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Design, Fabrication, and Performance Evaluation of Electric Motor Driven Cassava *(Manihot esculenta)* Grater with Juice Extractor

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ABSTRACT

Modern agriculture requires a modern approach which responds to the necessity of mankind. The study presents the fabrication and performance evaluation of a cassava grater with juice extractor. Such performance evaluation was conducted to determine its grating and juice extracting capacity and efficiency. It was made from locally available materials then tested experimentally using cassava with a grating capacity of 160 kg/hr. The study employed the Complete Randomized Experimental Design (CRD). In evaluating the experiment, the Two-way Analysis of Variance (ANOVA) was used to determine the significant effect of each factor and the Tukey's test was used to determine the significant difference between the combined treatments. Two factors with different levels were treated upon the experiment. These were mainly soaking time (0 min, 5 min, 10 min, 15 min) and the way the cassava was grated and juice extracted (Machine, Manual). Among these treatment combinations, the soaking time of 15 minutes obtained the highest grating and extracting capacity as well as for the grating and extracting efficiency leaving its quality and acceptable appearance on top. The computed benefit-cost ratio of 1.86 showed that grating and extracting cassava juice using the cassava grater with juice extractor was highly profitable and economical for local cassava producers.

***Keywords* —** Agricultural machinery, grating capacity, experimental design, Philippines

INTRODUCTION

Cassava, sometimes described as the 'bread of the tropics' (Adams, Murrieta, Siqueira, Neves & Sanches, 2009) is the third largest source of food carbohydrates in Africa after rice and maize (FAO, 1990; Fauquet & Fargette, 1990). Ravindran (1992) stated that cassava is a major basic food in the emerging world, which provides a basic nutrition for over half billion people. Hence, it is very wise to process the cassava within three days after harvest. As what Adjekum (2006) reported, cassava roots are fit for human consumption, but it contains cyanide, which is poisonous. These cases can be reduced only when the roots are processed properly.

Aside from removing the cyanide, processing this crop also provides cassava growers with extra market opportunities, instead of just selling the fresh cassava roots to the market. Traditional procedures of processing the roots of cassava may end up in reducing its quality, thus, will contain unacceptable levels of cyanide, be contaminated with foreign matter and disease-causing agents resulting to jeopardizing the consumers. Reducing cyanide levels in the processed crop, prolonging its shelf life, reducing post-harvest losses of fresh cassava roots and avoiding contamination of the products will convert cassava roots into safer and more merchantable products (James *et al.,* 2012). Manual processing (peeling, grating, pressing etc.) of cassava is laborious and intensive where there is retard process for producing such product.

In rural areas, manual operation in cassava processing is being practical because there are no locally available machines. As the world is emerging with various types of technologies for better quality of life and efficient production of food, automation and mechanization technology for agricultural machines are used for faster, lesser labor agricultural production of sustainable agriculture. Modern agriculture requires modern approach which responds to the necessity of mankind (Gumanit, 2015).

The industry has to raise the product quality through improved processing equipment to sustain its growth. Grater farmers, especially in rural areas, still utilize the traditional method which is manually grating and extracting the cassava. As a result, uneven grated cassava is inconsistent, and incidence of hand injuries during grating is high. Considering these difficulties, the researchers aimed to develop and fabricate a cassava grater with juice extractor to be used by the cassava farmers since no cassava grater with juice extractor were fabricated in the rural areas to solve and relieve the problem of many cassava grater farmers on the tedious manual grating and extracting operation.

OBJECTIVES OF THE STUDY

The study was conducted to evaluate the performance of a fabricated cassava grater with a juice extractor. Specifically, it aimed to determine**:** 1) the grating and extracting capacity of the fabricated cassava grater with juice extractor; 2) the grating and extracting efficiency of the fabricated cassava grater with juice extractor; 3) its benefit-cost ratio.

MATERIALS AND METHODS

Table 1. Materials used in the fabrication of a cassava grater with juice extractor

Items	Information
A. Core structure	
A-1 Length	107.00 cm
A-2 Height	77.50 cm
A-3 Capacity of the loading hopper	3,000 g
B. Grating drum	
B-1 Dimension $V=\pi r^2 h$	r= 5.00 cm; h=16.50 cm
B-2 Shape	Cylinder
C. Electric motor	
C-1 Type	YC 905-4
C-2 Rated power, KW	0.75
C-3 Rated speed. Rpm	1740
C-4 Voltage, V	220
C-5 Current, A	707
C-6 Frequency, 112	60
D. Discharge Chute	
D-1 length	199.00 cm
D-2 Width	13.00 cm
D-3 materials used	wood
E. Loading hopper	
E-1 length	21.50 cm
E-2 Width	20.00 cm
E-3 Height	40.00 cm
E-4 Materials used	wood
F. Shaft	
F-1 Diameter	2.50 cm
F-2 Length	61.00 cm
G. Extractor	
G-1 Height	40.00 cm
G-2 Width	24.00 cm

G-3 Length	27.50 cm
G-4 Materials used	wood
H. Tosser	
H-1 Length	16.50 cm
H-2 Width	11.20 cm
H-3 Thickness	1.80 cm
H-4 Handle length	21.50 cm
H-5 Material used	wood
I. Stopper	
I-1 Length	25.00 cm
I-2 Width	16.51 cm
I-3 Thickness	2.00 cm
I-5 Material used	wood

For the fabrication of a cassava grater with juice extractor, the researcher made use of angle bar, cross joint, electric motor with capacitor, pillow block, shaft, iron sheets and wood screw and tools and equipment such as hammer, welding machine, and welding rod.

Designing. The whole design of the machine was carefully planned by sketching it first in a piece of paper, and its parts were labeled with its corresponding dimension.

Lay-outing. The various parts of the machine such as the frame used, the angle bar, the drum grater is a stainless plate, feed hopper used a steel plate, and the presser is made up of screw type shaft with steel plate cover to press.

Cutting. The various stainless plate and angle bars were cut according to different sizes. Stainless plate used was 6"x12", in an angle bar, 3 bar 1x1/2, and used 4 feet of the shaft.

Assembling. The frame was positioned according to its structural design. Electric motor, cross joint, pillow block, cylindrical grater in line with the shaft were attached above it. The researchers used pillow block and crossed joint for safety and less movement of electric motor during operation. The juice extractor was attached to the frame.

Welding. The frame was welded. Welding was done properly to prevent accident during the operation.

Installing. The machine was provided with a plug and wire.

Painting. Paint was applied automatically after the construction to prevent from rusting.

Testing. The fabricated extracting and grating machine was tested using the cassava crops. Peeled cassava was tested using the one horsepower electric motor grater, and the grated cassava was pressed with the fabricated juice extractor.

RESULTS AND DISCUSSION

The fabricated cassava grating with juice extracting machine

A 113 cm x 150.5 cm area of extracting and grating machine was designed, fabricated and tested (Figures 1 and 2). The main features of the machine are**:** feeding hopper, discharge chute and cylindrical drum, the shaft and pillow block and the power transmission unit. The parts depending on their functions were made from stainless plate, wood, flat bar, angle bar, and bolts. It is a direct driven machine which do not used transmission belt, and the cassava grated can be extracted after the grating process.

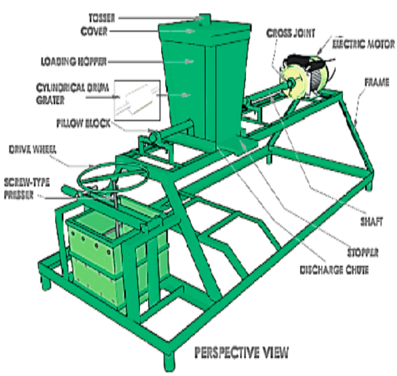

Figure 1. Perspective view of fabricated cassava grater with juice extractor

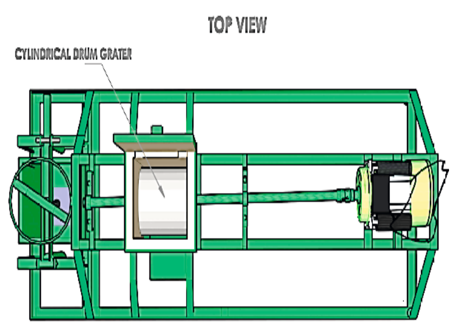

Figure 2. Top view of fabricated cassava grater with juice extractor

The design of the cassava grater with juice extractor was developed on the following considerations:

1. The grating machine was designed to produce cassava grates, and it can be extracted by the fabricated extractor.
2. The capacity and the efficiency of the machine were recorded
3. The machine was designed to be used as direct driven to avoid slippage.
4. The machine was designed for easy operation, maintenance, and safety.
5. The machine was designed in such a way that the grating and extracting operations are fast and easy compared to the traditional grating and extracting.

Grating Capacity

The grating capacity of the motor-driven cassava grater with juice extractor and the manual way of grating is shown in Table 2. Results showed that T4 had the highest grating capacity with a mean of 44.26 grams per second followed by T3, T2, and T1 with the means of 43.75, 41.83 and 40.72 grams per second, respectively for the fabricated machine. In the manual grating, T4 also has the highest grating capacity with a mean of 2.30 g/sec followed by T3, T2, and T1 with means of 2.71, 2.69 and 2.60 g/sec, respectively. However, analysis of variance revealed no significant differences among treatment means. These results imply that soaking time did not affect the grating capacity.

Table 2. Grating capacity of fabricated machine and manual grating

TREATMENT	FABRICATED MACHINE PARAMETERS			MANUAL PARAMETERS	
	Weight Fed (g)	Grating time (sec)	Grating Capacity (g/sec)	Grating time (sec)	Grating Capacity (g/sec)
T1 Control	3,000	73.67	40.72	1,154.00	2.60
T2 5 min. Soaking	3,000	71.72	41.83	1,116.05	2.69
T3 10 min. Soaking	3,000	66.33	43.75	1,105.05	2.71
T4 15 min. Soaking	3,000	69.00	44.26	1,301.67	2.30
F -Test			ns		ns
CV (%)			9.55		9.42

Extracting Capacity

The extracting capacity of fabricated cassava grater with juice extractor and the manual extraction is shown in Table 3. Analysis of variance revealed highly significant differences among treatment means. The results showed that T4 had significantly higher extracting capacity in fabricated extractor and T3 in the manual extraction. These results imply that soaking cassava significantly affected the extracting capacity of both manual and fabricated cassava grater with a juice extractor. According to Kajihausa, Fasasi and Atolagbe (2014), moisture content is increased by soaking. This is due to the absorption of water during soaking which resulted to higher juice content in cassava roots.

Table 3. Extracting capacity of fabricated machine and manual extraction

TREATMENT	FABRICATED MACHINE PARAMETERS			MANUAL PARAMETERS	
	Weight Fed (g)	Extracting time (sec)	Extracting Capacity (g/sec)	Extracting time (sec)	Extracting Capacity (g/sec)
T1 Control	3,000	427.67	7.01[a]	424.67	7.06[a]
T2 5 min. Soaking	3,000	626.67	4.79[b]	628.33	4.77[b]
T3 10 min. Soaking	3,000	643.33	4.66[b]	647.67	4.63[b]
T4 15 min. Soaking	3,000	663.67	4.52[b]	664.33	4.52[b]
F -Test			**		**
CV (%)			2.69		4.67

Grating Efficiency

Table 4 shows the grating efficiency of fabricated cassava grater with juice extractor and in manual grating. Results revealed that T4 with the mean of 92.94 % in fabricated machine and 76.33 % in manual grating has the highest average grating efficiency followed by T3, T2, and T1. However, analysis of variance revealed no significant differences among the treatment means. These results implied that soaking time could not affect the grating efficiency of both manual and fabricated motor –driven machine.

Table 4. Grating efficiency of fabricated machine and manual grating

TREATMENT	FABRICATED MACHINE PARAMETERS			MANUAL PARAMETERS	
	Weight Fed (g)	Weight Recovered (g)	Grating Efficiency (%)	Weight Recovered (g)	Grating Efficiency (%)
T1 Control	3,000	2715.00	90.50	2275.00	75.83
T2 5 min. Soaking	3,000	2755.00	91.83	2315.00	77.17
T3 10 min. Soaking	3,000	2764.67	92.16	2324.00	77.47
T4 15 min. Soaking	3,000	2788.20	92.94	2290.00	76.33
F -Test			ns		ns
CV (%)			1.13		3.31

Extracting Efficiency

The extracting efficiency of fabricated cassava grater with juice extractor and manual extraction is shown in Table 5. Analysis of variance revealed highly significant differences among treatment means. Results showed that in fabricated machine and manual extraction, T1 had significantly higher extracting efficiency with a mean of 77.08 percent for the fabricated machine and 82.23 percent in manual extraction, followed by T2, T3, and T4. The manual extracting efficiency values are higher than the values using the machine which imply that machine had better extracting efficiency than the manual extraction. The lower the extraction efficiency, the better is the device.

Table 5. Extracting efficiency of fabricated extractor and manual extraction

TREATMENT	FABRICATED MACHINE PARAMETERS			MANUAL PARAMETERS	
	Weight Fed (g)	Weight Recovered (g)	Extracting Efficiency (%)	Weight Recovered (g)	Extracting Efficiency (%)
T1 Control	3,000	2,312.50	77.08[b]	2,466.67	82.23[b]
T2 5 min. Soaking	3,000	1,963.33	65.44[a]	2,200.67	73.36[a]
T3 10 min. Soaking	3,000	1,955.67	65.19[a]	2,201.67	73.39[a]
T4 15 min. Soaking	3,000	1,943.04	64.77[a]	2,113.67	70.46[a]
F -Test			**		**
CV (%)			1.94		3.17

Benefit-Cost Ratio

The benefit-cost ratio was defined as the proportion of the gross income to the total operating cost. Table 6 shows benefit cost-ratio of the fabricated cassava grater with juice extractor. The benefit-cost ratio (BCR) of the machine was 1.86 which means that the project was economically feasible.

Table 6. Estimated economic value of the machine

	Value in Php/year
INVESTMENT COST	13,205.00 ($264)
FIXED COST	
Depreciation (5 years)	2,241.00 ($45)
Investment on capital (25 %)	3,301.25 ($66)
Tax and insurance (6 %)	792.30 ($16)
Repair and Maintenance (10 %)	1,320.50 ($26)
Total Fixed Cost	7,655.05 ($153)
VARIABLE COST	
Electricity (Php 8.08/kWh)	110.29 ($2)
Total Variable Cost	110.29 ($2)
Total Operating Cost	7,765.34 ($155)

RETURNS	
Peeled Cassava to be Grated @ P 15/kg	39,000.00 ($780)
Maximum Peeled Cassava Grated @ 10 kg/day	
Total Returns	39,000.00 ($780)
BENEFIT-COST RATIO	1.86 ($.03)

CONCLUSION

Based on the results of the study, the fabricated motor-driven extracting and grating machine has a good economic value and can serve a good alternative, for it has less time duration during operation, lesser cost, efficient, and can be easily operated. The computed benefit-cost ratio for the fabricated machine was 1.86. This means that for every peso spent in this venture, it is estimated that it will earn 1.86 pesos ($ .03). It is very obvious that the fabricated machine has a great benefit to offer to the local farmer graters.

Soaking peeled cassava in water cannot affect grating capacity and efficiency but it can affect extracting capacity and efficiency. Besides the economic advantage and availability of the materials used, the capacity and the efficiency of the fabricated extracting and grating machine is much better than the manual way of grating and extracting the cassava and its juice. The fabricated machine gives a lot of advantages to the local farmers specifically because of a short waiting for the return of investment or ROI.

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