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SOME PHYSICAL AND MECHANICAL PROPERTIES OF THE SHELL AND KERNEL OF NIGERIAN DURA AND TENERA OIL PALM VARIETIES

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Abstract: Some physical and mechanical properties of the shell and kernel of dura and tenera varieties of oil palm in Nigeria were evaluated at moisture contents of 4.5 and 5.0% w.b. for dura shell and kernel and 4.5 and 5.0% for tenera shell and kernel respectively. The properties determined include linear dimensions, coefficient of friction on four structural surfaces and angle of repose. Results show that for the two varieties linear dimensions range from 0.52 ±0.26 – 17.63±3.69, coefficient of friction range from 0.59 – 0.85 on the four structural surfaces while the angle of repose range from 23.46 – 25.16°. These data are useful in the design of handling and processing equipment for palm kernel.
Keywords: Physical, mechanical, moisture content, coefficient of friction, structural surfaces

1. INTRODUCTION

Oil palm (Elaeis guineensis) is widely grown in tropical rain forest of Africa due to its importance as a high yielding source of edible and technical oils. Oil palm fruit consists of the pulp which forms the exocarp and mesocarp and the central nut which is made up of the shell (endocarp) and an edible kernel. Palm oil is produced from the pulp while palm kernel oil is produced from the edible kernel. In Nigeria, there is high demand for both palm oil and palm kernel oil due to their domestic and industrial uses (Emeka and Olomu, 2007).

After expressing palm oil from the pulp, the hard nuts must be cracked to obtain the edible kernels from where palm kernel oil is produced. The usual methods employed in Nigeria are manual cracking and use of mechanical crackers. However both methods do not separate the shell from the kernels after cracking which necessitate the development of machines that can separate cracked shell from kernels.

Physical and mechanical properties of a crop are very important in the design of machines and analysis of the behaviour of the crop during agricultural process operations such as cleaning, sorting, drying, handling, planting, harvesting and threshing (Akaimo and Raji, 2006). Aderinlewo et al, (2011) also reported that in the design of any agricultural handling and processing machine, properties of the crop such as the grain size, shape, mass, hardness, angle of repose, grain-straw ratio, moisture content, kernel and bulk density must be taken into account.

Several researchers have investigated the physical and mechanical properties of different crops and food materials which include soybean (Deshpande et al., 1993), cumin seed (Singh and Goswani, 1996), paddy rice (Nalladurai, 2003), sheanut (Aviara et al., 2005), green wheat (Al-Mahasneh and Rababah, 2006), corinder seed (Coskuner and Ersankarababa, 2007), cowpea (Aderinlewo et al, 2011) and beniseed (Olayanju et al, 2009).

This work was therefore carried out to determine the physical and mechanical properties of two varieties of oil palm commonly grown in Nigeria namely dura and tenera.

2. MATERIALS AND METHOD

Dura and tenera varieties of palm kernels were obtained from the teaching and research farm of the Federal Universities of Agriculture, Abeokuta, Nigeria. The kernels were manually cleaned to remove foreign materials, dust, dirt and broken kernels. The kernels were then cracked with a palm kernel cracking machine available at the College of Engineering of the University.

The moisture content of the shell and kernel were determined by oven drying method and was found to be 4.5% and 5.0% w.b. for dura shell and kernel while for tenera it was 5.1% and 4.5%. w.b. respectively.

Fifty replicate samples of Dura and Tenera shell and kernel were randomly selected. Their mass was determined with an electronic beam balance reading to 0.001g. The three linear dimensions of each seed namely major, intermediate and minor diameters were measured with a micro meter screw gauge, reading to 0.01mm. The geometric mean diameter (D_g) was calculated using the formula as described by (Eric et al, 2009).

$$D_g = (L \times B \times T)^{\frac{1}{3}} \quad (1)$$

where: L is the longest intercept (length) in mm, B is the longest intercept normal to 'L' (breath) in mm, T is the longest intercept normal to 'L' and 'B' (thickness) in mm

The static coefficient of friction for the kernels and shells were determined on four structural materials namely: plywood, galvanized steel, mild steel and plastic. A topless and bottomless box of dimension 150 × 100 × 40 mm was filled with fifty pieces of kernel or shell and placed on the structural surface. One end of this surface with the box resting on it was raised gradually until the sample inside the box begins to slide down. The angle at which this takes place was noted and the process repeated five times. The average angle at the various loads for the five samples was then calculated and the coefficient of friction was obtained using the equation.

$$\mu = \tan\theta \quad (2)$$

where: μ = the co-efficient of friction , θ = the angle of inclination.

The apparatus used to determine the coefficient of friction is shown in Plate 1.

The angle of repose of Dura and Tenera shell and kernel were determined using a cylinder of height (7 cm) and diameter (10 cm) open at both ends. The shell and kernel were poured into the cylinder placed on a flat surface. The cylinder was lifted gently until it was completely removed, allowing the sample to form a pile. The spread and the height of the kernel and shell were noted and recorded. Then the angle of repose was calculated using the formula as described by Karaj, et al (2010).

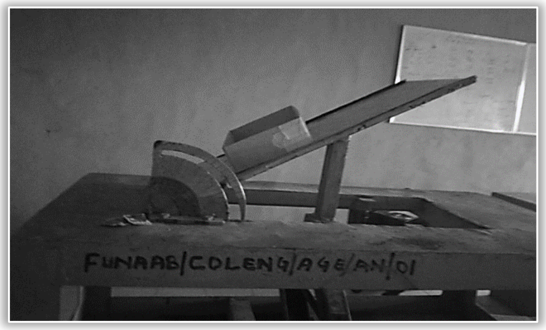

Plate 1: The apparatus for determining coefficient of friction

$$\theta = \tan^{-1}\frac{2h}{D} \quad (3)$$

where: θ = Angle of repose in degrees, h = height of piled sample (mm), D = Diameter of spread in mm. The experiment was repeated five times

3. RESULTS AND DISCUSSION

» The mass and linear dimensions of the kernels and shells of the two varieties of palm kernel are shown in Table 1.

Table 1: Mean values of linear dimensions for Dura kernel and shell

		Dura kernel		Dura shell	
Properties	Number of replication	Mean value	standard deviation	Mean value	standard deviation
Mass (g)	50	0.93	0.20	0.55	0.33
Major diameter (mm)	50	16.63	1.78	17.63	3.69
Intermediate diameter (mm)	50	11.61	1.41	13.12	2.38
Minor diameter (mm)	50	8.19	1.52	4.53	2.00

Table 2: Mean values of linear dimensions for Tenera kernel and shell

		Tenera kernel		Tenera shell	
Properties	Number of replication	Mean value	standard deviation	Mean value	standard deviation
Mass (g)	50	0.91	0.19	0.52	0.26
Major diameter (mm)	50	15.48	2.00	16.98	3.57
Intermediate diameter (mm)	50	10.84	1.18	12.88	2.32
Minor diameter (mm)	50	8.47	1.75	3.86	1.50

» The coefficient of friction for both dura and tenera on four structural surfaces are summarized in Table 3. It was observed that for galvanized steel, tenera shell has the highest coefficient of friction of 0.67, followed by dura shell with 0.66, tenera kernel with 0.64 while dura kernel has the least value of 0.60. For mild steel, dura shell has the highest value of 0.83, followed by tenera shell with 0.80, dura kernel with 0.71 while tenera kernel has the least value of 0.69.

Dura shell has the highest value of 0.85 on plywood, followed by dura kernel of 0.81, tenera shell of 0.72 while tenera kernel has the least value of 0.71. tenera shell has the highest value of 0.69 on plastic, followed by dura shell with 0.63, tenera kernel with 0.62 and dura kernel with 0.59. The analysis of variance table (ANOVA) summarized in Table 5 shows that there is significant difference in the coefficient of friction of both shell and kernel of the two varieties on each structural surface but there is no significant difference in their coefficient of friction on the different structural surfaces ($p \leq 0.05$). This information is imperative in its processing, particularly in transporting and conveyance of materials and other unloading devices for the cracking and milling machine.

Table 3: Mean values for Coefficient of Friction

	Galvanized steel	Mild steel	Plywood	Plastic
Dura kernel	0.60	0.71	0.81	0.59
Dura shell	0.66	0.83	0.85	0.63
Tenera kernel	0.64	0.69	0.71	0.62
Tenera shell	0.67	0.80	0.72	0.69

» The angle of repose for dura and tenera were summarized in Table 4. Tenera shell has the highest value of 25.16°, followed by dura shell with 24.72°, dura kernel with 23.98° and tenera kernel with 23.46°. This indicates that the seed would require steep angles for conveyance. The angle of repose of a sample is the angle made when the sample is allowed to flow to its natural slope.

Table 4: Mean values for Angle of Repose

Sample	Angle of Repose (°)
Dura kernel	23.98
Dura shell	24.72
Tenera kernel	23.46
Tenera shell	25.16

Table 5: Anova Table for Coefficient of Friction

Source of Variation	SS	df	MS	Fcal	F tab
Rows	0.015962	3	0.00532	2.43532	3.86255
Columns	0.065236	3	0.02175	9.95319	3.86255
Error	0.019663	9	0.00218		
Total	0.10086	15			

4. CONCLUSIONS

The following conclusions can be drawn from the study:

1. The average linear dimensions (major, intermediate and minor diameters) of the two oil palm varieties range from 8.19 to 16.63 mm for dura nut and shell and 8.47 to 15.48 mm and 1.5 to 3.57 mm for tenera nut and shell. Analysis of variance shows that there is significance difference in the coefficient of friction of both shell and nut on the different structural surfaces but there is no significant difference within the same structural surface.
2. The mean coefficient of friction range from 0.59 to 0.80 on the four structural surfaces namely galvanised steel, mild steel, plywood and plastic
3. The mean angle of repose range from 23.46 to 25.16 for the shells kernels of the two varieties.

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ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665