

# Effect of moisture content some physical properties of Groundnut seed for planter development

## ABSTRACT

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 to 14.10, 8.68 to 9.56 and 7.07 to 7.82 mm, respectively, as the moisture content, increased from 8.13 to 79.80% d.b. The roundness and Sphericity increased from 92% to 94% and 68% to 71%, respectively. In the moisture range of 8.13–79.20%, the seed volume increased from 0.803 to 0.984 cm<sup>3</sup>, 1000 seed weight, W<sub>1000</sub> from 328 to 380 g and the angle of repose from 32.62° to 36.5°. The bulk density decreased from 0.845 to 0.81 g cm<sup>-3</sup> in the moisture range from 8.13 to 79.80% d.b. The static coefficient of friction increased on three structural surfaces namely, stainless steel (2.013-2.32), aluminum (2.472-2.62) and wooden (2.251-2.42) as the moisture content increased from 8.13 to 79.20% d.b.

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

## 1. Introduction

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<sup>-1</sup>, respectively (2018-19). The main groundnut growing states are Gujarat, Tamil Nadu, Andhra Pradesh, Maharashtra, Karnataka and Rajasthan. Groundnut plays an important role in the dietary requirement of resource-poor women and children. Groundnut is called the King of oilseeds. 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 reasonably high calcium, pH 5.5 to 7.0 and 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% fat, 20 - 50% protein and 10 - 20% carbohydrate depending on the variety.

**Table 1: Notation**

Ac	area of the smallest circumscribing circle, mm <sup>2</sup>	W <sub>1000</sub>	1000 seed weight, g
Ap	projected area, mm <sup>2</sup>	mc	moisture content, % db
b	width of seed, mm	μ	coefficient of static friction
d	geometric mean diameter, mm	μ <sub>al</sub>	coefficient of static friction on aluminium
l	length of seed, mm	μ <sub>w</sub>	coefficient of static friction on wooden
Rp	roundness, %	μ <sub>ss</sub>	coefficient of static friction on stainless steel
Ds	sphericity, %	ρ	bulk density, g cm <sup>3</sup>
P	porosity, %	ρ	true density, g cm <sup>3</sup>

t	thickness of seed, mm	$\emptyset$	angle of repose, deg
V	seed volume, cm <sup>3</sup>		

## 2. Methodology

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  $105 \pm 3^{\circ}\text{C}$  until a constant mass was obtained. The following methods were used in the determination of some physical and engineering properties of groundnut.

### Size and shape

A digital Vernier calliper was used to measure the axial dimensions of the seeds; length, width and thickness. From the axial dimensions, the geometric mean diameter  $D_p$  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  $l$  in mm and  $t$ , the thickness, is the dimension along the longest axis perpendicular to both  $l$  and  $b$  in mm.

### Sphericity

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 a 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  $D_s$  was calculated as follows (Mohsenin, 1986):

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

$D_s$  – Sphericity,  $L$  – Length (mm),  $B$  - Width (mm),  $T$  - Thickness (mm)

### Bulk density

The bulk density was determined by filling an empty 1000 ml graduated cylinder with the seed and weighed (Mohsenin, 1986). The bulk density influences the design of the volume of the seed hopper and is affected by the 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.

$$\rho_b = \frac{W_s}{V_s}$$

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

The 1000 seed weight was measured by means of an electronic balance with a minimum least count of 001 g.

### Angle of repose

A vertical cylinder was filled with clean seeds and carefully lifted (Irtwange, 2000). The diameter of the base and the height of the cone formed by the heap of seed were measured and the angle of repose was calculated from

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

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

### **Coefficient of internal friction**

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. The coefficient and angle of internal friction were calculated as

$$\mu = \frac{w_{ss} - w_{se}}{w_{sc}}$$

$$\phi_I = \tan^{-1} \mu$$

where:  $\mu$  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  $\phi_I$  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.

## **3. RESULTS AND DISCUSSION**

### **3.1. Seed dimensions**

The mean length, width and thickness of the seed at a moisture content of 8.13% were 13.09, 8.68 and 7.07 mm, respectively. These dimensions were observed to increase with the increase in moisture content (Fig. 1). From this figure, it can be seen that as the moisture content of seed increased from 8.13 to 79.80% the length, width and thickness increased to 14.10, 9.56 and 7.30 mm, respectively. The length of the seed increased by 7.71% in the moisture range of 8.13–79.80%. It was observed that the length, width, thickness and geometric mean diameter of the seed increased at a higher rate up to 25% of moisture content and thereafter it remained constant. The respective values of length, width, and thickness of seed at a moisture content of 25% were 13.28, 8.80 and 7.16 mm, respectively. The relationship existing between the seed dimensions and moisture content was found to be logarithmic and can be expressed by the following equations for the length  $l$ , width  $b$ , thickness  $t$  and geometric mean diameter  $d$ :

$$l = 0.4431 \ln(x) + 12.031$$

$$b = 0.361 \ln(x) + 7.794$$

$$t = 0.0971 \ln(x) + 6.857$$

$$d = 0.2744\ln(x) + 8.603$$

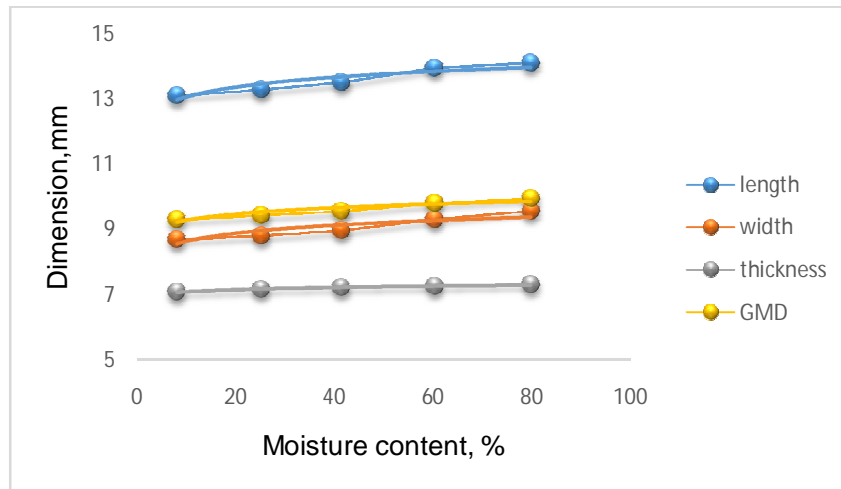


Fig. 1. Effect of moisture content on size of groundnut seed

where:  $X$  is the seed moisture content and the values for the coefficient of determination  $R^2$  are 0.852, 0.794, 0.980 and 0.860, respectively. The increase of spatial dimensions with an increase of moisture content was also observed by Ogut (1998) for white lupin.

### 3.2 Shape of groundnut seed

The shape of the seed, in terms of roundness and sphericity, was studied. Both roundness and Sphericity were observed to increase with the increase in moisture content up to 25% and, thereafter decreased. With the increase in moisture content from 8.13 to 25.20%, the roundness and sphericity increased from 93.3 to 94% and 70 to 71%, respectively. Thereafter, roundness and sphericity decreased and were 92 and 68%, respectively, at a moisture content of 79.80% (Fig. 2). The sphericity of seed after 1 h of soaking increased by 1% over the unsoaked seed, whereas a 0.7% increase in roundness was recorded for the same duration of soaking. With further increase in moisture content, a decrease of 4.33% and 3.2% were observed for roundness and sphericity, respectively, in the moisture range of 8.13–79.80% d.b. The roundness,  $R_p$  and Sphericity,  $D_s$  bear the following polynomial relationship with moisture content:

$$R_p = -1.196\ln(x) + 73.691$$

$$D_s = -0.793\ln(x) + 95.799$$

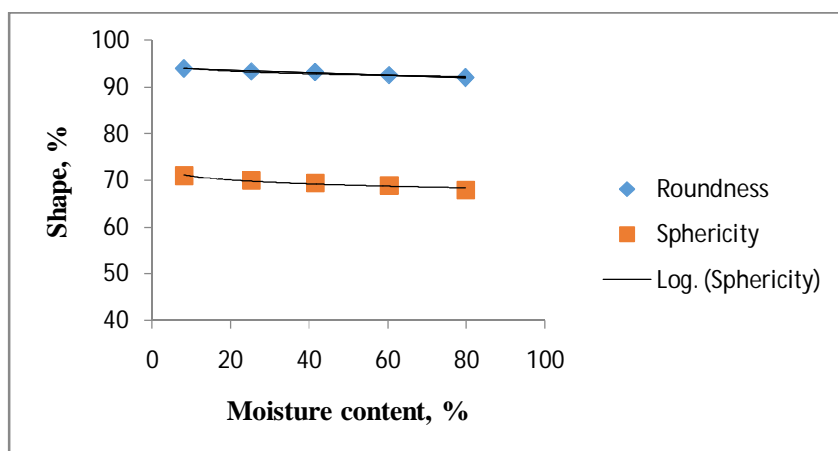


Fig. 2. Effect of moisture content on shape of groundnut seed

with values for  $R^2$  being 0.923 and 0.887 respectively. The initial increase of roundness and sphericity was due to a proportional increase in length, width and thickness. However, beyond seed moisture content of 25% d.b., there was a greater increase in length as compared to width and thickness and, therefore, beyond this level of seed moisture, the roundness and Sphericity showed a decreasing trend. However, a linear increase of sphericity with the increase of moisture content was reported by Deshpande et al. (1993) for soya beans.

### 3.3 Bulk density

The average bulk density of the seed was observed to decrease from 0.845 to 0.810  $\text{g cm}^{-3}$  as the moisture content increased from 8.13 to 79.80% (Fig. 3). The decrease in bulk density with an increase in seed moisture content was mainly due to the higher rate of increase in volume than weight. The bulk density of seed was found to have the following polynomial relationship with moisture content

$$\rho_b = -0.015\ln(x) + 0.8774$$

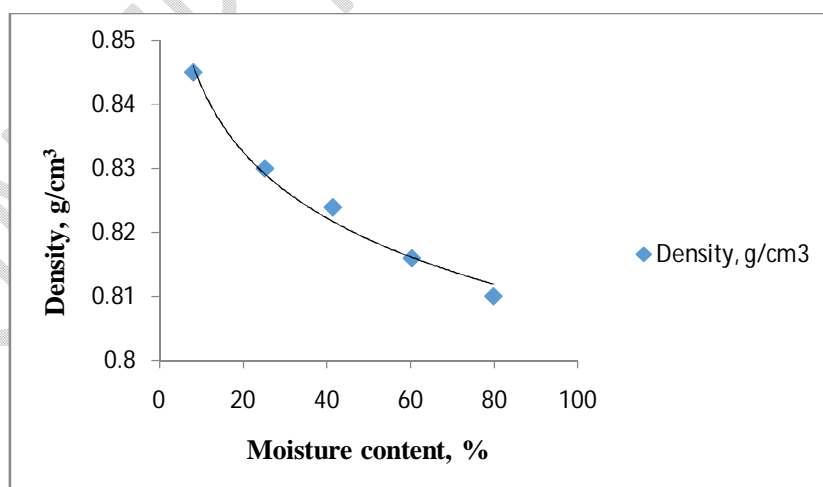


Fig. 3. Effect of moisture content on bulk density of groundnut seed

with the value for  $R^2$  of 0.985.

The negative linear relationship was also observed by Sahoo and Srivastava (2002) for okra seed.

### 3.4 Volume

The volume of a single seed of groundnut varied from 0.803 to 0.984 cm<sup>3</sup> as the moisture content increased from 8.13 to 79.80% (Fig. 4). An increase of 75% in volume of single soaked seed was recorded for groundnut seed in the above moisture range. The relationship between seed volume V and moisture content can be expressed by the equation:

$$V = 0.076\ln(x) + 0.6205$$

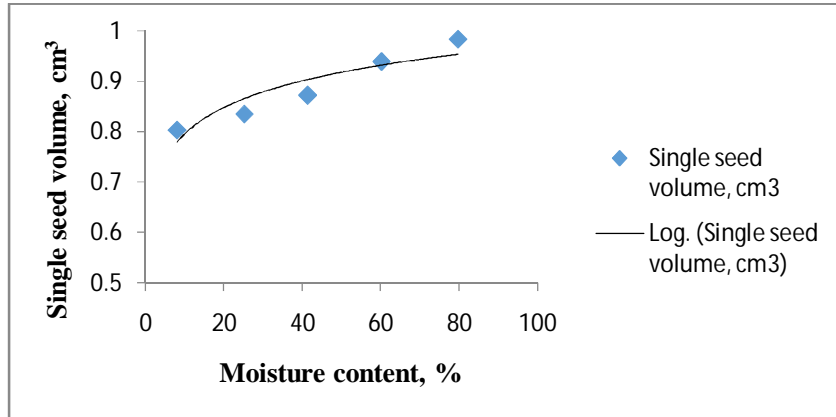


Fig. 4. Effect of moisture content on single seed volume of groundnut seed

with the value for R<sup>2</sup> of 0.845.

Deshpande et al. (1993) and Ogut (1998) also reported the increase of grain volume with an increase of moisture content for soya bean and white lupin, respectively.

### 3.5 One thousand seed weight

The value of the one thousand seed weight increased from 328 to 380 g as the moisture content increased from 8.13 to 79.80% d.b. (Fig. 5). An increase of 65% in one thousand seed weight, was recorded within the above moisture range. The following logarithmic relationship was found to exist between the 1000 seed weight W<sub>1000</sub> and moisture content.  $W_{1000} = 23.261\ln(x) + 274.67$

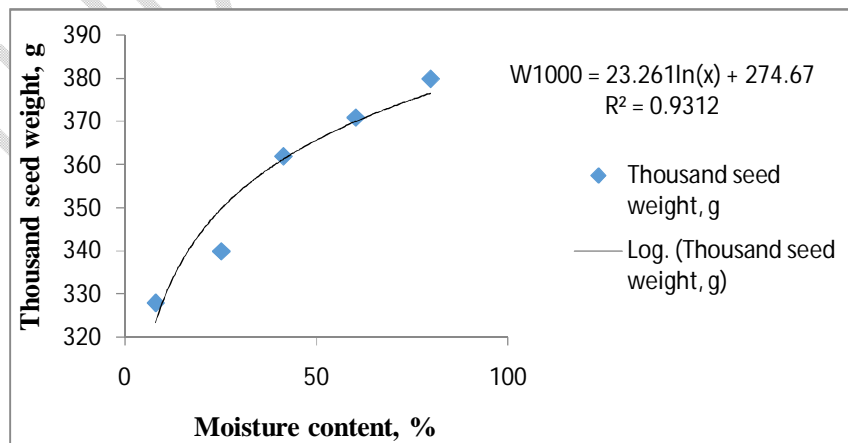


Fig. 5. Effect of moisture content on thousand seed weight of groundnut seed

Similar trends were observed by Sahoo and Srivastava (2002) for okra seed.

### 3.6 Angle of repose

The experimental result for an angle of repose concerning moisture content is shown in Fig. 6. It was observed that the angle of repose increased from 32.620 to 36.50 as the moisture content increased from 8.13 to 79.80% d.b. A logarithmic relationship was found to exist between the angle of repose and moisture content and this can be represented by the following equation:

$$\Phi = 1.5958\ln(x) + 28.79$$

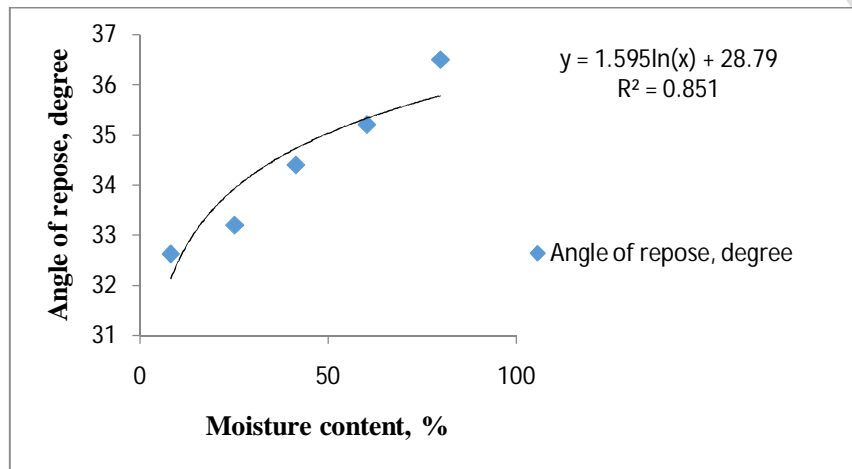


Fig. 6. Effect of moisture content on angle of repose of groundnut seed

The increase in the angle of repose of cumin seed with increase in moisture content was reported by Singh and Goswami (1996).

### 3.7 Coefficient of static friction

The plots of coefficient of static friction on three surfaces (stainless steel, aluminium and wooden) against moisture content are presented in Fig. 7. It was observed that the coefficient of static friction increased with an increase in moisture content for all the surfaces. The coefficient of static friction increased from 2.013 to 2.32 for stainless steel, 2.472 to 2.62 for aluminium and 2.251 to 2.42 for wooden as the seed moisture content increased from 8.13 to 79.80%. An increase of 5.98% in coefficient of static friction was observed for soaked groundnut seed over unsoaked seed in the case of the aluminium surface. This increased rate was minimum among the three surfaces tested. The highest increase of 15.25 percent of coefficient of static friction was recorded for stainless steel within the same moisture range. At higher moisture content, the seed became rougher and sliding characteristics were diminished. The sphericity and roundness also decreased with an increase in seed moisture content. Therefore, the coefficient of static friction increased with an increase in moisture content. The relationship between moisture content and coefficients of static friction on stainless steel, aluminium and wooden could be represented by the following equations:

$$\mu_{ss} = 0.1267\ln(x) + 1.7206$$

$$\mu_{al} = 0.0672\ln(x) + 2.3165$$

$$\mu_w = 0.077\ln(x) + 2.0723$$

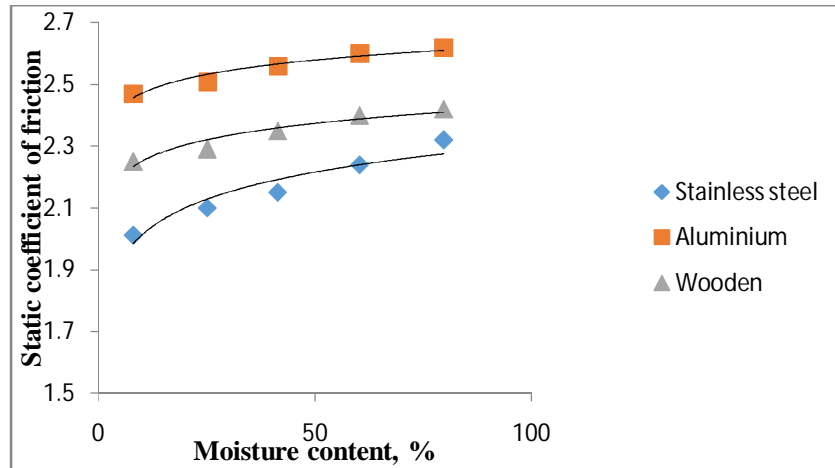


Fig. 7. Effect of moisture content on static coefficient of friction of groundnut seed

where, the values for the coefficient of determination  $R^2$  are 0.906, 0.941 and 0.925 respectively. However, there was no significant difference observed by comparing the means at any moisture content by comparing the averages by Student's t-test. Singh and Goswami (1996) reported an increase in the coefficient of static friction for mild steel surface, galvanized iron, steel and aluminium in the case of cumin seed with the increase in moisture content.

#### 4. Conclusion

- The average length, width and thickness of seed ranged from 13.09 to 14.10, 8.68 to 9.56 and 7.07 to 7.30 mm as the moisture content increased from 8.13 to 79.20% d.b., respectively.
- The roundness and sphericity initially increased from 93.3 to 94% and 70 to 71%, respectively, with an increase of moisture content from 8.13 to 25.20%. But with further increase of moisture content both roundness and sphericity decreased.
- Bulk density decreased from 0.845 to 0.81 g, with an increase in moisture content from 8.13 to 79.20% d.b.
- The 1000 seed weight, angle of repose and single seed volume increased logarithmically from 328 to 380 g, 32.62 to 36.50 and 0.803 to 0.984 cm<sup>3</sup> with the increase of moisture content from 8.13 to 79.20%.
- The static coefficient of friction increased with increasing moisture content from 8.13 to 79.20% d.b for all three surfaces, namely, stainless steel (2.013 to 2.32), aluminium (2.472 to 2.62) and wooden (2.251 to 2.42).

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