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Short Communication

Determination of some physical and mechanical properties of some cowpea varieties

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In order to design Agro-processing machine effectively, the study of the physical and mechanical properties of seed and grain is essential for optimal machine design, selection, and operation. In this study, some physical and mechanical properties of five cowpea (*Vigna unguiculata*) varieties- IT 716, Sokoto Red (SR), Ife Brown (IB), White (WH), and Oloka were determined in ten (10) replicates. The results obtained were subjected to analysis of variance revealing significant differences in all the various properties tested except for the coefficient of friction on plywood, for which the mean values were 0.3978, 0.3972, 0.39806, 0.402, and 0.38194 for IT 716, IB, SR, WH and Oloka respectively. Based on these results, the varieties considered can still be treated under the same condition in mechanical handling. Inferences and recommendation were made for efficient mechanical processing of cowpea.

Key words: Cowpea, physical properties, mechanical, varieties differences.
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INTRODUCTION

Cowpea constitutes about 60% of protein intake for the families in urban areas in Nigeria and contains vitamins A, B, and E (IITA, 1982). Consequently, Nigeria cultivates about 4.0 000 000 ha of cowpea and produces an estimated of 850,000 tons annually (Deshpande et al., 1993). Kano is one of the largest cowpea producing areas in the world cultivating about 4,050 ha which yields above 1,000 kg/ha, compared with the national average of 212 kg/ha (IITA, 1982). Common varieties include IT716, Ife Brown, Sokoto Red, White and Oloka.

Cowpea can be harvested mechanically or manually by frequent picking, which stimulates further flowering and podding (IITA, 1982). Little modern technology is still being applied in the harvesting, threshing and cleaning of cowpea. Harvest is done when the pods are matured at a moisture content of about 17.20% dry basis (Frazer, 1978). Harvesting is mainly by handpicking of the ripe pods, hence, there is limit to the quantity that can be plucked per day (IITA, 1982). Machine harvest is difficult and wasteful because the pods of these plants do not ripen at the same time. Harvesting by hand picking must, therefore, still be used if optimal yield is to be obtained. Thus, mechanization of the harvesting process is still an area of concern to the researchers and engineers.

The engineering properties of biomaterials constitute an important and essential data for design of machines, structures, processes and controls (Mohsenin, 1986). They are also useful in the analysis and determination of the efficiency of a machine or an operation, development of new products and equipment and the final quality of products (Mohsenin, 1986). Size and shape, as defined by length, width, and thickness of the seed, are important in determining the method of separation and clearing (Deshpande et al., 1993) especially by pneumatic method, density, and specific gravity are needed for calculating thermal diffusivity in heat transfer and

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Reynod's number in pneumatic and hydraulic handling or separation, and determination of terminal velocity. Sieve types are based on size and shape of materials to be separated. Cowpea seeds vary in size, shape and colour. The length is between 2 to 15 mm, globalar to kidney shaped smooth or wrinkled, and white, red, or brown in colour, possibly surrounded by a dark or red ring. Weight of 100 seeds is about 10.25 g (Lovegroove, 1968).

Mechanical properties such as compressive strength provide information on the resistance of produce to cracking under harvesting and handing conditions and energy required in size reduction (Deshpande et al., 1993). Compressive strength is relevant in the choice of stack height to avoid produce damage in storage. Coefficient of friction of materials on various structural surfaces is important in predicting the movement of the materials in handling and harvesting equipment and the pressure exerted on the walls of the storage structures (Deshpande et al., 1993). These engineering properties are not only useful to the engineers but also to food scientists, processors, plant and animal breeders, and other scientists who may exploit them in their various disciplines.

Some main objectives of this study were to determine the physical and mechanical properties of cowpea and to explore the relations that may exist among them.

METHODOLOGY

The cowpea seeds used for this experiment were obtained from a local market in Akure, Nigeria. Specimen samples include five cowpea varieties: IT716, Ife Brown (IB), Sokoto Red (SR), Oloka, and White (WH), each replicated ten (10) times. The physical properties determined were length, width, thickness surface area, and sphericity. The mechanical properties include coefficient of friction on plywood and galvanized steel, angle of repose, compressive strength, and shear strength.

For 100 grain weight, 10 seeds were selected at random from the bulk quantity of the seed and weighed. The average of the value obtained was determined by dividing the value by 10. The determined value was recorded as the weight for a grain. One hundred randomly selected seeds were measured for length, width, and thickness using a micrometer screw gauge (Kanon Instruments, Japan) reading 0.01 mm. Subsequently, the surface area *A* and the sphericity *S* were computed (Mohsenin, 1986; Orji, 2001; Olukunle and Atere, 2001) as:

$$A = \pi D^2{}_p \qquad (1)$$

Where D_p is the geometric mean of the length, width, and thickness. and

$$S = \frac{(abt)^{\frac{1}{3}}}{a} \qquad (2)$$

Where *a, b and t are* the length, width, and thickness, respectively.

Coefficient of friction, a function of moisture content, abrasive surface material, and environmental conditions (Buslow, 1961), was found with respect to two structural materials, unsanded plywood (rough surface) and galvanized steel (smooth surface) sheet, using the Inclined Plane Apparatus as described by Dutta et al. (1988). The table was gently raised and the angle of inclination to the horizontal at which the sample started to sliding was read off the protractor attached to the apparatus. The tangent of this angle was reported as coefficient of friction (Dutta et al. (1988). The dynamic angle of repose was determined on the same aforementioned surface using the method described by Maduako and Faborode (1990). The compressive and shear strength, expressed as ($KNmm^{-2}$) were determined with the aid of a tensiometer (Dutta et al., (1988).

Data for 100-seed-weight, length, width, thickness, surface area, sphericity, coefficient of friction on plywood and galvanized steel, angle of repose, compressive strength, and shear strength were subjected to Analysis of Variance (ANOVA) as a completely randomized design to determine where differences among varieties existed. A 0.05 significance level was required to demonstrate a difference. When a difference was detected, a protected least significant difference (LSD) was calculated to separate variety means.

RESULTS AND DISCUSSION

Table 1 shows the results of the analysis of variance (ANOVA) on the properties tested for all the varieties. There were significant differences in all the properties tested except for the coefficient of friction on plywood (rough surface).

The weight of 100 seeds of cowpea was highest (26 g) for sokoto red and least (14 g) value obtained for IT716 (Table 1). Others were 16, 18 and 22 g for Oloka, IB and WH respectively. Love groove (1968) stated that, the weight of about 100 seeds of cowpea was about 10.25 g for the WH. The variation in weight can be attributed to their difference in moisture content and size of the varieties considered Olukunle and Atere (2001).

The greatest seed length (10.83 mm) was for SR and the least (7.55 mm) was for IB (Table 1). The average greatest seed width (7.49 mm) was observed in SR and least (5.62) in Oloka. Also, the greatest seed thickness (5.46 mm) was found in WH and least (4.25) in IB. these results were a bit closer to that of the African breadfruit (*Genus species*) seed and gram (*Genus species*) with reported average principal dimensions of 11.91, 5.69, 4.64 mm, and 7.98, 5.95, 5.82 mm respectively (Dutta et al., 1988; Omobuwajo et al., 1999), and smaller than the oilbean (*Genus species*) seed with corresponding dimensions of 65.4, 41.3, and 13.7 mm (Oje and Ugbor, 1991). Tri-axial dimensions knowledge of the seeds is important in determining aperture sizes in the design of grain handling machinery (Omobuwajo et al., 1991). The above results show that, a single multivariate machine could be used for gravity and hydro separation of foreign materials from the five varieties. However, a single machine could be used in handling, cleaning and grading of these varieties.

The sphericity was highest for WH and least for SR. These values were higher than 60% reported for the oilbean seed (Oje and Ugbor, 1991), as well as the 60.61% reported for the African breadfruit seed

Table 1. Physical and mechanical properties of the seed of selected cowpea varieties and results of statistical analysis by protected least significant difference (P < 0.05). These evaluations were conducted at the National Centre for Agricultural Mechanization (NCAM) Ilorin**.**

Parameter	Cowpea varieties					5% LSD
	IB	SR	WH	IT716	Oloka	
Physical properties						
100-seed-weight						
Length (mm)	7.558[c]	10.827[a]	9.193[b]	8.642[b]	8.235[bc]	0.915
Weight (mm)	6.203[b]	7.491[a]	7.421[a]	6.208[b]	5.621[c]	0.582
Thickness (mm)	4.250[b]	5.140[a]	5.455[a]	5.048[a]	4.393[b]	0.513
Sphericity (%)	0.778[b]	0.689[e]	0.786[a]	0.753[c]	0.736[d]	0.059
Surface area (mm^2)	103.23[c]	168.45[a]	156.19[a]	126.99[b]	103.96[c]	18.57
Mechanical properties						
Coefficient of static friction on plywood (°)	0.397	0.398	0.402	0.398	0.382	NS
Coefficient of friction on galvanize sheet (°)	0.384[ab]	0.388[ab]	0.392[a]	0.370[bc]	0.360[c]	0.021
Angle of repose	0.258[a]	0.264[a]	0.254[ab]	0.257[a]	0.244[b]	0.013
Compressive strength (N/mm^2)	14.27[e]	14.47[d]	14.54[c]	14.64[b]	14.77[a]	0.02
Shear strength (N/mm^2)	10.84[c]	10.90[c]	10.99[bc]	11.23[b]	11.58[a]	0.31

Data are the means of 10 replicates for physical properties and 5 replicates for mechanical properties. [abc]Means in the same row followed by the same letter are not significantly different based on the 5% LSD.

(Omobuwajo et al., 1991), but in the same range as the corresponding value of 74% reported for Soybean (Dutta et al., 1988). Cowpea may therefore be treated as an equivalent sphere like grains. The seed may be expected to roll like grains rather than sliding like oilbean seed (Omobuwajo et al., 1991). This property is quite important in the design of hoppers for grain handling machinery Olukunle and Atere (2001).

Conclusion

The success of any agricultural engineering design effort is determined largely by the availability of data on the engineering properties of the agricultural materials. The tests conducted on the five varieties of cowpea revealed some engineering properties that are useful for machine design from planting, harvesting, handling to packaging. Results revealed that, there are significant differences among the cowpea varieties tested for all the various properties tested, except for the coefficient of friction on plywood. However, based on these results, the varieties considered can still be treated under the same condition in mechanical handling. Hopper and loading devices need not to be built steeply because of relatively low coefficient of friction. Still, further research should be carried out on the engineering properties of cowpea varieties, to form the basis for the design of machines and processing equipment that aid mechanization.

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