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# Fabrication and Performance Evaluation of a Pedal Driven Pulverizing and Sieving Machine for Dewatered Grated Cassava

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***ABSTRACT :*** *The traditional method of pulverizing and sieving cassava lump in garri production is very tedious, time consuming, unhygienic and consequently with low efficiency. The need to eliminate drudgery in the traditional method, will involves the mechanization of pulverizing and sieving process. This paper presents the fabrication and performance evaluation of a pedal driven pulverizing and sieving machine for dewatered grated cassava. The machine was designed to be driven like a bicycle, which sends rotary motion to the system. It was made to accept cassava lumps through the hopper to the pulveriser, which rotates at a speed greater than that of the lump, thereby breaking it into smaller particles. The performance of the machine increases with increase in the amount of cassava lump inserted into the machine. The efficiency of the machine shows that as the cassava lump inserted into the machine increases, the efficiency increases from 80% and 83% to 86% and 85% for the TMS 82/00058 and TMS 82/00661 varieties respectively*.

***Keywords*** *-Pedal Driven, Pulverizer, Cassava, Siever, Dewatered Grated Cassava*

## I. INTRODUCTION

Cassava (Manibotesculenta) is a major source of carbohydrates and the cheapest source of calorie in human diet especially regions of Africa, Latin America and Asia. Though Cassava originated from Latin America, Africa is the largest producer of Cassava, with 62% of the total world production. Nigeria is leading the world with 19 % of global market share [1]. The total world cassava utilization is projected to reach 275 million tons by 2020 [2]. Cassava can be used in various ways and each component of cassava plant, from leave to roots can be utilized in one way or another. In some communities, the leaves are consumed as a vegetable, or cooked as a soup ingredient or dried and fed to livestock as a protein feed supplement. The stem is used for cassava propagation and grafting. The roots are the main product of the plant and are typically processed for human consumption and industrial utilization [3].

*Garri* is the dominant product of Cassava and is widely consumed in both rural and urban areas. It can be consumed without any additives, or with variety of additives such as sugar, groundnut, fish, *kuli-kuli* and meat. When prepared in boiled water, it is consumed with soup or stew. It is estimated that more than 65% of the cassava consumed in Nigeria is in the form of *garri* [4]. *Fufu* and *Akpu*, a fermented wet paste from cassava is also widely consumed throughout the country especially in the southern zones [3]. In 2001, it was estimated that 16% of cassava root production was utilized as an industrial raw material in Nigeria. 10% was used as chips in animal feed, 5% was processed into a syrup concentrate for soft drinks and less than 1% was processed into high quality cassava flour used in biscuits and confectionary, dextrin pre-gelled starch for adhesives, starch and hydrolysates for pharmaceuticals and seasonings [5].

To obtain *garri*, Cassava undergoes different stages. These include peeling, washing, grating (mashing), dewatering/fermentation, pulverizing/sieving and frying. The interest of this paper is pulverizing and sieving. Pulverization is the process of breaking the lumps formed during the process of dewatering into smaller pieces before the commencement of sieving operation. Traditionally, pulverizing and sieving are done manually. Sieving is achieved by placing the pulverized lumps on a local mesh, made of raffia or metal and then rubs with hands. The aim of sieving is to eliminate fibrous contaminants and achieve fine granules for easy frying and better *garri* quality. The traditional method of pulverizing and sieving of *garri* production is very tedious, time consuming and have very low output produced.

The need for mechanization led to the fabrication of a cassava lump breaker by Sulaimon and Adigun [6]. Though the performance evaluation of the machine was not performed, they recommended the use of stainless steel instead of mild steel to prevent corrosion and allow hygienic operation. Oyeleke [7] designed, fabricated and carried out performance evaluation of a manually operated cassava sieving machine with locally sourced materials and achieved an overall machine efficiency of 89.6%. Similarly, Orojinmi [8] developed a cassava siever and achieved a machine efficiency and output capacity of 76% and 69.12kg/hr respectively. The above machines performed very well but did not achieve the much desired mechanization of pulverization and sieving as these were done separately, either manually or mechanically, thereby creating a backlogged of work in the manually operated side. To incorporate pulverization and sieving, Odigboh and Ahmed [9] designed and fabricated a prototype machine for pulverizing and sifting *garri* mash. The machine uses an electric motor and can produce up to 125kg/hr. Uthman [10] also designed and fabricated a motorized lump breaking and sieving machine. The machine optimal performance was at a speed of 265rpm. The lumps breaking and sieving gave efficiency of 97% with a throughout capacity of 1.91kg/hr. Another motorized cassava lump breaker and sifting machine was developed by Alabi [11]. He recommends that an outlet provision should be made for unsifted materials. Based on the recommendation by Alabi [11], Kudabo et al. [12] modified the design of Alabi [11] by making provision for the outlet of the unsifted materials and providing cover for the hopper to reduce the amount of spilled cassava lump. They achieved an overall efficiency and output capacity of 93.3% and 136.2 kg/hr respectively. Ikejiofor and Oti [13] carried out the development of a motorised combined cassava mash pulverizer and sifter machine. They obtained overall average machine efficiency for both varieties of cassava to be 86.7%.

Most of the recent development in mechanizing the process of pulverization and sieving requires an electric motor powered by electricity. This source of power is becoming increasingly scarce and expensive in most developing countries. There is therefore the need to have a human driven machine that can be used for pulverization and sieving operation. To achieve this, Okegbile et al. [14] designed a pedal driven pulverizing and sieving machine for dewatered grated cassava. This paper presents the fabrication and performance evaluation of the pedal driven pulverizing and sieving machine for dewatered grated cassava.

## II. METHODS

### 2.1 Materials Selection

The materials used for the design and fabrication of the pedal driven pulverizing and sieving machine were based on availability of materials, ease of fabrication, serviceability, strength, and cost. The key materials used are mild steel and galvanized iron sheet. Due to its ability to resist corrosion, galvanized iron sheet was used to fabricate component such as feed hopper, sieve shaker, discharge outlet and the conveyor. These parts are always in contact with water and cyanide acid. The bicycle body frame and pulveriser are the non-hygroscopic parts of the machine and are fabricated using mild steel. To minimise the effect of corrosion, the mild steel was painted. Mild steel has found application in various other locally fabricated machines in Nigeria such as refrigeration [15-17], water heater [18], hydraulic accumulator [19, 20], groundnut shelling, roasting and oil expelling machines [21-23].

### 2.2 Fabrication

***Hopper***

A galvanized iron sheet was shaped to form a pyramidal frustum with dimension 670 mm x 200 mm. The unit was then fitted above the pulveriser and firmly place-tighten on the frame of 500 x 200 mm of the mild steel angle box. The discharge hopper is a larger sieving channel and smaller rectangular size of dimension 550 x 160 mm and 300 x 120mm respectively.

***Chute, Mainframe, Connecting Rod and Bearing Support***

The mainframe was made of angle iron. The connecting rod and bearing support are made of mild steel materials, while the chute is made of galvanized steel. The chute is 470 x 280 mm and is projected at an angle of 40° to the horizontal to give away for easy sliding of the sieved cassava lump pulverized. The mainframe was rigidly welded together with a dimension of 775 x 550 x 685 mm. The connecting rod which carries the slider cranks metal to give momentarily movement to and fro by transforming a circular motion to reciprocating motion. The bearing support measures 165 x 240 mm and used to give base to the arrangement of pulley and bearing.

***Bicycle***

Is a hollow shaft and made of mild steel to resist tension fragility, sagging and shearing respectively.

***Angular Bar***

A pair of angular bar measuring 840 x 50 mm was used to give support to the bicycle to resist physical factors damages.

***Sprocket, Spikes, Chains and Pedals***

The sprockets are of 4-types with a pair supporting and transmitting torque in two directions and are arranged systematically to give kinematic movement in one plane. The Spikes has a length of 54mm welded firmly to the cylinder such that both make up the pulveriser to allow for sprockets attachment. The Pedals provides an inductive energy for motion. It employs a heavy bused semi-conductor to reduce heat energy and pressure inherent in the process of operating. The Chain is connected via the sprockets and transmits power from input to output sources. For the purpose of this design, roller chain was used.

***Machining of Shaft***

The shaft made of structural mild steel is about 800mm long with diameter of 35mm. The shaft was hold by high-speed chuck on the lathe machine for both the turning and facing operations.

***Pulveriser***

The pulverizing cylinder comprises of the rotating drum and spikes. This arrangement was selected based on the impact force required to break the pods without causing any structural failure on pulverizing cylinder. It is made up of mild steel of diameter 50mm hollow throughout to allow for a shaft of 25mm diameter to be force fitted which bring a length of 700mm for the main frame on the bearing. For this machine, a galvanized pipe was used for drum and baffles were welder at the ends of the pipe which the main shaft passes through.

The Spikes were made of 10mm diameter plate mild steel and 54mm long. The spikes were then welded on to the drum at $90^0$ with a distance of 20mm apart. The Galvanizer pipe is 700mm long, 2mm thick and a diameter of 25mm. It was attached to the bored plate at 20mm and welded. The End plates were circular and of 3mm thick with a hollow centre to allow passage of main shaft and welded on to the pipe both ends.

***The Sieve and Sieve Shaker***

The sieve shaker is a mild steel welded rectangular unit measuring 560 x 445 x 50 mm and assembled together with 2 pairs of 10mm diameter rod. An attachment of the sides to provide guides is done to prevent the sieve shake unit. It is made of mild steel material. The sieve is a rectangular frame of 550 x 390 x 150 mm welded together and incorporated with gauge wires of micro millimetre to allow the desired refine particle of sieve cassava to be obtain.

## III. OPERATION OF THE MACHINE

### 3.1 Description

The machine consists of three units: the pulverizing unit, the sieving mechanism and the bicycle unit. The pulverizing unit includes the feed hopper, discharge hopper and a pulverizer (a cylindrical shaft) where the cassava pulp into smaller particles and discharge it through the discharge hopper onto the sieve. The sieving mechanism is mounted on the main frame and with the chute beneath it for accepting the finer grain of *garri* after sieving. The sieving mechanism consists of a disc which is connected to the rectangular sieve housing for its reciprocating motion. A flywheel is mounted on the other side of the disc to enhance its efficiency. The bicycle unit consists of the power transmitting parts, which when peddled, transmits power through the help of sprocket and chain drive into the system.

### 3.2 Operational Principle

The cassava pulps are feed into the machine through the feed hopper and are reduced to smaller particles with the aid of the pulveriser. Motion is transmitted from the peddling of the bicycle via the chain drive arrangement. The rotating motion of the driven sprocket is changed to reciprocating motion via the connecting rod at the casing of the sieve. The reciprocating motion produces to and fro motion on the sieve box. This enables the grated cassava to vibrate. The vibrational motion forces the fine particles of grated product through the sieve and the finer particles are collected from the chute.

### 3.3 Maintenance Procedure

An important form of preventive maintenance activities is inspection at regular intervals. This has been adapted for this machine to achieve optimum performance. For the effective performance of the reciprocating sieve, the following activities are recommended:

- The chaff of the cassava should be removed after each operation and the sieves properly cleaned.
- Regular lubrication of the crankshaft bearing.
- Regular lubrication of the rollers, the connecting rod bearing.
- Apply protective coats of paints to the frame periodically to prevent corrosion.
- Machine should be properly covered from moist and dust with protective guard during operation and when not in use.
- Regular checking of bolts and nuts for likely loosening before on and after operation.
- Check for chain tension and adjuster regularly.

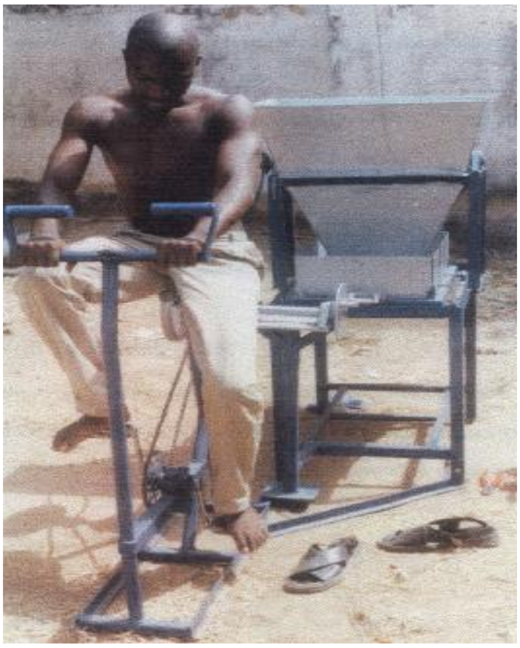

Figure 1. The Pulverizing and Sieving Machine being operated by an operator

## IV. PERFORMANCE EVALUATION

### 4.1 Performance

The performance of the machine was evaluated based on the sieving efficiency of the machine and is defined as:

$$\eta_m = \frac{W_{ps}}{W_l} X100 \quad (1)$$

Where, $\eta_m$ is the efficiency of the machine; $W_{ps}$is the weight of pulverized and sieved lump of cassava (Kg); $W_{fl}$is the weight of the fed lump (Kg).

**4.2 Test Procedure**

Two varieties of Cassava tubers (TMS 82/00058 and TMS 82/00661) were bought from local farmers in Minna, Niger State. The tubers were peeled, washed, grated, fermented and dewatered. 1.5 kg of the dewatered cassava pulps was weighed and poured into the hopper of the machine. As pressure was applied to the pedal by the operator, the pulveriser turns and breaks the cassava lumps into smaller particles. The smaller particles cassava lumps drops into the sieve box. The reciprocating motion produces to and fro motion on the sieve box. This enables the grated cassava to vibrate. The vibrational motion forces the fine particles of grated product through the sieve and the finer particles are collected from the chute. The weight of the finer particles was recorded. Similar procedure was carried out for both varieties of Cassava. The test was repeated for 3.5 kg and 5.5 kg for the two varieties of cassava recorded. The efficiency was calculated using equation (1).

**4.3 Result and Discussions**

The results of the performance evaluation of the locally fabricated pulverizing and sieving machine for dewatered grated Cassava are shown in Figures 2 to 4. Figures 2 and 3 show the weight of Pulverized and Sieved cassava for TMS 82/00058 and TMS 82/00661 varieties respectively. The results show that when 1.5 kg of cassava lump was inserted into the machine, 1.2 and 1.25 kg of pulverized cassava was received for the TMS 82/00058 and TMS 82/00661 varieties respectively. When 5.5 kg of cassava lump was inserted into the machine, 4.75 and 4.65 kg of pulverized cassava was received for the TMS 82/00058 and TMS 82/00661 varieties respectively. The performance of the machine increases with increase in the amount of cassava lump input. Figure 4 shows the comparative efficiency of the machines when using the two varieties of cassava. The efficiencies reveal that as the cassava lump inserted into the machine increases, the efficiency increases from 80% and 83% to 86% and 85% for the TMS 82/00058 and TMS 82/00661 varieties respectively as shown in Figure 4.

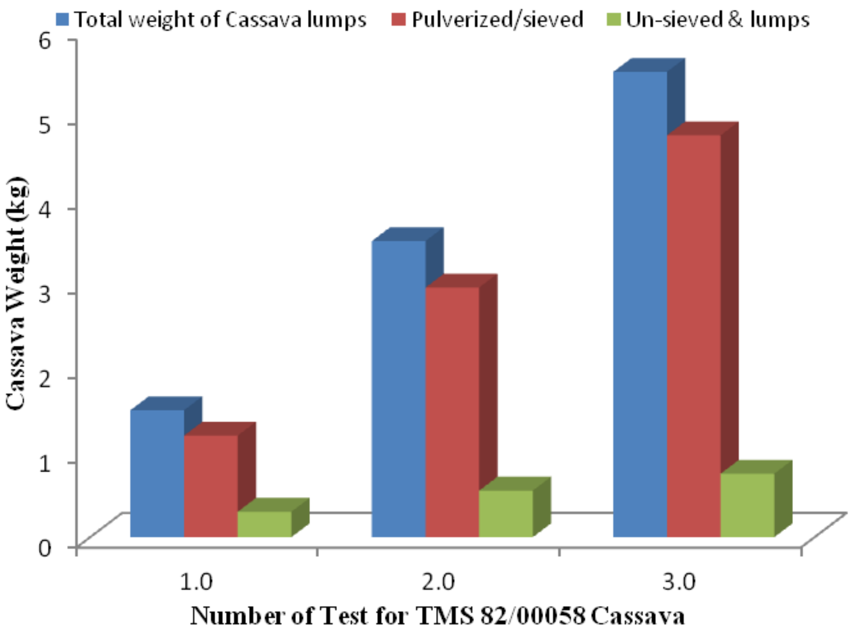


Figure 2. Performance of pulverizing and sieving machine for TMS 82/00 058 Cassava

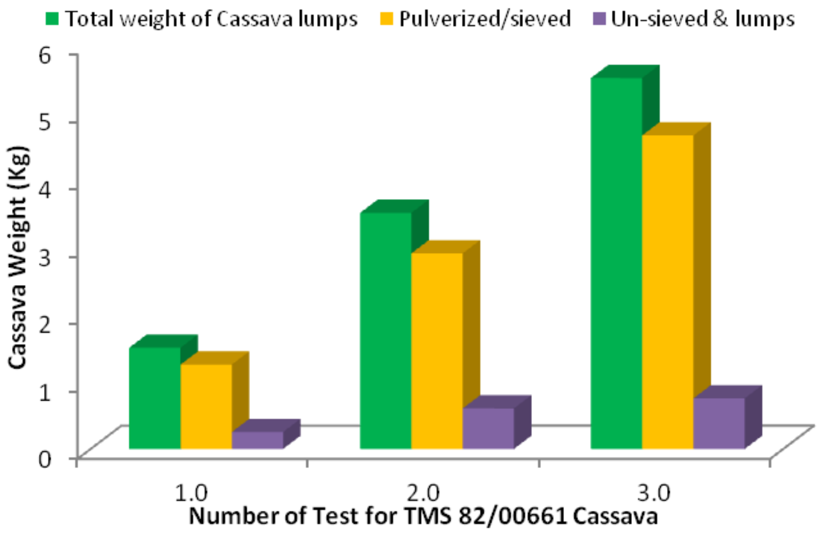


Figure 3. Performance of pulverizing and sieving machine for TMS 82/00661 Cassava

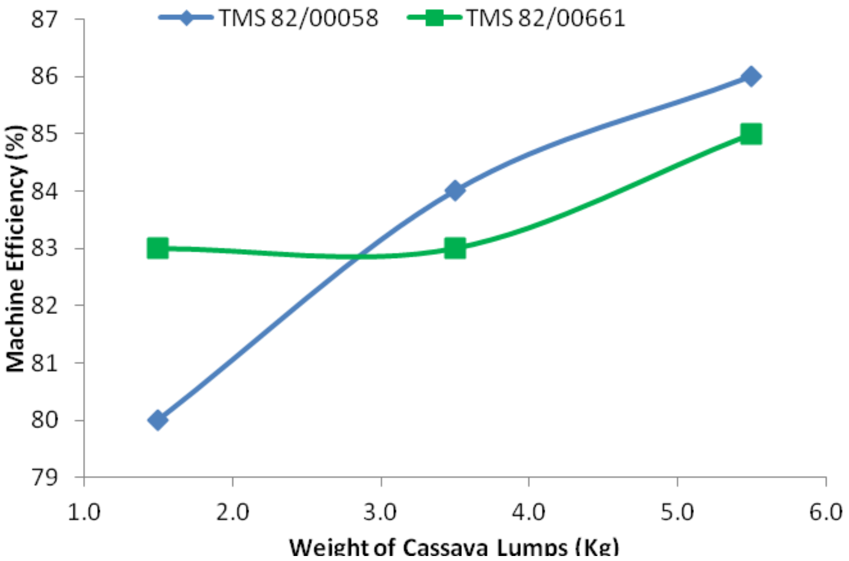


Figure 4. Machine efficiency of two varieties of Cassava

## V. CONCLUSION

The fabrication and performance evaluation of a pedal driven pulverizing and sieving machine for dewatered grated cassava has been presented. The performance of the machine increases with increase in the amount of cassava lump inserted into the machine. The efficiencies show that as the cassava lump inserted into the machine increases, the efficiency increases from 80% and 83% to 86% and 85% for the TMS 82/00058 and TMS 82/00661 varieties respectively. The success of the design and performance evaluation has proved that proper development of farm machinery using local resources is very important and economical. The workability is satisfactory and the efficiency is favourable when compared to the existing locally made designs. The uniqueness of this machine is its ability to be used in rural areas characterised by epileptic power supply. The design can be improved upon and adopted for commercial production nationwide to enhance processing of cassava in rural areas.

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