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# Design and Fabrication of a Cassava Processig Handling Machines

Dr. Olutayo, Lewis A.[1]; Ologunagba, F. O.[2]; Mogaji, K. O.[3]

[1,2,3]Department of Agricultural and Bio-Environmental Engineering Technology, Rufus Giwa Polytechnic, Owo, Ondo-State, Nigeria.

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**Abstract: Cassava processing handling machines that involves cassava grating and cassava mash dewatering machines was designed, fabricated and tested. The machines which are easy to operate and maintain has the following components: hopper, grating chamber, discharged outlets, transmission system, power unit and the frame for the cassava grater, and the cassava mash dewatering machine has the hydraulic screw jack, the rigid frame, compression spring and the dewatering chamber. The cassava grater was powered by 2.0 kW, single phase, 1640 rpm electric motor. The grater speeds varied are 1550 rpm, 1450 rpm and 1350 rpm and the results from the performance evaluation of the grating machine showed a higher capacity, improved efficiency and best performance was obtained at 1450 rpm grater speed of grating capacity of 250.45kg/h, throughput of 235.5 kg/h and efficiency of 96.8 %. Also, the dewatering machine has capacity of 400 kg/h and dewatering efficiency of 97.4%. it is therefore, recommended for the producers of garri and cassava products.**

***Keywords:*** *Design, Fabrication, Cassava, Processing Handling, Machine.*

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## I. INTRODUCTION

Cassava (Manihot esculenta crantz) Is a popular crop worldwide belonging to the family Euphorbiaceae. It is a tuberous root crop grown mainly on the tropical regions of the world such as Latin America, Sub-Sahara Africa and Asia (Ovat and odey, 2018). The ability to thrive in marginal soils and its drought tolerance have been widely acknowledged making it a reliable crop for many farmers. Specifically, Nigeria has been a world leading producer of cassava with an estimated annual production of 2.6 million tonnes from an estimated area of 1% million hectares of land (Agbetoye, 2005). Cassava is propagated by 20-30cm long cutting of the stem, spacing between plants is usually 1-1.5 meters and it is usually intercropped with beans, maize and other annual crops (Adetunji and Quadri, 2011).

Cassava can be used in various ways and each component of cassava plant from the leave to the root can be utilized in one way or the other. Cassava tubers can be processed into varieties of food for man. It is one of the most valuable staple food sources for about 500 million people around the world and tens of millions of people in the West African sub-region Adejumo *et al*., (2011). It is also fast becoming a foreign exchange earner as an industrial raw material in the production of starch, animal feed, concentrate for drinks, adhesives, confectionaries, seasonings, biofuels and hydrolysates for pharmaceuticals (Philip *et al*., 2004). However, harvested cassava tubers are highly perishable and may deteriorate within two to three days after harvesting (Adzimah and Gbadam, 2009), thus the need for it to be processed immediately after harvest. Cassava processing therefore deserves more attention in order to meet the local and international demand for its product.

Proper processing and preservation of harvested produce reduce post-harvest losses and thus help to conserve food supply. Mechanization of cassava processing operations had played significant role in promoting timely processing of large quantity of cassava tubers before they get spoilt. Some of the various machines required for processing cassava tubers into different products are; peeling machine for cassava peeling, washing machine for tuber cleaning, grater for depulping, racks and sacks for fermentation, press for dewatering, sifter for sieving, frying machine for roasting and dryers for drying.

Along this line, a number of machines have been designed and developed to replace the traditional ones as reported by Ale *et al*. (2016). However, some of these machines are not always adoptable by local farmers due to high cost of the machine, lack of operating skills, non-availability of machine parts and some other constraints relating to the capacity and efficiency of machine. Most critical are the machines for grating and dewatering which have not sufficiently satisfied the small- and medium-scale processors.

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In light of this, very simple, easy to operate, high throughput, highly efficient and economically affordable cassava processing handling machine that have grating and dewatering machines was designed and fabricated with locally available materials so as to improve on the mechanization of cassava processing through a streamlined workflow.

## II. REVIEW OF RELATED WORK

➢ *Overview of Cassava Grating Machine*

Traditionally, cassava roots are converted into a mash or pulp by grinding done either by pounding with mortar and pestle or with the use of a hand grater made of perforated metal sheet. These materials rust quickly and are different difficult to keep clean. These methods not only make the products unsafe for consumption, but are slow, labour intensive and generally have low throughput, making their products unsuitable to meet market demands and standards (Okonkwo *et al*., 2016; Kadurumba *et al*., 2018; Nnanna *et al*., 2023; Abama *et al*., 2024).

Many research efforts in developing cassava processing machines to meet local and international demands of cassava product have resulted in the production of several prototypes with different efficiencies and quality performance levels Darlene *et al*., (2019). Odebode (2011) in the research conducted on appropriate technology for cassava processing in Nigeria highlighted several key techniques that can be enhance efficiency of cassava processing machines and recommended that the farmers be trained in the use of these improved processing equipment such as the vibrating sieve, abrasive peeler, motorized grater, drum drier and screw jack, so as to reduce processing time, labour cost, product quality and improve the overall cassava value chain in Nigeria.

The work of Agbetoye *et al.* (2006) on the development of indigenous machinery for cassava processing and fruit juice production resulted in significant improvement in the processing capacities, throughputs and efficiencies of grating and dewatering machines. Recommendations were made for the improvement and adoption of these machines. Yusuf *et al.* (2019) designed and fabricated a simple pedal operated cassava grater for rural dwellers using locally sourced materials. The grating efficiency and capacity of the grater were reported to be 90.91% and 103.7 kg/h, respectively. The grater was suitable for grating cassava tubers in rural areas where electricity and petrol are not readily available. However, despite this improvement, the machine is still operated by human power which relatively limits its capacity and efficiency.

An improved cassava grating machine was designed and fabricated be Adetunji and Quadri (2011). The new grater design incorporated features that increase the surface area for grating which significantly reduced the time for processing the cassava and has a higher throughput when compared to the traditional graters. However, the machine is suitable for small-scale production and needed to be scaled-up. Ndaliman (2006) developed a cassava grating machine that focused on having dual operational mode that allows the machine to be powered either electrically or manually. The design addresses the lack of electricity supply that is prevalent in the rural areas. The design also minimized the labour and time required in processing the cassava tubers. Efforts are still required to improve on the usability and safety of the machine.

Another design and production of a powered cassava grating machine by Ugwuoke and Ikechukwu (2023) is also dual operational mode, the machine is powered electrically using electric motor or mechanically using a gasoline engine. The work focused on using locally sourced materials for the machine construction to make it affordable by both small- and medium- scale processors. The modified grating machine was reported to achieved a production rate of 454.55 kg/hr which is significantly higher than the existing models, but the overall machine cost and maintenance is still a constraint for small-scale farmers.

Development of mobile cassava grating machines by Aideloje *et al.* (2018) enhanced the movement to different locations of use, making it favourable to rural farmers who lack access to electricity. The mobile cassava grater also has substantial higher efficiency when compared to the traditional method. However, there are concerns about its long-term durability under rigorous use in rural setting. The initial cost required to purchase the machine could still pose a barrier for small-scale farmers. A double-action cassava grating machine was designed and evaluated by Oriaku et al. (2015) focusing throughput and efficiency in processing cassava tubers of difficult weights. The machine achieved average grating efficiency of 86.23% and a grating rate of 730.8 kg/hr, indicating its ability to handle large cassava efficiently with low mass loss. However, the machine's performance is limited to freshly harvested cassava tubers with a moisture content range of 68.2 - 77.8%, which may restrict its usability in certain conditions. The machine cost is also high.

A double- barrel cassava granting machine was designed, fabricated and evaluated by Nwadinobi et al. (2023) to enhance processing efficiency. The result of its performance indicated that the double-barrel machine has significant higher performance on machine throughput capacity and efficiency when compared with the single-barrel counterpart. However, despite its suitability for large-scale cassava processing, there are operational limitations such as wear and tear during prolonged use and the need of regular maintenance coupled with the initial high cost of the machine.

➢ *Overview of Cassava Mash Dewatering Machine.*

Dewatering of cassava mash is another critical process in cassava processing and it is aimed at reducing moisture content for better preservation and processing. Traditionally, dewatering and fermentation is done by using stones and logs as weights to press excess water out of bagged cassava mash which are then left to drain and ferment for a few days. These techniques are time consuming, unhygienic, labour intensive, full of drudgery and characterized with

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very low output (Okonkwo *et al*., 2016). Various techniques and machines have been developed to enhance this process, each with its own advantages and limitations.

The presses that uses the screw mechanism is common due to their simplicity, durability and low maintenance. The design typically features a rotating screw within a cylindrical barrel, which compresses the cassava mash against a screen, allowing the liquid to flow out while retaining solid residue. Studies indicated that the screw presses can significantly improve the efficiency of cassava processing compared to traditional methods. However, they have notable drawbacks such as significant manual labour, lower pressure and lower efficiency when compared with hydraulic operated presses (Kolawole *et al*., 2011; Precoppe and Komlaga, 2020).

Hydraulic press method has shown to be more effective in achieving moisture content reduction in the shortest time. It can be hand-powered using hydraulic Jack or motor-powered using hydraulic pump. Though the motor-powered offered increased efficiency and reduced drudgery when compared with the hand-powered hydraulic press, the motor-powered hydraulic press is more complex and requires higher capital and operational cost (Kolawole *et al*.,2011)

An innovative equipment for cassava dewatering by Precoppe and Komlaga (2020) uses a chain-hoist mechanism to mechanically dewater cassava mash, in the bid to address the challenges of the screw and hydraulic presses. Though the innovative press was quite effective, its throughput and manufacturing cost are only suitable for large-scale operation.

Considering the problems and constraints of many of the machines already developed, very simple, easy to operate, high throughput, highly efficient and economically affordable cassava processing handling machine that have grating and dewatering machines was designed and fabricated with locally available materials.

## III. DESIGN AND MATERIAL CONSIDERATION

- *The Following Factors were Considered in Designing the Machine and Selecting the Materials:*

- Size and weight: The weight per unit area of the chosen materials is negligible so that the machine can easily be transported from one location to another.
- Machinability: The materials selected were the types that can easily worked on and can be cut into various shapes
- Availability: This is the accessibility of the materials selected for the machine. This will help when the need to replace or repair any of the machine components.
- Maintenance: All materials selected are considered for easy of maintenance and possible replacement in case of damages.
- Power requirement: The machine was considered to be powered through electric motor.

- *Design Analysis*

- *Determination of Mass of the Grating Drum*

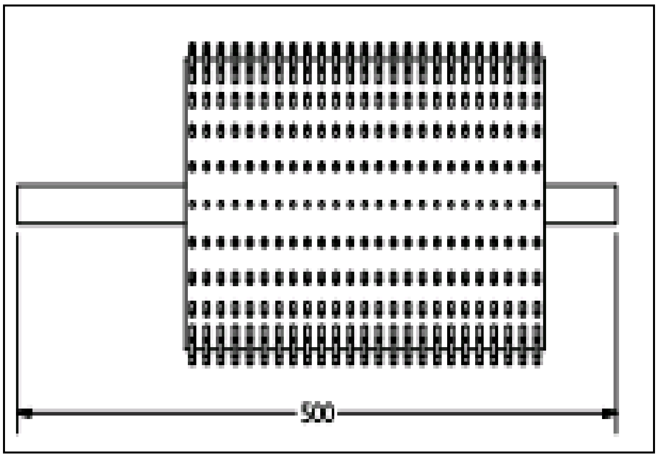

Fig 1 Grater Drum Schematics

Mass of the grater = density × volume of the grater.

Hence, volume of the grater, $V_g$ was calculated using equation 3.1

$$= \pi r2h \qquad (3.1)$$

- *Determination of the Velocity of the Grating Drum Shaft.*

  Velocity of the grater, Vs was determined using equation 3.2

$$= \pi dn \qquad (3.2)$$

- *Determination of the Forces Acting on the Grater Drum.*

  Forces ($F_c$) acting on the grater cylinder drum is given by equation 3.3, according to Kier and Jesal (2015);

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$$F_c = V.\rho.g \quad (3.3)$$

- *Determination of the Torque (T) on the Grater Shaft*
  This is the force required to turn the shaft of the grater, it is calculated using equation 3.4 Abubakar *et al.*, (2015)

$$T = Fc \times r \quad (3.4)$$

- *Determination of Power (Ps) Required to Drive the Grater Shaft*
  This is determined using equation 3.5

$$Ps = T \times \omega \quad (3.5)$$

- *Determination of Grater Shaft Speed Ratio.*
  This was calculated using equation 3.6 according to Khurmi and Gupta (2017);

$$N_1D_1 = N_2D_2 \quad (3.6)$$

- *Design of Cassava Grater Shaft Diameter*
  The shaft diameter was calculated using equation 3.7 Khurmi and Gupta (2017);

$$d^3 = \frac{16}{\pi \tau}\sqrt{(K_b M_b)^2 + (K_t M_t)^2} \quad (3.7)$$

➢ *Machine Drawing*
The isometric and exploded drawings of the cassava handling machines were presented in Figures 3.2-3.5 respectively.

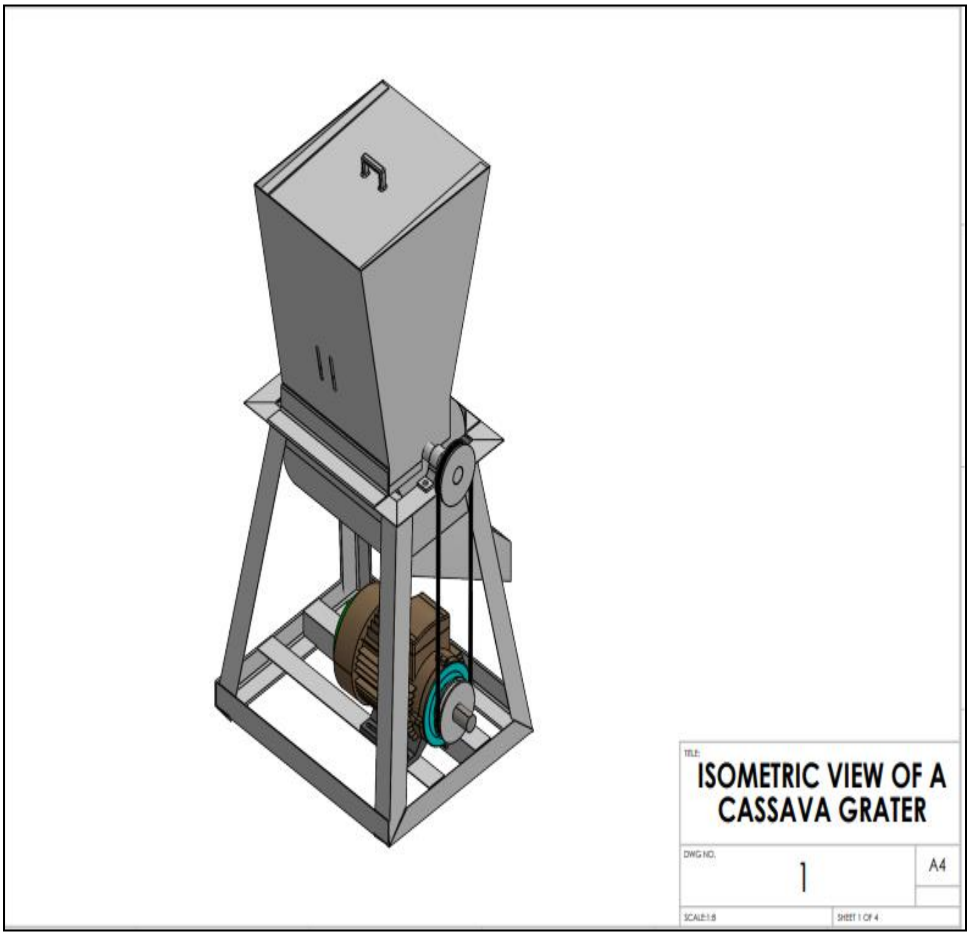


Fig 2 Isometric Drawing of the Cassava Grater

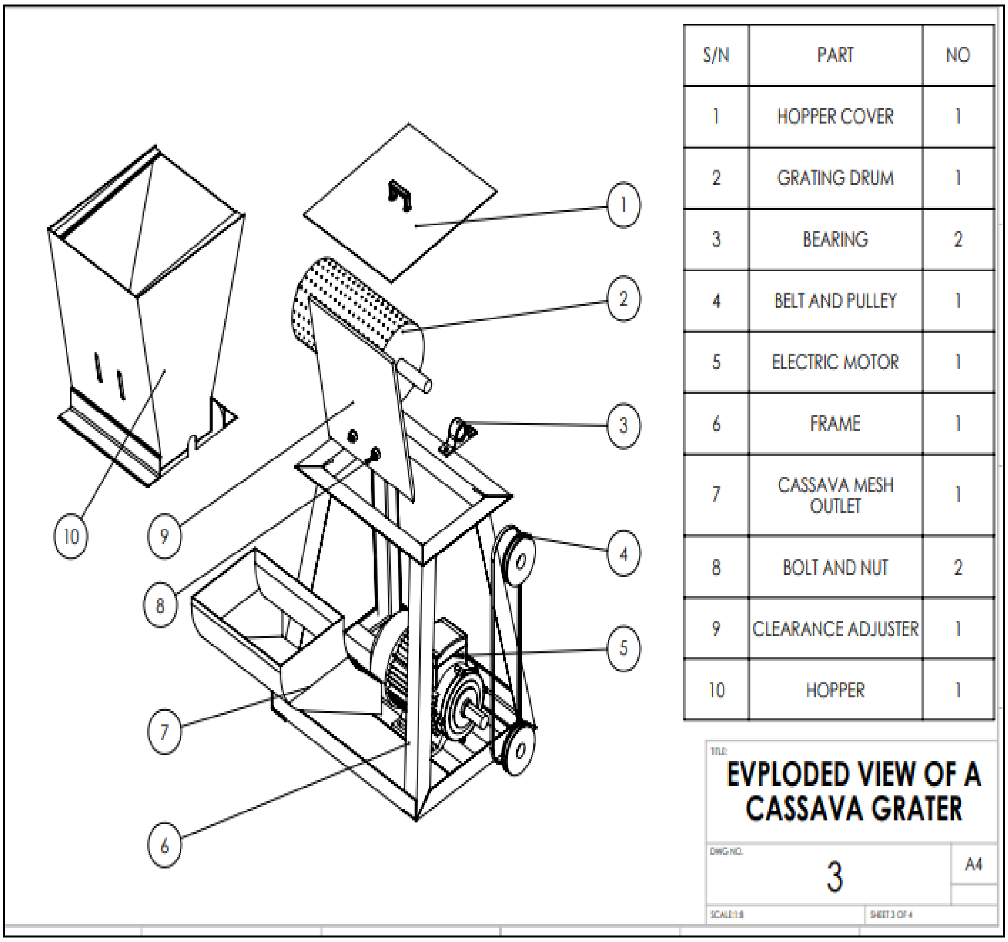


Fig 3 Exploded Drawing of the Cassava Grater

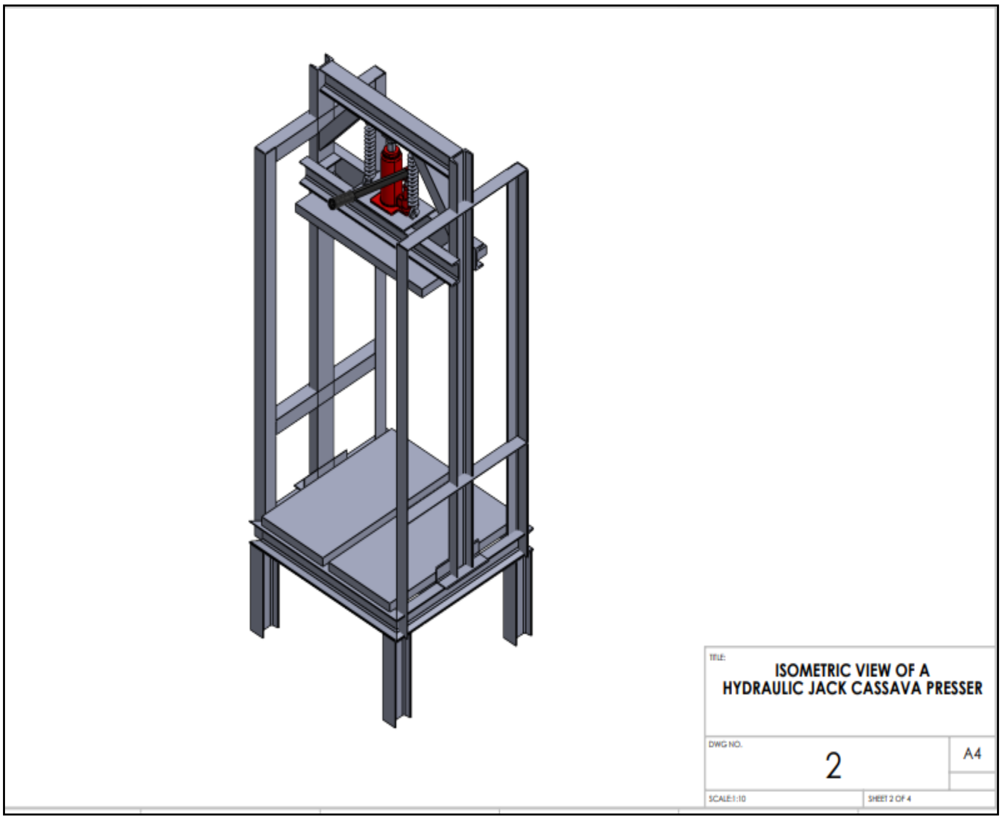


Fig 4 Isometric Drawing of Cassava Mash Dewatering Machine

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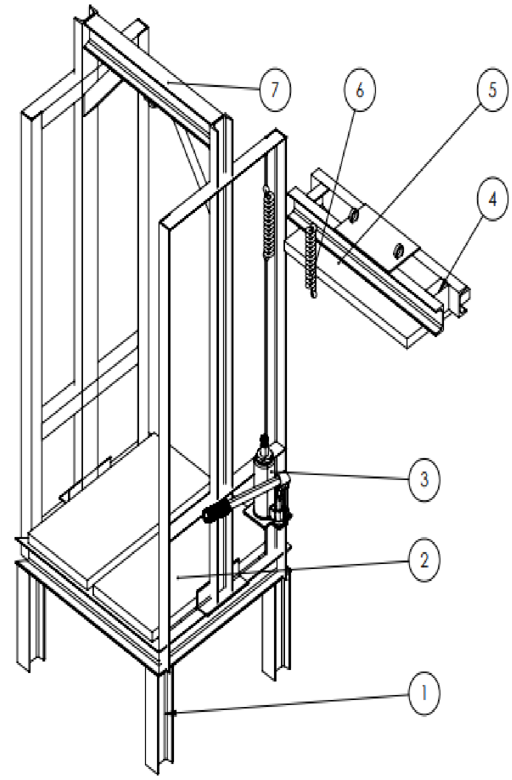


| S/N | PARTS | NO |
|---|---|---|
| 1 | FRAME STAND | 4 |
| 2 | BASE PRESS(SQUEEZE) PLATE | 2 |
| 3 | HYDRAULIC JACK | 1 |
| 4 | LINEAR MOTION SLIDE RAIL | 1 |
| 5 | TOP PRESS(SQUEEZE) PLATE | 1 |
| 6 | RETURN SPRING | 2 |
| 7 | FRAME BODY | 1 |

TITLE: **EXPLODED VIEW OF A HYDRAULIC JACK CASSAVA PRESSER**

Fig 5 Exploded Drawing of Cassava Mash Dewatering Machine

Fig 6 Pictorial View of Cassava Grater and Mash Dewaterimg Machine

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## IV. RESULTS AND DISCUSSION

➢ *Results*

- *Effects of Grater Speeds on Grater Capacity*

Three grater speeds (1350, 1450, 1550) rpm were tested against two improved (TMS 30001, TMS 30555) and one local (Odogbo) cassava varieties based on its recommendation Olutayo and Agbetoye (2022). The capacity of the grater increased as the speed increases in all the three varieties. The two improved varieties increased significantly against the local variety (Figure 4.1). The grater has its highest capacity (250.45 kg/h) at 1450 rpm with TMS 3001 cassava variety while the lowest capacity (182.44 kg/h) at 1550 rpm was recorded with local variety.

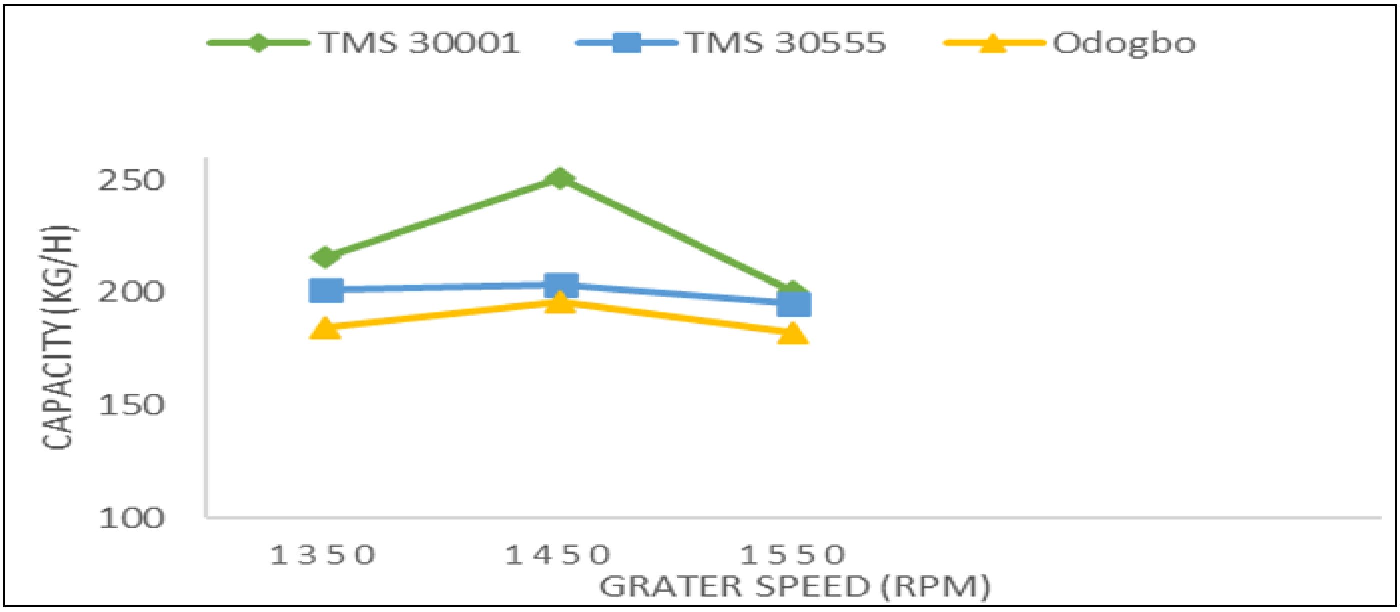


Fig 7 Effect of Grater Speeds on Capacity

- *Effects of Grater Speeds on Throughout*

The three grater speeds against the three cassava varieties was tested on the throughput of the grater, the three speeds have the same trend (Figure 4.2) on the three cassava varieties. Increased in speed increases the throughputs in all the three varieties, may while, TMS 30001 cassava variety performed better (108 kg/h) at 1450 rpm grater speed.

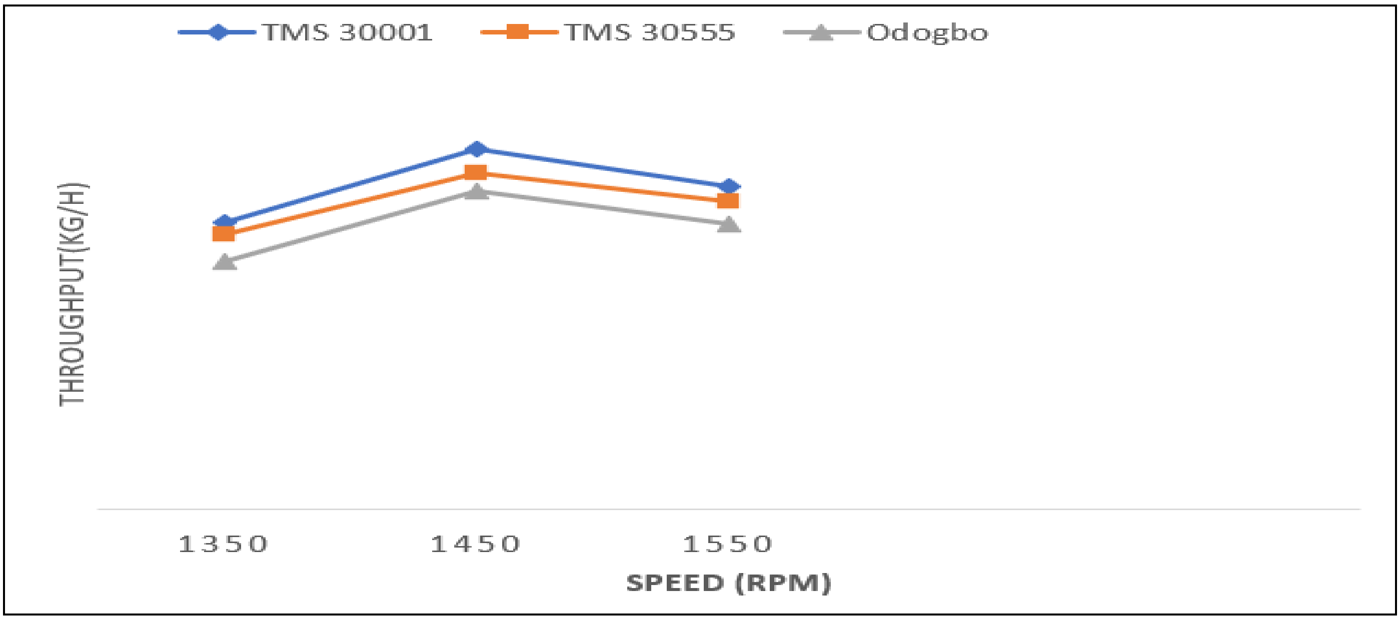


Fig 8 Effects of Grater Speeds on Throughout

- *Effect of Grater Speeds on Efficiency*

The Efficiency of the grater increased on the three cassava varirties tested as the grater speeds increases (Figure 4.3). Maywhile, at 1450 rpm, TMS 30001 has the better efficiency (96.8 %) over other varieties.

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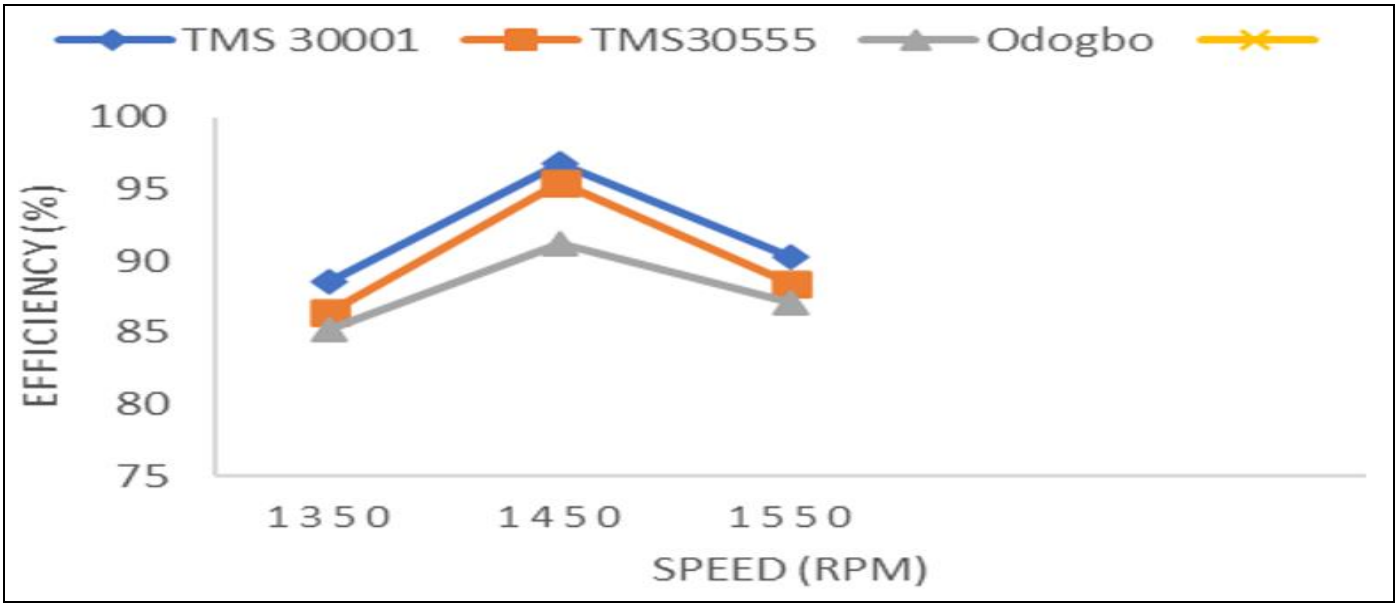


Fig 9 Effect of Grater Speeds on Efficiency

- *Effect of Applied Load, Process Time, Moisture Content and Efficiency on the Product*

Five trials were carried out on the cassava dewatering machine to determine the process time, the moisture content (wb) of the product, the weight of the dewatered cassava mash and the efficiency of the machine. Ten tonnes (98,100 N) of manual pumping jack was used constantly in dewatering the cassava mash with initial moisture content of 74%wb, the process time are 60,80,100,120, 140 minutes. The moisture content obtained after dewatering ranged from 44-58%wb, while the product obtained ranged from 88.38-99.08 kg of the dewatered cassava cake (Figure 4.4). The efficiency of the dewatering machine ranged from 78.1 – 95%. The 44-45%wb recommended moisture content Ovat and Odey (2018) was achieved at 120 minutes process time with 95% efficiency of 88.38 kg of dewatered cassava mash.

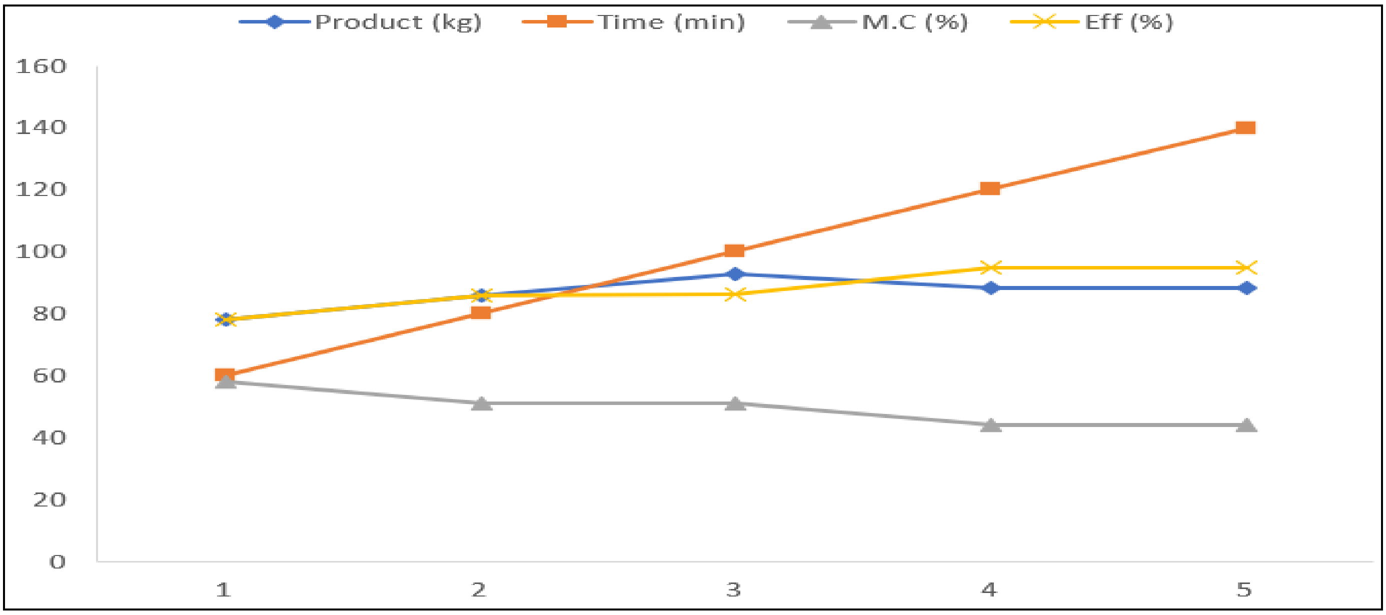


Fig 10 Effect of Applied Load, Process Time, Moisture Content and Efficiency on the Product.

## V. CONCLUSION

Cassava processing handling machines that involves cassava grating and cassava mash dewatering machines was designed, fabricated and tested. The three grater speeds varied are 1550 rpm, 1450 rpm and 1350 rpm and the results from the performance evaluation of the grating machine showed a higher capacity, improved efficiency and best performance was obtained at 1450 rpm grater speed of grating capacity of 250.45kg/h, throughput of 235.5 kg/h and efficiency of 96.8 %. Also, the dewatering machine has capacity of 400 kg/h and dewatering efficiency of 97.4%. it is therefore, recommended for the producers of garri and cassava products.

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