EFFECT OF MOISTURE CONTENT ON SOME PHYSICAL AND FRICTIONAL PROPERTIES OF AFRICAN LOCUST BEAN *(PAKIA BIGLOBOSA)*

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ABSTRACT

The moisture-dependent handling properties (linear dimensions, sphericity, bulk and true densities, porosity) and flow or frictional properties (angle of repose and static coefficient of friction) were investigated for African Locust Bean *(Pakia biglobosa)* at moisture contents in the range of 7.45% to 15.2% (d.b.). All the seed dimensions showed a linear response to an increase in moisture content within the range of moisture content studied. All other measured parameters increased polynomially with increased in moisture content. They are: seed equivalent diameter (11.02 to 12.73mm); seed volume (362.74mm^3 to 542.01mm^3); seed surface area (308.50mm^2 to 406.66mm^2); bulk density and true density (0.45g/cm^3 to 0.54g/cm^3 and 0.80g/cm^3 to 1.40g/cm^3 respectively); aspect ratio, sphericity and porosity (0.76 to 0.79, 0.71 to 0.70 and 0.41 to 0.61 respectively); angle of repose (21.05^o to 37.45^o); while static coefficient of friction increased for all surfaces from 0.53 to 0.92 for plywood, 0.45 to 0.84 for mild steel and 0.36 to 0.71 for aluminum with plywood giving the highest range of values. The data obtained from this study is useful in the structural design of hoppers, bins and silos for storing the seeds and the equipment for processing, sorting, sizing and other post-harvest operations.

KEYWORDS: African locust bean, moisture content, equivalent diameter, bulk density, porosity, angle of repose, static coefficient of friction.

1. INTRODUCTION

African locust bean *(Parkia biglobosa)* seed is a leguminous seed that grows on a tree common in the Savannah Zone of Nigeria. The tree is a perennial, growing where temperature is high, and relative humidity and precipitation are relatively low (Oladele *et al*., 1985). African locust bean fruit consists of bunches of pods which contain the edible part of the plant. The brownish-black seeds in each pod are enveloped in a yellow pulp, which is also edible, as it contains a high percentage of sucrose (Ogunjimi *et al*., 2002).

These seeds are extracted from the pod by plucking, cracking and tearing after which the remaining pulp is washed off and the seeds dried. Traditionally, these seeds are processed by boiling for about 8 hours to soften the testa, washing to separate the testa from the cotyledons, feet mashing, sieving in running water, boiling the cotyledons until desired moisture content is obtained for the fermentation of the resultant mash (Oje, 1993).

African locust bean (*Parkia biglobosa)* is of economic importance in Nigeria especially as it provides a cheaper source of protein for many inhabitants. The cotyledon or embryo is rich in nitrogen, phosphorus, potassium, magnesium, iron and zinc. The testa is rich in calcium, manganese and sodium when compared to that of the cotyledon, which is a rich source of lipids, carbohydrates, proteins, fibre and ascorbic acid (Alabi, 1991). The yellow powdery pulp is rich in carbohydrate (Oladele *et al*., 1985) and rich in oil suitable for the manufacture of soap (Owoyale *et al*., 1986). The husk is rich in tannins, making it a valuable source of tannins for the leather industry. The presence of fibres in the husk, together with tannins makes the husk a good raw material for the production of particle board (Owoyale *et al.*, 1986).

The production of *'ogiri (iru)* condiment' (the fermented cotyledons of the seeds) has over the years remained in the hands of rural families who process these seeds for home consumption and for sale, using rudimentary tools (Odunfa and Adewuyi, 1985). Due to the hectic nature of the process of making locust bean cake (*ogiri*), mechanization of this process has been of high interest in recent times in order to increase the efficiency of the production process. However, achieving optimum mechanization of the process cannot be made with success without proper study of the various physical, frictional, and mechanical properties of the African locust bean as a function of moisture content. To design equipment for the handling, separation, conveying, drying, storing, aeration and processing of African locust bean, determining their physical and flow properties as a function of moisture content is essential.

Ogunjimi, *et al*. (2002) investigated some engineering properties of a specie of locust bean (*Parkia fillicoidea)* at a particular moisture content of 10.25% (dry basis) and generated expressions for the relationship between their dimensions. as in Eqns. 1 and 2.

$$L = 1.4W = 1.85T \qquad 1.$$

And that of its seed (kernel) to be;

$$l = 1.39w = 2.85t \qquad 2.$$

Where; L and l = length, W and w = width, T and t = thickness (the upper case letters refer to pod and lower case, seed).

Oje (1993) found out that the locust bean pod has a major diameter ranging from 76mm to 277mm as against 8mm to 12mm of the seeds and average sphericity and roundness of 67% and 65% respectively. Subukola and Onwuka (2009) on the other hand investigated the effects of moisture content on some frictional properties of *Parkia fillicoidea*. Using plywood, galvanized iron, aluminum and stainless steel respectively as experimental surfaces and varying the moisture content from 7.37% to 28.09% (dry basis), they found out that the highest static coefficient of friction and angle of repose was on plywood surface which gave 0.47 to 1.00 and 21.43^0 to 37.46^0 respectively.

However, the main features of African locust bean and other agro and food materials that make them different from mineral materials are the strong influence of moisture content on their handling, flow and mechanical behavior and the high deformability of their seeds and granules. These differences bring about certain peculiar behaviors that necessitate the adjustments of models of material, experimental techniques and technological solutions (Molenda and Horabik, 2005).. Kibar *et al*. (2010) reported that for rice grains and other commodities, increased moisture content causes notable increases of pressure on silo walls. Because the increase of pressure requires an increase in the thickness of silo construction materials, costs of construction increase. Also, flow problems in silos such as arching, rat-holing, irregular flow and segregation occur with increased moisture content.

Many studies have been reported on the effect of moisture on the physical properties of seeds: guna seeds (Aviara *et al*., 1999); Roselle or sorrel (*Hibiscus sabdariffa*) seeds (Omobuwajo *et al*., 2000a; Sánchez-Mendoza *et al*., 2008); Ackee apple (*Blighia sapida*) seeds (Omobuwajo *et al*., 2000b); pigeon pea (Baryeh and Mangope, 2002); chickpea (Masoumi and Tabil, 2003); calabash nutmeg (Omobuwajo *et al.,* 2003); lentil seeds (Amin *et al.,* 2004); dried pomegranate seeds (Kingsly *et al.,* 2006); fibered flaxseed (Wang *et al.,* 2007); soybean (Kashaninejad *et al*., 2008); African oil bean seed (Asoegwu *et al.,*2006). The moisture content range used in Literature for its effect on some physical, mechanical, aerodynamic and other properties of agricultural products has been between 5 to 39% (d.b.), varying according to product type. However, limited work seems to have been done on the physical properties of African locust bean and their relationship with moisture content.

The aim of this study was to investigate some handling and flow (frictional) properties of African locust bean(*Parkia biglobosa)* as they are affected by moisture content in the range of 7.45% to 15.2% (d.b.) and establish some regression models to predict these effects.

2. MATERIALS AND METHODS

2.1 Physical Properties

About 9.5kg of samples of processed African locust bean seeds were obtained from the Abakpa market in Enugu state in the southeastern part of Nigeria and were carefully sorted to remove dirt, debris and unwholesome seeds after which 8.4kg of whole seeds were got for proper experimental use. To determine the initial moisture content of the seeds, a laboratory oven at the Food Science and Technology Department of the Federal University of Technology Owerri was used for the experiment. The initial moisture content was determined after oven drying 45 randomly selected seeds for 18 hours at a temperature of 125^{0}C using the Eqn. 3 (ASAE Standards., 1999).

$$MC = \frac{(W_1 - W_2)}{W_2} x100\% \qquad 3.$$

Where; W_1 = Initial weight of sample; W_2 = Final weight of sample; MC = Moisture content

Firstly, a batch of 1kg (batch 1) was kept at the initial moisture content of 7.45% without any further addition of water, this was used as control. The rest of the seeds were then divided into 4 parts of 1kg each and were conditioned to obtain four different moisture content levels between 10.2% and 15.2% dry basis, hence giving a total of 5 batches. This was done by adding different calculated amounts of water to each batch of the African Locust Bean seeds (*Parkia biglobosa*), using Eqn. 4(Gamayak *et al*., 2008);

$$Q = A\frac{(b - a)}{(100 - b)} \qquad 4.$$

Where; Q = mass of water to be added (g); A = Initial mass of sample (g); a = Initial moisture content of sample (% dry basis); b = Final/desired moisture content (% dry basis).

The batches were put in high density polyethylene bags and kept in a refrigerator at 2^{0}C - 5^{0}C for about 5days to allow for even distribution of water. Before each test was carried out, the sample was exposed for about 2 hours for equilibration to occur (ASAE standards, 1999). This rewetting technique to attain the desired moisture content in seeds and grains has frequently been used (Coşkun *et al*., 2005; Garnayak *et al.*, 2008; Sacilik *et al*., 2003).

The principal dimensions (L_1; L_2; & L_3) of the seed were determined using a micrometer screw gauge with an accuracy of 0.02mm.

The arithmetic mean diameter (F_1), geometric mean diameter(F_2), square mean diameter(F_3), equivalent diameter (D_e) were determined respectively using the formulae by Ciro (1997) and Asoegwu *et al.,* (2006);

$$F_1 = \frac{(L_1 + L_2 + L_3)}{3} \qquad 5.$$

$$F_2 = (L_1 x L_2 x L_3)^{1/3} \qquad 6.$$

$$F_3 = \left[\frac{(L_1 L_2 + L_2 L_3 + L_3 L_1)}{3}\right]^{1/2} \qquad 7.$$

$$D_e = \frac{(F_1 + F_2 + F_3)}{3} \qquad 8.$$

The aspect ratio (A_r) was determined by using equation (9) by Seifi and Alimardani (2010);

$$A_r = \frac{L_2}{L_1} \qquad 9.$$

Seed surface area (A_s) and seed volume (V) was calculated using the following relationships (Jain and Bal, 1997; Subukola and Onwuka, 2011):

$$A_s = \frac{\pi B L_1^2}{(2L_1 - B)} \qquad 10$$

$$V = \frac{\pi B^2 L_1^2}{6(2L_1 - 3)} \qquad 11.$$

$$Where\ B = (L_2 L_3)^{½} \qquad 12.$$

The bulk density (ρ_b) which is the ratio of the mass of the seeds to its total volume was determined by filling up a 600mL beaker with samples, striking off the top level without seed being compacted in any way, weighing the set up and subtracting the weight of the beaker. Equation (13) was used (Amin *et al.,* 2004; Subukola and Onwuka, 2011);

$$\rho_b = \frac{bulk\ kernel\ mass}{600mL} \qquad 13.$$

The true density (ρ_t) was determined using toluene displacement method. Toluene was used in place of water because it is absorbed by seeds to a lesser extent and also has a low surface tension with low dissolution power too (Aydin, 2002). 500ml of toluene was put in 1000mL graduated measuring cylinder. Seeds from each batch were first weighed using an electronic weighing balance and then immersed in toluene in six replicates. The amount of displacement was recorded as the volume. Hence true density was obtained using equation (14);

$$\rho_t = \frac{weight\ of\ seed}{V_2 - V_1} \qquad 14.$$

$$Where\ V_2 = final\ volume;\ V_1 = initial\ volume$$

Porosity (ε) was determined as a function of the volume fraction ($f_v = \rho_b/\rho_t$). The porosity expressed in percentage was calculated using equation (15) (Asoegwu *et al.,* 2006; Joshi *et al.,* 1993; Deshpande *et al.,* 1993; Suthar and Das, 1996; Nelson, 2002):

$$\varepsilon = (1 - f_y)x100\% \qquad 15.$$

Sphericity (ϕ) was calculated using equation (16) by Mohsenin (1986), Asoegwu *et al.,* (2006) and Gupta and Das (1997):

$$\phi = \frac{F_2}{F_1} \qquad 16.$$

2.2 Frictional Properties

The angle of repose (θ_r) was determined at different moisture contents using square box method. In this method, a specially constructed square box with removable front cover was used. The box was filled with the seeds from each batch; the front cover was then quickly removed, allowing the seeds to flow to its natural angle. The height (H) of the seeds was measured together as well as the length of spread (L) and the expression below (Oje and Ugbor, 1991) was used to determine the angle of repose for the different moisture contents:

$$\theta_r = tan^{-1}\left(\frac{H}{L}\right) \qquad 17.$$

Where H = maximum height of seeds in mm; L = spread length in mm

The static coefficient of friction of the various sample batches was determined against three (3) different structural materials, namely; mild steel, aluminum and plywood. A carton of St. Louis sugar was filled up to the brim with samples from each batch at a time and placed inverted on the structural surface lying on an adjustable tilting table. The carton was raised slightly so as to prevent the edges from touching the surface of the structural material. The entire set up was raised gradually using the tilt table screw device until the inverted carton of samples started to slide down and the angle of tilt (α) was read off using a protractor. Equation (18) was then used to determine the values of the static coefficient of friction (μ) on these structural surfaces at different moisture content levels (Singh and Goswami, 1996; Isik, 2007; Yalcin and Ozarslan, 2004).

$$\mu = \tan\alpha \qquad 18.$$

3. RESULTS AND DISCUSSION

It is observed that all the measured parameters were affected by increased moisture content. Table 1 shows the amount of water added to the African locust beans after being calculated with respect to mass of samples contained in each batch and the initial and desired moisture content levels.

3.1 Physical Properties

The seeds were grouped into five (5) batches of moisture content values of 7.45%, 10.2%, 11.4%, 12.9% and 15.2% respectively in dry basis. The average dimensions of volume, major, intermediate and minor diameters of each batch were determined by taking the average of the replicate values as shown in Table 2 for each of the batches.

3.2 Seed Dimensions

Table 2 shows the average major, intermediate and minor diameters for moisture content range of 7.45% to 15.2% dry basis. They were observed to vary from 15.09mm to 17.56mm, 11.50mm to 13.84mm and 7.19mm to 7.79mm respectively. Fig.1 show that they all increased linearly as moisture content increased. The following regression models (Eqns. 19 – 21) were developed for the effect of moisture content on seeds dimensions.

$$L_1 = 0.3389M + 12.588 \qquad (R^2 = 0.9568) \qquad 19.$$
$$L_2 = 0.3220M + 9.048 \qquad (R^2 = 0.9427) \qquad 20.$$
$$L_3 = 0.0872M + 6.4958 \qquad (R^2 = 0.9133) \qquad 21.$$

The increase in dimensions being moisture uptake in the intercellular spaces in the seeds, causing swelling and expansion. Hence, when these experimental values were regressed, linear and polynomial regression models gave the highest R^2-values. The linear relationship is recommended as the best that relates these properties to moisture content. Amin *et al.(*2004), Subukola and Onwuka (2011), Seifi and Alimardani (2010) and Tavakoli *et al.(*2009) all posited linear response of seed dimensions to moisture increase for lentil seeds, locust bean (*Parkia fillicoidea*), corn and barley grain respectively.

Table 1. Seed conditioning of batches

Batches	A(g)	Q (g)	b (% db)
1	1000	**Nil**	**7.45**
2	1000	18.1	10.2
3	1000	26.5	11.4
4	1000	36.9	12.9
5	1000	54.0	15.2

Table 2. Batch averages of dimensions

MC level	**L_1(mm)**	**L_2 (mm)**	**L_3(mm)**	**V(mm^3)**	**A_s (mm^2)**
M_1 (7.45%)	15.09	11.50	7.19	362.74	308.50
M_2 (10.5%)	15.51	11.99	7.29	399.78	329.69
M_3 (15.5%)	16.67	12.97	7.46	464.21	365.47
M_4 (20.5%)	17.16	13.34	7.73	507.77	388.81
M_5 (25.0%)	17.56	13.84	7.79	542.01	406.66

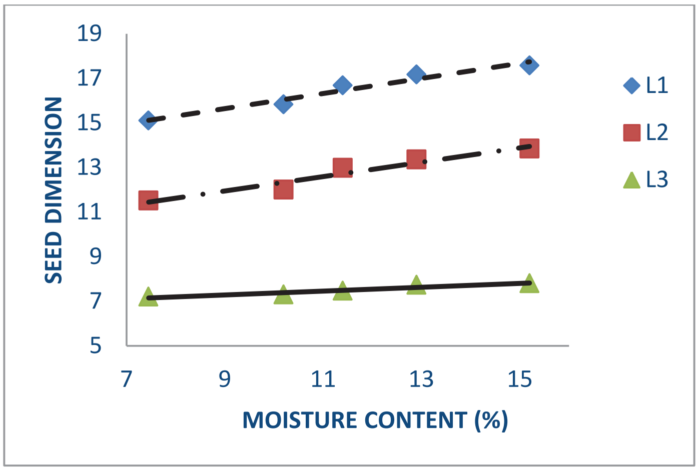

Fig 1. Effect of moisture content on seed dimensions

3.3 Seed Volume and Surface Area

Fig. 2 shows the behavior of seed volume and seed surface area with respect to changes in moisture content levels. Seed surface area ranged from 308.50mm^2 to 406.66mm^2 and seed volume between 362.74mm^3 to 542.01mm^3. The following polynomial regression models were developed to these effects;

$$V = -0.0064M^2 + 25.062M + 169.72 \qquad (R^2 = 0.9519) \qquad 22.$$

$$A_S = -0.0831M^2 + 15.528M + 193.75 \qquad (R^2 = 0.9510) \qquad 23.$$

From the above observations, seed volume and surface area increased polynomially as moisture content increased. This is dissimilar to the results of some researchers like Seifi and Alarmadani (2010) who suggested a linear increase of seed volume and seed surface area as moisture content of corn increased. Zareiforoush *et al.* (2009) and Kibar *et al*. (2010) posited a linear increase of these properties for paddy rice.

3.4 Equivalent Diameter

The equivalent diameter was seen to exhibit a polynomial increase as moisture content increased as shown in Fig 3. This is due to the fact that the seed dimensions increased when the seed (kernel) absorbed more moisture because more matter is then added to the seed, hence there is an expansion in size. Seifi and Alimardani (2010) reported a linear response for corn. Zeifouroush *et al.* (2009) reported a linear response too for paddy grain. Equation (24) gives the regression model to this effect,

$$D_e = -0.0048M^2 + 0.3479M + 8.6254 \qquad (R^2 = 0.9472) \qquad 24.$$

Asoegwu *et al.* (2011) reported linear relationship of equivalent diameter of African breadfruit seed with increasing moisture content.

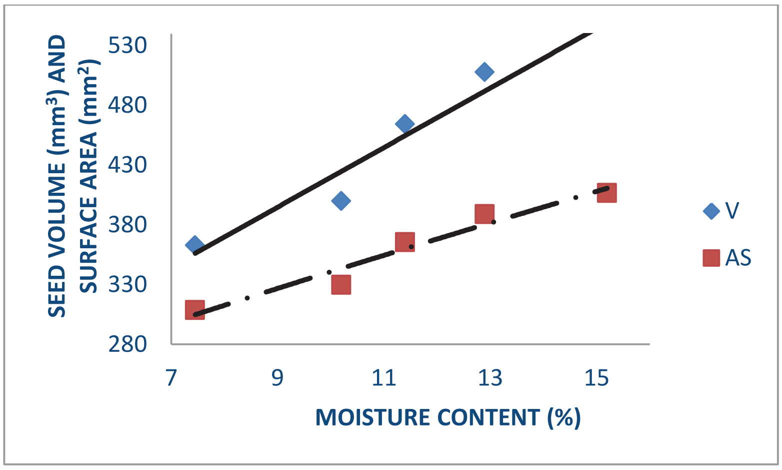

Fig 2.Effect of moisture content on seed volume and surface area

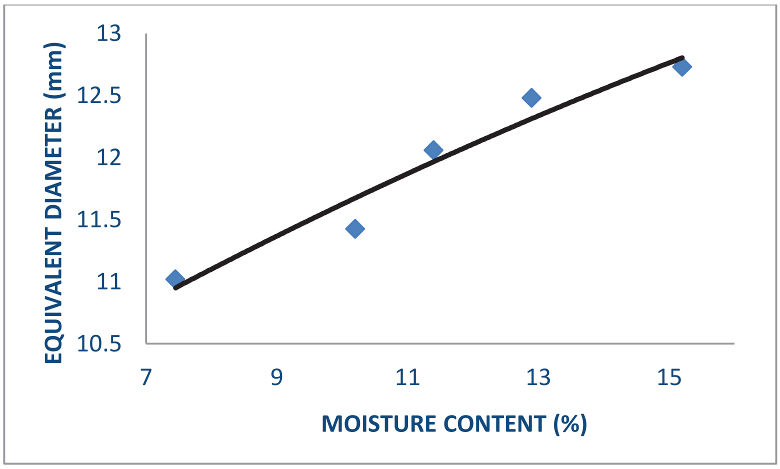

Fig 3. Effect of moisture content on equivalent diameter

3.5 Aspect Ratio and Sphericity

There was a gradual polynomial decrease of seed sphericity as moisture content increased as shown in Fig 4. This indicates that the seed is a little bit close to being a sphere as the principal dimensions of the seed increased with respect to moisture content. On the other hand, aspect ratio showed a third degree polynomially increasing trend. The following regression models were developed to these effects;

$A_r = -0.0003M^3 + 0.0118M^2 - 0.1282M + 1.2028$ ($R^2 = 0.9103$) 25.
$\Phi = 0.0003M^2 - 0.0086M + 0.7585$ ($R^2 = 0.9278$) 26.

Seifi andAlimardani (2010) suggested a linear response for the aspect ratio and sphericity of corn. Subukola and Onwuka (2011) and Zareiforoush *et al*. (2009) suggested a linear behaviour too for the sphericity of *Parkia fillicoidea* specie of locust bean and paddy grain respectively. Similar trends have been reported by Olajide and Ade-Omowaye (1999) for locust bean seed and Asoegwu *et al.* (2006) for African oil bean seed. Sánchez-Mendoza *et al*. (2008) reported a quadratic (polynomial) regression model for the effect of moisture on the sphericity of roselle seeds, while Asoegwu *et al.* (2011) suggested a power model for African breadfruit seeds.

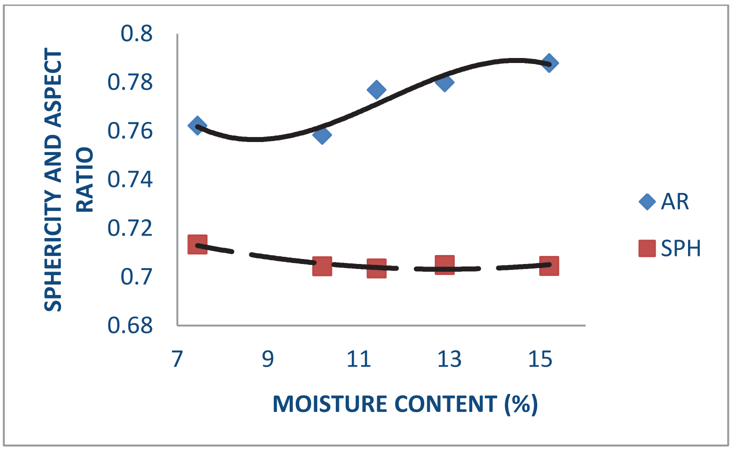

Fig. 4 Effect of moisture content on aspect ratio and seed sphericity

3.6 Density

From Fig. 5, bulk density increased polynomially from 0.4510g/m^3 to 5420g/m^3 and true density showed a third degree polynomial increase from 0.795g/m^{3}to 1.400g/m^3. A linear behaviour was suggested by Amin *et al*. (2004) for both the bulk and true densities of lentil seeds with respect to moisture content variance. Asoiru and Ani (2011) suggested an average safe storage density of yam bean to be 1.01779g/cm^3 and 1.0036g/cm^3 respectively for true and bulk densities. Nimkar and Chattopadhyay (2001) posited a linear increase in density of 807kg/m^3 to 708kg/m^3 (bulk density) and 1363kg/m^3 to1292kg/m^3 (true density) for green gram.

Equations (27) and (28) are regression models developed to these effects;
$\varrho_b = -0.0001M^2 + 0.016M + 0.3353$ ($R^2 = 0.9175$) 27.
$\varrho_t = -0.0082M^3 + 0.2872M^2 - 3.1368M + 11.632$ ($R^2 = 0.9748$) 28.

3.7 Porosity

The porosity of the seeds exhibited an increasing third degree polynomial trendline with respect to increase in moisture content as seen in Fig 6. This is because less pore spaces are created as the seeds absorb more moisture. The porosity varied from 41.10% to 61.32% as moisture content increases. Nimkar and Chattopadhyay (2001) suggested a linear increasing response of this parameter for green gram. Kingly, *et al.* (2006), Subukola and Onwuka (2011) and Tavakoli *et al*. (2009) suggested a decrease in porosity of pomegranate seeds, *Parkiafillicoidea*specie of locust bean and barley grains respectively with increasing moisture content.

Equation (29) is the regression model developed to this effect.

$$\varepsilon = -0.1942M^3 + 6.8146M^2 - 74.083M + 295.2 \quad (R^2 = 0.987) \qquad 29.$$

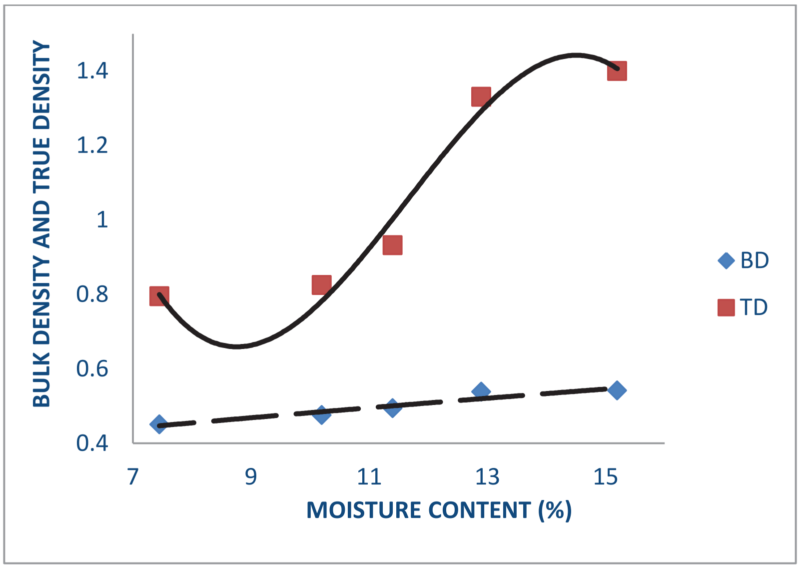

Fig. 5 Effect of moisture content on bulk density and true density

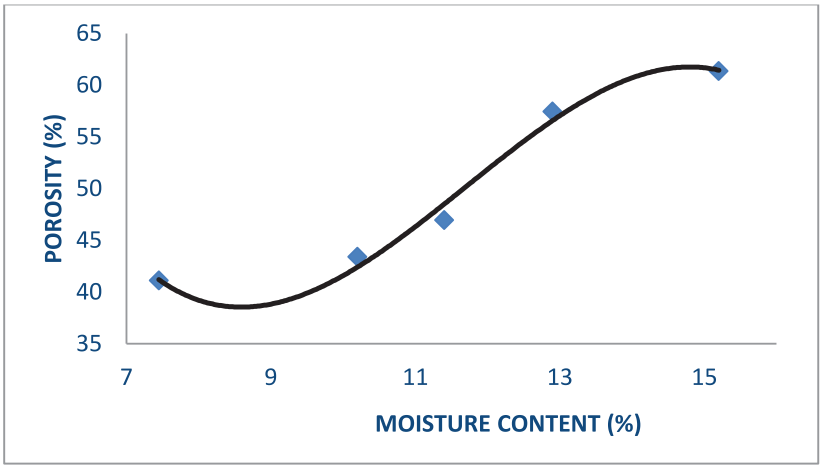

Fig. 6 Effect of moisture content on porosity

3.8 Static Coefficient of Friction

The static coefficients of friction of friction on the three different surfaces and at five different moisture content levels are shown in Fig 7. It can be observed that the static coefficient of friction for all the structural surfaces tested in the experiment had a polynomial increase as moisture content increases, with plywood having the highest coefficient followed by mild steel and lastly aluminum. This is due to the fact that the seeds become stickier as moisture content increases, leading to more resistance to relative motion between seeds and the surface. This increase in resistance therefore leads to an increase in the coefficient of static friction. It was also observed that the coefficient of static friction also varied with surfaces, this was as a result of the dependency of frictional properties and mechanical behavior of a material on the microstructure of the material.

Structural material grains shape and their crystallographic orientation are two features of microstructure that affect friction on this material. Due to the difference in crystallographic orientation of the grains which creates a difference in the surface texture, the material grains of the two surfaces prevent one surface from sliding freely on the other. The rougher the grains, the more the surfaces interlock, resulting in more resistance to relative motion between them which equally leads to increase in the coefficient of static friction. The material grains of plywood are rougher than those of mild steel and aluminum. Hence, the reason for the high coefficient of static friction with plywood. Therefore, the power demand of processing machines involving friction increases with increase in moisture content and also with increase in coefficient of static friction. This implies that in plywood constructed machines, higher power will be required than in similar machine constructed with aluminum. Appendix V gives the experimental values generated to this effect.

Asoiru and Ani (2011) posited linear increase for average values of coefficient of static friction from aluminum to asbestos to plywood at a safe moisture content for African yam bean. Oje and Ugbor (1991) also suggested a linear increase for oil bean seeds using galvanized steel, plywood, stainless steel, aluminum and mild steel with a simultaneous increase in moisture content and equally posited that plywood gave highest values. Kingly *et al*. (2006) posited a linear increase for pomegranate seeds for various structural surfaces with plywood giving the highest values.

The following are regression models developed to this effect;

$$\mu_{PLW} = 0.0004M^2 + 0.044M + 0.1763 \qquad (R^2 = 0.9902) \qquad 30.$$
$$\mu_{MS} = 0.002M^2 + 0.0069M + 0.2846 \qquad (R^2 = 0.9931) \qquad 31.$$
$$\mu_{AL} = 0.0015M^2 + 0.0113M + 0.1892 \qquad (R^2 = 0.9973) \qquad 32$$

3.9 Angle of Repose

Fig 8 shows the angle of repose at five different moisture contents and it was observed that the angle of repose had a third degree polynomial variation with increase in moisture content. The reason being that the higher the moisture content, the higher the cohesion between the seeds. In terms of flowability, the seeds are heavier and the inertia to move is increased. This increase in resistance to flow prevents seeds from sliding on each other, thereby increasing the angle of repose of the seeds. Appendix VI shows the experimental values generated to this effect.

Nimkar and Chattopadhyay (2001) , Subukola and Onwuka (2011), Tavakoli *et al.* (2009) and Zareiforoush *et al.* (2009) all suggested a linear increase too for green gram seeds, *Parkia fillicoidea* specie of locust bean, barley grains and paddy grains respectively.The following regression model was developed to this effect;

$$\Theta_R = -0.1366M^3 + 4.7214M^2 - 50.226M + 189.64 \qquad (R^2 = 0.9993) \qquad 33.$$

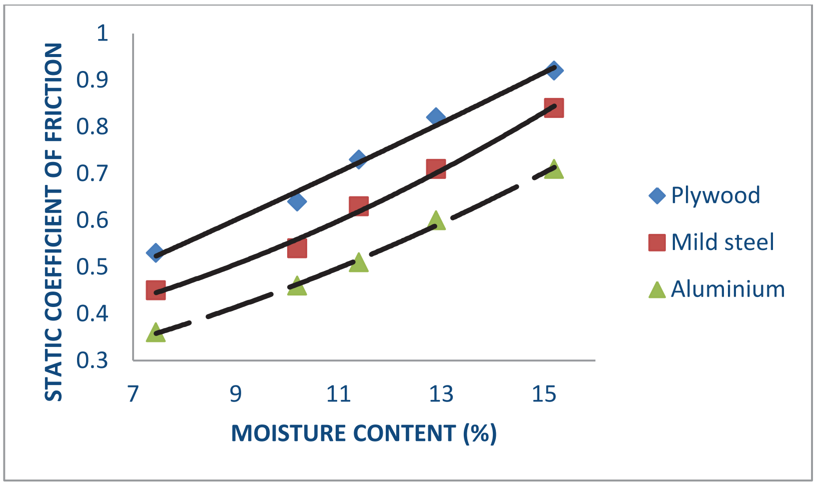

Fig. 7 Effect of moisture content on static coefficient of friction

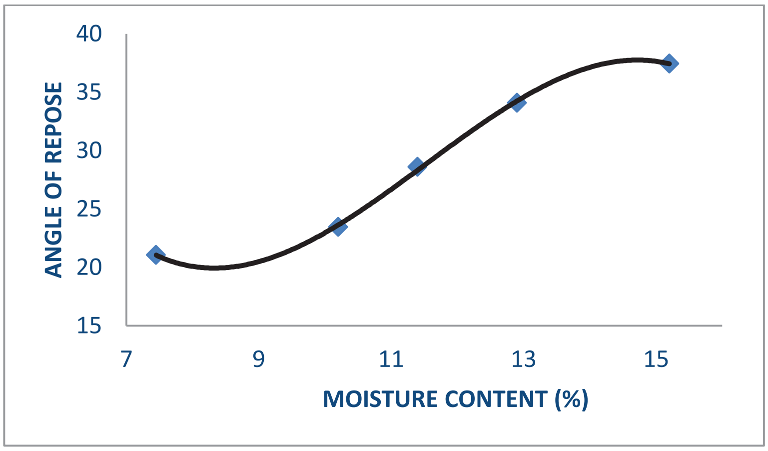

Fig 8 Effect of moisture content on angle of repose

4. CONCLUSIONS AND RECOMMENDATION

All properties studied were found to have a linear or polynomial response (second order or third) to moisture content increase within the moisture content range studied. The average dimensions; major, intermediate and minor and equivalent diameters increased from 15.09 to 17.56mm, 11.50 to 13.84mm, 7.19 to 7.79mm, and 11.02 to 12.73mm respectively as moisture content increased from 7.45% to 15.2% (dry basis). The seed volume and the seed surface area of *Parkia biglobosa* increased from 362.74mm^3 to 542.01mm^3 and 308.50mm^2 to 406.66mm^2 within the range of moisture content tested. Bulk density and true density increased from 0.45g/m^3 to 0.54g/m^3, and 0.80g/m^3 to 1.40g/m^3 respectively with increasing the moisture content range tested. Aspect ratio, sphericity and porosity of *Parkia biglobosa* varied with increase in the tested moisture content range from 0.76 to 0.79; 0.713 to 0.704 and 0.41 to 0.61 respectively. Angle of repose increased from 21.05^0 to 37.45^0 while static coefficient of friction increased from 0.53 to 0.92 (plywood), 0.45 to 0.84 (mild steel) and 0.36 to 0.71 (aluminum) as moisture content increased from 7.45 to 15.2% (dry basis). All resultant values generated in this research were statistically analysed using Microsoft office excel 2010, hence developing the regression models of the effects of moisture on all the properties studied.

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