International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 4, pp: 523-528 www.ijaem.net ISSN: 2395-5252

Determination of Strength and Physical Properties of Turmeric Rhizome at Different Geometric Size

P. C, Muogbo [1] and P. A, Obasa[2*],
[1] National Root Crops Research Institute, Nyanya Sub- Station, Abuja, Nigeria.
[2]Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Niger State Nigeria.
*Corresponding Author: P. A, Obasa

Date of Submission: 02-08-2020 Date of Acceptance: 20-08-2020

ABSTRACT: Strength properties and physical properties measured of biomaterials are very useful for development, design, model of processing machinery, feed hoppers, storage structure, material handling machinery/equipment and packaging purpose. This study includes mechanical properties like strength of material that deals with the solid behaviours of Turmeric Rhizome which consist of ultimate strength, deformation, compressive stress, holding force capacity. Turmeric rhizome sample was divided into three grades (I: 50– 60 mm, II: 60-70 mm, III: 70–80 mm) with a diameter of 15-20 mm range according to its major dimension to study its physico-mechanical properties. Second order polynomial models were developed for coefficient of static friction, compression force, force holding capacity, ultimate strength, numerical validation was conducted on the models the outcome shows that the models can be use on turmeric rhizome geometric size range of 50 to 120mm major diameter size. The Bulk density, True density, Porosity, Angle of Repose, Surface area, Deformation, ultimate strength, compressive force result from the turmeric grades in this study ranges between 460.5 – 554.74 kg/m^3, 1134 – 1154 kg/m^3, 78.4 -83.43 %, 37.5 – 39 0, 974- 1539 mm^2, 11.80 - 18.73 mm, 207-445.41 MPa, 3 -12.4 N respectively. More engineering properties were established in the study.

Keywords: Compressive force, Mechanical, Model, Rhizome, Strength

I. INTRODUCTION

Turmeric is artefact of Curcuma longa, a rhizomatous herbaceous perennial plant has its place to the ginger family Zingiberaceae, which is native to tropical South Asia.it has many species of Curcuma that have been identified worldwide [Mane et al., 2018].Turmeric is used in a wide variety of foods of the cuisines of in the world but locally it also applies as an antiseptic for skin abrasions and cuts [Robbins 1995]. Turmeric is a bright yellow-orange spice commonly used in curries and sauces. It comes from the turmeric root. The spice has been used for its medicinal, antioxidant, and anti-inflammatory properties for thousands of years. Turmeric tea is one popular form of consuming turmeric. It has a unique but subtle flavour [Healthline2014].

Freshly lifted Turmeric Rhizome

Plate 1: Turmeric plant

Source:[FAO., 2004].

Turmeric is the rhizome that develops as a tropical perpetual plant which, for gathering designs, is developed as a yearly plant. The plant as the root framework that becomes off the essential tuber of turmeric has long, level, brilliant green leaves growing up from the base to one meter high and resembles that of ginger, and some as light-yellow blossoms. The rhizomes, which are generally alluded to as fingers, are ginger-like in appearance and five to eight cm long. They are rounder in minor distance across than ginger, measure one and half centimetre thick and are profound orange–yellow in shading. Powdered turmeric is splendid yellow, has a particular gritty smell and shockingly satisfying, sharp, harsh, fiery, waiting profundity of flavour [Herbies(2012]. Numerous investigations on mechanical properties have left a few properties like quality of material that manages the strong practices of the biomaterial which incorporate extreme quality, disfigurement, compressive pressure, holding power limit, stripping power. Quality properties otherwise called mechanical properties of biomaterials were explored on turmeric rhizomes at three distinctive geometric size evaluations.

II. MATERIALS AND METHODS

Sample Preparation:The turmeric samples were obtained from National Root Crops Research Institute, Nyanya, Abuja, Nigeria. The rhizome plant was clean and graded into three (3) grade one(1) 70–80 mm, grade two (II): 60-70 mm, grade three (III): 50– 60 mm) with rhizome diameter of 15-20 mm range, the sample moisture content of the samples used in this study was 87.3%MC_{wb}.

Bulk density

Bulk density of turmeric rhizomes was resolute using [Athmaselviand Varadharaju, 2002]. The bulk density was expressed as the ratio of weight to volume of turmeric rhizome.

$$P_b = \frac{m}{V_c}$$

Where, ρ_b= Bulk density, kg/m^3
m = Mass of turmeric rhizome, kg
v_c = Volume of the container, m^3

True density

True density of the turmeric rhizomes was determined by the toluene (C_7H_8) displacement method [Mohsenin 1970;Balamiet al., 2014]. The true density ρ_t was then calculated

$$P_t = \frac{m}{V_f}$$

Porosity

Porosity is defined as the per cent voids of an unconsolidated mass of materials [Mohsenin 1970] The porosity of the turmeric rhizome was computed using the formula given below and expressed in per cent.

$$\varepsilon = 1 - \left(\frac{\rho_b}{\rho_t}\right) \times 100$$

Where,
ε = Porosity, per cent
ρ_b = Bulk density, kg/m^3
ρ_t = True density, kg/m^3

Size

Turmeric rhizomes were randomly selected to measure physical parameters like length, breadth and thickness of each rhizome by using Vernier caliper (least count 0.01cm). Twenty observations were made to get average values of length, breadth and thickness of the turmeric rhizome
[Mohsenin 1970;Balamiet al., 2014]

Angle of repose

Turmeric rhizome angle of repose (h) was attained using a cubic box of dimensions is 10× 10×10 cm, having a removable front panel. It is calculated from the ratio of the height to the base radius of the heap formed [Mohsenin 1970;Subhashiniet al., 2015.].

$$\theta = \tan^{-1}\left(\frac{h}{w}\right)$$

Where,
θ = Angle of repose, degree
h =Height of heap, cm
W = Width of the box, cm

Coefficient of static friction

Coefficient of static frictional properties of were determined for the following sliding materials surfaces: plywood, glass, and stainless. The sliding surface was gradually raised until the first rhizome started to slide down. The surface angle was recorded at the point the rhizome started sliding. The test continued by further raising the surface until all the remaining rhizome started sliding down, then the angle was recorded. Furthermore, another method was used by putting on the sliding surface one rhizome at a time. The sliding surface was gradually raised until the seed started to slide down, then the angle was recorded. The coefficients of friction were calculated using the average sliding angle(α) in which is the sliding angle (tilt angle) and μ is the static coefficient friction[Balami et al., 2014].

μ= tan α

Strength Properties Test

A static compression, ultimate strength, force holding test was carried out on universe testing machine (Plate2) MARXTEST (TS 176). The rhizome samples were placed in the machine in vertical orientation, in such a way that the dimension were the large axis and small axis of cross-sectional areas of the turmeric were subjected to the load.

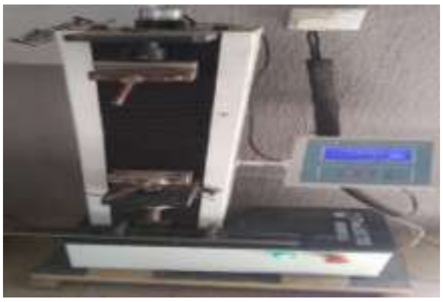

Plate 2: THE MARXTEST (TS 176). UTM machine.

III. RESULTS AND DISCUSSION

Microsoft Excel statistical analysis tools was used to present the graphical representation and trend analysis of the data's collected on the strength and physical properties of turmeric rhizome. The data collected at the three geometric grades I, II, III of 50-60, 60-70, 70-80 respectively was shown in Table 1. The Bulk density, True density, Porosity, Angle of Repose result from the turmeric grades in this study ranges between 460.5 – 554.74kg/m^3, 1134 – 1154 kg/m^3, 78.4 -83.43%, 37.5 – 39^0 respectively the result in this study was similar to the that of [Subhashiniet al,2016] on the physical properties of turmeric rhizome that was determined at different moisture contents checking the size, bulk density, true density, and porosity, by using standard procedures.

Table1:Physico-mechanical Properties of Graded Turmeric Rhizome

Properties	Grades	I	II	III
Bulk density (kg/m^3)		460.5	498.62	554.74
True density (kg/m^3)		1152	1141	1154
Porosity (%)		83.43	82.1	78.4
Size (mm)	Major	55	65	75
	Intermediate	53	59	72
	Minor	15	17	20
Angle of repose (^{o})		37.57	38.44	38.99
Coefficient of static friction	Plywood surface	0.89	0.96	0.83
	Stainless surface	0.97	0.91	0.86
	Glass surface	0.74	0.78	0.77
Surface Area (mm^2)		974	1257	1539
Strength Properties Test	Compressive max force (mm)	3	6	12.4
	Deformation (mm)	15.03	11.80	18.73
	Force holding Capacity (N)	2.4	5.5	10.2
	Strength (MPa)	207	267	445.41

Surface area of the rhizome varies between 974 – 1539 mm^2.The differences in grades properties wasprimary cause of getting value deviations. The coefficient of static friction determined using three main agricultural materials used in construction, design of processing machines. (wood, stainless steel, and glass) shows there was significant effect on the frictionalproperties of turmeric rhizomes Figure 1. The findings in this study was close to the findings of [Dhinesh and Ananda 2016,Khambalkaret al.,2017] that the Average of angle of repose, true density & bulk density such as 18.06^0, 1018.95kg/m^3& 529.66 kg/m^3. The average shape factor was calculated 0.03. The porosity was ranges from 32 to 63% respectively while the porosity in this study is 78.4 – 83.43%,The coefficient of static friction of the rhizome simulated using polynomial second order rule develop models for turmeric using three surfaces in equation one to three(Eq1, II, III) shows a reasonable inference of R^2 value of 99% model fit in all the model equations in the studyby [Subhashini 2015;Shelakeet al., 2018] developed linear model also to predict some physical properties but the R^2 value of second order polynomial model in this study was better and it major factor was the geometric size of the major diameter.

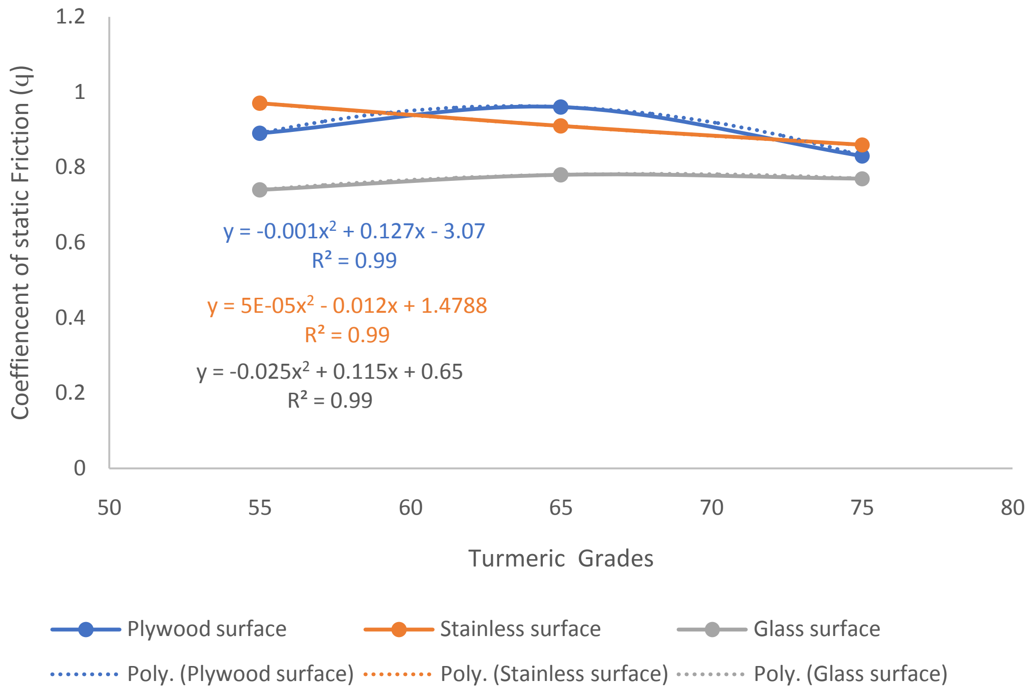

Figure1: Graphical Representation and Model of Turmeric Rhizome Coefficient of Static Friction.

Plywood surface polynomial model for coefficient of static friction of turmeric rhizome

$y = -0.001x^2 + 0.127x - 3.07$ ……………… ... EqI

Stainless Surface polynomial model for coefficient of static friction of turmeric rhizome

$y = (5(10^{-5}) x^2) - 0.012x + 1.4788$ …………Eq II

Stainless Surface polynomial model for coefficient of static friction of turmeric rhizome

$y = = -0.025x^2 + 0.115x + 0.65$………………. Eq III

Turmeric rhizome compressive force, force holding capacity, ultimate strength resolute was between (2-12.4N), (2.4 -10.2N), (207 – 445.41MPa) respectively.The data collected expressions Interaction stresses between bodies in contact with the rhizome the firmness and hardness of turmeric in relation to mechanical damage on the biomaterial during transportation, packaging or process, dead load and impact damage, vibration damage, friction, effect of load on deformation that was between 11.80 – 18.73mm, the result collected was similar to the polynomial second order rule develop models for turmeric compressive force, force holding capacity and ultimate strength in equation four, five and six (Eq1V, V, VI) with fit model R^2 value of 99%.

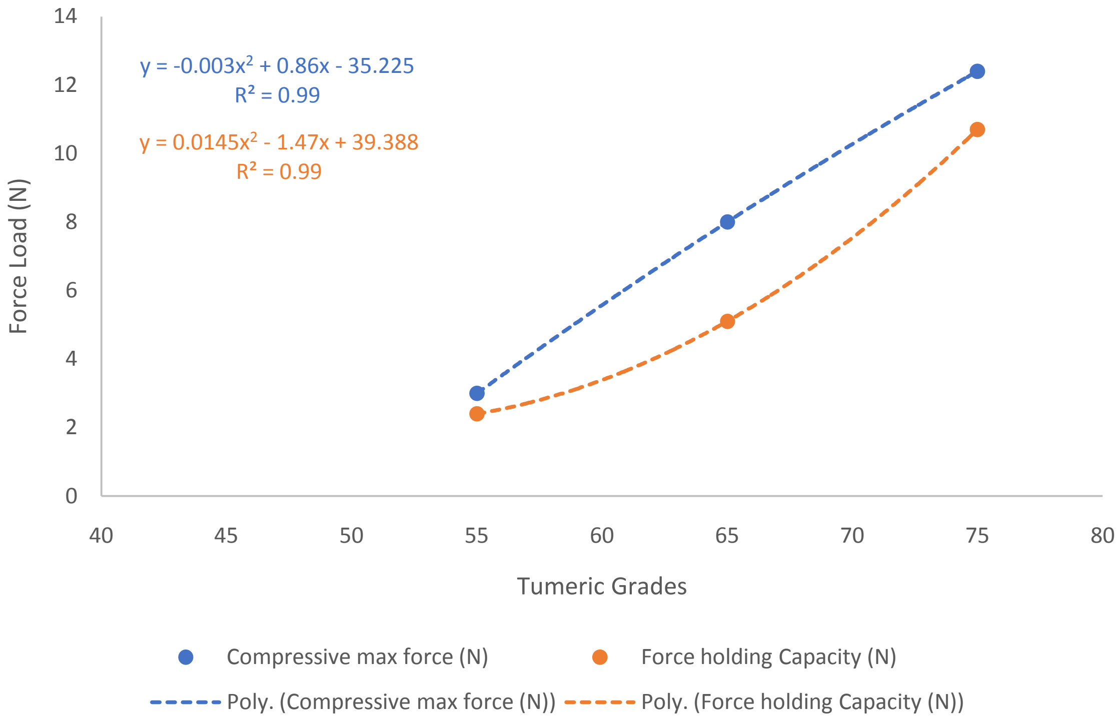

Figure 2: Turmeric Rhizome Compressive Force, Force Holding Capacity Models Graph.

Second orderpolynomial model for compressive maximum force of turmeric rhizome
$y = -0.003x^2 + 0.86x - 35.225$ …………. Eq IV.
Second order polynomial model for force holding capacity of turmeric rhizome
$y = 0.0145x^2 - 1.47x + 39.388$……….......Eq V

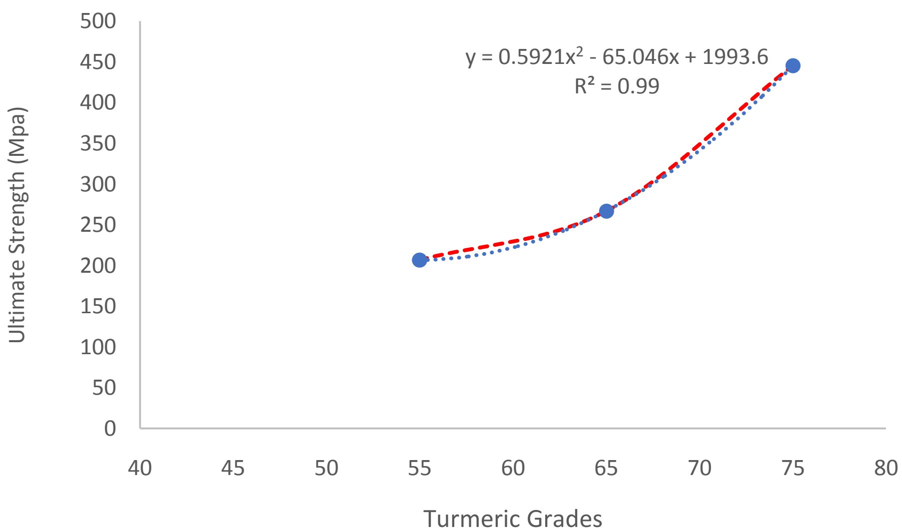

Figure 3: Turmeric Rhizome Ultimate Strength Models Graph.

The numerical model's validation analysis carried out on compression force, force holding capacity, ultimate strength of the graded rhizomes reviled that the second order polynomial model can be used within the grade sizes of 50- 120mm, 50 - 120, 55- 120mm respectively geometric major diameter of the Turmeric rhizome.

IV. CONCLUSIONS

In conclusion, the strength and physical analysis of turmeric rhizome were achieved at three different grades of 50 -60, 60 -70, 70- 80 mm. the strength properties show significant effect with relation to the geometric size of the turmeric and for compression force, force holding capacity, ultimate strength and there was non-significant effect on some physical properties of the roots. Model was developed for coefficient of static friction at different materials shapes as linear model fit of R^2 = 99 %, the compression force, force holding capacity, ultimate strength numerical model validation done shows the developed model can be used for prediction of turmeric engineering properties.

Acknowledgements: Appreciation to Mal ZEGI, Crop Processing Lab. Department of Agriculture and Bioresources Engineering. And Engr. Adeniyi A, Engr. Agbesin Emmanuel, Civil Engineering Lab of Federal University of Technology Minna, Niger State, Nigeria. For their assistant to the success of this research.

REFERENCES:

[1]. Athmaselvi, K. A., and Varadharaju, N. (2002). Physical and thermal properties of turmeric rhizomes. Madras Agricultural Journal, volume 89 issue 1.

[2]. Balami, A.A, Aliyu, M., Dauda S.M., and Peter O. (2014); Physical Properties of Neem (azadirachtaindica) Seeds and Kernels Relevant in the Design of Processing Machine; Arid zone Journal of Engineering, Technology and Environments. Volume 10: Pages 53-62.

[3]. Dhinesh K. Vand Ananda K. S. (2016); Physical and Engineering Properties of Turmeric Rhizome. Journal of Food Research and Technology Volume 4 Issue 1, Pages 30-34.

[4]. Food and Agriculture Organization (FAO).(2004). Post Harvest compendium of turmeric. www.FAO.org/inpho.docs.pdf, turmeric food and Agriculture Organization of the United Nations.

[5]. Healthline(2014); Seven Ways Turmeric Tea Benefits Your Health. https:// www.healthline.com/health/turmeric-tea-benefits.

[6]. Herbies(2012); Turmeric explained two on p ropagation methods.https://www.herbies.co m.au/general/turmeric-explained-2/.

[7]. Khambalkar V.P., Mahulikar A.M., Kalbande S. R. &Thakare S. H. (2017); Study on Physical Properties for Turmeric Rhizomes. An International Refereed, Peer Reviewed & Indexed Quarterly Journal in Science, Agriculture & Engineering, Volume. 6, Issue 19, Page 638.

[8]. ManeR.P, KshirsagarR.B, A.R Sawate, B.M Patil and R.G Kale.(2018). Studies on evaluation of physicochemical and nutritional properties of fresh turmeric rhizome Journal of Pharmacognosy and Phytochemistry; 7(2): 2895-2897.

[9]. Mohsenin NN (1970); Physical properties of plant and animal materials. Vol. 1. Structure, physical characteristics and mechanical properties. Physical properties of plant and animal materials. Volume. 1.

[10]. RobbinsP,.(1995). Tropical Commodities and their markets (A Guide and Directory).229230.

[11]. ShelakeP.S, Sagar Yadav, M.L, Jadhav and M. N, Dabhi.(2018); Effect of Moisture Content on Physical and Mechanical Properties of Turmeric (Curcuma longa) Rhizome Current Journal of Applied Science and Technology Volume 30 Issue5: Pages 1-7, Article no. CJAST.44672.

[12]. Subhashini.S, Anandakumar S. and Niveadhitha. S.(2015); To Study the Physical Properties of Turmeric Rhizomes at Different Moisture Content, Volume: 5 Issue: 6, ISSN - 2249-555X.