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Some Physical Properties and Proximate Composition of Ngologolo Fruits

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Abstract

In a bid to enhance the design of handling and processing machines and encourage consumption, some physical properties and proximate composition of Ngologolo fruits were studied. Results revealed that mean values of length, width, thickness, geometric mean diameter, surface area and volume were 13.11 ± 1.29 mm, 11.75 ± 0.85 mm, 5.87 ± 0.43 mm, 9.67 ±0.71 mm, 180.32 ±3.41 mm^2 and 3.788 ± 0.89 cm^3 respectively. Bulk density, true density and porosity were found to be 0.35 g/cm^3, 1.91 g/cm^3 and 82.1% respectively, while mean values of vitamins A and C were 0.22% and 0.60% respectively. It is therefore recommended that the technical information provided herein be applied for mechanization activities.

Keywords: Physical properties; Proximate composition; Fruits; Handling; Processing

Introduction

Ngologolo is a tropical forest shrub that is plentiful in the Deltaic region of Nigeria and other African countries. It is a wild crop that measures about 1-3 m in height, and 3-8 cm in stem diameter. The leaves are leathery, glossy and about 6-9 cm in length and 3-4 cm broad (Figure 1 and 2). The flowering and fruiting season of this delicious fruit is between October to November and is matured for harvest from January to March annually. About 2-3 seeds are always embedded in a reddish pulp of the fruit and the pulp is the most desired part of the fruit.

Figure 1: The Ngologolo fruits

The Ngologolo fruit is tasty and therefore eaten raw by humans, animals and birds. The pulp has a high sugar content, hence a delight for both farmers and children. Not withstanding, Ngologolo tree is still considered a wild crop but need to be domesticated for mechanized processing operations. This can only be realized when proper scientific studies are conducted on the physical properties and proximate composition of the fruits.

Figure 2: The Ngologolo tree

Physical properties of agricultural materials are those morphological attributes which when investigated are relevant to the design and development of harvesting, handling, processing and storage equipment for that particular material. These properties includes, mass, size, shape, surface area, volume, aspect ratio, sphericity, true density, bulk density, porosity and angle of repose. These properties are indeed measurable and they describe the physical state of the material at any given condition and time. The mass, size and shape are essential for sorting, grading and various separation operations. Bulk density, true density and porosity are useful for

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storage, transport and separation systems [1]. Pressure loads on storage structures is also dependent on angle of repose and frictional coefficients on bin wall materials. This has led numerous researchers to investigate the physical properties of different agricultural materials. Amongst them are Bart-Plange et al. [2] for maize; Heidarbeigi et al. [3] for wild pistachio; Kilickan et al. [4] for tef seed; Ozarslan C [5]for Cotton seed; Gursoy and Guzel [6] for wheat grains; Aydin [7] for hazel nuts; Burubai et al. [1] for African nutmeg and Carman [8] for Lentil seeds.

In the same vein, the proximate composition of a biological material when studied reveals the food value of that product. It indeed exposes the nutritional facts for safety concerns. Hence, similar studies have been conducted on different biomaterials to evaluate their fitness for human [9-11]. However, the physical properties and proximate composition of Ngologolo fruit is yet to be investigated to expose information needed for proper design of appropriate machines for handling and processing of this tasty fruit. Therefore, the objective of this work was to determine some physical properties and proximate composition of Ngologolo fruit.

Materials and Methods

10 kg of fresh and riped Ngologolo fruits were harvested from the Sabagreia forest in March, 2013. The fruits were immediately processed and all unwanted materials removed. They were then transported to the Food Process Engineering Laboratory of the Niger Delta University and the initial moisture content determined using the oven method and the remaining samples stored in an open plastic tray at a room temperature of 22 ± 3°C for 24 hours to equilibrate before experimentation.

Physical Attributes

100 fruits were randomly selected and their lengths (major diameter, a), widths (intermediate diameter, b) and thickness (minor diameter, c) were measured with a digital caliper (model CD-6BS-Mitutoyo Corporation, Japan) with a resolution 0.01 mm.

Sphericity

This property expresses the characteristics shape of a solid object relative to that of a sphere of same volume [12]. This property is relevant to fluid flow, and heat and mass transfer calculations. It is determined from the formula:

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

For a better understanding of the shape of Ngologolo fruit, another shape determinant called aspect ratio, described by Maduako and Faborode (1990) was calculated as:

$$Aspect\ ratio,\ R = \frac{b}{a} \times 100$$

Geometric Mean Diameter (GMD)

The geometric mean diameter information for the 100 fruits was obtained from the measured geometric dimensions of length, width and thickness for the 100 fruits as

$$GMD = (abc)^{1/3}$$

Radius of Curvature

This property determines how easily the object will roll. It is needed for the design of Conveyors and hoppers for particulate materials. The minimum radius of curvature (R_{min}) and maximum radius of curvature (R_{max}) were determined from the length and width as follows

$$R_{min} = \frac{b}{2}$$

$$R_{max} = \frac{b^2 + \frac{a^2}{4}}{2b}$$

Volume

Since the shape of Ngologolo fruit appears as triaxial ellipsoid, the volume was calculated from the length, width and thickness measurements in the following equation:

V=43 na bc

Surface Area

This is an important physical characteristic that is related to size and shape. It is useful in estimating the amount of packaging film to wrap the fruit and also relevant to rate of heating and cooling calculations. The surface area was calculated from the volume as:

$$S = (36\pi)^{1/3}\ V^{2/3}$$

1000 Kernel Weight (TKW)

The mass of 100 fruits was weighed on a top-loading electronic balance (EK 5350) with resolution 0.01g and the result multiplied by 10 to obtain the 1000 Kernel weight as was also applied by Gharibzahedi et al, [14] for prime nut and Tavakoli et al [15] for barley grains.

Angle of Repose

This property is essential for the design of storage structures and conveying systems. It describes the cohesion amongst the individual fruits of the bulk. Angle of repose for Ngologolo was determined with a bottomless cylinder (10 cm diameter, 15 cm height) as was also applied by Taser et al. [16] and Garnayak et al. [17]. The cylinder was placed over a smooth surface and filled with Ngologolo fruits. The cylinder was then raised slowly allowing the fruits to flow down and form a natural slope. The height (H) and diameter (D) of the heap formed were measured and the dynamic angle of repose calculated as follows:

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

Bulk Density

This is the mass of a group of individual particles divided by the space occupied by the entire mass, including the air space. The bulk density dictates the characteristics of the container or influences the strength of the packaging material. It was determined using a standard container (beaker) of known weight and volume. The container was filled with the sample without compaction, and the content weighed. Similar methods have been adopted by Bart-Plange et al. [2] for bambara groundnut. The bulk density was then calculated as the ratio of the mass of fruits only to the volume of container as:

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$$\rho b = \frac{Mass\ of\ fruits}{Volume\ of\ container}$$

True Density

This property is useful in numerous situations involving heat transfer. It is indeed the ratio of the unit mass to unit volume and was calculated as follows:

$$\rho T = \frac{Mass\ of\ individual\ fruit\ (kg)}{Volume\ of\ individuals\ \left(m^3\right)}$$

Porosity

It is the percentage of air between the fruits compared to a unit volume of fruit. This property therefore represents the amount of air spaces in the bulk. It is required for modeling and design of heat transfer processes and determination of packaging volume. Porosity was therefore calculated as follows:

$$Porosity,\ P = \frac{\rho T - \rho b}{\rho T} \times 100$$

Coefficient of Static Friction

The coefficient of static friction is often used to determine the angle at which a material must be positioned to achieve a consistent flow. It is the ratio of force needed to start sliding the sample over a surface by the weight of the sample. It was determined against two structural surfaces, namely plywood and plastic using the tilting-table apparatus. A wooden frame of 10 cm x 10 cm x 5 cm was filled with the fruits and lifted slightly about 2 mm to prevent contact with the test surface. The surface was gently raised and the angle of inclination to the horizontal at which the fruits begin to slide down was recorded with a protractor and the coefficient of static friction. Calculated using the following expression.

$Coefficient\ of\ static\ friction,\ \mu_S = tan\alpha$ Where α is the angle of tilt of table

Proximate Analysis

The chemical composition (food value) of Ngologolo fruit which actually reveals the nutritional information was determined at the Chemistry Laboratory of the Niger Delta University, Bayelsa State, Nigeria. Parameters investigated are moisture content, carbohydrate, ash content, fat content, crude protein, vitamin A and vitamin C.

Moisture content was determined using the oven method, crude protein by the Kjeildahl apparatus method, carbohydrate by difference, ash content by method described by Pomeranze and Meloan [18], fat content by Soxhlet apparatus and vitamins were determined using standard procedures described by Asibey-Berko and Tayie [9]. All determinations were replicated three times and analyzed statistically using XLstat 2010.

Results and Discussions

Results of some physical properties and proximate composition of Ngologolo fruit determined in this work are presented in Tables 1 and 2 below.

Physical Property	Unit of measurement	No. of samples	Mean value	Minimum value	Maximum value	Standard deviation
Major diameter, a	mm	100	13.11	10.3	16.5	1.29
Intermediate diameter, b	mm	100	11.75	10.08	13.5	0.85
Minor diameter, c	Mm	100	5.87	5.04	6.75	0.43
Sphericity	%	100	0.74	0.67	0.82	0.04
Surface area	mm^2	100	180.32	163.01	200.43	3.41
R_{min}	mm	100	5.87	5.04	6.75	0.43
R_{max}	mm	100	7.7	6.38	9.26	0.6
Aspect ratio	%	100	0.9	0.78	1.13	0.07
Angle of repose	Degrees	5	36.4	34.5	38.9	2.4
GMD	mm	100	9.67	8.08	11.45	0.71
Bulk density	g/cm^3	5	0.35	0.312	0.403	0.251
True Density	g/cm^3	5	1.91	0.92	2.05	0.61
Volume	cm^3	10	3.788	2.413	4.391	0.895
Porosity	%	10	82.1	73.4	85.6	2.43
Coefficient of static friction on plywood	-	3	0.532	0.5095	0.7813	0.03

Coefficient of static friction on plastic	-	3	0.728	0.675	0.7536	0.01

Table 1: Some physical properties of Ngologolo fruit

Geometric Characteristics

Data on both the basic geometric characteristics such as length, width, thickness, geometric mean diameter and volume, and the complex geometric characteristics such as sphericity, bulk density, true density, porosity, surface area, angle of repose and coefficient of static friction are shown in Table 1. Results show that mean values of length, width and thickness of ngologolo fruits were 13.11 mm, 11.75 mm and 5.87 mm respectively at 84.8% moisture level. These dimensional results show that Ngologolo fruit is bigger than Spinach seed [4] but smaller than Parkia speciosa seeds [19]. Also the high moisture content of 84.8% is an indication that Ngologolo fruit has short storage potential, therefore suggesting proper preservation methods to prolong the shelf-life during storage. The geometric mean diameter ranges from 8.08mm to 11.45mm with an average value of 9.67 mm (± 0.71). The mean volume which depends on the length, width and thickness was found to be 3.78 cm3. This volume is by far lower than that of African nutmeg [1].

Parameter	Obtained value (M ± SD)
Moisture Content (%)	84.80 ± 0.03
Ash Content (%)	1.20 ± 0.01
Fat (%)	0.20 ± 0.24
Crude Protein (%)	0.50 ± 0.06
Vitamin A (%)	0.22 ± 0.09
Vitamin C (%)	0.60 ± 0.53
Total Carbohydrate	8.40 ± 0.69

Table 2: Proximate composition of Ngologolo fruit (*M ± SD = Mean ± Standard deviation)

The mean sphericity and aspect ratio for 100 fruits was 74 ± 0.04% and 90 ± 0.07% respectively. These high sphericity and aspect ratio values indicated that the shape of Ngologolo fruit is close to a sphere and hence has the tendency to roll. These values are higher than that of Parkia speciosa seed [19]. The aspect ratio and sphericity data obtained here may therefore be useful for hopper design to handle the fruit. The surface area evaluated for 100 fruits was found to vary between 163.01 mm^2 and 200.43 mm^2 with a mean value of 180.32 mm^2. Mean values of true density, bulk density and porosity were found to be 1.91 ± 0.61 g/cm^3, 0.35 ± 0.25 g/cm^3 and 82.1% respectively. This shows that Ngologolo fruit is heavier than water and this data can be used to design separation or cleaning processes since lighter materials will float in water. The reported values of true density and bulk density are lower than those reported for quinoa seeds [20]. However, the porosity reported here is higher than Parkia speciosa seeds [19] and can be useful in containerization. Also, mean values of angle of repose, minimum radius of curvature and maximum radius of curvature were recorded to be 36.40 mm, 5.87 mm and 7.70 mm respectively for the 100 fruits tested. These parameters are useful in the design of both conveyor systems and storage structures. The coefficient of static friction data in Table 1 shows that mean values against plywood and plastic surfaces were 0.532 and 0.728 respectively. The values reported here are higher than those of Parkia speciosa seeds [19]. The static coefficient of friction values obtained here may be useful in determining the angle at which chutes and hoppers must be positioned in order to achieve consistent flow of the fruit through it [21].

The proximate composition data of Ngologolo fruit is presented in Table 2. Results show that moisture content, ash content, crude protein and fat content had average values of 84.8%, 1.2%, 0.50% and 0.20% respectively. Carbohydrate, Vitamin A and Vitamin C had mean values of 8.40%, 0.22% and 0.60% respectively. The high Vitamin C content in Ngologolo fruit is important for growth and repair of body tissues [22]. Vitamin C being a powerful antioxidant helps the body to heal cuts and wounds and keeps our teeth and gums healthy. In like manner, the abundance of Vitamin A in the fruit may aid the vision of consumers, while the presence of Carbohydrate and protein are likely to support energy production and repair of worn-out tissues in the body.

Conclusion

Some physical properties and chemical composition of Ngologolo fruit which may likely be helpful to the design and development of handling and processing machines were evaluated in this work. Average length, width, thickness, geometric mean diameter and angle of repose were found to be 13.11 ± 1.29 mm, 11.75 ± 0.85 mm, 5.87 ± 0.43 mm, 9.67 ± 0.71 mm and 36.40 respectively. It is therefore recommended that the technical data provided here be considered in the design of handling and process machines for Ngologolo fruit.

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