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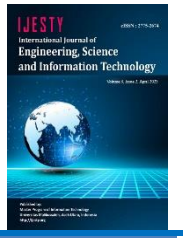

Design of Safe and Quality Potato Chips Product Packaging Using Quality Function Deployment Method

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Abstract

Packaging serves as a food storage system that protects food and goods from natural processes and facilitates ease of transportation. This study aimed to address the problems related to cassava chip packaging, such as inappropriate sizes and packages that are prone to breaking, by applying Quality Function Deployment (QFD) in designing packaging that meets food safety and quality. Through interviews with customers, the study confirmed the existence of packaging problems and the dissatisfaction expressed by customers regarding the product packaging. QFD was employed to determine consumer needs and desires for a product design that conforms to quality characteristics and technical requirements. The study also used a consumer assessment questionnaire to identify the most important product attributes and design requirements that meet consumer expectations. The study found that rectangular packaging shapes, bright colored primary packaging colors, polypropylene plastic packaging materials, the location of the logo on the packaging in the middle of the package square, four, light color, and an image of sweet potato chips on the logo are factors that influence product packaging design that meets food safety and quality. This study's findings can be useful for practitioners and researchers in designing packaging that meets consumer expectations, as well as for promoting food safety and quality.

***Keywords**: Packaging Design, Food Quality, Quality Function.*

1. Introduction

According to Kotler & Keller [1] packaging is a business founded by someone to maintain brand equity in order to promote sales. Packaging is a food storage system that aims to protect food, goods from the effects of weather or other natural processes. In addition, packaging also aims as a container, so that goods are easy to carry while on the go. Food and beverage packaging is not just a wrapper and container, but is also responsible for the safety and integrity of the quality of packaged food and beverages [2]
Development of distribution channels often occurs in terms of strategic marketing and introducing new products [3]. According to research that explains that packaging has two functions, namely a protective function with regard to product protection, climate differences, transportation infrastructure and distribution channels, all of which have an impact on packaging. With protective packaging, consumers do not need to bear the risk of purchasing damaged or defective products. While the promotional function has a role as a promotional medium for these foods with regard to the shape, color, size of the packaging.
According to field observations, there are still a lot of problems with cassava chip packaging, including sizes that do not match the size of the product and packages that are prone to breaking [4]. The existence of problems with packaging was confirmed by the results of interviews with several customers which indicated that customers expressed dissatisfaction with product packaging. The recommendations proposed are the use of attractive colors, the use of waterproof packaging materials, the use of packaging covers that are easy to open and close safely, the sizes that are easy to distribute, the inclusion of producer information, and the use of easy-to-read fonts [5].
A product has not been able to compete and increase market expansion because it is constrained by product packaging that does not meet packaging standards, this is also evidenced by the many customer complaints about product packaging problems, this problem causes non-fulfillment of customer needs and satisfaction. Therefore it is necessary to make improvements to the packaging design so as to create a package that provides attractiveness and guarantees the quality of packaged chip products. This study aims to provide recommendations for improving the design of chip product packaging using the Quality Function Deployment (QFD) method. The choice of the QFD method is based on customer involvement in the packaging design improvement process so as to guarantee customer satisfaction.
Chips are dry and practical food that is easy to store. One type of chips that is becoming popular in Indonesia is cassava chips with chili sauce. One of the home industries in the city of Lhokseumawe. The manufacture of chili cassava chips has a process stage starting from processing until the product can be marketed, including the preparation of raw materials, washing, cutting, drying, frying, seasoning and packaging. Of the several processes that are most important in maintaining the quality of chili chips to the hands of consumers is the packaging process. The packaging process so far in the home industry is dominated by unattractive, innovative and creative designs. According to Edwin [6], states that there are several factors that influence food quality (food quality), namely taste, aroma, consistency, freshness and appearance of the food.

Food products are only wrapped in plastic without complete information about the product so that it gives the impression of being unattractive to buyers and lacks competitiveness with its competitors. Stages in the planning and development of a product process determine the characteristics of the product to meet consumer desires. In the end, packaging design acts as product marketing by communicating the personality or function of a consumer product uniquely [7]. This packaging problem is also a weak point for MSMEs, especially those engaged in food and beverage processing [8]. The following is an example of the previous packaging before this research was carried out, which can be seen in Figure 1 below.

Fig 1. Previous product packaging

This research will provide solutions that can be used in product packaging. Researchers will redesign the packaging design for sweet potato chip products from Mrs. Fadia's home industry in Lhokseumawe City using the Quality Function Deployment (QFD) method with the aim of increasing the selling power of these products. QFD is considered a very effective method for linking product specifications to be produced with market needs [9]. QFD can also be used to bridge various customer needs (Irawati, et al.,[10]) and redesign products that are tailored to customer needs [11]. So that this QFD method can produce product specifications that meet customer needs [12]. With the above background, the author will take the title "Design of sweet potato chip product packaging that meets food safety and quality using the Quality Function Deployment method".

2. Literature Review

This study discusses the importance of using the Quality Function Deployment (QFD) method in designing safe and quality packaging for potato chips. The main goal of this research is to develop packaging design for potato chips products that meet food safety and quality standards, as well as satisfy consumer needs and preferences. The literature review results show that factors that influence the design of product packaging that meets food safety and quality standards include appropriate packaging shape, attractive colors, safe packaging material, and logo placement on the package. Therefore, this study uses the QFD method to design safe and quality packaging for potato chips products by considering these factors.

The QFD method is used in this study to identify consumer needs and preferences, as well as to integrate technical requirements and food safety and quality standards into the packaging design. In this study, QFD analysis is conducted to determine the relationship between consumer needs and technical characteristics of the product packaging. The results of the QFD analysis are used as a basis for developing packaging design for potato chips products that meet food safety and quality standards.

The results of this study conclude that the use of the QFD method is highly effective in designing safe and quality packaging for potato chips products. The recommended packaging design in this study is a square-shaped package, four bright colors, made of polypropylene plastic material, and with a logo that shows an image of sweet potato chips. This packaging design meets food safety and quality stanards and fulfills consumer needs and preferences.

Based on the literature review conducted in the research article, the state of the art in packaging design for food products involves considering factors such as food safety and quality standards, consumer needs and preferences, and technical requirements. The use of QFD methodology in packaging design has been shown to be effective in integrating these factors and developing packaging designs that meet both technical requirements and consumer needs. The recommended packaging design for potato chips in the research article, a square-shaped package, four bright colors, made of polypropylene plastic material, and with a logo that shows an image of sweet potato chips, represents the state of the art in packaging design for potato chips products that meet food safety and quality standards and fulfill consumer needs and preferences. Some related research studies on packaging design for food products : Design and Development of an Interactive Packaging System for the Intelligent Food Supply Chain [13], A Novel Packaging System for Extending Shelf Life and Ensuring Food Safety [14], Factors Affecting Consumer Acceptance of Sustainable Packaging: A Meta-Analytic Review , Innovative Packaging Solutions for Minimizing Food Waste: A Review [15].

These studies cover various aspects of packaging design for food products, including the use of innovative materials and technologies, sustainable packaging practices, consumer preferences and perceptions, and food safety and quality considerations. They provide insights into the current state of research and knowledge in packaging design for food products and suggest new directions for future research.

3. Methods

The research was carried out in the sweet potato chips home industry which is located around Paloh Puteh, Muara Satu District, Lhokseumawe City, Aceh Province. The overall research time was carried out this year, starting with the preparation stage of preparing a research proposal to completing the research report to date.

The data needed in this study are primary data and secondary data. Based on the source, the data is divided into two, namely:

1. Primary data (primary sources) Primary data is data obtained directly from the source, observed and recorded for the first time. The primary data used are:
   a. Observation. This data collection was carried out by direct observation and measurement of research subjects in the field.
   b. The questionnaire functions as a means of collecting data on the needs and desires of consumers. The questionnaire also determines the level of importance of the product attributes.
   c. Interviews were conducted to obtain technical characteristic values.

2. Secondary data (secondary sources) data obtained indirectly from the source, such as quoting from books, literature, scientific readings, and company archives that have relevance to the theme of writing Secondary data used in this research are
   a. Organizational structure
   b. General description of the research site.

Variables are concepts that have varying values and are defined. The operational variables in this study are as follows:

1. Redesigning the product packaging for sweet potato chips is designing existing products with new solutions for design modifications (variant designs). The packaging redesign of the sweet potato chips product was seen from the packaging design, packaging colors, and packaging logo.
2. Product packaging is a protective material or product safety from external influences that can accelerate the damage to the food contained therein.

Developing a Quality Function Deployment (QFD) is a method for explaining the needs and desires of consumers to a product design that is in accordance with certain quality characteristics and technical requirements. The framework used in QFD is the House of Quality (HOQ
The data processing steps in this study consist of several stages, namely:

1. Summary of Data Collection Results
   a. Collecting the results of data on the needs and desires of respondents using an open questionnaire.
   b. Collection of data on the importance level of packaging attributes from the closed questionnaire results.
   c. Collect data from observations
2. Calculating data validation that has been collected from closed questionnaires, instrument validity has two types, namely external validity and internal validity. External validity relates to the degree of accuracy of research results when applied to populations and generalizations are made where research data is taken. Internal validity relates to the degree of accuracy of the research design. The data collection plan includes a good research design that can identify the right data sources and the right data collection instruments or tools [16]. The calculation is carried out by the formula:

$$r_{xy} = \frac{n\sum xy-(\sum x)(\sum y)}{\sqrt{[n\sum x^2-(\sum x)^2][n\sum y^2-(\sum y)^2]}} \quad (1)$$

   Where, r : correlation coefficient between x and y
   x : independent variable score x
   y : independent variable score y
3. Calculating data reliability can be processed with the formula:

$$r = \frac{2R_{xy}}{1+R_{xy}} \quad (2)$$

   Where, r : Questionnaire reliability
   Rxy : The correlation coefficient determined between the two hemispheres
4. Preparation of Quality Function Deployment (QFD), the steps for making a QFD design are as follows[17]:
   a. Classification of design purposes
   b. Determination of the design function
   c. Formulation of needs and wants
   d. Determination of characteristics with the House of Quality (HOQ) matrix
      - *Customer needs and benefits*namely identifying consumer desires in the form of product attributes obtained from open questionnaires and closed questionnaires.
      - *Planning Matrix*namely determining the level of relative importance of product attributes.
      - *Technical Response*namely evaluating the attributes of the previous product.
      - *Relationships*namely identifying the relationship between product attributes with technical characteristics.
      - *Technical correlation*i.e. identify relevant interactions between the characteristics of the technique.
      - *Technical matrix*namely determining achievement targets for each technical characteristic.
   e. Build quality homes

4. Result and Discussion

4.1. Research result

In this study, to obtain the desired packaging of sweet potato chips, voice of customers data was needed through the distribution of open questionnaires and closed questionnaires. The data from the open questionnaire which was distributed to 15 respondents has been summarized in Table 1 below.

Table 1. Data from the open questionnaire results of sweet potato chip packaging design

Attribute			
Primary		**Secondary**	**Tertiary**
Design	1	Packaging Form	Rectangle
	2	Packaging Color	• Bright colors • Simple
	3	Packaging Dimensions	• Net weight 500 gr. • The length and width are adjusted according to the net weight.
	4	Decoration	• Owns a trademark • Sago Tree Image

			• Net weight information • Nutrition Information
Ingredient	5	Packaging	Transparent plastic
	6	The main function	Packaging
Multifunction	7	Additional functions	• Appeal and aesthetics • Product durability • Minimizes odor when carried

A closed questionnaire was distributed to 15 consumers of sweet potato chips in the city of Lhokseumawe, by giving a value for the quality of the packaging and the expectations of some of the attributes obtained from the questionnaire. The values that indicate attribute performance can be seen as follows:

A = 5 : shows very good performance
B = 4 : shows good performance
C = 3 : indicates sufficient performance
D = 2 : indicates poor performance
E = 1 : indicates very poor performance

The closed questionnaire recapitulation results from 15 respondents can be seen in Table 2 below:

Table 2. The results of the recapitulation of the closed questionnaire assessing the attributes of writing mathematical equations

Customer	Attribute Assessment Results (Questions)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	4	4	4	3	2	2	3	4	2	3
2	3	4	3	3	2	2	3	4	3	4
3	4	5	4	4	3	3	4	3	4	3
4	3	5	3	4	3	3	4	5	4	3
5	4	5	4	3	2	2	3	4	3	4
6	3	3	3	3	1	1	2	3	2	2
7	3	4	3	4	2	2	4	2	4	2
8	3	4	3	2	2	2	2	2	2	1
9	4	4	4	3	2	2	3	3	2	3
10	4	4	2	2	2	2	3	2	2	2
11	4	5	4	4	3	3	4	3	4	3
12	4	4	4	3	4	4	3	3	3	2
13	4	4	4	2	2	2	2	2	2	3
14	3	5	3	3	3	3	3	3	2	2
15	4	4	2	2	2	2	4	3	2	3

4.2. Discussion

Data Validity Test

The data collection plan includes a good research design that can identify the right data sources and the right data collection instruments or tools. Validity test was carried out to test the validity of the data obtained from the closed questionnaire. to test the validity will use the product moment correlation technique. The packaging of sweet potato chips products can be seen in Table 3 below:

Table 3. Test the validity of the attribute assessment of sweet potato chip product packaging

No	X	Y	X2	Y2	XY
1	5	31	25	961	155
2	3	31	9	961	93
3	4	37	16	1,369	148
4	5	37	25	1,369	185
5	4	34	16	1.156	136
6	3	23	9	529	69
7	4	30	16	900	120
8	3	23	9	529	69
9	4	30	16	900	120
10	4	25	16	625	100
11	5	37	25	1,369	185
12	4	34	16	1.156	136
13	4	27	16	729	108
14	3	30	9	900	90
15	3	28	9	784	84
Total	58	457	232	14,237	1,798

The results of the recapitulation of the validity test on the assessment of each attribute of sweet potato chip packaging can be seen in Table 4 as follows:

Table 4. The results of the recapitulation of the performance validity test of all attributes

No	Attribute	R-count	R-table	Information
1	Packaging form	0.694	0.514	Valid
2	Packaging color	0.683	0.514	Valid
3	Packaging material	0.622	0.514	Valid
4	Packaging design	0.768	0.514	Valid
5	Packaging quality	0.627	0.514	Valid
6	Put the logo on the packaging	0.515	0.514	Valid
7	packing size	0.664	0.514	Valid
8	packaging function	0.660	0.514	Valid
9	The size of the letters listed on the packaging	0.717	0.514	Valid
10	Packaging purposes	0.549	0.514	Valid

Reliability Test

Reliability or consistency is the level of confidence in the results of a measurement, so that it is known how far the measurement results can be trusted. Measurement is seen from how far the meaning of the instrument makes an item that has been measured independently and simultaneously becomes a set, becomes a very meaningful part of the whole. Instruments that produce high reliability tend to produce the same data about a variable or its elements if it is repeated at different times in the same group of individuals. The technique used to calculate the amount of reliability in research is by using the Sperm-Brown formula.

The values for reliability testing are derived from valid questionnaire item scores. Invalid items are not justified in reliability testing.

Testing steps:

1. Ho: The questionnaire is a reliable instrument and can be used.
   Ha : The questionnaire is not a reliable instrument.
2. The significant level chosen is $\alpha = 0.05$.
3. Determine the critical area.
4. From the Spearman Brown correlation price table with $\alpha = 0.05$ and N = 10 it is obtained: r table = 0.514, so the critical area is rtable = 0.514 < rcount.
5. Calculation r:
   a. Rearrange the items and values.
   b. Group even and odd numbered items, then total each group, the processing of these items can be seen in table 5 as follows:

Table 5. Grouping data based on odd and even

Respondents	Odd (X)	Even (Y)	X2	Y2	XY
1	16	54	256	2,916	864
2	14	48	196	2,304	672
3	19	55	361	3025	1045
4	20	60	400	3,600	1,200
5	16	52	256	2,704	832
6	12	36	144	1,296	432
7	17	45	289	2025	765
8	12	34	144	1.156	408
9	16	48	256	2,304	768
10	13	37	169	1,369	481
11	20	56	400	3.136	1,120
12	18	50	324	2,500	900
13	14	40	196	1,600	560
14	14	46	196	2.116	644
15	13	41	169	1,681	533
Total	234	702	3,756	33,732	11,224

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

$$r_{xy} = \frac{15\sum 11.224 - (\sum 234)(\sum 702)}{\sqrt{[15(3.756) - (234)^2][15(33.732) - (702)^2]}}$$

$$r_{xy} = \frac{4.092}{4568,45}$$

$$r_{xy} = 0,896$$

Then from the Spearman Brown correlation number, the reliability coefficient will be sought as follows:

$$r = \frac{2.\ R_{xy}}{1 + R_{xy}}$$

$$r = \frac{2.\ 0,896}{1 + 0,896}$$

$$r = \frac{1,791}{1,896}$$
$$r = 0,94$$

Conclusion :
Because the value of rcount > rtable (0.94 > 0.514) then Ho is accepted. This means that the questionnaire is a reliable instrument and can be used.
Processing Quality Function Deployment (QFD)
QFD processing uses data that has been collected using an open questionnaire, closed questionnaire data at the time of the study. QFD processing has several stages that must be carried out.
The steps in determining the target tree are as follows:

a. Make a list of product design goals that are tailored to consumer needs. The list of product design goals for potato chip packaging can be seen in Table 6 as follows:

Table 6. List of design goals for sweet potato chips

Question	Respondents Answer
Packaging form	Rectangular
Packaging color	Bright color
Packaging material	plastic
Packaging design	Has garnish and image of sweet potato chips
Packaging quality	So that the product is more hygienic, durable and easy to carry
Put the logo on the packaging	In the middle of the packaging
packing size	Adjusted for packing weight
packaging function	As the location of the product identity
The size of the letters listed on the packaging	According to packaging
Packaging purposes	To make it look attractive to buyers

Determination of the design function, this step is carried out to determine the functions that exist in product design including the functions needed and the limitations of the product design.

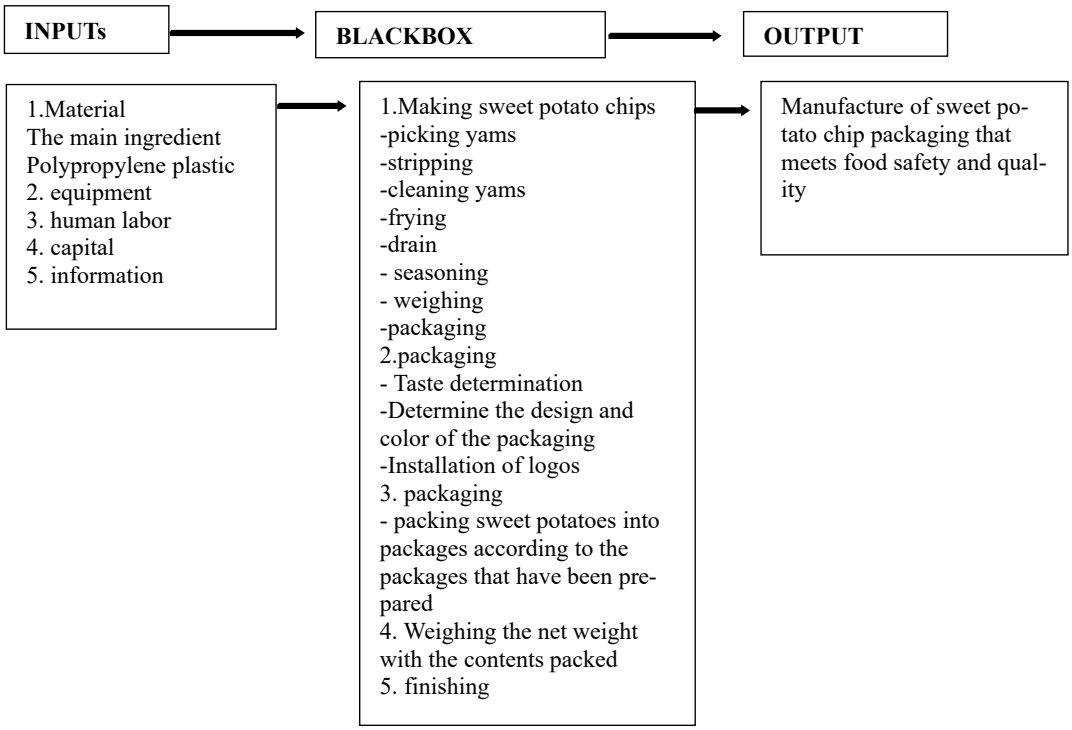


Fig 2. Input output system for designing sweet potato chips packaging

Compilation of needs and wants, while the specifications that have been determined can be seen in Table 7 as follows:

Table 7. Product specifications for potato chips packaging

No	D or W	Condition
1	W	Packaging form
2	W	Packaging color
3	W	Packaging material
4	W	Packaging design
5	D	Packaging quality

6	W	Put the logo on the packaging
7	D	packing size
8	W	packaging function
9	D	The size of the letters listed on the packaging
10	D	Packaging purposes

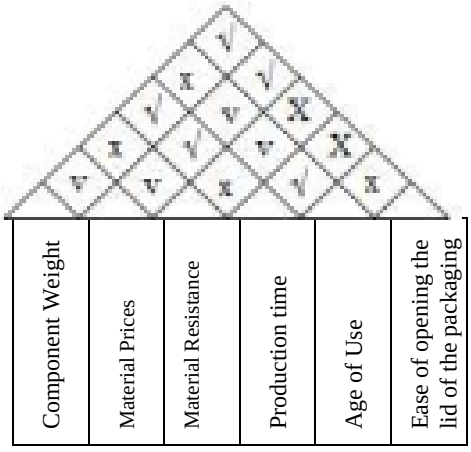
Determination of characteristics aims to determine the desires and needs of consumers for sweet potato chip packaging that meets the safety and quality of the food being designed.
The procedure for using the House of Quality matrix is [19]:

1. Identify consumer desires in the form of product attributes
2. Determine the level of relative importance of product attributes
3. Evaluate competitors' product attributes
4. Identify the relationship between product attributes with technical characteristics

	Component Weight	Material Prices	Material Resistance	Production time	Age of Use	Ease of opening the lid of the packaging
Packaging form	V	V	V	√	V	X
Packaging color	V	√	V	√	V	X
Packaging material	x	X	X	X	X	√
Packaging design	√	√	V	√	V	√
Packaging quality	x	X	√	V	X	V
Put the logo on the packaging	X	X	√	√	√	V
packing size	X	X	V	x	√	X
packaging function	√	√	√	V	V	V
The size of the letters listed on the packaging	X	X	X	x	X	X
Packaging purposes	X	√	√	X	X	X

Fig 3. Matrix between product attributes and technical characteristics of sweet potato chip packaging

5. Identify relevant interactions between engineering characteristics
   Interaction among technical characteristics as shown in Figure 4 below:



Degree of Relationship
V = Strong positive relationship, weight = 4
√ = Moderate positive relationship, weight = 3
x = Moderate negative relationship, weight = 2
X = Strong negative relationship, weight = 1

Fig 4. The relationship between technical characteristics

6. Determine achievement targets for each technical characteristic
7. Build quality homes

Problem Solving Analysis

Analysis of the Quality Function Deployment (QFD) design, the design with the QFD method is as follows:
Purpose Classification
Objective clarification is carried out to determine product design objectives and sub-objectives using the Objectives Tree Method. From the clarification of objectives, the objectives of designing sweet potato chip product packaging are obtained as follows:

a. Potato chip product packaging materials

1. Polypropylene plastic clip
2. Glue
3. Packaging

b. Sweet potato chip packaging design that meets food safety and quality
   1. The design of the plastic packaging is plain and transparent
   2. The color design on the packaging to be made is bright and attractive.
   3. The packaging design that will be made is square.
   4. Designs have colors, product images, and nutritional information.

c. Dimensions of potato chip product packaging
   1. The net weight of the packaging is 500 gr.
   2. The length of the package is adjusted to the net weight of the package

d. Color

The colors used are light
Function Assignment
Establishing Functions aims to determine the functions that occur in a design. The function of designing chips packaging is:

a. Measurement sub function
b. Printing sub-function
c. Finishing sub-function

Compilation of Needs
This step aims to make accurate manufacturing specifications for the design or design. Design product specifications are determined based on "demands" data from consumers and "wishes" data from designers.

Determination of Characteristics
The purpose of determining these characteristics is to find out the desired design or what is needed by consumers. QFD (Quality Function Deployment) with the final result being a quality house. The analysis from the quality house of sweet potato chip product packaging is:

a. Difficulty Level: Technical characteristics of component weight, material price, component durability, production time/difficulty and overall life span have a very difficult level of difficulty.
b. Importance: All engineering characteristics have an important degree of importance with the exception of the robustness of the component which has a very important degree of importance.
c. Estimated Cost: All engineering characteristics have a low estimated cost

Packaging is an important factor in a food processing business because of the function and usability of the packaging itself. In general, the function of packaging is as a protective material or product safety from external influences which can accelerate the occurrence of damage to the food contained therein (Noviadji,[20]).
The role of packaging gradually became more and more attractive to consumers. It was felt that it began to appear in the 1950s, at this time, especially in Indonesia, many supermarkets were popping up, where packaging had to be able to sell products on store shelves. But at that time the packaging only served to provide information to consumers about what was inside the package [21].
Analysis of packaging design that complied with food safety and quality, there were several differences between the previous cassava chip packaging and the proposed design, namely the addition of a logo to the packaging design, and changes in the shape of the packaging. The proposed sweet potato chip packaging used is in accordance with the wishes of consumers around Simpang Puloh. The proposed cassava chip packaging can be used all at once or as one product by taking into account the criteria for packaging product materials, namely:

1. Non-toxic
2. Water proof
3. Air-tight
4. Anti-microbial
5. Prevent product leakage
6. Does not damage the environment

The difference between the actual image and the proposed sweet potato chip product packaging can be seen in the following figure:

Fig 5. The difference between the initial packaging and the proposal

5. Conclusion

Factors influencing the design of product packaging that conforms to food safety and quality include the rectangular shape of the packaging, bright primary colors, the use of polypropylene plastic material, and placement of the logo in the middle of the packaging. Research has shown that a square shape, four bright colors, and an image of sweet potato chips on the logo printed on the package meet food safety and quality standards.

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