# Design, Fabrication and Testing of Cassava Chipping Machine

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**Abstract:** A 0.75 m x 1m x 1.07 m (0.8025 $m^3$) capacity cassava chipper was designed, fabricated and tested. The main features of the machine are: the frame and stand; the hopper, the chipping mechanism, the outlet chute; the shaft and bearings, and the power transmission unit. These component parts depending on their functions were made from cast iron, mild and stainless steel and aluminium. The uniqueness of the machine is that, the chipper can be operated using 3.75kW gasoline motor or manually operated by using the handle connected to the shaft. When tested with the 3.75 kW gasoline motor and manually driven, fine chips were produced with an average working capacity of 346 kg/hr and 36.28 kg/hr respectively. The efficiency of the machine was found to be 87.09% when powered with 3.75 kW gasoline motor and 91.83% when manually operated. The estimated cost of the machine is approximated to be N84, 500.00.

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**Key words**: Cassava, chipping machine, capacity, chipping efficiency

## 1. Introduction

Cassava (*Manihot esculenta Crantz*) is one of the cheapest sources of carbohydrate available. It originated from Brazil, it was probably first grown by the Red Indians **(**Msabaha, and Rwenyangira,1990**)**. It is grown extensively in many parts of Nigeria, especially in the rain forest areas and according to FIIRO (2006**),** Nigeria presently ranks as the number one producer of cassava in the world. The plant itself is classified as a perennial semi-shrub. Its high energy, carbohydrate-rich roots can be processed into a wide variety of products from food to industrial starches (FIIRO, 2006).

Cassava tuber is processed to form animal feed and the industrial uses of cassava include the production of starch, adhesives and industrial poison e.t.c. The cassava plant is made up of the roots, leaves and stem that are good source of carbohydrates and protein (Scott et al., 2000). Cassava deteriorates 2-3 days after harvesting mainly because the roots are reproductively inactive, hence the rapid setting in of physiological changes and subsequent rot and decay (Silayo, *et al.*, 2007). Losses of up to 50% in monetary value have been reported (Ndunguru, *et al*., 1999).

Inefficient harvesting and post-harvest handling (Silayo, *et al.*, 2007) can contribute to more quantitative losses. In Nigeria, traditional processing of cassava entails fermentation processes employed for the bitter varieties and non-fermentation processes employed for the sweet cassava varieties to obtain dry products for flour production (Ajisegiri, 2001). In these methods, peeling, size reduction through multiple slicing by hand held knife, and sun drying are involved (Silayo, et al., 2001). These methods are very rudimentary, leading to short shelf life. Improved and appropriate processing and packaging techniques will eliminate these problems (Nweke, *et al*., 1998)**.** Therefore, there is the need to improve the chipping process, improve quality and guide against any wastage of the product (cassava) as a result of improper processing of the product. The production of cassava chips therefore, is the simplest way of obtaining a product, which can be stored and reduce losses (Ajisegiri, 2001).

Size reduction is an important operation in cassava processing. It serves as the basis for effective drying, cooking, and other further processes of cassava (Damardjati and Dimyati, 1990).

### 1.1 Objective of the study

The broad objective of the study is was to design, fabricate and carry out performance evaluation test on chipping machine.

## 2. Materials and Methods

Generally, materials were chosen based on availability, cost and their inherent mechanical properties (Oladeji, 2012). The chipping plate is made of stainless steel because of its ability to resist corrosion and rusting (Redford, 2000). Other parts such as the chipping wheel, pathway and the hopper are made of aluminium. Cast iron in form of angle bar was used for the frame and the stand.

### 2.1 Design Consideration

The design of cassava chipping machine was developed on the following considerations;

i. Since cassava tuber is of various shapes and sizes, the design allows for the use of the largest size of tuber.

ii. The tuber moisture content was assumed to be constant throughout the tuber length thus there is no energy variation during chipping.

iii. Cassava chipping machine was designed to produce chips of length 60 mm, width 15 mm and thickness 2 mm.

iv. The efficiency of the machine was considered

v. The machine was designed to be movable (portability)

vi. The machine was designed for easy operation, maintenance and safety.

vii. Due to the fact that cassava produces a large amount of cyanogenic glycosides, materials that cannot degrade/ corrode easily due to the acidic content in cassava were selected.

**2.2 Description of Cassava Peeling Machine**

The cassava chipping machine consists essentially of the following parts; chipping plate, main frame and hopper. Others are housing and power units. The main frame is made of 50 mm by 50 mm by 4 mm angle iron to obtain a rectangular shape. This unit bears the overall load of the machine because on it are the shaft that carries the pulley which is connected to the 3.75kW petrol or diesel engine through a V-belt, hopper unit that carries the cassava into chips, trays on which peeled cassava tubers are placed, the lever that gives alternative source of power, especially when petrol or diesel are not available. The hopper is made of 1 mm mild steel material fabricated into rectangular form but bevel inner side to allow cassava slip to the mouth of chipping plate. This unit is about 300 mm high for it to allow large quantity of cassava. The chipping plate is made of stainless material that cut in cylindrical shape with a diameter of about 300 mm. The plate is punched and pushed outwards to obtain the sharp cutting edge. The chipping unit housing is equally made of 1mm thick mild steel material to partly cover the chipping plate and to provide an outlet for the discharge of the chips to the container. The pulleys are of two types, apart from the one already attached to the engine. These pulleys are made of cast iron. One is not really a pulley but an attachment that holds the chipping plate and the other is the V-belt pulley which connects to the engine or power. The power unit is made up of 3.75kW two stroke engine that transmits power to the chipping plate through a shaft that carries a V-belt pulley. Another alternative source of energy is the lever, which equally transmits power to the chipping plate to slice the cassava tuber into chips.

**2.3 Principle of Operation**

The machine was designed in such a way as to make its operation simple. When powered with 3.75 kW gasoline motor, the machine is coupled by a V-belt pulley on the shaft and when manually operated, the grating drum is set in revolution using the handle connected to the shaft. The peeled tubers are thoroughly washed before being fed into the machine through the hopper. At the base of this hopper is an inclined flat bar at an angle of $45^0$ to the frame to enable the tubers slide towards the chipping plate under the action of gravitational force.

The power was provided by an engine, which drives the pulley of the chipping machine and thus causes the chipping plate to rotate. Likewise, the lever is used to turn the shaft manually as an alternative source of energy to drive the chipping plate. As the chipping plate rotates, so the sharp cutting edge along the circumference of the plate cuts the cassava tubers into chips and passes through the punched holes in the plate and fall and discharges rightly at the bottom (outlet) of the housing unit into the container.

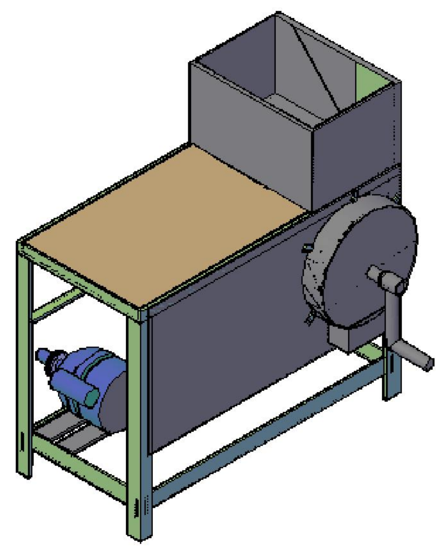

**Plate 1:** Pictorial view of fabricated cassava chipping machine

**3. Performance Test**

Series of tests were conducted using the machine. Cassava tubers were obtained from a farm and peeled manually and thoroughly washed and weighed using weighing balance scale. The machine was operated for some minutes to allow speed to stabilize. Peeled cassava was introduced into it through the hopper. A piece of wood was used to press the cassava against the drum to prevent scattering of the cassava caused by machine vibration. The pulp was collected into a sac and taking to a press for dewatering. The dewatered pulp was weighed and recorded using the weighing balance scale. The pulp was then sieved. The weight of sieved and un-sieved materials was recorded. Capacity and chipping efficiency were evaluated using equations 1 and 2 respectively:-

$$Capacity = \frac{W_1}{t} \quad (1)$$

$$Chipping\ efficiency = \frac{W_2}{W_1} \times \frac{100}{1} \quad (2)$$

Where $W_1$ = Input weight (kg) $W_2$ = Output weight of fine or normal chip (kg) $W_3$ = Output weight of crushed product (kg) $W_4$ = Weight of cassava not processed (kg) t = time (hr)

## 4. Results and Discussion

The results of performance test of the automated chipping machine (3.75kW gasoline engine) and manual chipping machine obtained were presented in Tables 1 and 2.

**Table 1:** Performance of machine during chipping operation of cassava at 65% wet basis using the motorized chipping machine.

| $W_1$ (kg) | $W_2$ (kg) | $W_3$ (kg) | $W_4$ (kg) | Time Sec | Capacity (kg/hr) | Efficiency (%) |
|---|---|---|---|---|---|---|
| 2.40 | 2.250 | 0.100 | 0.050 | 27 | 320.00 | 93.75 |
| 1.85 | 1.450 | 0.300 | 0.100 | 20 | 333.00 | 78.38 |
| 3.60 | 3.250 | 0.220 | 0.130 | 36 | 360.00 | 90.28 |
| 3.20 | 2.750 | 0.340 | 0.110 | 31 | 371.61 | 85.94 |

**Average capacity = 346kg/hr Average efficiency = 87.09 %**

**Table 2:** Performance of machine during chipping operation of cassava at 65% wet basis using the manual chipping machine.

| $W_1$ (kg) | $W_2$ (kg) | $W_3$ (kg) | $W_4$ (kg) | Time (sec) | Capacity (kg/hr) | Efficiency (%) |
|---|---|---|---|---|---|---|
| 0.70 | 0.650 | 0.040 | 0.010 | 71 | 35.49 | 92.86 |
| 0.45 | 0.410 | 0.040 | 0.000 | 43 | 37.67 | 91.11 |
| 0.45 | 0.390 | 0.060 | 0.000 | 43 | 37.67 | 86.67 |
| 0.60 | 0.580 | 0.010 | 0.010 | 63 | 34.29 | 96.67 |

**Average capacity = 36.28kg/hr Average efficiency = 91.83 %**

The chipping operation showed that the chipped cassava increased as the quantity of cassava to be chipped increased. The average chipping efficiencies of chipped cassava tubers for automated and manually chipped cassava are 87.09% and 91.83% respectively (Tables 1 and 2). Further analysis revealed that for automated cassava chipping, an average of 8.69% was crushed, while an average of 3.53% was not chipped. The manually powered chipper had an average of 6.82% crushed and 0.91% un-chipped. The machine has the ability to produce 346kg/hr for the automated operation and 36.28kg/hr for the manual operation. This result compared well to the automated machine produced by Akintunde and Akintunde 2001, with a capacity of 250kg/hr.

## 5. Conclusion

From the results of the chipping operation and performance evaluation test, the following conclusions were drawn:-

The average chipping capacity for automated machine is 346kg/hr, while the corresponding value for manually operated was 36.28kg/hr

The efficiency of automated machine was 87.9 %, while for manually operated type; an efficiency of 91.8 % was obtained.

The machine performed satisfactorily by producing uniform chip of required size which can be used both for human and animal consumption.

The machine can be used where petroleum-based fuel is not available

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