EFFECT OF MOISTURE CONTENT ON SOME SELECTED PHYSICAL PROPERTIES OF CASTOR SEED *(Ricinnus communis)*

BY

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JANUARY, 2011

DECLARATION

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 Information derived from personal communication, published and unpublished work were duly referenced in the text.

21/07/2011

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Date

CERTIFICATION

This is to certify that the project entitled " Effect of Moisture Content on Some Selected Physical Properties of Castor Seed *(Ricinnus communis)*" by Kolawole, Maye Joshua meets the regulations governing the award of the 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.

Engr. Dr. (Mrs). Z.D. Osunde Supervisor	14/02/2011 Date
Engr .Dr. A.A Balami Head of Department	14-02-11 Date
External Examiner	13/01/2011 Date

DEDICATION

This project work is dedicated to my wonderful and ever steadfast Parents and my Brothers.

ACKNOWLEDGEMENTS

My most profound gratitude goes to God the most powerful for his unending flow of mercy and favour towards me, seeing me through the hurdles of life and most especially for loving me beyond measure.

Life without good guidance is futile; therefore I specially thank my supervisor Engr. Dr. Mrs Z.D Osunde, for guiding me through the successful completion of this work.

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I want to say a very big thank you to the best Daddy and Mummy in the World, Mr. Kolawole Ezekiel , my mother, Mrs. Kolawole Ruth. Words can not express how much i love you all for your sacrifice and love; indeed I say I'm the luckiest child on earth. To my siblings, Kolawole Yinka, Femi , Pastor Niyi, Folorunsho Ayo I say thanks for the laughter you spurred from my belly, thanks for giving me memories to cause a smile. I greatly appreciate a dear friend, Angel Okereke Amarachi, indeed you are an Angel friend, and thank God I met you. I want to acknowledge my very good friend Malachy, Felix, Charles, Spannish, Martins, Nurudeen You all are Wonderful Friends. United we stand divided we fall. Also not to forget a very friend good Gideon Auta thank God I met you. I acknowledge my colleaques and all my FUT friends.

ABSTRACT

Some physical properties of castor seed were determined at different moisture content of the seed. The castor seeds were conditioned to moisture content of 20.2%, 17.6%, 14.0%, and 10.8% (w.b). The properties determined were, major, medium, minor, arithmetic mean diameter, geometric mean diameter and sphericity. The results for major diameter range from 15.36-14.5mm, for medium diameter range from 12.50-12.05mm, and for minor diameter range from 7.17-7.61mm.The arithmetic and geometric mean diameter were, 11.30 and 10.81mm at 20.2% moisture content, while at 17.6% moisture content were, 11.61 and 10.95mm, while at 14.0% moisture content were, 10.72 and 11.26mm, at 10.8% moisture content were, 11.60 and 11.11mm respectively . The sphericity at 20.2% moisture content were, 0.74, at 17.6% were, 0.73, at 14.0% moisture content was, 0.74, and at 10.8% moisture content was, 0.74. The studies conducted on the surface area, mass, weight, volume, true density, bulk density and porosity at 20.2% moisture content were, 224.97mm^2, 14.92g, 146.33g, 928.46mm^3, 3.0g/cm^{-3}, 0.77kgm^{-3} and 73.8%, while at 17.6% moisture content were, 2958.37mm^2, 14.82g, 145.42g, 934.20mm^3, 2.70g/cm^{-3}, 0.88kgm^{-3} and 71.35%, at 14.0% moisture content were, 312.77mm^2, 15.06g, 1004.42mm^3, 147.80g, 2.70g/cm^{-3}, 0.77kgm^{-3} and 63.9%, at 10.8% moisture content were, 4.13g/cm^{-3}, 0.77kgm^{-3}, 304.96mm^2, 956.35mm^3, 11.7g, 112.52g, and 79.70% respectively. The static coefficient of friction on metal, plywood and glass surface at 20.2% moisture content were, 0.183, 0.369 and 0.178, at 17.6% moisture content were, 0.184, 0.372 and 0.178, at 14 .0% moisture content were, 0.182, 0.371 and 0.178, while at 10.8% moisture content were, 0.188, 0.378 and 0.182 respectively . The results of these research showed that the moisture content affect the porosity. The static coefficient of friction can be used to design conveying machine and hopper used in planter, and also the size of castor bean can be used to design processing machine and equipment.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF PLATE

List of figure **Page**

Figure

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

The Castor seed plant "(*Ricinus communis*)" got its name from a latin word. Which belongs to the family of euphorbia originated from Egypt and India. Subquently spread abroad to Brazil, Thailand, Argentina, United States of America etc. it has about 1,400 year history that transmitted from India to china. The ancient Egyptian valued its oil almost as lightly as that of the olive for the lamps. This plant is often seen along the road sides and on the dump sites or heaps throughout the tropics and subtropics. The unique clusters of the seed capsules are spread on the ground until they dry, split open and the seed fall out. (Lewis *et al.,* 1977). The castor seed contains between 40% to 60% oil the is rich triglycerides, mainly ricinolein. It contains ricin and the alkaniod ricine. It contains ricin and the alkaloid ricinine. Ricin is on of the small groups of photoxins which also include arbin, cirnin, crotin and robin. It also contains allergens and one of the allergen has been identified as cholorogenic acid. The castor seed plant has methyu-lipid and butyl-lipid that is made from the seed oil by lipolysis change, but the oxidative stability and low temperature performance limits their wide spread use. The seed of castor beans are very poisonous to people animal and insect. Just one milligram of ricin, one of the main toxic proteins in the plant can kill; the seed is only toxic but agglutinate red blood cells of mammals while ricin is toxic but does not agglutinate red blood cells, the castor seed is compared with food crops. The castor plants can grow over a wide attitude range in the tropics and with both low to medium rainfall (Wiess, 1983). The castor seeds are shown in plate 1.1

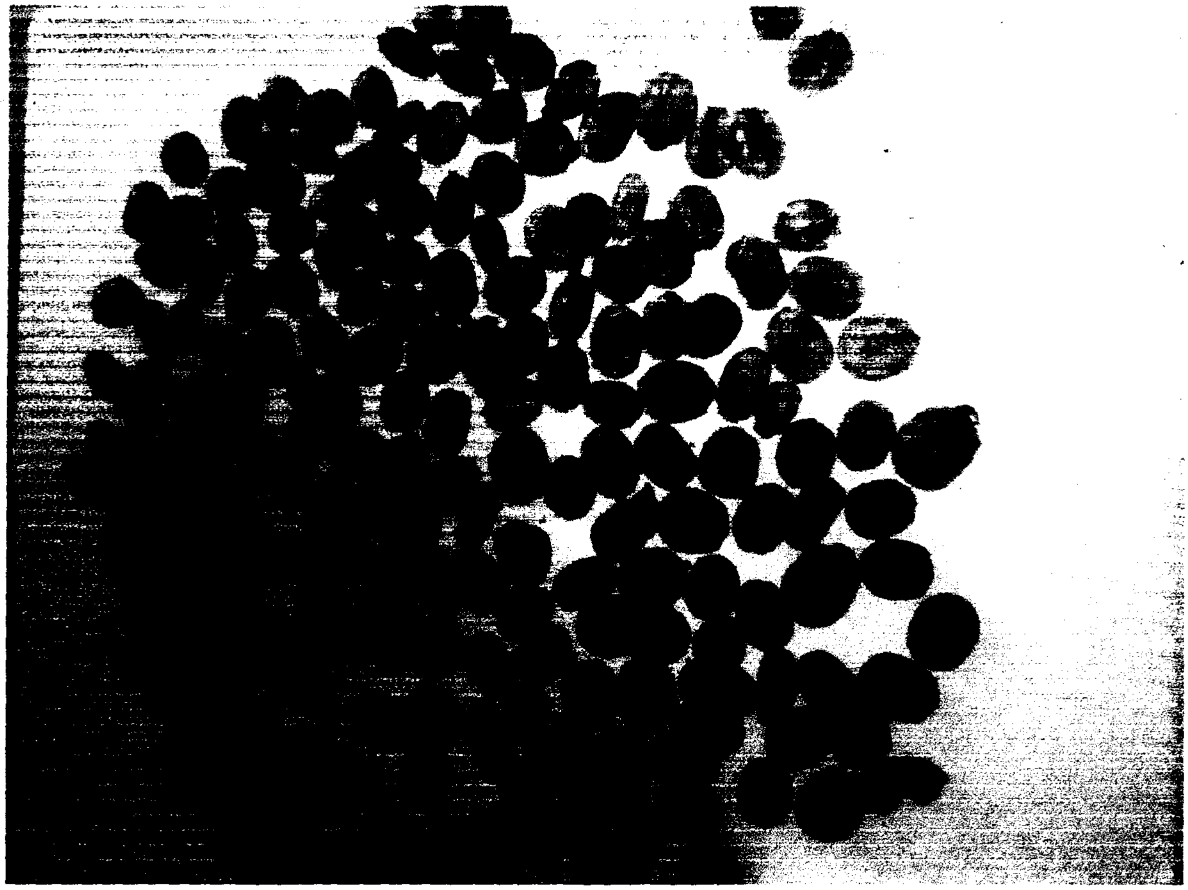

Plate 1.1 Castor seeds

1.2 Statement of the Problem

Considering the fact that, the derivatives of castor seed though still remain unknown and familiar to so many people in Nigeria. The seed it self is not widely known and this result in low productivity nation wide. To this effect, scientific data regarding its engineering properties are rarely available.

1.3 Objective of the Study

The objective of the study is to determine the effect of moisture content on some selected physical properties of castor seed. Specifically were determined at four different moisture contents range from 10.8%, to 20.2% (wb.)

1.4 Justification of the Study

The study of physical properties of castor seed have been attempt to provide objective measurement and more meaningful data for designing specific machines, processes and controls, in handling and storing of castor seed. It is necessary to determine their properties as a function of moisture content.

CHAPTER TWO

2.0 LITERATURE REVIEW

Castor seed plant (Ricinus Communis) is now grown in the tropic and warm temperate regions. The castor seed produces seed oil in which nearly 90% of the acyl residues are recinoliec acid, such as degree of homogeneity and the unique chemical properties of seed content makes it a valuable raw materials which is being utilized in industries (Marter, 1981). However, the seed are a source of numerous economically important products. Part of its residues are also use for fertilizer, this plant may grow up to 2 – 5 meters high in one season. Its larger palmately lobbed leaves may be 50cm across and resemble a typical arelia. Although its grow rapidly with little care or insect or pest, its cultivation can be improved upon through ,proper soil physical application for agronomical purpose in order to reap its industrial benefit (Weiss, 1983). Salunke and Desai, (1992). Reported that castor seed plant is usually a fair tall, many branched perennial, but when cultivated commercially, it is short lived, erect little resemblance to each other colour of foliage, stem seed size, clour and oil content, so that varieties often bear little resemblance to each other colour difference in leaves, stem and inflorescent aid in the reflection of horticultural and plant. Castor seed contain about 30 – 35% oil which can be extracted by varieties of processes such as pressing and solvent extraction. Weiss, (1983) stated that castor seed is a shining, pale grey palebuff to almost black with darker molttling, yellowish white caruncle at base, very variable in size 0.5 – 1.5cm long. 450 – 5,000 per lobe.

.1 Industrial uses of Castor Seed

Castor seed has hundred of industrial uses, hence castor oil is termed industrial oil, its uses ıclude in paint industries, pharmaceutical and cosmetics. Castor seed oil can be made into special ubricant for jet engine, racing cars and brakes fluid. The oil biodegradability result in decrease ›ersistence with the environment since it is unaffected by temperature. The seed has sufficient ıutrient and moisture to sustain the vigorous growth and it also contains poisonous ricin (RYE-ƷIN) and a very deadly protein called lectin (Robinson,1964). The castor seeds and its derivatives find outlet in industries because of ricinnoleic, which predominates, that usually has hydroxyl functional group, causes ricinoleic acid to be unusually polar also allow chemical derivatives that is not practical with most other seeds, also the hydroxyl group which make it valuable as chemical feed stocks (Tavokoli *et al.,* 2009). Lucinewton, (2005) reported the castor seed is a natural inputs to the proliferating perfumery and chemical industries. The seed is a plant that is largely used to impart numerous applications. For more than 100 products can be derived after deep processing.

2.2 Method of Cultivation

The castor seed is a tropical crop in Nigeria. The crop is grown in commercial scale despite the abundant land and ecological and climatic condition which are favourable to its cultivation, but naturally, the crop grown widely all over the country from coastal area to dry northern fringes. Hence the need to have it cultivated in commercial scale (Okeniyi, 2003). David and Adam (1992). There is many of wild and cultivated castors, varying in plant height, colour of stem seeds, bean size, etc. preferred the seed do not shatter when ripe and mature evenly. The tropical fall type are planted at spacing ranging from 90cm by 60cm to 15cm by 120cm seeding rate. The castor seed plant is fall cultivars are often topped to produce more branches, complete fertilizers should

120cm seeding rate. The castor seed plant is fall cultivars are often topped to produce more branches, complete fertilizers should be applied has high nutrient requirement. The bunches of fruits are cut manually when ripe, yield of up to 900kg of seeds per hectare were obtained.

2.3 Agronomical Practice

Castor seed plant in Nigeria, whose size of seed is influenced by environmental factor such as soil, temperature, humidity and level of water porosity of the soil, castor seeds varieties include wild types and improved breed types, it can be grown in both upland and lowland areas. Although castor plant can withstand very poor soil. However, the soil should be sufficiently loose (friable) and well drained. The optimum soil needed for castor seed planting can be obtained through the study of the soil physics of the site to be used for plantation.

Castor seed requires full sun exposure, the late summer and early fall, it is draught tolerant and best grown on soil with pH value 6.1 to 6.5 (mildly acid) or 6.6 – 7.5 (neutral). Propagation is through direct sun from the seed on a spacing of 90 – 120cm between rows and 3.5cm 40cm between plans (Weiss, 1983). The castor seed plants can be basically divided into two types, tall seed and short, commonly known as giant and dwarf castor. The period from emergence to maturity varies and is greatly influenced by the environment (14 to 160 days). Giant type have large well developed taproot system reaching several metres in length with profuse lateral and secondary root. In dwarf types, the taproot less apparent and their root system is well developed and often deeply penetrating to take maximum advantage of soil moisture. Making the plant fairly drought resistant. The system is round, glabous and covert with a waxy bloom, given red or green stems bluish, usually dark red, the leaves are alternate, except for two opposite leaves. The leaves can be mildly toxic to animal and some insects, and usually occurring as an attractive mottling on the testa. (Weiss,1983).

2.4 Storage of Castor Seed

The castor seeds are generally not stored for a long period of time. The colour and acidity of castor seeds stored at a high temperature do not increase even after one month of storage. The castor seed can be stored for one or two years without accumulating of [eroxide amount in oxidative rancidity (Kulkarni, 1977).

2.5 Effect of Diseases that causes severe decrease in Yield of Castor Seed Plant

Castor seed attached by a varieties of pests and diseases, causing a severe decrease in yield and quality, Agioles (Euxan) cut warm crickets (aryllotal pasp, Branchy trupes spin and Gryllessp), Flee beetle Aphihona whit, field bry, Hermaerphage ruficellis luc, stem borders, ostring nubilasis Hbxyleules capensis wik. Sphenopetra Arabica, Harmugera, spadoptera litum and slittoralis, Euproctissp. And a number of pests like jassids, leaf hoppers and including inflorescences (Weiss, 1983).

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 MATERIALS USED

The materials used for this project were castor seed and distilled water. The castor seed were gotten from a market (Oja-Oba) in Ilorin. The seed weighing 4.13kg were used for all the experiment. In this study, It was ensured that the seeds were cleaned to remove dirt foreign materials and free broken immature seeds.

3.1.1 Equipment Used

The equipment used for carrying out the moisture content determination and physical properties of this project were, electronic weighing balance, oven cardboard paper, polyethylene bags, vernier caliper, refrigerator, measuring cylinder and sinker.

All the experiments were carried out at the Agricultural and Bioresources Engineering processing laboratory. Federal University of Technology, Minna.

3.2 METHOD

3.2.1 Determination of Moisture Content

The direct oven dry method was used to determine the moisture content of castor seed. Two hundred grams of sample was taken from the whole sample of castor seeds for determined the moisture content of the seed. The seed was firstly weighed on weighing balance and were spread on cardboard paper in an oven, to dry at $50^{o}c$ for 24 hours. The sample were removed from the oven and reweighed as final dried matters weight. The moisture content were determined in percentage (% w.b) using the following formular (ASAE, 1998).

Moisture content (MC) = $\frac{(Wi-Wf) \times 100}{Wi}$

Where W_i = final mass of sample before oven drying

W_f = final mass of sample after drying

The seed sample was divided into four parts and labeled sample A, B, C, and D, in each weighing, 104.42g, 107.43g, 80.90g, 70.54g. The moisture content of sample B, C and D varied by adding masses of distilled water into the sample. The quantities of water added were calculated as follows through the relation between (Sacilik *et al.,* 2003).

$$Q = \frac{W_i(M_f - M_i)}{(100 - M_f)}$$

Where Q = Quantity of water added (g)

W_i = Mass of sample

M_i = Initial moisture content of the seed

M_f = Final moisture content of the seed

The quantities of water added into sample B, C and D were 9.45g, 2.85g and 5.40g. The samples were poured into separate polyethylene bags, were sealed tightly and kept at $5^0{}_C$ in a refrigerator for a week to enable the moisture distribute uniformly through out the sample. Before starting the test, the sample was taken out the refrigerator and allowed to equilibrate to the room temperature for about two hours (Koocheki *et al.,*2007). All the physical properties of the seed were determined at four moisture content with three replications.

3.2.2 Determination of Physical Properties

The following methods were used in determination of selected physical properties of castor seed.

3.2.3 Weight of Seed

One thousand seed weight (TSW) was measured at four different level by counting and weighing the seeds in an electronic weighing balance to an accuracy of 0.001g. (Mohsenin, 1970).

3.2.4 Size

To determine the size of seeds, a sample of 50 seeds was randomly selected and linear dimensions i.e. major (L), medium (W) and minor diameters (T) were measured using verier caliper (Joshi *et al.*, 1993). The geometric mean diameter (D_g) was computed using the following equation.

$$D_g = (LWT)^{1/3}$$

3.2.5 Sphericity Index

Where the Sphericity index (Φ), where L, the length is the dimension along the longest axis in mm. W, the width is the dimension along the longest axis, perpendicular to L in mm. and T, the thickness is the dimension along the largest axis perpendicular to both L and W in mm. The Sphericity was determined using the following relationship (Mohsenin, 1970).

$$\Phi = \frac{(LWT)^{1/3}}{L} \times 100$$

3.2.6 Bulk Density

The bulk density was determined by filling an empty 250ml graduated cylinder with the seed and weighed an electronic balance. The weight of the seeds was obtained by subtracting the weight of the cylinder from the total weight. The volume occupied was then noted, the process were replicated three time and the bulk density for each replications was calculated from the following relation. (Mohsenin, 1970).

$$P_b = \frac{W_s}{V_s}$$

Where P_b = Bulk Density in Kgm^{-3}

W_S = Weight of Sample in Kg

V_S = Volume Occupied by Samples in m^3

3.2.7 True Density

This is the ratio of mass and true volume by toluene [$C6H_5$ CH_3] displacement method. Toluene'was used as it absorbed to a lesser extent than water and has a low surface tension thereby enabling it to flow smoothly over the seed surface (Mohsenin, 1970). A sinker was used for both seeds as they float on water. Toluene was poured into measuring cylinder of capacity of $100cm^3$ the sinker was immersed in the toluene noting the final and initial level which the toluene rise. The difference between the final and initial levels gives the volume of toluene. The seed was then tied with an inextensible string to the sinker and both immersed in toluene. The differences procedure was repeated three times for each samples, the true density was calculated using the relationship.

$$P_t = \frac{Mass}{true\ volume}$$

3.2.8 Porosity

The percentage porosity (ξ) was calculated from the relationship between bulk density and true density (Mohsenin,1970).

$$\xi = \frac{(P_t - P_b)}{P_t} \times 100$$

Where ξ = percentage porosity

P_t = true density

P_b = Bulk density

3.2.9 Coefficient of Static Friction

Coefficient of static friction of castor seed was determined on three different surfaces on metal sheet, glass sheet, plywood. By filling a rectangular box with seeds. The box was placed on the surface, which was gradually tilted until the box just began to slide down the surface. The angle made with horizontal was taken. Coefficient of static friction (μ) was gotten by determined tangent of angle (Muller, 2010).

Where $\mu = \tan\theta$

θ = angle made between surface and horizontal

3.2.10 Surface Area

Due to the unavailability of a planimeter, the surface were found with analogy with a sphere of the same geometric mean diameter, using the following relationship. (Altuntaset and Demirtola, 2007).

$$S= \pi D_g^2 (mm^2)$$

Where S=Surface area, mm^2

D_g = Geometric mean diameter, (mm)

3.2.11 Volume

The seed volume was determined from the following equation (Usuf *et al.*, 2004).

$$V = 0.25[(\pi/6)L\ (W+T)^2] = (mm^3)$$

Where L = Major diameter. (mm)

W = Intermediate diameter (mm)

T = Minor diameter (mm)

3.2.12 Mass

The seed mass was determined from the weight of the seed and the number of seeds counted from the following equation. (Mohsenin, 1970).

Where $M = \frac{Ws}{Ns} = (g)$.

W_s = Weight of seed

N_S = Number of seeds sample counted

3.2.13 Arithmetic Mean Diameter

The arithmetic mean diameter was determined from the following equation (Joshi *et al.*, 1993).

$$D_a = (L+W+T)/3 = (mm).$$

Plate 3.1 Laboratory analysis of True Density

Plate 3.2 laboratory analysis of Static Co efficient of Friction.

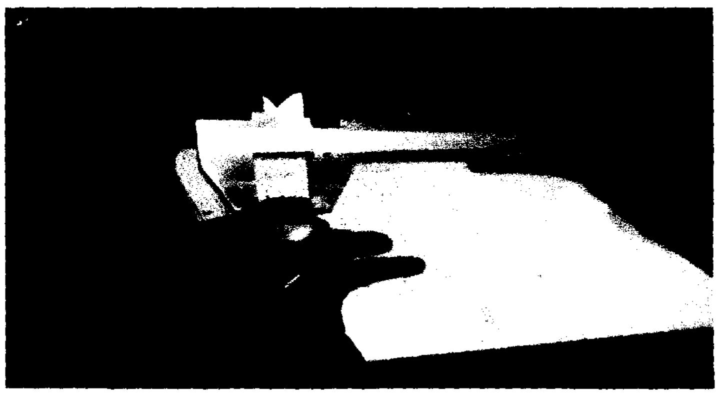

Plate 3.3 laboratory analysis of Size.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Moisture Content of Castor Seed

The moisture content of castor seed obtained after conditioning the seed were, 10.8%, 14.0%, 17.6%, and 20.2% (w.b). The investigations were carried out at the above moisture levels to determine the effect of moisture content on some selected physical properties of castor seed.

Table 4.1 Shows the results of Castor Seed Size at different Moisture Content. The major diameter ranges from 15.36-14.5mm, while the medium diameter ranges from 12.50-12.05mm, and the minor diameter ranges from 7.17-7.61mm for moisture content of 20.2%, 17.6%, 14.0% and 10.8% (w.b) respectively. These values showed that there was no effect of moisture content on size of castor bean within the moisture range of 20.2-10.8%. The arithmetic mean diameter and geometric mean diameter for castor seed at 20.2% moisture content were, 11.30 and 10.81mm, for moisture content at 17.6% were, 11.61 and 10.95mm, while for the moisture content at 14.0% were, 10.12 and 11.26mm, for the moisture content at 10.8% is 11.60 and 11.11mm respectively. The sphericity of castor seed at 20.2% moisture content was 0.74, at 17.6% moisture content was 0.73, while at 14.0% moisture content was, 0.74, and at 10.8% moisture content was 0.74. The results of sphericity showed that there was no effect of moisture content on the sphericity. The critical view at the axial dimension play important role in design of equipment and processing machine on some selected physical properties of castor seed.

Table 4.1 Size of Castor Seed at Different Moisture Content

S/N	MC:% (w.b)	Major (mm)	Medium (mm)	Minor (mm)	Arithmetic (mm)	Geometric (mm)	Sphericity ϕ
1.	20.2%	14.56	12.05	7.22	11.30	10.81	0.74
		(0.86,0.059)	(0.64, 0.053)	(0.30,0.040)	(0.57, 0.050)	(0.57,0.045)	(0.10,0.14)
2.	17.6%	15.06	12.16	7.17	11.61	10.95	0.73
		(0.91, 0.060)	(0.59,0.050)	(0.12,0.043)	(0.62,0.053)	(0.52,0.048)	(0.12,0.016)
3.	14.0%	15.04	12.50	7.61	10.72	11.26	0.74
		(0.90,0.060)	(0.55, 0.44)	(0.22,0.29)	(0.59,0.055)	(0.58,0.052)	(0.11,0.15)
4.	10.80%	15.36	12.12	7.43	11.60	11.11	0.74
		(0.95, 0.062)	(0.59, 0.049)	(0.18,0.017)	(0.65, 0.056)	(0.53,0.050)	(0.11, 0.15)

Values in bracket are the Standard Deviation and Coefficient of Variation

Table 4.2 Shows results of Some Selected Gravimetric Properties of Castor Seed at different Moisture Content. The results shows that the surface area, mass of castor seed, weight, volume, true density, bulk density and porosity of castor seed at 20.2% moisture content ware, 224.97mm^2, 14.92g, 146.33g, 928.46mm^3, 3.0g/cm^{-3}, 0.77kgm-^{3} and 73.8%, at 17.6% moisture content were, 2958.37mm^2, 14.82g, 145.42g, 934.20mm^3, 2.70g/cm-^{3,} 0.88kgm^{-3} and 71.35%, while at 14.0% moisture content were, 312.77mm^2, 15.06g, 1004.42mm^3, 147.80g, 2.70g/cm^{-3}, 0.77kgm-^{3} and 63.9%, and at moisture content of 10.8% were, 4.13g/cm-^{3}, 0.77kgm-^{3}, 304.96mm^2, 956.35mm^3, 11.7g, 112.52g and 79.7% respectively. These results showed that there was effect of moisture content on the true density, surface area, volume, weight, mass and porosity. The results of castor seed showed from the above data can be used to design machine for storage, drying and cleaning equipment.

Table 4.2 Some Selected Gravimetric Properties of Castor Seed at different Moisture Content.

;/N	MC: %(w.b)	True Density (g/cm^{-3})	Bulk Density (kgm^{-3})	Surface area (mm^2)	Volume (mm^3)	Mass (g)	Weight (g)	Porosity %
.	20.2%	3.0	0.77	224.97	928.46	14.92	146.33	73.8
		(0.54,0.197)	(0.068,0.088)	(174.94,0.0780)	(53.99,0.058)	(0.17,0.01)	(0.38,0.26)	(0.75, 0.010)
	17.6%	2.70	0.80	2958.37	934.20	14.82	145.42	71.35
		(0.50,0.185)	(0.30,2.67)	(3440.47,0.116)	(52.67,0.05)	(0.08,0.05)	(0.42,0.29)	(0.97,0.014)
	14.0%	2.70	0.77	312.77	1004.42	15.06	147.80	63.9
		(0.50,0.185)	(0.29,0.377)	(175.530,0.056)	(55.10,0.055)	(0.14,0.09)	(0.45,0.30)	(0.95,0.015)
	10.8%	4.13	0.77	304.96	956.35	11.47	112.52	79.7
		(0.49,0.119)	(0.071,0.092)	(173.46,0.057)	(52.30,0.055)	(0.10,0.087)	(0.44,0.39)	(0.910.011)

Values in bracket are the standard deviation and coefficient of variation.

ble 4.3 Shows the results of Static Coefficient of Friction of Castor Seed at different Moisture Content Metal sheet, Plywood sheet and Glass surface. From the results the static coefficient of friction **on** tal sheet, plywood and glass surface of castor seed at moisture content of 20.2% were,0.183, 0.369 and 78, at 17.6% moisture content were, 0.184, 0.372 and 0.178, while at 14.0% moisture content were, 82, 0.371 and 0.178, and at 10.8% moisture content were, 0.188, 0.378 and 0.182. These values owed that there was no effect of moisture content on the static coefficient of friction of castor seed on ss, metal and plywood surface. The results indicated that the plywood surface had the highest static indicated that the plywood surface had the highest static coefficient of friction followed by metal sheet, while the glass surface had the least values of the static coefficient of friction. Figure 4.3These properties studies play an important role in design of steepness of container and hopper or any other loading and unloading devices.

Table 4.3 Static Coefficient of Friction of Castor Seed at different Moisture Content on Metal Sheet, Plywood and Glass Surfaces.

S/NO	MC:%(w.b)	Metal Sheet	Plywood Sheet	Glass Sheet
1	20.2%	0.183	0.369	0.178
		(0.036,0.197)	(0.145,0.393)	(0.032,0.179)
2	17.6%	0.184	0.372	0.178
		(0.034,0.185)	(0.150,0.403)	(0.030,0.170)
3	14.0%	0.182	0.371	0.178
		(0.035,0.192)	(0.140,0.402)	(0.034, 0.191)
4	10.8%	0.188	0.378	0.182
		(0.037, 0.197)	(0.155, 0.147)	(0.031,0.170)

Values in bracket are the Standard Deviation and Coefficient of Variation.

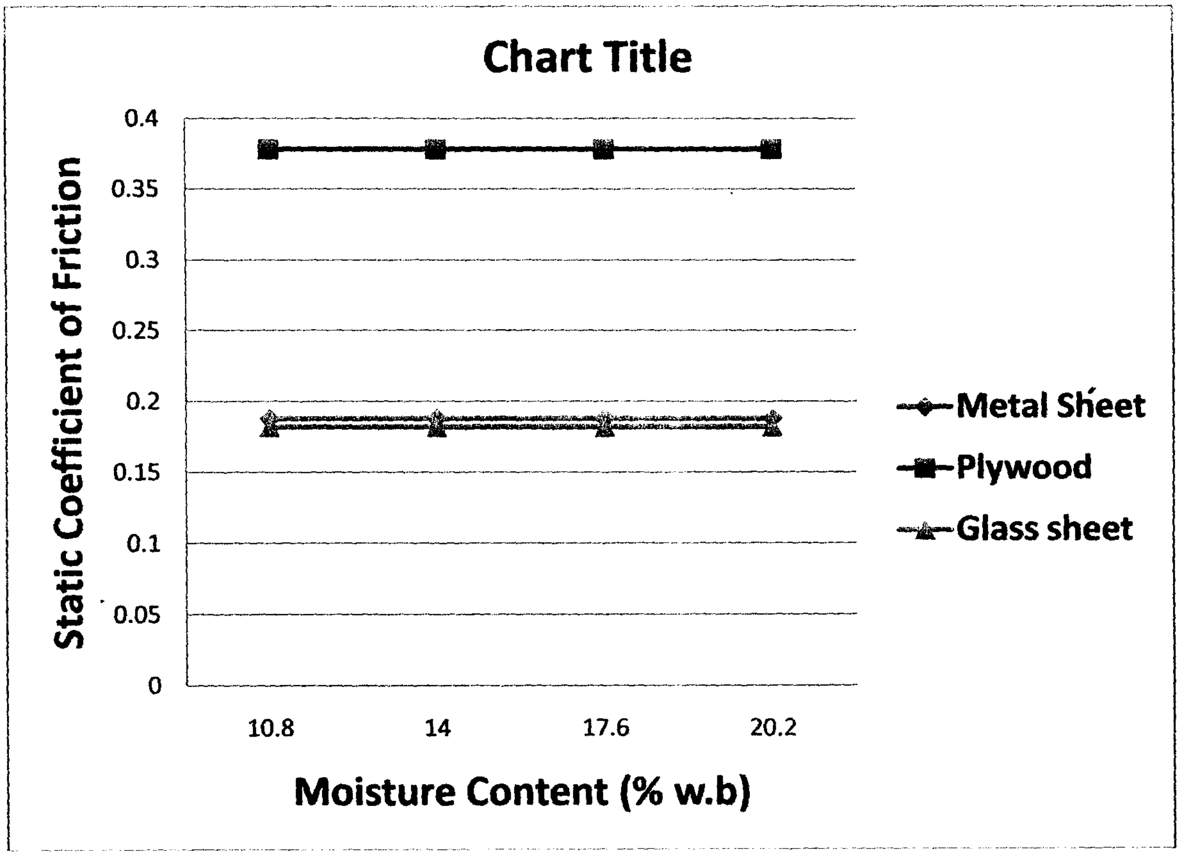

Fig. 4.3 Static Coefficient of Friction at Different Moisture Content of Castor Seed on Glass, Metal and Plywood

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The studies conducted on some selected physical properties of castor seed were determined at different moisture content. The physical properties determined on the castor seed showed that there was no effect of moisture content of castor bean within the moisture range, while the moisture content effect the porosity through the bulk density and true density . Results of the graph shown on fig. 4.3 of the static coefficient of friction indicated that the plywood surface had the highest static coefficient of friction followed by the metal sheet, while the glass surface had the least values of the static coefficient of friction. The results of this research showed that the size can be used to design processing equipment, while the static coefficient of friction of castor seed can be used to design equipment for handling, transporting, sorting and also for conveying machine and hopper used in planter machines when seeds are ground in mills.

5.2 Recommendations

Considering the fact that castors seed in Nigerian is not widely known across the country, it is imperative that intensive research work should be done with modern instrument and equipment. There should be availability and good climatic condition so that Nigerian farmer can have a favorable land where to cultivate castor seed plant.

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APPENDICES

APPENDIX A

Values of Size at Moisture Content of 20.2%.

amples	A1			A2			A3		
/N	major(l) mm	medium(w) mm	minor(t) mm	major(l) mm	medium(w) mm	minor(t) mm	major(l) mm	medium(w) mm	minor(t)
	15.20	11.20	7.10	15.50	12.80	7.20	13.60	12.20	7.10
	15.20	12.20	7.10	15.60	12.30	7.50	15.60	12.20	7.10
	15.50	12.80	7.20	15.60	13.60	7.20	13.30	11.20	7.20
	13.50	11.20	7.20	13.50	11.20	7.10	13.50	12.20	7.50
	13.30	11.20	7.50	13.30	11.20	7.20	16.20	13.20	7.10

APPENDIX B

Values of Size at Moisture Content of 17.6% (w.b)

	B1			B2			B3		
S/NO	Major	Medium	Minor	Major	Medium	Minor	Major	Medium	Minor
	(l)	(w)	(t)	(l)	(w)	(t)	(l)	(w)	(t)
1	15.20	12.50	7.50	15.60	12.70	7.00	15.60	12.60	7.10
2	14.60	11.60	7.10	15.20	12.30	7.40	14.60	11.20	7.10
3	14.60	12.20	7.10	14.70	12.40	7.10	15.20	12.50	7.50
	14.60	11.20	7.10	14.60	11.20	7.10	15.60	12.60	7.10
	15.60	12.60	7.10	15.60	12.60	7.10	14.60	12.20	7.10

alues of Size at Moisture Content of 14.0%

amples	C1			C2			C3		
no	major	medium	minor	major	medium	minor	major	medium	minor
	mm	mm	mm	mm	mm	mm	mm	mm	mm
	(L)	(W)	(T)	(L)	(W)	(T)	(L)	(W)	(T)
	15.20	12.70	7.80	13.00	12.60	7.30	16.70	12.40	8.40
	13.00	12.60	7.30	16.70	12.20	7.50	13.00	12.60	7.20
	16.70	12.20	7.50	16.70	12.40	8.40	15.30	12.60	7.40
	15.20	12.40	8.40	13.20	12.60	7.30	15.30	12.20	7.50
	12.20	12.60	7.40	15.20	12.60	7.40	15.20	12.60	7.30

APPENDIX C

Values of Size at moisture content of 10.8% (w.b)

	D1			D2			D3		
S/NO	Major (L) mm	Medium (W) mm	Minor (T) mm	Major (L) mm	Medium (W) mm	Minor (T) mm	Major (L) mm	Medium (W) mm	Minor (T) mm
1	16.20	12.40	7.10	15.20	12.10	7.10	15.60	12.20	8.40
2	15.20	12.40	8.10	15.20	12.60	7.50	15.30	12.60	7.50
3	15.60	12.20	7.50	15.60	11.60	7.50	13.20	11.40	7.30
4	15.20	11.80	7.40	16.20	12.40	7.20	16.30	12.60	7.20
5	14.60	11.60	7.10	14.50	12.70	7.30	14.50	11.20	7.30

Moisture content determination **(wet basis) of Castor Seed**

Samples	A	B	C	D
Wi, Initial weight of samples before oven drying (g)	104.42	107.43	80.90	70.54
Wf, final weight of samples after oven drying (g)	83.34	88.54	69.56	62.92

APPENDIXD

The Moisture Contents of Sample A $= \frac{wi - wf}{wi} * 100 = \frac{104.42 - 83.34}{104.42} = 20.2\%$

The Moisture Content of Sample B $= \frac{wi - wf}{wi} * 100 = \frac{107.43 - 88.54}{107.43} = 17.6\%$

The Moisture Content of Sample C $= \frac{wi - wf}{wi} * 100 = \frac{80.90 - 69.56}{80.90} = 14.0\%$

The Moisture Content of Sample D $= \frac{wi - wf}{wi} * 100 = \frac{70.54 - 62.92}{70.54} = 10.8\%$

Values of Sphericity at different Moisture Content of Castor Seed.

Samples	A	B	C	D
S/N	Ø mm	Ø mm	Ø mm	Ø mm
1	0.74	0.72	0.76	0.72
2	0.72	0.73	0.76	0.75
3	0.74	0.74	0.72	0.73
4	0.77	0.72	0.77	0.70
5	0.75	0.72	0.74	0.74
MC:%	20.2%	17.6%	14.0%	10.8%

APPENDIX E

Values of Mass and True Density of Castor Seed at Moisture Content of 20.2% (w.b)

S/N	MASS (g)	Initial vol. (cm^3)	Vol.displaced using sinker	Vol. of sinker (cm^3)	Final volume (cm^3)	True vol. (cm^3)	True density (g/cm^{-3})
A1	14.90	290.00	324.00	30.00	224.00	4.0	3.70
A2	14.92	289.00	323.00	29.00	295.00	6.0	2.40
A3	14.93	290.00	323.00	28.00	295.00	5.0	2.90

Values of Mass and True Density of Castor Seed at Moisture Content of 17.6 %(w.b)

S/N	MASS (g)	Initial vol. (cm^3)	Vol. displaced using sinker	Vol. of sinker	Final vol. (cm^3)	True vol. (cm^3)	True density g/cm^{-3}
B1	14.80	290.00	326.00	30.00	226.00	6.0	2.5
B2	14,82	289.00	324.00	29.00	295.00	5.6	2.6
B3	14.85	290.00	322.00	28.00	294.00	5.0	3.0

APPENDIX F

Values of Mass and True Density of Castor Seed at Moisture Content 14.0%(w.b)

S/N	MASS (g)	Initial vol.	Vol. displaced using sinker	Vol. of sinker	Final vol	True vol.	True density g/cm^{-3}
C1	15.02	290.00	326.00	30.00	226.00	6.0	2.5
C2	15.10	289.00	325.00	29.00	295.00	5.6	2.6
C3	15.07	290.00	325.00	28.00	294.00	5.0	3.0

Mass and True Density of Castor Seed at 10.8%

S/N	MASS (g)	Initial vol. (cm^3)	Vol. displaced using sinker (cm^3)	Vol. of sinker (cm^3)	Final vol. (cm^3)	True vol. (cm^3)	True density g/cm^{-3}
D1	11.45	290.00	322.00	30.00	292.00	2.0	5.7
D2	11.46	289.00	322.00	30.00	292.00	3.6	3.8
D3	11.50	290.00	322.00	30.00	292.00	4.0	2.9

APPENDIX G

Values of Bulk Density at different Moisture Content

kgm^{-3}

MC:	20.2%	17.6%		14.0%		10.8%	
A1	0.80	B 1	0.76	C 1	0.81	D1	0.77
A2	0.76	B 2	0.8	C 2	0.74	D2	0.80
A3	0.75	B 3	0.75	C 3	0.75	D3	0.75

Values of Porosity at different Moisture Content

(%)

S/N	A	B	C	D
1	78.4	68.0	68.0	86.0
2	68.8	71.27	65.5	79.0
3	74.1	74.77	58.3	74.0
MC:	20.2%	17.6%	14.0%	10.8%

APPENDIX H

Values of Coefficient of Static Friction at different Moisture Content

Samples	Metal Sheet	Ply Wood	Glass Sheet	MC:
A1	0.1835	0.3699	0.1763	
A2	0.1817	0.3674	0.1781	20.2%
A3	0.1799	0.3699	0.1781	
B 1	0.1853	0.3719	0.1763	
B 2	0.1817	0.3699	0.1799	17.6%
B 3	0.1835	0.3699	0.1763	
C 1	0.1799	0.3679	0.1763	
C 2	0.1835	0.3659	0.1781	14.0%
C 3	0.1835	0.3679	0.1781	
D 1	0.1908	0.3779	0.1817	
D 2	0.1871	0.37	0.1835	10.8%
D3	0.1853	0.3799	0.1817	