DEVELOPMENT AND PERFORMANCE EVALUATION OF A DEPODDING MACHINE FOR FRESH MELON PODS

[1]Adebayo, A. A. and [2]Olaoye, J. O.

[1] Department of Agricultural and Bio-Environmental Engineering Technology,
School of Engineering Technology, Auchi Polytechnic, Auchi, Edo State, Nigeria.
[2] Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin.
Kwara State, Nigeria.
E-mail:[1]ajibolaadebayo975@yahoo.com [2]jolanoye@unilorin.edu.ng

ABSTRACT

The aim of this study was to develop a new melon depodding technique that would remove the drudgery, time consuming and seed wasteful fermentation process associated with the traditional melon depodding techniques. A depodding machine for fresh melon pods was designed, fabricated and evaluated. Operating components of the fresh melon depodding machine are the hopper, rotor shaft, concave screen, hammers, rotor disk and electric motor. During evaluation two operational factors were varied; screen size (S) at four levels (i.e. 15, 20, 25 and 30 mm) and operating speed (P) at three levels (i.e. 650, 850 and 1200 rpm). The statistical design was 4x3x3 factorial experimental design replicated thrice and 36 experimental runs were made. Statistical software SPSS 18 was used to carry out statistical analysis of variance (ANOVA) and Duncan's New Multiple Range Test (DNMRT) on the evaluation data of the fresh melon depodding machine. However, results of the (ANOVA) and (DNMRT) of the machine showed that the two operational factors (i.e. screen sizes and operating speeds) have no significant effect on the material discharge index (MDI) of the machine at $P \leq 0.05$. Also, (ANOVA) and (DNMRT) results showed that only the screen size was significant on depodding performance index (DPI) and machine performance index (MPI) at $P \leq 0.05$, while the operating speed and its interactions were not significant at $P \leq 0.05$. In addition, the (ANOVA) and (DNMRT) results showed that both the screen size and operating speed have significant effects on mechanical damage index (MEDI) at $P \leq 0.05$ of the depodding machine. Also, the evaluation experimental data of the machine were subjected to further statistical analysis using SPSS to plot graphs that showed the interactions between the operational factors and the parameters. The graph revealed that material discharged index (MDI) has high percentage mean values (i.e. 98%) at all operating speeds and screen sizes. Also, the graphs revealed that depodding performance index (DPI) and machine performance index (MPI) were generally high (i.e. 97%) at lower operating speeds (i.e. 650 and 850 rpm), with higher screen sizes (i.e. 25 and 30 mm). However, the mechanical damaged index (MEDI) graphs showed low percentage of (MEDI) (i.e. 1.3 %) at lower operating speeds (i.e. 650 and 850 rpm), with higher screen sizes (i.e. 25 and 30 mm). The throughput (C_t) of the depodded machine was measured to be 150.15 kg/h at all operating speeds and screen sizes. Hence, the new melon processing technique for extracting and washing melon seeds from its pods is a fast and efficient technique.

Keywords: Fresh melon pod, depodded melon materials, fermented melon materials, melon seeds

1. INTRODUCTION

Melon *(Citrullus lantus)* is an annual creeping plant, which produces the melon pod with bitter pulp and edible seeds. It is among the 300 melon species commonly found in tropical Africa and reported to have originated from western Kalahari region of Namibia and Botswana in Africa. Also, melon is grown in India, China, Japan and other Asian countries between 10th - 16th centuries (Vander-vossen *et al.,* 2004). There are two major types of melon fruits; one with bitter pulp called *tsama-melon* and the other type is mainly used as source of water during draught period called water-melon. The West Africa melon plant requires an average annual rainfall of at least 700-1000 mm, daily temperature of 28-35 °C and that excessive rainfall will resorted in vegetative growth which leads to low productivity (Vander-vossen *et al.,* 2004). FAO (2002) reported that the total world production of melon seeds in 2002 was 576,600 tonnes produced from 608,000 ha of farmland. The production from Nigeria amount to 347,000 tonnes, Cameroon produced 57,000 tonnes, Sudan produced 46,000 tonnes, DR Congo produced 40,000 tonnes, Central Africa Republic produced 23,000 tonnes and China produced 25,000 tonnes. In other word, Nigeria alone produces 60% of the World production of melon seeds (FAO, 2002).

All over Africa countries, melon seeds are grinded and added as thickener to prepare *egus*i soup or grinded and fermented to produce a local sweetener called *ogiri*. Also, melon seeds could be roasted, pounded, wrapped in leaves and then boiled to produce another sweetener called *igbalo* (Vander-vossen *et al.,* 2004). Melon seed is also grown for its oilseeds; the oil is used for cosmetic purposes and it is of great value to the pharmaceutical industries. Studies have shown that melon oilseed contains five main fatty acids; palmitic (10%), stearic (8.33%), oleic (13.7%), linolenic (5.3%) and linoleic with the most abundant fatty acid valued at 64.15%. This linoleic is used industrially as drying agent in glossy paint, detergent and soap making (Essien and Eduok, 2013). In addition, melon oilseed is classified as good energy source; for it has some fuel quality parameters that make it economical for biodiesel production. Therefore, using melon oilseed as biodiesel production in future is eminent because of its fuel properties which were analyzed to be closed to that of petro-diesel and biodiesel (Ogunwa *et al.,* 2015). In spite of huge economic importance of the melon seeds to Nigeria and the World at large, the processing stages, especially depodding and washing of the fresh melon pods and melon seeds are yet to be effectively mechanized (Orhorhoro *et al.* (2018), Adebayo, (2019) and Osasumwen *et al.* (2020).

Oloko and Agbetoye (2006); Agbetoye *et al.* (2013); Nwakuba (2016); Orhorhoro *et al.* (2018) and Osasumwen *et al.* (2020) designed and fabricated melon depodding machines that are highly efficient in depodding only the fermented melon pods. In addition, Agbetoye *et al.* (2013) redesigned and modified an existing depodding machine to be able to depod and wash melon seeds and this also performed efficiently well on fermented melon pods only. Therefore, depodding fresh melon pods without first fermenting the pods remain a serious challenge. However, Jackson *et al.* (2013) asserted that fermentation of melon pods before depodding its seeds does not alter the nutrients and mineral compositions of the melon seeds. Hence, eliminating or reducing the rigorous and time consuming fermentation processes become necessary and this form the basis for this study. The aim of this study was to develop a melon depodding machine for fresh melon pods. The view was to evaluate the performance of the developed depodding machine for fresh melon pods.

2. MATERIALS AND METHODS

The essential steps in machine development were adopted in the development of the fresh melon depodding machine as enumerated by Olaoye (2011); Oloko and Agbetoye (2006) and Olaoye

(2016). The essential components of the melon depodding machine were identified, designed and constructed. Appropriate performance indices were established to meet the requirements for the evaluation of the machine integrity and the products quality.

2.1 Design Considerations

In the proper designing and development of the fresh melon depodding machine, the following were put into consideration as observed by Olaoye and Aturu (2018) and Adebayo (2019).

i. Capacity of the hopper,
ii. The angle of repose of melon for the hopper design,
iii. The physical and mechanical properties of the melon pods and melon seeds,
iv. Availability of the construction materials,
v. Cost of the available construction materials,
vi. The hydrodynamic properties and frictional forces inherent in melon slurry and seeds,
vii. The speed of the electric motor/rotor gang and the impact force required to separate the melon seed from the other plant materials in the melon slurry,
viii. Magnitude of force developed by the spinning rotor gang to break the melon pods,
ix. Thickness and length of shaft,
x. Careful selection of the clearance between the set of hammers and the concave screen,
xi. Stability and strength of the frames to carry other components of the machine with the view to withstand further impacted load.

2.2 Description of Components of the Melon Depodding Machine

The fresh melon depodding machine is a device that was designed to break the fresh melon pods and to extract the seeds from the pods without breaking the melon seeds (Adebayo (2019); Ajaka and Adesina (2014) and El Shal *et al.* (2010). Also, this depodding machine was designed to adopt the principle of hammer impact force to depod melon seeds from the pods without the usual initial fermentation process of the melon pods. The Pictorial view of the depodding machine is as shown in Figure 1 and its five major components; the main frame, hopper, depodding chamber, concave screen and pulp outlet are shown in Figures 2. These components are described as follows:

2.2.1 The main frame

The main frame is the structure that determined the shape and strength of the machine. It provides point of attachment for other components of the machine to fit into and form a rigid body. It is fabricated using $100 \times 50\ \mathrm{mm}^2$ mild steel U-channel, cut into various sizes and welded together to form A-shaped frame on each side of the machine. The dimensions of the main frame are 720 mm × 770 mm × 1600 mm as shown in Figures 2 and 3.

2.2.2 The hopper

The hopper of the melon depodding machine was fabricated with the dimensions of 520 mm x 180 mm x 550 mm with volume of 51,480 cm^3 and a cover. It plays the role of temporary storage for the melon pods before being fed on motion to the depodding/crushing chamber. The hopper was designed to have a curve shape that will facilitate the tangential rolling of the melon pods into the depodding chamber as shown in Figures 1, 2 and 3. The reason for the hopper shape was to create a momentum on the melon pods, a condition that will ensure smooth crushing of the pods as it collides with the fast rotating hammers in the depodding chamber. The hopper was fabricated from mild steel plate of 3 mm thickness.

Figure 1: Pictorial view of the melon depodding machine

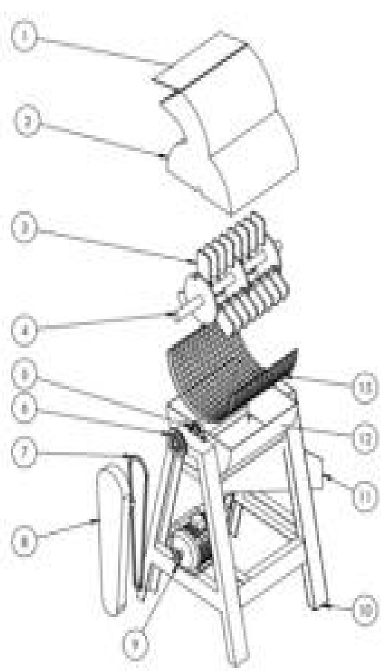
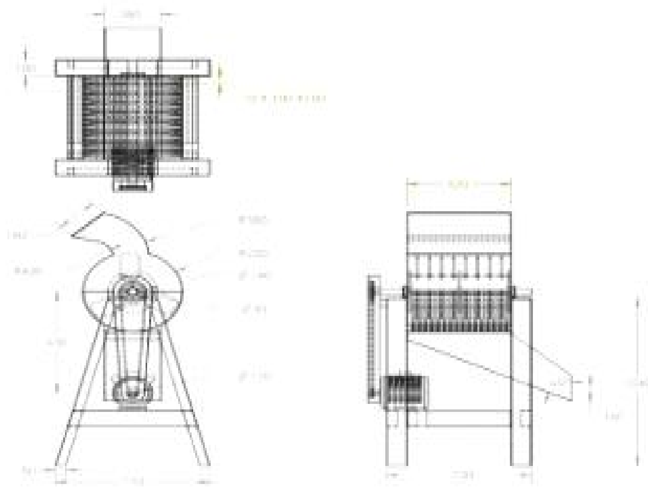


Figure 2: Assembly drawing of the melon depodding machine

1.	Lock Gate	2.	Hopper	3.	Hammer	4.	Shaft
5.	Pillow Bearing	6.	Pulley	7.	Belt	8.	Belt Guard
9.	Electric Motor	10.	Frame	11.	Discharge Chun		
12.	Concave Drum	13.	Screen				



(Dimension in mm)

Figure 3: The orthographic views of the melon depodding hammer mill

2.2.3 The depodding chamber

The depodding chamber comprises of the rotor gang and the concave screens as shown in Figures
2 and 3. The description of the components of the depodding chamber is as follows:

(i) Rotor gang

The rotor gang comprises of the rotor shaft, rotor plates, hammers, pivot rods, ball bearings and the pulley as shown in Figures 2 and 3.

(ii) Rotor shaft

The rotor shaft is the machine element that transmits power from electric motor through belt drive arrangement to other components of the rotor gang. It carries all other machine components of the rotor gang. The shaft was supported by two ball bearings, one at each end of the shaft as shown in Figures 2 and 3. The rotor shaft was fabricated from the mild steel rod with dimensions Ø45 mm and 800 mm.

(iii) Rotor plate

The rotor plate is the machine element that transmits the rotary motion to the hammers through the three pivot shafts that were mounted on its circumference. There are three rotor plates fabricated from 4 mm thick mild-steel plate of outer diameter 200 mm and inner diameter of 46 mm. The three rotor plates were strategically positioned at 225 mm interval to each other with one in the middle of the rotor shaft. The rotor disks are permanently welded to the rotor shaft as shown in Figures 2 and 3.

(iv) Pivot shaft

The three pivot shafts that carry the hammers are made to pass through the three rotor plates. The pivot shaft was made from mild-steel and welded to the rotor discs. The dimensions of the pivot shaft is Ø20 mm and 450 mm long. The three pivot shafts anchored the 24 hammers and connected them to the rotor as shown in Figures 1 and 2.

(v) Hammer

The hammer is the machine element that made use impact force to strikes and breaks the melon pods. It breaks the melon pods in collaboration with the concave screen through rubbing action (Xu et al., 2012; Ajaka and Adesina, 2014; El Shal et al., 2010). The hammers are 24 in numbers and were fabricated from 6 mm thick mild steel plate. The dimension of each hammer is 70 mm × 150 mm × 6 mm thick. A hole of $\emptyset 20\,mm$ was drilled at the extreme end of all the hammers through which the pivot shaft connects all the hammers to the rotor plates as shown in Figures 2 and 3.

2.2.4 Concave screen

The concave screen is the part of the machine that assists the hammers in breaking the melon pods through the impact provided by the hammers and rubbing action provided by the concave screen. The concave screen was fabricated from 4 mm thick mild steel plate and folded into half-round shape as shown in Figures 2 and 3. The screen sizes for the four concaves are 15, 20, 25 and 30 mm and one screen was fixed on the machine at a time. The average length and width of an unshelled melon seed were determined to be 16.57 and 10.47 mm respectively (Adebayo, 2019; Bande *et al.,* 2012; and Abu Shieshaa *et al.,* 2007) and these values were used as a guide for determining the sizes of the four concave screens used for the evaluation.

2.2.5 Melon pulp outlet

The melon pulp outlet is the part of the machine that receives the depodded materials as it comes out of the depodding chamber and discharges the materials out of the machine. The pulp outlet was fabricated from the 3mm mild steel plate. The plate was marked, cutout and welded to shape at an angle that will allow the outlet to deliver the depodded material as shown in figure 2.

2.3 The Principle of Operation of the Melon Depodding Machine

The developed melon depodding machine was powered by a 5.5 kW electric motor with the pulley-belt driven arrangement as shown in figures 1, 2 and 3. The electric motor on the machine was switched-on and was allowed to run freely for about 30-60 seconds, after which 5 kg of fresh melon pods were fed into the machine at a time. The depodding period of about 120 seconds was observed for each run before another 5 kg of melon pods were fed into the machine. After all the runs for the three operational speeds were completed, the concave screen was changed to the next one and the operation continues until the last screen size was mounted on the machine.

2.4 Experimental Method for the Fresh Melon Depodding Machine

The developed melon depodding machine was tested and some operational factors varied. The reasons for varying the factors are to generate data and to determine the effects of the operational factors on the performance parameters of the depodding machine. These operational factors are sieve size (S) at four levels (i.e.15, 20, 25 and 30 mm) and operating speed at three levels (i.e. 650, 850 and 1200 rpm). During evaluation of the depodding machine, the electric motor was switched-on and the machine was allowed to run freely for about 30 seconds, after which 5 kg of melon pods were fed into the machine at a time. The depodding period of 120 seconds was observed for each run before another 5 kg of melon pods were fed into the machine. The depodded melon materials for the runs were collected and packed into bags of different materials in readiness for short period fermentation. Thereafter, the depodding performance data for the runs were generated, analyzed and tabulated as shown in Table 1. After the washing operation, the clean melon seeds were sun dried for 2 to 3 days before bagging them for storage.

2.5 Performance Evaluation Equations for the machine

Evaluation equations were developed for the purpose of estimating the performance of the fresh melon depodding machine. The derived evaluation equations used for determining the performance of the depodding machine are stated in Equations (1) to (5).

2.5.1 The ratio of extractable seeds from the fresh melon pods ($\boldsymbol{i}$)

This is defined as the ratio of mass of extractable melon seeds to that of mass of certain quantity (5 kg) of melon pods from which the seeds were extracted. Percentage of extractable seeds ($\boldsymbol{i}$) from certain mass (5 kg) of melon pods was estimated (Oloko and Agbetoye, 2006; Nwakuba, 2016) using Equation (1).

$$\boldsymbol{i} = \frac{\mathrm{M_e}}{\mathrm{M_p}} \times 100\ \% \qquad (1)$$

Where; $\mathrm{M_e}$ is the mass of the seeds depodded from certain mass of fresh melon pods (kg)
$\mathrm{M_p}$ is the mass of certain (5 kg) fresh melon pods fed into the machine (kg)

2.5.2 Material discharge index (MDI)

This is the ratio of mass of unwanted melon materials discharged from the machine outlet to the total mass of unwanted materials fed into the machine. The derived Equation (2) was used for the estimation of material discharge index (MDI) (Adebayo, 2019)**.**

$$(\mathrm{MDI}) = \frac{\mathrm{M_2}}{\mathrm{M_1} - \mathrm{M_1}.\boldsymbol{i}} \times 100\ \% \qquad (2)$$

Where; $\mathrm{M_1}$ is the mass of fresh melon pods (5 kg) fed into the machine (kg)
$\mathrm{M_2}$ is the mass of unwanted melon material depodded and discharge (kg)
($\mathrm{M_1} \times \boldsymbol{i}$) is the percentage of mass of extractable melon seeds (%)

2.5.3 Depodding performance index (DPI)

This is the ratio of the mass of depodded melon seeds (broken and unbroken melon seeds) to the mass of extractable melon seeds in the fresh melon pods (5kg) fed into the machine. The derived Equation (3) was used for the calculation of ($\mathbf{DPI}$) (Adebayo, 2019)**.**

$$(\mathbf{DPI}) = \frac{\mathrm{M_3}}{\mathrm{M_1} \times \boldsymbol{i}} \times 100\ \% \qquad (3)$$

Where; $\mathrm{M_1} \times$ i is the percentage of mass of extractable melon seeds (%)
$\mathrm{M_3}$ is the total mass of depodded melon seeds (broken and unbroken seeds) (kg)

2.5.4 Machine performance index (MPI)

This is the product of materials discharge index and depodding performance index. The derived Equation (4) was used for the calculation of ($\mathbf{MPI}$)**.**

$$(\mathbf{MPI}) = (\mathrm{MDI} \times \mathrm{DPI})\ \% \qquad (4)$$

2.5.5 Mechanical damage index (MEDI) %

This is the ratio of mass of broken/deformed melon seeds depodded to the mass of extractable seeds in percentage. The derived Equation (5) was used for the calculation of (**MEDI**) (Adebayo, 2019).

$$(\mathbf{MEDI}) = \frac{M_4}{M_1 \times i} \times 100\ \% \quad (5)$$

Where; $M_1 \times i$ is the percentage of mass of extractable melon seeds (%)
M_1 is the mass of fresh melon pods (5 kg) fed into the machine (kg)
M_4 is the mass of broken/deformed seeds in the depodded materials (kg)

2.5.6 Throughput (C_t)

This is the total mass of fresh melon pods depodded by the machine over the total operating time. It is the rate at which the machine depodded the fresh melon seeds from the pods. The derived Equation (6) is used.

$$\mathbf{C_t} = \frac{M_p}{T} \quad (\mathrm{kg/h}) \quad (6)$$

Where; M_p is the mass of the total fresh pods (5 kg) fed into the machine (kg)
T is the total time used for the depodding operation (hr)

3. STATISTICAL ANALYSIS

The two operational factors used in evaluation of the melon depodding machine are screen size (S) at four levels (i.e. 15, 20, 25 and 30 mm) and operating speed (P) at three levels (i.e. 650, 850 and 1200 rpm) and the two factors were replicated thrice. The experimental design was 4 x 3 x 3 factorial design and the total experimental runs were 36 runs. The machine performance data were generated with their replicates and results were recorded and tabulated as shown in Table 1. The statistical analysis of variance (ANOVA) were determined and used for determining the effects of the operational factors on the performance parameters of the of the melon depodding machine at 95 % confidence level. Also, additional statistical results were obtained by using Duncan's New Multiple Range Tests (DNMRT) to compare the percentage mean values among different levels of the experimental factors. Tables 2 to 5 showed the statistical results of (ANOVA) of the effects of the operational factors on the performance parameters of the machine at 95 % confidence level. Also, Tables 5 and 6 showed the statistical results of (DNMRT) which compare the percentage mean values among different levels of the experimental factors.

4. RESULTS AND DISCUSSION

The performance data of the fresh melon depodding machine for the various experimental runs were recorded and tabulated in Table 1. Tables 2 to 5 showed the results of (ANOVA), Tables 6 and 5 showed the results of (DNMRT) and the effects of the operational factors on the performance parameters of the melon depodding machine are discussed as follows:

4.1 Effect of Screen Size and Operating Speed on the Material Discharge Index (MDI)

The results obtained using statistical analysis of variance (ANOVA) in Table 2 showed that the two operational factors (i.e. screen sizes and operating speeds) have no significant effect on the material discharge index (MDI) of the melon depodding machine at $P \leq 0.05$.

Table 1: Effects of Operating Factors on the Performance Parameters of the Melon Depodding Machine (Replicated Thrice)

Experimental Factors	Material Discharged Index MDI (%)	Depodding Performance Index DPI (%)	Machine Performance Index MPI (%)	Mechanical Damage Index MEDI (%)	Depodding Throughput Capacity C_a (kg/h)
P_1S_1	98.96 ± 0.25	76.54 ± 0.10	75.76 ± 0.11	2.66 ± 0.54	150.15
P_1S_2	97.96 ± 0.90	87.32 ± 0.34	85.44 ± 0.52	2.04 ± 0.21	150.15
P_1S_3	98.00 ± 1.02	96.31 ± 0.83	96.12 ± 3.32	1.52 ± 0.26	150.15
P_1S_4	98.89 ± 0.39	96.46 ± 1.05	95.74 ± 1.43	1.38 ± 0.76	150.15
P_2S_1	98.37 ± 0.26	77.75 ± 0.48	74.47 ± 0.62	1.62 ± 0.13	150.15
P_2S_2	97.85 ± 0.78	87.29 ± 1.53	85.39 ± 1.74	1.23 ± 0.57	150.15
P_2S_3	97.85 ± 0.72	96.85 ± 1.21	94.65 ± 1.97	1.11 ± 0.63	150.15
P_2S_4	98.00 ± 8.00	96.70 ± 1.12	94.82 ± 1.26	0.92 ± 0.80	150.15
P_3S_1	98.22 ± 0.80	79.69 ± 1.56	78.15 ± 1.72	1.49 ± 0.25	150.15
P_3S_2	95.85 ± 2.96	82.45 ± 4.42	84.28 ± 3.37	1.38 ± 0.23	150.15
P_3S_3	97.48 ± 2.00	97.77 ± 0.76	95.85 ± 1.46	0.99 ± 20.12	150.15
P_3S_4	97.85 ± 2.06	97.35 ± 0.96	96.26 ± 1.31	0.87 ± 0.22	150.15

*P is the operating speed; P_1 = 1200 rpm, P_2 = 850 rpm and P_3 = 650 rpm
*S is the concave screen size; S_1 = 15 mm, S_2 = 17 mm, S_4 =23 mm and S_4 =30 mm
*Mean of three replicates of each parameter $\pm$ standard deviation

Table 2: Analysis of Variance (ANOVA) for the Effect of Operating Speed and Screen Size on the Material Discharge Index (MDI)

Source	Type III Sum of Squares	Degree of freedom	Mean Square	F	Significance
Corrected Model	20.435[a]	11	1.858	1.033	.450[NS]
Intercept	345326.646	1	345326.646	1.920E5	.000*
Speed	7.392	2	3.696	2.055	.150[NS]
Screen Size	8.724	3	2.908	1.617	.212[NS]
Speed * Screen Size	4.318	6	0.720	.400	.872[NS]
Error	43.166	24	1.799		
Total	345390.247	36			
Corrected Total	63.601	35			

a. R Squared = 0.321 (Adjusted R Squared = 0.010)

* Significant at $P \leq 0.05$

Table 3: Analysis of Variance (ANOVA) for the Effect of Operating Speed and Screen Size on the Depodding Performance Index (DPI)

Source	Type III Sum of Squares	Degree of freedom	Mean Square	F	Significance
Corrected Model	2231.326[a]	11	202.848	177.463	0.000*
Intercept	290494.051	1	290494.051	2.541E5	0.000*
Screen Size	2210.909	3	736.970	644.744	0.000*
Operating Speed	1.327	2	.664	.581	0.567[NS]
Screen Size * Operating Speed	19.090	6	3.182	2.783	0.034[NS]
Error	27.433	24	1.143		
Total	292752.810	36			
Corrected Total	2258.759	35			

a. R Squared =0.988 (Adjusted R Squared = 0.982)

* Significant at $P \leq 0.05$

Table 4: Analysis of Variance (ANOVA) for the Effect of Operating Speed and Screen Size on the Machine Performance Index (MPI)

Source	Type III Sum of Squares	Degree of freedom	Mean Square	F	Significance
Corrected Model	2264.903[a]	11	205.900	62.016	.000*
Intercept	280416.142	1	280416.142	8.446E4	.000*
Operating Speed	2.999	2	1.499	.452	.642[NS]
Screen Size	2247.235	3	749.078	225.618	.000*
Operating Speed*Screen Size	14.669	6	2.445	.736	.625[NS]
Error	79.683	24	3.320		
Total	282760.727	36			
Corrected Total	2344.586	35			

a. R Squared = 0.966 (Adjusted R Squared = 0.950)

* Significant at $P \leq 0.05$

Table 5: Analysis of Variance (ANOVA) for the Effect of Operating Speed and Screen Size on the Mechanical Damage Index (MEDI)

Source	Type III Sum of Squares	Degree of freedom	Mean Square	F	Significance
Corrected Model	8.552[a]	11	.777	3.670	0.004*
Intercept	74.132	1	74.132	349.982	0.000*
Operating Speed	3.887	2	1.944	9.176	0.001*
Screen Size	4.049	3	1.350	6.372	0.002*
Operating Speed * Screen Size	.615	6	.103	.484	0.814[NS]
Error	5.084	24	.212		
Total	87.767	36			
Corrected Total	13.635	35			

a. R Squared = 0.627 (Adjusted R Squared = 0.456)
* Significant at $P \leq 0.05$

This was also confirmed by the Duncan's New Multiple Range Tests (DNMRT) in Tables 6 and 7, which showed that mean values of the (MDI) were not significantly different at different screen sizes and operating speeds. Also, results obtained from the evaluation data in Table 1 showed that the highest material discharge index (MDI) obtained was 97.85 % for most of the screen sizes and operating speeds. However, slight dropped of (MDI) was observed from 97.85 to 95.85 % at speed range of 850 to 1200 rpm. This agreed with Agbetoye *et al.* (2013) dropped from 65 to 45 % at the speed range of 112 to 229 rpm for the unsliced fresh melon pods, Nwakuba (2016) whose values of the material discharge efficiency dropped from 53.4 to 22.0 % at the speed range of 300 to 400 rpm for fermented melon pods and that of Oloko and Agbetoye (2006) dropped from 82.4 to 38.9 % at the speed range of 300 to 400 rpm for fermented melon pods.

4.2 Effect of Screen Size and operating Speed on Depodding Performance Index (DPI)

The statistical analysis of variance (ANOVA) results in Tables 3 showed that only the screen size was significant on depodding performance index (DPI) at $P \leq 0.05$, while the operating speed and its interactions were not significant at $P \leq 0.05$. Also, Duncan's New Multiple Range Tests (DNMRT) results in Tables 6 and 7 confirmed that the percentage mean values of (DPI) at different screen sizes are significantly different at $P \leq 0.05$, while that of the operating speed and its interactions are not significant. The graphs in Figure 4 showed the highest depodding performance index (DPI) (i.e. 98 to 94 %) for screen sizes of 25 and 30 mm at all operating speeds, with throughput of over 150 kg/h of fresh melon pods. This performance results for depodding fresh melon pods indicated significant improvement over the existing one; Agbetoye *et al.* (2013) rated to have unsliced fresh melon depodding efficiency ranging between 74.8 to 53.4 % at the operating speeds ranging between 229 to 122 rpm for unsliced fresh melon pods; Oloko and Agbetoye (2006) have depodding efficiency ranging between 62.1 to 31.8 % at the operating speed range of 300 to 400 rpm for fermented melon pods.

Table 6: Duncan's Multiple Range Test of the Effect of Screen Size on the Performance Parameters of the Depodding Machine

Experimental Factor	Material Discharged Index MDI (%)	Depodding Performance Index DPI (%)	Machine Performance Index MPI (%)	Mechanical Damage Index MDI (%)
S_1	98.52[a]	77.99[a]	76.79[a]	1.927[ab]
S_2	97.22[a]	87.51[b]	85.04[b]	1.550[ab]
S_3	97.78[a]	96.98[c]	95.60[cd]	1.206[bc]
S_4	98.25[a]	96.84[cd]	95.61[d]	1.058[cd]

*S is the concave screen size; S_1 = 15 mm, S_2 = 17 mm, S_4 = 23 mm and S_4 = 30 mm
* Means in each column with the same letters are not significantly different at $P \leq 0.05$, but Means with different letters are significantly different at $P > 0.05$

Table 7: Duncan's Multiple Range Test of the Effect of Operating Speed on the Performance Parameters of the Depodding Machine

Experimental Factor	Material Discharged Index MDI (%)	Depodding Performance Index DPI (%)	Machine Performance Index MPI (%)	Mechanical Damage Index MDI (%)
P_1	98.45[a]	89.74[a]	88.33[a]	1.183[a]
P_2	98.02[a]	89.65[a]	87.87[a]	1.223[ab]
P_3	97.35[a]	90.10[a]	88.57[a]	1.8993[c]

*P is the Operating speed; P_1= 1200 rpm, P_2= 850 rpm, P_3= 650 rpm
* Means in each column with the same letters are not significantly different at $P \leq 0.05$, but Means with different letters are significantly different at $P > 0.05$

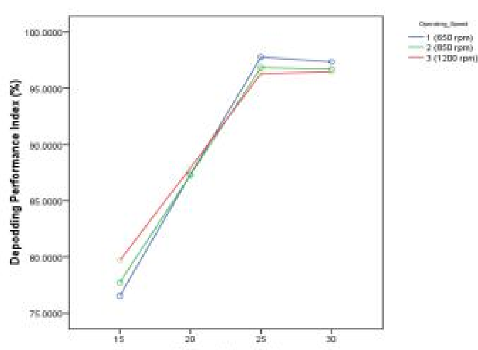


Figure 4: Effects of screen size and operating speed on depodding performance index

4.3 Effect of Screen Size and Operating Speed on the Machine Performance Index (MPI)

Also, the statistical analysis of variance (ANOVA) results in Tables 4 showed that only the screen size was significant on machine performance index (MPI) at $P \leq 0.05$, while the operating speed and its interactions were not significant. Also, Duncan's New Multiple Range Tests (DNMRT) results in Tables 6 and 7 confirmed that the percentage mean values of (MPI) at different screen sizes are significantly different at $P \leq 0.05.$, while that of the operating speed and its interactions are not significant. The graphs in Figure 5 showed the highest machine performance index (MPI) (i.e. 97 to 95 %) for screen sizes of 25 and 30 mm at all operating speeds. Also, machine performance index (MPI) results for this machine appeared to be higher than that of Agbetoye *et al.* (2013) rated between 65.4 to 32.6 % at the speed range of 229 to 122 rpm for unsliced fresh melon pods.

4.4 Effect of Screen Size and Operating Speed on the Mechanical Damage Index (MEDI)

The analysis of variance (ANOVA) results for the performance data of this machine analyzed in Table 5 showed that both the screen size and operating speed have significant effects on mechanical damage index (MEDI) at $P \leq 0.05.$ Also, this was corroborated by Duncan's New Multiple Range Tests (DNMRT) results in Tables 6 and 7 shown that mean values of the mechanical damage index (MEDI) at different screen size and operating speed are significantly different at $P \leq 0.05.$ Again, Figure 6 revealed that mechanical damage index (MEDI) of this machine ranges between 2.7 to 0.99 % as the screen sizes varied from 15 to 30 mm at all operating speeds. However, (MEDI) was observed to be excessively high (i.e. 2.7%) at the highest operating speed (i.e. 1200 rpm), but lower range of (MEDI) (i.e. 0.8 to 1.2%) were observed at lower operating speeds (i.e. from 850 to 650 rpm) and higher screen sizes (i.e. 25 and 30 mm) for all operating speeds as shown in Figure 6. The type of mechanical damage observed was not seed breaking, but seed shelling at the highest operating speed (i.e. 1200 rpm), with lower screen sizes (i.e. 15 and 17 mm). The seed peeling/shelling was due to excessive impacted energy on the melon pods at highest speed (i.e. 1200 rpm) and longer waiting time of the melon pods in the crushing chamber at lowest screen sizes (i.e. 15 and 17 mm).

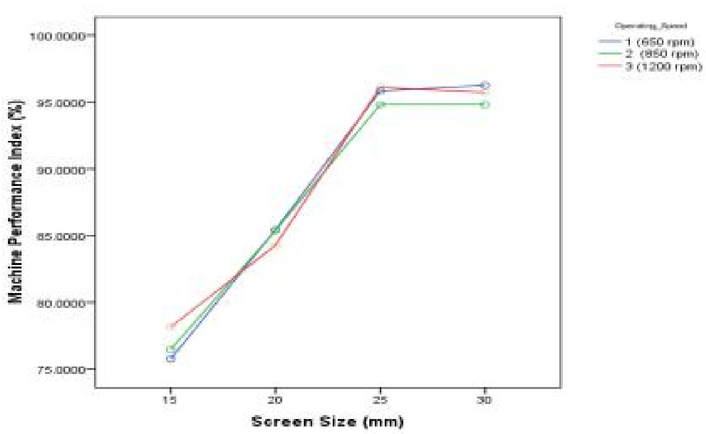


Figure 5: Effects of screen size and operating speed on machine performance index

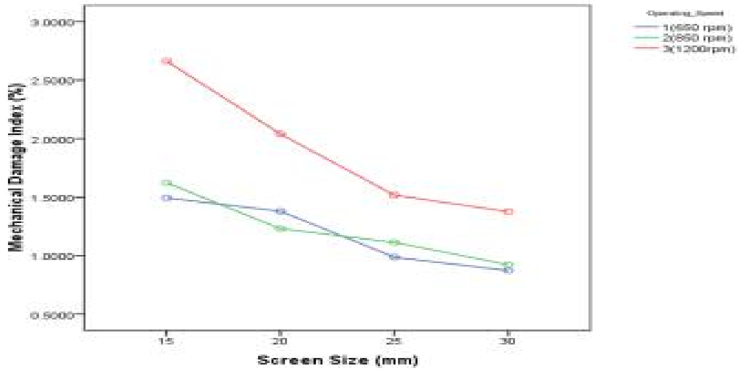


Figure 6: Effects of screen size and operating speed on mechanical damage index

5. CONCLUSION

In this study, a fresh melon pods depodding machine was developed and the performance evaluation was successfully carried out at the Fabrication Workshop of the Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Nigeria. The results obtained from this study absolutely mitigate the challenges associated with traditional method of depodding melon pods. The raw data obtained from the evaluation results of the fresh melon depodding machine were analyzed using statistical software SPSS 18. The statistical analysis of variance (ANOVA) and Duncan's New Multiple Range Tests (DNMRT) results revealed that screen size (S) and operating speed (P) were significant to the depodding performance index (DPI), machine performance index (MPI) and mechanical damage index (MEDI) at $P \leq 0.05$. Again, the results of the statistical analyses revealed that material discharge index (MDI) was observed to be generally high (i.e. 97%) for all the operational factors. In addition, results from graphs revealed that percentage mean values of (DPI) and (MPI) were generally high (i.e. 98-95 %), while that of (MEDI) was low (i.e. 1.3 %). The melon pod throughput (C_s) of the fresh melon depodding machine was evaluated to 150.15 kg/h. Hence, the new melon processing technique for extracting and washing melon seeds from its pods is a fast and efficient technique.

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