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Design, Construction and Testing of Motorized Cassava Peeling Machine for Use by Small and Medium Scale Farmers in Nigeria

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ABSTRACT ***Original research paper***

A cassava peeling machine fitted with1.0 kW electric motor was designed, constructed, and tested locally with a view to addressing the challenges of traditional manual peeling methods commonly used in Nigeria. The developed machine was intended to enhance peeling efficiency, reduce physical strain, and improve productivity for small- and medium-scale cassava processors. The motorized peeler was therefore tested for efficiency, throughput and reliability.

Locally available materials were employed to ensure cost-effectiveness and ease of maintenance. Design considerations focused on ergonomics, safety, durability, and adaptability to varying tuber sizes. The performance evaluation showed that the machine achieved effective peeling with minimal flesh loss and consistent throughput.

The results of the test indicated improved peeling efficiency of 69.57% and the test results further shows that 10kg weight of unpeeled cassava could be peeled within a period of 4minutes, suggesting superiority of this machine over traditional methods. The total cost of fabrication placed at less than 2 USD (₦196, 000,) makes it affordable for smallholder farmers and processors. This motorized peeling machine represents a step forward in mechanizing cassava processing in Nigeria, contributing to food security, value addition, and rural economic development.

1. Introduction

Cassava (*Manihot esculenta*) is an important crop in Nigeria's agricultural sector, with a vital source of sustenance and economic livelihood for millions of Nigerians. It is a starchy root tuber, a native to South America but now deeply entrenched in African agricultureand it has earned its place as a staple food crop and industrial raw material across the nation (Otekunrin&Sawicka, 2023). Cassava plays a vital role in food security, income generation, and industrial applications hence its significance in Nigeria cannot be overemphasized.

Nigeria is adjudged the world's largest producer of cassava, accounting for approximately 20% of global production and this underscores the crop's importance to the country's agricultural sector and economy at large (Adeyemo et al., 2022). The versatility of cassava is evident in its diverse uses, ranging from direct consumption as a food source to its utilization in various industrial processes. This adaptability has contributed to the steady increase in cassava production over the years, with Nigerian farmers recognizing its potential as a cash crop and a means of improving their livelihoods.

However, the journey from harvesting cassava to its final utilization encounter challenges, particularly in the post-harvest processing stages. One of the most labor-intensive and time-consuming steps in cassava processing is the peeling operation. Traditionally, cassava peeling has been performed manually; a method that is not only inefficient but also poses health risks to workers due to the presence of gynogenic compounds in the cassava peel (Okafor et al., 2021). The manual peeling process is slow, tedious, and often results in significant wastage of the edible portion of the tuber.

The need for mechanization in cassava processing, especially in the peeling stage, has become increasingly apparent as Nigeria strives to modernize its agricultural sector and enhance food production efficiency. Mechanized cassava peeling offers numerous advantages, including increased processing speed, reduced labour requirements, improved product quality, and minimized waste (Onyenwoke&Simonyan, 2021). These benefits align with Nigeria's agricultural transformation agenda, which aims to boost productivity, reduce post-harvest losses, and create value-added products from agricultural commodities.

The evolution of cassava processing technologies in Nigeria has been gradual but progressive. Early attempts at mechanizing cassava peeling faced challenges such as low efficiency, high tuber damage, and inability to handle the varying shapes and sizes of cassava tubers. However, recent advancements in engineering and design have paved the way for more sophisticated and efficient cassava peeling machines (Adebayo et al., 2022). These modern machines incorporate innovative features such as adjustable blades, variable speed controls, and safety mechanisms, addressing many of the shortcomings of earlier models.

In conclusion, the background to this study underscores the critical importance of developing an efficient, effective, and contextually appropriate motorized cassava peeling machine for Nigeria.

This endeavor sits at the intersection of agricultural innovation, economic development, and social progress. It represents a tangible step towards modernizing Nigeria's cassava value chain, with potential ripple effects across the broader agricultural sector. As we move forward with this project, we are not just designing a machine; we are contributing to the future of agriculture in Nigeria, paving the way for increased productivity, improved livelihoods, and enhanced food security for millions of Nigerians.

The traditional method of peeling cassava involves manual labor, utilizing simple tools such as knives. This method is not only labor-intensive but also inefficient, leading to significant post-harvest losses due to poor peeling precision and high wastage. Furthermore, the manual peeling process is time-consuming and poses ergonomic challenges, increasing the risk of injuries among workers.

Given these challenges, there is a pressing need to develop a more efficient, reliable, and safer method for cassava peeling. The introduction of a motorized cassava peeling machine offers a promising solution to these problems. Such a machine has the potential to enhance the efficiency of the peeling process, reduce labor costs, minimize wastage, and increase the overall productivity of cassava processing operations.

This study centers on the design and construction and testing of a motorized cassava peeling machine targeted at addressing the limitations of traditional peeling methods. By automating the peeling process, the machine is expected to improve the speed and accuracy of peeling, thus contributing to the overall improvement of cassava processing and supporting the economic livelihoods of farmers and processors who rely on this vital crop.

2. Materials and Methods

2.1 Material Selection and Description

Steel materials were selected considering the following qualities: stainless steel materials are made of aluminum alloy, for its ease of being worked on and be welded. The constructed system consists of the following parts;

i. Mild steel sheet
ii. Angle Iron
iii. Bevel gears
iv. Stainless steel shaft
v. Bolt and nut
vi. Flat bar
vii. Screw bar
viii. Paint
ix. V-belt
x. 1 kW single phase electric motor.
xi. Pulley
Xii Bearings

2.1.1 Construction Materials

1. Cutting machine
2. Rolling machine

3. Electric arc welding machine
4. Drilling machine
5. Filling disc
6. Cutting disc
7. Electrode
8. Spraying machine
9. Hammer
10. Spanner

2.1.2 Measuring Materials

1. Tape
2. **Divi**der
3. Punch
4. Steel rule
5. Square (Angle Square)

2.1.3 Materials and Equipment for Performance Evaluation

The materials and equipment used in conducting the experiments are;

i. Weighing Balance;
ii. Stop watch;
iii. Vernier caliper
iv. Cassava roots sample

2.2 Methods

2.2.1 Design Analysis

a. Design Considerations

The considerations for design of the cassava peeler encompassed both the choice of bio material used (Cassava) and the construction materials. The strength of bio materials under maximum loading was characterized by Engineering properties such as;

i. materials for construction were considered in term of their strength, rigidity and simplicity.
ii. Specific weight and size
iii. Required force to peel the cassava.
iv. The machine components durability was considered.
v. Easy movement of the machine.
vi. Ease ofserviceability, inspection, and machine maintenance.
vii. Construction cost;
viii. Operation ease, as well as maintenance and energy requirement.

b. Economic Factors and Safety Considerations

The selection of construction materials was selected based on safety andeconomic factors. The factors include;

i. The cost of construction materials and their availability;
ii. Lifespan of materials and their strengths;
iii. Method of fabrication.
iv. Peeling efficiency
v. Corrosion resistant properties.

c. Design Drawings

The working drawings are shown below in figures 2.1, 2.2 and 2.3.

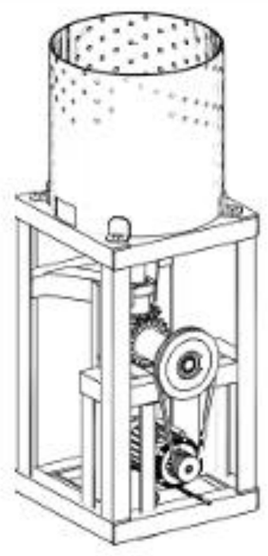
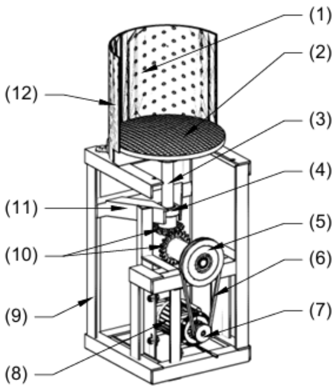


Fig.2.1 Cassava Peeling Machine.

Isometric Drawing



Part Description	
1	Perforated Drum
2	Base Plate
3	Shaft
4	Ball Bearing
5	Driven Pulley
6	V-belt
7	Driving Pulley
8	Electric Motor
9	Frame
10	Bevel Gears
11	Bracket
12	Housing Drum

Fig.2.2 Cassava Peeling Machine (Sectioned and Detailed)

Orthographic Drawing

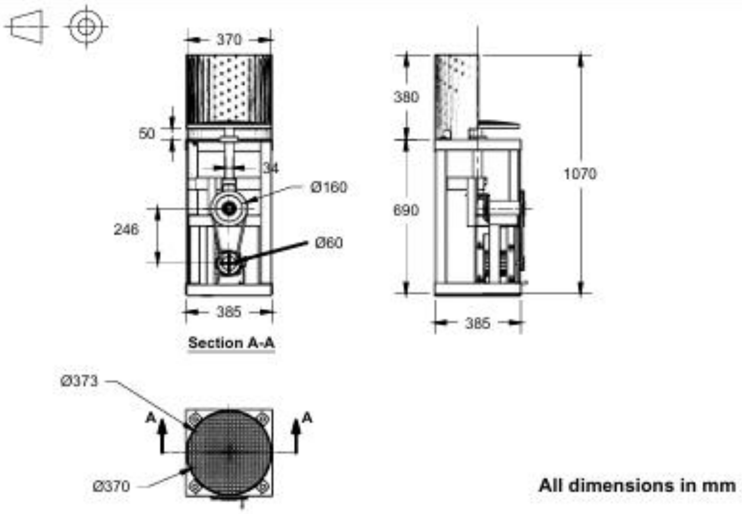


Fig.2.3Cassava Peeling Machine (Orthographic)

d. Design Calculations

i. Efficiency of Motor

Intended efficiency of 95% is anticipated for the machine at engine speed N1=1400rpm 95% Efficiency of 1hp will become

$$\frac{95}{100} \times 1hp = 0.95hp$$

But 1hp = 0.75kW

$$0.95hp \rightarrow 0.95 \times 0.75kW = 0.713kW$$

From standard table engine pulley diameter of 152mm was selected and also belt thickness of 0.12mm selected.

Diameterof pulley, $d1 = 152mm or\ 0.152m$

Radius, $r1 = 0.076m$

velocity of engine (Angular), $\omega 1 = \frac{2\pi N1}{60}$

N1 = engine speed $\omega 1 = \frac{2\pi \times 1400}{60} = 146.6, 147rad/\sec$ (3.1)

The linear velocity of the engine, V = wr1 (3.2)

Substitute the value of w_1 in (3.1) into (3.2) we have,

$$V = 146.6 \times 0.076 = 11.14 m/s \qquad (3.3)$$

ii. Selection Belt and Pulley

Take 3 to be the speed reduction ratio

$$\mu = \frac{N1}{N2}$$

N1 and N2 represent Speed of driver driven pulley respectively, $Reductionratio = 3$

$$N2 = \frac{N1}{\mu} = \frac{1400}{3} = 466.7 rpm \qquad (3.4)$$

Diameter of driven pulley, d2

$$\frac{N1}{N2} = \frac{d2}{d1} = (KhurmiandGupta, 2005) (3.5)$$

Where $N_1 = Speedofdriverpulley, N_2 = Speedofdrivenpulley, d_1 = diameterofdriverpully, d_2 = diameterofdrivenpulley.$

Substitute the value of N2 in (3.4) into (3.5) we have,

$$d_2 = \frac{N1d1}{N2} = \frac{1400 \times 0.152}{466.7} = 0.456 \sim 0.46m (3.6)$$

Driven pulley Radius, r2

$$r2 = \frac{0.46}{2} = 0.23m$$

Angular velocity of the driven pulley,

$$\omega 2 = \frac{2\pi N2}{60} \qquad (3.7)$$

Substitute the value of N2 in (3.4) into (3.7) we have,

$$\omega 2 = \frac{2\pi \times 466.7}{60} = 48.87 rad/sec \qquad (3.8)$$

iii. **Belt Size**

According to (Reshetor, 1978) the least angle of contact of the belt on the smaller pulley should not be less than 120^0 so as to able obtain an efficient torque in V-belts. So, 165 is selected or the smaller pulley.

iv. **Belt Arrangement**

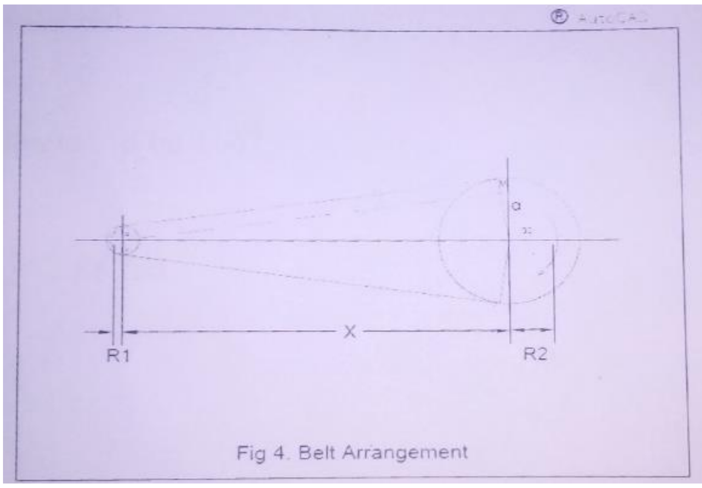


Fig.2.4 Belt Arrangement

$$sin = \frac{O2m}{O1O2} = \frac{r2 - r1}{x} = \frac{d2 - d1}{2x} (KhurmiandGupta, 2005). \qquad (3.8)$$

Where r1 and r2 are radii of smaller and larger pulleys, x is the distance between centers of the two pulleys and the angle of contact (∅) in this case is 165^0

$$But \emptyset = 180 - 2a$$

$$a = \frac{180 - \emptyset}{2} = \frac{180 - 165}{2} = \frac{15}{2} = 7.5$$
$$or\ 7.5 \times \frac{\pi}{180} rad = 0.13 rad$$
$$Butsina = \frac{d2 - d1}{2x} = \frac{d2 - d1}{\sin a}$$
$$2x = \frac{0.46 - 0.152}{sin7.5} = 2x\frac{0.308}{0.13}$$
$$x = \frac{0.308}{2 \times 0.13} = 1.18m$$

An A24 V-belt size is selected

Let, Ø be 165^0

So,

$$\emptyset = 165 \times \frac{\pi}{180} = 2.88 rad$$

Then:

$$2.3 \log \left(\frac{T1}{T2}\right) = \mu \times \emptyset$$

Coefficient of friction, μ for rubber belt material on dry cast iron is 0.3

$$2.3 \log \left(\frac{T1}{T2}\right) = \mu \times \emptyset = 0.3 \times 2.88 = 0.864$$
$$Log \left(\frac{T1}{T2}\right) = \frac{0.864}{2.3} = 0.376$$
$$= \log -1(0.376) = 2.37 \quad (3.9)$$

Power transmitted by belt,

P = (T1 – T2) v

Where P = Power in watts

T1 – T2 = Overall belt tension

T1 = Tension in tight side of belt

T2 = Tension in slack side of belt

$$P = (T1 - T2)v$$
$$0.713 \times 103 = (T1 - T2)11.14$$
$$T1 - T2 = 64N \quad (3.10)$$

From equation (3.9) T1 = 2.37T2

Substituting the value of T1 into equation (3.10)

We have,

$$2.3T2 - T2 = 64N$$
$$1.37T2 = 64N$$
$$T2 = \frac{64}{1.37} = 46.7\ N \quad (3.11)$$

Substituting T2 in (3.11) into (3.10)

We have,

$$T1 - 46.7 = 64$$
$$T1 = 64 + 46.7 = 111N$$

v. Designing the Shaft

The pulley is carried by the shaft of the machine and its powered by an electric motor by means of a v-belt, as well asthe peeling drum and two bearings.

The minimum shaft diameter required to check failure of the shaft was determined as follows: -

Power Transmitted by Shaft

$$T_A = \frac{60p}{2\pi N_A} \quad (3.12)$$

P is the power delivered to the pulley via the motor, and N_A is the speed of the rotation of the pulley, which may be calculated from the speed ratio of the shaft and the motor as follows: -

$$\frac{N_A}{N_M} = \frac{d}{D}$$

$$N_A = \frac{N_M d}{D} \qquad (3.13)$$

$$N_A = \frac{1400 \times 14}{50} = 392$$

Where N_M is the motor speed, d is the motor pulley diameter, and D is the shaft pulley diameter.
The torque T_C acting at C must be equal to that at A for equilibrium of the shaft. Hence,

$$T_C = \frac{60p}{2\pi N_A} (3.14)$$

$$T_C = \frac{60 \times 466.7}{2 \times 3.142 \times 392} = 11.37 \times 10^3 N - mm$$

Loads on the Shafts

At A

The belt tension ratio is given by,

$$\frac{T_2}{T_1} = e^{\mu\theta} \qquad (3.15)$$

Where θ is the contact angle at the small pulley, μ is the coefficient of friction between the pulley and belt; T_1 and T_2 are the belt tensions on the tight and slack side respectively

If $e^{\mu\theta}$ is represented ask, then equation (3.15) can be rewritten as,

$$T_1 = kT_2 \qquad (3.16)$$

The vertical load, F_A on the shaft is the bending load and is given by

$$F_A = T_1 + T_2$$

Substituting equation (3.16) gives,

$$F_A = T_2(k+1) \qquad (3.17)$$

The driving load F_d is given by,

$$F_d = T_1 - T_2$$

Substituting equation (3.16) gives,

$$F_d = kT_2 - T_2$$

Therefore:

$$F_d = T_2(k-1) \qquad (3.18)$$

The driving load, in terms of the torque, is given by,

$$F_d = \frac{T_A}{D/2} \qquad (3.19)$$

Combining equation (3.18) and (3.19) gives,

$$T_2(k-1) = \frac{T_A}{D}$$

Therefore:

$$T_2 = \frac{2T_A}{D(k-1)} \qquad (3.20)$$

putting (3.20) into (3.17) gives,

$$T_2 = \frac{2T_A(k+1)}{D(k-1)}$$

Note $k = e^{\mu\theta}$

$$F_A = \frac{2T_A(e^{\mu\theta}+1)}{D(e^{\mu\theta}-1)} \qquad (3.21)$$

$$F_A = \frac{2 \times 11.37(165+1)}{50(165-1)} = 0.46Kg$$

At point C

The vertical load F_{VC} on the drum as a result of friction is the tangential load between it and the cassava, and is given by,

$$F_{vc} = \frac{2T_C}{Dd} \qquad (3.22)$$

$$F_{vc} = \frac{2 \times 11.37}{50 \times 14} = 30.78Kg$$

The total load F_C on the drum is given by,

$$F_C = F_{VC} + W$$

$$F_C = 30.76 + 15 = 45.76Kg$$

vi. Length of Belt

$$L = \frac{\pi}{2}(d2 + d1) + 2x + \frac{(d2 - d1)^2}{4x}(KhurmiandGupta, 2005)$$

$$L = \frac{\pi}{2}(0.46 + 0.152) + 2(1.18) + \frac{(0.46 - 0.152^2}{4(1.18)}$$

$$0.96 + 2.36 + \frac{0.09486}{4.72} = 3.34m$$

vii. Bevel gears

Mechanical advantage of the gears can be calculated as:

$$M.A = \frac{load}{effort} = \frac{950}{1400} = 0.679$$

Velocity Ratio can be calculated as:

$$V.R = 1.5$$

$$Efficiency = \frac{M.A}{V.R} \times 100\%$$

$$Efficiency = \frac{0.679}{1.5} \times 100 = 45.2\%$$

viii. Drum Volume and Capacity

The drum is cylindrical and the volume can be calculated by the given dimensions expressed by the equation:

$$v = \pi r^2 h$$

Where r is radius of the cylinder (m); h is height of the cylinder (m).

$$v = 3.142 \times 1.9^2 \times 11.93$$

$$v = 135.32m^2$$

2.3 Construction (fabrication) Process

a. Frame Construction

Measurement for the construction of the machine frame dimensions were made, then the angle iron was cut into four sections of length 690mm each for the main frame, another angle iron with length of 385mm each was cut into 8pieces to support the frame of the machine, the four lengths support the frame at the top where the peeling drum with the peeling mechanism is fixed and the other four lengths support the legs of the frame to make the machine rigid. An angle iron of 380mm each was cut and welded to the frame to make a provision for electric motor stand. All the joining processes were carried out using an electric arc welding machine where the members were all welded to make the frame.

b. Drum Construction

The drum is Cylindrical with the height of (Mild steel sheet of 1193mm by 380mm) it was cut using the cutting machine, the cut portion was taken to the rolling machine where the sheet was rolled and welded to the frame of the machine. A bottom plate with diameter 380mm was marked using punch and divider to get the circle and was joined (wielded) to the drum with a hole of 30mm for the passage of shaft was drilled and grinded and a discharge was made on the drum for the removal of the peels.

c. Rotating Plate Construction

A round plate of diameter 370mm was measured and marked using divider and was cut, after cutting it, a shaft with bearing housing was welded to the rotating plate to stabilize the shaft. A flange of diameter 70mm by 75mm that serve as housing for the bearing was welded to the bottom plate of the drum. The rotating plate is made in such a way that it rotates freely inside the drum to roll the cassava and peel them by abrasion.

Peeling Mechanism

The peeling mechanism is an abrasive mild steel sheet with a diameter of 370mm and length of 270mm, was cut, rolled and welded to the drum in such a way that, the rotating plate rotates the cassava round the abrasive material to peel it.

2.4 Evaluation of the Performance of the Peeling Machine

According to (Abdulkadir, 2012), the determination of the workability of the cassava peeling machine is a function of its peeling efficiency, peeling capacity and flesh loss. Hence the percentage peeling efficiency (PE) is the ratio of peeled to the mass in a batch per given period of time.

$$Peeling efficiency(\%) = \frac{W_2}{W_1} \times 100 \qquad (3.12)$$

W_1 and W_2 represent mass in a batch, kg and mass fraction of peeled cassava, kg respectively.
The flesh loss any particular type of cassava used (bitter cassava), is a primary test carried out first to check for the percentage of peel of the tuber used. It was discovered that the peel is made up of 18.2% out of the whole tuber without flesh loss; this was then used in estimating flesh loss.

So, approximate loss in flesh can be estimated thus:

$$\frac{18\%(W_2 - W_4)}{W_2} \times 100 \qquad (3.13)$$

$$Peeling capacity\left(\frac{g}{s}\right) = \frac{W_1}{t} \times 100 \qquad (3.14)$$

Were,
W_1 = weight of cassava tuber, kg; W_2 = weight of flesh, kg;
W_3 = weight of unpeeled cassava tuber, kg; W_4 = weight of lump, kg; t = time (mins)
Throughput capacity (Ihom et al, 2024):

$$T_s = \frac{W_1}{t} kg/mins$$

$$T_s = \frac{16}{6.24} = 2.56 kg/mins$$

The peeling efficiency of the machine was determined using the ratio; Thickness of tuber peeled by machine (W_2): actual thickness to be peeled by machine (W_1) so,

$$efficiency = \frac{W_2}{W_1} \times 100\%$$

1.4 Testing

At the end of the entire work the machine was subjected to testing to ascertain the efficiency of its peeling. No variations were noticed on all the aspects regarding the design concepts: the results were religiously followed and arrived at with little or no variations. Linear cassava was used in conducting the test. Rotating the electric motor continuously brings the tuber in contact with the peeling drum which rapidly peels by bruising it. Three samples were tested as samples I, II and III respectively as shown below.

Sample 1

Initial diameter of the tuber = 47.10mm
Final diameter when peeled = 45.9mm
Actual thickness of tuber peeled by the machine (W_2) = 1.2mm
Actual thickness to be peeled (W_1) = 2.30mm

$$efficiency of peeler = \frac{W_2}{W_1} \times 100\%$$

$$= \frac{1.2}{2.30} \times 100\% = 52.2\%$$

Sample 2
Initial diameter of the tuber= 50.0mm
Final diameter when peeled = 48.90mm
Thickness of tuber peeled by the machine (W_2) = 1.1mm
Actual thickness to be peeled (W_1) = 2.30mm

$$efficiency of peeler = \frac{W_2}{W_1} \times 100\%$$

$$= \frac{1.1}{2.30} \times 100\% = 47.8\%$$

Sample 3
Initial diameter of the tuber = 55.50mm
Final diameter when peeled = 53.90mm
Thickness of tuber peeled by the machine (W_2) = 1.6mm
Actual thickness to be peeled (W_1) = 2.30mm

$$efficiency of peeler = \frac{W_2}{W_1} \times 100\%$$

$$= \frac{1.6}{2.30} \times 100\% = 69.6\%$$

3. Results and Discussions

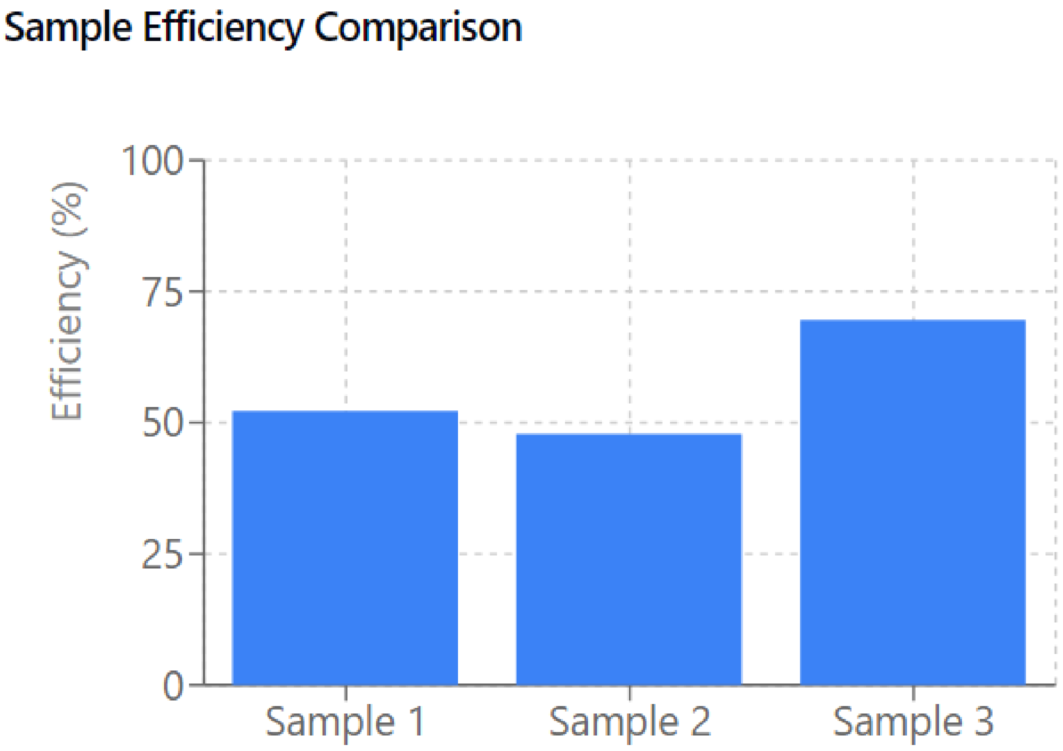
3.1 Results

Table 1: Showing the quantities of cassava tubers peeled in kg/time.

S/N	Weight of unpeeled cassava tuber kg (W_1)	Time taken to peel the cassava tubers, time (mins)	Weight of peeled cassava tuber (x_1)
1.	1kg	24sec	0.8kg
2.	5kg	2mins	4kg
3. `	10kg	4mins	8kg

The table 2:Results of cassava peeling efficiency calculations for all three samples: the efficiency is calculated as (W2/W1) × 100%.

Sample	**Initial Diameter (mm)**	**Final Diameter (mm)**	**Actual Thickness Peeled W2 (mm)**	**Ideal Thickness W1 (mm)**	**Efficiency (%)**
1	47.10	45.90	1.20	2.30	52.17
2	50.00	48.90	1.10	2.30	47.83
3	55.50	53.90	1.60	2.30	69.57



Figire1: showing variations between the different samples

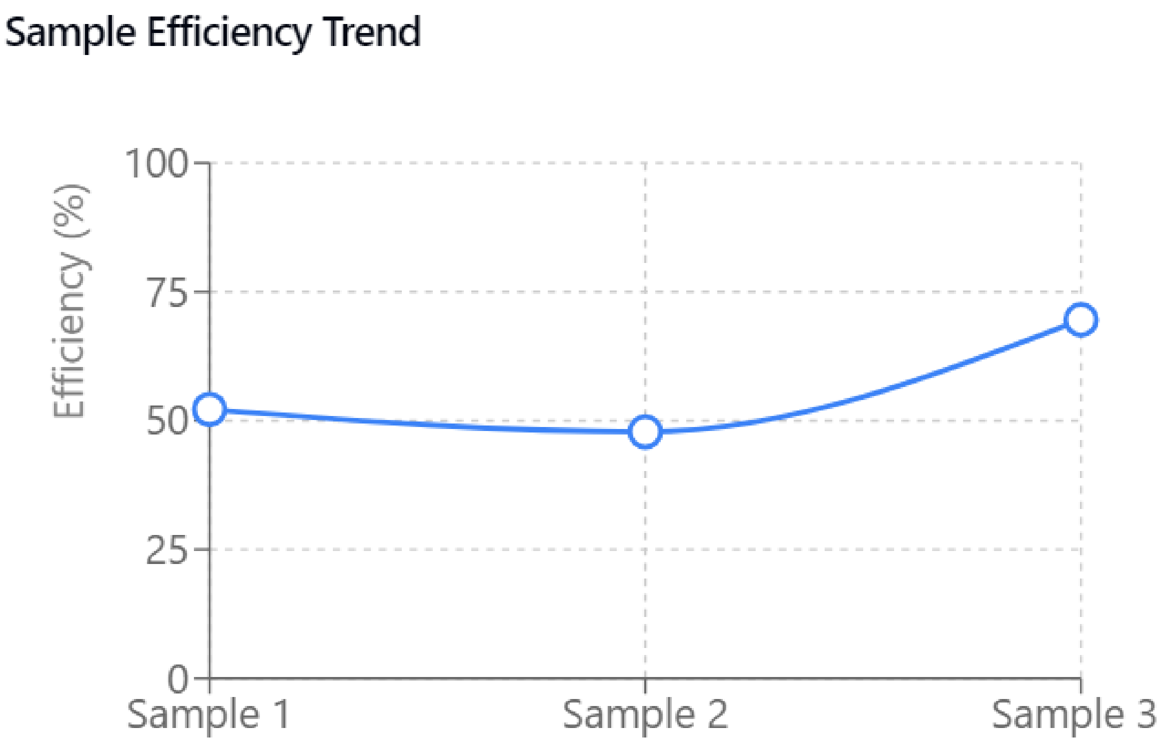


Figure 2: Showing Graphical Representation of the Three Samples

3.2 Discussions of Results

The performance evaluation of the constructed motorized cassava peeling machine provided insightful data on the impact of varying drum fill levels on peeling efficiency, peeling capacity, and percentage flesh loss. The machine was tested under controlled conditions to determine how different operational parameters influence its performance and output. The tests were carried out at three different drum fill percentages—10%, 30%, and 50%—with corresponding measurements of peeling efficiency, flesh loss, and throughput capacity. The results highlight important trade-offs between efficiency and output, especially as the feed rate changes.

At 10% drum fill, the machine demonstrated a peeling efficiency of 69%, which was the highest, recorded across all tests. This level of fill also produced a minimal flesh loss of 7%, indicating that the peeling mechanism was operating optimally, making sufficient abrasive contact with the tubers while avoiding over-peeling. The peeling capacity at this level was 6.2 kg/hr, and the optimal residence time recorded was between 20 to 30 minutes. This suggests that the lower the quantity of cassava in the drum, the more effective the abrasive mechanism becomes in maintaining both efficiency and minimal damage to the edible portions. The low residence time also indicates an ideal balance between processing speed and output quality when operating at low capacity.

However, when the drum fill was increased to 30%, the peeling efficiency dropped to 52%. This reduction can be attributed to a decreased level of interaction between the cassava tubers and the abrasive drum surface. With more tubers in the drum, individual pieces had less exposure to the peeling mechanism, which resulted in incomplete or uneven peeling. At the same time, flesh loss increased to 14.7%, more than double the flesh loss recorded at 10% fill. This higher loss is possibly due to tumbling and friction among the tubers themselves, which may have led to unnecessary bruising and over-peeling in some areas. Nevertheless, the peeling capacity rose significantly to 21.3 kg/hr, indicating that more cassava was processed within the same time frame, even though the quality of peeling declined. This presents a trade-off between quantity and quality—more cassava is peeled, but with greater loss and reduced efficiency.

At 50% drum fill, the machine recorded its lowest peeling efficiency of 47.8%, while flesh loss peaked at 15%. The high drum load created a congested environment inside the peeling chamber, where tubers frequently collided with each other, leading to inefficient and inconsistent contact with the abrasive surface. This condition resulted in many cassava pieces exiting the machine with only partial peeling, thus reducing the overall effectiveness. However, the peeling capacity increased further to 31 kg/hr, demonstrating that the machine, though less efficient per unit, was capable of handling larger volumes within the same time frame. This level of operation may be suitable for processors more concerned with volume than product appearance or precision in peeling.

A consistent observation throughout the tests was that as feed rate increased, peeling efficiency decreased. This inverse relationship is likely due to limited surface contact between the cassava tubers and the peeling mechanism. In a lightly filled drum, the abrasive surface is more accessible to each tuber, allowing for uniform peeling. In contrast, a fuller drum reduces the exposure time of each tuber to the peeling surface, and the abrasive action is distributed across more surfaces, weakening its overall impact. This outcome emphasizes the importance of carefully controlling the feed rate, especially in applications where high peeling efficiency and minimal flesh loss are critical. The above discussion on peeling efficiency corroborates that of Ihom et al (2024) and Adegbite et al, (2021) in its entirety.

In contrast, both flesh loss and peeling capacity increased with higher drum fill levels. This pattern reflects the increase in physical interactions between tubers, where excessive tumbling can cause damage to the edible parts of the tubers. Additionally, the mechanical power exerted by the rotating drum on a larger volume of cassava creates more friction, leading to peeling beyond the surface level. These findings are consistent with the expected mechanical behavior of abrasive peeling systems, where volume-related frictional forces can result in excessive removal of tuber flesh, especially when residence time is prolonged.

From an engineering and operational perspective, the results highlight a clear trade-off between peeling efficiency and processing capacity. While higher capacities are beneficial for large-scale operations, the compromise on peeling efficiency and product quality must be considered, particularly for processors dealing with high-quality or export-grade cassava products. Conversely, operating at a lower drum fill allows for better quality control and minimal losses, but at the cost of slower processing speed.

To optimize machine usage, operators may consider calibrating the feed rate and residence time based on the quality of cassava tubers and the desired processing outcomes. For instance, processors focused on producing peeled cassava for local food consumption may accept higher flesh loss in exchange for faster throughput. Meanwhile, processors targeting high-grade cassava products for industrial or commercial use might prefer operating the machine at lower fill levels to maintain high-quality output.

4. Conclusions

This study successfully designed, constructed, and evaluated a motorized cassava peeling machine aimed at addressing the major limitations of manual cassava peeling methods in Nigeria. The study demonstrated that the traditional manual peeling process, which is labor-intensive, time-consuming, and often results in significant flesh loss, can be significantly improved using a mechanized approach.

The machine was fabricated using locally available materials and designed to be affordable, efficient, and easy to operate, making it suitable for small- and medium-scale processors. Performance tests showed that the machine is capable of achieving a peeling efficiency of up to 69% with minimal flesh loss (7%) at lower drum fill levels, and a capacity of up to 31 kg/hr at higher fill levels. However, increased drum fill resulted in reduced peeling efficiency and increased flesh loss, indicating a trade-off between processing speed and quality of output.

The results also showed that the machine performs best at 10% drum fill, where optimal abrasive contact between the drum and tubers is achieved. As fill rate increased, abrasive contact was reduced, leading to less efficient peeling but higher throughput. This indicates the importance of balancing fill rate and residence time during operation to optimize performance.

The motorized cassava peeling machine provides a practical solution to the challenges faced by cassava processors, improving productivity, reducing drudgery, and enhancing processing efficiency. With further improvements and customization, the machine can significantly contribute to the mechanization of cassava processing in Nigeria and beyond.

The results obtained from testing confirm that the motorized peeling machine enhances cassava processing by significantly reducing labor intensity and peeling time. The incorporation of abrasive peeling mechanisms, coupled with an optimized rotating drum, ensures uniform peeling, making the machine suitable for small- and medium-scale cassava processors. Additionally, the machine's design facilitates ease of maintenance and operation, ensuring long-term usability.

By mechanizing the cassava peeling process, this study contributes to improving food security and agricultural productivity. The machine aligns with Nigeria's ongoing agricultural transformation efforts by supporting value addition and reducing post-harvest losses. While the prototype performed effectively, further refinements could enhance its performance and scalability for broader adoption.

References

1. Adebayo, A. O., Olaniran, A. F., Ayayi, O. M., &Ojo, O. C. (2022). Advances in cassava processing technologies: A review. Food Reviews International, 38(4), 762-789.
2. Adeyemo, T. A., Abass, A. B., Amiri, H., Diallo, Y., &Manyong, V. (2023). Sustainable cassava production and processing in West Africa: Current practices and future prospects. Sustainability, 15(1), 492.
3. Adegbite, S. A., Olukunle, O. J., &Ogunsina, B. S. (2021). Optimization of cassava peeling blade geometry using computational fluid dynamics. Journal of Food Process Engineering, 44(4), e13638.
4. Abdulkadir, B. H.: Design and Fabrication of a Cassava Peeling Machine, IOSR Journal of Engineering (IOSRJEN). 2 (6): 01-08. 2012.
5. Khurmi, R.S& Gupta, J.K. (2005). Text Book on Machine Design. 14th edition, New Delhi EURASIA Publishing House, 400 – 506.
6. Ihom A. P., Aniekan O., Odeh,E. U. Umoh, P. I. Sambo E. E., ibia S. E. and Eton E.I. (2024).Design and Production of cassava Peeling Machine for Easy Peeling of Cassava in the Tropical Region. International Journal of Engineering and Modern Technology (IJEMT)E - ISSN 2504 – 8848, P- ISSN 2695 - 2149, 10(3) (2024) 4 – 21.
7. Okafor, C. E., Ihueze, C. C., & Njoku, O. S. (2021). Design and Development of Cassava Peeling Machine for Small and Medium Scale Industries. International Journal of Engineering and Management Research, 11(2), 73-82.
8. Onyenwoke, C. A., &Simonyan, K. J. (2021). Cassava post-harvest processing and storage in Nigeria: A review. African Journal of Agricultural Research, 16(6), 947-956.
9. Otekunrin, O. A., &Sawicka, B. (2023). Cassava production, processing, and utilization in Nigeria: Challenges and prospects. Plants, 12(3), 624.
10. Reshetor D. N. (1978). Machine Design, 1st Edition, MoscowMIR Publishers,.590 - 650