Development of a Gari Pulverizing and Sieving Machine

Olutayo, L.A; Mogaji, K.O; Fasoyin, S.A.
Department of Agricultural and Bio-Environmental Engineering Technology
Rufus Giwa Polytechnic, Owo, Ondo-State, Nigeria

Abstract
The pulverization and sieving of cassava lumps during gari production are predominantly carried out manually. This conventional method is characterized by high labour requirements, considerable time consumption, unhygienic and characterized by low operational efficiency resulting in reduced productivity and inconsistent product quality. These limitations underscore the need for the development of mechanized pulverizing and sieving system to enhance processing efficiency, improved product quality, and ensure hygiene during gari production. This research aimed at the development of a gari pulverizing and sieving machine which transforms the circular motion of the electric motor into the reciprocating motion of the sieving unit using slider crank mechanism. The machine is designed to receive cassava lumps through the hopper and directed to the pulverizer, which rotates at a speed sufficient to crush the lumps into smaller particles. The smaller particles pass through the screen opening due to vibration and gravity while the large particles remain on the screen and are discharged separately. The performance evaluation of a newly developed gari pulverizing and sieving machine was done using three machine speeds 550 rpm, 650 rpm and 750 rpm on a cassava variety TMS 30395. The machine had a better performance when compared both in capacity and efficiency at 650 rpm across the three speeds tested. The capacity of the machine was 106.01 kg/h for 550 rpm, 155.66 kg/h for 650 rpm and 135.98 kg/h for 750 rpm. Also, the efficiency of the machine increases by 82% for 550 rpm, 93% for 650 rpm and 84% for 750 rpm respectively. The electrically powered pulverizing and sieving machine performed better in capacity, efficiency and time saving when compared to the manual or bicycle type of the machine. Based on its performance, the machine is recommended for small-and -medium-scale processing operations of gari and other cassava products.

Key words: Development, Gari, Machine, Pulverizing, Sieving

1.0 Introduction

Cassava is a tuberous root plant, due to its high amount of starch content. It is typically processed into edible forms before being consumed (Okoko *et al*., 2019). It is a plant that possesses a natural ability to adapt to and grow under a wide range of environmental conditions (Burns *et al*., 2010). The root of the plant from which *gari* and other cassava products is produced, provides valuable nutrients, including dietary fiber, copper and magnesium (Ovat and Odey, 2018).Cassava ranks among the most extensively cultivated food plants in southern and eastern Nigeria. Nevertheless, the harvested roots required adequate processing from their raw state into various edible products before they are suitable for consumption, which can serve as food and nutrients for both human and animal such as *gari*, *fufu*, and cassava flour etc Olutayo *et al.*, (2025).Cassava is highly valued for its ability to thrive in marginal soils and tolerate prolonged period of drought, making its dependable food security and cash

ISSN:2584-2706 DOI: https://doi.org/10.67317/IJMSRT26JUL090

crop for millions of farmers. Nigeria remains the world's largest producer of cassava, with an annual production of approximately 60-63 million tonnes harvested from about 9-10 million hectares of cultivated land (Agbetoye, 2005). The crop is propagated vegetatively using health stem cutting measuring 20-30 cm in length. A planting spacing of 1.0 × 1.0 m is commonly adopted, although spacing may vary up to 1.5 m depending on the cropping system and production objectives. Cassava is intercropped with other crop such as maize, beans to maximize land use and improve farm productivity (Adetunji and Quadri, 2011). In recent years, an increasing proportion of cassava 60% has been utilized as an industrial raw material for the production of starch, flour, ethanol and animal feed and the remainder is processed into traditional food products such as gari, fufu, and tapioca for household consumption as reported by Olutayo and Agbetoye (2022). Among root and tuber plants, cassava is the most perishable, often undergoing rapid deterioration within two to three days after harvest. In the words of Lasisi *et al*., (2019) "the major limitation of cassava is its rapid post-harvest deterioration which often begins within 24 hours after harvest". Furthermore, according to Kolawole (2012) labour is becoming more expensive for the processing of cassava tuber which involves peeling, washing, grating, dewatering, pulverizing, sieving and frying/drying. These processes are still being done in the same old way. Traditional tools were the options available, and the result of using this usually leads to low productivity, poor labour efficiency and high post–harvest losses. The end product sometimes may not be hygienic.

1.1.Existing Gari Sieving Method and Machine

1.2Traditional Sieving

Cassava mash consists of agglomerated starch particles that form compact lumps after dewatering. Sieving is therefore an essential operation, as it breaks down these lumps into fine particles that pass through the sieve openings (undersize) while separating coarse, undesirable particles (oversize), which are discarded after each sieving batch Maclar, (2021). Traditionally, this operation is carried out manually using raffia sieve. In most cases, local craftsmen fabricate these sieves and determine the sieve aperture size arbitrarily or by experience, without considering the effects of aperture size on sieving efficiency, processing speed, product quality, or operator comfort.

1.3. Improved Traditional Sieving Method

Although improvements have been made to the traditional sieving technology, these have largely been limited to the materials used in sieve construction. while traditional sieves woven from raffia palm remain in use, improved versions fabricated from synthetic materials, metal mesh, and aluminum types are now widely available. These modern sieves offer greater durability, improved hygiene, and longer service life than their traditional counterparts.

1.4. Mechanical Gari Sieving

Extensive research has been undertaken to develop *gari* sieving machines capable of meeting the increasing local and international demand for cassava products. Consequently, several prototypes have been developed, exhibiting varying degrees of operational efficiency and product quality performance. Ovat and Odey (2018) developed a motorized gari sieving machine comprising a main frame, hopper, lump breaker, sieving chamber, and an electric motor. The machine achieved a sieving efficiency of 78%, demonstrating its effectiveness in improving the gari sieving process. Suleiman and Adigun (2008) developed a cassava lump breaker using locally sourced material. Although, the machine successfully fabricated, its performance was not comprehensively evaluated with respect to operational efficiency and processing capacity. The authors recommended the use of stainless steel in subsequent designs to improve corrosion resistance, enhance durability, and promote hygiene operation. Samaila, *et al*., (2010), developed a cassava sifter powered by a 3.41kW petrol engine. The machine, with overall dimensions of 1117 mm × 1045 mm × 500 mm, comprises a rotating shaft fitted with alternating rods, brushes, and spikes for effective pulverization of cassava mash lumps before sieving. The performance evaluation indicated a sifting efficiency of 90% at a sifting speed 450 rpm, an input capacity of 132.78kg/h, and a cassava mash moisture content of 40%. Abubakar *et al.,* (2015) fabricated a pedal driven pulverizing and sieving machine, the components of the machine are: Chute, Mainframe, Connecting Rod and bearing support, bicycle, sprocket, spikes, chains and pedal and pulveriser, the sieving efficiency of the machine was 83%. Jackson and Oladipo (2013) evaluated the performance of a dewatered cassava mash separator at operating speeds of 400, 500, 600, and 650 rpm using a 15kg dewatered cassava mash sample. The time required to complete the sieving operation at each speed was recorded. The machine achieved its highest sieving efficiency of 85.5% at 500 rpm, with an output of 12o kg/h, while the lowest efficiency of 65.5% was obtained at 650 rpm, indicating that excessive operating speed adversely affected sieving performance.

In the light of these challenges, a newly developed *gari* pulverizing and sieving machine was subjected to performance evaluation in the Department of Agricultural and Bio-Environmental Engineering Technology, Rufus Giwa Polytechnic, Owo, Ondo-State, Nigeria.

2.0.Materials and Methods

2.1Design Considerations

Some of the factors considered during the designing of *Gari* Pulverizing and Sieving machine were:

i. Crop properties such as surface texture, moisture content, bulk density were taken into account to ensure efficient pulverization and effective separation of the fine particles from the coarse particles during sieving process.
ii. The selection of construction materials was based on machine design requirements, including rigidity, resistance to deflection, wear and corrosion resistance, vibration control, and structural stability.
iii. The materials used for the machine were source locally for possible replacement of damaged components.
iv. Provision of two chutes for the discharged of fine and coarse particles.

2.2Design Analysis

i. **Hopper**: The machine was designed to achieved a targeted throughput of 160 kg/hr. Accordingly, pyramid shape hopper was selected with top opening of 250mm × 250mm, bottom opening 230mm × 230mm and side length of 150mm that is inclined at 45^0 to the horizontal to promote the smooth and continuous flow of materials into the sieving unit.
ii. **Pulley and belt drive**: The machine is pulley- driven, with power transmitted through a V-belt and pulley arrangement. The pulverizing and sieving mechanisms are driven via this system, while the nibbler shaft driven directly by 2.0kW electric motor.
iii. **Power requirement**: The power requirement of the machine was calculated using the equation (1) as proposed by Kurmi and Gulta (2019).

$$P = \frac{2\pi n T}{60} \qquad (1)$$

Where, P =Power in Watt, n = shaft speed, (rpm), T = torque required to turn the shaft circumference of the driven pulley (Nm). Power required to drive the shaft = 1.85kW. Assuming, 10% power loss due to friction, total power required = 2.04kW. Therefore, 2.20kW (3hP) was selected.

iv. **Belt speed,** is given by

$$S = \pi nd \text{ ---}(2)$$

Where, d = diameter of the driven pulley, (m) and n = speed of the driver pulley(rpm). Calculated belt speed, S= 4.2m/s

The sieving shaft took its drive from nibbler shaft; thus, the pulley size was determined using the expression:

$$D/d_2 = (n_2/n_1)\,\eta \text{ --}(3)$$

Where, D = diameter of the driver (nibbler) pulley, d_2 = diameter of driven (sieve) pulley, n_1 = speed of the driver pulley, n_2 = speed of driver pulley and η = assumed efficiency of the drive = 0.98, calculated pulley diameter = 174mm, selected pulley diameter = 180mm.

v. **Shaft selection:** The shafts diameters were calculated using the ASME design equation for solid transmission shafts under combined bending and torsional as recommended by (Hall *et al.*, 1980)

$$d^3 = 16/\pi\, Ss\, [(K_b M_b)^2 + (K_t M_t)^2]^{1/2} \text{ ------------------------------}(4)$$

where, d = diameter of the shaft, (m), M_b = Maximum bending moment, (Nm), M_t = Maximum torsional moment, (Nm), K_b = combine shock and fatigue factor applied to bending = 1.5, K_t = combine shock and fatigue factor applied to torsional moment = 1.0,

Ss = Ultimate stress. Calculated pulveriser diameter = 28.7mm and Sieve diameter = 27.5mm. therefore, shaft diameter 30mm was selected for both shafts.

Sieve selection: A 1mm sieve size was selected to obtain fine grain particle

2.3.Description of the Gari Pulverizing and Sieving Machine

ISSN:2584-2706 DOI: https://doi.org/10.67317/IJMSRT26JUL090

The machine Gari Pulverizing and Sieving Machine (Plate 2) consists of five units:(the pulverizing unit, sieving unit, frame, power and transmission unit and the discharged units). The pulverizing unit includes the feed hopper and the rotating spikes, the sieving unit includes the inclined sieve tray, the frame give support to the machine, the electric motor been the source of power, transmitted rotary motion through the pulley and belt to the crank which converted it to reciprocatory motion of the to and fro movement of the sieve, and the two discharge outlets, where the fine particles and the coarse particles discharged respectively.

Plate 2: Gari Pulverizing and Sieving Machine

2.4.Operational Principle of the Gari Pulverizing and Sieving Machine

The machine (Plate 2) was designed to operate on reciprocatory motion to the system. The machine is designed to receive cassava lumps through the hopper and directed to the pulverizer, which rotates at a speed sufficient to crush the lumps into smaller particles. The smaller particles pass through the screen opening due to vibration and gravity while the large particles remain on the screen and are discharged separately. This causes the smaller particles of dewatered cassava lump to move on forward and backward direction. The smaller particles pass through the screen opening due to vibration and gravity while the large particles remain on the screen and are discharged separately. The machine’s performance increased with an increase in the quantity of material fed into it.

2.5.Performance Evaluation

2.5.1Experimental Design

Table 1 showed the experimental design of the experiment

Table 1: Experimental design

Variables	**Level**	
Cassava Variety	TMS 30395	**1level**
	550, 650, 750 Rpm	**3 Levels**

2.5.2 Experimental Procedure

ISSN:2584-2706 DOI: https://doi.org/10.67317/IJMSRT26JUL090

The experiments were carried out on a cassava variety TMS 30395 based on their proven quality. A single sample was used for each test while the machine speed was varied over the selected range of operating speeds of 550, 650, 750 rpm at 100 rpm interval as recommended Ovat and Odey (2018). A sample was weighed before pulverizes and sieved at constant optimum moisture content of 14% wet basis. A 10 kg sample was initially used to stabilize the machine before performance evaluation. Thereafter, 10 kg experimental samples were fed into the machine at the selected operating speeds. Each test was replicated three times, and the mean output was recorded using Tabletop Scale (Plate 3). The mean output (fine particles) Plate 4 in kg and operation time in minutes were recorded. The data were used to determine the parameters on capacity and efficiency of the machine.

1. **Machine Capacity (Mc):** Machine capacity is the quantity of material processed per unit time

$$MC = \frac{M}{T} \quad \text{--}(1)$$

Where, MC = Machine capacity (kg/h), M= Mass of gari processed (kg). T= Processed time (h)

2. **Throughput (Tp)**: Throughput is the actual amount of finished product obtained per uniy time.

$$Tp = \frac{Mo}{T} \quad \text{--}(2)$$

Where, Tp = Throughput (kg/h)
Mo = Mass of Pulverized and sieved gari collected at the outlet (kg)
T = Processing time (h)

3. **Machine Efficiency (ɳ)**: Machine efficiency is the percentage of input material successfully processed into desired output

$$ɳ = \frac{Mo}{Mi} \times 100 \quad \text{---}(3)$$

Where, ɳ = Machine Efficiency, Mo = Mass of acceptable pulverized and sieved obtained (kg), Mi = Total mass of gari fed into the machine (kg)

Plate 3: Sample on a Tabletop Scale Plate 4: Sieved Gari

3.0 Results and Discussion

3.1 Effect of Machine Speed on Output

The quantity of gari fine particles discharged from the machine increased with increasing machine speed up to 650 rpm after which no further improvement was observed. The highest output obtained from 650 rpm, indicating this as the optimum operation speeds among the three speeds tested. The machine produced outputs of 7.5 kg, 9.3 kg and 8.2 kg at operating speeds of 550. 650 and 750 rpm respectively, as presented in Figure 3. These results are consistent with the findings of Darlene *et al*.

(2019) and Olutayo and Agbetoye (2022) that the output of the machine increased between 550 – 750 rpm machine operating speeds.

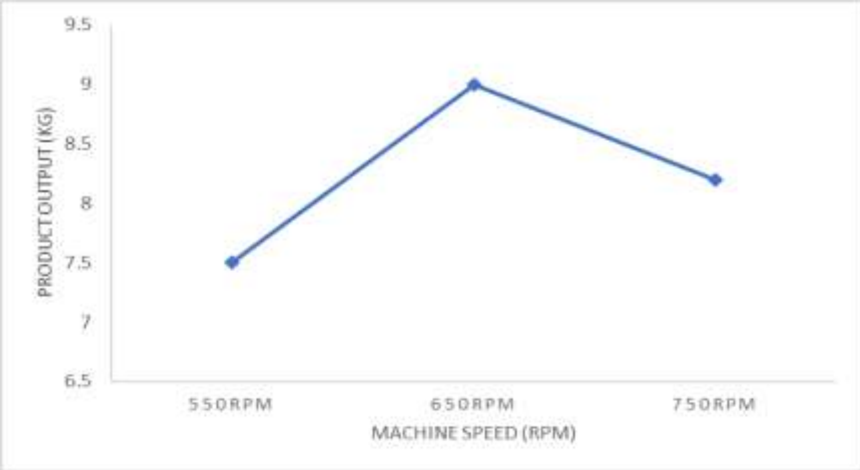

Fig. 3: Effect of Machine Speed on Output

3.2.Effect of Machine Speed on Capacity

The capacity of the machine increased on the three operating speeds tested (Figure 4). The capacity of the machine ranged between 106.03 kg/h, 155.66 kg/h and 135.98 kg/h For 550 rpm, for 550, 650 and 750 rpm respectively. However, the highest capacity of 155.66 kg/h was recorded at 650 rpm. The results presented in Figure 4 showed that, the capacity increased as the input and speed increased across the three speeds.

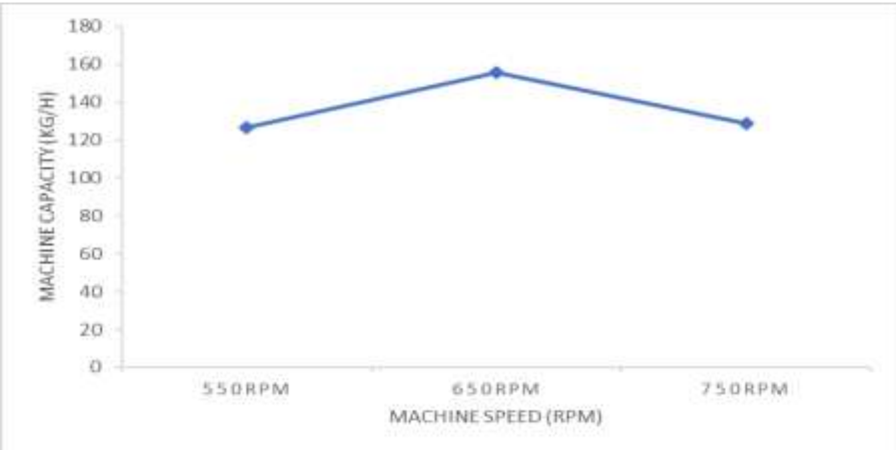

Fig. 4: Effect of Machine Speed on Capacity

3.3. Effect of Machine Speed on Efficiency

The sieving efficiency of the machine increased on the three speeds tested (Figure 5). The capacity of the machine ranged between 80%, 93% and 82% for 550, 650 and 750 rpm respectively. However, the highest efficiency of 93% was recorded at 650 rpm. Ovat and Odey (2018) also had similar observation.

ISSN:2584-2706 DOI: https://doi.org/10.67317/IJMSRT26JUL090

Fig. 5: Effect of Machine Speed on Efficiency

4.0.CONCLUSION

Gari Pulverizing and Sieving machine was designed, fabricated, and the performance evaluation was carried out using three machine speeds 550 rpm, 650 rpm and 750 rpm against TMS 30395 cassava varieties. The machine had a better performance when compared both in capacity and efficiency at 650 rpm across the three speeds tested. The capacity of the machine was 106.01 kg/h for 550 rpm, 155.66 kg/h for 650 rpm and 135.98 kg/h for 750 rpm. Also, the efficiency of the machine increases 82% for 550 rpm, 93% for 650 rpm and 84% for 750 rpm. The electrically powered pulverizing and sieving machine performed better in capacity, efficiency and time saving when compared to the manual or bicycle type of the machine.

References

Abubakar M, Abdulkadir B. H., Katsina C. B., Abdulkarim N., Olawale J. O., and Dele S. Jimoh (2015). Fabrication and Performance Evaluation of a Pedal Driven Pulverizing and Sieving Machine for Dewatered Grated Cassava. *American Journal of Engineering Research (AJER)* e-ISSN: 2320-0847 p-ISSN: 2320-0936. Volume-4, Issue-2, pp-146- 152. www.ajer.org

Adetunji, O. A. and Quadri, S. A. (2011). Design and Fabrication of an Improved Cassava \Grater. *The Pacific Journal of Science and Technology*. 12(2), 120-128

Agbetoye, L. A. S (2005). Improving the Technology of Cassava Harvesting and ProcessingMechanization for Food Security in Nigeria. *Proceedings of the International Conference on Science and Technology*. Federal University of Technology, Akure, Nigeria, 196 – 205.

Burns, A., Gleadow R, Cliff J, Zacarias A and Cavagnaro T (2010). Cassava: the drought, war and Famine Crop in a changing world sustainability, 2(11), 3572- 3607.

Daniel, M. M. (2021). Design and Construction of Gari Sieving Machine. *Academic Scholarly Journal of Researchers* | Published by Academic Scholarly & Scientific Research Society https://damaacademia.com/dasj r/ Feb 2021 Pages: 04-22 Volume 6 | Issue

Darlene, U. E., Guillermo, P. P., Michelle O. S. and Jane S. M. (2019). Design, Fabrication and Performance Evaluation of Motor-Operated Cassava Grater. *Mindanao Journal of Science and Technology. 17, 227-241*

Doydora, K.J, Bodod, R.J, Lira, J.A and Zamoramos, M.B (2017). Design, fabrication and Performance Evaluation of Electric Motor Driven Cassava (*Manihot esculenta*) Grater with Juice extractor. *Philippine Journal of Agricultural Economics*. 1(1), 17-28.

Hall, A.S, Holowenko, A.R and Laughlin, H.G. (1980). Theory and problems of Machine Design S.I Metric Edition. McGraw-Hill Book Company, New York Pp.115

Jackson, B. and Oladipo, A. (2013). Evaluating Sifting Efficiency of a Dewatered Cassava Mash Sifter at Different Operating Speed. Afr. J. Agric Res, 8(23):2819-2824.

Kier D. Gumanit and Jesal O.Pugahan (2015). Design Fabrication and Performance Evaluation of an Automated Combined Cassava Peeler; Grater and Presser for small scale processing Unpublished M. Sc thesis, Faculty of Engineering Science, College of Engineering and Information Technology, Caraga State University, Ampayon, Butuan city.

Kolawole, O. P (2012), Development and Performance Evaluation of Cassava Mash Process Handling Machine, Ph.D. Thesis Agricultural Engineering Department, FUTA, Nigeria.

Kurmi, R.S. and Gulpta, J.K. (2019). A Text Book of Machine Design. 15th Edition Schand and Company Ltd. New Delhi. Indian

Lasisi, D., Adewumi, B.A., Dairo. O.U and Awonorin, S.O. (2019). Optimization of Cassava Mash Sifting using Response Surface Methodology. *Proceedings of the NigerianInstitution of Agricultural Engineers* (NIAE).40 the Annual and 20th International Conference. 16th- 20th Sept.,2019. Pp 1152-1163.Omu -Aran, Kwara-State, Nigeria.

Maclar, D. M. (2021). Design and Construction of Gari Sieving Machine. Dama Academic Scholarly *Journal of Researchers* | Published by: Dama Academic Scholarly & Scientific Research Society Pp: 04-22 Volume 6 | Issue

Sulaiman M.A. and Adigun R.A, (2008). Fabrication of Cassava Lump Breaker. Unpublished project report submitted to the Department of Mechanical Engineering Kwara State Polytechnic Ilorin.

Samaila, S. R., Ogunjirin, O. A. and Olowonibi, M. M. (2010). Development and Performance Evaluation of Motorized Cassava Mash Sifter. *Journal of Agricultural Engineering and Technology (JAET),* Vol. 18 (No. 2), Pp.46-54.

Olutayo, L. A.; Ologunagba, F. O.; and Mogaji, K.O. (2025). Design and Fabrication of a Cassava Processing Handling Machines. *International Journal of Innovative Science and Research Technology*. Volume 10, Issue 8, ISSN No: -2456-2165.

Olutayo, L.A and Agbetoye, L.A.S. (2022). Performance Evaluation of Grating and Dewatering Machine, *International Journal of Computational Engineering Research (IJCER).* ISSN(e): 2250-3005, Vol. 12. www.ijceronline.com

Okoko Joseph; Akindele Alonge; and Patrick Ngoddy (2019). High Quality-Cassava Flour (HQCF) Composites: Their characteristics in retrospect, *Proceedings of the Nigerian Institution of Agricultural Engineers* (NIAE). 40th Annual and 20th International Conference. 16th - 20th Sept. 2019.Pp 1102-1111, Omu -Aran, Kwara State, Nigeria.

Ovat, F. A., and Odey, S. O. (2018). Development and Performance Evaluation of a Motorized Gari Sieving Machine. *European Journal of Advances in Engineering and Technology*, 2018, 5(7), 459-465

Uthman, F. (2011). Design and Fabrication of Cassava Lump Breaking and Sieving Machine, *Oasis Journal of Research and Development*, Vol 1 No 2):42-50.