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Original Research Article

DEVELOPMENT OF CASSAVA (*MANIHOT*) CHIPPING MACHINE USING ELECTRIC MOTOR CUM MANUAL OPERATION

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Abstract: An electric motor cum manually operated cassava (*Manihot Esculenta crantz*) chipping machine was developed and its performance evaluated. The purpose is to increase surface area which aid in quick drying of cassava chips. Local available materials were used for the fabrication. This machine consist majorly of a hopper, chipping blades, transmission shaft, collection box, electric motor, a handle and frame. The machine was evaluated using 300-400 rpm speeds. The varying speeds were carried out using different diameters of pulleys. Analysis of variance was used to determine the significant effect in efficiency, speed of operation, chip size and time at p < 0.05. Duncan's New Multiple Range Test (*p*<0.05) was used to analyze the difference in the various parameters investigated. The results indicate that speed has significant effect on the mass of well chipped cassava and its efficiency, but has no significant effect on the chipping time at 95% confident level for the dual power types investigated. The dimensions of the chips obtained were in the range of 10-20mm for electric motor and above 20mm for manual. As the operational speed increased from 300-400rpm, there was a decrease in efficiency of the dual power types investigated. 300rpm gave the highest efficiency of 86.7% and 83.12% for electric motor and manual turning operation respectively and better chipping geometry than other speeds. The machine has a feeding capacity of 209kg/hr. This machine is simple to operate and maintain for small and medium scale farmers.

Keywords: Electric –Motor, Manual, Cassava, Chipping and Machine

Introduction: Cassava, *Manihot Esculenta Crantz* is dicotyledonous perennial plant belonging to the botanical family *Euphorbiacea.*[1]. It is starchy root crop that is grown almost entirely in the hotter lowland tropics. The crop is also known under a variety of names according to the region in which it is cultivated; *Cassava* in the English speaking countries of North America, Europe and Africa; *Manioc* in French speaking countries; *Tapioca* in the English speaking countries of South America[2].

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Varieties, Climate, Soil Requirement and Propagation

Reported[3] that cassava is often classified by the amount of bitter substance in the root. Bitter and sweet cultivars are also available. The bitterness is caused by Cyanogenic Glucoside contained in the roots. Cyanide is released upon crushing the roots. Soil and climate conditions determine the amount of this compound found in the roots. A sweet cultivar in one location may be bitter in another location. Cassava is highly adapted to various environments. It grows on almost all types of soil but does better on well drained sandy loam or light alluvial soil rich in nutrients. It has high resistance against drought though such conditions cause reduction in yield. Cassava is a tropical crop and requires high temperature, high humidity and adequate sunshine. Optimum condition for its growth includes a yearly rainfall of 1000mm to 2000mm and 20^{o}C to 59^{o}C temperature. The altitude should not be more than 1000metres.Stem cuttings 20 to 30cm long from the previous crop is used to plant a new crop of cassava. The stem cuttings are planted 10cm deep and are planted in grid pattern with 60 to 140cm between cuttings. The crop remains in the field from 10months to 3years. Yields are higher, the longer the crop grows. High Nitrogen content in the soil and irrigation tend to decrease yield because of excessive top growth. The crop is harvested by simply digging the roots once they have reached the desired size[3].

Processing of Cassava Tubers

After harvesting, cassava roots are susceptible to spoilage and without any preservation measures can only be stored for about 48hours before they begin to deteriorate[4]. Therefore, the roots must be processed as soon as possible after harvest to arrest the deterioration process. Other factors favouring the processing of the cassava are that the processed products can be stored for longer periods. Processing is therefore undertaken primarily to detoxify the cassava product, to improve its palatability and convert it to a consumable and storable form[4]. Cassava is widely used in Nigeria as food. It is mostly consumed in the form of *garri*, *tapioca*, fufu, *starch* and *lafun*. In the Northern part of the country, the sweet variety is eaten raw as snacks. Cassava is an important raw material for the non-food industries. The low amylase, high amylopectin content of cassava starch gives it the necessary viscosity for high quality adhesives and for use in the paper and textile industries. Cassava starch is also used for the production of dextrin, which are utilized in glues. Another industrial product made from cassava is "*Ethyl Alcohol*" (Ethanol) [4].

Cassava Chips

Cassava chips are pieces of dried, sliced or chipped roots not exceeding 6cm length with starch content of 70% or more. The method of processing chips consists essentially of preparing the roots, slicing and then drying the slices until they have a storable moisture content of about 12%. Cassava roots when processed into chips and pellets can be used in compounding animal feed for cattle, sheep, pig, poultry and goats. Traditional methods of chipping cassava are still in vogue in most parts of the Nigeria which adversely affects the production. Costs of most conventional chipping machines are high and unaffordable due to high foreign exchange; moreover the non availability of adequate labour during harvest season has necessitated the development of this device. The objectives of this work are to design and construct an electric-motor cum manual operated cassava chipping machine for cassava slicing and evaluate the performance of the chipping machine [5].

Materials and Methods

Description of the Machine

Figure 1 is the exploded views of the cassava chipping machine showing the various components. The chipper consists of hopper, chipping units, driving hand pulley, and frame which are made of galvanized mild steel. The hopper (Part No. 1) is curved in shape measuring (640mm x 750mm x 3mm), inclined at 45^{o} for easy sliding of the tubers into the clipping knife (Part No. 4) and the chute (Part No. 2). The machine is driven via pulley (Part No. 7) of diameter 160mm. The frame is made up of angle iron (Parts No. 10 – 13) measuring 670mm x 700mm x 400mm firmly welded together for stability. Attached to the frame is the electric motor/engine seat (Part No. 6).

Delivery chute (Part No. 2) discharges the chipped cassava by gravity. The handle (Part No. 14) which is attached at the left hand side of the shaft is used when operated manually. The shaft passes through the chipping unit. The shaft has series of cutting knives arranged used for slicing, chipping and dicing. Belt (Part No. 9) is used for transmission of power generated from the electric motor (small pulley). Except the frame, shaft and pulley, the machine parts are made of galvanized iron to avert corrosion and contamination[6].

The hopper is rectangular in shape; the frame is trapezoidal in shape. The bearings (Part No. 3) are bolted on the left and right sides of the frame, through which the shaft passes. The shaft (Part No. 5) transmits power. Figure 2 is a picture of the assembled cassava chipping machine.

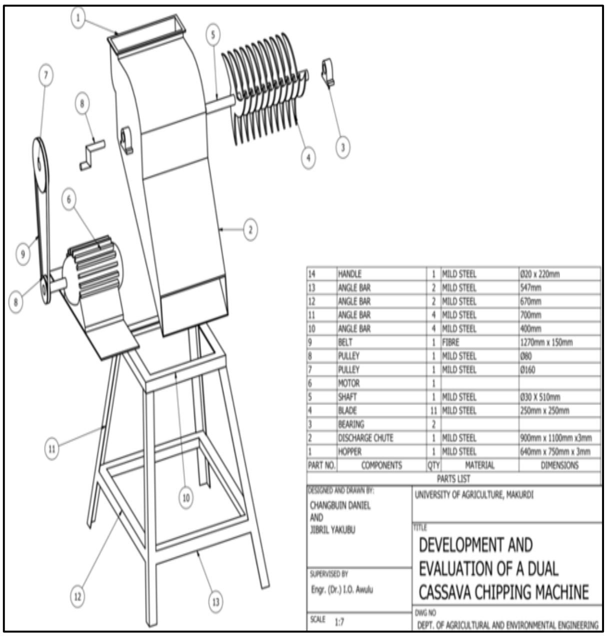

Figure 1: Exploded view of cassava chipping machine

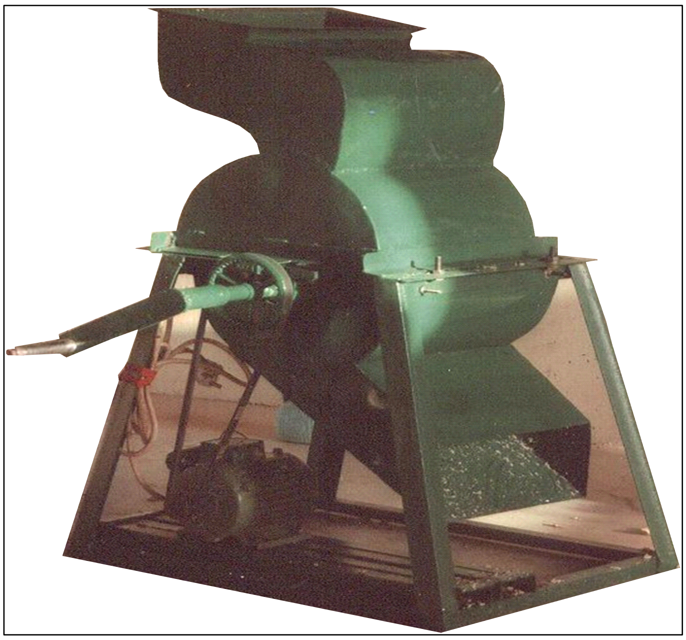

Figure 2: Assembled Cassava Chipping Machine (to show components, a safety guard in belt drive has been removed).

Determination of Cassava Properties

Cassava properties were determined and used for hopper design.
These properties include;

i. Size (length and diameter of cassava) (figure 3)
ii. Weight of cassava

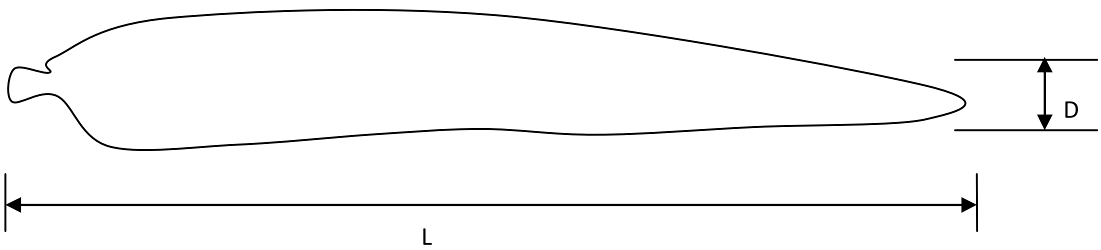

Figure 3: Cassava tuber

Performance Evaluation

Performance evaluation of the machine was carried out using one variety of cassava (*Manihot Palmate*) one type of chipping knife and three varying speeds (300, 350, and 400 r.p.m). Fresh harvested cassava tubers were peeled and washed manually in clean water fairly regular sized tuber was randomly selected and introduced into the machine. The chips from the chute were collected and manually separated.

The machine was evaluated[7] for chipping efficiency and feeding rate using equations 1 and 2.

The evaluation was found in accordance with the following definitions:

Chipping efficiency, $\eta_s =$

$$\frac{W_{wc}}{W_i} \times 100 \qquad (1)$$

$$\text{Feeding rate (Fr)} = \frac{W_{tc}}{T_c}\frac{kg}{hr} \qquad (2)$$

η_s = Chipping efficiency

F_r = Feeding rate

Where: W_{wc} = mass of well chipped cassava

W_{tc} = mass of total chipped cassava

W_i = initial mass of cassava tuber

T_c = chipping time

Statistical analyses were carried out using a software program called SPSS. The means separation was done using New Duncan multiply range test.

Results and Discussions

Tables 1 showed Cassava chipping performance test using electric motor and manual operation on the chipping machine. The mass of well chipped cassava ranges from 1.27 to 1.73kg representing 63.5 to 86.5% of the mass loaded in the hopper for evaluation for electrical motor operation. The highest mass of welled chipped was obtained at a speed of 300rmp while the lowest mass was obtained at a speed of 400rpm. Chipping time for electrically operated motor ranges from 26.0 to 26.76 seconds while the efficiency ranges from 68 to 86.7%. The highest efficiency of 86.7% occurred at a speed of 300rpm and the lowest efficiency of 68% occurred at speed of 400rmp.

Mass of well chipped cassava for manual operation ranges from 1.42 to 1.68kg representing 71 to 84% of the mass loaded in the hopper for evaluation. The highest mass of welled chipped was obtained at a speed of 300rmp while the lowest mass of 1.42kg was obtained at a speed of 350rpm. The chipping time for the manual operation ranges from 25.6 to 29.74 seconds. The efficiency ranges from 69.2 to 83.12%, with the highest efficiency of 83.12% occurring at a speed of 300rpm while the lowest efficiency of 69.2% occurring at the speed of 350rpm. As the operating speed increases the efficiency decreases in both operation types. This is in agreement with the findings of [8]. The efficiency of this machine when compared with that of [9] and [10] showed a higher value indicating an improvement over the previous designs. Average feeding rate of the machine was 209kg/hr.

Table 1: Performance Evaluation of Electric motor/ Manual Chipping Machine

Operation used	Speed (rpm)	replication	W_i (kg)	W_{wc} (kg)	T_c (s)	η_c %	Fr (kg/hr)	Size of chips, Ø (mm)
Electric motor	300	3	2	1.5 ^{a} (0.10)	26.76^a (4.0)	86.7^a (7.64)	209	10 - 20
	350	3	2	1.73^b (0.58)	26.0 ^{a} (2.65)	70.0 ^{b} (0.0)	209	10 - 20
	400	3	2	1.27^c (0.12)	26.0^a (2.55)	68.0 ^{b} (7.2)	209	10 - 20
Manually operated	300	3	2	1.68^a (0.03)	29.74 ^{a} (1.1)	83.12^a (1.61)	209	20-50
	350	3	2	1.42 ^{b}(0.08)	28.09 ^{a} (3.38)	69..2 ^{b} (5.2)	209	20-50
	400	3	2	1.47^b (0.06)	25.6^a (4.22)	70.0 ^{b} (0.0)	209	20-50

*Different letters within the same column indicate significant differences according to Duncan's New Multiple Range Test ($p<0.05$). *Numbers in Parenthesis are the Standard deviation.

Table 2 shows ANOVA Table on the Evaluation of the Machine. It was observed that speed has a significant effect on the mass of well chipped cassava and its efficiency, but has no significant effect on the chipping time at 5% confident level for the dual power types investigated.

The mean separation shows that for both electric motor and manual operation, the means of the mass of well chipped cassava at the three operating speeds were different from each other; these could be due to the fact that as the speed increases at constant feeding rate the surface area for chipping reduces. The separation also showed that for the three selected speeds the chipping time are not different from each other; these also may be due to the fact that the speed range is too close to each other more over, the quantity of cassava used for these evaluations were too small (2kg only). For the efficiency the mean separation showed that the higher the speed the lower the efficiency (this is further shown graphically in figure 4). This is due to the fact that the more you increase the speed without adjusting the feed rate; both the chipping size and weight are affected therefore affecting the efficiency of the machine.

Table 2. Test of Hypotheses for Efficiency, Speed, Mass of Well Chipped and Chipping Time.

Source 0f variation		Sum of squares	Degree of freedom (df)	Mean square	F	Sig
Electric Motor						
	Speed					
	Mass of well chipped	0.327	2	0.163	18.375	0.003*
	Chipping Time	1.145	2	0.573	0.057	0.945NS
	Efficiency	630.2	2	315.1	8.568	0.017*
Manual						
	Speed					
	Mass of well chipped	0.121	2	0.06	18.083	0.003*
	Chipping Time	26.068	2	13.034	1.214	0.361NS
	Efficiency	370.06	2	185.028	18.711	0.003*

*Significant (p<0.05)
NS = Not Significant (p<0.05)

Figure 5 is a picture showing cassava chippings obtained from the dual operation types. Measurements carried out on the chips indicated that electric motor operation has sizes between 10 - 20mm while the sizes from the manual operation was coarse and found to be between 20-50 mm showing that cassava chips from electric motor operation will dry quicker than that of manual operation type.

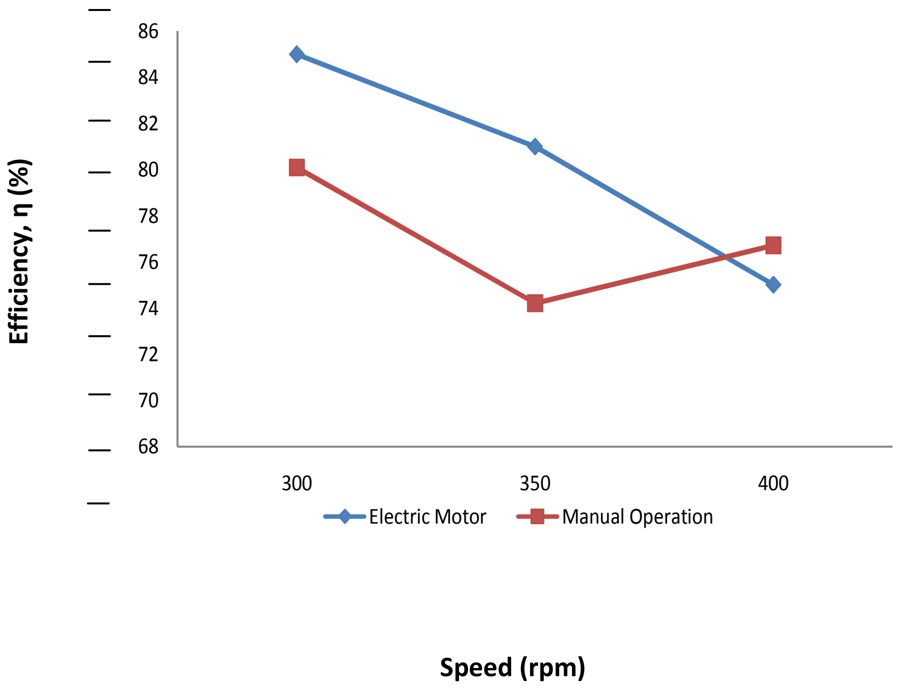

Figure 4: Effect of speed on Cassava Chipping Efficiency

(a) (b)

Fig. 5 (a) Electric motor Chipped (b) Manually Chipped Cassava

Conclusion

i. Development and performance evaluation of an electric-motor cum manual operated Cassava chipping machine was successfully carried out;

ii. The machine has a feeding capacity of 209kg/hr, efficiency of 84.9% and performed best at operational speed of 300 rpm for the dual power types investigated;

iii. As the operational speed of the machine increased there was a decrease in the efficiency.

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