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A Cassava Washing Appliance Design for The Home Industry

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Abstract— The food business opportunity is very interesting for home industry entrepreneurs in West Sumatra, a home industry of cassava chips. The step of the cassava chip production process that takes longer time than the other step is the washing process. The cassava washing process is carried out manually because washing device that uses motor drives are not affordable for home industry entrepreneurs. In addition, the cassava washing process makes a physical complaint from the operators. Therefore, this research designs a cassava washer that is affordable for the home industry by considering design methods, ergonomic aspects, and customers' needs. This design is carried out using the Quality Function Deployment (QFD) method to translate the voice of the customer into technical and design characteristics, morphological charts for generating alternative designs, and an objective weighted method for evaluating that alternative. The result of this research is the design of a cassava washer which is more practical because it makes the operator works easier and can save time in the washing process. It is also very affordable, with an estimated cost of production of IDR2,397,743.

Keywords: Cassava, Washing Machine, Home Industry, Quality Function Deployment (QFD), Morphological Chart.

1. Introduction

Indonesia is an archipelagic country with natural potential which significantly helps the economy of its people [1, 2]. A nation's potential resources must be utilized and developed as optimally as possible for the continuity of sustainable living so that they become opportunities and even business investments for the community and the country itself [3, 4]. The rapid development of technology from every era can affect the increase in economic growth in a business environment [5]. It will bring about changes that require an effort to maintain its existence from rapid environmental changes. One of the efforts that emerged because of changing times was in the industrial sector [6].

The industrial manufacturing processing industry certainly influences the economic growth of the community [7, 8]. Various natural products in Indonesia can be managed in one industry to obtain a higher selling value. Industrial processing of natural products that can obtain a high selling value, one of which is derived from tubers. A tuber product that is quite popular now is cassava, which is mainly processed to produce cassava chips.

The cassava chip home industry is a small and medium industry that is quite common in West Sumatra, Indonesia. Although the direct use of cassava tubers as a staple food in West Sumatra is much

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reduced, the use of processed cassava products is increasing rapidly. The snack food industry is one of West Sumatra province's five leading industrial commodities [9, 10]. The cassava chip manufacturing process in West Sumatra generally consists of several stages: removing the cassava skin, washing the cassava, cutting, washing after cutting, frying, and packing. In general, each of these processes is still done manually. Based on the observations of several cassava chips industries, it was found that the longest time in the manufacturing process was found in the cassava washing process. Washing cassava is done manually by rubbing and rinsing the cassava using water one by one in the cassava washing area and done in a squatting position.

Observations in one industry found that it takes approximately 1 hour to manually clean 1-2 sacks of cassava (50-60 kg). In contrast, the amount of cassava that needs to be washed daily is an average of 8 sacks. The time for washing cassava is very time-consuming for operators, where operators work around 6-7 hours/per day. It also resulted in delays in other work, such as adding spices and packing. In addition, the manual washing process also causes physical complaints from operators, such as muscle aches and backaches due to an uncomfortable working position (squatting position) for quite a long time.

One effort that can be made to overcome this problem is using a cassava washer. Currently, cassava washer has been found in the market. However, to use this cassava washing machine, a large amount of money is required for a home industry scale. The price of a cassava washer using a motor on the market today is between IDR18 million – IDR19 million [11, 12]. This cost is less affordable for home industry businesses that have small capital. So, home industry entrepreneurs still survive using the manual method even though it takes quite a long time to process. In addition, based on observations, the use of a cassava washer using a motor can cause the quality of the cassava washed to decrease. The washed cassava has a substantial impact on the wall of the machine, so much of the cassava is broken and cannot be used to make long-sized cassava chips. Therefore, the food processing industry with cassava as raw material on a home industry scale requires an innovative cassava washer that is practical, affordable, and can maintain the quality of cassava-washed products. This study designed a practical and economical ergonomic cassava washer for the home industry. The limitation of the problem in this study is that the capacity set is 10kg/process.

2. Method

This study uses customer voice data with the stages of data collection are (1) Interviews with ten cassava washer operators in various business locations to determine the variables in designing the questionnaire; (2) Designing a questionnaire and then validating it with the construct validity method; (3) Distributing validated questionnaires to operators of the cassava washer; (4) Fill out the questionnaire based on the level of importance; (5) The result is the voice of the customer (VoC) for use in data analysis.

Other data needed are anthropometric data for Indonesians [13] and an overview of the design of the cassava washing machine using a pre-existing motor. Data analysis is carried out in several stages, namely:

a. House of Quality (HoQ)/Quality Function Deployment (QFD) [14]:
b. Morphological chart [15]. This method uses data from HoQ, anthropometric data, and the design of a pre-existing cassava washing machine. The data that has been combined is used as a sub-solution that can be used as a variety of design alternatives.
c. The objective weighted method [16] is an evaluation of alternative designs from a morphological chart using a matrix so that the weight of each objective is obtained. After that, each alternative is weighted against its objective to obtain the utility value. The highest utility value is the selected product design concept.
d. The results of the selected product designs are displayed in 2D and 3D images using Solidworks Software.
e. The calculation of the cost of production.

3. Result and Discussion

3.1 House of Quality (HoQ)

Based on the survey results by distributing questionnaires to 10 cassava washer operators, it was found that the importance level of the cassava washer is shown in Table 1. Voice of customers (VoC) is a technical and operational requirement derived from the questionnaire. Through VoC, information on needs is obtained through the level of importance. The VoC is grouped based on the eight dimensions of product quality [17] described in Table 2. Table 3 shows the priority of technical characteristics based on customer needs.

Table 1. Recapitulation of Scores and Order of Interest of Respondents for The Cassava Washing Machine

Statement	Importance Level	Importance Score	Importance Level Order
The results of washing cassava must be hygienic	40	4	1
Large washing process capacity	38	3.8	2
Washing results are flawless	38	3.8	2
It only requires 1 operator to operate the machine	37	3.7	4
Using durable material	36	3.6	5
The material used is stainless	35	3.5	6
Affordable prices	34	3.4	7
Able to clean cassava quickly	32	3.2	8
Low maintenance costs	32	3.2	8
Easy to move	32	3.2	8
The operation of the tool is easy	31	3.1	11
Long tool life	31	3.1	11
Use lightweight materials	31	3.1	11
Do not use the automatic drive	30	3	14
Has water circulation that can carry dirt out of the tool	30	3	14
The washing process does not tire the operator	30	3	14
The size of the tool does not take up space	30	3	14
Tool safety	28	2.8	18
The operator position is standing while operating the tool	25	2.5	19
The operator's position is sitting in operating the tool	24	2.4	20
Using cheap materials	23	2.3	21
Use a contrasting color for the outside of the tool	22	2.2	22
Use a dark color for the outside of the tool	21	2.1	23

3.2 Morphological Chart

A morphological chart is a list or a summary of the analysis of changes in shape systematically to find out how the shape of a product is made [18]. The morphological chart combines various possible solutions to form different or varied products. The combination of the morphological chart of this design comes from the results of the QFD and the description of the cassava washer that already existed. The components used in the morphological chart are foot position, cylinder tube, stirrer blade, inlet funnel, outlet funnel, and bearings. The wheel component was not selected for alternative generation on the morphological chart because the wheel component only has one type of variation, so there is no need to generate alternatives. Meanwhile, the rubber component on the mixer blade is combined with the mixer blade in an alternative generation to make it more effective. In this morphological chart, each component has three alternative solutions. The solution is obtained from the results of identifying the summary of each machine's components and the ideas the designer considers. The solution is then considered, and the best, according to the expert, is selected (Table 4).

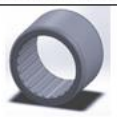
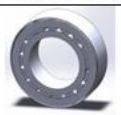
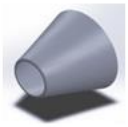
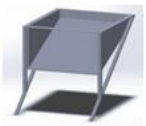
Table 2. Technical Characteristics for The Cassava Washing Machine

Priority Order	Technical Characteristics
1	The process is done manually
2	The cylinder tube is made of aluminum alloy
3	The time for a washing process is ± 2 minutes
4	The capacity for a wash is about 10 kg
5	Equipment prices range from IDR5,000,000 – IDR10,000,000
6	Using transmission
7	The dimensions of the tool are about 125cm x 50cm x 105cm
8	The geometry of the mixing blade does not damage the cassava
9	It has water circulation that can carry dirt out
10	Requires 1 operator
11	The size of the tool adjusts to anthropometric data aged 20-47 years
12	The weight of the tool is around 6-15 kg
13	Tensile strength yield of 350-400 MPa for tool feet
14	Tensile strength yield of 20-50 MPa for cylindrical tubes
15	The corrosion rate of the cylinder tube material is around 2.15 gr/m²
16	Different colors between lever and cylinder tube

Table 3. VoC Grouping based on Product Quality Dimensions

Criteria	Item	Statement
Ergonomic Interaction	Safety	Safe use of tools
	Dimension	The size of the tool does not take up space
		Use lightweight materials
	Comfort	The operator's position is standing operating the tool
		The operator's position is sitting while operating the tool
	Save Effort	The washing process does not tire the operator
	Easy to Use	Only requires 1 operator to operate
		The operation of the tool is easy
Ergonomic Emotion	Aesthetics	Use a contrasting/dark color for the outside of the tool
	Style	Use a contrasting/dark color for the outside of the tool
	Semantics	Use a contrasting/dark color for the outside of the tool
	Attractions	Low maintenance costs
	Easy to Learn	The operation of the tool is easy
	Maintenance	Using durable material
		The material used is stainless
		Long tool life
Ergonomic Performance	Efficiency	Able to clean cassava quickly
		Has water circulation that can carry dirt out of the tool
	Effectiveness	The results of washing cassava must be hygienic
		Washing results are flawless
	Function	The results of washing cassava must be hygienic
		Washing results are flawless
		Large washing process capacity
		Affordable prices
	Environmental Protection	Do not use the automatic drive
	Save Energy	Do not use the automatic drive

Table 4. Morphological Chart of Component Selection

Component	Alternative 1	Alternative 2	Alternative 3
Bearings			
Position Feet			
Cylinder Tube			
Mixing Blade			
Exit Funnel			
Inlet Funnel			

3.3 Selected Design Concepts

The selected design concept is Alternative B, with a utility value of 8.625. It was selected based on the design concept evaluation using the objective weighted method in Table 5. The results of these designs can be seen in Figure 1. Data on shoulder height and elbow height of Indonesians aged 20-47 years was derived from the online site [13] and were used to design the size of the cassava washer (Table 6). The cost of production for the selected cassava washer design based on calculations is IDR2,397,743.

3.4 Working Principle

The working principle of the proposed cassava washing design is that the peeled cassava is inserted one by one through the inlet funnel. When the cassava is already in the cylinder, it is rotated with a crank to move the stirring blade, which functions to help clean and push the washed cassava out of the tool. During the washing process, water is sprayed into the cylinder tube, which is assisted by a water pump machine. Some water will come out through the holes in the cylinder and be replaced with new water from the pump. After the washing, the cassava comes out through the outlet funnel and is ready to be accommodated.

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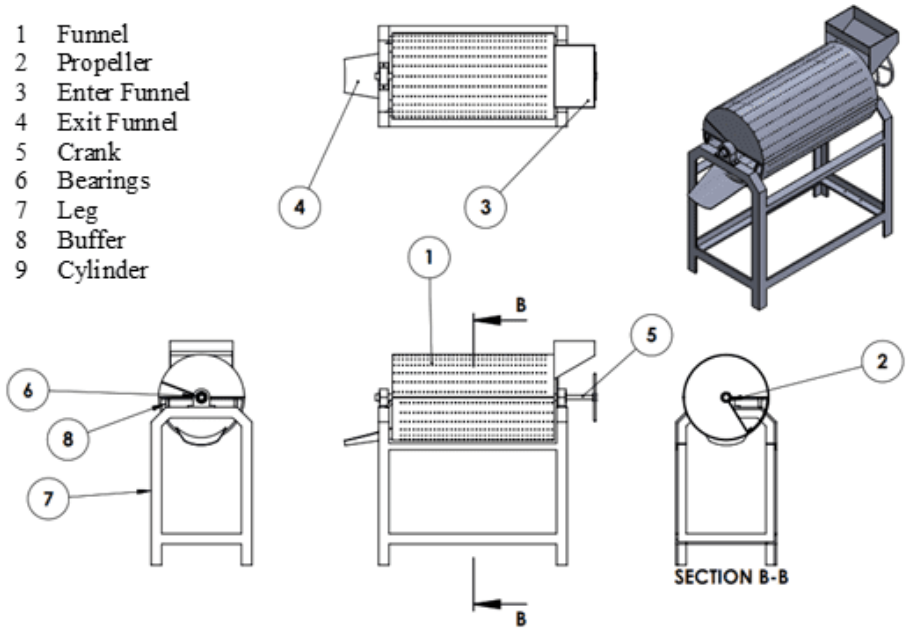

Figure 1. The Selected Design of Cassava Washing Appliance

Table 5. Relative Utility Values of Alternative Designs

Objective	Weight	Alternative A		Alternative B		Alternative C	
		Score	Value	Score	Value	Score	Value
Bearings Type	0.125	9	1.125	6	0.750	3	0.375
Cylinder Tube	0.375	6	2.250	9	3.375	3	1.125
Mixing Blade Geometry	0.125	6	0.750	9	1.125	3	0.375
Water Circulation	0.125	6	0.750	9	1.125	3	0.375
Position Feet	0.250	6	1.500	9	2.250	3	0.750
Overall Utility Value		6.375		8.625		3	

Table 6. Anthropometric Data Used

Anthropometric Variable	Percentile			SD	Function
	5^{th}	50^{th}	95^{th}		
Shoulder Height	124.11	136.82	149.53	7.73	Determine the inlet height
Elbow Height	92.5	102.6	112.7	6.14	Determine crank height

3.5 Discussion

This study covers the design of a cassava washing machine for domestic use. The famous snack meal cassava chips is made from cassava tubers. One of the most important steps in the production process is washing the cassava, which is carried out manually by rubbing and rinsing each individual piece. The lengthy manual process might lead to physical problems from the operators, such as backaches and muscular aches from an unpleasant working position. Although a motor-powered cassava washer is commercially available, it is pricey for home-based enterprises. In order to retain the quality of the cassava-washed product while remaining practical and ergonomic, this research develops a cheap cassava washer. Utilizing the Quality Function Deployment (QFD) approach, morphological charts for generating alternative designs, and an objective weighted method for evaluating the alternative designs, the design is completed. The result is a cassava washer design that is practical, saves time, and affordable with an estimated production cost of IDR2,397,743.

A comparison between the existing market design and proposed designs is presented in Table 7. The inlet and outlet funnels consider anthropometric data so that the operator has no difficulties entering and removing cassava. In the existing design, the operator had difficulty inserting the cassava because the funnel was too high, so the operator needed a tool such as a chair. The height of the inlet funnel considers the shoulder height with the 5% percentile so that with several variations in height, the operator has no difficulty inserting cassava into the tool. The spiral-shaped stirrer blade, which is flexible and can push the cassava out, has several advantages over the previous product. The flexible stirring blade maintains the cassava's quality to keep it clean and not broken during the washing process. In addition, the spiral-shaped mixing blade also helps the cassava being washed slowly push out of the tool towards the outlet funnel.

The study emphasizes the value of technology in industrial manufacturing and processing as well as how it affects local economic development. It also underlines the necessity of making the best use possible of a country's potential resources in order to promote sustainable living. The study's research technique comprises gathering information through interviews and questionnaires, using anthropometric data on Indonesians, and providing a general overview of the construction of current cassava washers.

Table 7. Comparison of an Existing Design in The Market with Proposed Designs

No.	Existing Design	Proposed Design
1	Using bearings	Using bearings
2	Inlet and outlet funnels do not consider anthropometric data	Inlet and outlet funnels consider anthropometric data
3	Using a mixer blade	Using a spiral-shaped stirrer blade which is flexible and can push cassava out of the tool
4	Capacity 500-1500 kg/hour	Capacity 10kg/process
5	Using a driving motor	Not using a driving motor
6	Not using a crank	Using a high crank where the crank is located considering anthropometric data
7	The cylinder material uses stainless steel	The cylinder material uses Aluminum Alloy
8	The material for the foot position uses mild steel	The material for the foot position uses the L profile ST 37
9	The price of tool is relatively expensive	The price of the tool is cheaper
10	Using the water pump	Using the water pump

The study is significant because it gives a solution to the issues experienced by home industry entrepreneurs in cassava chip manufacture, particularly in the cassava washing process. The cassava washer design is a practical and economical option that can enhance the manufacturing process and the quality of the cassava-washed product. It also discusses the significance of adopting design techniques such as the Quality Function Deployment (QFD) method in designing products that fulfill the needs and requirements of customers.

Finally, the paper offers valuable information on the design of a cassava washing machine for home industries. The article's findings are valuable for home industry entrepreneurs in the cassava chips production business, food processing industry researchers, and other stakeholders interested in enhancing the efficiency and quality of cassava production. The article also underlines the need to maximize a country's potential resources for sustainable existence.

4. Conclusion

This study designed an economical and functional cassava washer for home industry entrepreneurs. The cassava chip production process in West Sumatra, Indonesia, typically consists of multiple stages, with the cassava washing process, which is done manually, taking the most time. The

manual washing method also generates bodily issues among operators, such as muscular aches and backaches from working in an uncomfortable position for an extended time. A cassava washer with a motor must be affordable for home industry entrepreneurs. As a result, this study produced a practical and cost-effective ergonomic cassava washer for the home industry by employing the Quality Function Deployment (QFD) method to translate the customer's voices into technical and design specifications. The study result is the design of a cassava washer that can make the operator work easier and save time in the washing process. It is very affordable, with an estimated cost of production of IDR2,397,743. Future research is to make a prototype of the proposed design so that it can be carried out to increase the productivity of the cassava chips manufacturing process.

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