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DETERMINATION OF SOME ENGINEERING PROPERTIES OF DRUMSTICK SEEDS (*MORINGA OLEIFERA*)

*,[1]Koyenikan, O. O., [2]Adesoun, Y. M., & [3]Isinkaye, O. D.
[1,2, & 3]Department of Agricultural and Bio-Environmental Engineering
Federal Polytechnic, Ado Ekiti, Nigeria
Corresponding author: koyenikanomolola@gmail.com

ABSTRACT

Engineering properties of agricultural products such as Drumstick (Moringa oleifera) are very important in the design and manufacturing of processing machines. Drumstick (Moringa oleifera) seeds contain a significant amount of oil that is commercially used for the production of many products. The aim of this research work is to determine some engineering properties of Drumsticks (Moringa oleifera) for the design of a Moringa de-podding machine. The methods adopted in the experimentation were standard laboratory procedures for the determination of the engineering properties selected. In this research, the dimensional, gravimetric, and frictional properties of Moringa oleifera seeds were determined as design parameters for the development of a Moringa de-podding machine. The values obtained for average true density, bulk density, average porosity, unit mass and thousand seed mass at 15.82% (db.) moisture content were 0.610±0.030 gcm^{-3}, 0.253±0.005 gcm^{-3}, 58.52%, 0.350±0.055 g, and 273.396±8.079 g respectively. The values obtained for the mean angle of repose, and static coefficient of friction on three different surfaces (glass, galvanized steel, and plywood) at 7.82% (db.) moisture content were found to be 17.834±0.350, 0.437±0.003, 0.481±0.002, and 0.569±0.003 respectively. It was deduced from the research work that a significant change in the moisture content will lead to a significant change in the physical and mechanical properties of the seed. It was, recommended that efforts should be directed towards the plantation of drumstick seeds to increase the production of more seeds and scientists should embrace the design of the Moringa de-podding machine.

KEYWORDS: Drum Stick; Moisture Content; Angle of Repose; Compressive Force; Static Coefficient of Friction

INTRODUCTION

Drumstick (*Moringa oleifera*) is native to some parts of Africa and Asia and it is the sole genus in the flowering plant family Moringaceae (Zaku et al., 2015). Drumstick has been in use for many centuries in traditional alternative medicine to heal or prevent hundreds of diseases (Aremu & Akintola, 2014). Because of its numerous healing and nutritional properties, it is called “Miracle Tree”, “Mother’s Best Friend” and “Never Die”. The other common names of *M. oleifera* include “horseradish tree” and “drumstick tree”. It is also a readily available diet used to help prevent malnutrition in children, pregnant women, and nursing mothers (Ndubuaku et al., 2014). The leaves and seeds are highly nutritious and medicinal producing edible oil that is clear and odorless. It burns without smoke and will not turn rancid. The seeds are 35% oil and the remaining seed cake can be used as fertilizer or to purify water (Abdullah et al., 2013). The seeds contain a significant amount of oil that is commercially known as "Ben oil" or "Behen oil" because oil

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contains high amounts of behenic acid which is used in many products for its ability to smoothen the skin and improve hair condition. It could also be used in cooking, cosmetics, fuel, and lubrication among others.

The characteristics of *M. oleifera* seed oil can be highly desirable, especially with the current trend of replacing polyunsaturated vegetable oils with those containing high amounts of monounsaturated acids (Adejumo & Abayomi, 2012). In recent times, increased attention has been focused on the utilization of under-exploited locally available agricultural products and by-products for food/fibre processing in developing countries. Obviously, such utilization would help these countries, especially African countries that are currently facing adverse economic problems. There are complexities of modern technology for the production, handling, storage, processing, preservation, value addition, and utilization of Moringa seeds (Aremu & Akintola, 2014).

MATERIALS AND METHOD

The major material used for this research work is the drumstick seeds botanically identified as *Moringa Oleifera.* They were obtained where its production was predominant and used for all the experiments in the study. The following materials used in carrying out the experiment were also moisture can, measuring cylinder, weighing balance, aggregate impact testing machine, oven, ruler, galvanized metal, wood/plywood, glass, and digital Vernier caliper.

Experimental Procedure

The drumstick pods were harvested and de-podded manually, the seeds were cleaned to remove foreign matters such as; dirt, stones shaft as well as immature and damaged seeds. It was then sealed and kept in a polythene bag for 78 hours to equilibrate the moisture content of the seed. The following determination of some engineering properties of Moringa seed according to (Niveditha et al., 2013) was carried out in the post-harvest laboratory, and civil laboratory as follows:

Determination of moisture content

The moisture content was determined by using the air oven method as shown in Equation 1.

$$M.C = \frac{W1-W2}{W2} \times 100 \qquad (1)$$

Where,

M.C is the moisture content

W_1 is the initial moisture content in grams

W_2 is the final moisture content in grams

Dimensional measurement

Determination of geometric mean

The geometric mean diameter was calculated using this equation used by (Niveditha et al., 2013) as shown in Equation 2.

$$GMD = \sqrt[3]{(DM\; Di\; Dm)} \qquad (2)$$

Where,

GMD is the Geometric Mean Diameter;

DM is the major axis in mm;

Di is the intermediate axis in mm;

Dm is the minor axis mm.

Determination of sphericity (φ)

The Sphericity of the drumstick seed was obtained using Equation 3

$$\varphi = \frac{(LWT)^{1/3}}{L} \qquad (3)$$

Where,

φ is the Sphericity;

L is the length in mm;

W is the width in mm; and

T is the thickness in mm.

Determination of surface area (s)

The surface area, (S) in mm^2 was calculated by using Equation 4 below.

$$S = \pi Dg^2 \qquad (4)$$

Where;

S is the surface area; and

Dg is the geometric mean diameter.

Gravimetric measurement

Determination of unit and one thousand seed mass

The mass of 1000 seeds of *M. oleifera* was determined by counting 100 seeds randomly and measured using an electronic compact scale (Model SBS 130) with a maximum capacity of 600 g and accuracy of 0.01 g and then was multiplied by 10 to give the mass of 1000 seeds and divided by 100 to give the unit mass. The test was done in ten replicates and the mean value was taken while the volume and true density, bulk density, and porosity were calculated.

Determination of volume and true density

A sample of 20g was weighed and filled into 100 ml of distilled water the difference in liquid displacement was taken as shown in equation 5.

$$T_d\,(g/cm^3) = \frac{Ws}{V} \qquad (5)$$

Where,

T_d is the true density in g/cm^3

Ws is the weight of the sample in grams

V is the volume of distilled water displaced in g/cm^3

Determination of bulk density

The bulk density was determined by filling an empty 500 ml graduated cylinder with the seeds and weighing it. The weight of the seeds was obtained by subtracting the weight of the cylinder from the weight of the cylinder and seeds. To achieve uniformity in bulk density, the graduated cylinder was tapped to cause the seeds to consolidate. The process was replicated three times, and the bulk density for each replication was calculated from the following relation was used to determine the bulk density of the grain sample as shown in Equation 6.

$$(pb) = \frac{ws}{vs} \qquad (6)$$

Where,

ρb is the bulk density in $kg/(m^3)$,

W_s is the weight of the seed (kg),

V_s is the volume occupied by the sample (m^3).

Determination of porosity

The porosity is defined as the ratio of the space of seeds to their total volume. This was calculated from the measured values of densities (Bulk and True) and was calculated using the Equation below:

$$P = (1 - \frac{pb}{ps} \times 100) \qquad (7)$$

Where,

P is the Porosity

ρ_b is the bulk density (g/cm^3); and

ρ_s is the solid/true density (g/cm^3)

Frictional properties

Determination of angle of repose

The angle of repose of the *M. oleifera* seeds was determined using the cylindrical pipe method as shown in plates 1, 2 & 3. Equation 8 below was used to determine the angle of repose. The test was done in ten replicates and the mean value was taken.

$$\theta = tan^{-1}(\frac{2h}{r}) \qquad (8)$$

Where,

Θ is the angle of repose (o);

h is the height of piled seed (cm); and

r is the radius of the base of the cone (cm)

Determination of static coefficient of friction

The static coefficient of friction was determined on three different surfaces including wood, galvanized steel, and glass. This can be expressed as the degree of resistance of the seed to flow on a given surface. A plastic cylinder of 100 mm, in diameter and 50 mm in height was used. The cylinder was filled with seed and placed on an adjustable inclined surface. The plastic cylinder was raised slightly so that its open bottom edge did not touch the inclined surface only the seed samples were touching the surface. All three surfaces were raised slowly until the cylinder filled with seeds started to slide down. At that point, the angle of tilt, (α) was recorded. The coefficient of static friction (μ) was calculated using Equation 9 as described by (Niveditha et al., 2013). The test was done in ten replicates and the mean value was taken.

$$\mu = tan\,\alpha \quad (9)$$

Where,
(μ) is the Coefficient of static friction
α is the angle of tilt

Determination of crushing force/compression test

The compression test was carried out in the civil engineering department of the Federal Polytechnic Ado-Ekiti, using an Aggregate Impact Testing Machine. The seed was poured into the mechanical sieve shaker to remove dirt, and placed on the weighing balance to determine the weight of the seed. The height of the fall height of the cup, the diameter of the cup, and the load were determined. The seed was weighed and poured into the cup and force was applied by giving the seed 10 blows. After the blow, the seed was sieved to remove the shaft and was reweighed to get the weight of the crushed seed, and the shaft was subtracted from the seed. The test was done in five replicates. It was calculated using the equation 10 below:

$$E = \frac{m \times ht.of\ f \times no.of\ b \times no.t}{vol} \quad (10)$$

Where,
M is the mass in grammes
Ht. of F is the height of fall in metres
No. of b is the number of blows
No. of t is the number of trials
V is the volume.

RESULTS AND DISCUSSION

The results of the determination of some engineering properties of the drumstick seeds were represented in tables and charts.

Discussion

Gravimetric properties of drumstick seeds

The properties of the Drumstick seeds are presented in Table 1. The mean value of the true and bulk densities were found to be 0.92±0.02 gcm^{-3}, and 0.19±0.24 gcm^{-3}, the porosity was computed from the values of the true and bulk densities as 09%. The true density of the M. oleifera seeds shows that the seeds were slightly less dense than water (1.00 g/cm3) and therefore will float on water. It was noticed±0.055 g/cm3 at 15.82% moisture content. The 1000 seeds mass also increased from 272.051±11.827. Based on the gravimetric analysis of the seed, the result shows that the different moisture contents have the same effect on the 01true density, and thousand seed weight of the seed, except the bulk density of the seed in which there was a significant difference in their mean effects

Frictional properties of drumstick seeds (Moringa oleifera)

Table 2 presents the mean of the angle of repose($\emptyset$), coefficient of static friction (μ), and compression force for the drumstick seed, determined through the use of plastic glass and two other structural material surfaces respectively. The values for both angle of repose and coefficient of friction with respect to different surfaces are the surface with the highest angle of repose and coefficient of friction is galvanized steel with 18.84° and 0.3412 respectively, while glass is the surface with the lowest angle of Repose and coefficient of friction, with average values of 15.06° $\pm$0.2691, respectively.

The mean angle of repose for *M. oleifera* seeds was 15.96$\pm$0.23, 18.84$\pm$0.32$, and$ 18.84 $\pm$ 0.32 with a corresponding average of coefficient of friction on three different surfaces, glass, plywood, galvanized steel were found to be 0.2691$\pm$0.005$,$ 0.297 ± 0.006 and 0.341$\pm$0.006

respectively. It was observed that the mean angle of repose was found to be 15.96 ±0.23°.

CONCLUSIONS AND RECOMMENDATIONS

The engineering (physical and mechanical) properties of drum stick seeds in relation to the design of a Moringa de-podding machine for the crop have been determined. The experiment was performed at an average seed moisture content of 10.35 % dry basis. The average True Density of the seed was obtained as 0.92g/cm³ varying from 0.91g/cm³ to 0.95cm³ while the bulk density of the seed was calculated as 0.19g/cm³ ranging from 0.18g/cm³ to 0.21g/cm³. The average porosity calculated was 9%.

Secondly, regarding the mechanical properties of *Moringa oleifera* seeds, the angle of repose ranged from for the glass surface has the lowest 14.8° with a mean value of 15.59. The coefficient of static friction for the glass structural surface had the lowest value (0.269) while the galvanized steel structural surface had the highest value (0.341). The determination of some engineering properties of *Moringa oleifera* seeds at a moisture content of 10.35% dry basis shows that the higher the moisture content present in the seed, the higher the value of its length, width, and thickness. This study also shows that a significant change in the moisture content will lead to a significant change in the physical properties of the seed.

These parameters would provide essential data for the efficient design of the oil expeller. The following recommendations were made based on the result and test carried out:

i Drumstick (*Moringa oleifera*) is not poisonous to the health and thus, it can be used for nutritional and health purposes and vegetable oil can be extracted from it.

ii There is a need for the provision of apparatus to carry out scientific experiments, and to carry out design data for the development of the Moringa de-podding machine.

iii Efforts should be directed towards the plantation of drumstick seeds to increase the production of the seeds.

iv Scientists should embrace the design of the Moringa de-podding machine,

v Government should encourage its production by farmers and industries, because it is medicinal, and can be used for cooking.

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Table 1: Mean Value of Gravimetric Properties of Drumstick seeds (*Moringa oleifera*)

S/N	Physical properties	S.I Unit	Qty	Mean ($\boldsymbol{\mu}$)	Min	max	SD($\boldsymbol{\sigma}$)
1	Moisture content	% (d.b)	5	10.35	9.89	11.08	0.68
2	One thousand seed mass	G	3	272.05	316.8	326.7	11.82
3	True density	g/cm^{-3}	3	0.92	0.91	0.95	0.2
4	Bulk density	g/cm^{-3}	3	0.19	0.18	0.21	1.44
5	Porosity	%	3	09	1.1	13	1.53

Table 2: Frictional Properties of Drumstick Seeds *(Moringa oleifera)*

Physical properties	S.I unit	Qty	mean($\boldsymbol{\mu}$)	Min.	Max	SD ($\boldsymbol{\sigma}$)
Moisture Content (%)	% (d. b)	3	10.35		11.08	0.68
Angle of Repose ($\boldsymbol{\theta}$)	° (deg)					
Glass		3	15.06	14.8	15.4	0.24
Plywood		3	18.4	18.5	19.2	0.32
Galvanized Steel		3	18.84	18.5	19.2	0.32
Coefficient of Static Friction ($\boldsymbol{\mu}$)						
Plywood	-	3	0.297	0.283	0.301	0.006
Galvanized Steel.	-	3	0.341	0.33	0.34	0.006
Plastic Glass	-	3	0.269	0.264	0.275	0.005
Compression Test	kN/m^2	3	39.2	63.19	93.1	

Figure 1. Determination of angle of repose on plywood

Figure 2. Determination of angle of repose on glass

Figure 3. Determination of angle of repose on galvanized steel

Figure 4. Determination of compression test, using the aggregate testing machine

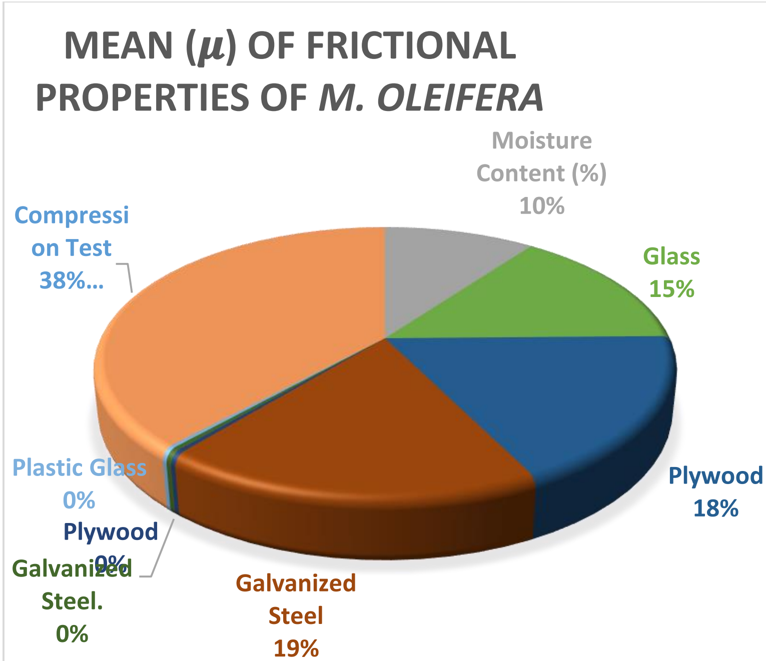

Figure 5. Chart showing the frictional properties of drumstick seeds