© Universiti Tun Hussein Onn Malaysia Publisher's Office

IJIE

Journal homepage: http://penerbit.uthm.edu.my/ojs/index.php/ijie
ISSN : 2229-838X e-ISSN : 2600-7916

The International Journal of Integrated Engineering

Safety and Quality Improvement of Street Food Packaging Design Using Quality Function Deployment

Muhammad Faishal[1,2], Effendi Mohamad[1*], Azrul Azwan Abdul Rahman[1], Shabilla Desviane[2], Alfian Ramawan[2], Mohamad Ridzuan Jamli[1], Okka Adiyanto[1,2]

[1]Fakulti Kejuruteraan Pembuatan,
Universiti Teknikal Malaysia Melaka, Melaka 76100, MALAYSIA

[2]Teknik Industri, Fakultas Teknologi Industri,
Universitas Ahmad Dahlan, Jalan Ring Road Selatan, Tamanan, Bantul Yogyakarta 55166, INDONESIA

*Corresponding Author

DOI: https://doi.org/10.30880/ijie.2021.13.01.003
Received 14 February 2020; Accepted 23 June 2020; Available online 30 January 2021

Abstract: Product packaging shows product detail and characteristics and can influence consumer desire. A well-packaged product, when seen or felt, improves product perception and attitude. In Yogyakarta, fried meatballs are popular street food. Customers often complain about packaging post-purchase. Customers have often complained about the packaging and the common concerns are 'hot to touch' and 'easily damaged packaging'. This study proposes to study the effect of consumer perception and attractiveness of the fried meatballs by improving the packaging. The Quality Function Deployment (QFD) technique was used during the designing phase to study consumer behaviour and desire to create attractive product packaging in line with customer expectations. Survey results indicated eight significant characteristics for fried meatball packaging. Those are; an attractive design, oil resistance, heat resistance, easy-to-handle packaging, durable material, food-grade packaging, environmental friendliness, and practical carrying ability. The eight attributes were reduced to five using QFD methodology and these five attributes are used as reference points for the development of better packaging. These five attributes of packaging design are; heat resistance, oil resistance, food-grade material, environmental friendliness, and not easy to tear. SolidWorks software was used to create 3D models. The design process was controlled to achieve the House of Quality (HOQ) target for consumer desire.

Keywords: Packaging design, QFD, street food, customer need

1. Introduction

Food packaging does not serve merely as a package. The packaging should have other attributes like safety, quality, and comfort, among others. Product and packaging go together. It is difficult to treat the two as separate products, especially when fast-moving products like food and beverages are considered. Packaging is also vital when it comes to presenting the product[1]. Packaging needs continuous attention from distributors, marketers, and researchers especially in the street food segment, to tailor it to the needs of the consumers [2]. This is quite reasonable because the primary objective of packaging is to protect the contents[3]. This, however, is often overlooked during the environmental analyses of packaging systems, and thus consumers have to face inconvenience. Knowing consumer expectation is crucial to improve packaging design [4], [5].

*Corresponding author: effendi@utem.edu.my

The campus area in Yogyakarta has numerous street food options. There is a high demand for this street food because of the palatable taste. Observations indicate that a majority of food sellers pay little thought to food packaging safety despite the fact that most consumers carry out the food. Fried meatballs are one product that is carried home quite often. Consumers buy the meatballs despite the complaints of the food being wrapped only in plastic, as shown in Fig. 1. Discussions and customer complaints questionnaires reveal that the food feels hot because the packaging is torn due to hot oil. Consumers find it unattractive to carry the oil-laden slippery packaging. This research intends to study consumer complaints and expectations and use the data to design high-quality packaging that is in line with consumer expectations. The improvement in the design must attract the attention of the customers and serve as a communication to the consumer [2]. Packaging design assumes higher relevance in a hypercompetitive market and may serve as the best marketing tool for the product [5]. Research suggests that product packaging represents the product itself [6].

Fig. 1 - Initial packaging for fried meatballs

Well-packaged products are likely to increase customer satisfaction. Consumers tend to judge product quality based on the visual appeal of the packaging and hence develop brand preferences[7]. Brand preference alters the perception of food quality both directly and indirectly by the perceived value of the product. For these reasons, a technique is required that can develop products that are not in conflict with consumer mood and requirements. Ojieun [8] indicates that QFD is a technique that systematically translates customer requirements into technical descriptors for every stage of product development. Hence, meeting customer expectations or exceeding them cannot be achieved solely through maintenance or improvement of product performance. In addition, Nemat et al. [9] reviewed the relationship between the behavior of costumer on sorting and recycling the household waste and food packaging.

Many researches have been done by employing QFD across sectors, and packaging is one of them. Vanany [10] suggest using multi-phased QFD techniques to pinpoint key processes and prioritize the program to improve food production using halal methods. Not only in design, QFD also can be employed to develop healthcare infrastructure models [11]. In that research, QFD could transparently integrate quality with the operational and infrastructural aspects notably when service integration is the intended target. Additionally, the blend of QFD and FMEA can steer the quality control in a different manner of thinking with the help of QFD analysis, acknowledge the vital quality parameters to assess customer requirements, perform weight calculations, and conducting failure mode and effect analyses (FMEA) on the key technology employed. The results obtained by QFD comprehensive sorting, when arranged using FMEA, better represent the quality control requirements [12]. Then, Steenish et al. [13] studied the effect of sustainable design strategies towards consumers' purchase intention. The results show the customers tends to choose a circular design strategy (e.g. biodegradable materials) rather than linear redesigns (e.g., packaging light weighting) and they prefer to use a single redesign strategy than multiple sustainable design strategies. Meurer et al. [14] proposed a descriptive study of the Ultra High Temperature (UHT) packaging material, type of opening, and their dimension. It results the suitable design for complete emptying of the content could decrease the waste of milk which effect to food safety and environmental protection.

QFD methodology also helps in the identification of customer satisfaction in the first stages like product design. This data allows businesses to handle quality-related aspects better [15].Similarly, Salleh et al. [16] worked on products employing QFD and MCDM along with an amalgamation of these two methodologies [17]. Other studies recommend using the Weber-Fechner law by using House of Quality to facilitate better analysis of consumer's opinions. QFD is used in product design in addition to its use in the betterment of quality [18]. The impact of packaging and its design was analyzed on competitive advantage gained towards the marketing of consumer products [19]. Multi-phased QFD models have been employed to pinpoint key processes and priority areas to enhance halal food production [10]. Currently QFD was developed for QFD-Based Quality Enhancement to acquire knowledge about defect probability at each separate production stage [20]. According to previous research there are still a few research related to food street packaging. It is important because there are high demand but high environmental effect. There for this research propose

to redesign packaging street food. The objective of the research is to work out a new, high-quality food packaging design that is safe and in line with the feedback received in customer complaints.

2. Methodology

The primary objective of this research is to work on an innovative food packaging that meets the expectations of quality and safety, as stated in customer feedback. The steps used to determine the design phases are as per the rules of the methodology used. The steps, as used in this work, are described in Fig. 2.

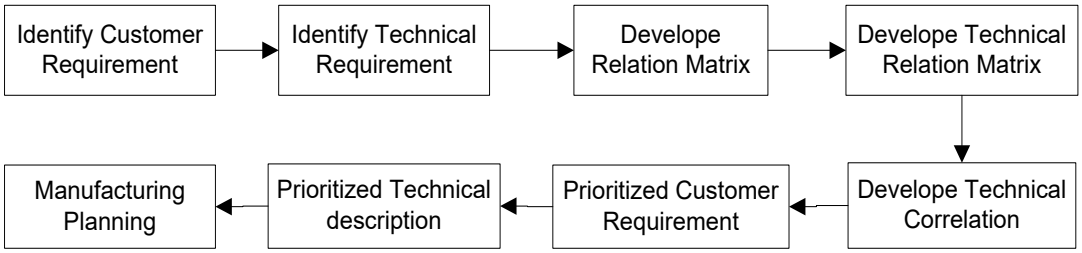


Fig. 2 - Methodology

This research step starts from identifying customer requirements. At this stage, an open survey is conducted. Then identifying technical requirements is the voice of the company with a closed survey. Furthermore, develop a relation matrix between the 'voice of the customer' and 'the voice of the company'. Next, develop the technical relation matrix and then develop the technical correlation. Then, prioritized customer requirements and technical description are carried out and entered into the manufacturing planning stage.

2.1. Data collection technique

The data collection technique employed in the research uses a questionnaire consisting of multiple questions. The purpose of this data collection is to identify consumer desires and the company's ability to respond to consumer requirements. The survey contains both open-ended and close-ended questions. Open-ended questions require the respondents to provide feedback on existing product packaging. On the other hand, close-ended questions need the selection of a choice among the provided options. The research used a non-probabilistic sampling technique with defined saturation. As per Sugiyono [21], a saturation sampling technique is employed if the sample size is small (<30). An instance of a saturated sample could be one where responses are recorded for each member of a population. Interviews of the owners reveal the presence of 20 regular and loyal customers. All these customers who are most likely to purchase fried meatballs serve as the sample in the study.

The diversity of the respondents is determined by gender, age, occupation, and monthly income. These characteristics should help provide a satisfactory response and get quality data pertinent to the problem and the research objectives. Table 1 highlights the respondent's diversity based on gender.

Table 1 - Characteristic respondent

Questionnaire type	Age (years)	Sex		Job
		M	F	
Open	18-25	9	11	Student
Close	18-25	9	11	Student

2.2.Data Analysis Techniques

SPSS was used to analyses the data to gauge the reliability and validity of the research questionnaire. Test validity may be understood as the test's accuracy considering the size of the sample. A high-validity test is one that can precisely measure and model the responses to fulfil the measurement objectives. Reliability is concerned with size consistency. The instruments measuring a specific parameter must bear similar results each time the test is conducted [22].

3. Result and Discussion

During the first stage of the research, open questionnaires were handed to regular customers who frequented the food joints. Survey data was obtained to get an initial impression of consumer expectations. This data was intended for

use in product development based on the problems faced by consumers. The initial questionnaire consisted of open-ended questions. The result is depicted in table 2.

Table 2 - Result from open questionnaire

Code Attributs	Answers
A1	The attractive design
A2	Heat resistant packaging
A3	Oil resistant packaging
A4	The packaging is easy to handle
A5	The packaging is made not easy to damage
A6	packaging for food
A7	environmentally friendly packaging
A8	practical packaging

Subsequently, another questionnaire was circulated to gauge the weights of the answers in correlation to the close-ended questions. The researchers then analyse the coefficients for attributes such as level of desire, customer satisfaction, and importance based on customers' answers. Answers were subsequently run through SPSS to determine their validity.

3.1. Validity and Reliability Test

Validity tests are conducted to examine whether the indicators representing the variables are valid. Tests need to be carried out to measure the extent of importance, level of satisfaction and level of desire. Reliability tests determine consistency in the survey responses collected over a period of time. SPSS was used to run validity tests and the result showed invalid points based on the values of $R_{hitung\ and}$ $R_{table.}$ The questionnaire was revised several times until the answer point was valid. Three variables are analysed to determine validity. These variables are – 1) Level of importance, 2) Desire, and 3) Satisfaction. The values of Cronbach's alpha were greater than R_{table}. Hence, the questionnaire passed the reliability tests [23].

3.2. House of Quality (HoQ)

The House of Quality consists of several parts among which one is the matrix relationship. Fig. 3 shows how the correlation between customer requirements and technical requirements is used to determine the relationship matrix [24]. Table 3 describes the symbols and respective relationship strength:

Table 3 - Information on relationship matrix symbol

Symbol	Value	Information
◎	9	Very strong relationship
O	3	Moderate relationship
Δ	1	Weak relationship
X	0	No connection

Attribute		Technical Requirement							
		A	B	C	D	E	F	G	H
		Add color and product information	The packaging is made from heat-resistant material	Change to oil-resistance material	Ergonomic packaging	Taft packaging	Foodgrade packaging	The packaging is easy to recycle and decomposes	The packaging is made easy to carry
Customer Requirement	The attractive design	◎					○		
	Heat resistance packaging		◎	○					
	Oil resistance packaging		○	◎					
	The packaging is easy to handle	○			◎		○		○
	Taft packaging		○	○		◎			
	Safety packaging		○	○			◎		
	Enviromental friendly							◎	
	Practical packaging				○	○			◎

Fig. 3 - Relationship matrix

Once the relationship matrix is in place, the next step is to formulate the technical correlation matrix. This matrix represents the connection between technical requirements and is shown in Table 4.

Table 4 - Technical correlation matrix

	Attribute	A	B	C	D	E	F	G	H
A1	Packaging with color and product information					O			
A2	Packaging of heat resistant material			O	◎		◎		
A3	Has oil resistant properties		O				◎		
A4	Ergonomic packaging is made of grips		◎						O
A5	The packaging is made not easy to damage	O							O
A6	Safe packaging for food		◎	◎				O	
A7	Environmental friendly packaging						O		
A8	Practical packaging				O	O			

The next step is to use the information obtained from the technical correlation matrix and fill the rooftop of the House of Quality (HOQ). The shape obtained is shown in Fig. 4.

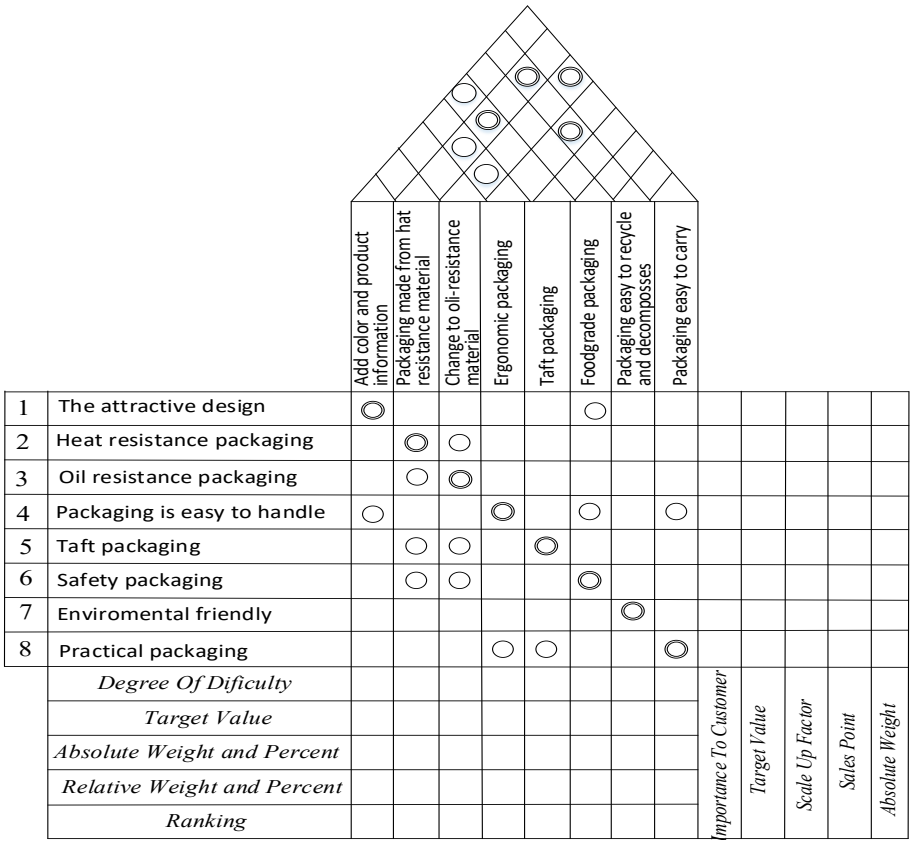


Fig. 4 - House of quality 1

HOQ calculations are essential and serve as reference points in product developments. There are two aspects – Prioritized customer requirements (vertical) and prioritized technical description (horizontal).

a. Importance to Customer (vertical)
The 'importance to customer' column is obtained from the average of each attribute that has been determined from the results of the questionnaire at level of desire; for example, for attribute 1, the average score obtained from the questionnaire at the desire level of 2.8 and so on.

b. Target Value (vertical)
The 'target value' column is obtained from the average of each attribute that has been obtained at the satisfaction level of the distributed questionnaire.

c. Scale Up Factor
Scale up factor is attained from the formula as below:

$$Scale\ up\ factor = \frac{Importane\ to\ customer}{Target\ value} \quad (1)$$

Table 5 shows the attributes and the values of the scale-up factor calculated as per the formula.

d. *Sales Point* (D)
Sales point determines the unique propositions for the product to be developed, and its value is arrived upon in consultation with the owner. In the calculations, all attributes have a uniform value of 1.2 because the development team feels appropriate that all attributes have a medium sale value.

e. *Absolute Weight* (E)
The formula specified below is used to calculate the absolute weight:

$$Absolute\ Weight: Importance\ rating\ x\ Scale\ up\ factor\ x\ Sales\ point \quad (2)$$

Using the formula, the absolute weights are highlighted in detail in Table 5.

Table 5 - Absolute weight of attribute

Atribut	Importance To Customers	Target Value	Scale Up Factor	Sales Point	Absolute Weight
A1	2.85	3.40	0.84	1.20	2.87
A2	2.70	2.80	0.96	1.20	3.12
A3	3.30	2.60	1.27	1.20	5.03
A4	1.85	3.30	0.56	1.20	1.24
A5	3.05	2.95	1.03	1.20	3.78
A6	3.05	2.95	1.03	1.20	3.78
A7	2.90	3.00	0.97	1.20	3.36
A8	1.90	1.95	0.97	1.20	2.22

f. *Degree of difficulty* (Horizontal)

The difficulty level that can potentially be experienced by the developer in the process of designing is represented through this matrix [24]. From the perspective of technical requirement points based assessment, packaging materials made of environmentally friendly substance and components, and strong packaging with ergonomic grip are attributed a value of 3, implying that actual manufacturing of such materials in design development is substantially challenging. The restrained stock of materials owned by the development team is primarily responsible for this. On the other hand, packaging materials that are resistant to oil and high temperature are assigned a value of 4. This indicates that real manufacturing in design development is not that difficult. For product packaging that are easy to manufacture and are of food grade quality, a value of 2 is assigned.

g. Target *Value* (Horizontal)

This matrix presents the target that is expected to be achieved by the development team, and which is consistent with the team's present capabilities to execute a technical response [8]. With respect to all technical responses, the rating on this matrix is assigned a value of 3, which implies that all technical responses that are expected to be implemented by the development team should be at a considerably difficult level. The value of the level of difficulty has the potential to be further impacted.

h. Absolute Weight and Percent

These are applied to ascertain the value of the importance level of the attribute so that the attribute with the greatest significance or importance can be derived. As represented by RM, the relationship matrix A indicates the significance to the customer, and hence the given formula is used to perform the calculation:

$$Absolute\ Weight\ and\ Percent = (RM_1 x A_1) + (RM_2 x A_2) \ldots\ldots (RM_N x A_N) \quad (3)$$

i. Relative Weight and Percent(I)

The comparative priority of technical responses provided by the development team is determined on the basis of the abilities and wishes of the developers, which involves multiplying the absolute weight value with the value of the technical relationship. RM indicates the relationship matrix and E represents absolute weight, and the relationship between these can be expressed using the given formula:

$$Absolute\ Weight\ and\ Percent = (RM_1 x E_1) + (RM_2 x E_2) \ldots\ldots (RM_N x E_N) \quad (4)$$

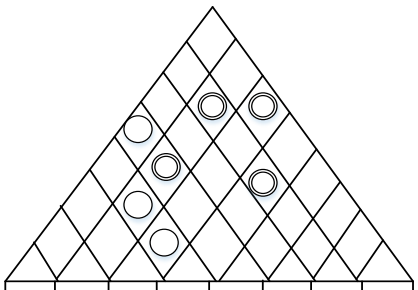
j. *Ranking* (J)

Ranking is assigned on the basis of the value derived in the form of absolute weight and percentage, and relative weight and percentage, and then ordered from the largest to the smallest as presented in Table 6. Then all value input into HoQ 2 as show in Fig. 5.

Table 6 - Horizontal calculation HoQ

Atribut	Degree of Difficulty	Target Value	Absolute Weight and Percent	Relative Weight and Percent	Rangking
A1	2	3	26.20	29.53	6
A2	4	3	45.60	84.71	1
A3	4	3	48.75	65.96	2
A4	3	3	22.35	17.87	8
A5	3	3	35.40	40.72	4
A6	2	3	41.55	46.39	3
A7	3	3	26.10	30.28	5

Atribut	Degree of Difficulty	Target Value	Absolute Weight and Percent	Relative Weight and Percent	Rangking
A8	2	3	22.65	23.61	7



		Add color & product information	Packaging made from heat-resistance material	Change to oil resistance material	Ergonomic packaging	Taft packaging	Foodgrade packaging	Packaging easy to recycle and decomposses	Packaging easy to carry					
1	The attractive design	◎					○			2.85	3.4	2.8	1.2	9.71
2	Heat resistance packaging		◎	○						2.7	2.8	2.97	1.2	9.62
3	Oil resistance packaging		○	◎						3.3	2.6	1.27	1.2	5.77
4	Packaging is easy to handle	○			◎		○		○	1.85	2.3	0.56	1.2	1.24
5	Taft packaging		○	○		◎				3.3	2.9	1.03	1.2	4.07
6	Safety packaging		○	○			◎			3.05	2.95	1.03	1.2	3.76
7	Enviromental friendly							◎		2.9	3	0.96	1.2	3.34
8	Practical packaging				○				◎	1.9	1.95	0.97	1.2	2.21
	Degree Of Dificulty	2	4	4	3	3	2	3	2	Importance To Customer	Target Value	Scale Up Factor	Sales Point	Absolute Weight
	Target Value	3	3	3	3	3	3	3	3					
	Absolute Weight and Percent	26.2	45.6	48.75	22.35	35.4	41.55	26.1	22.65					
	Relative Weight and Percent	91.11	127.4	104.3	17.79	43.26	66.69	30.06	23.61					
	Ranking	6	1	2	8	5	4	6	7					

Fig. 5 - House of quality 2

3.3. Manufacturing Planning

In order to select priority contributions on the basis of rankings in HoQ, Technical Response Priority Analysis has to be taken into consideration [24]. Discussions with the owner are necessary to ascertain this development priority so as to consider the competence to realise the improvement. By accounting for the priority scale of the technical responses, the top five attributes were selected for analysis:

1. Heat-resistant packaging
2. Oil-resistant packaging
3. Food grade packaging
4. Not easy to damage
5. Environmental-friendly packaging

Depending on the company's capabilities, the other priorities will also be included. Based on the discussion with the owner with the five identified criteria, a number of design sketches have been developed that eventually agreed to have the proposed packaging in the form of paper boxes, where the paper boxes will be made of environmentally friendly, biodegradable, food-grade, 1-minute max microwave paper, with anti-paper leak out. This type of packaging is already

on the market; therefore, this suggestion is easy to implement. Additionally, the packaging will have printed information on product composition and nutrition, along with the halal logo. The selected packaging design's size is adjusted to the desired specifications deemed comfortable by the majority of consumers who responded to the survey. Therefore, this design can be said to be the closest to customer expectations. SolidWorks software has been used to create the 3D design under the supervision of the owner as represented in Fig. 6.

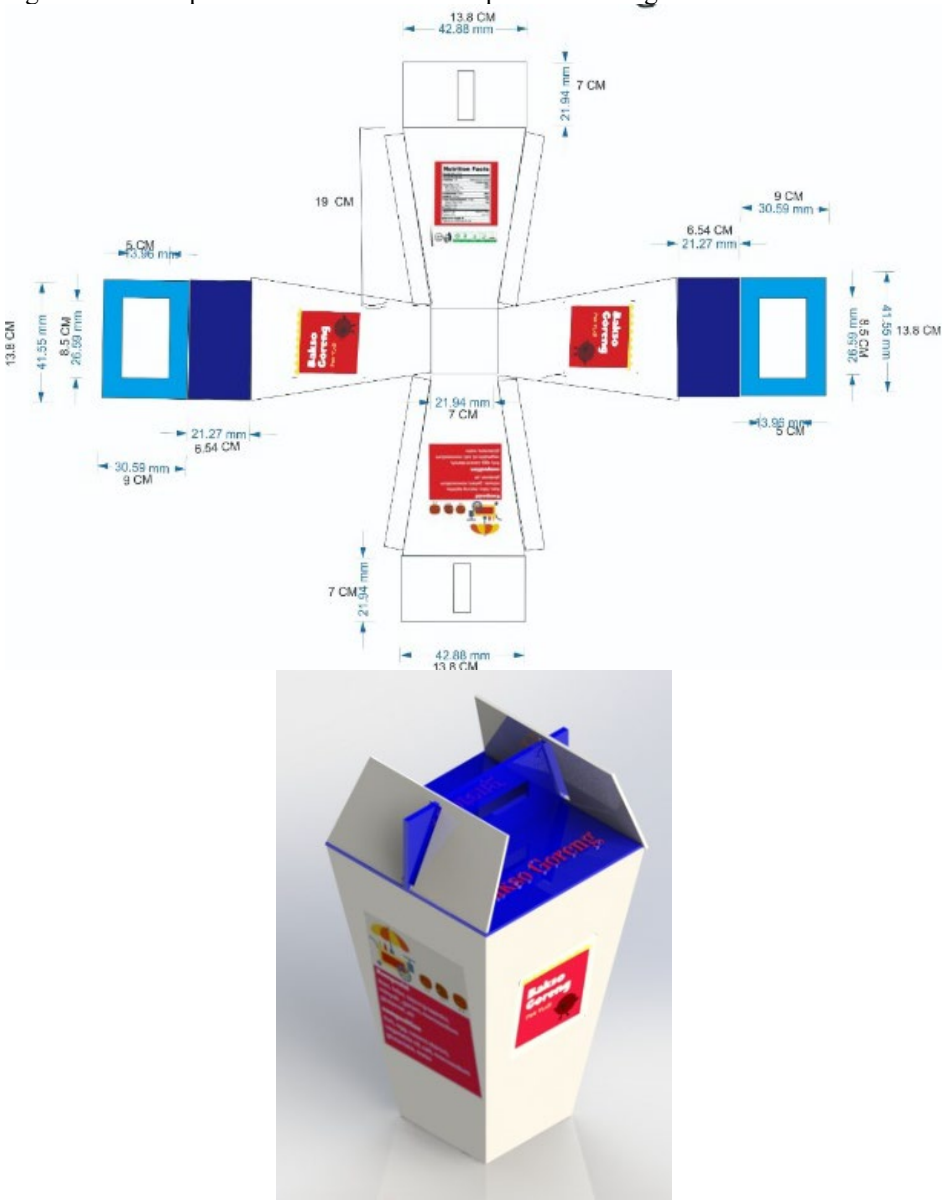


Fig. 6 - 3D packaging design

4. Conclusions and Future Works

The use of QFD to capture the needs and expectations of customers is a decisive step in including the irregular voices of customers in the desired design improvements. It can be made further effective when the tools meant for capturing consumer inputs are pooled with various other such components, for instance, focus group discussions, customer audits, and customer tests. The objective of this study is to improve street food packaging according to customer complaints. The results indicate that the improvement of packaging design has been successfully carried out with the existence of eight criteria. Derived based on consumer input, weighting is carried out through discussions and surveys with the owner as a counterweight. Of the eight improvement plans developed, the top five are prioritized for implementation, which involves packaging being oil-resistant, heat-resistant, made from good food-grade materials, which are environmentally friendly and not easily damaged. Therefore, the material chosen is paper, and its size is adjusted to meet the requirements of the majority of consumers who responded to the survey. Therefore, the new packaging designs can be easily obtained and implemented. Future research can be about designing cost-effective packaging of the same quality.

Acknowledgment

The authors would like to thank the Teknik Industri, Fakultas Teknologi Industri, Universitas Ahmad Dahlan, Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka (UTeM) and Malaysian Government for their support and cooperation.

References

[1] G. Vladić, M. Kecman, N. Kašiković, M. Pál, and M. Stančić, "Influence of the shape on the consumers perception of the packaging attributes.," *J. Graph. Eng. Des.*, vol. 7, no. 1, pp. 27–32, 2016.

[2] L. E. Wells, H. Farley, and G. A. Armstrong, "The importance of packaging design for own-label food brands," *Int. J. Retail Distrib. Manag.*, vol. 35, no. 9, pp. 677–690, 2007.

[3] F. Wikström, H. Williams, K. Verghese, and S. Clune, "The influence of packaging attributes on consumer behaviour in food-packaging life cycle assessment studies - A neglected topic," *J. Clean. Prod.*, vol. 73, pp. 100–108, 2014.

[4] K. Crow, "CUSTOMER-FOCUSED DEVELOPMENT WITH QFD Kenneth Crow," *DRM Associates*. pp. 1–8, 2009.

[5] R. R. Ahmed, V. Parmar, and M. A. Amin, "Impact of Product Packaging on Consumer's Buying Behavior," *Eur. J. Sci. Res. Eur. J. Sci. Res.*, vol. 120, no. 2, pp. 1450–216, 1450.

[6] A. Brenes, G. Marín-raventós, and G. López, "Improving Packaging Design Using Virtual Reality in the Market Research Process," in *MDPI*, 2019, p. 12.

[7] E. S. T. Wang, "The influence of visual packaging design on perceived food product quality, value, and brand preference," *Int. J. Retail Distrib. Manag.*, vol. 41, no. 10, pp. 805–816, 2013.

[8] Ojieun, "Planning Food Products Using Quality Function Deployment," *Ewha Womans Univ.*, 2016.

[9] B. Nemat, M. Razzaghi, K. Bolton, and K. Rousta, "The role of food packaging design in consumer recycling behavior-a literature review," *Sustain.*, vol. 11, no. 16, pp. 1–23, 2019.

[10] I. Vanany, G. A. Maarif, and J. M. Soon, "Application of multi-based quality function deployment (QFD) model to improve halal meat industry," *J. Islam. Mark.*, vol. 10, no. 1, pp. 97–124, 2019.

[11] B. Dehe and D. Bamford, "Quality Function Deployment and operational design decisions–a healthcare infrastructure development case study," *Prod. Plan. Control*, vol. 28, no. 14, pp. 1177–1192, 2017.

[12] Q. Guo, K. Sheng, Z. Wang, X. Zhang, H. Yang, and R. Miao, "Research on Element Importance of Shafting Installation Based on QFD and FMEA," in *Procedia Engineering*, 2017.

[13] N. D. Steenis, I. A. van der Lans, E. van Herpen, and H. C. M. van Trijp, "Effects of sustainable design strategies on consumer preferences for redesigned packaging," *J. Clean. Prod.*, vol. 205, pp. 854–865, 2018.

[14] I. R. Meurer *et al.*, "Quantification of whole ultra high temperature UHT milk waste as a function of packages type and design," *J. Clean. Prod.*, vol. 153, pp. 483–490, 2017.

[15] E. C. Cordeiro, G. F. Barbosa, and L. G. Trabasso, "A customized QFD (quality function deployment) applied to management of automation projects," *Int. J. Adv. Manuf. Technol.*, vol. 87, no. 5–8, pp. 2427–2436, 2016.

[16] S. A. Salleh *et al.*, "Product Development using QFD , MCDM and the Combination of these Two Methods Product Development using QFD , MCDM and the Combination of these Two Methods."

[17] Y. Klochkov, A. Volgina, and E. Klochkova, "Human Factor In Quality Function Deployment," 2016.

[18] N. O. Erdil and O. M. Arani, "Quality function deployment: more than a design tool," *Int. J. Qual. Serv. Sci.*, vol. 11, no. 2, pp. 142–166, 2019.

[19] B. Rundh, "Packaging design : creating competitive advantage with product packaging," *Br. Food J.*, vol. 111 (9), pp. 988–1002, 2009.

[20] D. Aydarov, Y. Klochkov, N. Ushanova, E. Frolova, and M. Ostapenko, "Developing Plans for QFD-Based Quality Enhancement," *Syst. Perform. Manag. Anal. Asset Anal.*, pp. 241–249, 2019.

[21] Sugiyono, *Metode Penelitian Pendidikan Pendekatan Kuantitatif, kualitatif, dan R&D*. Bandung: Alfabeta, 2010.

[22] R. Heale and A. Twycross, "Validity and reliability in quantitative studies," *Evid. Based. Nurs.*, vol. 18, no. 3, pp. 66–67, 2015.

[23] R. E. Walpole and C. B. Allendoerfer, *"Introduction to statistics,"* Vol. 2. New York, 1974.

[24] K. Yang and B. S. El-Haik, *Design for Six Sigma, A Roadmap for Product Development*, Second Edi. The McGraw-Hill Companies, Inc., 2009.