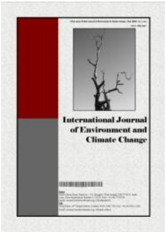

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Effect of Moisture Content on Physical Properties of Groundnut Seed for Planter Development

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The physical properties of groundnut seeds were calculated as a function of moisture content. The average length, breadth and thickness of the seed various 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. Also the seed volume increased from 0.803 to 0.984 cm^3, 1000 seed weight, W_{1000} from 328 to 380 g, the angle of repose from 32.620 to 36.50 and the bulk density decreased from 0.845 to 0.81 g cm^{-3} for the same range of moisture content. The static coefficient of friction increased on three structural surfaces namely, stainless steel (2.013-2.32), aluminum (2.47-2.62) and wooden (2.25-2.42) as the moisture content increased from 8.13 to 79.80% 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 plants and occupies an area of 473 m ha with production and productivity of 6.72 m tonnes and 1422 kg·ha^{-1}, respectively" [1]. "The primary groundnut-growing states are Andhra Pradesh, Karnataka, Gujarat, Tamil Nadu, Maharashtra and Rajasthan. Groundnut may be grown-up on all kinds of soils including sandy, sandy loam and

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heavy black soils. The most suitable soils for groundnut production are light textured, loose sandy loam or sandy clay loam soils with desirable drainage, having fairly high calcium and pH of 5.5 to 7.0" [2].

2. METHODOLOGY

Seed properties play an important role in optimizing the singulation of seeds. The physical properties of the seed, namely, arithmetic mean diameter, shape, size, sphericity, and bulk density are considered as pertinent parameters that influence the seed singulation in a seed metering mechanism. The mechanical properties of seeds, namely, coefficient of friction and angle of repose are essential for the design of seed hopper.

2.1 Moisture Content of Seeds

The sample seeds were taken and weighed. Then the sample was dried at 105˚C for 24 hours in an hot air oven and the weight of the dried sample was recorded. The moisture content of grains on dry basis % was calculated by using the following expression [3].

$$M = \frac{w_1 - w_2}{w_2} \times 100$$

where,
M - Moisture content of grains (per cent, dry weight basis)
w_1 - Weight of wet sample, kg
w_2 - Weight of the oven dried sample, kg

2.2 Arithmetic Mean Diameter of the Seed

The arithmetic mean diameter (D_a) of the seed was used to determine the cell size of the metering roll and was computed by using the following equation with three axial dimensions [3].

$$\text{Arithmetic mean diameter } D_a = \frac{a.b.c}{3}$$

Where,
a = Length of a seed, mm
b = Width of a seed, mm
c = Thickness of a seed, mm

2.3 Sphericity

Sphericity affects the seed flow through various components of the planter. The sphericity of the seeds was computed by using the following equation [3,4].

$$\text{Sphericity} = \frac{(l.b.t)^{1/3}}{l}$$

where,
l = Length of a seed, mm
b = Width of a seed, mm
t = Thickness of a seed, mm

Fig. 1. Measurement of axial dimensions of the groundnut seed

2.4 Bulk Density

The bulk density influence the design volume of the seed hopper and is affected by the degree of seeds packing. A known volume of seeds were taken in a cylindrical container and seeds were filled sufficiently to get desired degree of packing and their weight was measured and recorded for 3 to 5 trials. The average value of the weight per unit volume was computed [5].

$$\text{Bulk density} = \frac{\text{weight of seeds (g)}}{\text{volume of cylinder (cm}^3\text{)}}$$

2.5 Thousand Grain Weight

Thousand-grain weight is an indicator of average seed weight and it influence the seed rate. The thousand seed weight was determined by weighing thousand seeds employing an electronic weighing machine having an accuracy of 0.001 g. This was repeated for three different samples which were selected from three different locations of the seed heap and the average value was recorded [6].

2.6 Angle of Repose

The angle of repose was used to design the angle of inclination of the seed hopper or box inclined sides. The angle of repose was measured using a hollow rectangular box by placing on a smooth plain surface and filled with seeds to the maximum level. Then the box was gently removed upward from the plain surface without disturbing the flow of seeds due to gravity and the seeds were allowed to settle and form a conical heap. The diameter and the height of the conical heap were then measured. The experiment was repeated thrice to eliminate experimental error. The average value of height and radius of the heap was worked out and the angle of repose was computed by using the formula [3].

$$\theta = \tan^{-1}\left(\frac{2H}{D}\right)$$

where,
θ - Angle of repose
H - Height of cone, cm
D - Diameter of cone, cm

2.7 Coefficient of Friction

Coefficient of friction is the friction experienced between grain mass and the contact surface of the container. The coefficient of friction apparatus consists of a horizontal plate, a bottomless open container and a pan connecting to the container through rope and pulley as shown in Fig 2. A known weight of grain was taken in the container which was placed on the horizontal plate. The weights were added to the pan connecting to the rope in an increment of 50 g and the instant at which the container starts to sliding was considered as the frictional force (F) between material surface and the seeds. The coefficient of static friction was computed for plywood, galvanized steel, mild steel and aluminium sheet surfaces and were compared to select the suitable material for fabricating the seed hopper [3].

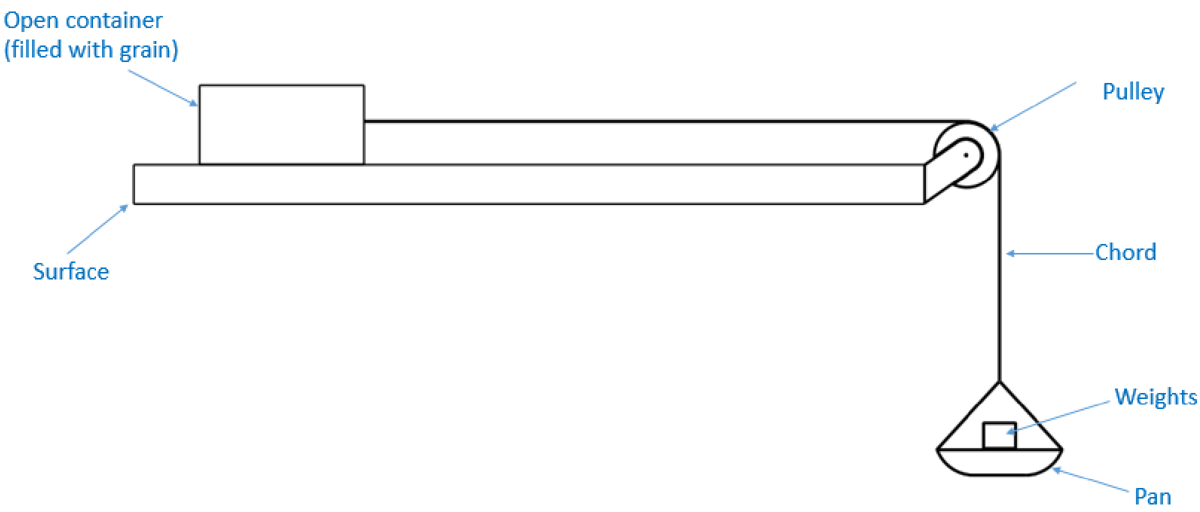

Fig. 2. Schematic sketch of the apparatus used for determining coefficient of static friction of seeds

$$\mu = \frac{F}{N}$$

where,
μ - Coefficient of static friction
F - Frictional force (Force applied), kg
N - Normal force (weight of grain), kg

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. From this Fig. 3, it can be seen that as the moisture content of the 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%. The seed dimensions and geometric mean diameter of the seed were increased up to 25% of moisture content and thereafter they remained constant. The respective values of length, width, and thickness of seed at a moisture content of 25% have been 13.28, 8.80 and 7.16 mm, respectively. The relationship between seed dimensions and moisture content was discovered to be logarithmic and can be demonstrated by the following equations for length l, width b, thickness t, and geometric mean diameter d:

$$l = 0.4431\ln(x) + 12.031$$
$$b = 0.361\ln(x) + 7.794$$
$$t = 0.0971\ln(x) + 6.857$$
$$d = 0.2744\ln(x) + 8.603$$

Where,
x is the seed moisture content

The values for the coefficient of determination R^2 of each seed dimensions and geometric mean diameter were 0.852, 0.794, 0.980 and 0.860, respectively. Ogut [7] noted the same trend for white lupin, noting that seed size increased as moisture content increased.

3.2 Shape of Groundnut Seed

The roundness and sphericity of the seed's shape were investigated. It was found that the values of roundness and sphericity were increased from 93.3 to 94% and 70 to 71%, respectively when the moisture content got increased from 8.13 to 25.20% because of the proportional increase in length, width and thickness. Thereafter, as the moisture content increased up to 79.80% (Fig. 4), the values were decreased to 92 and 68%, respectively because there was a greater increase in length compared to width and thickness. The roundness, R_p and Sphericity, D_s undergo a logarithmic relationship with moisture content with values for R^2 being 0.923 and 0.887 respectively and are given below:

$$R_p = -1.196\ln(x) + 73.691$$
$$D_s = -0.793\ln(x) + 95.799$$

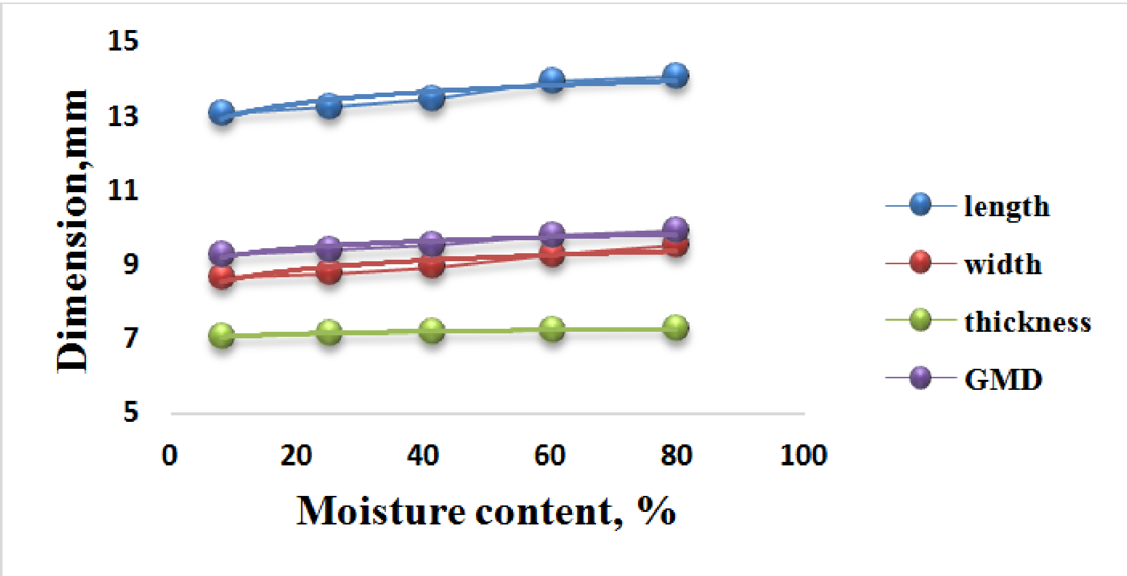

Fig. 3. Effect of moisture content on size of groundnut seed

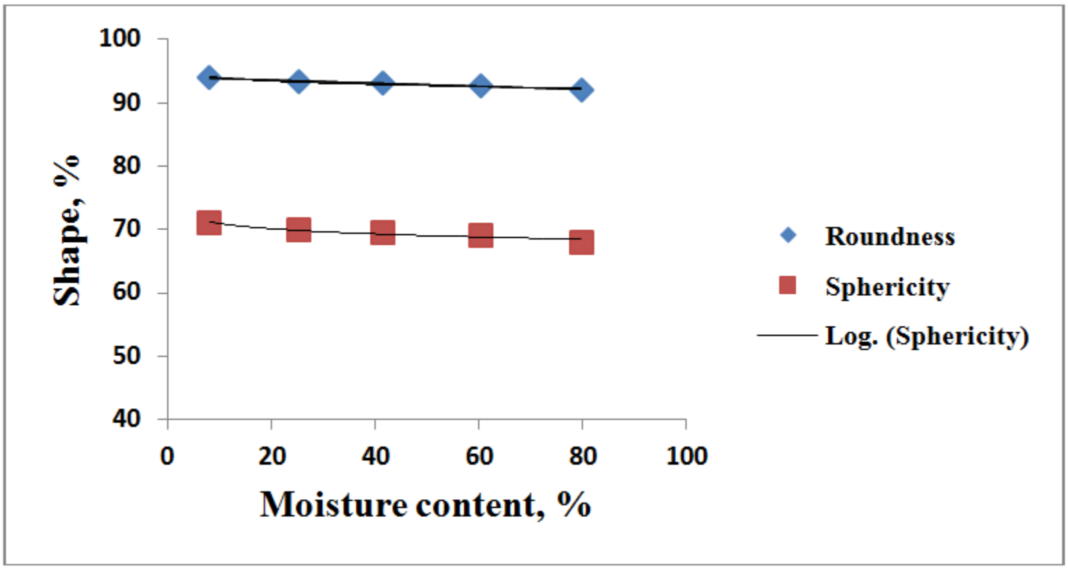

Fig. 4. Effect of moisture content on shape of groundnut seed

However, a linear increase of sphericity with the increase of moisture content becomes stated by using Deshpande et al. [8] for soya beans.

3.3 Bulk Density

The average bulk density of the seed was observed to be decreased from 0.845 to 0.810 g cm^{-3} as the moisture content increased from 8.13 to 79.80% (Fig. 5). This occurs specifically because of the higher rate of increase in volume than weight. The bulk density of seed was observed to have the polynomial relationship with moisture content with R^2 of 0.985 and are given below.

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

However, a negative linear relationship was also observed by Sahoo and Srivastava [9] for okra seed.

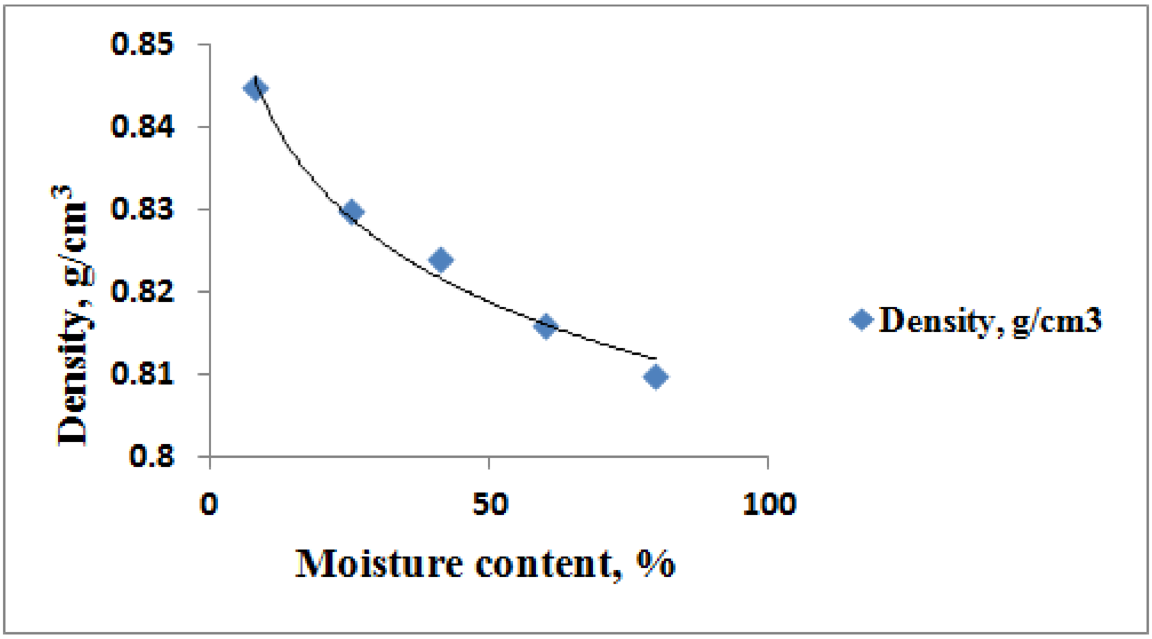

Fig. 5. Effect of moisture content on bulk density of groundnut seed

3.4 Volume

The volume of a single seed of groundnut was varied from 0.803 to 0.984 cm^3 as the moisture content increased from 8.13 to 79.80% (Fig. 6). 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 was found to be logarithmic with the value for R^2 of 0.845 and was expressed by the following equation:

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

Deshpande et al. [8] reported "the increase in grain volume with an increase in moisture content for soya bean and white lupin, respectively".

3.5 One Thousand Seed Weight

The value of the one thousand seed weight was increased from 328 to 380 g as the moisture content increased from 8.13 to 79.80% d.b. (Fig. 7). An increase of 65% in one thousand seed weight, was recorded within the above moisture range. A logarithmic relationship was found to exist between the one thousand seed weight W_{1000} and moisture content with R^2 of 0.9312 and is given below.

$$W_{1000} = 23.261\ln(x) + 274.67$$

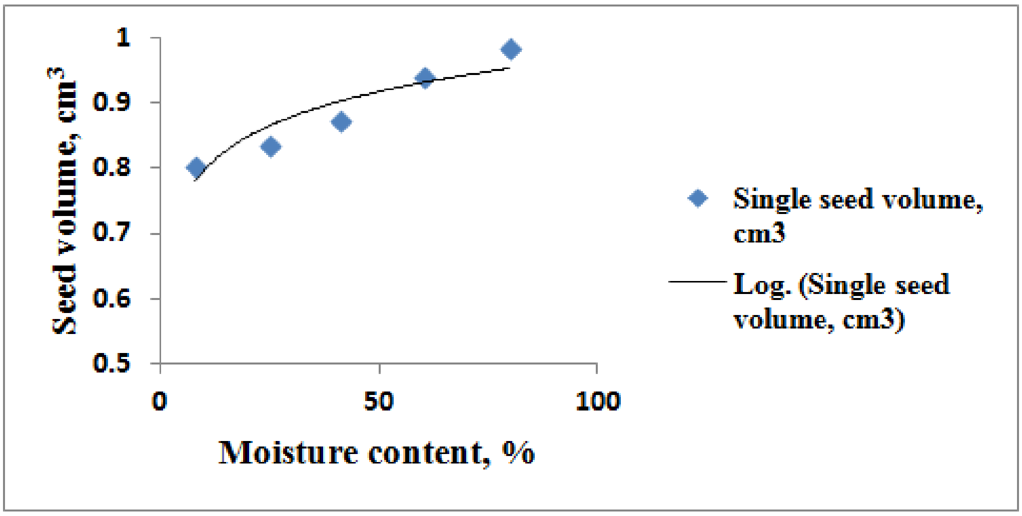

Fig. 6. Effect of moisture content on single seed volume of groundnut seed

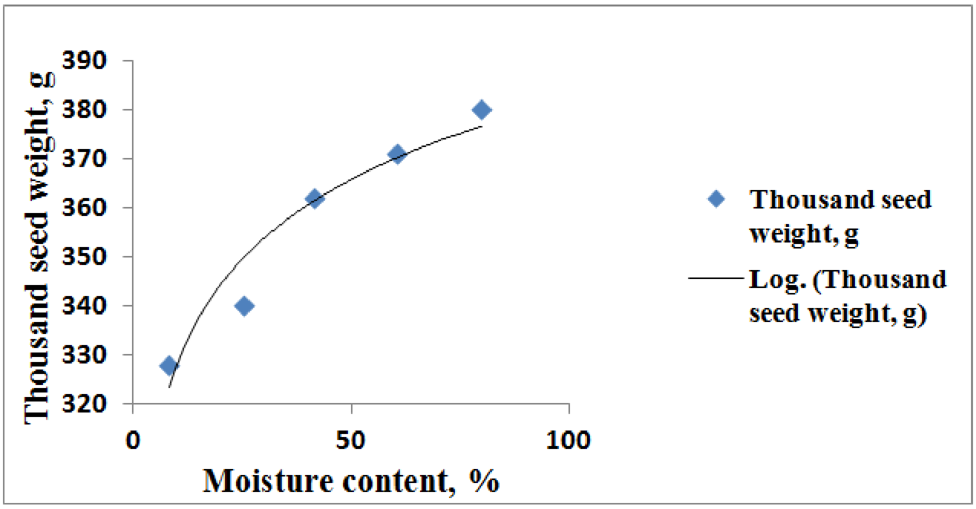

Fig. 7. Effect of moisture content on thousand seed weight of groundnut seed

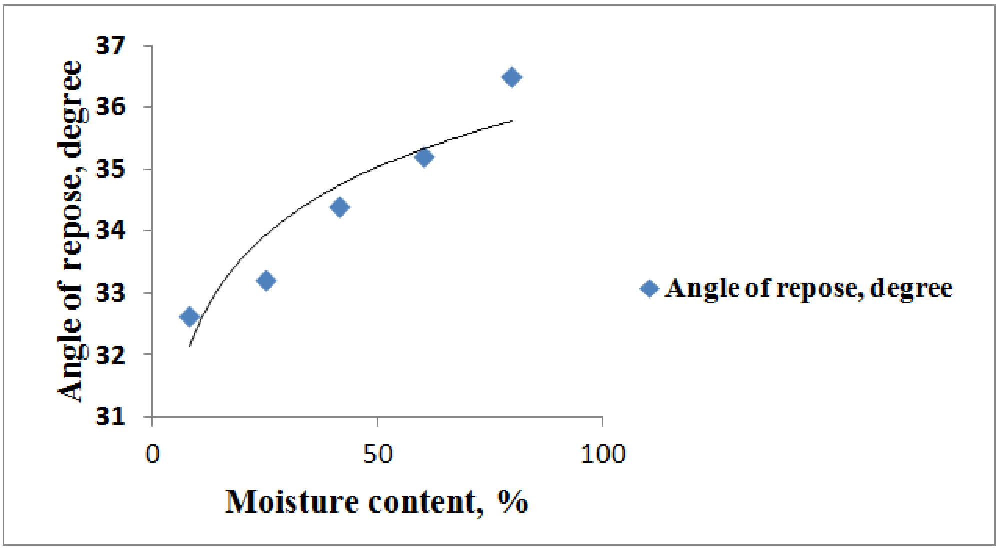

Fig. 8. Effect of moisture content on angle of repose of groundnut seed

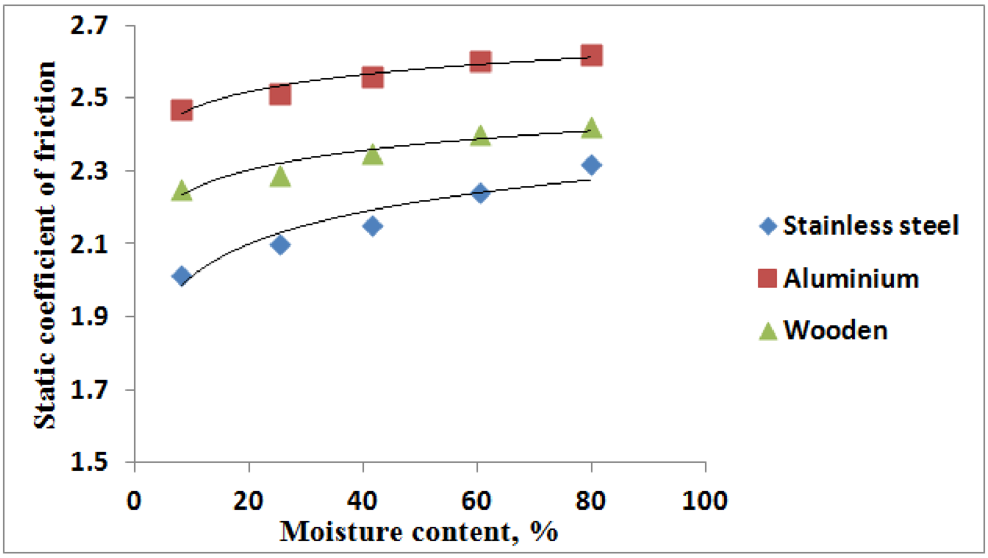

Fig. 9. Effect of moisture content on static coefficient of friction of groundnut seed

Similar developments had been discovered by Sahoo and Srivastava [9] for okra seed.

3.6 Angle of Repose

From the Fig. 8. it was observed that the angle of repose was 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 with R^2 of 0.8516 and this can be represented by the subsequent equation:

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

"The increase in the angle of repose of cumin seed with an increase in moisture content was reported" by Singh and Goswami [10].

3.7 Coefficient of Static Friction

From Fig. 9. it was observed that the coefficient of static friction on 3 surfaces (stainless steel, aluminium and wooden) increased with an increase in moisture content.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%. In the case of the aluminium surface, an increase of 5.98% in coefficient of static friction was found for soaked groundnut seed over unsoaked seed. The relationship among moisture content and coefficients of static friction on stainless steel, aluminium and wooden were represented by the subsequent equations with R^2 value of 0.906, 0.941 and 0.925 respectively:

$$\mu_{ss} = 0.1267\ln(x) + 1.7206$$
$$\mu_{al} = 0.0672\ln(x) + 2.3165$$
$$\mu_{w} = 0.077\ln(x) + 2.0723$$

Singh and Goswami [10] mentioned "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 the 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 79.80% 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 a further increase in 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 79.80% d.b.
- The thousand 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^3 with the increase of moisture content from 8.13 to 79.80%.
- The static coefficient of friction increased with increasing moisture content from 8.13 to 79.80% d.b for all 3 surfaces, namely, stainless steel (2.013 to 2.32), aluminium (2.472 to 2.62) and wooden (2.251 to 2.42).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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