Abstract. The tribological properties of nanostructured aluminum oxyhydroxide (boehmite) have been studied. The addition of boehmite to oils increases the running-in rate by 2–2.5 times, reduces wear, and ensures a low coefficient of friction. A comparative study of the physicochemical properties of boehmite and serpentine makes it possible to consider its use as a repair and restoration preparation promising.

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PHYSICAL AND MECHANICAL PROPERTIES OF PEANUT PODS AND KERNELS FOR POST-HARVEST THRESHING PROCESS

Abstract. *The study was carried out to determine some physical and mechanical properties of peanut pods and kernels for the design of peanut threshing machine. These properties included geometric diameter, surface area, sphericity, angle of repose, and coefficient of friction. The average values of the geometric diameter, surface area, sphericity, angle of repose, and coefficient of friction were found to be 11.90 mm, 373.30 mm2, 38.25 %, 27.50, and 0.42, respectively at moisture content of 6.82 % (db) for the peanut pods. Furthermore, the average values of the geometric diameter, surface area, sphericity, angle of repose, and coefficient of friction were found as 6.89 mm, 149.16 mm2, 62.06 %, 23.63 and 0.44, respectively at moisture content of 6.82 % (db) for the peanut kernels. The energy required to crush the peanut pods was determined as 1.88 kJ/kg for particular SAMNUT 24 peanut variety. The mean rupture force for the breaking of peanut pods was measured by keeping the pods on the test bench longitudinally, laterally and verti-*

cally; the rupture force was found to be 62.37 N, 250.21 N and 32.74 N respectively.

ФИЗИКО-МЕХАНИЧЕСКИЕ СВОЙСТВА СТРУЧКИ И ОРЕХА АРАХИСА ДЛЯ ПРОЦЕССА ПОСЛЕУБОРОЧНОГО ОБМОЛОТА

Аннотация. *Исследование проведено с целью определения некоторых физико-механических свойств стручков и ядер арахиса для конструкции молотилки для арахиса. Эти свойства включали геометрический диаметр, площадь поверхности, сферичность, угол естественного откоса и коэффициент трения. Средние значения геометрического диаметра, площади поверхности, сферичности, угла естественного откоса и коэффициента трения составили 11,90 мм, 373,30 мм^2, 38,25 %, 27,50 и 0,42 соответственно при влажности 6,82 % (дб), для стручков арахиса. При этом средние значения геометрического диаметра, площади поверхности, сферичности, угла естественного откоса и коэффициента трения составили 6,89 мм, 149,16 мм^2, 62,06%, 23,63 и 0,44 соответственно при влажности 6,82 % (дб) для ядра арахиса. Энергия, необходимая для разрущения стручков арахиса, была определена как 1,88 кДж/кг для конкретного сорта арахиса SAMNUT 24. Среднее усилие разрыва при шелушении стручков арахиса измеряли, удерживая стручки на испытательном стенде в продольном, поперечном и вертикальном направлениях; сила разрыва составила 62,37 Н, 250,21 Н и 32,74 Н соответственно.*

Introduction

Peanut is one of the best oil crops for cooking in Nigeria and in the world at large. In Nigeria, it is planted on about 34 % of total cultivated area and contributes to 23 % of household cash revenue [1]. Due to its economical nature, peanut oil is used in soap making, cosmetic and food industry. Peanut kernels and residual oilcake have various usage such as peanut butter, edible oil and used as a fodder for livestock respectively.

The residual oilcake contains the three major elements (N, P_2O_5 and K_2O) in fertilizer which can be used by the farmers [2]. According to [3] and [4], peanut kernel contains 43–55 % edible oil, 40–50 % fat, 20–50 % protein, and 10–20 % carbohydrate depending upon variety and agronomic conditions of the peanut. Post-harvest manual processing of peanut consumes a lot of time and laborious and about two-third of the world's peanut production is crushed for oil and the remaining is consumed directly or sometimes as an ingredient in food [5].

Many scientists and researchers such as [6], [7] and [8] are of the opinion that there is need for determination of agricultural materials in terms of their physical and mechanical properties in relation to design of post-harvest machines. Most of the agriculture machines engaged in post-harvest processing of peanut pods are fabricated without considering the design parameters of the pods and kernels' physical and mechanical properties [9]. Knowing these properties build the engineering data required for machines design as well as help in increasing output efficiency and decreasing losses during operations [10] and [11]. [12] measured the size of peanuts and found mean major, intermediate, and minor diameters of the kernels as 8.54, 3.55, and 6.93 mm, respectively. It was also determined the angle of repose of kernels as 17°. [13] explained the variation in dimensions of groundnut kernels with moisture content. Therefore, this study was undertaken to determine some relevant physical and mechanical properties of Nigerian peanut such as weight, size, angle of repose, and coefficient of friction on wooden and metallic surfaces, which are necessary in the design of a peanut threshing machine.

Materials and Methods

Physical Properties of Peanut Pods and Kernels

About 5 kg of improved SAMNUT 24 variety of peanut pods were procured from Sokoto Agricultural Development Project (SADP) office in Sokoto, Nigeria. The physical and mechanical properties of peanut pods and kernels were measured at the Department of Technical Education, Shehu Shagari College of Education, Sokoto, Nigeria. Initially, the moisture content of peanut pods was determined using the standard hot oven dryer method described by ASAE (1983) at 103°C for 72 hours [14] which found to be 9.82 % (db).

Determination of the size of the peanut pods and kernels

One hundred peanut kernels and pods were randomly selected, and their three principal dimensions were measured using digital Vernier caliper with 0.01 mm accuracy. The geometric mean diameter (Dg), sphericity (ϕ), surface area (S) and aspect ratio (AR) were calculated as described in [15] and [16].

Determination of Thousand Kernel Mass

About one kilogram of peanut was divided in 10 equal portions. Thousand kernel mass (TKM) of peanut pod and its kernel was randomly picked from each portion, and separately weighed using a digital electronic balance (with accuracy of 0.01g, Battery Advanced Electronic Digital Weighing Scale, China). The experiments were replicated five times to minimize the error.

Determination of angle of repose

The peanut pods and kernels were taken onto a cylindrical box with a hole that allowed the pods and kernels to fall onto a level surface. The pods and kernels formed a conical heap on the level ground surface. The height (H) and diameter (D) of the conical heap were measured [17]. Then the angle of repose of peanut pods and kernels was determined by the following equation (1).

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

Determination of coefficient of friction

The coefficient of friction of peanut pods and kernels was determined using the method described by [18]. The peanut pods and kernels were taken into a box of 160 mm length, 110 mm width and 50 mm height without base, and placed onto an adjustable inclined plate. The adjustable inclined plate was raised slightly until the sample box starts to slide onto the inclined plate and the inclined plate at which the sample box just begins to slide tight with the protractor through the adjustable screw. The vertical distance (V) and horizontal distance (H) were measured by the scale, and the coefficient of friction of peanut pods and kernels was determined by the following Equation (2).

The angle of internal friction can be measured directly by the protractor at which the sample box just starts slide on the inclined plate.

We know that,

$$\mu = \tan\alpha = \frac{V}{H}$$

$$\alpha = \tan^{-1}\frac{V}{H} \quad (2)$$

Where, V – vertical distance from the fixed plate to the adjustable plate while sample box just start slide; H – horizontal distance between the connection point of plates to the point when sample box just starts slide and α – angle between the inclined plate and horizontal plate at which the sample box just starts slide (angle of internal friction).

Mechanical Properties of Peanut Pods

In order to break the peanut pod, there is need find out the actual force to perform this action without any damage to the kernels. The peanut pods were placed on a rupture testing machine at a predetermined load rate. The test was conducted when the pods are placed longitudinally, laterally, and vertically while applied forces were recorded in three replicates. The cracks formed on each position were analyzed with its corresponding force.

Table 1 – Physical and mechanical properties of peanut pods and kernels

S/N	Properties	Qty. of samples	Mean value		Standard deviation	
			pod	kernel	pod	kernel
1.	Length (mm)	100	28.50	11.11	±1.04	±1.46
	Width (mm)	100	7.17	4.53	±1.02	±0.56
	Thickness (mm)	100	6.41	4.05	±0.94	±0.82
2.	Geometric mean diameter (mm)	100	10.90	6.89	±1.02	±1.00
3.	Surface area (mm2)	100	373.30	149.16	± 133.71	± 43.31
4.	Sphericity (%)	100	38.25	62.06	± 4.81	± 6.41
5.	Aspect ratio (%)	100	25.16	40.77	± 5.62	± 7.99
6.	Moisture content (%, db)	10	7.00	6.02	±0.44	±0.54
7.	Weight (g)	1000	1091.5	520.6	± 22.28	±18.61
8.	Angle of repose pods (0)	10	27.5	23.63	±4.61	±6.12
9.	Coefficient of friction	10	0.42	0.44	±0.001	±0.002
10.	Crushing energy (kJ/kg)	10	1.88	–		–

Determination of energy requirement to crush the peanut pods

According to [19], the energy required to crush a peanut pod is calculated by the following formula (3):

$$E = 0.3162 \times W_i \left(\frac{1}{\sqrt{L_2}} - \frac{1}{\sqrt{L_1}} \right) \quad (3)$$

Where, E – energy required to crush (kJ/kg); Wi – work index of peanut pods for crushing (9 to14 kWh/ton) [20]; L1 – average length of uncrushed peanut pod (mm); and L2 – average length of crushed peanut kernel (mm).

The average length of peanut pods and kernels were measured L1=28.50 mm and L2=11.11 mm, respectively (Table 1), and the energy required to crush the peanut pods was calculated as E = 1.88 kJ/kg.

Results and Discussion

The obtained physical and mechanical properties of peanut pods and kernels are shown in Table 1 below. The mean length, width and thickness were found to be 28.50, 7.17, 6.41 and 11.11, 4.53, 4.05 mm respectively for SAMNUT 24 of peanut variety. According to [21], these parameters are useful when designing some important parts of the threshing machine such as hopper, crushing drum as well as the clearance between drum and the clearance between the drum flat iron beaters and the concave of threshing machine. They can also be used to determine the apertures of sieves in separation chamber of peanut threshing machine. The mean geometric diameter, surface area, sphericity and aspect ratio of peanut pods and kernels were calculated as 10.90 mm, 373.30 mm2, 38.25 %, 25.16 % and 6.89 mm, 149.16 mm2, 62.06 %, 40.77 % respectively. It is clear that the sliding effect of kernels is higher than that of pods as seen from their values. The mean weight of of peanut pods and kernels can be used to determine the size and capacity of feeding hopper as well as the crushing chamber that require stability during operation of the machine. Both angle of repose and coefficient of friction of pods and kernels are found to be 27.50, 0.42 and 23.630, 0.44 respectively. Due to rough surface of the peanut pods, it was observed that angle of repose for pod higher than that of kernels. However, the values of static coefficient of friction pods and kernels are useful conveying and threshing equipment [22].

Conclusion

Conclusively, in order to avoid breaking, crushing and damaging both pods and kernels during threshing and other post-harvest processing operation there is need to know the physical and mechanical properties of peanut pods that are useful in designing the agriculture post-harvest machines. This is also to overcome pod and kernels quality reduction and losses, therefore, there is need to characterize the pods and kernels in terms of these properties before designing the threshing machine. The crushing force depend on the peanut variety and agronomic conditions of the crop but all the same, these varietal differences in the physical properties of peanuts were found to be non-significant at 95% probability level, one threshing machine can effectively handle varieties as experimented in the study.

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