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Design of Betel Nut Peeler Machine Based on Quality Function Deployment and Value Engineering

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ABSTRACT

The goal of this study is to design a betel nut peeler machine based the Quality Function Deployment (QFD) and Value Engineering methods to optimize the stripping of betel nut process. A case study was carried out in the Keritang District of the Tembilahan Regency of Riau Province, Indonesia. Previously, the Keritang District community used the manual processes stripping technique, thus the final production cannot be in huge amounts. The method was implemented through several steps that began with gathering data and information about the machines desired by the community using QFD and Value Engineering. The machine was designed with the goals of being simple to use, efficient, and responsive to the needs of the community in mind. Each of these characteristics is discussed in the House of Quality. As a result, the Value Engineering approach was developed to uncover effective costs to deliver good quality, appearance, or features, and it may be used to improve product quality, lower costs, boost efficiency, and reduce risk. Finally, an appropriate and optimal design for the betel nut peeler was developed. The benefit of betel nut peeler machine design is supposed to be simple to use and to provide big amounts of stripping results quickly. As a result, the production of betel nut peeling rises.

KEYWORDS: *Betel nut, Design, Peeling machine, Quality Function Deployment, Value engineering.*

1.0 INTRODUCTION

The process of peeling betel nut can be done manually or by using a machine. Manual peeling is usually done by splitting the betel nut into two using a machete or similar tool, after that the split betel nut is dried in the sun, stripping in this way certainly takes a long time and is very risky for work accidents. Peeling betel nut manually using a machete or knife is only able to produce 10-15 kg/day [1]. Peeling betel nut using a machine is easier and faster than manual peeling, the harvested betel nut can be directly inserted into hooper, so that the results of stripping using a machine can save time and energy and can increase the production of betel nut. Betel nut peeler machine is a machine used to peel the outer skin of betel nut so as to produce betel nuts quickly [2]. This needs to be considered to the process of stripping betel nut still takes a very long time. Therefore, it needs a tool that is simple and affordable by the community at a relatively cheap price to make it easier and at the same time lighten the burden on farmers, one of which is the betel fruit peeler machine [3-5].

The conventional betel nut peeling process produces poor quality. This is because the betel nut that has been halved is very susceptible to fungus when dried. Betel nut that has been split in half may not be intact and the betel nut releases sap, so that affects the quality of the betel nut. The application of technology in the form of a betel nut peeler, which in its working process can produce completely peeled betel nut seeds and has a high selling value. The real impact for the community with the quality and selling value of betel nut is high, the level of welfare of the community's life will be better. The application of appropriate technology as a solution to overcome community problems can be resolved properly [4-6].

Previous research conducted the betel nut peeling machine had not been successful in stripping betel nut. This is due to the use of cutting blades that are not suitable, so that the betel nut peeling results were not peeled perfectly, the cutting blades used in this study are spiral and threaded. The solution can be applied the addition of paring nails and sharp and pointed nails to maximize peeling results and the adjustment of the cutting eye distance can be adjusted to the average size of the betel nut.

Quality Function Deployment (QFD) is a methodology for designing a process in response to customer needs [7]. QFD translates what the customer needs into what the organization produces. QFD enables organizations to prioritize customer needs, find innovative responses to those needs and improve processes to achieve maximum effectiveness. QFD is also a practice towards process improvement that can enable organizations to exceed customer [8]. The QFD method is far more advanced than the analysis of consumer or customer preferences, because in the structure of QFD information on customer desires is accommodated in technical capabilities in production planning [9-10].

Previous research reported the successful use of Quality Function Deployment (QFD) to design a betel nut peeler

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machine [11]. The design using the quality function deployment is the basis for determining the parameters needed to design a betel nut peeler machine that is desired by the community. Based on the results of the research, the betel nut peeler machine is based on the quality function deployment, the machines needed by the community are easy to operate, relatively cheap prices, fast work, lots of peeling results and the machine size is not too large [11].

Understanding Value Engineering in general is a management technique that uses a systematic, creative, and organized approach directed at analyzing the functions of a system with the aim of achieving the required functions at the lowest possible cost [12]. However, it is still in accordance with applicable functional and technical limitations so that the results still guarantee the reliability of a project or product [13].

According to [14], the incorporating of Quality Function Deployment and Value Engineering allows the organization to obtain an insight of better possibilities in design process that not only give greater valuation but also retain the cost of goods or service [14].

Therefore, the purpose of this article is to design a betel nut peeler machine based on the wishes and needs of the community, which is accomplished via the use of Quality Function Deployment (QFD) and Value Engineering methods. The QFD is used to meet the wants of consumers, whereas Value Engineering is used to identify alternative products with the best value costs.

2.0 METODOLOGI

In this research, a summary of the work from start to finish, it can be seen in the flow of activities as shown in Figure 1. The translation of the research flowchart in Figure 1 is as follows:

1. Literature and Observation
Studies Conduct learning studies to find theoretical references relevant to the problems found. The reference contains the betel nut peeler machine, the design of machine elements using the methods of QFD and the Value Engineering.

2. Problem
Identification Problem identification is carried out as an analysis of the problems discussed in the study. In this study, the problem identified was to formulate how to overcome the problems raised by designing a betel nut peeler machine based on observations made and at an optimal cost. In a previous study was observed that the peeling machine had not been successful in stripping betel nut. This was due to the inappropriate using of cutting blades. In previous studies the results of stripping were less than optimal where the peeling results were not perfect in peeling betel nut. The problem would be solved, which the cutting blades can be added with paring nails that is functioned to maximize the stripping results and the distance between the cutting blades will be adjusted based on the average size of the betel nut.

3. Data Collection
The data was collected in the form of consumer needs questionnaires. The consumer needs questionnaire was used to find out the concepts of betel nut peeling machines needed and desired by consumers. The samples were taken in this study were 30 respondents, in the Keritang District of the Tembilahan Regency of Riau Province, Indonesia.

4. Validation and Reliability Questionnaires
The validation was carried out to determine whether a questionnaire was valid or not. The questionnaire can be valid if it was able to reveal something that would be measured by the questionnaire.

5. Data Processing
At this stage, data processing was carried out to find alternative design of betel nut machine that were in accordance with the integrity of the community by using the Value Engineering analysis method, in accordance with the target, then proceed to analysis.

a) Quality Function Deployment (QFD)
After the requirements have been translated, they are inputted into the House of Quality method. The QFD was applied to evaluate the potential design of betel nut peeling machine in the Tembilahan area, especially in the Keritang sub-district.

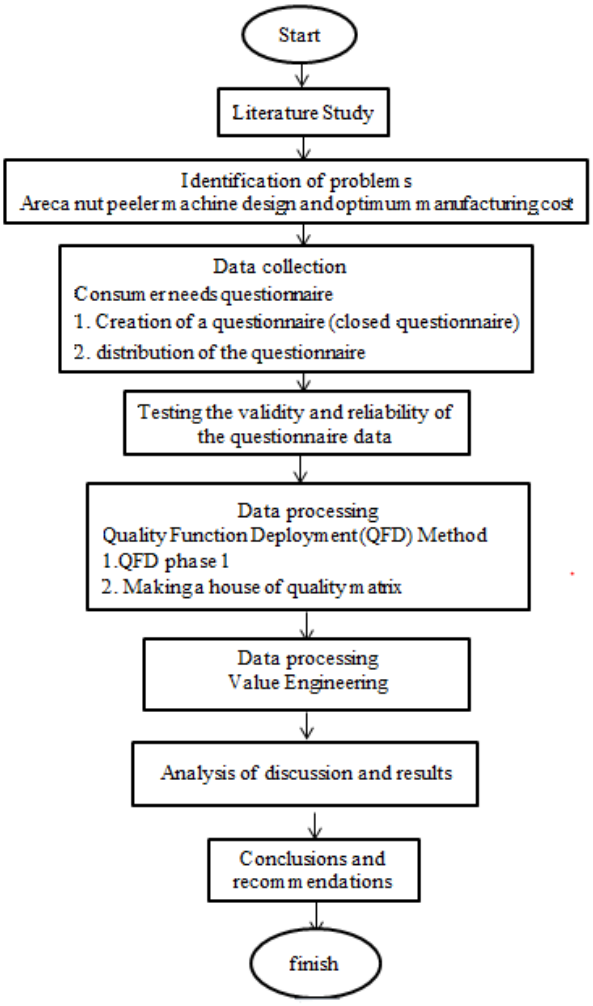

Figure 1: Flowchart of design of betel nut peeler machine based on quality function deployment and value engineering

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It was hoped that this method can obtain the target to be achieved, namely the efficiency of the betel nut peeler machine to increase productivity. This method was also expected to help the community to save economic and ergonomic costs. The method considered the aspects of being easy to operate, efficient and in accordance with the needs of the community [15]. Each of these aspects was described in the House Of Quality (HOQ).

b) Voice of Customer
To obtain customer desires, in this study an interviews and closed questionnaire were applied. The following were the stages of questionnaire implementation:

1. Distribution of closed questionnaires and demographic data to the community in Keritang District.

2. Processing the most votes for the selection of attributes from the most important to the least important.

3. The distribution of closed questionnaires and the selection of characteristic relationships with the voice of customers.

4. Master data processing to determine validation and reliability.

5. Making HOQ to find out the target opportunities of the betel nut peeler machine design.

6. Value Engineering
The Value Engineering was to identify efficient costs to provide good quality, appearance or features and can be used to improve product quality, get lower costs, increase efficiency, and reduce risk. The Value Engineering was a stage that was carried out after the Quality Function Deployment. The explanation of these steps is as follows [14], [16-19]:

a. Information
Stage The information stage is the stage of collecting information regarding the needs of users and the priorities of user needs. Information regarding user needs is obtained from the QFD stage that has been carried out previously.

b. Analysis
Stage The analysis stage is the stage of elaborating the critical functions of the betel nut peeler machine and obtained several solutions that are used in the design and development of the betel nut peeler machine. The solutions include adjusting the cutting mechanism, adjusting the shape of the cutting blade, adjusting the dimensions, and determining the material.

c. Creative Stage
At this stage, alternatives will be developed for the product. Making this alternative is based on the results of QFD and the description of the critical function that has been done previously.

d. Evaluation
Stage The evaluation stage is the stage of assessing the value of each concept. This assessment is done by assessing the function and cost for each concept. The value for function is done with the formula as below. Where A is the concept value for each attribute and W is the weight or weight for each attribute. The value of the concept is based on a Likert 1-4. [20]:

$$Function = \Sigma(Ai\ x\ \%\ Wi) \quad (1)$$

e. Development
Stage The development stage is the stage for selecting alternatives to be developed further. Alternative selection is based on the highest value.

$$Value = \frac{Function}{Cost} \quad (2)$$

In determining value, value is a quantity without units, while cost has units. For this reason, the function will be changed in the same unit as cost. To change the value function in currency units based on the following formula:

$$V_0 = \frac{F_0}{C_0} = 1$$

$$V_0 = V_n \cdot$$

$$\frac{F_0}{C_0} = \frac{F_n}{C_n}$$

$$C'n = \frac{Fn.Co}{Fo} \quad (3)$$

Description:
Vo : value Initial
Vn : value Product alternative
Fo : function Initial design
Fn : function Product alternative
Co : Initial design cost
Cn : Product alternative cost
C'n : Function in rupiah

The hourly wages were calculated using the formula according to the Regulation of the Minister of Public Works and Public Housing Number: 28/PRT/M/2016 concerning Analysis of Work Units in the Public Works Sector in Indonesia, is bellowed:

Hourly wages = wages of workers per month 25 days x 7 working hours (4)

7. Analysis and Results
After obtaining the results of data processing, then it can analyze the concept of value was obtained for the most efficient betel nut machine design.

3.0 RESULT

The steps in identifying the potential of betel nut peeling machine in Petalingan Village, Keritang Sub-district in order to obtain the required parameters according to the customer's wishes. In stripping betel nut using a betel nut peeler machine based on Quality Function Deployment and Value Engineering.

Distribution of Questionnaires
In this study, the location for distributing questionnaires was in Petalongan Village, Keritang District, Tembilahan Regency,

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Table 1: Demographic questionnaire data

No	Questions	Answered	Number of respondents
1	Gender	Male	14
		Female	16
2	Community ages	25-35 Years	6
		35-45 Years	13
		>45 years	11

Riau Province, Indonesia. In this study, the selected respondents were the people of Petalongan village. The number of respondents to fill the questionnaires were 30 respondents. From the calculation to determine the number of samples, the result of number of respondents gender and ages groups that is depicted in Table 1.

Product Concept Development

In product concept development, there were two stages to get the product concept to be used. These stages consist of quality function deployment and value engineering.

Identification of User Needs (Voice of Customer)

Identification of user needs was carried out by direct interviews with betel nut peeler workers. This interview was conducted to obtain the needs of the betel nut peeler workers for the betel nut peeler machine. The results of these statements were interpreted into user needs. The interpretation of user needs can be seen in Table 2. The results of the interpretation of user requirements were used in determining the attributes of the product. The product attributes obtained from the interpretation of needs were as follows:

1. Security
2. Ease of use
3. Low price
4. Convenience
5. Not easily damaged
6. Easy to move
7. Has aesthetic value and pleasing to the eye
8. Minimalist size.

Table 2: Interpretation of user needs

No	Customer Statements	Interpretation of Needs
1	Hands were often injured by knives when peeling betel nut	A safe peeler
2	The fibers in the betel nut cause discomfort to the hands	Minimizing the fibers from the hands
3	The betel nut peeler must be modified as needed	Tools according to needs and affordable
4	Body feels sore from sitting too long while peeling	Peeler that was comfortable to use
5	Peeling knife that was often dull and problematic	A peeler was not easily damaged
6	Betel nut peelers often move from place to place in stripping betel nut	The peeler was easy to move
7	Betel nut workers often feel bored when stripping too long	Peeler was pleasing to the eye
8	The size of a machete or knife that was too large	Minimalist peeler

Table 3: Relative Important Index (RII) attribute

No	Attribute	RII
1	Security	3
2	Ease of use	3
3	Low price	4
4	Convenience	3
5	Not easily damaged	3
6	Easy to move	3
7	Has aesthetic value and pleasing to the eye	3
8	Minimalist size	3

The questionnaire was used to determine the level of importance of each product attribute. The results of the importance level were used in making the house of quality. The making House of Quality (HOQ) was done by referring to the steps in preparation of the HOQ.

1. Determination Customer Needs

Determining customer needs was from the results of the voice of customer that had been done previously. User needs were indicated by the following product attributes:

A. Security
B. Ease of use
C. Low price
D. Convenience
E. Not easily damaged
F. Easy to move
G. Has aesthetic value and pleasing to the eye
H. Minimalist size

2. Formation of Planning Matrix

The determination planning matrix was done to get the weight of each attribute. Determination planning matrix was done by determining the level of importance of each attribute, benchmarking with competitors, and calculating the weight.

Determination of the level of importance for each attribute was done by distributing questionnaires to workers. Workers assessed the importance of each of these attributes. The results of the recapitulation of the importance level of the attributes are shown in Table 3. The mode of each attribute was used as the value of the importance level or RII (Relative Important Index). Table 3 shows the level of importance (RII) of each attribute.

4.0 DISCUSSION

The concept cost was obtained by comparing the function value. In determining value, a quantity without units, while cost has units. To change the value of the function in units of currency, the assumption of the value of the benchmark concept that concept 3 was equal to 1. Changing the value of the function in units of cost is carried out using the formula 3. An example of calculating the change in function value in unit costs is as follows:

Concept function value 1: 2.715
Benchmark concept function value (initial concept): 2.1
Benchmark concept fee (initial concept): IDR 3,090,332

$(Rupiah)$ = (Fi.Co)/Fo
$(Rupiah)$ = (2,715 × 3,090,332)/2.1
$(Rupiah)$ = IDR 3,995,357

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The next step was calculated the value used formula 3. An example of calculating the value is as follows.

Function (rupiah) concept 1: Rp 3,995,357
Concept fee 1: IDR 3,099,314

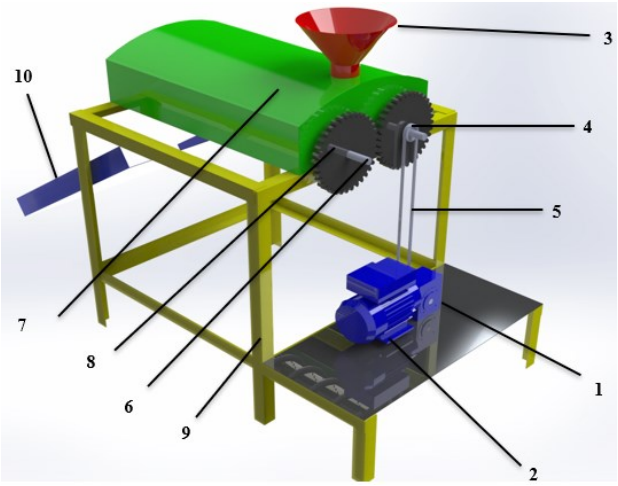
Concept value 1 = Function/cost
Concept value 1 = 3,995,357/3,099,314
Concept value 1 = 1.28

The development stage was to choose an alternative that was developed further. Alternative selection was based on the highest value from the alternating design results. Based on the value calculation, the concept with the highest value was concept two with a value of 1.58. Then, it was used in product development of the shape of the horizontal cutting edge of stainless-steel material, the frame material of iron elbow and various colors.

The assessment of the price attribute was based on the price to realize the concept. This study, a frame design used the welding process, the frame material was iron elbow, and the transmission used V-belt and pulley. The assessment based on the price of iron elbow, which was cheaper than cast iron. The price of chains and prokets, which were more expensive than v belts and pulleys.

The security attribute was assessed based on the safety when the tool was used. The concepts with horizontal blades were safer than vertical blades. This was because the concept with a horizontal knife can be equipped with a buffer under the cutting edge. The cutting blade have a protective cover to protect the hands from the paring blade.

The color attribute varies depending on the color of each component of the betel nut peeling machine. This study used the color variations. The attribute of ease of movement was affected by the weight of the tool. The material was a factor that affects the weight of the tool. Frame material with iron elbow was lighter than cast iron material. The weight of the betel nut peeler was 15 kg**.** Finally, the design concept 2 was chosen, as shown in the Figure 2.



1. Gearbox, 2. Electric motor, 3. Hooper, 4. Pulley, 5. V-Belt, 6. Shaft, 7. Protective cover, 8. Gear, 9. Frame, and 10. Output channel.

Figure 2: The design of betel nut peeler machine selected

5.0 CONCLUSION

Based the design stages of betel nut peeler using the Quality Function Deployment (QFD) method, 8 attributes were obtained, namely: security, convenience, ease of use, low price, not easily damaged, easy to move, pleasing to the eye, and a minimalist size. The attributes of the product were supported by technical responses, namely: the tool dimensions, cutting edge material, tool material, machine frame material, tool mechanism, tool weight, machine color, cutting edge mechanism, cutting eye shape and the hooper shape. The design of value engineering obtained the concept of a tool with the highest value, namely concept 2 with a value of 1.58. The concept has a function value of 3.46 at a cost of Rp. 3,229,210. From concept 2 was obtained the component of horizontal cutting edge, the iron elbow frame material, the stainless steel of tool and the color varies. From the design of the machine frames, the calculation values for motor power, capacity, torque, pulley, and V-belt that were safe. Therefore, the design alternative of betel nut peeler machine was selected the concepts 2.

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