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FABRICATION OF HAMMER MILL FOR CASSAVA FLOUR PRODUCTION

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Abstract

The use of hammer mill is one of the simplest methods of processing agricultural raw materials, alternative to the traditional methods of using stone, mortar and pestle. Crushing process reduces the size of solid materials by mechanical action, and this can be achieved by breaking them into smaller particles. This research aimed at developing a hammer mill that will be faster, user-friendly and more convenient for use by agro-processors in solving the challenges of high product loss and drudgery experienced in the use of traditional methods. The dried cassava grinding machine is made up of the following component parts; hopper, frame, pulley, transmission belt (V-belt), shaft, bearing, hammers and sieve. The equipment was fabricated in the workshop of the Agricultural and Bio-Environmental Engineering Department, Oyo State College of Agriculture and Technology, Igboora, Nigeria. The frame was fabricated using mild steel angle iron (3mm); the hopper was made of stainless steel. The main shaft was made of stainless steel and supported at both ends by ball bearings. A beater shaft which suspended the hammers was fabricated from a stainless steel rod of 12 mm in diameter. The machine was powered by a 5.5 hp gasoline engine. The machine was tested using dried cassava tubers. The following parameters (throughput capacity, crushing capacity, crushing efficiency and % losses) were determined. The results obtained from the study showed that the machine has an average crushing capacity and efficiency of 359.34 kghr and 95.62 % respectively. The results obtained from the fabricated machine in terms of performance indices confirmed that it performed its intended function effectively and can be deployed for small and medium scale milling operation of dried cassava tubers.

Key words: *Fabrication, hammer mill, cassava, flour, size reduction*

Introduction

Cassava (*Manihot esculentus*, Crantz) is one of the root crops grown for food and industrial applications. It has been one of the mainstays of several tropical and sub-tropical countries of the world. According to FAO statistics, the world's cassava production had been on the increase from about 176–277 metric tons per year from the years 2000 – 2013. Africa contributed between 54 and 58 % of the world's cassava within these periods (FAO, 2014). Nigeria is the largest cassava root crop producer in the world. The impacts of cassava on the economies of different countries have changed in the last two decades. Previously, in some economies, it was an economic crop while in some others it constituted merely a poverty alleviation crop. Except in a very few countries, cassava has assumed a prominent position as an industrial crop with constantly growing utilization avenues. The roots are highly perishable due to their high moisture content at harvest. Besides the advantage of preserving the root, processing is also used to add value to the raw roots by converting them to several primary and secondary products of varying economic importance. Flours and starch powders are the two major primary products from cassava roots traded world-wide. They are essentially dried products, often packaged, stored or marketed at low moisture levels (10–14 %, wet basis). Cassava flour (CF) refers to the dry, fibrous and free-flowing particulate product obtained from cassava roots. Due to the changing status of cassava from poverty alleviation to an economically important crop, there has been a shift in the level of cassava processing technology. Nowadays, improved (mechanized) processing techniques are now replacing the existing manual operations. The greatest drudgeries of manual peeling, size reduction, pressing, drying and milling have now been removed by the advent of various mechanical devices that perform those mentioned operations. Milling is an energy-intensive operation which

leads to production of particulates size of less than 400 μm , referred to as flour in many instances. Regardless of processing scales, it is carried out mechanically with the use of milling machines. The most popular types of milling machines used are attrition and hammer mills (Nwaigwe *et al.*, 2012). A study of cassava processing machineries in Nigeria indicated that milling machines are the third-most popular after graters and pressing machines. Dry milling operations in the processing factories surveyed are manned mainly by males (Davies *et al.*, 2008).

Few studies had been conducted on dry milling of cassava. Nwaigwe *et al.* (2012) designed a mechanical mill for converting cassava chips into flour due to some ineffectiveness of existing machines to produce acceptable flour grade for the bakeries. The mill was based upon an impact and shearing action, with a pneumatic conveying and classifying action. The modified milling gave an efficiency of 82.3 % with fineness modulus of 0.31 and average particle size of 0.075 mm compared to 2.35 and 0.085 mm of an existing hammer mill, respectively.

The influence of moisture content on the dry milling characteristics of dried cassava chips was studied by Shittu *et al.* (2002). The amount of energy use in dry milling depends on the initial particle size of feed and moisture content. Increased feed size and moisture leads to higher milling energy consumption to produces flour of specific particle size. The effect of milling was studied by Adesina and Bolaji (2013). Although the authors did not describe moisture content and size of the cassava chips milled, they reported that milling affected the flour yield and mill recovery. The crushing of crops is on the increase with the global quest for the particle size reduction of agricultural products. Among the various types of grinding equipment available, hammer mills are the best-known equipment used for the milling/grinding, in which the material is subjected to complex forces and the resultant particles are used for various purposes. The Cassava flour is made from dry cassava tubers and takes lot of time degrading using most local method (mortar and pestle) as it requires a lot of operations before the dried cassava commonly known as (elubo lafun) by Yoruba people can be converted to flour. Therefore, this study aimed at fabricating a domestic hammer mill to ease the stress of material reduction.

Materials and methods

Material selection

The following materials were used for the fabrication of the hammer mill: 30 mm diameter stainless steel solid shaft, pulley, belt, 30 mm bearing/casing, 50 $\times$ 50 $\times$ 50 mm angle iron, stainless steel plates, mild steel angle bars,, bolts and nuts. Table 1 depicts materials selected for the different components.

Table 1 Material selection for fabrication of the machine

S/N	Part	Materials
1	Hopper	Stainless sheet (3 mm)
2	Frame	Mild steel angle iron
3	Main shaft	Stainless steel (30 mm in diameter)
4	Hammers shaft	Stainless steel (12 mm in diameter)
5	Shaft supports	Ball bearings of (30 mm) size
6	Pulley	Mild steel
7	Screen	Stainless steel

Fabrication considerations

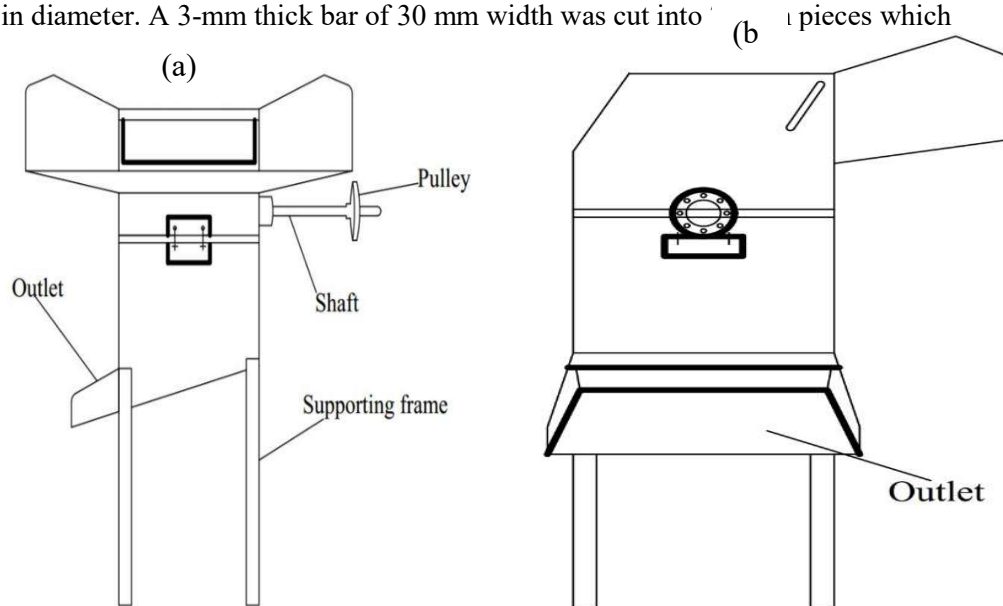
The following were considered while fabricating the machine

- (i) Availability of materials locally to reduce the cost of production.
- (ii) The hopper was designed as an open type in order to allow easy loading of dried cassava tubers.
- (iii) The milled cassava flour outlet was designed at an angle greater than the angle of repose of cassava flour for effective discharge.
- (iv) Internal combustion petrol engine was used as the source of power supply so as to enable the machine to be moved from one place to the other and to solve the problem of power failure.

- (v) Ease of replacement of component parts in case of damage or failure.
- (vi) Durability of the materials used in fabricating the machine.

Fabrication and assembly of the Machine

The equipment was fabricated in the workshop of the Agricultural and Bio-Environmental Engineering Department, Oyo State College of Agriculture and Technology, Igboora, Nigeria. Marking out of materials were done using rule and scribe. Cutting, drilling, welding and machining operations were also done in the workshop. The frame of the machine was fabricated with angular mild steel bar of cross section 360 mm x 360 mm (Figures 1 and 2). The angular mild steel bar was chosen because of its rigidity, availability and relative cheapness. The angular bar was cut into four pieces to form the four legs of the stand and welded to a frame to form a table stand. The hopper is a truncated pyramid in shape. The shape was cut out and pasted on the stainless steel sheet. Scribe was used to trace the shape on the steel sheet and snipers used to cut out the marked out shape. The cut out sheet was folded to the required shape and the lapping edges were welded to form a hopper. A 32 mm diameter stainless steel rod was cut to a 480 mm length using power hacksaw. The shaft was then faced and turned to 30 mm diameter to form the main shaft. The main shaft is mounted horizontally on the frame and supported at both ends by ball bearings. A beater shaft which suspended the hammers was fabricated from a stainless steel rod of 12 mm in diameter. A 3-mm thick bar of 30 mm width was cut into 1 pieces which



Figure

1:

Orthographic projection of the fabricated hammer mill : (a) front elevation (b) side view.

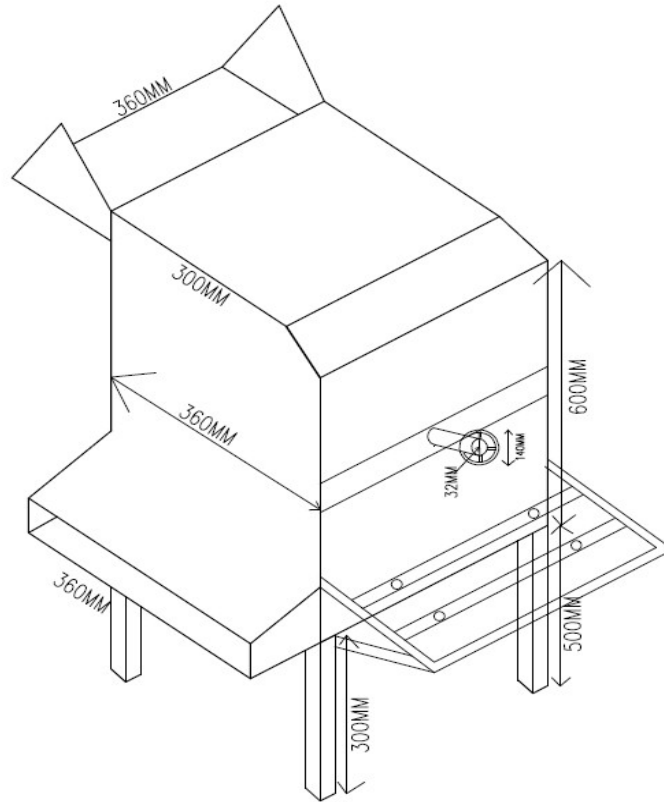


Figure 2: Isometric projection of the fabricated hammer mill

served as the hammers. A hole of 13 mm was drilled at the bottom of each hammer, using twist drill, to enable it to be put into position on the beater shaft.

Testing Procedures

The machine (hammer mill) was tested using dried cassava tubers. 5 kg of dried cassava tubers was fed into the crushing chamber of the machine through the feed hopper. The time used for crushing the sample was recorded. The weight of the crushed sample was taken after crushing. The process was repeated for four samples of weight 5 kg, 5kg, 4.5 kg and 3 kg respectively making five trials. The following parameters (throughput capacity, crushing capacity, crushing efficiency and % losses) were calculated using the equations by Khurmi and Gupta, 2004.

$$C_t = \frac{W_a}{T} \times 100 \quad (1)$$

Where,

C_t = Throughput capacity (kg/hr)

W_a = Weight of material before crushing (kg)

T = Time of crushing (s)

$$C_c = \frac{W_b}{T} \times 100 \quad (2)$$

Where,

C_c = Crushing capacity (kg/hr)

W_b = Weight of material after crushing (kg)

$$C_e = \frac{C_c}{C_t} \times 100 \quad (3)$$

Where,

C_e = Crushing efficiency (%)

$$\% L = \frac{W_a - W_b}{W_a} \times 100 \quad (4)$$

Where,

L = losses

RESULTS AND DISCUSSION



Plate 1: Hammer mill in operation

Plate 1 showed the picture of the fabricated hammer mill in operation. Dry cassava tubers were fed into the hopper and the hammer mill was switched on. The crushing time was noted. This was repeated four times and averages used for determination of throughput capacity, crushing capacity, crushing efficiency and % losses. From the result of the test, the average throughput capacity was found to be 375.50 kg/hr; average crushing capacity was 359.34 kg/hr while crushing efficiency of the machine was found to be 95.62 % (Table 2). The value of crushing efficiency obtained (95.62 %) was similar to that of Nasir (2005) who developed a hammer mill with an efficiency of 96 % compared to Nwaigwe *et al.*, 2012 who obtained a little bit lower efficiency of 82.3 %. It is clear from the crushing capacity and efficiency above that the performance of the machine was satisfactory. The average percentage losses (4.38 %) obtained was due to the sticking of the powdery materials to the wall of the crushing hammer and some strains that did not pass through the screen.

Table 2 Determination of throughput capacity, crushing capacity, crushing efficiency and percentage losses

S/N	Initial wt. of dry cassava tubers (kg)	Final wt. of dry cassava tubers (kg)	Time of crushing (s)	Throughput capacity (kg/hr)	Crushing capacity (kg/hr)	Crushing efficiency (%)	% losses (%)
1	5.0	4.6	43.0	418.60	385.12	92.0	8.0
2	5.0	4.7	58.0	310.34	291.72	94.0	6.0
3	5.0	4.8	60.0	300.00	288.00	96.0	4.0
4	4.5	4.4	35.0	462.86	452.57	97.78	2.22
5	3.0	2.95	28.0	385.71	379.29	98.33	1.67
Mean				375.50	359.34	95.62	4.38

Conclusion and recommendation



The hammer mill machine was fabricated and tested with dry cassava tubers at approximately 12 % to 14 % moisture content. From the performance results, it can be concluded that the hammer has the ability to crush at an average of 95.62 % crushing efficiency and crushing capacity of 359.34 kg/hr. The machine is therefore recommended for small and medium scales cassava processors.

References

- Adesina, B.S. and Bolaji, O.T (2013). Effect of milling machines and sieve sizes on cooked cassava flour quality. *Nigerian Food Journal*, **31(1)**: 115–119.
- Davies, R.M., Olatunji M.O. and Burubai W. (2008). A survey of cassava processing machinery in Oyo State. *World Journal of Agricultural Sciences*, **4(3)**: 337–340.
- FAO (2014). Final 2012 Data, and Preliminary 2013 Data, for five major commodity aggregates.
- Khurmi, R.S. and Gupta, J.K. (2004). Shaft, V-belt and Rope Drives: A Textbook of Machine Design, 13th Ed., S. Chand and Co. Ltd., New Delhi, pp. 456 – 498, 657 – 659.
- Nwaigwe, K.N., Nzediegwu, C. and Ugwuoke, P.E. (2012). Design, construction and performance evaluation of a modified cassava milling machine. *Research Journal of Applied Sciences, Engineering and Technology*, **4(18)**: 3354–3362.
- Shittu, T.A., Awonorin, S.O., Sanni, L.O. and Idowu, M.A. (2002). Dry milling characteristics of dried cassava chips as related to moisture content. *Journal of Applied Science and Technology*, **2(1)**: 13–18.