International Journal of Agriculture, Environment and Bioresearch

Vol. 1, No. 01; 2016

www.ijaeb.org

PERFORMANCE TESTING OF A LOCALLY DEVELOPED MELON DEPODDING MACHINE

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ABSTRACT

A local melon Depodding machine was designed, developed and evaluated for performance in extracting edible melon seeds, which are time-consuming and tedious operation. The design was based on the principle of impact force. The machine has a maximum capacity of 25kg of melon per batch powered by a 1.5kW, 1140 rpm single-phase electric motor. Some engineering properties necessary for melon pod depodding such as pod major, intermediate and minor diameters; weight, volume, unit density, impact velocity, and impact energy were determined and their values are0.94cm±1.77cm,11.50cm±1.74cm,11.44cm±1.98cm, 555.83g±283.26g, 891.62cm3±457.65cm3, 0.63g/cm3±0.014g/cm3, 2.36m/s and 2.776J respectively. The determined arithmetic, geometric, square and equivalent mean diameters are approximately the same(11.3cm±1.82cm). The performance characteristics of the machine include: depodding efficiency, material discharge efficiency and overall efficiency, were evaluated at six operating speeds (200 rpm, 250 rpm, 300 rpm, 350 rpm 370 rpm and 400 rpm). The Depodding efficiency varies between 32% and 74% , while seed discharge efficiency varies between 22% and 70%. The pulp discharge efficiency varies between 0.6% and 2.1%, while the overall efficiency varies between 7.2% and 53.4%. In all, the maximum efficiency occurred at the operating speed of 300 rpm. Statistical analysis conducted indicated that there were significant differences in the means of materials discharged from the machine at different machine speeds. The magnitudes of depodding efficiency (Ed), seed discharge efficiency (Es), material discharge efficiency (Emd) and overall efficiency (Eo) tested at all speeds were significantly different. Recommendations and prospects for future works were suggested.

Keywords: Egusi melon, melon pod, depodding machine, engineering properties, and depodding efficiency.

Introduction

Egusi melon*, Citrilluslanatus*, plant is a vine with a non-climbing creeping habit. Its leaves are deeply lobed and blue-gray in colour. The egusi fruit physically resembles the water melon in many respects. The Nigerian name, ‘egusi’ is used here instead of “melon” because of the apparent confusion regarding the correct name of the food seeds generally agreed to be of the citrullus species (Odigboh, 1979). It is a succulent fleshy whitish pendam with a relatively hard but smooth and greenish epicarp. Though some varieties have their green colour streaked with white. The majority of the fruits are nearly spherical in shape but some are ellipsoids having slightly elongated head-tail axial dimensions (Nwosu, 1988, Chen *etal.*, 1996). It looks so much like a water- melon plant that most botanists think it is one. The fruit looks so much like a small, round, watermelon that the two are also easily confused. Unlike water melon, its flesh is bitter and therefore not edible. Egusi fruit is composed of a thick and tough outer coat, the apicarp, a softer fleshy part, the mesocarp, a segmented endocarp and the seeds. The epicarp is strongly attached to the much softer mesocarp to form what is jointly referred to as the rind. The segmented endocarp is separated from each other by the septum and within the segments are the seeds. However, on the inside, egusi fruit is neither red, nor luscious, nor sweet. Indeed, it is white and dry and bitter enough to be repulsive. This is one fruit not even monkeys bother with. Egusi melon is a West African melon. The area where it is widely cultivated includes the Caribbean, Indonesia and African. Egusi is increasingly exported to Europe. In Brussels it is sold under the Congolese name, ‘mbika’. In Paris, retailers use the (North African, Asian and Cameroonian) name ‘courge’. In London and Madrid, the seeds are sold under the commercial name of egusi. In Nigeria, the existence of melon dates back to the 17th century (Douglas, 1982).

Egusi fruit is grown for the seeds. The seeds are numerous and on the average constitute 3.5% of the fruit by weight (Nwosu,1988). The seeds are very nutritious, rich in protein and very important in the Nigerian diet. The seeds contain about 53% oil by weight (Oyolu, 1977) and 32.6% crude protein (Oyenuga, 1998) and also unsaturated fatty acids. Its amino-acid content compares well with those of soybean and whole poultry egg (Oyolu, 1977). Egusi melon is a popular fruit in Nigeria because of the edible seeds which are commonly used in the preparation of local soup or stew and snacks such as fried melon seed ball known as “Robo” in South-Western Nigeria and “agbara-ataa” in Eastern region. In the East, the seeds are sometimes boiled and eaten as snacks too. Egusi cake is a delicacy that is served in important traditional ceremonies. In some communities it constitutes items of demand in traditional mariages,burial ceremonies. It is also eaten fried (immature tender seeds). Egusi melon is also an important component of the traditional cropping system usually interplanted with such staple crops as cassava, maize, sorghum, etc. (Omidiji*et al.,* 1985).

Egusi fruits mature in about 120-150days after sowing. Harvesting begins when the fruits begin to enlarge. The fruits keep well, and can be stored several months without decaying. Generally, the traditional method of extracting egusi seeds in from the fruits involves manual cracking of the fruit with wooden clubs or cutting off the head or tail portion of the fruit with a knife, all done in order to create access for microorganisms to enter and cause the decomposition of the fleshy mesocarp and endocarp (fermentation). The fruit so treated is left for about 7 days to decompose. Then the seeds are removed by washing in water. The traditional processing is time consuming and laborious, the condition prevalent at this level is generally unsanitary and inherent unhygienic conditions. Generally operation involves depodding, fermentation, washing, drying, cleaning and shelling. In Nigeria, farmers still employ several age-old methods of depodding that range from: (i) breaking open the fruits with a hard piece of wood; (ii) burying the fruits whole to decompose underground;(iii) to crack the shells to remove the seeds (http.// www.nap.edu/open book php.record–id =11763 & page=154). Improper depodding methods have been observed to cause problems in other processing unit operations such as separation of seeds from the pulp and loss of the seed by – germination of the seed, slashing of the seed and discarding the seed with the pulp and are environmental hazard.It is therefore very important to properly depod melon pods to enhance the extraction and recovery of clean seeds from the pods. And it is based on the premise to obtain proper depodding of melon pods that necessitated this research into the design and development of a melon depodding machine which will reduce the associated problems of traditional depodding as well as to boost high efficiency of melon depodding, and enhances the economy of Nigeria in terms of foreign exchange earnings.

Therefore, the main objective of this research work is to design and develop a melon depodding machine for such a high nutritional and economic crop that can be affordable and easy to maintain by local farmers in order to increase their production and reduce the drudgery associated with its processing with minimal or no damage of the seeds.

MATERIALS AND METHOD

Description of Component Parts

The machine assembly drawing of the melon depodding machine is as shown in Figure 1. The constructional features of the various components are as follow: hopper, depodding chamber, shaft and spikes, bearing, discharge chute, and frame support.

Figure 1: Pictorial view of the melon depodding machine.

1. **Hopper:** The hopper is fabricated from 2mm thick mild steel of dimension 30cmx30cm inlet and 15cm x 15cm base with a height of 30cm. The hopper base is welded tothe 15cm x 15cm opening base created on the cylindrical chamber housing at the left hand side. The hopper is the inlet through which the fermented melon pods areadmitted into the depodding chamber.
2. **Depodding Chamber:** A 2mm metal sheet of dimension 88cmx62cm was cut and shaped into cylindrical form of diameter 28cm.This serves as the housing for the depodding chamber. The depodding chamber consists of the parts that break open the melon pods to release the seeds. The depodding unit consists basically of spikes welded on a horizontal shaft driven through a belt drive by a 1.5kw, 1140 rpm single-phase electric motor. The entire bottom of the cylinder was perforated to the size of 12mm (average length of an egusi seed) to serve as the screen through which the seeds and the pulp materials can be fallen out onto the lower discharge outlet.
3. **Shaft and Spikes:** The shaft is 3cm diameter and 70cm length of mild steel. Only the diameter was determined mathematically, the shaft length was chosen based on the total length of the chamber.At the extremes of the shaft, 1.075cm was machined out using the lathe machine to a length of 4cm.This is for bearing mounting. The shaft was mounted on a bearing at two horizontal ends and then to a sheave of 15.2cm in diameter. The

spikes,13cm in length and 1.5cm thick werearranged in three columns on the shaft in alternating rows whose loci trace a sinusoidal or sine wave along the spike shaft. In 3 dimensions, it traces a spiral motion. Thespikeswere welded on the shaft at 90 degrees and are pointedly positioned within a cylindrical chamber.

iv. **Bearing:** Two self-aligning ball bearings, 5cm outer diameter were used, which support the shaft at the two ends. The shaft was machined 1.075cm to force-fit into the bearings. The ball bearings however, were selected in preference to journal and roller bearings. This is because ball bearings are known for their less noisy operation, reduced rate of wear, and durability. In addition, their selection was made based on the recommendation of the Antifriction Bearing Manufacturers Association (AFBMA).

v. **Discharge Chute:** The chamber has two discharge outlets that were constructed with 3mm thick mild steel sheet. The upper discharge outlet that measures 30cmx30cmx13cm was welded to the sloped end of the cylindrical housing at 45^0 for discharging of the waste (pulpy) materials. The lower discharge outlet (fig.4.5) that measures 58cmx45cmx4cm had its one length welded at 45^0 to the cylindrical housing insuch a way that it situates directly under the entire surface of the screen that formed the bottom of the cylindrical housing. The lower discharge outlet allows for the discharging of a mixture of seeds and pulp.

vi. **Frame Support:** The frame is the mounting support for all the components of the machine. The frame consists of four vertical stands of 5mm x 5mm x 56cm angle iron for thetwo left side stands and 5mm x 5mm x 46mm angle iron for the two right side stands. The length of the lower end of the leg supports is held in place by angle iron 5mm x 5mm x 80cm on two sides of the leg support. The length of the upperend of the leg supports is held in place by angle iron 5mm x 5mm x 76cm on two sides of the leg support. Also the width of the lower end of the leg supports isbraced together with angle iron 5mm x 5mm x 60cm on the two sides of the leg supports. Again, the width of the upper end of the leg support is braced with angleiron 5mm x 5mm x 36cm on the two sides of the leg supports. A welding machine was used to weld the frame to the side of the cylindrical chamber housing. Also, the leg supports formed a framework where the electric motor base was located.

PRINCIPLE OF OPERATION OF MACHINE

The mechanics of depodding include compression, shearing and impact. The design concept for the melon depodding machine was based on the principle of impact force and this was chosen because it has been utilized in the design of machines for coarse, medium and fine grinding materials. The melon depodding machine was designed to be powered by a single phase 1.5kW electric motor of 1140rpm. A single phase 1.5kW (2Hp) motor was chosen because of ease of connecting single phase motors to our power systems. Also the nearest motor in speed to 1110 rpm is 1140rpm. The excess power will take care of inertia and other friction forces associated with mechanical drives.Through the hopper, fermented melon pods are fed into the machine. As the spiked shaft rotates, the spikesimpact and break the pods releasing themelon seeds which are separated from the pod and are subsequently collected at the outlets. The spiked conveyor conveys the depodded melon, pulp and seeds into the discharge outlets and then operating the machine for a period of two to seven minutes.

DESIGN CONSIDERATION

In the design of the melon depodding machine, the engineering properties (physical and mechanical properties) of the egusi melon such asaxial dimensions, sphericity, weight, volume, density, and rupture strength of the melon pods, impact velocity, and rotational energy to break the Pods, were considered; the diameters, shape and size were also considered in the design and perforation of the concave screen; cost, availability and suitability of the construction materials for the working conditions; strength, vibration, stability, rigidity, durability and portability of the depodding machine were of paramount importance in the design.

The following expressions guided the determination of the physical and mechanical properties of the melon pods:

Measurement of Axial Dimensions

The axial dimensions of the fermented pod samples were determined using a venier caliper of 0.01mm sensitivity. The principal dimensions of major (L_1), intermediate (L_2) and minor (L_3) diameters were measured and recorded in centimeters (cm). The above measurements were used to estimate the mean lengths of the major, intermidiate and minor axes/diameters.Using the above measured axial dimensions, the following size descriptors were calculated:

1. The Arithmetic Mean Diameter (AMD) or $F_1 = L_1 + L_2 + L_3$ 1
2. The Geometric Mean Diameter (GMD) or $F_2 = (L_1 . L_2 . L_3)^{1/3}$
3. The Square Mean Diameter (SMD) or $F_3 = \sqrt{\left(\frac{L_1L_2 + L_1 + L_3 + L_2L_3}{3}\right)}$
4. The Equivalent Diameter (ED) $= \left(\frac{F_1 + F_2 + F_3}{3}\right)$
5. The Sphericity (Ψ) $= \frac{GMD}{L_1}$ 5

Determination of Pod Weight and Volume

A digital weighing balance (model P1210 and 0.01kg sensitivity) was used to measure the weight of the pods. Measurements were replicated 20 times.The volume of each pod was measured by the water displacement method (Zoerb, 2002). A graduated beaker of volume 1000cm^3 was used. Each pod was lowered into the water. The level of water in the beaker was observed to rise. The new level was read and the original volume subtracted from it to give the volume of the pod. This was replicated 20 times.

Rupture Strength

The melon pod was subjected to impact tests by a drop hammer method (Planck, 1980). In this method, a hammer is allowed to fall vertically onto a static pod on a hard surface. The potential energy of the hammer of mass, M, at a height, H, dropped on a pod of equivalent diameter, D_e, is given as equation (6) suggested by Oloko*et al.* (2002):

$$E = Mg(H - d) \qquad 6$$

In which: E = Energy to break the pod (J); M = Mass of hammer (kg); g = acceleration due to gravity (m/s^2); H =Height of drop hammer (cm); and d = equivalent diameter of pod (m).

Determination of Impact Velocity

The impact velocity of the hammer on the pod is determined through conversion ofthe kinetic energy of the hammer into potential energy to break the pod using equations (7a and 7b):

$$K_E = P_E = {}^1\!/_2 MV^2 = Mg(H - d) \qquad 7a$$

Or $V = \sqrt{[2g(H - d)]}$ $\qquad 7b$

Where:M=Mass of the hammer (kg); V= velocity of the drop hammer (m/s); d = equivalent diameter of the pod (m).

Determination of Rotational Energy to Break the Pod

For a rotating body, the kinetic energy (K.E) is given by equation (8) (Swainger, 1975):

$$KE = {}^1\!/_2 I\omega^2 \qquad 8$$

Where: K.E = Kinetic energy of the rotating body (J); I = Moment of inertia of the rotating body (Kgm^2); ω = Rotational velocity of the rotating body (rad/s)= $\left(\frac{2\pi N}{60}\right)$; N = Rotational speed of the spikes (rpm).

But, $$I = \left(\frac{M_s r^2{}_s}{2}\right)$$

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Where: M_s = Mass of rotating spikes (kg); r_s= Radius of the rotating spikes (m).

Substituting into (8) yields the energy to break the pod = the kinetic energy of the mild steel rotating spikes of radius, r_s; thickness, t_s; density, ρ_s(7.87 x 10^{3}kg/m^3).

, and mass, M_s:

$$K.E = \left(\frac{M_s r^2{}_s \omega^2}{4}\right)$$

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Performance Test

On the completion of the design and construction of the melon depodding machine as shown in Figure 1, the melon pods obtained from a rural farmer at Owerri, Imo State, Nigeria were used for the performance evaluation of the machine. Reliable data were obtained on the machine performance by exploring some of the useful parameters of the machine using the method ofOloko*et al.* (2002). These parameters include: percentage extractable seed, depodding efficiency, seed discharge efficiency, pulp discharge efficiency, material discharge efficiency, and overall efficiency. Tests were conducted at six different speeds of the machine ranging from 200rpm to 400rpm. Speed variation was achieved bychanging the diameter of the driven (machine) pulley. Clearance setting between the auger and the screen was maintained at 10mm. after each run, materials were collected from the discharge outlet and weighed accordingly. Symbols used for the different parts of melon are given as: M_1= mass of melon pods fed into machine, kg; M_2= mass of seeds and pulp discharged, kg.M_3= mass of seeds in the mixture of seeds and pulp discharged, kg; M_4= mass of pulp in the mixture of seeds and pulp discharged, kg; M_5= mass of seeds left inside machine, kg; M_6 = mass of pulp inside machine, kg; and M_7 = mass of undepodded melon pods inside machine, kg.The parameters of the developed egusi melon depodding machine were explored as follow:

Percentage Extractable Seed (E_S,%)

In order to calculate the performance efficiency of the melon depodding machine, it was necessary to determine the ratio or the percentage of extractable seeds per given mass of melon pods. This was determined, by manually extracting seeds contained in 5kg of fermented melon pods, and thereafter measuring its mass using an electronic weighing balance –which was replicated 7 times.The ratio of extractable seeds from melon pod, E_S was calculated using equation (11) proposed by Davies (2010):

$$E_S = \left(\frac{M_S}{M_P}\right) X\ 100\% \qquad 11$$

Where: M_s = Mean mass of seed manually extracted from pods,kg; M_p= Mass of whole fermented pods; The value of 'i' obtained was 0.40 or 40%. This means that the melon pods used for the tests had 10% seeds by mass.

Depodding Efficiency (E_d,%)

This is the mass of extracted seeds expressed as a percentage of extractable seeds contained in the melon pods fed into the machine, and was determined using equation (12) suggested by Kushwaha *et al.*(2005):

$$E_D = \left(M_3 + \frac{M_5}{M_1} X E_S\right) X\ 100\% \qquad 12$$

Where the parameters (M_1 to M_7) are as earlier defined.

Seed Discharge Efficiency (E_S)

This is the mass of seeds discharged expressed as a percentage of the mass of extractable seeds, and was calculated using equation (13) as used by Kushwaha *et al.*(2005):

$$E_S = \left(\frac{M_3}{M_1} X E_S\right) X\ 100\% \qquad 13$$

Pulp Discharge Efficiency (E_P)

This is defined as the mass of unwanted materials discharged expresssed as a percentage of the mass of unwanted materials fed into machine; and was calculated using equation (14) proposed by Kushwaha *et al.*(2005):

$$E_P = \left(\frac{M_4}{M_1} - M_1 X\ E_S\right) X\ 100\% \qquad 14$$

Material Discharge Efficiency (E_{md})

The mass of materials that were discharged out of the machine expressed as a percentage of the material fed into the machine, and was calculated using equation (15):

$$W_{md} = E_S + E_p = \left(\frac{M_2}{M_1}\right) X\ 100\% \quad 15$$

Overall Efficiency(E_o)

This is the product of E_d and E_{md}, and was deduced by equation (16) proposed by Kushwaha *et al.*(2005) and Oloko*et al.* (2002):

$$E_O = E_d X E_{md} \quad 16$$

RESULTS AND DISCUSSION

The average values of measured and calculated values of melon pod with mass as the independent variable as well as the linear relationship between the mass of the melon pods, measured and calculated parameters of the melon pods are shown in Tables1 to 4.The linear regression shows that the pod mass correlates linearly with all the parameters. The coefficient of determination of the volume is the highest (R^2 = 0.9986) amongst the measured parameters. The calculated parameters have high coefficient of determination (F_1 = 0.9503, F_2 = 0.9506, F_3 = 0.9505 and D_e = 0.9516). The value for D_e, which is the highest amongst the calculated axial dimensions serves as the representative diameter in calculations involving melon pod.

However, the results obtained from the performance evaluation of the locally developed egusi melon depodding machine were presented in Tables 5and6. One-way Analysis of Variance (ANOVA) in a Complete Randomized Design (CRD), Least Square Method, and regression analysis were used to analyze the obtained data as shown in Tables 7and 8. Preliminary tests with unfermented melon pods confirmed that because of the firm attachment of seeds to the pulp, it was practically impossible to depodmelon without initial fermentation. Depodding of the fermented pods was achieved with the machine, and it was required to observe time between 2 and 10 minutes per run of machine at all the speeds of operation. The fermented pods were easily shattered under the pressure of the auger as it rotates within the depodding chamber. The average depodding efficiency (E_d) was observed to range from 64% at the speed of 200 rpm to an optimum level of 74% at a speed of 300 rpm speed before reducing gradually to 32% at a speed of 400 rpm as indicated in Figure2.The increase in depodding efficiency from speed of 200 rpm to a speed of 300 rpm was probably due to the greater impact energy induced on the pods.

Beyond 300 rpm speed, the depodding efficiency reduced probably because the melon pods were driven so fast on the spikes of the auger that they escaped undepoded. Both the seed discharge efficiency (E_s) and pulp discharge efficiencyy (E_p) increased from speeds of 200 rpm up to a maximum at speed of 300 rpm, and then reduced to lowest at speed of 400 rpm. The corresponding values of the seed discharge efficiency; pulp discharge efficiency and therefore material discharge efficiency (E_{md}) at speed of 300 rpm are 70%, 2.1% and 72.1% respectively as shown in Figure 3. In terms of the overall efficiency (E_o) of the depodding machine, the speed of 300 rpm gave the best value, equivalent to 53.4%. Below and above speed of 300 rpm, the overall efficiency is reduced as indicated in Figure 4.

Data obtained from the tests were subjected to one way analysis of variance (ANOVA)and test of significance using Least Significant Difference (LSD) at 0.025 level of probability. Results of the analyses carried out indicated that there were significant differences in the means of materials discharged from and left inside the machine at different machine speeds.Also the calculated machine efficiencies were subjected to one way analysis of variance (ANOVA) and test of significance using the least significant difference at 0.025 level of probability.Results of the analyses showed that there were significant differences in the magnitudes of depodding efficiency (E_d), seed discharge efficiency (E_s), material discharge efficiency (E_{md}) and overall efficiency (E_o) at all speeds tested. Therefore, there were no significant differences in the mean differences of E_p at 200 rpm versus E_p at 350 rpm, E_p at 350 rpm versus E_p at 370 rpm and E_p at 370 rpm versus E_P at 400 rpm at both levels of probability.

Table1: Actual values of major, intermediate and minor diameters of egusi melon pods.

S/N	Major diameter,L_1 (cm)	Intermediate diameter,L_2 (cm)	Minor diameter,L_3 (cm)
1.	9.60	10.01	9.85
2.	9.20	9.60	9.44
3.	11.70	12.60	12.48
4.	8.94	9.32	9.17
5.	9.63	10.04	9.88
6.	14.80	14.91	15.65
7.	10.52	11.33	11.22
8.	11.52	12.40	11.28
9.	9.43	9.84	9.68
10.	11.64	12.54	12.42
11.	13.80	13.91	14.60

12.	10.41	11.22	11.11
13.	9.06	9.44	9.29
14.	10.51	11.32	11.21
15.	9.62	10.03	9.87
16.	14.64	14.75	15.48
17.	11.71	12.61	12.49
18.	11.60	12.50	12.38
19.	9.70	10.11	9.95
20.	10.72	11.55	11.44
Mean	**10.94**	**11.50**	**11.44**

Table 2: Values of mass, volume and density of fermented melon pods.

S/N	**Fermented pod Mass, g**	**Fermented pod Volume, cm^3**	**Fermented pod Density, g/cm^3**
1.	325.30	504.54	0.64
2.	311.85	483.68	0.64
3.	596.82	976.76	0.61
4.	302.90	469.80	0.64
5.	326.28	506.06	0.64
6.	1181.18	1884.11	0.63
7.	536.63	878.25	0.61
8.	587.23	960.90	0.61
9.	319.64	495.77	0.64
10.	593.87	971.92	0.61
11.	1101.69	1757.31	0.63
12.	531.23	869.40	0.61
13.	306.83	475.90	0.64
14.	536.22	877.58	0.61
15.	325.94	505.54	0.64
16.	1168.41	1863.74	0.63
17.	597.38	977.68	0.61
18.	591.86	968.75	0.61
19.	328.65	509.74	0.64
20.	546.83	894.95	0.61

Mean	**555.83**	**891.62**	**0.63**

Table3: Calculated values of arithmetic mean, geometric mean, square mean,equivalent diameters and sphericity of egusi melon pod.

S/N	Arithmetic Mean Diameter,F_1 (cm)	Geometric Mean Diameter,F_2 (cm)	Square Mean Diameter,F_3 (cm)	Equivalent Diameter,ED (cm)	Sphericity Ψ
1.	9.82	9.82	9.82	9.82	1.02
2.	9.41	9.41	9.41	9.41	1.02
3.	12.26	12.25	12.26	12.26	1.05
4.	9.14	9.14	9.14	9.14	1.02
5.	9.85	9.85	9.85	9.85	1.02
6.	15.12	15.12	15.12	15.12	1.02
7.	11.02	11.02	11.02	11.02	1.05
8.	11.73	11.72	11.72	11.72	1.02
9.	9.65	9.65	9.65	9.65	1.02
10.	12.20	12.20	12.20	12.20	1.05
11.	14.10	14.10	14.10	14.10	1.02
12.	10.92	10.92	10.91	10.91	1.05
13.	9.26	9.26	9.26	9.26	1.02
14.	11.01	11.01	11.01	11.01	1.05
15.	9.84	9.84	9.84	9.84	1.02
16.	14.96	14.95	14.95	14.95	1.02
17.	12.27	12.27	12.27	12.27	1.05
18.	12.16	12.16	12.16	12.16	1.05
19.	9.92	9.92	9.92	9.92	1.02
20.	11.24	11.23	11.23	11.23	1.02
Mean	**11.29**	**11.29**	**11.29**	**11.29**	**1.03**

Table 4: Weight versus the measured and calculated parameters, slope, intercept, correlation, coefficient of determination and regression equation of the melon pod.

S/N	**Variable**	**Slope**	**Intercept**	**Correlation (R)**	**Coefficient of correlation (R^2)**	**Regression equation**
1	W vs. L_1	0.064	74.023	0.9821	0.9645	$L_1 = 0.064W + 74.023$
2	W vs. L_2	0.064	79.230	0.9775	0.9555	$L_2 = 0.064W + 79.230$
3	W vs. L_3	0.072	74.620	0.9775	0.9555	$L_3 = 0.072W + 74.620$
4	W vs. V	1.613	-4.887	0.9993	0.9986	V = I.613W - 4.887
5	W vs. F_1	0.066	76.250	0.9749	0.9503	$F_1 = 0.066W + 76.250$
6	W vs. F_2	0.066	76.159	0.9750	0.9506	$F_2 = 0.066W + 76.159$
7	W vs. F_3	0.066	76.255	0.9749	0.9505	$F_3 = 0.066W + 76.255$
8	W vs. E_D	0.066	76.305	0.9755	0.9516	$D_e = 0.066W + 76.305$
9	W vs. ρ	-0.00035	1.137	-0.1994	0.0398	$\rho = -0.00035W + 1.137$

Table 5: Mean mass of materials fed into, discharged from and left inside machine at different machine speeds.

Machine Speed	**Mass of Material, Kg**						
rpm	**M_1**	**M_2**	**M_3**	**M_4**	**M_5**	**M_6**	**M_7**
200	5.00	2.70	2.20	0.50	1.00	0.30	0.06
250	5.00	3.04	2.32	0.72	1.14	0.42	-
300	5.00	4.32	3.20	1.03	0.27	0.17	-
350	5.00	2.41	2.00	0.41	1.20	0.30	0.50
370	5.00	2.41	1.80	0.61	1.20	0.35	1.10
400	5.00	2.08	1.80	0.28	1.00	0.06	1.70

Table 6: Average machine efficiencies at different machine speeds.

Machine speed	Machine Efficiency (%)				
(rpm)	E_d	E_s	E_p	E_{md}	E_o
200	64.0	44.0	1.1	45.1	28.9
250	69.2	46.4	1.6	48.0	33.2
300	74.0	70.0	2.1	72.1	53.4
350	68.0	40.0	0.9	40.9	26.8
370	54.0	36.0	0.8	36.8	19.9
400	32.0	22.0	0.6	22.6	7.2

Table 7: ANOVA of Data of mean mass of materials fed into, discharged from and left inside machine at different machine speeds.

Sources of Variation	Degree of Freedom	Sum of Square	Mean Square	F-cal.	F-tabular 5%	F-tabular 1%
Speed	5	4.72	0.944*	62.93	3.11	5.06
Error	12	0.18	0.015			
Total	17	4.90				

*Significant at both levels of probability.

Table 8: ANOVA of average machine efficiencies at different machine speeds.

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F-cal.	F- tabular 5%	F- tabular 1%
Speed	5	3541.691	708.338*	15071.02	3.11	5.06
Error	12	0.567	0.047			
Total	17	3542.258				

*Highly significant at both levels of probability.

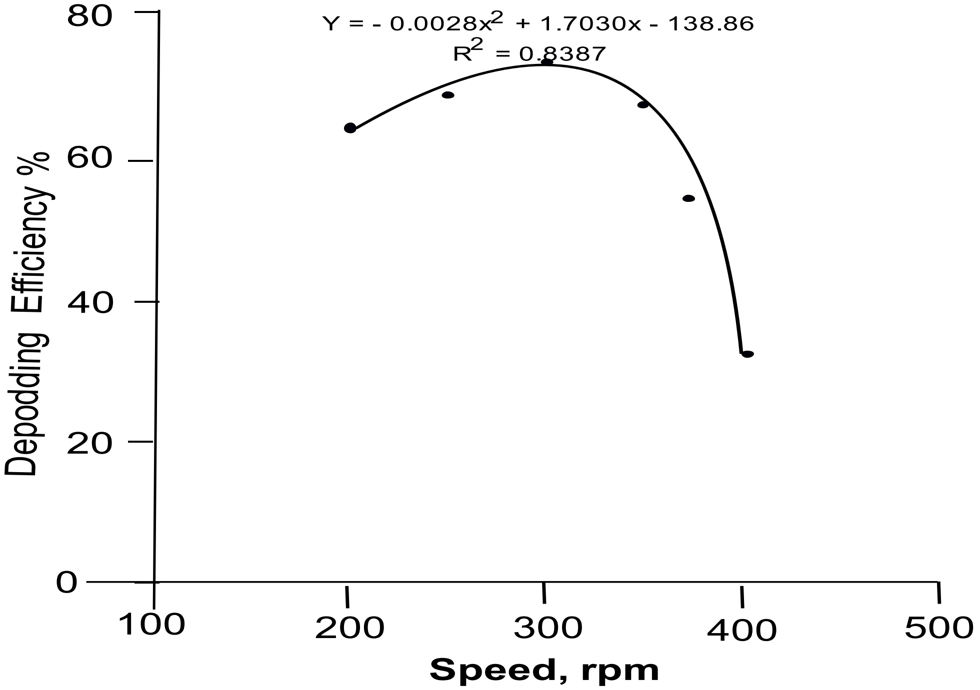

Figure 2: Effect of machine speed on depodding efficiency.

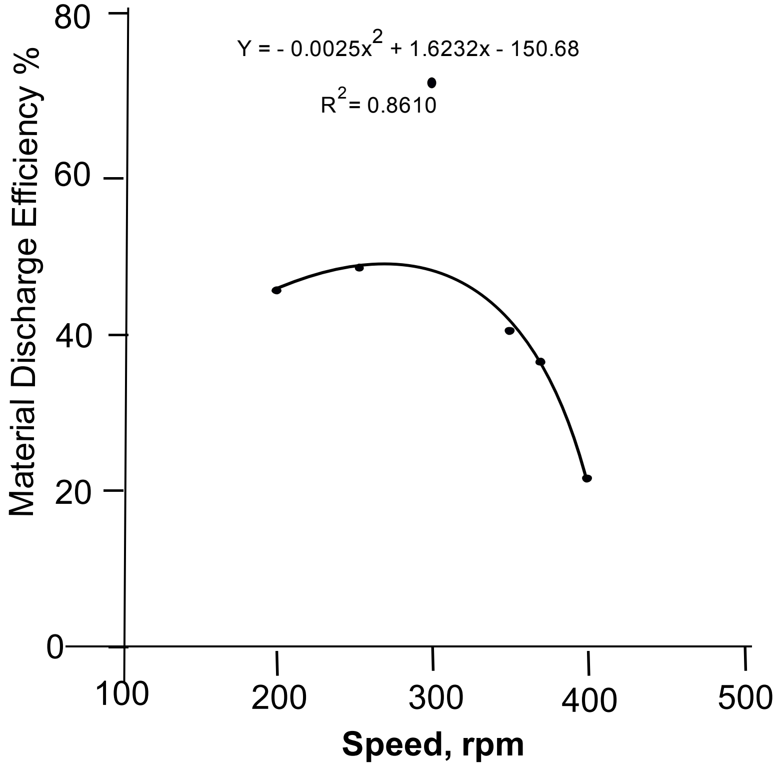

Figure3: Effect of machine speed on material discharge efficiency.

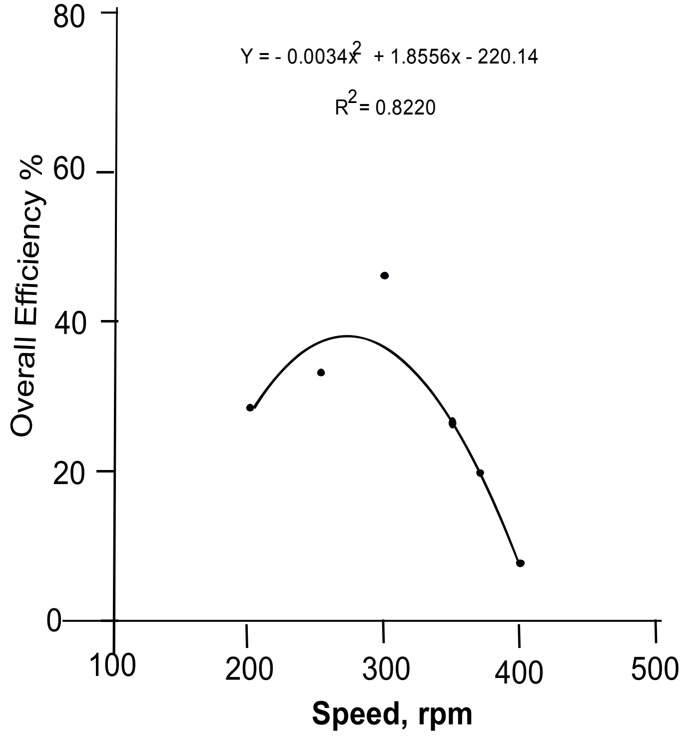

Figure4: Effect of machine speed on overall efficiency.

CONCLUSION

The results of this research work reveal that the machine has a maximum capacity of 23.8kg of melon per batch.The performance characteristics of the machine, including depodding efficiency, material discharge efficiency (product of Seed discharge efficiency and pulp discharge efficency) and overall efficiency, were evaluated at six operating speeds (200 rpm, 250 rpm, 300 rpm, 350 rpm, 370 rpm, and 400 rpm) and one clearance setting (10mm) between the spiked–screw conveyor and the cylinder wall. The Depodding efficiency varies between 32% and 74% while the seed discharge efficiency varies between 22% and 70%. The Pulp Discharge Efficiency varies between 0.6% and 2.1%, while the Overall Efficiency varies between 7.2% and 53.4%. In all, the maximum efficiency occurred at the operating speed of 300 rpm.

However, experimental data obtained were subjected to one-way analysis of variance (ANOVA)and test of significance using Least Significant Difference (LSD) at 0.025 level of probability. Results of the analyses carried out indicated that there were significant differences in the means of materials discharged from and left inside the machine at different machine speeds. Also the results showed that there were significant differences in the magnitudes of depodding efficiency (E_d), seed discharge efficiency (E_s), material discharge efficiency (E_{md}) and overall efficiency (E_o) at all speeds tested. However, there were no significant differences in the mean differences of E_p at 200 rpm versus E_p at 350 rpm, E_p at 350 rpm versus E_p at 370 rpm and E_p at 370 rpm versus E_P at 400 rpm.

Lastly, the high depodding efficiency (74%) of this machine is limited to only fermented egusi melon; and with proper and adequate maintenance, the locally developed melon depodding machine suits the need of peasant farmers and could alleviate the bottlenecks encountered in manual melon depodding operation encountered byrural farmers, given its affordability, portability and ease of maintenance. For future work, the following are therefore recommended:

i. An in-depth study of the mechanical properties of the melon pod other than the impact behaviour of the melon pod be carried out.

ii. Work is to be done in the area of adding water into the depodding chamber while depodding is in progress so as to ascertain its effect on the efficiency of the depodding machine.

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