Turkish Journal of Food and Agriculture Sciences

TURJFAS

6(1): 26-37 (2024)

Research Article

DOI: https://doi.org/10.53663/turjfas.1385212

Modification and performance evaluation of yam peeling machine

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ARTICLE INFO

HISTORY

Received: 2 November 2023
Revised: 30 December 2023
Accepted: 17 January 2024
Online Published: 30 June 2024

KEYWORDS

Flesh Loss
Peeling Capacity
Peeling efficiency
Time efficiency
Yam peeling

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ABSTRACT

Yam is a versatile crop and plays a vital role in tropical regions, where it can be transformed into various food products. Peeling is an essential step in the processing of yam, as it increases its value. While manual peeling with knives is common in households, larger-scale production requires the use of yam peeling machines. The objective of this study was to analyze and enhance the performance of an existing yam peeling machine. The key components of the machine include the machine frame, a wire mesh-like drum, a speed reduction gear motor, a pumping machine, sprockets, pipes, and a water container. The yam peeler is powered by a three-phase 2 hp electric motor. The machine was tested on three different types of yams with varying moisture contents and at different speeds. Various performance parameters such as peeling efficiency, peeling capacity, flesh loss, and time efficiency were evaluated. Statistical analysis and SPSS models were utilized to examine the relationship between different factors and the performance metrics of the machine. The study revealed that as the peeling speed increased, the efficiency decreased. The peeling efficiency ranged from 63.27% to 92.74%, peeling capacity ranged from 2.28 kg/h to 11.34 kg/h, and flesh loss varied from 7.26% to 36.73%. The moisture content of the yams, peeling speeds, and tuber morphology were found to have significant effects on peeling efficiency, flesh loss, peeling capacity, and time efficiency. The yam peeler production cost is estimated to be $150. The machine demonstrated suitability for small-scale food industries due to its low cost and minimal maintenance requirements.

Citation: Adetola, O. A., & Mustapha, I. A. (2024). Modification and performance evaluation of yam peeling machine. *Turkish Journal of Food and Agriculture Sciences*, 6(1), 26-37.

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e-ISSN: 2687-3818

1. Introduction

The term "yam" refers to a group of Dioscorea-related tuber crops. Around 72.6 million tons of yams were produced worldwide in 2018 (FAOSTAT, 2018). *Dioscorea rotundata*, *D. alata*, *D. trifida*, *D. polystachya*, and *D. esculenta* are some of the common yam species (Arnau et al., 2010). The most significant yam in the world is the white Guinea yam (*D. rotundata*), which is mostly produced in West and Central Africa, particularly in the "yam belt" countries of Côte d'Ivoire, Ghana, Togo, Benin, Nigeria, and Cameroon (FAOSTAT, 2018). The yam plays significant roles in the lifestyle and culture of the people in the main yam-growing regions and is a staple crop in many tropical nations (Obidiegwu and Akpabio, 2017; Obidiegwu et al., 2020). But because of its limited global distribution, yam has been labeled an "orphan crop" and has gotten far less research funding than other main crop species.

The majority of yam tubers produced have been lost due to manual processing steps caused by a lack of machinery or equipment, which has limited yam processing to a home scale. For most uses, peeling-the process of removing the hard, scaly, brown skin is an essential step in the yam processing process. Because it is challenging to manufacture a peeling machine locally, tuber peeling is best done by hand (IITA, 2008). Most peeling is still done in Nigeria using traditional way. In the traditional method, the yam is peeled using a knife or small cutlass and this led to huge loss of the yam and also be very unhygienic. Due to lack of adequate, reliable and faster means of processing, apart from the manual, most of these yams are wasted. This informs the design of this machine, for effective processing of yam tuber into various food items. The research thus far on the creation of material peeling systems has identified five general peeling techniques: mechanical, human, heat, and abrasive action. Mechanical peeling is the category under which this work fits. Using abrasive techniques, this mechanical peeling may still be divided into manual and automated categories.

Additionally, due to the considerable diversity in root diameters and cortical thickness, existing tuber peeling machines are only moderately efficient and suffer from substantial tuber losses (Egbeocha et al., 2016). As a result, the peel is not correctly or entirely removed. Large tubers have been peeled inefficiently, and in some cases, roots have broken or been crushed (Adetan et al., 2005). Additionally, it had been noted that large-scale tuber peeling operations result in high labor input and substantial processing losses (Ukatu, 2005; Egbeocha et al., 2016).

Some yam peelers have been developed overtime with low efficiency, and appreciably high-speed damage were associated with the operation of the yam peelers and also most of the yam peeler cannot peel all varieties of yam efficiently. Ukatu et al. (2005) developed an industrial yam peeler with three spring-loaded peeler arms and peeler blades that scrape the tuber body to a predetermined depth. The material recovery rate ranged from 82.7 to 88.8%. The efficiency of peeling ranges from 62.7 to 80%. Adetan et al. (2005) designed a spring-loaded cassava peeling machine with five spring-loading points spaced at 140 mm intervals. Onorba (2010) used pressurized steam method to create a home yam peeling machine. restricted to yam tubers with a peeling efficiency of 47.8% that are no longer than 30 cm and have a somewhat curved shape. A yam peeling machine was developed by Adetoro (2012). It has a drum that is eccentrically attached on a shaft and rotates at different speeds, ranging from 20 to 50 rpm. The peeling efficiency, peeling capacity, flesh loss, power rating, and operating speed were 95%, 38.88 kg/ha, 3.90%, 0.973 kW and 20-50 rpm respectively. It cannot be used on yam of less than six tubers of yam. For a yam processing plant, Ayodeji et al. (2014) developed a yam peeling and slicing machine. With an average peeling time of 12.2 seconds, the machine's efficiency was 87-86%. A dual-functioning yam peeling machine was designed by Ojolo et al. (2016). During the peeling process, the machine uses power screw mechanics and spring-loaded peeling knives. The peeling efficiency, peeling capacity, flesh loss, power rating, and operating speed were 71-100%, 218 kg/h, 3.67-14.29%, 1.50 kW and 200 rpm respectively. The yam tuber's diameter has an impact on how well it peels. Bello et al. (2020) developed a yam peeling machine with two functions. It is a revolving drum with wire gauze that is constructed on a frame composed of iron rods and flat bars that are arranged longitudinally for a yam processing plant. In a motorized operation of the yam peeling machine, peeling loss ranged from 3.67-14.29%, while manual operation resulted in peeling loss ranging from 3.91 %-16.96 % respectively.

Ukatu (2005) reported a higher flesh loss of 17.30% while Bello et al. (2020) reported a flesh loss of 20-25%; Fadebiyi and Ajao (2020) achieved a flesh loss of 18% in their multi-tuber peeling machine. Adetoro (2012) achieved a peeling capacity of 38.88 kg/h, while the highest peeling capacity of 920.00 kg/h was achieved by Isa and Olukunle (2021). The peeling efficiency, peeling capacity, flesh loss, power rating, and operating speed were 90%, 700 kg/h, 3.67-14.29 %, 2.50 kW, and 350-750 rpm respectively. The peels or waste are passed through the perforated portion of the drum, while the tubers are fed and discharged through its single opening. Based on the surface scratching principle, Fadebiyi and Ajao (2020) designed and fabricated a batch loading tuber-peeling machine with a capacity of 10 kg/min. The peeling efficiency, peeling capacity, flesh loss, power rating, and operating speed were 40.20-61.10%, 600 kg/h, 18%, 3.0 kW, and 350 - 750 rpm respectively. As the shaft speed increased, so did the amount of flesh loss and the percentage of peel weight (Isa and Olukunle, 2021). The peeling efficiency, peeling capacity, flesh loss, power rating, and operating speed were 62.27-83.16%, 920 kg/h, 14.13%, 5.25 kW, and 1400 rpm respectively. Its performance evaluation revealed that the tuber size and auger-brush speeds had a significant impact on peeling efficiency, material recovery, and tuber loss.

Thus, the development of an efficient mechanical yam peeler with more good output results, cost effectiveness and also a yam peeler that can peel two to three varieties of yam. The development of this yam peeler would reduce the time consumed when peeling manually and also will increase the standard of living of local farmers by increasing the quality of crops produced and also make life easier and more comfortable for them by solving the challenges encountered when peeling the yam manually. For this reason, effective and reasonably priced tuber peeling machines are needed for the critical peeling stage of tuber processing. The purpose of the study is to modify the existing machine and evaluate its performance.

2. Materials and methods

2.1. Description of the existing machine

The yam peeling machine was originally developed in the Agricultural and Environmental Engineering department of the Federal University of Technology, Akure, Ondo State, Nigeria (coordinates: 7.2872° N, 5.1968° E). The machine features a wire mesh-like drum that is 45.3 cm in length and 15.5 cm in diameter and rotates on a shaft that is 92 cm in length and 3 cm in diameter. The distance between the drum-carrying shaft and the gear shaft is 45 cm. Figure 1.1a shows the design of the machine. The exploded view of the machine (1-handle; 2-right drum head; 3-rod; 4-wire gauze; 5-left drum head; 6-v-belt; 7- pulley; 8-motor seal; 9-electric motor; 10-shaft, 11- frame) is generally described in Figure 1.1b. The machine is composed of a rotating drum built with wire gauze wounded on a frame made of iron rods and flat bars in a longitudinal manner.

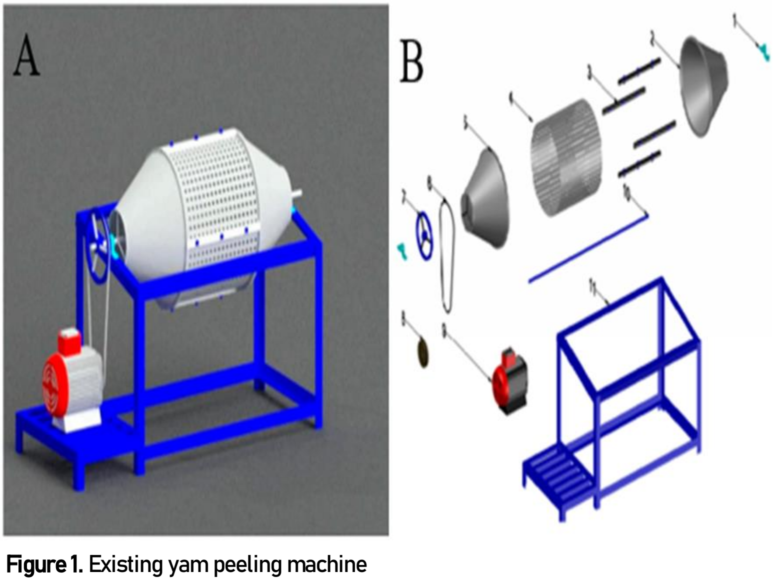

Figure 1. Existing yam peeling machine

A shaft is made to pass through the center of the drum supported at both ends with pillow bearings and at one end is mounted the pulley that enables the belt to be connected to the electric motor supported at the base with another frame. The entire component is placed on a frame support big enough to give the required rigidity. The drum has only one opening where the tubers are fed and discharged while the peels or wastes are passed through the perforated portion.

2.2. Modification of the existing design

In order to enhance the adaptability of the yam peeling machine, several factors were considered during its modification which include availability of locally sourced materials, cost of modification, safety, and selection of corrosion-resistant materials.

The modification carried out on the existing machine includes the introduction of a 0.5 horsepower pumping machine to keep the yam wet and wash away the peeled skin from the yams. The process was repeated until a cleaner peeled yam was obtained. Other modification includes the introduction of recycling water pipes (a 25 mm length pipe with a 1-inch diameter), strong stand to ensure good stability, and sprockets to get the optimum speed for the peeling machine.

2.3. Design analysis

The physical and mechanical variations between the various tuber kinds were taken into account when designing the yam peeling machine. The machine's capacity exceeds that of the human peeling technique, and the materials required to build it are easily accessible. The device drastically minimizes the amount of labor necessary for conventional peeling techniques and does away with the hassle of using a mono-tuber peeler. The peeling chamber, transmission unit, and cleaning mechanism for the redesigned machine are the main parts that need to be designed.

2.3.1. Determination of volume of peeling drum

Jimoh et al. (2012) recommended Equation 1 to determine the volume of the peeling drum.

$$v=\pi (D^2 L)/4 \tag{1}$$

where, V is the volume of the peeling drum (mm^3), D is the diameter of the drum in m = 0.0155 m, L is the length of the drum in m= 0.43 m. Therefore volume = 81148.04 ⟦mm⟧^3

2.3.2. Power requirement for peeling tubers

The torque of the peeling machine and the power required to operate the peeling drum, also known as the power to peel the tubers, were calculated using Equations 2 and 3 as recommended by Khurmi and Gupta (2005).

$$T=60P/2\pi N \tag{2}$$

Where T is the torque in Nm, p is the power in kW = 2.238 kW and N is the speed of rotation in rpm. Three different speeds of rotation for the drum were assumed (40 rpm, 50 rpm, and 60 rpm), Therefore torques of 534.21 Nm, 427.37 Nm and 3561.14 Nm were obtained respectively.

$$p=T\ 2\pi N/60 \tag{3}$$

Where, P is the power required to turn the peeling drum in kW = 2.238 kW, T1 is the torque on the drum in Nm = 534.21 Nm at the speed of rotation of 60 rpm, T2 is the torque on the drum in Nm = 427.37 Nm at the speed of rotation of 50 rpm and T3 is the torque on the drum in Nm = 3561.14 Nm at the speed of rotation of 40 rpm respectively.

The torque was determined using Equation 4 as recommended by Khurmi and Gupta (2005).

$$T=Fr \tag{4}$$

Where; T is the torque, F is the force acting on the inner drum wall = mg = mass of yam in kg = 2.89 kg, g is the acceleration due to gravity in 9.81 ms^{-2} and r is the radius of the peeling drum in m = 0.35m. Therefore, torque = 9.92 Nm.

The power requirement was determined using Equation 5 as recommended by Khurmi and Gupta (2005).

$$P=(T \times \omega)/(1000 \times \eta) \quad (5)$$

Where; p is the power in kW, T is the torque in Nm, ω is the angular velocity in rad/s and η is the efficiency in % = 92.74% = 0.9274.

The angular velocity was determined using Equation 6 as recommended by Khurmi and Gupta (2005).

$$\omega=2\pi N/60 \quad (6)$$

Where ω is the angular velocity, and N is the speed of the machine in rpm, which are 40, 50, and 60 rpm. Therefore, angular velocities for the three speeds are 4.18 rad/s, 5.24 rad/s and 6.28 rad/s. Power requirements for the machine at speed 40, 50, and 60 rpm using Equation 5 are 0.045 kW, 0.056 kW and 0.067 kW.

2.4. Component parts of the machine

A general breakdown of the modified machine's parts is shown in Figure 2. The machine consists of a revolving drum made of material that resembles wire mesh and is coiled longitudinally on a frame made of flat bars and iron rods. The drum's center is made out of a shaft that is supported at both ends by pillow bearings. To link the chain to the electric motor, which is supported on a different frame at the base, a pulley is installed at one end of the shaft. To guarantee enough stiffness, the complete unit is placed on a robust frame. Tubers are fed into and removed from the drum by a single entrance, while peels or other waste materials are released through the perforated area.

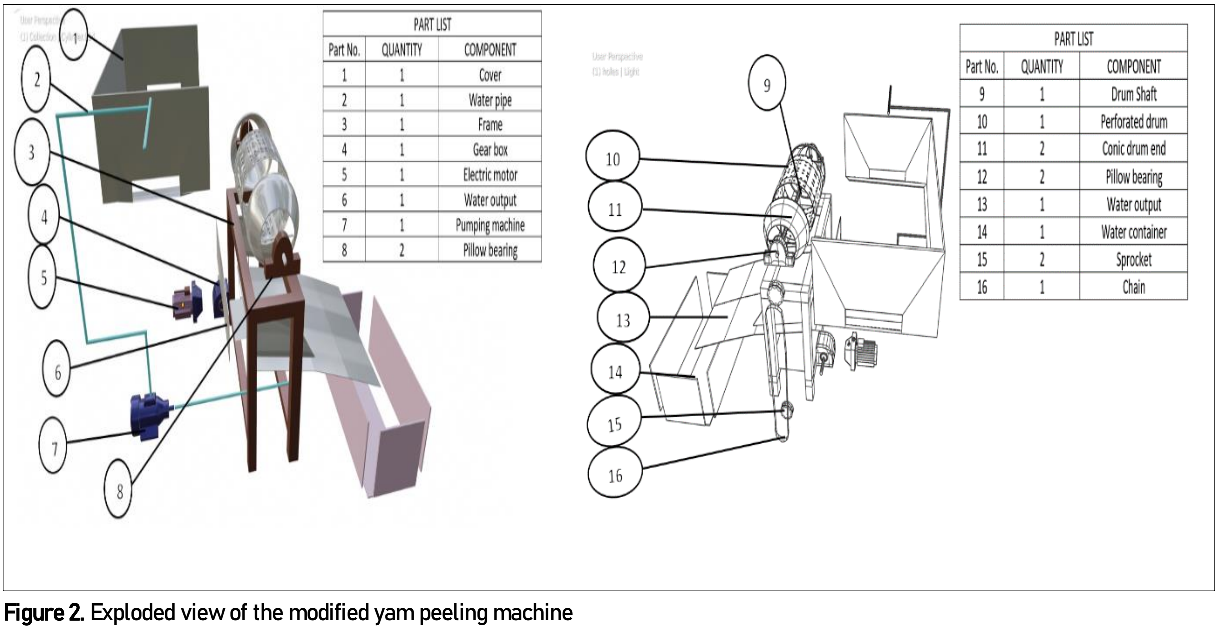

Figure 2. Exploded view of the modified yam peeling machine

2.4.1. Assembly of the new components

The peeling machine utilized various bought-out components, including a sprocket, pumping machine, water container, water pipe, elbow, t-joint, and angle bar iron. To accommodate the water container, angle bar iron was welded onto the four legs of the frame to increase the machine's height. Additionally, a sprocket was affixed to the machine to enable power transmission, and a pumping machine was installed to facilitate the cleaning of yams during the peeling process.

2.5. Construction detailed drawing

The peeling machine's isometric and orthographic projections can be seen in Figure 3, which provides a comprehensive view of the machine's construction.

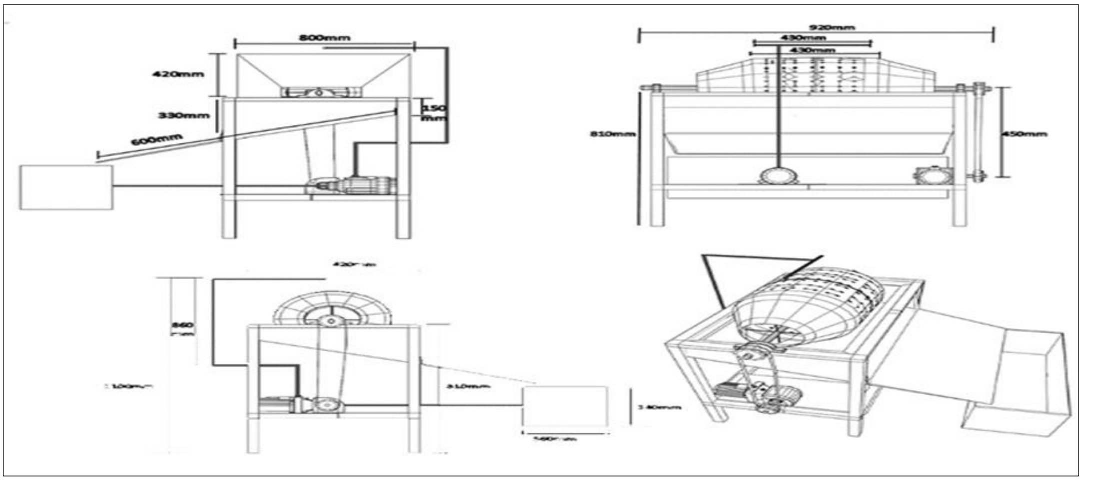

Figure 3. Orthographic view of the modified yam peeling machine

2.6. Performance evaluation of the modified machine

Three varieties of yam - white yam (*Dioscorea rotundata*), white guinea yam (*Dioscorea rotundata*), and water yam (also known as *Dioscorea alata*) - were procured based on their morphological aspect. Straight, fairly cylindrical yams were obtained, sorted by size, and fed into the yam peeling machine to ensure even tuber clearance. The weight of each yam tuber was recorded before and after mechanized peeling, along with the duration of peeling, the mass of peel removed by the machine, and the mass of the tuber after manual peeling. The experiment was conducted in triplicates, with three yam tubers of each variety tested at three different drum speeds (40, 50, and 60 rpm). Moisture content, tuber length, and size were measured following standard procedures, taking into account both transverse and longitudinal sections. The oven-dried technique was used to calculate the moisture content. The performance of the machine was determined based on varieties of yam, moisture content, the speed of the machine and the rate at which it cleans. The following performance indicators were statistically studied which are; capacity (kg/h), efficiency (%), peel loss (%), and time efficiency (kg/h). The peeling duration was set at 10 min, and the peeling speed was varied at 40 rpm, 50 rpm, and 60 rpm. The tests were repeated thrice, and the outcome was measured in terms of the machine's time peeling efficiency in kilograms per hour (kg/h).

2.7. Determination of performance evaluation parameters

2.7.1. Determination of peeling efficiency

The peeling efficiency of the yam peeling machine was calculated as the ratio of its throughput capacity to its theoretical capacity and expressed as a percentage using Equation 7 as recommended by Balami et al. (2012).

$$\varepsilon = \frac{M_{po}}{M_{pr}} \times 100 \quad (7)$$

Where, ε is the peeling efficiency (%), M_{po} is the weight of yam peeled (kg), M_{pr} is the weight of yam fed into the machine (kg).

2.7.2. Determination of peeling capacity

The peeling capacity was determined using Equation 8 as described by Agrawal (1987).

$$W_p = \frac{M_p}{M_o} \times 100 \quad (8)$$

Where, W_p is the peeling capacity (kg/h), M_o is the time taken (h) and M_p is the total weight of tuber (kg).

2.7.3. Determination of flesh loss percentage

The flesh loss percentage refers to the amount of yam that is lost during the peeling process and it was calculated using Equation 9 as described by Agrawal (1987).

$$FL = \frac{M_o - M_f}{M_o} \times 100 \quad (9)$$

Where FL is the flesh loss percentage (%), M_f is the weight of flesh removed (kg) and M_o is the total weight of tuber (kg).

2.7.4. Moisture content determination

The machine was run under different operational parameters, including machine speeds of 40 rpm, 50 rpm, and 60 rpm. The moisture content of each tuber was determined by weighing the initial and final weight using a digital weighing scale. The moisture content of the yam was removed using the oven drying method set at 20℃ and the time was set to 10 min at every interval until the value became constant. Equation 10 was used to determine the moisture content.

$$M_c = \frac{W_w - W_D}{W_w} \% \quad (10)$$

Where, M_c is the moisture content, W_w is the weight of tuber, W_D is the weight of dried yam.

2.8. Statistical analysis

The data obtained from the experiment was analyzed using graphical method and with the use of SPSS. In SPSS, one-way ANOVA was used to investigate the effect of speed on peeling efficiency, flesh loss, and capacity for the three varieties of yam.

3. Results and discussion

3.1. Effect of speed and varieties on yam peeling efficiency

Figure 4 illustrates the effect of peeling speed on the peeling efficiency of the machine. The results indicate an inverse relationship between speed and peeling efficiency, whereby as the speed increases, the peeling efficiency decreases. The highest peeling efficiencies were obtained at the lowest speed (40 rpm) with mean values of 92.73%, 82.51%, and 91.00% for white yam (*Dioscorea rotundata*), water yam (*Dioscorea alata*), and white guinea yam (*Dioscorea rotundata*), respectively. At a speed of 50 rpm, the mean peeling efficiency dropped to 84.83%, 73.51%, and 83.67% for the respective yam varieties. The lowest mean peeling efficiencies of 74.90%, 63.26%, and 72.04% were recorded at the highest speed (60 rpm) for all moisture content levels (64.93%, 75.76%, and 66.95%). The highest peeling efficiency was at the highest with water yam (*Dioscorea alata*) having 75.76% and white yam (*Dioscorea rotundata*) having the moisture content of 64.93% while white guinea yam (*Dioscorea rotundata*) has 66.9% this shows that moisture content of yam tuber has influence on the peeling efficiency of the machine. These findings suggest that to achieve optimal peeling efficiency, yam peeling requires low machine speeds, which is consistent with the observations made in previous studies (Olukunle, 2012; Jimoh et al., 2014; Isa and Olukunle, 2021) regarding the correlation between increased mechanical damage and loss of yam ground tissue at higher machine speeds. According to Ojolo et al. (2016), the mass of the tubers is one more factor that could influence peeling efficiency in addition to speed. Ukatu (2005) reported that the diameter of the tuber has no bearing on peeling efficiency, Adetoro (2012) proposed that peeling efficiency is based on the size of the tuber. This disparity may be due to the various methods used in designing the yam peeling machine. The modified machine used in this study exhibited higher peeling efficiency compared to the initial machine developed.

The current research achieved a peeling efficiency range of 63.27-92.74%. The variation in peeling efficiency could be attributed to differences in the design and operating conditions of the yam peeling machine used in each study, as well as the yam varieties and properties used. However, the current research's peeling efficiency is relatively consistent with the results reported in other recent studies. Therefore, the yam peeling machine used in this study can be considered efficient in terms of peeling performance. The peeling efficiency mean ranged from 72.04 %-92.7%, with the White yam (*Dioscorea rotundata*) variety achieving the highest peeling efficiency of 92.7% at a machine speed of 40 rpm and moisture content of 64.93% respectively. This is because White yam (*Dioscorea rotundata*) has a fairly rough skin. The water yam (*Dioscorea alata*) variety recorded the lowest peeling efficiency of 63.26% at a machine speed of 60 rpm with a moisture content of 75.76%.

The soft skin and high moisture content of water yam (*Dioscorea alata*) result in the lowest peeling efficiency. The graph illustrates that the peeling efficiency of the machine increases at a machine speed of 40 rpm but declines as the speed increases to 50 rpm and 60 rpm. The results obtained in this study is higher than the ones obtained in the previous machine.

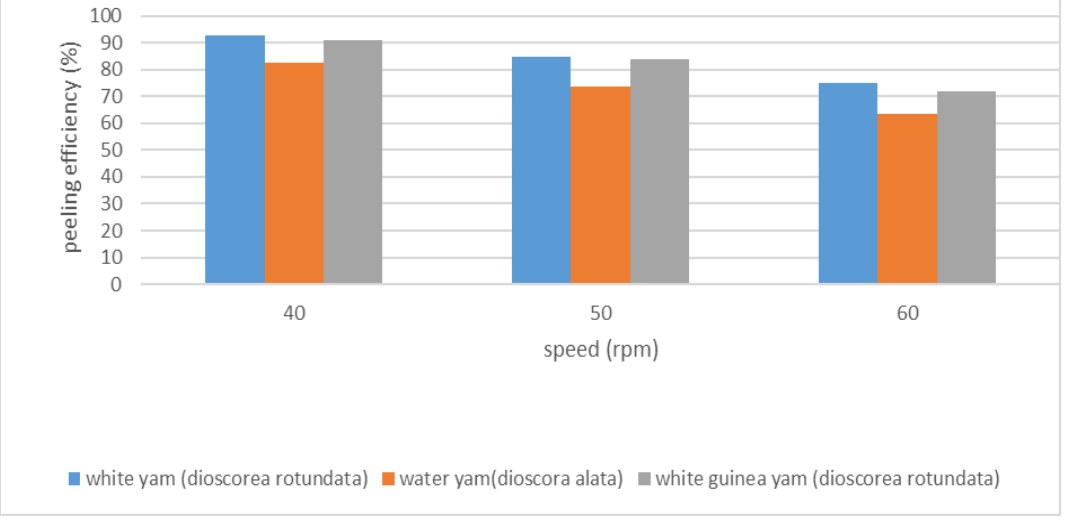

Figure 4. Effect of speed and varieties on yam peeling efficiency

3.2. Effect of speed on the flesh loss of yam

Figure 5 illustrates the impact of yam peeling machine speed on the flesh loss of different yam varieties. Overall, there is a direct relationship between the speed of the machine and the amount of flesh loss during peeling. The highest flesh loss was observed at the highest speed (60 rpm), with mean values of 25.09%, 36.73%, and 27.96% for white yam (*Dioscorea rotundata*), water yam (*Dioscorea alata*), and white guinea yam (*Dioscorea rotundata*), respectively. At a speed of 50 rpm, the flesh loss decreased to 15.16%, 26.48%, and 16.32% for the respective yam varieties. The lowest flesh loss of 7.26%, 17.48%, and 9.00% were recorded at the lowest speed (40 rpm) for all moisture content levels (64.93 %, 75.76%, and 66.95%). The findings suggest that to minimize flesh loss during yam peeling, it is preferable to use lower machine speeds. This finding is consistent with previous studies conducted by Isa and Olukunle (2021), which indicated that tuber loss increases with higher brush speeds and abrasive strength. Ojolo et al. (2016) found no clear correlation between the diameter or mass of the tubers and peeling loss.

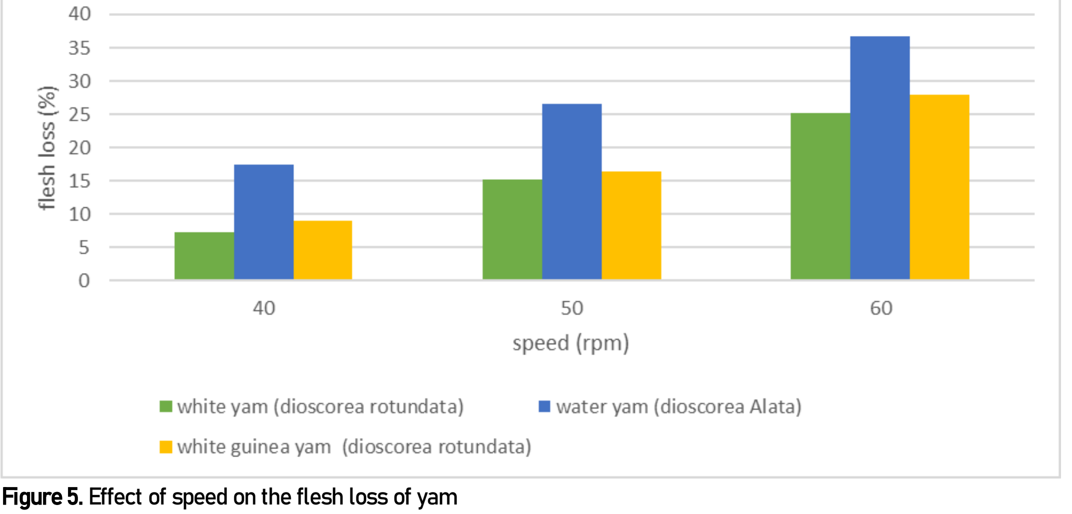

Figure 5. Effect of speed on the flesh loss of yam

Isa and Olukunle (2021) confirmed a direct relationship between abrasive force, speed of the peeling brush, and tuber loss. The current research showed a range of 7.26-36.73% for flesh loss. The variation in flesh loss across all studies can be attributed to differences in yam varieties and the methodology employed in designing the yam peeling machines.

The flesh loss ranged from 7.26-36.73%, with the Water yam (*Dioscorea alata*) variety recording the highest flesh loss of 36.73% at a machine speed of 60 rpm and 75.76% moisture content. The morphology of water yam (*Dioscorea alata*) might have a direct effect on the high flesh loss and the soft skin of the yam. In contrast, the white yam (*Dioscorea rotundata*) variety recorded the lowest flesh loss of 7.26% at a machine speed of 40 rpm. The graph illustrates an increase in flesh loss with higher machine speeds of 60 rpm, followed by a decline as the speed reduces to 50 rpm and 40 rpm. These findings suggest that yam peeling should be carried out at lower machine speeds to achieve lower flesh loss, which is consistent with previous studies by Isa and Olukunle (2021) who found that tuber loss increases with abrasive strength at higher brush speeds. The results obtained in the modified machine is higher than the ones obtained in the previous machine.

3.3. The effect of speed on the time efficiency

The graph in Figure 6 shows the relationship between the speed of the machine and the meantime efficiency. It can be seen that the highest time efficiency was recorded at the highest speed (60 rpm), with values of 8.49 kg/h, 2.13 kg/h, and 4.80 kg/h for white yam (*Dioscorea rotundata*), water yam (*Dioscorea alata*), and white guinea yam (*Dioscorea rotundata*), respectively. At a speed of 50 rpm, the mean peeling efficiency dropped to 7.38 kg/h, 1.68 kg/h, and 5.37 kg/h for the respective yam varieties, with Water yam (*Dioscorea alata*) having the lowest time efficiency. On the other hand, at speed 40 rpm, the results show 8.07 kg/h, 3.39 kg/h, and 5.73 kg/h for all moisture content levels (64.93%, 75.76%, and 66.95%).

The results suggest that the time efficiency of the yam peeling machine varies significantly with the peeling speed. Water yam (*Dioscorea alata*) has the lowest time efficiency due to the soft skin and high moisture content which made it easy for the machine to peel it much faster following white guinea yam (*Dioscorea rotundata*) and white yam (*Dioscorea rotundata*). Ojolo et al. (2016) found that a motorized yam peeling machine significantly reduced the time required for peeling compared to manual peeling. At the lowest speed of 40 rpm, the machine achieved a relatively consistent peeling efficiency, while at higher speeds of 50 rpm and 60 rpm, the efficiency was more variable. These findings indicate the importance of selecting an appropriate peeling speed to optimize the performance of the yam peeling machine. The graph illustrates that the peeling efficiency of the machine varies as the machine speed changes from 60 rpm to 50 rpm and 40 rpm. The results obtained for the time efficiency in the modified machine is higher than the ones obtained in the previous machine.

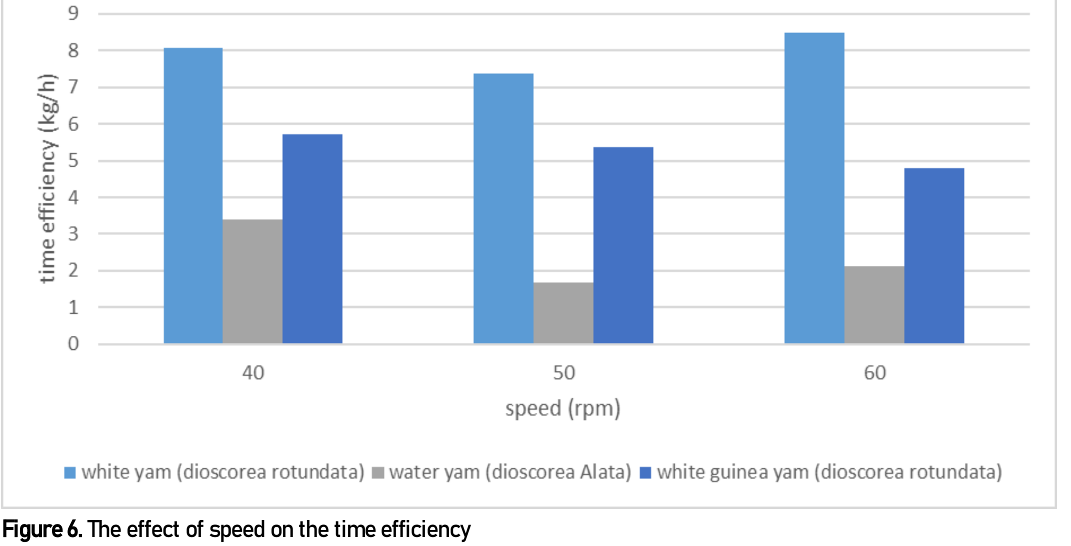

Figure 6. The effect of speed on the time efficiency

3.4. Impact of speed on yam peeling capacity

From Figure 7 it can be observed that the peeling capacity of the yam peeling machine is affected by the peeling speed. The peeling capacity is the highest at the highest speed (60 rpm) and decreases as the speed decreases (50 rpm and 40 rpm). For example, at the highest speed, the mean peeling capacity ranges from 3.36 kg/h to 11.34 kg/h for the different yam varieties, while at a speed of 50 rpm, it ranges from 2.28 kg/h to 8.70 kg/h, with water yam (*Dioscorea alata*) having the lowest peeling capacity. At a speed of 40 rpm, the mean peeling capacity was 8.70 kg/h, 4.11 kg/h, and 6.30 kg/h for all moisture content levels (64.93%, 75.76%, and 66.95%). The results indicate that the peeling capacity of yam peeling machines has indeed varied widely in previous research studies since 2012. The peeling capacity of the machines ranged from 38.88 kg/h to 920.00 kg/h, depending on the specific study. The current research achieved a peeling capacity ranging from 2.28 kg/h to 11.34 kg/h. The findings also highlight that the peeling capacity significantly differs among the studies, which can be attributed to various factors such as the design of the machine, the type of yam being peeled, and the specific operating conditions used in each study. Therefore, when designing or selecting a yam peeling machine, it is crucial to carefully consider the optimal peeling capacity required to meet the desired processing capacity for the specific type of yam being utilized.

Therefore, it can be concluded that the higher the peeling speed, the higher the peeling capacity, as more yam can be peeled per hour at a faster speed. However, it is important to note that the peeling capacity also depends on other factors, such as the moisture content, skin toughness, shape, and varieties of the yam. The graph illustrates that the peeling capacity of the machine varies at a machine speed of 60 rpm to 50 rpm and 40 rpm.

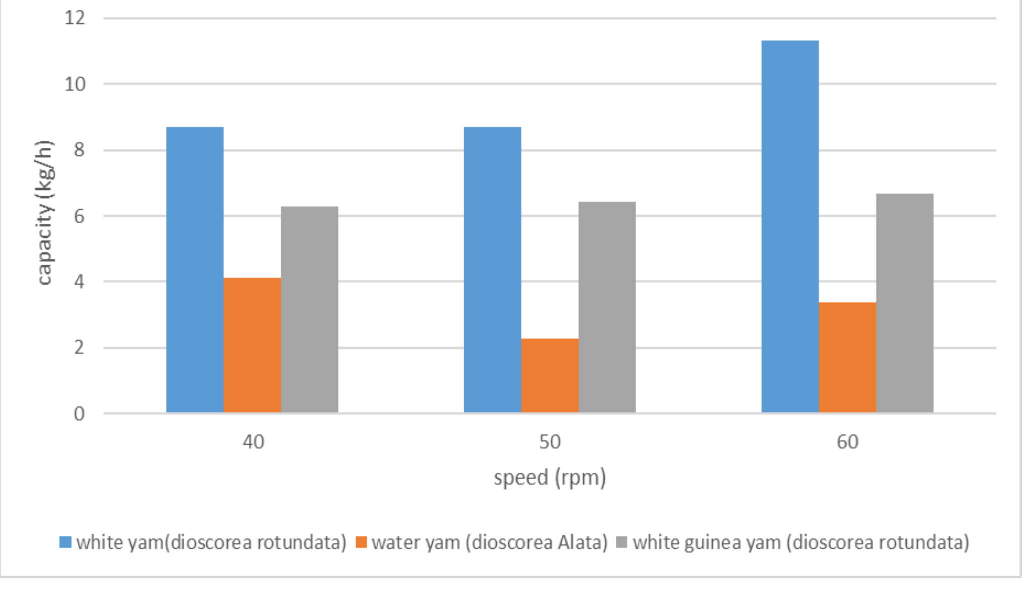

Figure 7. Impact of Speed on Yam Peeling Capacity

4. Conclusions

The peeling efficiency and capacity of the yam peeling machine are influenced by the operating speed and the variety of yam being peeled. The study found that the lowest speed of 40 rpm achieved relatively consistent peeling efficiency while higher speeds of 50 rpm and 60 rpm resulted in more variable efficiency. The highest peeling capacity was recorded at the highest speed (60 rpm), with mean values ranging from 3.36 kg/h to 11.34 kg/h, while the lowest capacity was recorded at a speed of 50 rpm for Water yam (Dioscorea Alata). In addition, the operating speed and yam varieties had a significant impact on the peeling efficiency and capacity with a p-value less than 0.05 which suggests that it is important to select an appropriate peeling speed and yam variety to optimize the performance of the yam peeling machine.

5. Recommendations

However, further research could be conducted to optimize the design and operating conditions of the yam peeling machine to achieve even higher peeling efficiency. Additionally, it is essential to consider factors such as cost-effectiveness, ease of use, and maintenance requirements when designing yam peeling machines for commercial use.

Compliance with Ethical Standards

Conflict of Interest

As the author of article declare that there are no conflicts of interest with respect to the research, authorship, and/or publication of this article.

Authors' Contributions

Olufemi Adeyemi ADETOLA: Conceptualization, writing original draft, review, and editing and validation.

Idris Ajibola MUSTAPHA: Investigation, methodology, formal analysis, writing original draft and data curation.

Ethical approval

Not applicable.

Funding

No financial support was received for this study.

Data availability

Not applicable.

Consent for publication

We humbly give consent for this article to be published.

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