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Design and Fabrication of a Mechanised Centrifugal Melon Shelling and Cleaning Machine

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Abstract A mechanized centrifugal melon shelling and cleaning machine with a capacity of 114kg/h was developed and tested at the fabrication workshop of Agricultural and Biosystems Engineering, University of Ilorin. It comprised of the hopper, feed control mechanism, shelling unit, cleaning unit, power transmission unit and the frame. The machine performance was evaluated using a $2 \times 3 \times 5$ factorial experimental design for shelling two varieties of melon seeds, (eastern and northern) varieties .The factors in the factorial experiment were at three levels each of shaft speed (1400 rpm, 2100 rpm and 2800 rpm), melon varieties (eastern and northern) and the moisture content of the seed (7%, 12%, 17%, 22% and 27% wet basis). Each treatment combination was performed in triplicates making a total of 90 values. The results showed that the highest shelling efficiency for variety E was at 78.7% at a moisture level of 17% and operating speed of 2100 rpm while the highest shelling efficiency for variety N was 76.5% at a moisture content of 22% and operating speed of 2100 rpm. Also, the highest cleaning efficiency for variety "E" was recorded as 66.4% at a moisture content of 17% and operating speed of 2800 rpm while the highest cleaning efficiency for variety "N" was recorded as 64% at a moisture content of 22% and operating speed of 2800 rpm. Therefore, melon shelling machine based on this technology could provide quality melon seeds at low cost for domestic use and for melon oil processing industry.

Keywords: Melon, oil, efficiency, moisture, speed

Introduction

Melon *(Citrullus Species)* popularly referred to as *"egusi"* in Yoruba language is one of the important oil-seed crops widely grown and consumed in tropical Africa. They are grown in Nigeria not for their pulp which is bitter, but for their seeds which are particularly rich in protein and fat, in addition to essential vitamins and minerals. The seed kernel (*Egusi)* has been used as the basis for a number of soups where it results in thickening, emulsifying, fat binding and flavouring. The oil is also used and is highly valued (Oyenuga and

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fetuga, 1975). Processing of melon include fermentation, coring, washing, drying, shelling and oil extraction (Kassim *et al*., 2011).

Previous researches done by Mohammed (2005) and Anibaloye (1985) reported that in Nigeria, melon are shelled traditional using twisting and pulling method, bulk sack impact method and bulk sack stamping method. These methods are usually slow, time consuming, tedious, inefficient and involve drudgery, thus limiting the availability of the product in the market. This has given concern to scientist and researchers in the recent past, particularly since women are the major processors of the melon especially at shelling stage (Kassim *et al*., 2011).

In Nigeria, some mechanised shelling techniques for melon seed have been introduced which includes attrition (friction) and impact method. In the impact method, Centrifugal force plays a major role in this method of dehusking. This force refers to an inertia force (also called a 'fictitious' force) directed away from the axis of rotation that appears to act on all objects when viewed in a rotating reference frame. Centrifugal shelling principle entails the use of centrifugal force to direct and shell seeds. Shelling of melon takes place throughout the circumference of the encasement. The advantages include; high productivity in dehusking and separation with reduction in dehusking and separation time (Oriaku *et al.*, 2013).

Some of the locally developed and fabricated machines for melon shelling are those of Odigbo (1979), Olusegun and Adekunle (2008) and Rotimi (2006). Odigbo (1979) employed arrangement of radial vane impeller, impeller with vane positioned at varying angles to the radius and impeller with vane positioned at right angle to the radius having four vanes each. The study revealed that impeller with vane positioned at 45^0 to the radius gave the best combination of higher shelling and low percentage of damage to the shelled melon. Similarly, Olusegun and Adekunle (2008) replaced the metal disc shellers with ones made of seasoned wood. The shelling of melon seeds was increased and the percentage of seeds broken was reduced.

Melon shelling and winnowing in Nigeria is still done manually or traditionally using hands to crack open the seeds or hitting the melon in a sack against a hard surface or stone. Winnowing is done locally by using tray to throw the cracked melon into the air. With the difference in the aerodynamic properties of the chaff and the inner cotyledon, the natural flowing air separates the chaff from the clean seeds. This method is usually stressful, time consuming and often requires more labour to accomplish this task. With the increasing demand and orientation on the economic value of melon, the traditional method would not be able to increase its productivity. Melon post-harvest processing which involves shelling and winnowing can not be sustained by the current low level of mechanization in the midst of the production that is in the order of an astronomical demand, where traditional methods are used in separating the seeds from the pods. This method is usually usually stressful, time consuming and often requires more labour to accomplish this task. With the increasing demand and clamour for value addition in the production chain of melon seed processing, the traditional method would be needed to be appraised with the possibility to increase its productivity.

The development in the mechanization of melon *(egusi)* shelling machines is still passing through phases of improvement. The existing machines are not generally acceptable to users because of their sophistication, low output and absence of cleaning unit. Development of agricultural processing machine is essential with the view to enhancing the capacity and enforcing potentials of the cottage industry in a growing economy (Olaoye, 2011).

The manual traditional method of shelling melon is highly energy demanding and time consuming. This makes it necessary to develop a mechanised centrifugal melon shelling and cleaning machine.

The objective of this study was to develop a mechanized centrifugal melon shelling and cleaning machine.

Materials and methods

Design Considerations

In the proper designing and development of the melon shelling and cleaning machine, the following were put into consideration:

i. Capacity of the hopper;
ii. The angle of repose of melon for the hopper design;
iii. The aerodynamic properties of the melon;
iv. The speed of the electric motor and the impact force required to crack open the melon;
v. Magnitude of centrifugal force developed by the spreader disc; and
vi. Stability and strength of the frames to carry other components and necessarily withstand further impacted load.

Design Calculations

The aim of the design calculations and other considerations is to evaluate the necessary design parameters and the selection of appropriate materials for the construction process.

A centrifugal force is set up on the rotating shelling disc assembly due to the rotation of the shaft and shelling drum. The centrifugal force generated is determined by applying Equation 1.

$$F_C = \frac{M_T \omega^2 D}{2} \tag{1}$$

where,

$F_C = Centrifugal\ Force$
$M_T = Total\ mass\ of\ shelliing\ disc\ and\ shaft\ (kg)$
$\omega = angular\ velocity\ of\ the\ shelling\ disc\ assembly\ (rad/s)$
$D = Diameter\ of\ shelling\ disc\ (m)$

The shaft diameter is needed in order to determine the load carrying capacity of the shaft. For a solid shaft with little or no axial load, the diameter of the shaft is determined by Equation 2 as presented by Khurmi and Gupta (2005).

$$d^3 = \frac{16}{\pi S_s} \times \sqrt{(K_b M_b)^2 + (K_t M_t)^2} \tag{2}$$

where,

d= is the diameter of the shaft
S_s= is the allowable stress
K_b= Combine shock and fatigue factor applied to bending moment = 1.5 (Hall *et al*., 1980)
M_b= is the bending moment
K_t= Combine shock and fatigue factor applied to torsional moment = 3.0 (Hall *et al*., 1980)

The shaft is under a combined load of bending moment and torque and is given by Equation 3 as defined by Khurmi and Gupta (2005).

$$\tau_{max} = \frac{16}{\pi d^3} \sqrt{(M^2 + T^2)} \tag{3}$$

where,

τ_{max} = Maximum shear stress (N/m)
T= Torque (Nm)
M= Bending moment of shaft (Nm)
d= shaft diameter (m)

The capacity of the hopper was obtained by taking the angle of repose for the granular fertilizer as 30^0 into consideration and by following the principle of determining volumetric and gravimetric capacity of hopper as given by Olaoye (2016) and Agidi *et al*. (2013). Assuming 2kg of melon would be shelled in one minute and the bulk density (ρ_b) of melon, *bera* is $405kg/m^3$.

$$C_{mph} = C_{vph} \times \rho_b \tag{4}$$

where:

C_{mph} is the machine capacity in mass per (kg/hr)

C_{vph} is the machine capacity in mass per (m^3/hr)

$$C_{vph} = \frac{4.9 \times 10^{-3} \times 60}{1} = 0.294m^3/hr$$

$$C_{mph} = 0.294 \times 405 = 119kg/h$$

The power required to shell the melon was calculated using the equation as specified and as cited by Oluwole and Adedeji (2012) and Olusegun and Adekunle (2003).

$$P_s = T\omega \tag{5}$$

where,

$P_s =$ Power required to shell the melon in Watts

T = Torque of the shelling drum in Nm

$\omega =$ Angular velocity in rad/s

$$\omega = \frac{2\pi N}{60}$$

N = Speed of the shelling drum given as 950rpm

T= ωr

r =Radius of the shelling disc (m)

The shelling drum shaft was determined to know the size of the shaft diameter that will withstand the applied loads by following the expression in (2).

The blower duty was created by the spinning of the shelling disc and velocity of air generated by the circular motion of the shelling disc (V_g).

$$V_g = \omega \times r \tag{6}$$

where,

ω = angular velocity of the spinning shelling drum (rad/s)

r = radius of shelling disc (m)

Pneumatic separation of grains involves the separation of foreign materials from the grain with the aid of air stream. The air is made to pass through the disposed material to effect their separation. The design of a piping system for effective grain cleaning takes advantage of the variation in the aerodynamic properties of the grain. The terminal velocity of the shelled seeds and chaff was determined as follows (Mohsenin, 1970).

$$Mg = \tfrac{1}{2} \rho V_t^2 C_d A \quad (7)$$

$$\therefore V_t = \sqrt{\frac{2Mg}{\rho C_d A}} \quad (8)$$

where:

M = one thousand unit mass of melon = 94g = 94×10^{-6}kg/melon seed

g = gravitational acceleration = 9.81 m/s^2

C_d = drag coefficient for short cylinders = 1.15 (Tritton, 1988)

ρ = air density = 1.225kg/m^3

A = projected area of melon = $22.31 \times 10^{-6} m^2$ (Ali *et al., 2015*)

V_t= terminal velocity (m/s)

Description and Fabrication of the Component Parts

The main components of the fabricated shellers are the hopper, shelling unit, cleaning unit and power transmission system and the frame (Figure 1).

The hopper is a pyramidal frustrum with upper and lower openings. This is the structure through which melon seeds are been fed into the shelling unit. It is constructed of mild sheet of 1.5 mm thickness. The hopper has a top diameter of 300 mm, base diameter of 137 mm and slant height of 100 mm.

The shelling unit comprises of two circular wooden discs separated from each other by U channel shaped metal sheets to which rubber beaters are attached to. The bottom circular disc is attached to the shaft via a flange and connected to the electric motor through belt and pulley arrangement. The rotating shelling disc assembly generates a high air velocity in a whirly pattern at the base of the encasement so that any seed (shelled, unshelled and broken) that falls down on the base of the encasement after been beaten can easily be blown by the circular motion of the wind through a tangential path into the cleaning chamber.

The cleaning chamber serves as a conveying channel which helps to carry the shelled seeds through a piping chamber of varying diameters. This unit is formed from metal sheets of 1.5mm. It comprises of piping system connected to two large conical diametric openings. The first large diametric section serves as the chamber where fully shelled and clean seeds are collected while the second diametric opening serves as the chamber where shelled and broken seeds are collected. The final outlet serves as the chaff outlet.

The power transmission system comprise mainly of a 2hp electric motor, belt, pulleys and the shaft. The frame is made from 2 inches angle iron. The entire shelling unit rests on a circular frame made from 2 inches flat bar while the cleaning unit and electric motor rests on a 2 inches angle iron.

Mode of Operation of the Machine

Wetted melon at predetermined moisture content was fed into the machine through the hopper. Figure 1 shows the exploded view of the melon shelling machine. At this point, the electric motor has already been switched on to provide the shelling power needed. The seeds fed in between the two shelling discs was distributed and thrown by centrifugal force against the shelling vanes where the beaters are attached and these flings the melon against the metallic encasement housing the shelling discs in order to weaken their shells. The rotating shelling disc assembly generates a high air velocity in a whirly pattern at the base of the encasement so that any seed (shelled, unshelled and broken) that falls down on the base of the encasement after been beaten was easily blown by the circular motion of the wind through a tangential path into the cleaning chamber. The cleaning chamber serves as a conveying channel which helps to carry the shelled seeds through a piping chamber of varying diameters. At the first large diametric section, the shelled seeds falls freely under gravity and was collected while the broken and immature grain falls through the second chamber opening. Finally the chaff was blown out through the final chaff outlet. Figure 2 presents the Pictorial View of the fabricated melon shelling and cleaning machine.

Performance Evaluation

Test Materials

5kg each of variety E and N of melon seeds purchased from the market was used for testing the shelling machine. The melon seeds were cleaned from impurities and divided into three samples corresponding to the three operating speeds, each sample was weighed and soaked in water for ten minutes and subjected to natural air drying in order to obtain five different moisture contents (7, 12, 17, 22 and 27% wet basis) of melon seeds. Instant moisture meter was used to determine their moisture contents. The two varieties of the seed are variety E from the eastern part of Nigeria and variety N from the Northern part of Nigeria. The two seed varieties would be shelled at three different operating speeds (1400, 2100 and 2800rpm) so as to ascertain the best shelling speed of the machine. Prior to the shelling operation, each variety to be used was weighed and recorded so as to be able to know the weight of fed melon, shelled melon, unshelled melon, broken melon and losses. During the shelling operation, a stop watch was used to record the time spent for each shelling operation. The combination of two seed varieties, three speed levels and five moisture levels is so as to be able to ascertain the variety, operating speed and moisture content that gives the best result.

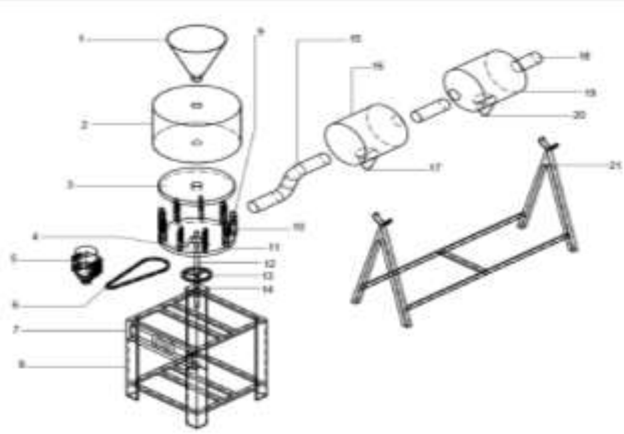

Figure 1. Exploded view of the Melon Shelling Machine

1-Hopper, 2-Shelling unit Casing, 3-Top Wooden Frame, 4-Metal plate, 5-Electric Motor, 6-Belt, 7-Electric Motor Base, 8-Frame, 9-Rubber Beaters, 10-Vanes, 11-Base Wooden Plate, 12-Shaft, 13-Pulley, 14-Bearing Holder, 15-Seed Passage, 16-Clearance Chamber 1, 17-Whole seed Outlet, 18-Chaff Outlet, 19-Clearance Chamber 2, 20-Broken Seed Outlet, 21-Clearance Chamber Frame

Figure 2. Pictorial View of the Fabricated Melon Shelling and Cleaning Machine

Performance Indices

In carrying out the performance evaluation, the following parameters were used (Olaoye, 2016):

1. **Shelling Capacity (S_c):** This is the weight of melon shelled (W) per unit time (T) expressed as:

$$S_c = \frac{W}{T} \text{ (kg/h)} \tag{9}$$

2. **Cleaning Capacity (C_c):** This is the quantity of seeds cleaned (C_q) per unit time (T) expressed as:

$$C_C = \frac{C_q}{T} \text{ (kg/h)} \tag{10}$$

3 **Shelling Efficiency (S_e) %:** This is the ratio of the weight of shelled melon obtained to the total weight of shelled melon seeds expected in percentage and is evaluated using the formular below:

$$S_e = \frac{X_a}{X_b} \times 100 \tag{11}$$

where,

$S_e = Shelling\ efficiency$ (%)

X_a = Weight of shelled melon obtained (g)

$X_b = Weight\ of\ shelled\ melon\ expected\ (g)$

4 **Cleaning Efficiency (C_e) %:** This is the ratio of the weight of separated impurities obtained to the total weight of separated impurities expected which is expressed in percentage and is evaluated using the formular below:

$$C_e = \frac{X_d}{X_d + X_c} \times 100 \tag{12}$$

where,

$C_e = Cleaning\ efficiency$ (%)

$X_d = Weight\ of\ seperated\ impurities\ obtained\ (g)$

X_c = Weight of separated impurities expected (g)

5 **Percentage Broken (P_b) %**: This is the ratio of melon loss to the total quantity of melon fed into the hopper expressed as a percentage and is given as:

This was evaluated as given below:

$$P_b = \frac{X_e}{X_f} \times 100 \tag{13}$$

where,

$P_b =$ Percentage Broken (%)

$X_e =$ Weight of seeds and chaff received at the seed and chaff outlets (kg)

X_f = Total weight of seeds fed into the hopper (kg)

Results

Operational Performancce of the Centrifugal Melon Shelling and Cleaning Machine

The results obtained from the operational performance of the developed centrifugal melon shelling and cleaning machine are presented in Tables 1 and 2.

The Effects of Moisture Content and Operating Speeds on the Performance of Shelling Machine

The effect of moisture content on shelling efficiency is presented in Fig. 3. Figures 4, 5, 6, 7 and 8 present details on the effect of operating speed on shelling efficiency, effect of moisture content on cleaning efficiency, effect of operating speed on cleaning efficiency, effect of moisture content on broken percentage, and effect of operating speed on broken percentage, respectively.
The effect of moisture content on the shelling efficiency of the melon is as shown in Figure 3. The highest shelling efficiency was recorded as 76.5% at a moisture content of 22% and operating speed of 2100 rpm while the lowest shelling efficiency was recorded as 26.1% at a moisture content of 7% and operating speed of 1400 rpm.

Table 1. Results of Melon Shelling Machine Using Variety "E"

Moisture Content %	**Shelling Speed (rpm)**	**N_0 (g)**	**N_1 (g)**	**N_2 (g)**	**N_3 (g)**	**N_4 (g)**	**N_5 (g)**	**N_6 (%)**
7	1400	500	100	80	220	40	40	26.7
	2100	500	180	90	145	20	65	48.0
	2800	500	150	110	143	20	70	40.0
12	1400	500	150	55	198	72	22	40.0
	2100	500	240	110	62	34	52	64.0
	2800	500	222	147	45	35	51	59.2
17	1400	500	180	30	200	55	30	48.0
	2100	500	295	50	50	40	60	78.7
	2800	500	240	110	30	30	83	64.0
22	1400	500	185	30	195	68	20	49.3
	2100	500	280	68	50	45	55	74.7
	2800	500	240	130	28	35	75	64.0
27	1400	500	172	38	200	70	18	45.9
	2100	500	250	100	60	40	50	66.7
	2800	500	225	148	40	35	50	60.0

N_0 = Total weight of the melon seeds fed into the hopper, N_1= Weight of the whole shelled seeds, N_2= Weight of broken shelled seeds, N_3= Weight of unshelled seeds, N_4= Weight of un-separated impurities, N_5= Weight of separated impurities, and N_6= Shelling Efficiency

Table 2. Results of Melon Shelling Machine Using Variety "N"

Moisture Content %	Shelling Speed (rpm)	N_0 (g)	N_1 (g)	N_2 (g)	N_3 (g)	N_4 (g)	N_5 (g)	N_6 (%)
7	1400	500	98	85	210	43	43	26.1
	2100	500	170	98	150	25	55	45.3
	2800	500	133	135	152	20	52	35.5
12	1400	500	140	61	203	75	20	37.3
	2100	500	224	117	67	43	47	59.7
	2800	500	214	152	50	35	48	57.1
17	1400	500	173	40	200	70	15	46.1
	2100	500	270	73	60	45	50	72.0
	2800	500	228	142	32	33	63	60.8
22	1400	500	172	35	209	52	30	45.9
	2100	500	287	59	60	40	53	76.5
	2800	500	235	115	39	30	80	62.7
27	1400	500	164	46	206	64	18	43.7
	2100	500	240	110	70	35	43	64.0
	2800	500	218	153	50	35	40	58.1

N_0 = Total weight of the melon seeds fed into the hopper, N_1= Weight of the whole shelled seeds, N_2= Weight of broken shelled seeds, N_3= Weight of unshelled seeds, N_4= Weight of un-separated impurities, N_5= Weight of separated impurities, and N_6= Shelling Efficiency

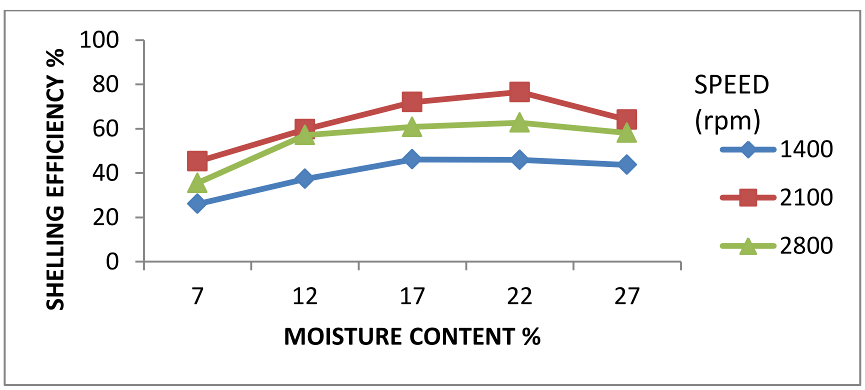

Figure 3. Effect of Moisture Content on the Shelling Efficiency for Variety "N"

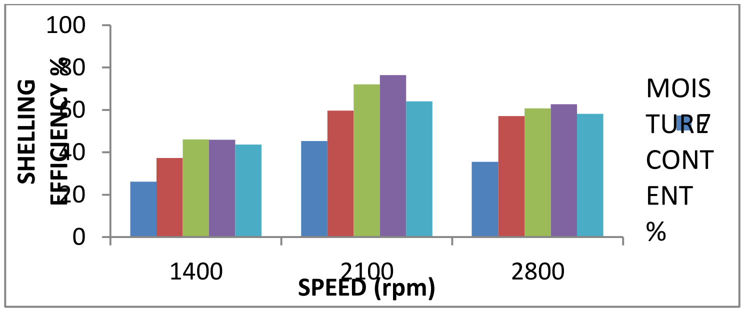

Figure 4. Effect of Operating Speed on Shelling Efficiency for Variety "N"

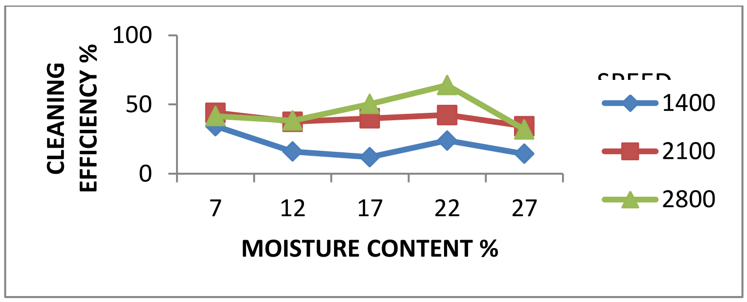

Figure 5. Effect of Moisture Content on Cleaning Efficiency for Variety "N"

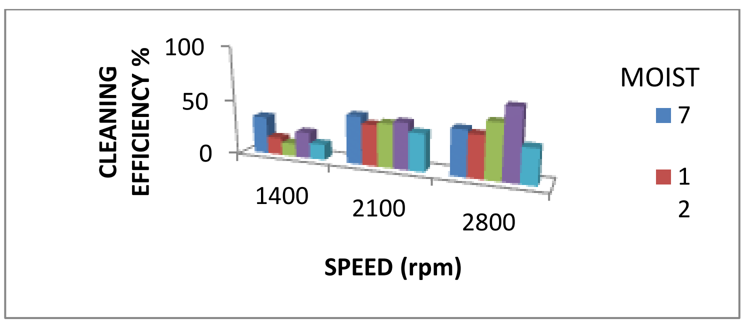

Figure 6. Effect of Operating Speed on Cleaning Efficiency for Variety "N"

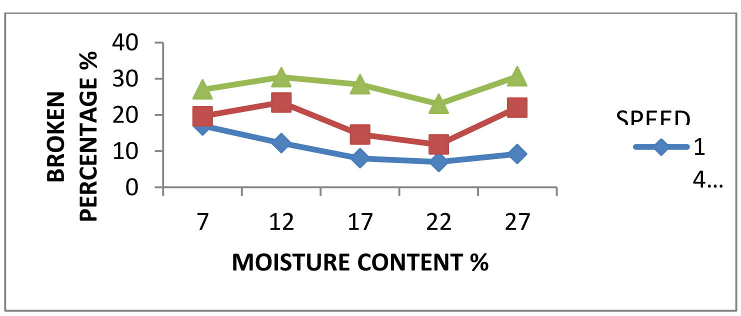

Figure 7. Effect of Moisture Content on Broken Percentage for variety N

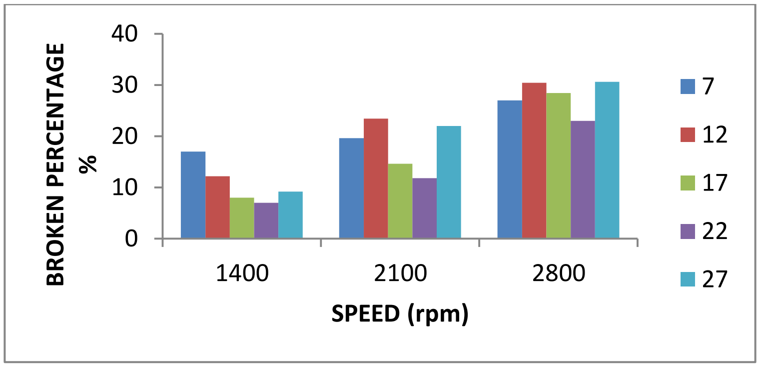

Figure 8. Effect of Operating Speed on Broken Percentage for variety N

Figure 3 showed that as moisture content increases from 7 - 27%, shelling efficiency also increases up to 22% moisture content. Above 22% moisture content, it was observed that the shelling efficiency dropped.

The effect of operating speed on the shelling efficiency of the melon is as shown in Figure 4. The highest shelling efficiency was recorded as 76.5% at an operating speed of 2100 rpm and moisture content of 22% while the lowest shelling efficiency was recorded as 26.7% at an operating speed of 1400 rpm and moisture content of 7%. The chart revealed that at an operating speed of 1400rpm, the shelling efficiency was low due to a low degree of centrifugal impact of the melon against the metallic encasement. At an optimum shelling speed of 2100rpm, the highest shelling efficiency was recorded with very minimal breakage recorded at a moisture content of 22%.

The effect of operating speed on the cleaning efficiency of the melon is as shown in Figure 6. The highest cleaning efficiency was recorded as 64% at an operating speed of 2800 rpm and moisture content of 22% while the lowest cleaning efficiency was recorded as 12% at an operating speed of 1400 rpm and moisture content of 17%.

Discussion

Effect of Moisture Content on Shelling Efficiency

Moisture content refers to the amount of water remaining in a product at a condition. The moisture content of melon is an important factor that affects the shelling and cleaning of shelled melon seeds. Olusegun and Adekunle (2008) stated that it is known that moisture increases the ease of shelling of melon to particular moisture content after which further increase in moisture content might lead to reduced shelling while leading to a high degree of breakage.

The difference in the optimum shelling moisture content for the two varieties revealed that the shells of variety “N” are harder and as such needed more moisture in order to crack open during the shelling operation without breakage. This is observation is corolated with the observed trend in the moisture content variation while cracking palm nut for recovery of its nut in a mechanical cracker cum separator (Olaoye and Adekanye, 2017).

Effect of Operating Speed on Shelling Efficiency

According to Makanjuola (1972), drum Speed has a significant effect on the shelling efficiency of melon as increase in operating speed increases shelling efficiency to a point where further increase in operating speed can lead to increased breakages of the shelled melon. This is similar to the observed trend that indicated that at a very high speed of 2800rpm, though there was a high degree of shelling efficiency, there was also high degree of broken seeds due to the high impact of the seeds against the metallic encasement.

The corresponding shelling efficiency with respect to the shelling speed also changes and this was similar to the findings reported by Olaoye (2016).

Effect of Moisture Content on Cleaning Efficiency

The moisture content of melon during shelling is an important factor that affects the degree to which the shelled melon would be cleaned from its. The effect of moisture content on the cleaning efficiency of the melon is as shown in Figure 5. The highest cleaning efficiency was recorded as 64% at a moisture content of 22% and operating speed of 2800 rpm while the lowest cleaning efficiency was recorded as 12% at a moisture content of 17% and operating speed of 1400 rpm. The chart revealed that at different moisture levels, the corresponding cleaning efficiency also changes, similar findings were reported by Kassim *et al.* (2011). The relationship between the moisture content and cleaning efficiency is also in a sinusoidal form.

Effect of Operating Speed on Cleaning Efficiency

Operating speed was a significant effect on the cleaning efficiency of melon as increase in operating speed increases cleaning efficiency at all moisture levels. Figure 6 revealed that at an operating speed of 1400rpm, the cleaning efficiency was low due to a low degree of centrifugal air flow rate generated. As the speed increases, cleaning also increases. This is similar to findings as reported by Kassim *et al.* (2011).

Effect of Moisture Content on Broken Percentage

The effect of moisture content on the percentage broken seeds is as shown in Figure 7. The highest broken percentage was recorded as 30.8% at a moisture content of 27% and operating speed of 2800 rpm while the lowest broken percentage was recorded as 7% at operating speed of 1400rpm and moisture levels of 22%. This confirmed the observation in level of nut breakage in a mechanical cracker cum separator (Olaoye and Adekanye, 2017).

Effect of Operating Speed on Broken Percentage

According to Makanjuola (1972), drum Speed has a significant effect on broken percentage as increase in operating speed increases broken percentage. The effect of operating speed on the broken percentage of the melon is as shown in Figure 8. The highest broken percentage was recorded as 30.8% at an operating speed of 2800 rpm and moisture content of 27% while the lowest broken percentage was recorded as 7% at an operating speed of 1400 rpm and moisture content of 22%. At a very high speed of 2800rpm, though there was a high degree of shelling efficiency, there was also high degree of broken seeds due to the high impact of the seeds against the metallic encasement.

Conclusion

The melon shelling and cleaning machine was designed, constructed and tested. The machine was developed from the available locally sourced materials. Based on the result of testing carried out the operating speed 2100rpm has the highest shelling efficiency of 76.5 % at 22 % moisture content for variety N. These are the important factor to be considered when operating the machine. The cleaning efficiency of 64% for variety N was achieved at 2800rpm operating speed of the machine increases at 17% and 22% moisture content level of the melon seeds and the least percentage broken seeds was recorded as 7% at 1400rpm and moisture level of 22%.

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