Short Communication

Study on physical and engineering properties of groundnut seed for planter development

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Absract

The physical properties of groundnut seeds were evaluated as a function of moisture content (m.c). The average length, breadth and thickness of the seed varied from 13.09, 8.68 and 7.07 mm, respectively, as the moisture content of 8.13% db. The roundness and sphericity are 68 and 71 per cent respectively, 1000 seed weight (W_{1000}) ranged between 333.3 and 315.78 g, the angle of repose ranged between 31.61^0 and 32.62^0 while the bulk density measured as 845 kg m^{-3}. The static coefficient of friction increased on three structural surfaces namely, aluminium (2.472), wooden (2.216) and stainless steel (2.013) as the moisture content increased. These data are useful for development of precision planter.

Keywords: Ground nut, Moisture content, Physical properties, Sphericity , Surface area.

In India, groundnut is one of the most important oilseed crops and occupies an area of 4.73 m ha with production and productivity of 6.72 m tonnes and 1422 kg/ha, respectively (2018-19). The main groundnut growing states are Gujarat, Tamil Nadu, Andhra Pradesh, Maharashtra, Karnataka and Rajasthan. It is also known as peanut, monkey nut or *moongfali*. Botanical name of groundnut is *Arachis hypogaea* which is derived from Greek word *Arachis* means legume and *hypogaea* means below ground, referring to formation of pods in the soil.

Groundnut plays an important role in the dietary requirement of resource poor woman and children. Groundnut is called as the King of oilseeds. It is one of the most important food and cash crops of our country. Groundnut can be grown on all types of soils such as sandy, sandy loam and heavy black soils. Most suitable soils for groundnut production are well-drained, light-textured, loose sandy-loam or sandy clay loam soils with good drainage, having reasonable high calcium, pH 5.5 to 7.0 and a moderate organic matter. Groundnut has several uses as whole seeds or is processed to make groundnut butter, oil, and other products. Groundnut is one of the most important oilseed plants in the world. Its seeds contain 40 - 50 per cent fat, 20 - 50 per cent protein and 10 - 20 per cent carbohydrate depending on the variety.

This study was therefore carried out to determine the geometric properties (length, width, thickness, geometric mean diameter, sphericity and surface area), gravimetric properties (including unit mass, 1000 grain weight, 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 hopper and sieve.

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Notation

Ac	area of the smallest circumscribing circle, mm^2
Ap	projected area, mm^2
b	width of seed, mm
d	geometric mean diameter, mm
l	length of seed, mm
Rp	roundness, %
Ds	sphericity, %
P	porosity, %
t	thickness of seed, mm
	angle of repose, deg
V	seed volume, cm^3
W_{1000}	1000 seed weight, g
x	moisture content, % db
ì	coefficient of static friction
$ì_{al}$	coefficient of static friction on aluminium
$ì_{w}$	coefficient of static friction on wooden
$ì_{ss}$	coefficient of static friction on stainless steel
ñ	bulk density, g cm^3
ñ	true density, g cm^3

In the present study, the groundnut seed Jaya variety was used. The initial moisture content of the seed was found to be 8.13% d.b. The moisture content of the seed was determined by the oven method (Ranganna, 1986). The seed was kept in an oven at a constant temperature of 105 ± 3^0C until a constant mass was obtained. The following methods were used in the determination of some physical and engineering properties of ground nut.

A digital Vernier caliper was used to measure the axial dimensions of the seeds; length, width and thickness. From the axial dimensions, the geometric mean diameter Dp in mm was determined by using the following formula (Frontezak & Metzgen, 1985; Joshi et al., 1993): $D_p = (lbt)^{1/3}$

where: *l*, the length is the dimension along the longest axis in mm; b, the width is the dimension along the longest axis perpendicular to a in mm and t, the thickness, is the dimension along the longest axis perpendicular to both a and b in mm.

Figure 1. Measurement of axial dimensions of the groundnut seed

It measures the shape character compared to a sphere of the same volume. Assuming that the volume of seed is equal to the volume of triaxial ellipsoid with intercepts *l*, b, t and that the diameter of the circumscribed sphere is the longest intercept of the ellipsoid, the degree of sphericity, Ds was calculated as follows (Mohsenin, 1986):

$$D_s = \frac{(lbt)^{1/3}}{l}$$

The procedure was repeated for 20 seeds selected randomly. The mean was taken as the characteristic value of sphericity.

The arithmetic mean diameter of seed was used to determine the cell size of metering roll. The arithmetic mean diameters (Da) of the seeds were computed by using the following equation with three axial dimensions (Mohsenin, 1970 and Singh and Goswami, 1996).

Arithmetic mean diameter $D_a = \frac{l.b.t}{3}$

Where: l, length of a seed in mm; b, width of a seed in mm; t, thickness of a seed in mm.

Twenty (20) groups of ground nut seeds with each group containing 1000 seeds were carefully counted and weighed on a digital balance to an accuracy of 0.001 g in all the 20 groups. The mean and standard deviation (SD) of the 20 groups were calculated to ascertain the uniformity in weight for 1000 seed weight (Akaaimo and Raji, 2006).

The bulk density was determined by filling an empty 1000 ml graduated cylinder with the seed and weighed (Mohsenin, 1986 and Sahoo and Srivastava, 2002). The bulk density influences the design of volume of seed hopper and is affected by degree of packing. A known volume of cylinder seeds was taken, at three trails and their weight was measured and recorded. The average value of the weight per unit volume was computed.

$$ñ_b = \frac{Ws}{Vs}$$

Where: $ñ_b$ is the bulk density in kg m^{-3}; Ws is the weight of the sample in kg; and Vs is the volume occupied by the sample in m^3. The mean value and SD for the 20 replications were determined to obtain the bulk density.

The seeds were allowed to fall from a height of 300 mm on circular discs of 200, 150, and 100 mm diameter until maximum height was reached and the height of seed heap was noted. The experiment was replicated five times for each seed kind and the average values were computed (Jayan and Kumar, 2004). The following equation was used to calculate the angle of repose of the selected seeds,

$$\theta = tan^{-1} \frac{2H}{d}$$

Where: is the angle of repose; H is the height of the cone in mm, and d is the diameter of the base in mm.

The coefficient of internal friction is the friction of seed against seed and was measured using an apparatus. The guide frame and the cell were filled with the sample material. The cell was tied with a cord passing over a frictionless pulley attached to a pan. Weights were loaded into the pan gradually to cause the pan to just slide and the weight-on-sliding was noted. The cell was then emptied and the weight to cause the cell to just slide was again noted (Chukwu, et al. 2018). The coefficient and angle of internal friction were calculated as

$$ì = \frac{W_{ss} - W_{se}}{W_{sc}}$$

$$ö_I = tan^{-1}\ ì$$

where: ì is the coefficient of internal friction; w_{ss} is the mass-on-sliding when the cells are filled with the sample; w_{se} is the mass-on-sliding when the cells are empty in g; W_{sc} is the mass of the sample material in the cell in g, also given by the product of the volume of cell in m^3 and bulk density in kg m^{-3}; and $ö_I$ is the angle of internal friction. The process was replicated five times and the average of the five readings was taken as the representative value.

Figure2. Measurement of angle of repose

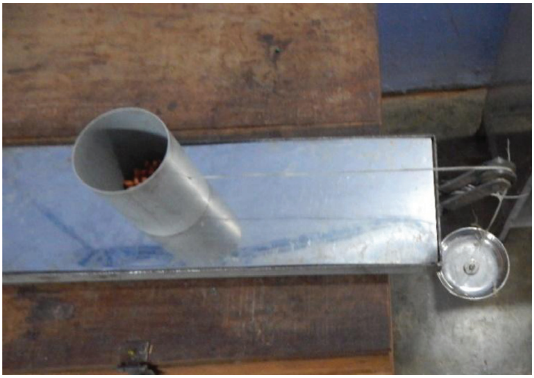

Figure 3. Measurement of angle of internal friction

The coefficient of friction on some material surfaces was determined using the set up similar to the one used for determination of coefficient of internal friction except that instead of the guide frame, the cell was placed on a table with changeable surface. The experiment was conducted on three material surfaces; these are plywood, aluminium sheet and stainless steel sheet. The experiments were replicated five times for each surface and the average of the results obtained for the five replications was taken as the representative value

Table 1. Some physical and engineering properties of ground nut seed at moisture content of 8.13% (d.b.)

Physical properties	No. of sample	Mean	Maximum	Minimum	SD
Length, mm	20	13.09	14.10	12.10	0.71
Width, mm	20	8.68	9.56	7.74	0.67
Thickness, mm	20	7.07	7.82	6.32	0.55
Geometric mean diameter, mm	20	9.29	9.93	8.69	0.538
Sphericity	20	0.71	0.758	0.687	0.0296
One-thousand seed weight, g	20	333.3	337.07	315.78	9.64
Surface area (mm^2)	20	271.77	309.8	237.27	31.56
Aspect ratio (%)	20	66.3	67.8	63.9	1.54

SD, standard deviation.

for each surface. The coefficient of friction on material surface was calculated as the ratio of limiting force to the corresponding normal pressure with the mass-on-sliding when the cell placed on another material surface was filled with the sample used as w_{ss} and the mass to cause sliding when the cell placed on another material surface was empty used as w_{se}.

The average values for the length, width, thickness, dimensions, geometric mean diameter, sphericity and surface area of groundnut measured at moisture contents 8.13% dry basis (d.b.) are given in Table 1. The average magnitudes of the major, intermediate, and minor diameters for groundnut were 14.10, 13.28 and 12.10mm respectively. The average diameter of the groundnut for geometric mean is 9.29 mm. The mean sphericity was calculated and obtained 0.71. The aspect ratio of groundnut was 66.3 per cent. 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 333.3g. The corresponding reported values of simarouba kernel were 330.26 (±29.35), jatropha 688g, African nutmeg 897.5g (REF). The average surface area of groundnut was 291.56mm². A cursory look at Table 2 revealed bulk density was 845(±15.22) kgm^{-3} for groundnut while the true density was 1046.5(±16.76) 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}.The mean porosity of groundnut grain was 44.77(±2.1) per cent. The static coefficient of friction for groundnut, were determined with the respect to three difference structural surfaces as shown in Table 2. It can be observed that the static coefficient of friction was highest against aluminium surface 2.47 (±0.003) followed by stainless steel 2.01(±0.004) plywood 2.21(±0.003). The least coefficient of friction was observed with stainless steel 2.01 (±0.004). It was observed that the smoother the structural surface the lower the coefficient of friction of agricultural products.

Table 2. Gravimetric and frictional properties of groundnut at 8.13% (d.b.)

Properties	Values	SD
Bulk density, kg m^{-3}	845(±15.22)	10.5
True density, kg m^{-3}	1046.5(±16.76)	16.7
Angle of repose, deg	32.62^0	1.3^0
Porosity, %	44.77(±2.1)	2.47
Plywood (Static Coefficient of friction)	2.21(±0.003)	0.005
Stainless steel(Static Coefficient of friction)	2.01(±0.004)	0.003
Aluminium (Static Coefficient of friction)	2.47 (±0.003)	0.004

SD, standard deviation.

The following conclusions are drawn from the study of some physical properties of groundnut grain moisture content of 8.13 per cent dry basis:

- The average length, width, thickness, arithmetic and geometric mean diameter of grains were13.09, 8.68, 7.07 mm and 9.29 mm², respectively.
- The results obtained from this research indicated that static coefficient of friction for aluminium was highest while stainless steel recorded the lowest.
- The bulk density, porosity, sphericity, aspect

ratio, surface area and 1000 grain mass were all investigated and reported.

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