Design and Performance Evaluation of a Cassava Peeling Machine for Food Processing

*[1]Temidayo C. Esenamunjor, [2]Chukwuma H. Kadurumba, [1]Kingsley I. Mejeh and [1]Daniel I. Kalu
[1]Department of Mechanical Engineering, Abia State Polytechnic, Aba, Nigeria
[2]Department of Mechanical Engineering, Michael Okpara University of Agriculture, Umudike, Nigeria
temidayoesenamunjor@abiastatepolytechnic.edu.ng|kadurumba.chukwuma@mouau.edu.ng|mejehkingsley@gmail.com

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Abstract- The study focuses on the design and performance evaluation of a cassava peeling machine, with the primary objective of mitigating labour-intensive tasks and enhancing the efficiency of processing cassava into different food products. The machine consist of a peeling chamber using a perforated stainless-steel plate as an abrasive surface, an integrated water system, a structured support frame, and a 1hp electric motor as its power source. Evaluation was based on the effect of peeling drum utilization, encompassing different cassava root mass variations (5, 10, 15, and 20kg) and residence time on key performance indicators (proportion by weight, peeling efficiency and throughput capacity). The machine exhibited commendable performance and was operated at a reduced speed achieved through a reduction gear mechanism, resulting in an average peeling efficiency of 87%. The machine's average throughput capacity stood at 105.10 kg/hr, and the average proportion by weight was 0.86 kg across all cassava root varieties (TMS 30572, TME 419 and TMS 30555). The introduction of a water system into the machine design facilitated the cleansing of peeled cassava roots, rendering them more amenable to subsequent processing and also contributing to heightened cassava root moisture content, which in turn bolstered peeling efficiency.

Keywords- Cassava peeling, cassava root, design, efficiency, machine

1 INTRODUCTION

Cassava (*manihotesculeta*) is an edible root and a perennial woody shrub, which grows in tropical and sub-tropical areas of the world. Cassava root has its origin from tropical America and was first introduced into Africa in the Congo basin by the Portuguese around 1558. Cassava is rich in carbohydrate, calcium, and vitamin B and C (Kordylas, 2002). It is an important dietary source of carbohydrates for approximately 800 million people in Africa, Asia and Latin America (Sowmyapriya et al., 2017). Also, cassava provides a livelihood for over 30 million farmers and countless processors and traders (Kolawole & Agbetoye, 2007).

Cassava root processing operations are often preceded by peeling which makes it a very important operation. Peeling the root of the cassava is the first procedure carried out after harvesting the cassava and debris has been removed. It entails peeling off the outer skin of the cassava roots or the thin layer elimination (more often called the peelings) from the cassava root. Peeling, therefore, must make sure which layer to take out, so that the cassava root peeled and the peels can be used for various purposes (Adetan et al., 2006). After cassava root peeling, it will be easy processing cassava root into garri or cassava flour, but the drudgery associated with peeling cassava manually (using of knife) has always been a challenging task. Thus, the need for mechanization of cassava root peeling machine is of immense significance.

* Corresponding Author

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Mechanization of the peeling process will extensively increase production rate, products quality and their general make it readily available (Aniedi et al.,2012). Mechanical peelers have diverse types of processes that interact directly with cassava skin which removes it in that way providing high quality fresh final products and they are environmentally friendly and nontoxic (Shirmohammadiet al.,2012). According to Kadurumba & Aririguzo (2021), several made attempts to solve these problems, has resulted in developing various cassava peeling machines. However, the common setback with these cassava root peelers is that cassava roots are reduced to a uniformly cylindrical profile with large amount of useful flesh wastage before achieving adequate peeling, having an efficiency as low as 45%. Therefore, a machine to facilitate the peeling of cassava root effectively and efficiently is important for those who want to engage in small- and large-scale cassava processing.

Olukunle et al. (2013) developed a double action/self-fed cassava root peeler. The machine requires resizing the cassava roots to 10cm and above before the peeling process. Machine throughput capacity was reported to be 410 kg/h, with 77 % efficiency and recorded a loss of useful cassava root flesh of 8 %. The brush speed and auger also influenced the cassava root peeling machine performance but has been given that a predetermined gear ratio linking them is maintained. The designed cassava root peeling machine is bulkier and incorporates intricate mechanical systems with complex operational procedures when compared to previous designs. It is also imperative to note that cassava root not up to 10 cm in length would be inadequately handled while peeling is done using this model. It is suitable to make sure that the cassava roots length is above 10 cm while trimming.
Jimoh & Olukunle (2012) designed an automatic cassava root peeler based on the developing and modifying of

the cassava root peeling tool of an earlier fabricated cassava root peeling machine utilizing the impact peeling principle. The cassava root machine peeler was tested and evaluated with different lengths of cassava root ranging from 150 – 300 mm and 150 – 600 rpm varied speed range. The result revealed that the size range tested, had a throughput capacity ranging from 76.0 – 442 kg/h, with peeling efficiency range between 55 – 78 %, having a mechanical damage ranging from 13 – 45 %, performance efficiency also ranged from 21 – 67 %, having peel retention with a range from 7.6 – 32.0 %. They stated that these results revealed significant development over the manual method (hand peeling) but had a lower throughput capacity of about 1000 kg/h as recorded by Olukunle & Adesina (2004) from the machines they developed.

A report on an automated cassava root peeling machine that consists of the cutting unit, metering unit and peeling unit inside the peeling chamber was reported by Olukunle & Akinnuli (2013). Their model was able to eradicate manual interference during cassava root peeling process since the device for metering was introduced to feed a pre-determined amount of cassava root into the chamber for peeling per unit time. The machine utilizes a rotary impact motion on the cassava root through abrasion or shear effect necessary for the cassava root peeling process, with about 500 – 583 kg/h throughput capacity. Their results revealed that increased speed of conveyor (160 – 285 rpm) with decreased brush speed (500 – 3000 rpm) resulted in a decreased peeling efficiency (88.72 – 48.50 %). Through a conveyor and speed of brush (150 rpm and 3000 rpm) respectively, peeling efficiency of 88.73 % was achieved, while at the conveyor and speed of brush (275 rpm and 500 rpm) respectively, peeling efficiency of 48.40 % was recorded, as the conveyor and brush speed ratio increased also from 0.050 to 0.550, respectively. It was observed also that increase peel thickness 0.10 – 5.0 mm resulted in decreasing the efficiency from 88.74 – 54.40 %. However, as the cassava root moisture content increased (46 – 75 %), the efficiency of peeling also increased (31.21 – 48.60 %). This might be as result of the higher the cassava root moisture content, the lower the adhesion of peel to the root the easier it is to be removed. However, there was a dispute that most factors that affect the cassava root moisture content for example days after harvest, maturity, climatic conditions, might had an influence in their result partially. Thus, cassava root moisture content and its time of residence in the machine peeling chamber ought to be put into consideration to prevent cassava root grating and high loss of cassava root useful flesh. Furthermore, peeling early immediately after harvesting should be promoted for improved peeling efficiency and production of quality produces.

A cassava root peeler and also cassava root washing machine developed by Ugwu & Ozioko (2015) was evaluated using different feed rates and speeds. With 15 pieces of cassava root input rate, the efficiency of peeling was 72.2 % at 750 rpm and 55.3 % at 385 rpm. Using 20 pieces of root feed input, gave 70.0 % at 450 rpm and 63.0 % at 385 rpm. With 25 pieces root feed input, machine peeling efficiency was 72.0 % at 450rpm and 59.0 % at 350 rpm. It was difficult to establish which machine speed performance was most excellent since only two speeds were used. The root pieces sizes were not also recorded, making evaluation and assessment of their machine difficult.

Adopting the abrasive drum principle, Akintunde et al. (2005) designed and fabricated a cassava root peeler which peels cassava roots that has been soaked in water in other to make the cortex softer. However, the peeling process was done using two perforated drums that are made to rotate in reverse direction. They gave a report of 83.0 % peeling efficiency and useful cassava root loss of about 5.4 %, having a 40 kg/hr throughput capacity. However, previous research on abrasive drum cassava root peelers by Nwokedi (1984), Ezekwe (1979) & Odigboh (1983a) reviewed that resizing cassava roots, enhance its efficiency more than the 45 %.

An abrasive multi-roller cassava root peeling machine designed by Edeh (2020), made up of an hopper, chamber for peeling, abrasive rollers, root discharge and chute for waste peel was developed and performance evaluation was conducted. The machine development was hinged on engineering specification and standards while putting into consideration cassava roots crop properties. The operational factors taken into account for the machine, encompassed characteristics such as the abrasive property of the peeling surface, the speed at which peeling occurred, and the duration of each peeling cycle. The peeling process was executed based on the abrasive principle... The cassava root peeler was tested for performance in throughput and peeling efficiency with commonly used cassava varieties NR 8082, 8083, 8208, 09/0581 and UMUCAS 38 at moisture content of 63.33, 64.50, 65.40, 63.50, and 84.33% respectively. The outcome of the performance evaluation carried out at a roller speed of 360 rpm revealed a 91% peeling efficiency; 2.17kg/min throughput capacity and 0.9% average peel proportion by weight. It further revealed that the cassava root moisture content assisted peeling. The machine removed the drudgery connected with manual cassava root peeling, and also the time and useful root flesh loss in conventional method of root peeling and gave an improved quality product when compared with already existing machines. The work revealed that cassava root moisture content affected the effective peeling of cassava root, and recommended peeling at increased moisture content.

2 Materials and Methods

2.1 Materials

The materials used for the fabrication of the cassava root peeling machine, presented in plate 1, are steel drum, perforated stainless steel sheet, agitator, axle (speed reducer), shaft, belt and pulley, framed angle iron and a knuckle joint.

2.1.1 Description of the Cassava Root Peeler

The machine comprises the following components: electric motor and gearbox (axle), belt and pulley drive,

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shafts, knuckle joint, cassava tuber feed section, peeled cassava root discharge chute, waste peel discharge chute, drum base plate with abrasive surface and support frame as shown in Figs. 1. Each of the components has function(s) to perform for the efficient performance and functionality of the cassava root peeling machine.

The cassava root peeling machine was powered by a 1hp electric motor with an incorporated gearbox serving as a speed reducer. With two shafts (running in and out of the gear box) aligned in a horizontal and vertical configuration, mechanical energy was transmitted from electric motor and gearbox through the belt and pulley drive system to the peeling chamber (drum) equipped with abrasive surfaces (in form of perforated sheets) for the purpose of cassava root peeling. The rotational motion of the peeling drum with its abrasive surface effects the peeling of the roots, while the introduction of an agitator inside the peeling drum assist in shuffling the cassava to enable every side of the cassava root to be peeled. The top of the peeling drum serves as the feed section was designed to serve as a portal through which the cassava tubers are introduced into the peeling chamber where the roots undergo peeling action. The peeled roots fall through the discharge Chute at the side of the machine. The peeling drum (perforated sheet) was assembled to a 5 mm clearance in between to allow for waste peel/flake discharge. Below the peeling chamber, there was a peel discharge chute designed as an inclined casing, facilitating the removal of peels or flakes from the peeling chamber. The whole assembly was mounted on mild steel angular bar support frame robustly designed to withstand torsional and vibrational energy occasioned by the operation of the machine.

The machine outer body was made up of a cylindrical mild steel drum that will be positioned vertically for operation, and an abrasive stainless-steel plate (for peeling) mounted around the internal surface of the drum and also on a rotating mild steel plate on the base of the inner drum. The inner drum would also have attached a water sprinkling system (sprinkling head), that would help for distribution of water across the peeling drum during peeling operation. Introducing the water system was to increase the cassava root moisture content for improved peeling, and also for washing of the peeled cassava roots (Edeh, 2020).

2.1.2 Principle of Operation

The element of the cassava peeling machine was meticulously designed and constructed to provide robustness and stability throughout its operation, ensuring efficient output. Freshly harvested cassava roots were introduced into the peeling drum via the upper aperture. As the drum base rotated, the cassava roots underwent peeling due to the friction generated by their contact with the abrasive surfaces within the peeling drum. Peeling occurs as a result of the interaction between the root and the abrasive surface, combined with their axial and rotational movements. During the peeling process, clean water is supplied into the peeling drum via a water sprinkler. This serves the dual purpose of elevating the moisture level of the cassava roots and effectively cleansing them as they undergo peeling. The 5mm spacing between the base plate and the drum inner wall, permit the peels to fall off the drum, into the waste collector. While the base plate is in motion, the peeled cassava is expelled through an aperture situated on one side of the drum. The machine imparts a rotary motion to the cassava roots, causing them to come into contact with the abrasive surface encircling the inner drum and the drum's base. This mechanism ensures the necessary and efficient peeling of the cassava roots. The machine is driven by a 1hp electric motor, with the base plate and speed reducer connected to it via a shaft. The speed reducer helps increase the resident time cassava roots will spend in the peeling drum to achieve better peel of the cassava roots (Kadurumba and Aririguzo, 2021). The electric motor was connected directly to the speed reducer (axle) through a shaft, with a knuckle joint, to enhance the connection alignment. The bottom part of the peeling chamber has a waste discharge chute, which assist in eliminating waste water and cassava peels from the system.

2.1.3 Material Selection Criteria

Material selection is of utmost importance to make certain that the components to be fabricated have the desired performance requirements. Given that the diverse components of the cassava peeling machine would encounter differing types and levels of stresses, strains, torque, and frictional forces, the selection of materials possessing suitable engineering properties was made. The materials consider for the fabrication of the cassava root peeling machine were selected after a careful study of the desired physical, mechanical and chemical characteristics of a number of proposed materials. For this project, due economic considerations and raw materials availability, high and medium mild steel and stainless steel was mostly used for body parts and peeling chamber while cast iron was chosen for the pulley, Khurmi and Gupta (2004).

2.2 METHODS

2.2.1 Machine Fabrication

The manufacturing process involved in this work includes, joining of metal parts by welding and fastening, cutting using hacksaw and hand cutting machine and punching to perforate the stainless-steel sheet. Each machine component is fabricated separately before they are assembled. The following are the procedure of fabrication of each component of the cassava root peeling machine and the final assembly.

A. Peeling Drum and Shaft Assembly

This assembly consists of several components, including the peeling drum, shaft, speed reducer, pulley, and knuckle joint. To streamline the construction process and manage costs, the pulleys, which can be relatively expensive to fabricate, were procured from the market due to their ready availability. A pulley with a diameter of 169mm and a 23mm 'shaft hole' was chosen based on the design specifications. The peeling drum itself was crafted from a sheet of medium carbon steel metal, with a dimension of 565mm x 40mm. To create the spikes on

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the drum, holes were punched into one side of the metal sheet in close proximity to each other. This punching process resulted in the rough texture on the opposite side of the metal sheet. The spacing and depth of the spikes were carefully controlled to ensure they were rough enough to effectively peel the cassava skin without penetrating too deeply into the useful flesh of the cassava root.

Subsequently, the metal sheet was folded into a cylindrical shape, and its edges were joined together using electric arc welding. Additionally, a circular end was cut out from another medium carbon steel sheet. Holes with a diameter of 23mm were drilled in the centre of this circular end, and it was welded to both ends of the drum. The drum was then mounted onto the shaft, with one end positioned 70mm from one end of the shaft and the opposite end of the drum situated 120mm from the other end of the shaft. These connections were securely welded in place. Bearings were also affixed to the shaft, each positioned 45mm away from the drum's ends and firmly welded to the shaft. Finally, the pulley was installed on the lower section of the shaft, maintaining a 15mm gap from the bearing, and secured in place with a bolt tightly fastened to the shaft.

B. Frame

High carbon steel angular iron was employed. Four 330mm lengths served as the frame's legs for ergonomic operation. Additionally, six 8000mm lengths were cut: two for leg support, two for the top frame, and the remaining two for the peeling compartment support. These components were securely welded using an electric arc welding machine.

C. Agitator

A spherical stainless-steel sheet was introduced to the system as an agitator to enable effective peeling of the cassava tubers. It helps the roots from sticking on the surface of the peeling drum.

D. Axle (speed reducer)

In the design of this cassava peeling machine, the axle functions as a speed reducer. This reduction in speed extends the duration cassava roots spend in the peeling drum, enhancing peeling efficiency and reducing peel weight (Kadurumba & Aririguzo, 2021). The increase in peel weight at higher speeds is due to the displacement of roots from abrasion as they move towards the exit, reducing contact during the operation. This finding has been documented by Ugwu & Ozioko (2015), Akintunde et al. (2005), Enyabine & Bassey (2013), Ukenna & Okechukwu (2014), and Nwokedi (1984).

2.3 Machine Design Considerations

The machine was designed with a focus on achieving high efficiency, acceptable throughput, portability, and reliability. It also has higher capacity compared to manual operation; ease of maintenance of the machine parts and component; versatility of the machine to peel cassava root of different sizes, shapes and varieties. Reliability, durability and rigidity of the materials for the machine components was ensured and proper arrangement of the transmission components so as to transmit efficient power. Lastly, cost and availability of the materials was considered.

ITEM NO.	PART NUMBER	QTY.
1	Frame	1
2	Gear Box	1
3	Gear Box Drive shaft	1
4	Waste colector	1
5	Washing drum	1
6	Spining wheel	1
7	larg Pulley	1
8	Floor Abrasive material	1
9	Wal Abrasive materal	1
10	Electric motore	1
11	Smal Pulley	1
12	Belt	1
13	Cover	1
14	shower	1
15	Discharge Door	1

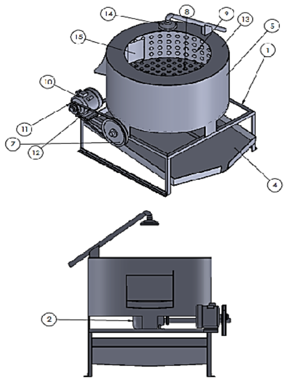

Fig. 1: BOQ of the fabricated cassava peeling machine

Plate 1: Picture of the fabricated cassava peeling machine

2.4 Machine Design Parameters

Presented in Table 1, are the various parameters used for designing the machine and their results.

2.5 Performance Test and Evaluation of the Cassava Peeling Machine

The design and fabrication of the cassava peeling machine were finalized, and the machine was subjected to testing to confirm the adequacy of its peeling efficiency. The cassava peeling machine was tested with cassava roots varieties (TMS 30572, TME 419, TMS 30555) sourced from the National Root Crops Research Institute (NRCRI) Umudike, Abia state, Nigeria. The machine was evaluated for performance in terms of proportion of weight of peel, throughput capacity, and peeling efficiency. The throughput was measured in terms of mass of roots per batch of peel per unit time.

The mass of peeled root, time of peel, mass of waste peel was duly noted during the test. According to Edeh (2020), the throughput capacity, T_C; proportion of weight of peel, P; and peeling efficiency, μ was obtained from the expressions of equations (3.19 – 3.21) given by Olukunle and Akinnuli (2013) and Olukunle and Jimoh (2012)

$$T_C = \frac{M_{pc}}{t} \quad (1)$$

$$P = \frac{M_{PC}}{M_C} \quad (2)$$

$$\mu = \frac{M_{pc}}{M_{PR} + M_{PC}} \quad (3)$$

Where M_C = mass of cassava (kg), t = time taken in seconds, M_{PC} = mass of peeled cassava (kg), M_{PR} = mass of peel retained (kg).

Table 1. Machine Design Parameters

Part Name	Input	Analysis	Result
Force on cylinder of the drum, F_c	M_d = density of mild steel (V_d) = volume of cylinder g = force due to gravity	$F_d = M_d \times g$	F_d = 188.4915 9N
Cylindrical base load of the drum F_b	M_b = density of mild steel g = force due to gravity	$F_b = M_b \times g$	F_b = 49.35013 N
Total load on the drum W_T	W_d= weight on the drum W_b = weight on the base	$W_T = W_d + W_b$	W_T = 237.8420 2N
Maximum working load of the cassava, F_w	γ_w= working strength of the machine A_d = cross-sectional area of the drum	$F_w = \gamma_w \times A_d$	F_w = 94.24580 N
Power required to drive the machine	The power is supplied by 1horse power (HP) electric motor single phase	1HP = 746watts	0.746KW
Speed of the driven pulley	N_1 is the speed of the driven pulley D_1 is the diameter of the driven pulley N_2 is the speed of the drive pulley D_2 is the diameter of the drive pulley	$N_1D_1 = N_2D_2$ $N_1 = \frac{N_2D_2}{D_1}$	N_1 = 86.868RPM
Differential gear of the machine	ring gear has 41 teeth (drive gear) pinion gear has 11 teeth (driven gear)	The gear ratio = $\frac{41}{11}$	Ring gear: pinion gear = 1: 3.73
centrifugal force of rotation of the cassava F	m = mass of the material = 9.61kg r is the radius of the drum = 0.3812m F = centrifugal force of rotation of the cassava ω_d = angular speed of the drum	$F = m\omega_d^2 r$	F = 21.789N
torque (Ʈ) of the machine	L = length of the shaft = 0.1016m G = 80 × 10⁹ N/m² $J = \frac{\pi}{32} \times d^4$ d = 0.035m θ = 0.3882rad	$\frac{Ʈ}{j} = \frac{G\theta}{L}$	Ʈ = 45026.48 98Nm

3 Results And Discussion

3.1 Parameters For Performance Evaluation

The data from the cassava varieties and parameter results for performance evaluation are as presented in Table 2. The table reviewed the time the machine took to peel the various varieties of cassava roots in respect to the varied weight of the cassava roots (5, 10, 15, 20kg) respectively fed into the machine for peeling. This showed that the more the cassava roots fed into the machine, the more time it took to peel, with 0.17hr recorded as the highest peeling time for all varieties. The weight of the peel from the cassava roots, weight of the peeled cassava roots, weight of the peel removed by hand and weight of root lost were also recorded. From the table, the variety TMS 30572 had a greater mass of peeled root of 17.11kg, and lower mass of root loss of 0.04kg. The average mass of root loss was 0.22kg across all varieties.

Table 2. Varieties and parameters for performance evaluation of the cassava peeling machine

Type	Mass of root before peeling Mc (kg)	Mass of peel, Mp (kg)	Mass of peeled root Mpc (kg)	Time of peel, t (hr)	Mass of peel removed by hand Mpr(kg)	Root loss MF (kg)
TMS 30572	5	0.54	4.42	0.039	0.54	0.04
	10	1.13	8.67	0.08	1.13	0.20
	15	1.53	13.22	0.13	1.53	0.25
	20	2.62	17.11	0.17	2.62	0.27
TME 419	5	0.62	4.21	0.038	0.62	0.17
	10	1.24	8.54	0.08	1.24	0.22
	15	1.55	13.18	0.13	1.55	0.27
	20	2.64	17.00	0.17	2.64	0.36
TMS 30555	5	0.57	4.38	0.04	0.57	0.05
	10	1.28	8.52	0.08	1.28	0.20
	15	1.54	13.24	0.13	1.54	0.22
	20	2.58	17.06	0.17	2.56	0.38

3.1.1 Performance Evaluation of the Cassava Peeling Machine

Presented in table 3 is the performance evaluation of the cassava peeling machine. The performance indicators which are throughput capacity, Proportion by weight and Peeling efficiency were obtained from equation (1) - (3) respectively. The machine throughput capacity was evaluated, from the results obtained, the throughput capacity of the machine increased with increase in mass of the cassava root. This was attributed to the fact that throughput is a function of input mass and process time, and also increased surface contact of the cassava roots. The variety TMS 30572 had the highest throughput capacity of 113.33Kg/hr at 5Kg mass of cassava fed, while the TME 419 variety had the lowest throughput capacity of 100Kg/hr at 20Kg cassava mass fed.

The proportion by weight was also determined using equation 2. From Table 3, the average proportion by weight across all varieties was 0.86Kg. The highest value of 0.88Kg for the proportion by weight was recorded for

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all varieties, and the lowest value of 0.84Kg was recorded for the TME 419 variety at 5Kg cassava mass fed. For machine efficiency, equation 3 was applied. From the results obtained, the machine had the highest efficiency of 90% for the varieties of TMS 30572 and 30555 at 5Kg mass of fed cassava. The lowest efficiency record across all varieties was 87% as captured in Table 3, this was attributed to the machine design and increased moisture content introduced during peeling from the water system. The overall average efficiency of the machine recorded across all varieties was 87%.

Table 3. Results of the Performance Evaluation of the Cassava Peeling Machine

Type	Mc (Kg)	Proportion by weight P	Mechanical damage (kg)	Peel retention (PR)	Peeling efficiency (µ) (%)	Throughput Capacity Tc (kg/h)
TMS 30572	5	0.88	0.05	0.04	0.89	113.33
	10	0.87	0.06	0.05	0.88	108.38
	15	0.88	0.04	0.03	0.90	101.69
	20	0.86	0.07	0.06	0.87	100.65
TME 419	5	0.84	0.04	0.03	0.87	110.79
	10	0.85	0.05	0.04	0.87	106.75
	15	0.88	0.05	0.05	0.89	101.38
	20	0.85	0.04	0.03	0.87	100.00
TMS 30555	5	0.88	0.04	0.03	0.88	109.50
	10	0.85	0.04	0.03	0.87	106.50
	15	0.88	0.05	0.04	0.90	101.85
	20	0.85	0.05	0.04	0.87	100.35

3.2 The Effect of Cassava Mass Variation on Proportion by Weight of the Cassava Peeling Machine

The proportion by weight, P of the cassava peeling machine was determined from two variables namely; weight of peeled roots, M_{PC} and weight of roots before peeling, M_C using equation 2. From Figure 2, the proportion by weight determined the rate of the peel removed including root losses. This was observed to attain its highest value of 0.88kg across all varieties at 15kg weight of cassava root per batch of peeling on the machine. The lowest value was observed to be 0.84kg for the TME 419 variety at 5kg weight of cassava root per batch of peeling.

3.3 Effect of Cassava Mass Variation on Peeling Efficiency of the Cassava Peeling Machine

Based on the data presented in Figure 3, the study assessed how the varying masses of cassava roots affected the peeling efficiency of the cassava peeling machine. The analysis revealed that the highest peeling efficiency, reaching 90%, was achieved when processing a batch of 15kg cassava roots, and this result was consistent for both TMS 30572 and TMS 30555 varieties. This determination of peeling efficiency was made using equation 3. Conversely, the lowest peeling efficiency observed across all cassava root varieties was 87%. It's worth noting that the improved peeling efficiency of this machine, compared to previously designed ones, can be attributed to the incorporation of a water system. This system enhances the moisture content of the cassava roots, a practice recommended by Edeh (2020).

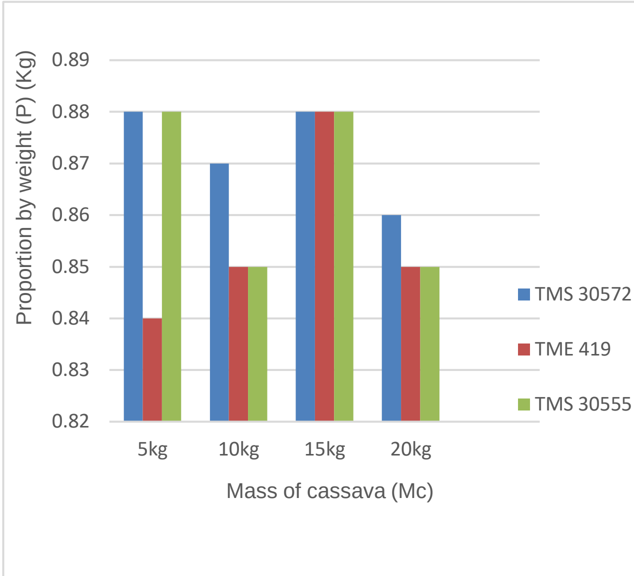

Fig. 2: Effect of cassava mass variation on proportion by weight of the cassava peeling machine

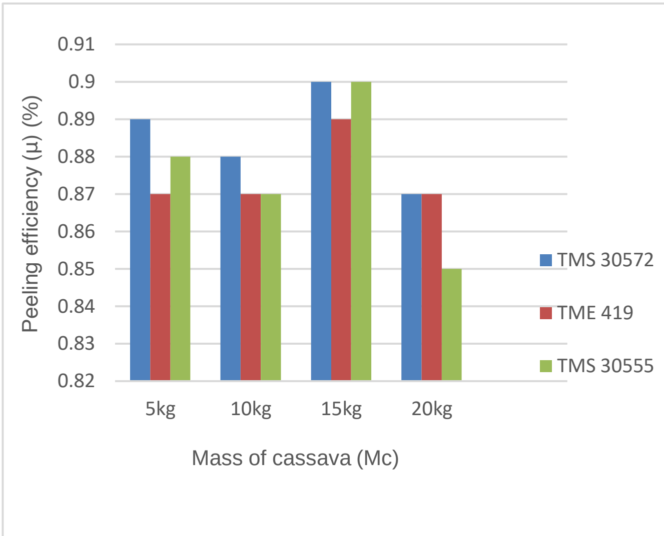

Fig. 3: Effect of cassava mass variation on peeling efficiency of the cassava peeling machine

3.4 The Effect of Cassava Mass Variation on Throughput Capacity of the Cassava Peeling Machine

Figure 4 illustrates the connection between the variation in cassava mass and the machine's throughput capacity. To compute the throughput capacity, we applied equation 1. As depicted in Figure 4, there's a notable decrease in the machine's throughput capacity as the cassava mass increases. This phenomenon can be attributed to the fundamental relationship between throughput, input mass, and processing time. When more cassava mass is fed into the machine, it requires a longer processing time. Among the findings, the machine achieved its highest throughput capacity,

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reaching 109.50 kg/hr, when processing 5kg of cassava mass for the TMS 30572 variety. Conversely, the lowest recorded throughput capacity was 100 kg/hr, observed when processing 20kg of cassava mass for the TME 419 variety.

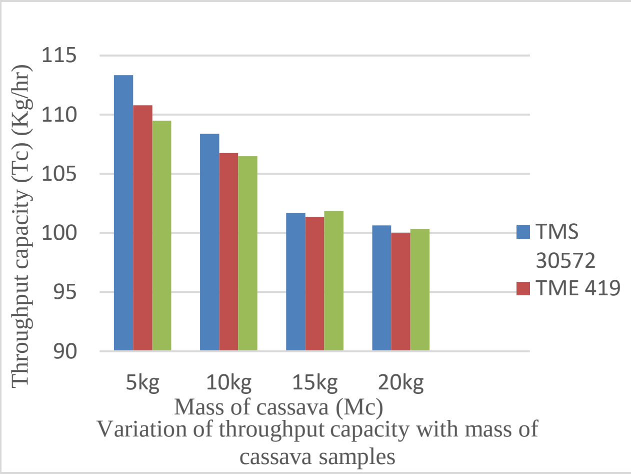

Fig. 4: Effect of cassava mass variation on throughput capacity of the cassava peeling machine

4 Conclusion

After an extensive review of the literature, followed by the fabrication and rigorous performance evaluation, we successfully developed a highly satisfactory cassava peeling machine. This machine exhibited an impressive average efficiency rate of 87%, achieved through the utilization of readily available raw materials and techniques. In the operation of the machine, cassava roots were manually loaded into the peeling drum, where the peeling process occurred. We systematically varied the mass of loaded cassava roots, ranging from 5kg to 20kg, to investigate its impact on the machine's performance indicators.

The machine demonstrated an admirable average throughput capacity of 105.10 kg/hr. Notably, its overall performance surpassed that of many existing cassava peeling machines. Consequently, due to its efficiency, affordability, and user-friendly design, the machine is deemed well-suited for industrial purposes. Nevertheless, some persistent issues associated with previous models of cassava peeling machines, particularly those related to the irregular shapes of cassava roots, were only partially resolved. To address this, we addressed the problem by resizing the roots to more uniform, linear dimensions. For enhanced efficiency, it is recommended that cassava roots be sorted by size, and the peeling machine be redesigned with adjustments tailored to the dimensions of the different cassava groups.

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