EVALUATION OF SOME PHYSICAL PROPERTIES OF AGRICULTURAL PRODUCTS (SHEA NUT AND CASHEW NUT) AT DIFFERENT MOISTURE CONTENT

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FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

NOVEMBER, 2008.

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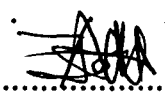
BEING A FINAL YEAR PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING

FEDERAL FUNIVERSITY OF TECHNOLOGY, MINNA

NOVEMBER, 2008.

DECLARATION

I here by declare that this project is a record of a research work that was untaken and written by me. It has not been presented before for any degree or diploma or certificate at any university or institution. Information derived from personal communication, published works of others were duly referenced in the text.



..... 19/11/2008 .....

Agwari Musa Abduljalil Date

CERTIFICATION

This project entitled "Evaluation of some physical properties of Agricultural products (shea nut and cashew nut) at different moisture content" by Agwari Musa Abduljalil of Agricultural and Bioresources Engineering Department meets the regulation governing the award of Degree of Bachelor of Engineering (B.ENG) of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

19/11/2008 .....

Engr. Dr (Mrs) Zinash D. Osunde — date

Supervisor

19/11/2008 .....

Engr, Dr (Mrs) Zinash D. Osunde — date

Head, Department of Agricultural and Bioresources

..... 18/11/08

External Examiner — date

DEDICATION

I dedicate this project to Almighty God, the Creator of the Universes, He who gives wisdom and understanding to whom ever He wishes.

Also, I dedicate this project to my parent and to all members of the family and their descendants.

ACKNOWLEDGEMENTS

I thank God Almighty through whom all blessing, strength, and grace to see me through my programme. My thanks go to my supervisor which is also my H.O.D Engr. Dr (Mrs) Zinash D. Osunde, my appreciation goes to Engr. Sadiq, Engr. Mrs Mustapha, Engr Dr O. Chukwu, my level adviser Engr. Peter Adeoye and other lectures and staff of Agricultural and Bioresources Engineering Department who took it upon themselves to see that best knowledge was impacted on me.

I wish to acknowledge with sincere gratitude, the tireless support of my loving parents Mall. Musa S. Agwari, Mall. Hadiza, Mall. Zainab, Mall Zainab 'Anikoro,' Mall. Sabira, for their moral support, financial support, their inspiration and for all they did to make me what I am today.

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ABSTRACT

Sheanut tree belongs to the family of *Sepataceae* and is abundant in the savannah area of West Africa. Cashew tree on the other hand belong to the family *Anacardiaeae* and is native to Latin American. In the international trade of nuts crops, it ranks third after almond. Agricultural product need to be handled with care whether they are to be used as planting materials or as food. The engineering properties studied are the physical properties of cashewnut and sheanut at different moisture content. The results obtained for size of cashew are major diameter, 30.9mm intermediate diameter 25.9mm, minor diameter 22.5mm, while the size of shanut are major diameter 40.3mm, intermediate diamteter, 35.9mm, minor diameter 32.6mm. The moisture content of sheanut are 4%, 8% and 12% while that of sheanut are 26%, 15%, and 12% density of sheanut and cashewnut are 2.71 x 10^3kg/m^3 and 6.6 x 10^3kg/m^3. The parameters observed changes appreciable these are due to the moisture content.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Origin of Sheanut

Sheanut tree *(Vitellaria paradoxa)* belongs to the family of *sepataceae.* (keay, 1989). It is abundant in the savannah areas of West Africa, where it is often protected and inherited, especially trees in most predominant in the Northern part of the country:- Bauchi, Niger, Kwara, Adamawa, Zaira, Nasarawa, Kaduna. In western Nigerian, it is found in Oyo, Ibandan, Abeokuta. In Eatern Nigerian, it found in Ogoja province, (Keay, 1989). The local names are: Hause-Ka'danya; Yoruba-Emi, Ibo-Osis-Okwuma; Fulani-Kareje; Nupe-Epe; Gwari-Kombwa, (Purseglove, 1974). It is a major forest but discovered to be one of the most important trees in the area. Mohsein (1986) reported that the tree grows well and widely in a Sudan climate with a pronounce dry season of 4-5 months according to Keay, (1989), the crop is not usually cultivated in Nigeria, but the plant gown widely on a natural vegetation. The ripe seed drops to the ground and germinate. The germinated seed can be transplanted to the desired field, thus begin to flower after many years. The flower has long stalk and clustered at the end of the leaflets twigs with sepal covered with pinkish brown hair petals. Fruiting is normally around May to August. The fruit is greenish grey in appearance, ellipsoid about 4cm long to 2cm broad and a hard testa.

The sheanut fruit is greenish brown in appearance.

Olaoye (1997) stated that the tree is readily available and grows predominantly in the guinea savannah zone of Nigeria. Morphologically, the tree is small and deciduous, growing to a height of 7-13 meters (Purseglove,. 1974, Nair,

1980 and FAO, 1982).

It was reported that the tree has a branch crown the base is short and has a diameter of 1.5-1.8 meters at breast height. The bark is horizontally and vertically fissured, thick, blackish and rough.

The leaves are clustered at the ends of branches, oblong having dimensions of 10-25cm by 5-8cm (Purseglove, 1974). According to Olajide (1992), it was said that the branch tips, oblong, having an undulating margin, curvaceous, shining and 10-20cm by 5-8cm in dimension. The flowers are white clustered at the end of shoot and about 1cm long (Purseglove, 1974). Flowering occurs during the dry season and fruiting begins in the middle of rainy season. With a seasonal yield of about 15 - 20kg fruit per tree (FAO, 1982 and Olajide, 1992).

The fruit is ellipsoided in shape with flesh pulp (mesocarp) and is usually one-seeded, seeds are about 2.5-5cm in length, shiny and dark brown sport at one side (Purseglove, 1974).

1.2 Description of sheanut

The sheanut tree is a small deciduous tree, 7-13m high. The back is dark grey, rough, deeply fissured into more or less square pieces, slash red, exuding a white latex. Seedling produce a long tap root which makes transplanting difficult, and they best plant in-situ. Trees start bearing fruits at 12-15years and take 30 years to mature. The leaves are clustered at the ends of stout twigs, up to 10-25cm long, 5-8cm broad, elongated or slightly broader in the upper half usually rounded at the apex. Flowers are clustered at the ends of leaflet twigs, and have white petals. The fruit are yellow, ellipsoidal, 4-5cm long, with flashy pulp and usually one seed some times can contain 2-3 seeds (Ogunshina, 1997).

The seed is more or less avoid, about 3-5cm long and 2.5cm broad, with a shining dark-brown, hard bony testa and a shield shaped white scar down one side. The seeds are removed after the decomposition of the pulp or after drying. The nuts are inside the shinny dark-brown hard bony shell and remove freely when dried. Major producing countries are: Nigeria; Mali; Burkina-Faso; Benin Republic; Senegal; Ivory Coast; Ghana; and Gambia.

1.3 Origin of Cashew Nut

The cashew tree belongs to the family *Anacardiaceae* and is native to Latin America. It is 10-15 meters high the branches which are dense and spreading, may almost reach the ground.

The leaves, entire thick and glossy are oval shaped 10-20 centimeters long and 5- 10 centimeters wide. The small, yellow flowers hang in terminal clusters on the branches of the tree. The fruits consists of two parts the cashew apple, which is really the swollen penduncle of the fruit and the cashew nut containing the kernel rich in oil. The cashew tree has a very deep taproot with rigorous lateral roots (Dupriez (1989).

Environment: The cashew requires deep soil which the root can penetrate freely. It shows good resistance to drought and impoverished soils but is less productive in these conditions. The cashew grows in full sunlight.

Propagation: The cashew is propagated by seeds and by laying. Mature stem cutting can also be used. Approach grafting with scions taken from terminal shoots gives good results the cashew is grown in orchards either on its own or with other plants. The kernel of the cashew nut is eaten as a delicacy, or added to

sauces. The kernel also yields oil that is sometimes made into a kind of butter.

1.4 Maturities, Harvesting and Handling of Cashew Nut

Cashew apple is ripe when the basic colour of the outer skin turns yellow or yellowish. Generally ripped fruits fall to the ground and they are gathered manually sometimes they are detached from the penduncle or cashew apple, although manual detachment can provides the fall of flowers, small fruits and unripe fruits. Partial mechanization of cashew harvest is possible, adopting the techniques used for olives such as nut and shakers and also separation of the fruit from cashew apple can be mechanized, provided that producers are interested in trying new methods (Dupriez, 1989).

At present gradual ripening imposed harvesting at short intervals (2-4days) for peduncle or longer intervals (7-10days when they are not to be used for processing. In fact fruits may remain on the ground for 7-10 days without damaging the kernel.

After harvesting and the detachment of fruits form their peduncle, they cannot be stored because of their high moisture content, thus they were desiccated and exposed to sun for 4-5 days in layers. When moisture decreases, the fungus attacks reduce, so it can be stored for seeds or other food stuff.

(Solunke *et.al,* 1984) recommended a storage temperature of 0^0 C to 1.7^0 C with 85-90% relative humidity. Under these conditions, the cashew nut can be stored for up to 5 months. The commercial harvest of cashew nut starts from 5^{th} to 6^{th} year of planting and the economic life of a cashew tree is about 40 years. (Linchoistrobin, 1994).

1.5 Uses of Shea and Cashew Nut.

The cashew apple juice is commercialized for direct consumption, as a fresh or preserved product and for the preparation of alcoholic beverages. It may be consumed immediately after squeezing or it can be preserved after filtration, bottling and pasteurization.

The industrial uses of cashew nut shell liquid (**CNSL**) are mainly in the rubber industries. However, 90% of the CNSL are used to make resins utilized for clutches, for drum and disk brake. CNSL by - product may also be used to prepare paints garnishes, enamel, insecticides -fungicides, pigments, plasticizers, and adhesives, special quality lacquers and water-proof emerge paper.

Roasted and fried kernels, salted and sugared are demanded all over the world as snacks to accompany drinks at cocktails as ingredients when preparing food as basic ingredients for confectionaries. Apart form being a tasty and energy giving food, the nutritious characteristic of cashew kernel makes it highly digestible and very suitable for the preparation of infant formula, and some old age diets, (Linchoistrobin, 1994.)

Uses of sheaut

Almost all parts of the tree have some practical use. The bark is an ingredient in traditional medicine against childhood ailments and minor scrapes and cuts. The shell of the nut can repel mosquitoes. Above all the fruity part of the nut, when crushed yield a vegetable oil that can be used in the manufacturing of cocoa –butter equivalent (solid fraction), and high quality chocolate as well as a base for high quality cosmetics, and more recently in the aromatherapy industry (Keay, 989).

1.6 Objective of the Study

The objective of this project work is to determine some physical properties of cashew and shea nut at different moisture content which should be taken into consideration before any processing plant could be designed.

1.7 Justification of the Study

The study which is determination some physical and mechanical properties of sheanut and cashew nut, at different moisture content of the nuts to obtained result which can be used in future for more efficient methods of processing and storage conditions, and design of plants.

1.8 Scope of the Study

There are so many physical properties of Biomaterial in which some of these are selected for determination within the work of the project.

CHAPTER TWO

2.0 LITERATURES REVIEW

2.1 Production and Distribution of Cashew Nut

The cashew nut production and distribution lead all other tree nuts with its word product of 450,000 metric tones (MT). It ranks third (20% of the market) in the international trade of nut crops after hazel nut (29%) and almond (21%), (Linchoistorbin, 1994).

India is the largest producer of cashew nut producing more than 40% of the world cashew nuts, the other major producers of cashew nut are Mozambique, Brazil, Tanzania and Kenya. The production in the African countries has significantly decreased during the last decades (Ogunshina, 1997).

2.2 Planting of Seed

Cashew plant can be grown at an elevation as high as 1000m but it does best below 500m (Keay 1989) the cashew trees sometimes reach a height of 12m. They have large, Leathering, green leaves up to 15cm long and 10cm wide (Linchoistorbin, 1994).

2.3 Engineering Properties of Biomaterials

Agricultural products are usually things that need to be handled with care whether they are to be used as planting materials or as food. Therefore, the engineering properties of these products must be understood and are very important in the design of machine structure, processes control. The engineering properties are physical, mechanical, thermal, electrical, optical, aerodynamics and hydrodynamics properties all these properties are very useful in handling, storage, processing, preservation, quality evaluation distributing and marketing of

agricultural crops.

2.3.1 Physical Properties

Shape, size, volume, surface area, density, porosity, internal angle of friction, colour and appearance are some of the physical properties which are important in many problems associated with the design of a specific machine or analysis of the behavior of the product in handling of the materials.

Size and shape are inseparable in physical object and both are generally necessary if the object is to be described satisfactory.

Criteria for describing shape and size are found In Mothsenin (1970) as shown below

Table 2.1 Criteria for describing shape and size

Shape	Description
Round	Approaching spheroid
Oblate	Flatten at stemmed in shape
Oblong	Vertical diameter greater than horizontal diameter
Conic	Tapered toward the apex
Ovate	Egg shaped and broad at steamed
Elliptical	Approaching ellipsoid
Truncate	Having both end square or flattened
Unequal	One half higher than the other
Regular	Horizontal section approaches circle
Irregular	Horizontal section depart materially from circle

Source: Mohsenin, (1970)

Shape and size is also important in problem of stress distribution in the material under load, in electrostatic separation of seeds and grains, in light reflections and colour evaluation and in development of sizing and grading of machinery.

A knowledge of density and specific gravity of agricultural products is needed in calculation of thermal diffusivity in heat transfer problems in determining Reinolds number in pneumatic and hydraulic handling of the materials as in predicting physical structure and chemical composition.

Surface colour and appearance of agricultural products are valuable physical characteristics for selecting and separation in the field and, subsequent handling of the materials and processing. In selective harvesting of fruits and vegetables in post harvest sorting and grading and during storage desirable product can be selected on the basis of colour and appearance.

2.3.2 Mechanical Properties

In an attempt to obtain more material and usable data on mechanical properties of agricultural products, many investigators have approached the problem by employing testing procedure used for non-biological material. In this section, techniques for obtaining data on force deformation, firmness value (Q), Toughness value (T) and stress-strain data from compression test of Shea and cashew nut is discussed.

Hardness of grains has been a subject of interest of millers, livestock feeders, breeders, and other agricultural scientist. Biting or cutting the grain has provided a qualitative evaluation of grin hardness.

Mechanical properties such as compressive strength, impact and shear resistance are important and in same cases, necessary engineering data in studying

size reduction of cereal grain as well as seed resistance to cracking under harvesting and handling conditions. From an engineering stand point, this information can be used to determine the best method (shear, impact or stated crushing to brake upon grinding grains).

Static sliding co-efficient of frictions or grain forage materials and some other farm products on metals, wood and other materials are need by design engineers for national design and predicting motion of the materials in harvesting and handling equipment (Mohsenin,1970).

Co-efficient of friction is also important in determining the pressure of grain and silage against bin walls and silos. Compressibility, expansion characteristics, co-efficient of internal friction and cohesion, and elasticity of forage or silage mass are important in studying compressibility of the materials determining methods of compressing and packaging. Shearing resistance and bending strength of forage crops as they are cut are also important mechanical properties for understanding the nature of the cutting process and energy requirements in moving machines.

2.4 Processing of Cashew Nut.

The operation s which were involved in the processing of cashew nut are as follows. The consignment of cashew nut contains plant debris, small stones and particles, which constitutes impurities. These are removed during washing, from washing machine, the nuts come out graded into three sizes viz large, medium and small. The nuts are humidified for a periods of 6-72 hours to increase the moisture content as shown in Fig 2.1. There is no fixed regulations on how to carryout humidification because the operation is highly affected by the

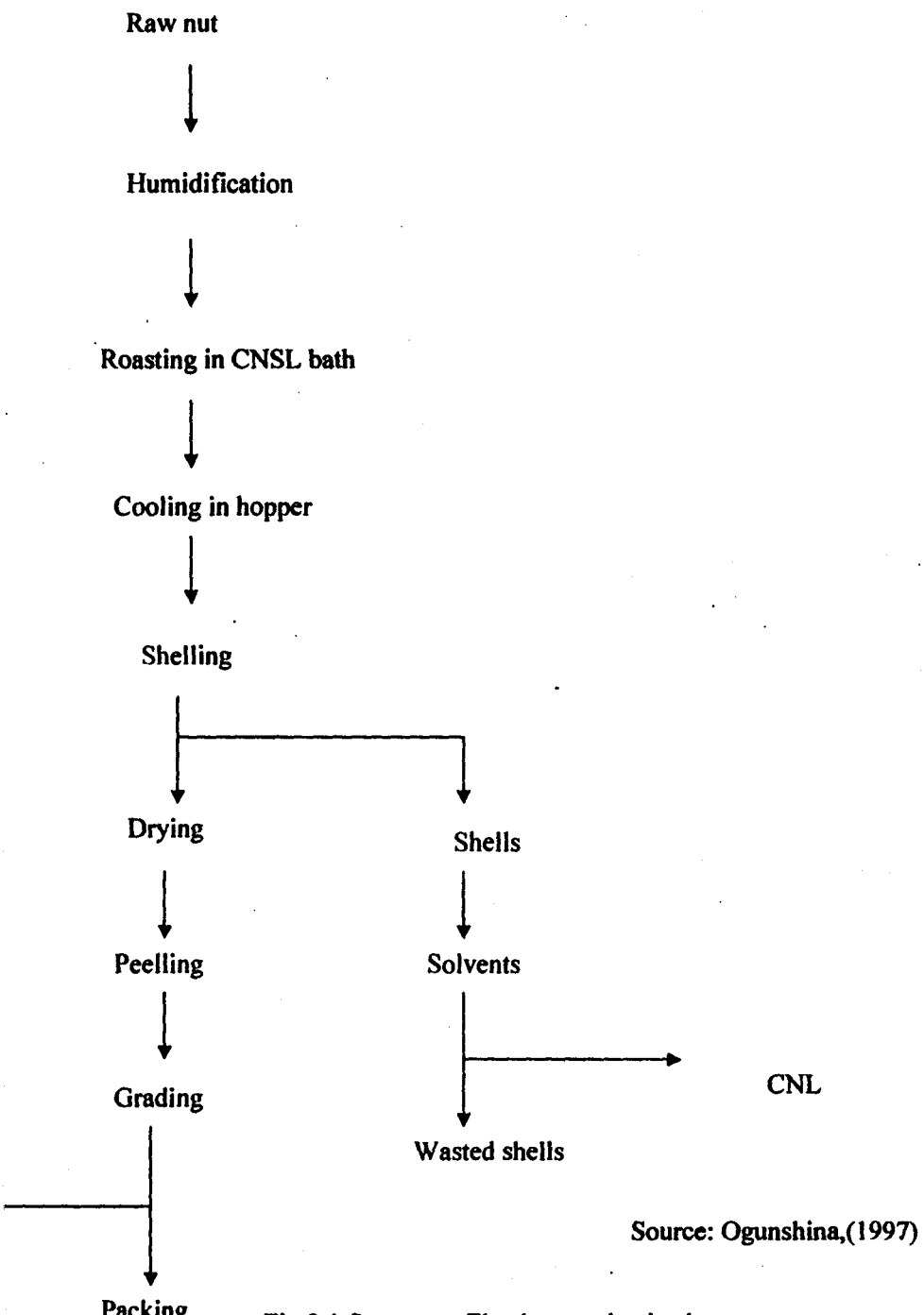
nature of nuts, place of harvest and initial moisture contents. Each lots humidification (large, medium or small) nuts are roasted at a temperature of 190°C-200°C and allowed to cool for 4hours. Cooling is necessary to facilitate shelling. During roasting the nuts (large, medium or small) go into the same cooling hoper and get mixed up as a result the nuts are therefore calibrated again into large, medium or small to facilitate proper shelling, during shelling the nuts is cracked. Shelling is perhaps the greatest bottle neck along the processing lives as achievement of production target is highly dependent on the capacity of the shelling machine.

After shelling, separation of the kernels from the shell is achieved by a pneumatic mechanism. The moisture content of the kernel at this stage is between 6-7%.

The kernels are subjected to 70-80°C to reduce the moisture content to 3% at which the testa is dry enough to facilitate peeling. (Ogunshina, 1997).

During pilling, the outer covering of the kernel testa is removed. In addition, the kernels are calibrated into whole, split and pieces. The peel kernels undergo sorting and resorting directly, while the unpeeled ones are peeled by hand before sorting and resorting is carried out. Hand peeling, sorting and resorting of kernels are labour intensive operations requiring through supervision and quality control monitoring for good results. During sorting and resorting, the kernel are graded according to colour, size, structure based on acceptable international market standards. As a result of consumers and commercial buyers increasing preference for white whole kernel, the general target in a cashew nut processing plant is to get a high percentage of white kernels. Other grades are.

Dessert white, butts, splits an pieces. The kernels according to these grades are packed, packing of kernels into galvanized tins is done harmatically with introduction of carbon dioxide for preservation (Ogunshina, 1997).



Source: Ogunshina,(1997)

Fig 2.1 Sturtevant Fletcher mechanized system

2.4.1 Traditional Processing Methods

The real fruit of the cashew is a kind of nut whose spongy mesocarp contains liquid known as CNSL the kernel is covered by a thin resistant peel which is not edible. Cashew nut processing must take into account the characteristics of the nut avoiding changes in colour and breakage of the kernel during roasting, shelling and peeling.

Cashew nut processing began in India in the 20s with manual shelling and peeling. Just before the Second World War, the first attempts were made to soften the shell to facilitate shelling by putting the nut in CNSL at a temperature of 2000°C. Later research was undertaken to mechanize partly or totally the shelling phase. Completely mechanized system for the processing of cashew nut was set up until in the 60s.

2.4.2 Indian Method

Today in India cashew nut processing is carried out using traditional method in what may not be defined as real factories. The raw materials are prepared for shelling either by drying in the sun. The nuts are then roasted in the hot CNSL or put in the rotating drum over a fire. In some regions an autoclave is used before shelling this operation is done without roasting.

Shelling is often carried out at home by individual workers paid in the basis of whole kernels yield. Shelling is done by hand with hammer or with pedal operating shealeq shears. The kernel are then dried before manual peeling. After grading the kernel are packed for shipping.

CHAPTER THREE

3.0 MATERIALS AND METHODS

The main material used in this study is sheanut and cashew nut. These can be obtained from the local market. The nuts were cleared manually to remove all foreign matter, broken and immature nuts.

3.1 Determination of Moisture Content.

This is the measurement of amount of water content. The moisture content of the nut was determined by using oven dry method.

The moisture content is then calculated or determined using the following equation.

$$MC = \left[\frac{Ww - Wd}{Ww}\right] \times 100$$

In which

M.C = moisture content (%) of material in (Wet basis)

Ww = weight of the sample and

Wd = weight of the sample after drying.

3.2 Selected Physical Properties

3.2.1 Size of Shea and cashew nut.

To determine the size of the nut diameter according to (Mohsenin, 1970), the mutually perpendicular axes a and b referred to as major and minor diameter also referred to as intermediate diameter were measured using vernnier caliper.

3.2.2 Shape of the nuts

To determine the shape of the nut, tracing of the longitudinal and lateral

cross section of the material was done. This is compared with the shape listed on the charted standard (Mohsenin1970). Using the standard charts. Description terms were used to define the shape of the product over fire replicates.

3.2.3 Seed Weight

This is the measurement of quantity of cashew and sheanut e.g. mass in kg unit ands counted numbers of the nuts (N) the weight of Shea and cashew nut was determined by using electronic weighing balance. The weight of the nuts then calculated using the formulae as given below

$$WC = \frac{M}{N}(Kg)$$

Where M = mass of cashew and shea nut form the scale

N = number of nuts counted

3.2.4 Volume and density

Water displacement method was used to determine the volume of the product due to irregular shape (Mohsenin, 1970). The material was first weight on a beaker by means of sinker road. The second reading of the scale with the product submerged minus the weight of the container and water gives the weight of the displaced water. Using the following expression the volume and density were determined (Mohsenin, 1970).

$$Volume = \frac{\text{weight of displaced water } (kg)}{\text{weight density of water } \left(\frac{kg}{m^3}\right)}$$

3.2.5 Sphericity

This is measurement of sphericity of Shea and cashew nut determined by obtaining the value of major, minor and intermediate diameter of the nuts.

The spericity was then calculated using formular.

Spericity $S = \left[\frac{bc}{a^2}\right]^{1/3}$ (Mohsenin, 1970)

Where a = major diameter

b = *intermediate diameter*

c = *minor diameter.*

3.2.6 Roundness

This is a measure of the sharpness corners of shea and cashew nut. The roundness was determined by using the value of largest projected natural area of the circumferences of nut and smallest natural area. Also by the area of a circle and area of shape.

Roundness was calculated using the formular

Roundness, $R = \frac{AP}{AC}$

where R= roundness

AP =area of largest projected nature or area of shape

AC = area of smallest projected nature or area of circle.

3.2.7 Internal Angle of Friction

The internal Angle of friction of sheanut and cashew nut is determine at different moisture content by loading the box which is open at both ends, so as the have contact with the surface of the plate form. The surfaces used of the determination are: mild steel, Galvanized steel and plywood. The handle of the machine is been rotated

clock wise, as the handle is been rotated the plate form on which the box rest on is move upward at an inclination with the help of a mesh gear which lift the platform. At the side of the plate form is a wooden carved protractor used in taking the angle of slide of the box from the surface.

When the box which contains the grain sliding down the plate form, the rotation of the handle is stop and the reading of the inclination of the plate form is taken as the internal angle of friction.

3.2.8 Colour

The colour of shea cashew nut determined by reflectivity and absorptive character using the electromagnetic radiation or by the view of transmission of light.

The colour can be determined with nature sight and comparing with the standard colours.

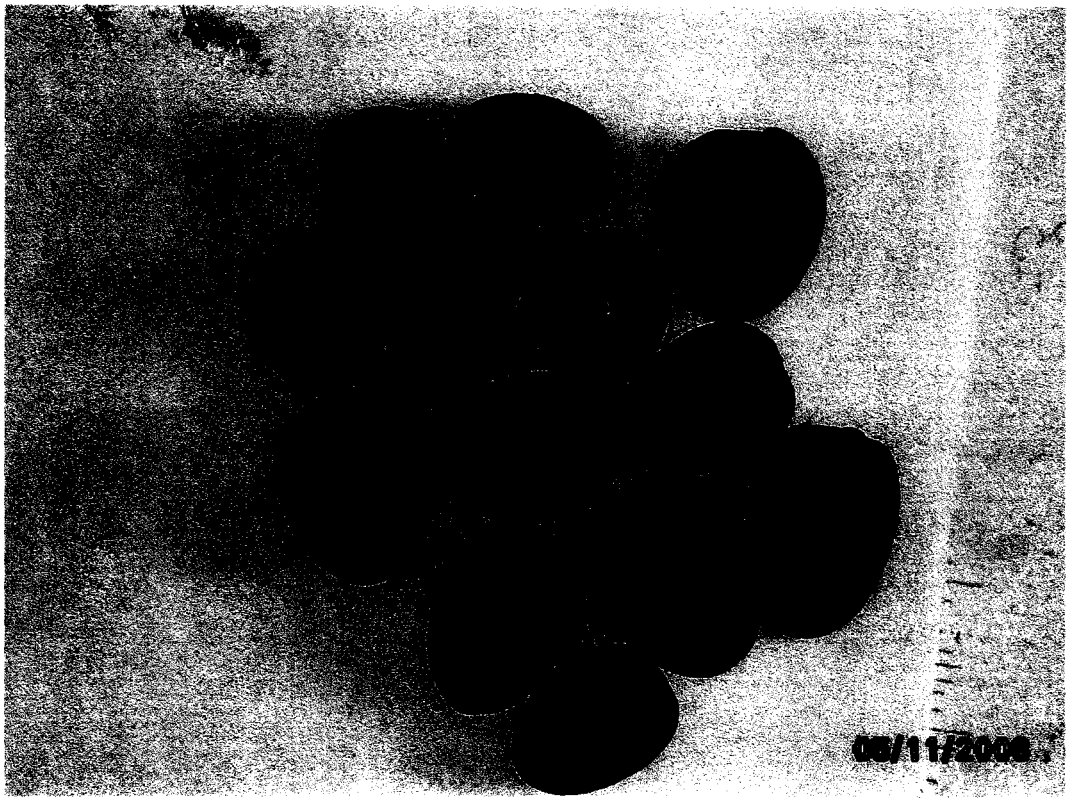


Plate 3.1 Shea nut Sample

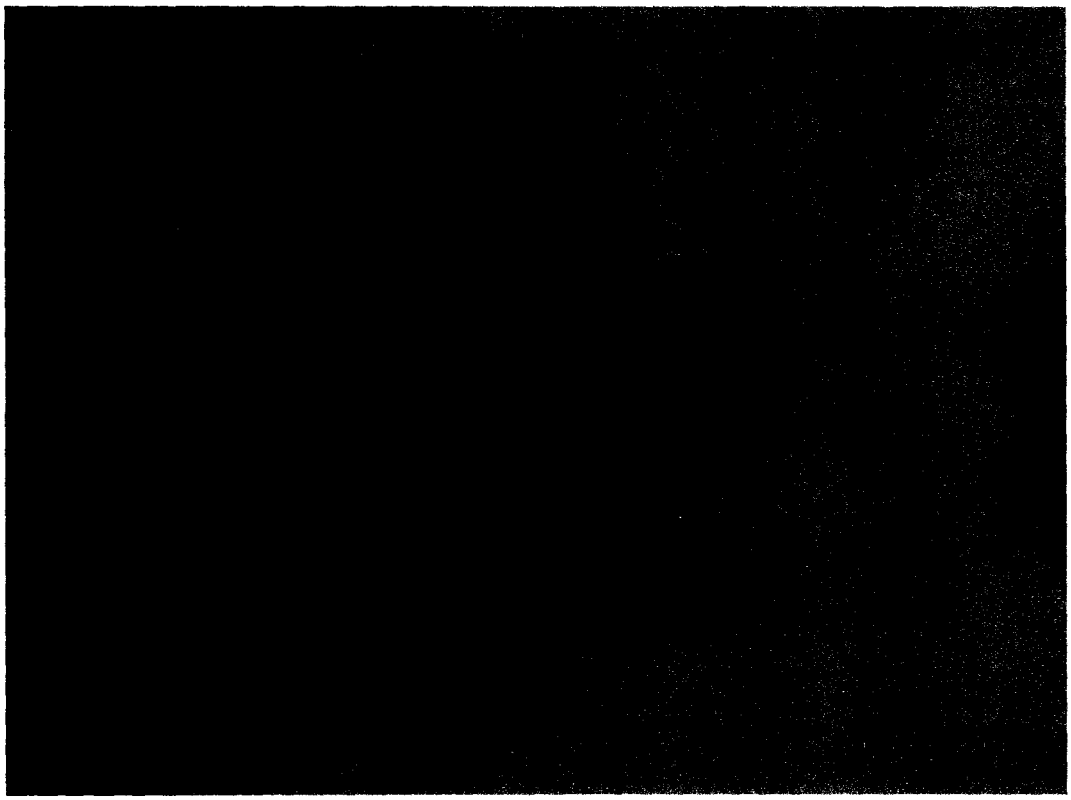


Plate 3.2 Cashew nut Sample

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

The data obtained from this work are show on table 4.1, 4.2, and 4.3 respectively. The result show the mean volume of five sample selected for the test of physical properties.

4.1 Moisture Content

Moisture content determine of sheanut and cashew nut. The result of moisture content are 4%, 8% and 12% respectively. The values of moisture content of cashew nut are 26%, 15% and 12%.

4.2 Size Determination of Seeds

The result obtained for size are the major diameter, intermediate diameter and minor diameter.

4.2.1 Major Diameter

The major diameter of sheanut is 40.3mm

The major diameter of sheanut is 30.9mm

4.2.2 Intermediates Diameter

The result of intermediate of diameter of sheanut is 35.9mm

The intermediate diameter of cashew is 25.2m.

4.2.3 Minor Diameter

The minor of sheanut is shown on table 4.1

The minor diameter of cashew nut is 22.5mm.

4.3 Shape Determination

The shape of sheanut is shown on table 4.1 as defined by the standard chart.

The shape of cashew nut is kidney-shaped.

4.4 Weight Determination

The weight of sheanut is obtained to be 45.11 X 10^{-3}kg while that of cashew nut is 8.66 x 10^{-3} kg

4.5 Volume and Density Determination

The volume and density of sheanut and cashew nut are both shown on table 4.1.

4.6 Determination of Sphericity

The sphericity sheanut sample is 0.90 and that of cashew nut 0.84.

4.7 Roundness Determination

The roundness of sheanut is 4.20 and 2.66 for cashew nut.

4.8 Determination of Internal Angle of Friction

The results obtained for the internal angle of friction of sheanut at different moisture content of 4%, 8% and 12% respectively are shown on table on table 4.2

The value obtained for cashew nut at different moisture content is show on table 4.3

4.9 Colour Determination

The result of colour determination of sheanut and cashew nut are shown on 4.1

Table 4.1 result of physical properties of sheanut and cashew nut

S/N	Properties	Mean values of sheanut	Mean value of cashew nut
1	Shape	Oblong	Kidney-shaped
2	Colour	Brown nut, Green Apple	Brown
3	Size		
	(a) major diameter	40.3mm	30.9mm
	(b) intermediate diameter	35.9mm	25.2mm
	(c) minor diameter	32.6mm	22.5mm
4	Weight	45.11×10^{-3} kg	$8.66kw^{-3}kg$
5	Volume	$1.66 \times 10^{-5}m^3$	$6.6 \times 10^{-6}m^3$
6	Density	$2.71 \times 10^3kg/m^3$	$1.32 \times 10^3kg/m^3$
7	Moisture content	8%	18%
8	Sphericity	0.90	0.84
9	Roundness	4.20	2.66

Table 4.2 Internal Angle of friction of sheanut at different moisture content and on different surfaces

Moisture content (%)	Mild steel (^{0})	Galvanized sheet (^{0})	Plywood (^{0})
4	25.2	25.4	28.3
8	27.4	26.0	27.5
12	26.5	26.0	27.8

Table 4.3 Internal Angle of friction of cashew nut at different moisture content and on different surfaces

Moisture content (%)	Mild steel (°)	Galvanized sheet (°)	Plywood (°)
26	25.9	26.0	26.5
15	27.4	26.9	27.8
12	27.0	27.0	28.1

4.9.1 Discussion

In the literature review the values of size obtained for size of cashew are major diameter 32.4mm, intermediate 25.0mm, and minor diameter 20.0mm while in the work the result obtained are major diameter 30.9mm, intermediate diameter 25.2mm, minor diameter 22.5mm. These variation in the result may be due to the moisture content which is been used in the determination of the sizes.

The sphericity and roundness from the literature are 0.75, and 2.18, volume 7.2 x $10^{-6}m^3$ while in my work it was 0.84 roundness of cashew nut, 2.66 sphericity of cashew nut, 6.6 x $10^{-6}m^3$ volume of cashewnut there are appreciable changes in these figures due to the moisture of the samples used.

The size of sheanut from the literature are major diameter 41.2mm, intermediate diameter 36.0mm, minor diameter 34.0 mm volume as 2.96 x $10^{-3}m^3$, density as 1.72 x 103 kg/m^3 while for this work the values are major diameter, 40.5mm intermediate diameter, 35%mm and minor diameter, 32.6mm, volume as 1.66 x $10^{-5}m^3$ density as 2.71 x $10^3kg/m^3$, weight as 45.11 x $10^{-3}kg$.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The determination of physical properties of sheanut and cashewnut are carried out at different moisture content which are 4%, 8% and 12% for sheanut and 26%, 15% and 12% for cashew nut.

The result show on table 4.1, 4.2 and 4.3 are the mean of the different moisture content value.

The result of this work shows that the sample of sheanut have the following parameters, Brown, Green Apple Colour, obling in shape size (a) major diameter 40.3mm (b) intermediate diameter 35.9mm (c) minor diameter 32.6mm moisture content of 8% volume of $1.66 \times 10^{-5} m^3$ and density of $2.71 \times 10^3 kg/m^3$

Comparison of the size of the sheanut and cashew show the size of cashew for the major, minor and intermediate diameter respectively is less them the values of the sheanut with 10mm.

5.2 Recommendations

I recommend that the University Authority should provide three phase power supply to the machine installed at Gidan Kwanu for the accuracy of the work of determination and mechanical properties of biomaterials.

There is need for the acquirement in the Agricultural laboratory to be updated with the recent equipment in carrying out practical. The oven at the Agric laboratory has difficultly of power supply to the switch for the operation, some time even when

there is power supply one finds out that the sockets has no power supply, which cal for more attention.

Also, I recommend that the equipment in the Agricultural laboratory should be property maintained.

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APPENDIX I (Cashew nut)

Five samples are selected for the determination of moisture content. After oven drying the sample for 2 hours moisture content is determined

Mass of can = 24.39grm

Mass of five sample + can = 68.32grm

Mass of can + sample after drying = 56.86grm

Ww = 68.32-24.39= 43.93grm

Wd = 56.86-24.39= 32.47grm

$$MC = \left[\frac{Ww - Wd}{Ww}\right] \times 100 = \left[\frac{43.93 - 32.47}{43.93}\right] \times 100$$

$$= 26.08\%$$

After oven drying for 4 hour at 100^0C

Mass of con = 24.35grm

Mass of sample + can = 69.20grm

Mass of sample + con after oven drying = 62.33grm

W_w = 69.20-24.35= 44.85grm

W_d = 62.33 -24.35 = 37.98grm

$$MC = \left[\frac{44.85 - 37.98}{44.85}\right] \times 100 = 15.32\%$$

After oven drying for 6 hour at 100^0c

Mass of con = 24.32grm

Mass of can + sample = 65.45grm

Mass of sample + can after drying = 60.46grm

$$MC = \left[\frac{41.13 - 36.14}{41.13}\right] \times 100 = 12.13\%$$

$$\text{Average moisture content} = \frac{26.08+15.32+12.13}{3} = \frac{53.53}{3}$$

$$= 17.84\%$$

$$= 18\%$$

Size determination at different moisture content of cashew nut

Moisture content (%)	Major diameter(mm)	Intermediate diameter (mm)	Minor diameter (mm)
26	29.90	24.50	23.00
	33.10	27.00	25.40
	30.00	25.60	21.10
	34.90	28.50	25.50
	30.90	26.40	21.90
15	29.80	24.00	22.5
	32.0	25.00	23.2
	29.5	24.5	20.0
	33.5	27.0	23.3
	29.5	25.5	21.9
12	28.9	23.0	22.5
	31.1	24.5	23.2
	29.0	22.5	20.0
	32.5	27.0	23.0
	28.5	23.5	21.7

At 26% *moisture* content

$$\textit{major diameter} = \frac{29.9+33.1+30+31.9+30.9}{5} = \frac{158.8}{5} = 31.76mm$$

$$\text{int}\textit{erme diaterdiameter} = \frac{24.5+27+25.6+28.5+26.4}{5} = \frac{132}{5} = 26.4mm$$

$$\text{min}\textit{or diameter} = \frac{23+25.4+21.1+25.5+21.9}{5} = \frac{116.9}{5} = 23.38mm$$

At 15% *moisture content*

$$major\ diameter = \frac{29.8+32+29.5+33.5+29.5}{5} = \frac{154.3}{5} = 30.86mm$$

$$\text{int}ermediater\ diameter = \frac{24+24.5+27+25.5+25}{5} = \frac{126}{5} = 25.3mm$$

$$\text{min}or\ diameter = \frac{22.5+23.2+20+23.3+21.9}{5} = \frac{110.9}{5} = 22.18mm$$

At 12% *moisture content*

$$major\ diameter = \frac{28.9+31.1+29.0+32.5+28.5}{5} = \frac{150}{5} = 30mm$$

$$Intermediate\ diameter = \frac{23+24.5++22.5+27+23.5}{5} = \frac{120.5}{5} = 24.1mm$$

$$Minor\ diameter = \frac{22.5+23.2+20+23+21.7}{5} = \frac{110.4}{5} = 22.08mm$$

$$Average\ major\ diameter = \frac{31.76+30.86+30}{3} = \frac{92.62}{3} = 30.09mm$$

$$Average\ intermediate\ diameter = \frac{26.4+23.2+24.1}{3} = \frac{75.7}{3} = 25.2mm$$

$$Average\ Minor\ diameter = \frac{23.38+25.3+22.08}{3} = \frac{67.64}{3} = 22.5mm$$

Weight determination

At 26% moisture content

Mass of can = 24.39grm

Mass of can + sample = 68.32g

Mass of sample = 68.32 - 24.39 = 43.93g

$$Weight = \frac{Mass}{N} = \frac{43.93}{5} = 8.786g = 8.786\times10^{-3}kg$$

At 15% moisture content

Mass of can = 24.35gm

Mass of can + sample = 69.20gm

Mass of sample = 69.2 - 24.35 = 44.85gm

$$Weight = \frac{Mass}{N} = \frac{44.85}{5} = 8.97g = 8.97 \times 10^{-3} kg$$

At 12% moisture content

Mass of can = 24.32g

Mass of can + sample = 65.45gm

Mass of sample = 65.45-24.32 = 41.13gm

$$Weight = \frac{Mass}{N} = \frac{41.13}{5} = 8.226g = 8.226 \times 10^{-3} kg$$

$$Average\ weight = \frac{8.786 \times 10^{-3} + 8.97 \times 10^{-3} + 8.226 \times 10^{-3}}{3} = \frac{25.982 \times 10^{-3}}{3}$$

$$= 8.66 \times 10^{-3} kg$$

Volume and density determination

Five samples are selected to determine the volume and density

At 26% moisture content

Initial water level = 50cm^3

Final water level 87cm^3

Volume displaced = 87 – 50 = 37cm^3 $= \frac{3.7 \times 10^{-5} m^3}{5} = 7.4 \times 10^{-6} m^3$

$$\text{Density} = \frac{Mass}{volume} = \frac{8.786 \times 10^{-3}}{7.4 \times 10^{-6}} = 1.187 \times 10^3 kg/m^3$$

At 15% moisture content

Initial water level = $50cm^3$

Final water level = $83cm^3$

Volume displaced = $83 - 50 = \frac{33cm^3}{5} = 6.6\times10^{-6}m^3$

Density = $\frac{Mass}{volume} = \frac{8.97\times10^{-3}}{6.6\times10^{-6}} = 1.359\times10^3 kg/m^3$

At 12% moisture content;

Initial water level = $50cm^3$

Final water level = $79.0cm^3$

Volume displaced = $79 - 50 = \frac{29cm^3}{5} = 5.8\times10^{-6}m^3$

Density = $\frac{Mass}{volume} = \frac{8.226\times10^{-3}}{5.8\times10^{-6}m^3} = 1.418\times10^3 kg/m^3$

$$Average\ Volume \frac{7.4\times10^{-6} + 5.8\times10^{-6} + 6.6\times10^{-6}}{3} = \frac{19.8\times10^{-6}}{3} = 6.6\times10^{-6}m^3$$

$$Average\ Density = \frac{1.187\times10^3 + 1.359\times10^3 + 1.418\times10^3}{3} = \frac{3.964\times10^3}{3} = 1.32\times10^3 kg/m^3$$

Sphericity = $\left[\frac{bc}{a^2}\right]^{1/3}$

a = 30.9mm

b= 25.2mm

c = 22.5mm

$$S = \left[\frac{25.2 \times 22.5}{(30.9)^2}\right]^{1/3} = (0.5938)^{1/3} = 0.84$$

Roundness Determination

$$Roundness = \frac{AP}{AC}$$

$$AP = \frac{\pi D^2}{4}, \qquad D = 3.1mm$$

$$AC = \frac{\pi d^2}{4}, \quad d = 1.9mm$$

$$Roundness = \frac{3.142 \times (3.1)^2}{4} \div \frac{3.142 \times (1.9)^2}{4} = \frac{7.548}{2.836}$$

$$= 2.66$$

Internal Angle of friction at different moisture content

Moisture content (%)	Mildsteel (^{0})	Galvanized sheet (^{0})	Plywood (^{0})
26, Rep1	25.0	24.5	25.8
Rep2	27.3	25.9	28.3
Rep3	25.5	27.5	25.5
15, Rep1	25.3	24.9	25.5
Rep2	28.7	28.4	29.4
Rep3	28.3	27.5	28.5
12 Rep1	27.5	27.6	28.9
Rep2	26.5	26.8	27.9
Rep3	27.5	26.5	27.5

APPENDIX II (SHEANUT)

Moisture content determination

Five samples are selected for the determination

After oven drying the sample for 2 hour the moisture content is determined as

Mass of can = 25.4grm

Mass of can + sample = 273.4grm

Mass of can + sample after oven drying = 263.1 g

$$Mc = \left[\frac{Ww - Wd}{Ww}\right] \times 100 = \left[\frac{248 - 237.3}{248}\right] \times 100 = 4.15\% = 4\%$$

After oven drying for 4 hours at 100^0C

Mass of can = 24.45grm

Mass of can + sample = 257.45grm

Mass of can + sample after oven drying = 238.95grm

$$Mc = \left[\frac{233 - 214}{233}\right] \times 100 = 7.94\% \cong 8\%$$

After oven drying for 6 hour at 100^0C

Mass of can = 26.43grm

Mass of can + sample = 22.03grm

Mass of can = sample after oven drying = 197.93grm

Ww = 222.03 – 28.43 = 195.6grm

Wd = 197.93 – 26.43 = 171.5grm

$$Mc = \left[\frac{Ww - Wd}{Ww}\right] \times 100 = \left[\frac{195.6 - 171.5}{195.6}\right] \times 100 = 12.32 \cong 12\%$$

$$\text{Average Moisture Content} = \frac{4.15 + 7.94 + 12.32}{33} = \frac{24.41}{3} = 8.13\% \cong 8\%$$

Size determination at different moisture content of sheanut

Moisture content (%)	Major diameter (mm)	Intermediate diameter (mm)	Minor Diameter (mm)
4	41.20	37.50	34.01
	39.40	36.20	33.21
	42.11	38.10	34.45
	48.20	35.10	32.10
	37.50	33.00	29.50
8	41.00	37.45	34.00
	39.30	36.15	33.10
	42.01	38.05	34.40
	38.10	35.00	32.05
	37.35	33.01	29.40
12	40.95	37.34	34.01
	39.25	36.10	33.05
	43.00	38.10	34.35
	38.00	35.01	32.00
	37.20	33.00	29.35

At 4% moisture Content

$$major\ diameter = \frac{41.2+39.4+42.11+48.2+37.5}{5} = \frac{208.26}{5} = 41.652mm$$

$$\text{int}erme\ diate\ diameter = \frac{37.5+36.2+38.1+35.1+33}{5} = \frac{179.9}{5} = 35.85mm$$

$$\text{min}or\ diameter = \frac{34.01+33.21+34.45+32.1+29.5}{5} = \frac{163.27}{5} = 32.654mm$$

At 8% moisture content

$$major\ diameter = \frac{41+39.3+42.01+38.1+37.35}{5} = \frac{197.76}{5} = 39.552mm$$

$$intermediate\ diameter = \frac{37.45+36.10+38.15+35+33.01}{5} = \frac{179.66}{5} = 35.932mm$$

$$minor\ diameter = \frac{34+33.1+34.4+32.05+29.9}{5} = \frac{162.95}{5} = 32.95mm$$

At 12% moisture content

$$major\ diameter = \frac{40.95+39.25+43+38+37.2}{5} = \frac{198.4}{5} = 39.68mm$$

$$Intermediate\ diameter = \frac{37.34+36.1+38.1+35.01+33}{5} = \frac{179.55}{5} = 35.91mm$$

$$Minor\ diameter = \frac{34.01+33.05+34.35+32+29.35}{5} = \frac{162.76}{5} = 32.552mm$$

$$Average\ major\ diameter = \frac{41.652+39.552+39.68}{3} = \frac{120.884}{3} = 40.3mm$$

$$Average\ intermediate\ diameter = \frac{35.98+35.932+35.91}{3} = \frac{107.822}{3} = 35.9mm$$

$$Average\ Minor\ diameter = \frac{33.65+32.59+32.552}{3} = \frac{100.796}{3} = 33.6mm$$

Weight determination

Five samples are selected for weighing

At 4% moisture content;

Mass of can = 25.4g

Mass of con + sample = 273.4grm

Mass of sample 273.4 - 25.4 = 24.8grm

$$\text{Weight} = \frac{\textit{Mass of sample}}{\text{No of Sample}} = \frac{248}{5} = 49.6g = 49.6\times10^{-3}kg$$

At 8% moisture content:

Mass of can 24.45grm

Mass of can + sample =257.45grm

Mass of sample = 257.45 – 24.45 = 233grm

$$\text{Weight} = \frac{\textit{Mass of sample}}{\text{No of Sample}} = \frac{233}{5} = 46.6g = 46.6\times10^{-3}kg$$

At 12% moisture content;

Mass of can =26.43grm

Mass of can + sample=222.03grm

$$\text{Weight} = \frac{\textit{Mass of sample}}{\text{No of Sample}} = \frac{195.6}{5} = 39.12g = 39.12\times10^{-3}kg$$

$$\text{Average weight} = \frac{49.6\times10^{-3}+46.6\times10^{-3}+39.12\times10^{-3}}{3} = \frac{135.32\times10^{-3}}{3} = 45.11\times10^{-3}\text{kg}$$

Determination of volume and density

Five samples of sheanut are selected for the determination

At 4% moisture content:

Initial water level = 200cm^3

Final water level = 291cm^3

Volume displaced = $291-200=\frac{91}{5}cm^3=1.82\times10^{-5}m^3$

Density = $\frac{Mass}{volume}=\frac{49.6\times10^{-3}}{1.82\times10^{-5}}=2.725\times10^3 kg/m^3$

At 8% moisture content:

Initial water level = $200cm^3$

Final level = $283cm^3$

Volume displaced = $283-200=\frac{83}{5}cm^3=1.66\times10^{-5}m^3$

Density = $\frac{Mass}{volume}=\frac{46.6\times10^{-3}}{1.6610^{-5}}=2.807\times10^3 kg/m^3$

At 12% moisture content:

Initial water level = $200cm^3$

Final water level = $275cm^3$

Volume displaced = $275-200=\frac{75}{5}cm^3=1.5\times10^{-5}m^3$

Density = $\frac{Mass}{volume}=\frac{39.12\times10^{-3}}{1.5\times10^{-5}}=2.608\times10^3 kg/m^3$

$$Average\ Volume=\frac{1.82\times10^{-5}+1.66\times10^{-5}+1.5\times10^{-5}}{3}=\frac{4.98\times10^{-5}}{3}=1.66\times10^{-5}m^3$$

$$Average\ Density=\frac{2.725\times10^3+2.807\times10^3+2.608\times10^3}{3}=\frac{8.14\times10^3}{3}=2.71\times10^3 kg/m^3$$

$$\text{Sphericity} = \left[\frac{bc}{a^2}\right]^{1/3}$$

a = 40.3 mm

b= 35.9mm

c = 32.6mm

$$S = \left[\frac{35.9 \times 32.6}{(40.3)^2}\right]^{1/3} = (0.7206)^{1/3} = 0.896 \cong 0.90$$

Roundness Determination

$$Roundness = \frac{AP}{AC}$$

$$AP = \frac{\pi D^2}{4}, \qquad D = 4.1mm$$

$$AC = \frac{\pi d^2}{4}, \quad d = 2.09mm$$

$$Roundness = \frac{3.142 \times (4.1)^2}{4} + \frac{3.142 \times (2.0)^2}{4} = \frac{13.204}{3.142}$$

$$= 4.202 \cong 4.20$$

Internal angle of friction of sheanut at different moisture content and surfaces

Moisture content (%)	Mildsteel (^{0})	Galvanized sheet (^{0})	Plywood (^{0})
4, Rep1	24.5	25.3	28.5
Rep2	24.7	24.5	29.0
Rep3	26.5	26.3	27.4
8, Rep1	26.3	25.0	27.5
Rep2	28.4	27.0	28.0
Rep3	27.5	26.0	26.9
12, Rep1	28.5	28.3	26.3
Rep2	24.6	24.3	27.8
Rep3	26.3	25.4	29.4