DETERMINATION OF SOME PHYSICAL PROPERTIES OF THREE GROUNDNUT VARIETIES

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ABSTRACT
The determination of physical properties of some groundnut varieties is of paramount importance in the design and development of systems and machines for the shelling of groundnuts. Three varieties of groundnuts namely ICGV-SM-93523, RMP-9 and RMP- 12 were collected and some of the physical properties, such as weight, angle of repose, coefficient of friction, bulk density, size, shape and moisture content were determined.

The angle of repose for the three varieties was found to *range from* 27.5 - 29.5^0 *f or tire pods, 20.3 - 20.8^0 for the seeds and* 33.7 - *36.0^0 for the shells. Coefficient of friction averaged 0.56 on wood and 0.41 on galvanized steel for the three varieties of groundnut pods. The moisture contents of the pods, seeds and shells were found to be* 7.4%, 6.4% *and* 11.3% *(wet basis) on the average respectively. The results also showed that groundnut pods and seeds were neither round nor spherical, but may be oblong in shape. Statistical single-factor analysis of variance (ANOVA) carried out* to *compare the mean values of the physical properties of the three varieties of groundnuts showed that there were no significant varietal differences at p≤ 0*.5 *probability level. Tire implication of no significant varietal difference at p≤ 0*.5 *is that one machine can conveniently handle the shelling operation for the three varieties of groundnuts.*

INTRODUCTION

Groundnut (Arachis. hypogea) is one of the major export crops of Northern Nigeria. The mechanization of the post-harvest shelling of groundnuts and other legumes, such as cowpea and soyabean produced in Nigeria is long overdue [1]. However, knowledge of the relevant physical properties of groundnuts is essential in the design and fabrication of appropriate systems and machines for the shelling operation.

The need for the characterization of agricultural and biological materials in terms of their physical, mechanical, thermal, electrical and optical properties necessary in the design of systems and machines for their post-harvest handling and processing has often been emphasized [2,3,4, 5 and 6]. This paper discusses the results of such investigations for some relevant physical properties of groundnuts such as weight, size, shape, moisture content, angle of repose, bulk density and coefficient of friction on wooden and metallic surfaces, which are necessary in the design of a groundnut shelling machine.

2.0 MATERIALS AND METHODS

2.1 Sampling

Three sample varieties namely: ICGV·SM-93523, RMP-9 and RMP-12 which are commonly grown in Adamawa State, were collected from the Department of Crop Production, School of Agriculture and Agricultural Technology, Federal University of Technology, Yola. One hundred (100) pods of each variety were randomly picked from a 50kg bag of groundnuts.

2.2 Determination of Size:

The length and diameter of each groundnut pod and seed were determined by measurements using Vernier Calipers. Twenty samples were randomly selected from the bulk of one hundred groundnut pods. Also the thicknesses of broken groundnut shells were measured with the Vernier Caliper.

2.3 Determination of Coefficient of Friction

The coefficient of friction of pods, seeds and shells were determined on

plywood and galvanized steel surfaces using a tilting table. The angle of inclination of the table to the horizontal at which samples started sliding was measured with the protractor attached beside the inclined plane apparatus. Measurements were replicated five times for each sample. The tangent of the angle was the coefficient of friction.

2.4 Determination of Bulk Density:

A 138 x 48 x 58mm box was filled with groundnut pods and weighed using an electric balance of 0.001g accuracy. This was repeated five times using different sets of pods and the bulk density was calculated from the weight of the pods divided by the volume of the box. The same procedure was used for the bulk density of groundnut seeds and shells.

2.5 Determination of Moisture Content:

The moisture contents of groundnut pods, seeds and shells were determined using the oven method. The initial weights of samples were determined using the electric balance. Triplicate samples were dried in air convection oven set at temperature of 105°C and monitored over a period of 24 hours at 6 - hour intervals until the weights of the samples were found to be constant. The moisture content (wet basis) was calculated as the weight of moisture (initial weight minus final weight of sample) divided by the initial weight of sample and expressed in percentage.

2.6 Determination of Angle of Repose

A box (138 x 48 x 58mm) was filled with groundnut pods and gently lifted up 20mm above a flat surface whereupon the bottom of the box was uncovered. The lifting of the box was continued gradually until all the groundnut pods formed a conical heap on the floor. The height and diameter of the heap were measured. This procedure was repeated 5 times and the angle of repose was calculated from these measurements. The same procedure was adopted for determining the angles of repose for the groundnut seeds and shells respectively.

2.7 Determination of Shape

Twenty pods of groundnuts were randomly selected from the samples. The selected samples were opened along their line of symmetry (lengthwise) into two halves after measuring their lengths using vernier calipers. The shape of one-half of each sample at its natural rest position was traced on paper. The largest inscribed circle and the smallest circumscribing circle were constructed on each tracing and the diameters of both circles were noted. The area of the smallest circumscribing circle (A_c) was calculated and the largest projected area (A_p) of each sample was measured using a planimeter model JA-PAT 481120 because a shadowgraph was not available. The shape of each sample was expressed in terms of roundness (R) and sphericity (S) indices using equations: (l) and (2):

Roundness, R (%) = AP/Ac x 100% (1)

Sphericity, S (%) = di/ dc x 100% (2)

Where di = the diameter of the largest inscribed circle dc = the diameter of the smallest circumscribing circle

Ap = the largest projected area

Ac = area of smallest circumscribing circle.

Note: Equations 1 and 2 are as defined by equations 3.6 and 3.12 (illustrated in Fig. 3.2) on pp. 56 and 58 -59, respectively, of Mohsenin (1980) and reported earlier by Maduako and Faborode (1990).

3.0 RESULTS AND DISCUSSION

3.1 Size

The length of groundnut pods was found to range from 28.5mm in ICGV to 29.1mm in RMP-12 and the diameter also ranged from 1l.3mm in ICGV to 13.2mni in RMP 12, while RMP 9 had intermediate values of 28.8mm length and 1l.7mm diameter, as shown in Table 1. The length and diameter of the pods averaging 28.8mm and 12.1mm respectively for the three varieties will determine the dimensions of the hopper outlet or metering unit, concave apertures and the clearance between the drum beaters and the concave of any pod shelling machine.

The lengths and diameters of groundnut seeds range from 14.1mm in

ICGV to 14.9mm in RPM-12, and from 8.80mm in ICGV to 9.80mm in RMP-12, respectively, as shown in Table 2. The length and diameter of seeds averaging 14.4mm and 9.2mm, respectively, for the three varieties will determine the dimensions of the apertures of sieves in the separation chamber of groundnut shelling machine.

In Table 3 the thickness of groundnut shell ranges from 1.05mm in RMP 9 to 1.20mm in ICGV and RMP.12 and averaged 1.15mm for the three varieties. It is also expected that the shell thickness will have a significant effect in the breaking strength of groundnut pods, as it has been reported for cocoa pods [3].

TABLE 1: Physical properties of groundnut seeds ($x \pm \delta$)

S/N	Physical property	Variety		
		ICGV-SM-93523	**RMP-9**	**RMP-12**
1	Size: Length(mm) Diameter (mm)	 28.50±1.04 11.3±1.0	28.80±0.44 11.7±0.4	29.10±0.64 13.2±0.18
2	Angle of repose(^{0})	27.5 ±1.0	28.4 ±1.0	29.5 ±0.4
3	Coefficient of friction: i Wood surface ii Galvanized steel surface	0.47 ±0.01 0.42±0.01	 0.55 ± 0.02 0.38 ± 0.01	0.65±.0.02 0.43 ± 0.01
4	Bulk density (kg/m^3)	331.0 ± 0.7	349.0 ± 0.2	365.0 ± 0.6
5	Weight (g)	1.40 ± 0.08	1.43 ± 0.06	1.54 ± 0.08
6	Moisture content (%wb)	7.0	7.0	8.1
7	Shape Roundness (%) Sphericity(%)	 38.1± 1.5 44.0 ± 1.5	 48.2 ± 2.5 54.1 ± 3.0	 48.8 ± 1.8 52.3 ± 2.4

Table 2: physical properties of groundnut seeds ($X \pm \delta$)

S/N	Physical property	Variety		
		ICGV-SM-93523	RMP-9	RMP-12
1	Size: i Length(mm) II Diameter (mm)	14.1±0.9 8.80±0.16	14.20±0.19 8.9± 0.15	14.90±0.51 9.8±0.26
2	Angle of repose(^{0})	20.3 ±0.3	20.5 ±1.0	20.8 ± 0.4
3	Coefficient of friction: i Wood surface ii. Galvanized steel surface	 0.39 ±0.01 0.33±0.01	 0.41 ± 0.01 0.29 ± 0.01	 0.43±.0.01 0.35 ± 0.01
4	Bulk density (kg/m^3)	587.0 ±13.6	611.0 ±5.0	659.0±15.0
5	Weight (g)	0.578 ± 0.040	0.547±0.020	0.688±0.040
6	Moisture content (%wb)	6.0	6.0	7.2
7	Shape: i Roundness (%) II Sphericity(%)	 50.3± 3.5 62.9± 1.4	 491.1 ± 2.5 67.7 ± 1.6	 63.5 ± 2.8 69.4 ± 3.6

Note: x = mean value

δ = standard deviation

Table 3: physical properties of groundnut shells (X± δ)

S/N	Physical property	Variety		
		ICGV-SM-93523	**RMP-9**	**RMP-12**
1	Shell thickness (mm)	1.20±0.41	1.05±0.04	1.20±0.06
2	Angle of repose(^{0})	33.7 ±1.0	36.00 ±0.33	34.4 ±1.0
3	Coefficient of friction: Wood surface ii. Galvanized steel surface	 0.79 ±0.02 0.57±0.01	 0.80 ± 0.01 0.49 ± 0.01	 0.86±.0.10 0.55 ± 0.01
4	Bulk density (kg/m^3)	92.00 ±0.01	85.0 ±1.6	91.0±1.5
5	Weight (g)	0.25± 0.02	0.18±0.01	0.25±0.01
6	Moisture content (%wb)	11.5	11.5	11.0

Note; x = mean value

δ = standard deviation

2 ANGLE OF REPOSE

As can be seen in Tables 1, 2 and 3, the angles of repose of the pods, seeds and shells range from 27.5^0 in ICGV to 29.5° in RMP-l2; 20.3° in ICGV to 20.8° in RMP-12 and 33.7 in ICGV to 36.00 in RMP-9, respectively. These averaged 28.5°, 20.5° and 34.7° for the pods, seeds and shells, respectively in the three varieties.

The angle of repose for the shell is greater than that of the whole pod, probably because of the roughness of the surfaces and irregular nature of the shells. Hence, the shells tend to fix into one another, giving rise to a very large angle of repose.

Usually for any material to flow freely down an inclined plane, the angle of inclination of the plane to the horizontal must be at least about 10 above the angle of repose of the material [2]. The values obtained in this work will be useful in determining the angle of inclination of the sides of the hopper, feeding chutes and discharge chute of a groundnut shelling machine. Since the angle of repose of the groundnut shell is greater than that of the seeds and both materials would flow out of the pod-shelling unit, the angle of repose of the shell would be more appropriate in determining the inclination of the seed-delivering chute and seed separators.

3.3 COEFFICIENT OF FRICTION

The coefficient of friction of the pods for the three varieties ranges from 0.47 in ICGV to 0.65 in RMP-12 on wood and 0.38 in RMP 9 to 0.43 in RMP-12 on galvanized steel. For groundnut seeds, it ranges from 0.39 in ICGV to 0.43 in RMP-12 on wood and 0.29 in RMP-9 to 0.35 in RMP-12 on galvanized steel. Similarly for the shells, it ranges from 0.79 in ICGV to 0.86 in RMP-12 on wood and 0.49 in RMP-9 to 0.57 in ICGV on galvanized steel (see Tables I, 2, and 3).

The coefficients of friction of groundnut pods on wood and galvanized steel averaged 0.56 and 0.41, respectively for the three varieties as shown in Table 1. For the seeds, it averaged 0.41 on wood and 0.32 on galvanized steel, respectively for the three varieties as shown in Table 2. As for the shells, it averaged 0.82 on wood and 0.52 on galvanized steel for the three varieties as shown in Table 3. Thus the coefficients of friction of groundnut pods, seeds and shells were greater on wood than on galvanized steel, implying that they encounter more friction or resistance to sliding on wood. This information is useful in estimating the power losses due to friction so that provision can be made for such in computing the power requirement of the shelling machine, and in choosing the appropriate materials for fabricating

different parts of the machine.

3.4 BULK DENSITY

Bulk densities for the three varieties of pods, seeds and shells ranged from 331.0kg/ m^3 in ICGV to 365.0kg/ m^3 in RMP- 12, then 587.0kg/ m^3in RMP-9 to 92.0kg/m^3in ICGV to 659.0kg/m^3in RMP-12 and 85.0kg/m^3 in RMP-9 to 92.0kg/ m^3 in ICGV, respectively as shown *in* Tables 1, 2 and 3. The average bulk densities of groundnut pods, seeds and shells were found to be 348kg/ m^3, 619kg/m^3 and 89.3kg/m^3, respectively.

The bulk density of groundnut pods will help in determining the size and capacity of the hopper of a groundnut sheller. The density of groundnut seeds is important in estimating the maximum load per unit area that the seed separators of a ground nut sheller can withstand without sagging.

3.5 WEIGHT

The weights of groundnut pods, seeds and shells ranged from 1.40g in ICGV to 1.54g in RMP-12 and 0.547g in RMP-9 to 0.688g in RMP-12 as well as 0.l8g in RMP-9 to 0.25g in ICGV, and RMPl2 respectively, as shown in Tables 1, 2 and 3. Also for the three varieties, it averages 1.46g, 0.60g and 0.227g for the pods, seeds and shells, respectively (see Tables 1, 2 and 3). The weight is significant in estimating the size of hopper and the maximum dead load on the machine parts like the sieves, and will be also useful in determination of the stability of the machine when in operation.

3.6 MOISTURE CONTENT

The moisture contents of groundnut pods, seeds and shells were found to range from 7.0% in ICGV and RMP-9 to 8.1 % in RMP12, 6.0% in ICGV and RMP-9 to 7.2% in RMP-12 and 11.0% in RMP-12 to 11.5% in ICGV and RMP-9 respectively, as shown in tables 1, 2 and 3. Hence, moisture contents average 7.4% in the pods, 64% in the seeds and 11.3% in the shells. A groundnut shelling machine will consume more energy in breaking the pods and will tend to crush the seeds when the moisture content is high. Therefore, it *is* advisable to dry them sufficiency before shelling and milling.

3.7 SHAPE

The roundness and sphericity of the pods (as expressions of the shape) were found to range from 38.1 % in ICGV to 48.8% in RMP- 12 and 44.0% in ICGV to 54.1 % in RMP-9, respectively (see Table 1). And for the seeds, the roundness and sphericity range from 49.7% in RMP-9 to 63.5% in RMP-12 and from 62.9% in ICGV to 69.4% in RMP- 12, respectively, as shown in Table 2.

Thus, the roundness and sphericity of pods average 45% and 50.2%, respectively, but for the seeds, they average 50.5% and 65.4% respectively. These imply that the pods and seeds are neither round' nor spherical, but may be oblong in shape.

The shape of pods and seeds will determine the shape of apertures in the concave and sieves or separators of the shelling machine.

3.8 Analysis of Variance on Varietal Differences

Statistical Single-factor analysis of variance (ANOVA) carried out to determine the significant differences in the physical properties of the three varieties of groundnuts indicated that the varieties do not differ significantly. As can be seen in Table 4, the observed F-values were found to be less than those in the F-Table at 5% level of confidence, which signifies the non-existence of significant differences between the varieties. This implies that one machine can conveniently handle the shelling operation for the three varieties of groundnuts.

Table 4: Test of Significance of Varietal Differences

S/NO	Physical property	Observed F-Ratio	F-Ratio from the F-Table at upper 5% point	Difference at 5% confidence level
1	Size (mm)	0.023	3.68	ns
2	Angle of repose (^{0})	0.024	4.26	ns
3	Coefficient of friction	0.450	3.68	ns
4	Bulk density (kg/m^3)	0.024	5.14	ns
5	Weight (g)	0.042	5.14	ns
6	Moisture content (%wb)	0.001	5.14	ns
7	shape	0.953	4.46	ns

Note: n.s = not significant at 95% probability level

4.0 CONCLUSION

The physical properties of groundnuts, namely size, angle of-repose, coefficient of friction, bulk density, weight, moisture content and shape were determined. The angle of repose for the three varieties of groundnuts investigated ICGV, RMP-9 and RMP-12 averaged 28.5^0, 20.5° and 34.5^0 for the pods, seeds and shells, respectively, while the coefficient of friction of the pods averaged 0.56 on wood and 0.41 on galvanized steel. Moisture contents of pods, seeds and shells were found to be 7.4%, 6.4% and 11.3% on the average, respectively. These physical properties determine the dimensions of machine parts such as hopper, metering unit, shelling drum, concave, and separating sieves and the angles of inclination and clearances of these parts in relation to one another. The choice of construction materials for different machine parts and the computation of power requirement of the machine in view of the desired throughout capacity also depend on a working knowledge of these physical properties. .

To avoid breaking and crushing the seeds during the pod shelling operation and thereby reducing the quality and causing seed losses, there is need to characterize the pods in terms of these physical properties before designing the shelling machine. Since varietal differences in the physical properties of groundnuts were found to be non-significant at 95% probability level, one shelling machine can effectively handle any of the three varieties investigated.

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