Global Scientific JOURNALS

GSJ: Volume 11, Issue 7, July 2023, Online: ISSN 2320-9186
www.globalscientificjournal.com

DEVELOPMENT OF AN IMPROVED CASSAVA GRATER

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ABSTRACT

Nigeria belongs to one of the agricultural nations. Despite the fact that most populace of the country practice agriculture either as primary or secondary occupation but most of the crop processing operations follow traditional methods. The traditional method of cassava grating is by using hands to rub the cassava against perforated plate. Further improvement in grating operation is by the use of power operated grating machine. This study deals with the design and fabrication of an improved cassava grating machine using locally sourced materials and evaluate to determine the machine output capacity and efficiency. The wedging mechanism incorporated into the design of the machine brings an improvement on the existing machine. The machine consists of a hopper, delivery outlet, wedging, grating and power units. The throughput of the machine ranges between 59.50 and 61.33 kg/hr while the efficiency is between 88.0 and 91.0 %. The outcome of this study tends to reduce time of grating and increase efficient grating operation for small and medium scale farmers.

KeyWords
Cassava, chute, efficiency, grating machine, hopper, machine output, wedging

1. INTRODUCTION

Cassava is one of the major staple food and source of carbohydrate in most developing nations of the world, it can be processed into various forms such as gari, pupuru, lafun and so on. In 2017, Nigeria was the world's largest producer of the crop with a record of 20.4 % of the world total production (FAOSTAT, 2019). Cassava processing thus deserves serious attention in other to meet the local and international demand for cassava products. Peeling and washing are the two operations that are common to all the various forms of cassava processing while other operations such as grating, dewatering, pulverizing, sieving and frying are required for the form which the cassava is to be processed into.

Cassava grating is considered to be a vital unit operation in the process of cassava root into garri and food form. Manual and mechanical types of graters have been designed and fabricated over the years with one short coming or the other. Darlene *et al.*, 2019 carried out a research on a motor – operated cassava grater and the machine was found to have a percentage loss of 8.44 % and fineness modulus of 3.38. Adetunji and Quadri (2011) worked on design and fabrication of a cassava grater. The machine efficiency, safety factor and portability were considered in the research but no value was recorded for the grating efficiency.

Despite the efforts of researchers that carried out their work on cassava grater there is no literature of any machine that has incorporated mechanized wedging mechanism. Therefore, the main objective of this study is to design and fabricate a cassava grater with an incorporated mechanized wedging mechanism.

2. METHODOLOGY

The methodology of this research centered on the components design of the improved grater, materials selection, assembly, and AutoCAD of the machine.

2.1 Description of the Machine Components

The Main Frame: The main frame was constructed with angle iron. The angle irons were welded together to form the frame work.

The Hopper: The hopper is the receptacle through which cassava fed into the machine for grating.

The Grating Unit: This unit consist of the shaft, perforated mesh, rolled sheet, circular discs and rivet pins. The drum formed by the shaft passing through the rolled cylindrical sheet and welded in place by circular discs. The drum wrapped with perforated mesh and attached by riveting.

Motor and Pulley System: A gasoline motor was used to power the machine. A reduction pulley system used to transmit power to the grater's drum at reduced speed and increased torque.

The Discharge Unit: This is a continuation of the grater's frame connected to the hopper. It directed the flow of cassava pulp to a container.

2.2 Operating principle

The machine was designed in such a way as to make its operation simple and motorized. The machine was coupled to a motor by a V- belt pulley on the shaft. Cassava was fed through the hopper into the grating unit, the incorporated mechanized wedging mechanism then operated to wedge the cassava on grater. The pulps collected through the discharge chute into a container.

2.3 Design Calculations

Hopper Design

The Volume of the hopper was obtained as suggested by Ndaliman (2008):

$$V = L \times B \times H \ (m^3) \tag{1}$$

where V is Volume of the hopper, L is hopper's length, B is hopper's breath, and H is hopper's height

The mass of Hopper is given as:

$$M = \rho \times V \ (kg) \tag{2}$$

where ρ is density of material.

Grating drum design

The grating drum is cylindrical in shape. The volume of the cylinder is given in equation 3 as suggested by Bello *et al*., 2020; Ndaliman, 2008.

$$V_c = \pi \times r^2 \times l \ (m^3) \tag{3}$$

where, V_c is volume of cylinder, R is radius of cylinder, and L is length of drum.

The force acting on the cylinder drum is given as:

$$F = V \times \rho \times g \tag{4}$$

where g is acceleration due to gravity.

Pulley Selection

Torque of motor shaft (driving shaft) was obtained as suggested by Aideloje *et al*., 2018:

$$T_m = \frac{P_m}{W_m} \tag{5}$$

where P_m is Motor power, T_m is motor torque, and W_m is angular speed of motor

Angular velocity can be deduced using the motor rating as:

$$W_m = \frac{2\pi N}{60} \quad (6)$$

where N is speed of motor in Rev/min

To prevent a belt drive due to loading from complete slipping, the motor pulley (driving pulley) diameter chosen as suggested by Chernilesk *et al*., 1994; also, the diameter of the cylindrical drum pulley (driven pulley) as given by Chernilesk *et al*., 1994; Hall *et al*., 1982 as given in equation (7):

$$D_2 = \frac{D_1 W_1}{W2} (1 - \varepsilon) \quad (7)$$

where D_2 is diameter of cylindrical drum pulley, D_1 is diameter of the motor pulley, W_1 is angular velocity of driving shaft, W_2 is angular velocity of driven shaft and ε is slipping coefficient

Belt Design

The centre distance was determined by using the formula suggested by Adetunji and Quadri, 2011 as given below:

$$C = \frac{D_1 + D_2}{2} + D_e \quad (8)$$

where D_1 is diameter of driver (mm), D_2 is diameter of driven (mm) and C is centre distance of the two pulley (mm)

Determination of length of belt was suggested by Adetunji and Quadri, 2011 as:

$$L = 2C + \frac{\pi}{2}(D_1 + D_2) + \frac{(D_1 - D_2)^2}{4C} \quad (9)$$

where L = Length of belt (mm), $\pi = 3.124$

Determination of belt contact angle was suggested by Hannah and Stephen, 2004 as:

$$A = 180^0 \pm 2\,\mathrm{Sin}^{-1}\frac{(R_2 - R_1)}{C} \quad (10)$$

where A is angle of wrap of pulley (degree), R_1 is radius of driver pulley (mm) and R_2 is radius of driven pulley (mm)

Shaft Design

Determination of shaft speed. The desired range for the shaft speed (rpm) of the machine was suggested by Hannah and Stephen, 2004; Ojomo and Fawohunre, 2020 as:

$$D_d N_d = D_e N_e \quad (11)$$

where N_d is speed of the driven, rpm, N_e is speed of the driver, rpm, D_d is diameter of the driven (mm) and D_e is the diameter of the driver (mm).

The determination of shaft diameter was suggested by Khumi and Gupta (2006).

$$d^3 = \frac{16n}{\pi Ss}\sqrt{(Kb \times CBM)^2 + (Kt \times CTM)^2} \quad (12)$$

where d is diameter of shaft (mm), π *is Constant* (3.142), CBM is combine bending moment, CTM is combine torsional moment, Ss is allowable stress, n is factor of safety, Kb is combined shock and fatigue factor applied to bending moment and Kt is combined shock and fatigue factor applied to torsional moment.

Power Requirement

The power required to turn the shafts of the machine on the maximum applicable load and speed for effective grinding was given by Hall *et al*., 1982 as:

$$p = w^2 \times r \quad (13)$$

$$\omega = \frac{2\pi N}{60} \quad (14)$$

where ω is speed in radian, N is maximum rpm, r is radius of grating unit and p is power requirement

Grating efficiency

The grating efficiency parameter was calculated using equation 15 as suggested by Bello *et al*, 2020.

$$\eta_g = \frac{W_1}{W_2} \times 100\% \tag{15}$$

where, W_1 is weight of cassava recovered and W_2 is the weight of cassava fed into the grater

2.4 Performance evaluation

The evaluation of the machine was carried out in five runs using 10 Kg measured of cassava for each run. The quantity of cassava fed into the machine and quantity recovered were determined through a weigh balance. The time taken for each operation was also recorded. The performance of the machine was determined using the following parameters: Output capacity, grating efficiency and percentage loss as suggested by Bello *et al*., 2020; Aideloje *et al*., 2018.

$$\eta_g = \frac{W_r}{W_f} \times 100 \tag{16}$$

$$C_g = \frac{W_f}{T} \tag{17}$$

$$P_l = \frac{W_f - W_r}{W_f} \times 100 \tag{18}$$

where η_g is grating efficiency (%), C_g is grating capacity (kg/hr), P_l is percentage loss (%), W_r is total weight recovered (kg), W_f is total weight fed in (kg) and T is time taken (s).

3.0 RESULTS AND DISCUSSION

The picture and component drawings of the fabricated improved cassava grating machine are presented **in plate 1 and figure 1** respectively while the parameters and performance studies carried out on the machine are presented in **tables 1 and 2** respectively. Grating efficiency of the machine ranges between 88 and 91 % while the output is between 59.50 and 61.33 kg/hr. The percentage loss and the time of grating for each operation are different despite the fact that the same quantity of cassava were used.

Plate 1: The picture of the fabricated cassava grater

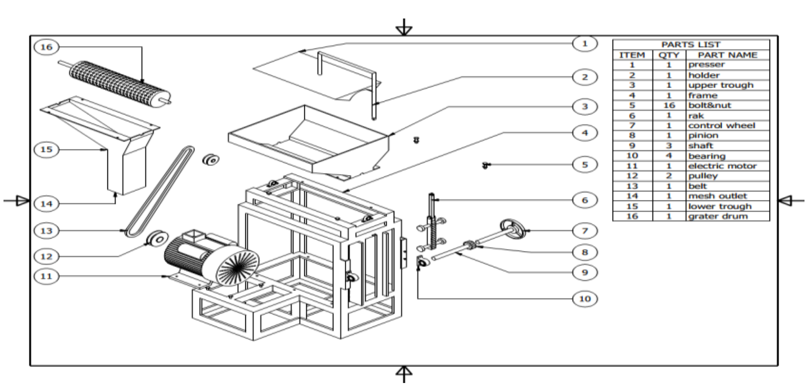

Figure 1: The components drawing of the cassava grater

Table 1: Parameters and specification of the cassava grating machine

S/N	Parameters	Symbols	Value
1	Hopper volume	V	7.5×10^{-5} m^3
2	Overall height	H	1.13×10^{-1} m
3	Power Calculated	Pc	12.2 HP
4	Power of the motor	P	13.0 HP
5	Diameter of the motor pulley	Øm	7.2×10^{-2} m
6	Diameter of the grater pulley	Øg	1.72×10^{-1} m

Table 2: The process and performance studies on the cassava grating machine

No of operation	Weight of Cassava fed (Kg)	Weight of Cassava recovered (Kg)	Time taken (sec)	Percentage loss (%)	Machine Output (Kg/hr)	Grating efficiency (%)
1	10	8.8	605	12	59.50	88
2	10	9.1	596	9	60.40	91
3	10	8.6	599	14	60.10	86
4	10	8.7	587	13	61.33	87
5	10	9.0	592	10	60.81	90

4.0 CONCLUSION

It can be concluded from the results of this research that, an improved cassava grating machine was designed and locally fabricated. The incorporation of the wedge mechanism made the machine to be highly efficient with an average machine output of 60.43 kg/hr, simple to operate and affordable due to the fact that the components are made from locally sourced materials. The grater can be used by small and medium scale cassava processors.

Acknowledgment

The authors wish to thank Tertiary Education Trust Fund (TETFund) for given fund for this research through the Centre for Research and Development, Rufus Giwa Polytechnic, Owo, Nigeria.

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