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DETERMINATION OF SOME PHYSICAL PROPERTIES OF PALM KERNEL

[1]Y.Mijinyawa and [2]S.Omoikhoje
1. Department of Land Use and Mechanization, Faculty of Agriculture, University of Swaziland. Mijin1957@yahoo.com.
2. Department of Agricultural and Environmental Engineering, University of Ibadan, Nigeria

ABSTRACT

Experiments were carried out to determine the dimensions of palm kernel, the shell thickness, kernel and nut densities as useful parameters in its handling and processing. The major, intermediate and minor diameters of the kernel were found to vary from 26.5 to 44, 21.5 to 34.5 and 16.5 to 28mm respectively. Sphericity was calculated to be between 76 and 80 and was independent of the size of the kernel. Nut densities varied from 0.8 to 2g/cm^3 while kernel densities varied from 0.93 to 1.33g/cm^3. The nut densities were generally higher than the kernel densities and the variation is attributed to the large volume but lightweight of the shell. The shell thickness varied from 2 to 6.5mm. These parameters are useful in the design of handling and processing equipment for palm kernel.

KEY WORD: *Palm kernel shell, sphericity, kernel density, shell thickness, geometric mean diameter*

INTRODUCTION

The engineering properties of biomaterials constitute an important and essential data for design of machines, structures, processes and controls. 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 are important in determining the method of separation and cleaning especially by pneumatic method, density and specific gravity are needed in calculating thermal diffusivity in heat transfer and 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. Mechanical properties such as compressive strength provide information on the resistance of produce to cracking under harvesting and handling conditions and energy required in size reduction. 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 storage structures.

These engineering properties are not only useful to the engineers but also to food scientists and processors, plant and animal breeders and other scientists who may exploit them in their various disciplines.

The oil palm *Elaeis guineensis* is a tall straight branchless trunk tree with leaves clustered at the top, which is believed to have originated in the tropical rain forest region of West Africa. (Zeven, 1965., Jacquemard, 1988., Purseglove,1992., FAO 2005). The tree grows well in the forests of equatorial tropics of Africa, Southeast Asia and America. The main belt runs through the southern latitudes of Cameroon, Côte d'Ivoire, Ghana, Liberia, Nigeria, Sierra Leone, Togo and into the equatorial region of Angola and the Congo. The oil palm is found in many parts of Nigeria with a larger concentration in the southern part of the country either as wild growing or in established plantations. It provides employment for the rural populace either as palm oil processors or palm wine tapers. Although there are a number of varieties such a dura, tenera, pisisfera and other hybrids, the wild oil palm groves of Central and West Africa consists mainly of a thick-shelled variety with a thin mesocarp, called Dura.(FAO, 2005) This is the species commonly found in western Nigeria.

The oil palm is often described as the princes of the plant kingdom because virtually every part of it has an economic value. Palm kernel is one of the many products obtained from the oil palm in the process of extracting palm oil. It is of high economic importance as it is both a cash crop and locally used in the countries where it is produced. The palm kernel oil has a medicinal value, the nut residue after the oil extraction is referred to as the cake which is an important ingredient for livestock feed. The shell is used as a source of fuel especially in the areas where it is produced. A few attempts have been made to extend the utilization of the shells. Such attempts include Ogedengbe and Olawale (1983) who reported on the potentials of activated palm kernel shells for water treatment as it is capable of removing taste, colour, turbidity, acidity and iron from bad water and render it fit for human consumption while Mijinyawa and Okedokun, (1999) tested concrete cubes in which part of the coarse aggregates was replaced with palm kernel shells and obtained compressive strength within the limits specified by codes on structural use of concrete.

Although the processing of oil palm and its products is an old practice for which traditional methods are available, new methods will not only reduce the drudgery of handling but will expand the areas in which most of the products can effectively be utilized. Data on engineering properties of the palm kernel are therefore very important. The engineering properties of a biomaterial are dependent on a number of factors such as species or variety and the climatic environment where it is cultivated. This makes it desirable that the engineering properties of locally cultivated varieties be determined. The engineering properties determined and reported in this paper are size, Sphericity, density and shell thickness of oil palm cultivated under a rainforest climate of western Nigeria.

MATERIALS AND METHODS

Collection of samples

The samples used for this study was the dura species which is the most common variety found in southwestern Nigeria. The samples were collected from the Lomiro Oil Mill at Ijebu Ode in Ogun State.

Experimentation

The experimentation involved the measurements of the dimensions of the kernel , cracking of kernels , measurement of shell thickness, densities of kernels and nuts. One hundred nuts were selected from the materials collected at random after having been cleaned and mixed for use in each of the experiments.

Size and shape of kernel

The three major axes of the palm kernels were measured using a venier sliding caliper with a calibration of 1mm. *The mean, median and mode* were calculated for each of the axes. Table 1. The Sphericity of the kernels, which is an expression of the shape character of the *kernel relative to that of a sphere of the* same volume, was calculated from the expression presented by Mohsenin (1986) and which has also been used by Alabadan (1996) and Orji (2001):

$$\text{Sphericity} = \frac{Geometric\ mean\ diamet}{Major\ diameter}$$

$$= \frac{(axbxc)^{1/3}}{a}$$

Nut and kernel densities

After the dimensions of the kernels were measured, their weights were determined using a weighing balance with a calibration of 1gm while the volume was determined using the liquid displacement method. The nuts of the same kernels were collected after cracking and their weight and volume determined as for the kernels. The density for kernel and nut was calculated from the equation.

$$\text{Density} = \frac{\text{mass of sample}}{\text{Volume of sample}}$$

Shell thickness

The collected cracked shells were measured using a venier-sliding caliper. The readings were recorded against the data for the kernels from which they were obtained.

RESULTS AND DISCUSSION

Size and shape

The average magnitudes of the major, intermediate and minor diameters were 34.9, 26.4 and 21.6mm respectively. The arithmetic and geometric mean diameters were therefore calculated as follows

AMD = (34.9 + 26.4 + 21.6)/3

= 27.63mm

GMD = (34.9 x 26.4 x 21.6)⅓

= 27.01mm

The Sphericity was obtained as

Sphericity = GMD/34.9 =77.6%, which indicates a good closeness to the shape of a sphere. Size and shape are important parameters in the design of crackers.

Densities

The nut densities were generally higher than those for the kernel. The average density of nut was 1.25g/cm^3 as against 1.09 g/cm^3 for the kernel. Orji (2001) made similar observation for breadfruit while Ogunjimi *et al* (2000) observed same for locust bean. A possible explanation for this observation is the high volume of the shell but light weight while in addition, a circumferential void between the nut and the inner wall of the shell adds to the volume of the kernel and further reduces the density. The two parameters are of importance in deciding in which form the material is best handled. Density is relevant in establishing the volume of hopper in cracking machines.

Shell thickness

The shell thickness varied from 2mm to 6.5mm, the mode being 4mm while the average was 3.75mm.This is within the range of 2 – 8 mm thick reported by Hartley (1977) and Purseglove (1992).The thickness is not necessarily a function of the kernel size as some small sized kernels had thicker shells than large sized ones. Thicker shells generally required higher forces to rupture the shells although in a few instances, shells of lesser thickness required higher forces.

CONCLUSION

The major, intermediate and minor diameters of the kernel were found to vary from 26.5 to 44, 21.5 to 34.5 and 16.5 to 28mm respectively. Sphericity was calculated to be between 61.5 and 97.7% and was independent of the size of the kernel. Nut densities varied from 0.8 to 2g/cm^3 while kernel densities varied from 0.93 to 1.33 g/cm^3. The nut densities were generally higher than the kernel densities and the variation is attributed to the large volume but lightweight of the shell. The shell thickness varied from 2 to 6.5mm.These parameters are useful in the design of handling and processing equipment for the palm kernel.

Table 1. Some physical properties of palm kernel (dura species)

Property	Minimum value	Maximum value	Mean	Mode	Median	Standard deviation
Width, mm	16.5	28.0	21.6	22.0	21.5	2.18
Breadth, mm	21.5	34.5	26.4	27.0	26.5	2.71
Length, mm	26.5	44.0	34.9	35.0	35.0	3.51
Sphericity, %	61.5	97.7	77.5	70.0	77.2	7.05
Nut weight, gm	1.0	4.0	2.1	2.0	2.0	0.43
Nut volume, cm^3	0.5	3.0	1.76	2.0	2.0	0.53
Nut density, g/cm^3	0.8	2.0	1.25	1.2	1.2	0.35
Kernel weight, gm	6.5	13.0	8.59	8.0	8.5	1.13
Kernel volume, m^3	6.0	12.0	7.9	7.0	8.0	1.02
Kernel density, g/cm^3	0.93	1.33	1.09	1.14	1.08	0.07

Shell thickness, mm	2.0	6.5	3.75	3.0	3.65	0.81

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