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Some Physical Properties of Groundnut Grains

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Abstract: Investigation of physical and mechanical properties of groundnut is essential for design of equipment for harvesting, processing, transportation, cleaning, sorting, separation and packaging. In this research some physical properties of groundnut grains were evaluated such as axial dimensions, geometric mean diameter, thousand grain mass, true and bulk density and grain volume at moisture content 7.6% dry basis. The sphericity, aspect ratio, surface area and porosity were 0.69, 56%, 120.82mm2, 36.4% respectively. Static coefficient of friction for glass, plywood, galvanized steel and concrete structural surfaces were 0.11, 0.13, 0.14 and 0.16, respectively and angle of repose 28°.

Keywords: Groundnut grains, length, moisture content, physical properties, thickness, width

INTRODUCTION

Groundnut otherwise known as *Arachis hypogeae* is regarded as one of the most important protein-rich and it occupies the fifth position as oilseed crop globally after soybean, cottonseed, rape seed, and sunflower seed (El-Sayed *et al.*, 2001). It is grown as annual crop on about 19million hectares of land in tropical regions and the warmer areas of temperate regions of the world (Adejumo *et al.*, 2005).

Despite the economic potential of groundnut little is known about the physical properties. The processing operations are predominantly done manually. The manual processing of groundnut are time consuming and laborious, the condition prevalent at this level is generally unsanitary and inherent unhygienic conditions. The knowledge of physical and mechanical properties of groundnut like any other biomaterial is fundamental because it facilitates the design and development of equipment for harvesting, handling, conveying cleaning, delivering, separation, packing, storing, drying, mechanical oil extraction and processing of agricultural products, their physical properties have to be known (Mohsenin, 1980; Aviara *et al.*, 1999). Presently, the equipment used in processing groundnut have been generally design without taken into cognizant the physical properties of groundnut which include the size, mass, bulk density, true density, sphericity, porosity, coefficient of static friction and angle of repose and resultant systems leads to reduction in working efficiency and increase in product losses (Manuwa and Afuye, 2004; Razari *et al.*, 2007). The physical properties have been studied for various agricultural products by other researchers such as soybean (Manuwa and Afuye, 2004), bambara groundnut (Adejumo *et al.*, 2005),cocoa bean (Bart-plange and Baryeh, 2003), locust bean seed (Ogunjimi *et al.*, 2002), wheat (Tabatabaeefa, 2003),pigeon pea (Baryeh and Mangope 2003) and pistachio nut and its kernel (Razari *et al.,* 2007).

This study was therefore carried out to determine the geometric properties (length, width, thickness, geometric and arithmetic mean diameter, sphericity and surface area), gravimetric properties (including unit mass, 1000 grain mass, true volume, true density, bulk density, and porosity) and frictional properties (angle of repose and static coefficient of friction) of groundnut in order to develop appropriate equipment that will reduce post-harvest losses and thus enhance productivity.

MATERIALS AND METHODS

The groundnut was procured for the study from Yenegoa market in Bayelsa State, Niger Delta, Nigeria on 12th January, 2009. The sample were selected and cleaned manually. It was ensured that the grains were free of dirt, broken ones and other foreign materials. The grains were kept in the room temperature for two days. Moisture content was immediately measured on arrival. The experiments were conducted at the moisture content of 7.6% dry basis (d.b).

For this experiment, 100 groundnut grains were randomly selected, the length (L), width (W) and thickness (T) and mass of groundnut grain were measured using a micrometer screw gauge with a reading of 0.01mm. The average diameter was calculated by using the arithmetic mean and geometer means of the three axial dimensions. The arithmetic mean diameter, D_a, and geometric mean diameter, D_g, of the soybean were calculated by using the following relationships (Galedar *et al.*, 2008; Mohsenin, 1980).

$$D_a = (L + W + T)/3 \qquad (1)$$

$$D_g = (LWT)^{1/3} \qquad (2)$$

Where D_a – Arithmetic mean diameter (mm), D_g – geometric mean diameter (mm), L – length (mm), W-Width (mm) T-thickness (mm).

The sphericity (ϕ) (%) was calculated by using the following relationship (Koocheki *et al.*, 2007; Milani *et al.*, 2007)

$$\Phi = \frac{(LWT)^{1/3}}{L} \quad (3)$$

The surface area S (mm^2) was found by the following relationship given by Mc Cabe *et al.* (1986)

$$S = \pi D_g^2 \quad (4)$$

The aspect ratio, R was calculated by applying the following relationships given by (Maduako and Faborode, 1990):

$$R_a = (W/L)100 \quad (5)$$

The unit volume of 100 individual grain was calculated from values of L, W and T following formula

$$V = LWT/6\ (4) \quad (6)$$

The 1000 unit mass was determined using precision electronic balance to an accuracy of 0.01g. To evaluate the 1000 unit mass, 50 randomly selected sample was weighed and multiplied by 20. The reported value was a mean of 20 replications.

The bulk grains were put into a container with known mass and volume (500 ml) from a height of 150mm at a constant rate (Milani *et al.*, 2007). Bulk density was calculated from the mass of bulk grain divided by the volume containing mass

$$\rho_b = M_b / V_b \quad (7)$$

where: e_d - bulk density (kgm^{-3}), M_b – mass of seeds (kg) V_b – volume of container (m^3).

The true density ρ_t was determined using the unit values of unit volume and unit mass of individual grain and calculated using the following relationship

$$\rho_t = M/V \quad (8)$$

where ρ_t – true density (kgm^{-3}), M – mass of individual seed (kg), *V*- volume (m^3).

The porosity (ϵ) of the bulk grain was computed from the values of the true density and bulk density of the grains by using the relationship given by Mohsenin (1980).

$$\rho_t = (1 - \rho_b) / \rho_t \ x\ 100 \quad (8)$$

Where ϵ – porosity (%)

ρ_b - bulk density (kgm^{-3})
ρ_t - true density (kgm^{-3})

The static coefficient of friction for soybean grains determined with respect to four test surfaces namely plywood, galvanized iron sheet, concrete and glass. A glass box of 150 mm length, 100 mm width and 40 mm height without base and lid was filled with sample and placed on an adjustable tilting plate, faced with test surface. The sample container was raised slightly (5 – 10 mm) so as not to touch the surface. The inclination of the test surface was increased gradually with a screw device until the box just started to slide down and the angle of tilt was measured from a graduated scale. For each replicate, the sample in the container was emptied and refill with a new sample. The static coefficient of friction (m_s) was calculated based on this equation, (Mohsenin, 1980).

$$m_s = \tan\theta \quad (9)$$

The filling or static angle of repose with the horizontal at which the material will stand when piled. This was determined using topless and bottomless cylinder of 0.15 m diameter and 0.25 m height. The cylinder was placed at the centre of a raise circular plate having a diameter of 0.35 m and was filled with groundnut grains. The cylinder was raised slowly until it formed a cone on a circular plane. The height of the cone was measured and the filling angle of repose θ_f was calculated by the following relationship (Karababa, 2006; Kaleemullah and Gunasekar, 2002)

$$\theta_f = \tan^{-1} [\ 2H/D] \quad (10)$$

where X and Y are the height and diameter of the cone respectively.

RESULTS AND DISCUSSION

The average values for the length, width, thickness, dimensions, geometric and arithmetic mean diameter, sphericity and surface area of groundnut measured at moisture contents 7.6% wet basis (d.b.) are given in Table 1.The average magnitudes of the major, intermediate, and minor diameters for groundnut were 14.42, 9.94 and 7.57mm respectively. According to El-Sayed *et al.*(2001) reported that Egyptian groundnut variety which have the following dimension, length, width, thickness, geometric diameter and mass 12.60 - 24.85mm, 5.35 -11.25mm, 4.40-10.80mm, 7.19-13.77mm, and 0.22-1.17g, respectively. He also reported three varieties of groundnut pod obtained from three different countries (China, America and Egypt) showed the following range of geometric diameter 21.05, 20.59, and 20.34mm and 2.21, 2.17 and 2.13g of mass, respectively. The corresponding average dimension values of African nutmeg as reported by Burubai *et al.* (2007) for length, width and thickness were 16.6762, 11.5193 and 9.9805 mm, respectively. Analysis of variance (ANOVA) revealed that the difference in physical dimensions of groundnut and African nutmeg were statistically significant at the

Table 1. Some physical properties of groundnut grains at 7.6% dry basis.

Properties	No. of sample	Minimum	Maximum	Mean	Standard deviation
Length (mm)	100	13.05	15.42	14.21	1.05
Width (mm)	100	7.25	8.45	7.94	0.78
Thickness (mm)	100	7.04	8.33	7.57	0.03
1000grain mass (g)	50	360.54	396.32	380.50	10.54
Arithmetic mean diameter(mm)	100	8.98	10.16	9.91	0.97
Geometric mean diameter (mm)	100	9.16	9.93	9.49	0.86
Sphericity	100	0.66	0.70	0.60	0.03
Surface area (mm)	50	101.91	125.29	120.82	8.75
Volume(mm^3)	100	350.21	501.08	422.17	31.73
Aspect ratio(%)	100	53.6	56	55.5	1.12

Table 2: Gravimetric and frictional properties of groundnut at 7.6% dry basis.

Properties	Values	Standard deviation
True density kgm^{-3}	752.34	15.57
Bulk density kgm^{-3}	479.28	10.48
Porosity (%)	36.4	2.72
Angle of repose	28°	1.2°
Glass (static coefficient of friction)	0.10	0.004
Plywood (static coefficient of friction)	0.13	0.003
Mild steel (static coefficient of friction)	0.14	0.009
Concrete (static coefficient of friction)	0.16	0.007

level 0.05. The average diameter of the groundnut for arithmetic and geometric mean were 9.91 and 9.49 mm, respectively. There was no significant difference between at a significant level of 0.05.

The mean sphericity was calculated and obtained 0.67. These values were closer to the corresponding values of 0.64 as reported for jatropha kernel (Dash *et al.* 2008). Conversely, ANOVA showed that there was difference in the average sphericity values 0.74 and 0.77 reported by Burubai *et al.* (2007), Musa and Haydar (2004) at a significant level of 0.05.The aspect ratio of groundnut was 56% and corresponding the aspect ratio of simarouba kernel was 56.41% as reported by Dash *et al.* (2008). This result indicated that there was no significant difference in their shapes. The ability of any grains or fruits to either roll or slide depends on the aspect ratio and as well as sphericity.

The average 1000 grain mass of groundnut was 376g as shown in Table 1. The corresponding reported values of simarouba kernel were 330.26 (±29.35), jatropha 688g, African nutmeg 897.5g .(Dash *et al.* (2008) and (Burubai *et al.* (2007).

The average surface area of groundnut was 120.82mm². The corresponding values of simarouba fruit and kernel were 687.94mm² and 252.08mm², respectively.

A cursory look at Table 2 revealed bulk density was 479.28(±16.23) kgm^3 for groundnut while the true density was 753 .34(±17.76) kgm^{-3} .It also revealed a significant difference ($p<0.05$) between the average value of true and bulk density. The corresponding true and bulk density for African nutmeg were 830.54 and 488.76 kgm^{-3} as reported by Burubai *et al.* (2007).

The mean porosity of groundnut grain was 36.4 (±2.1) %.

The static coefficient of friction for groundnut, were determined with the respect to four difference structural surfaces as shown in Table 2. It can be observed that the static coefficient of friction was highest against concrete surface 0.16 (±0.003) followed by mild steel 0.14(±0.009) plywood 0.13(±0.03). The least coefficient of friction was observed with glass 0.10 (±0.002). It was observed that the smoother the structural surface the lower the coefficient of friction of agricultural products.

CONCLUSION

The following conclusions are drawn from the study of the some physical properties of groundnut grain moisture content of 7.6% dry basis:

- The average length, width, thickness, arithmetic and geometric mean diameter of grains 14.21, 7.94. 7.57. 9.91 and 9.49mm, respectively .
- The results obtained from this research indicated that static coefficient of friction for concrete structural surfaces was highest while glass recorded lowest.
- The bulk and true densities, porosity, sphericity, aspect ratio, surface area and 1000 grain mass were all investigated and reported.

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