit Jawa. The customer feedbacks with a positive comment to this new developed packaging, since it could increase the sale of the Satay product by attracting more customers. Besides that, the Satay with new designed packaging by this study could be sold by using cash on delivery (COD) method without worrying the peanut sauce spill out. However, the Satay packaging material used is absorbing the oil from inside to outside at the bottom area of packaging. Hence, the food wrapping paper is used to prevent the oil from absorbing to the packaging. Figure 12 shows the Satay packaging delivery box with addition of label and food wrapping paper.

Figure 12: Satay packaging box (a) with graphic label (b) addition of food wrapping paper

4. Conclusion

In conclusion, the packaging of Satay was successfully redesigned and better than the current packaging following the criteria selected for this project. The packaging was redesigned based on customer requirement through a useful method which is QFD. Thus, the objective of this project was successfully achieved by evaluating the food quality with the usage of a new developed design of Satay packaging delivery box. The Satay that is placed inside the current plastic packaging is sweating due to

the heat being trapped inside it. When this happens, the microorganism is easy to grow, and the Satay has a shorter shelf life compared to other packaging types tested in this study. Satay that is placed inside the new design prototype shows better temperature control and freshness quality for up to 25 hours.

From the design perspective, the redesigned Satay packaging is easy to be packed by anyone as well as it is convenient to the user since it does not require glue to assemble. Besides that, the material used is biodegradable since it uses a white paper board. Furthermore, the customer gives positive feedback about the new packaging design and hopes that the packaging will be widely used in the industry. Therefore, the new design of Satay packaging delivery box developed in this study is recommended to be applied in the Satay industry. However, it could be improved by more in-depth study on food contact effects and printing technology application before the mass production.

Acknowledgement

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