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Evaluation of Some Physical and Thermal Properties of *Thevetia Peruviana* (*Apocynaceae*) Nut as affected by Days of Storage

[1] TITUS ADEYINKA **ILORI**, [2]ABUDUGANIY OLAYINKA **RAJI** and [3]TAOFIK OYEDELE **DAUDA**

[1]Department of Agricultural Engineering, Federal College of Agriculture, Ibadan, Nigeria.

[2]Department of Agricultural and Environmental Engineering, University of Ibadan, Nigeria.

[3]Farming System Research and Extension Programme, Institute of Agricultural Research and Training, Obafemi Awolowo, University, Moor Plantation, Ibadan, Nigeria.

E-mails: iloritaa@yahoo.com, abdulganiy.raji@mail.ui.edu.ng and abdulganiyr@yahoo.com

Abstract

Study on evaluation of some physical and thermal properties of *thevetia peruviana* kernel (*Apocynaceae*) as affected by days of storage was conducted using a 100 randomly selected kernel collected from different fields in Ibadan. The average dimension of 3 principal diameters (major, intermediate and minor diameters) and average seed weight were 33.12mm, 17.77mm, 15.36mm and 6.79g respectively. There were no significant differences in the variation of the intermediate diameter, minor diameter, geometric mean diameter and sphericity. Geometric mean diameter and sphericity obtained are 20.81mm and 62.96% respectively while the coefficient of static friction on glass, stainless, mild steel surface, plywood (parallel to grain and perpendicular to grain) varied from 0.20 to 0.43. The dynamic angle of repose varied from 28.62° to 33.13° on these aforementioned surfaces. These properties are useful information in the handling and processing as well as design of processing equipment for the crop currently used as edge shrub in South-Western Nigeria despite its untapped potentials

KEYWORDS.

***Thevetia pervuiana*, Physical properties, Freshly Harvested Nut (FHN), Days After Harvest (*dah*), Storage.**

INTRODUCTION

Thevetia pervuiana, (*Apocynaceae*) is an evergreen tropical shrub or small tree that bears yellow or orange-yellow trumpet like flowers funnel shaped with spectral spirally twisted and its fruit is deep green in colour encasing a large seed. The leaves are specially arranged linearly about 130 to 150 mm in length. It contains a milky sap containing a compound called theventin that is used in heart stimulant [1]. *Thevetia peruviana* (*Apocynaceae*), native to Mexico, is reported as one of the largest species of flowering plant on earth surface but was introduced to West Africa for ornamental purpose. The family includes diversities of species such as annual, perennial stems, succulent vines, and shrubs and is well represented in parks and gardens. It is known as yellow oleander (nerium), gum bush, bush milk and exile tree in India, *keremuje, kerebuje, kanminko* in Yoruba, South-Western Nigeria, and is used as edge shrub. *Thevetia peruviana* has a wide range of application not only in horticultural sector, but also in pharmaceutical sectors among others. World petroleum situation due to rapid depletion of fossil fuels and degradation of the environment due to the combustion of fossil fuels has simulated interest in the use of the plant for alternative fuel [2].The fruits of *Thevetia peruviana* are rhomboidal in shape with a fissure on the ventral side where it can be opened up. It consists of deep green-waxy pericarp, fleshymesocarp and a hard endocarp. On decorticating the pulpy meso-pericarp (hull), the endocarp is exposed. The hard endocarp (shell) has been referred to as **NUT** in these work

Thevetia peruviana is very rich in oil with the oil content in the kernel being as high as 62.14% (w/w) while other part of the fruit bears negligible amount of oil [3], and due to its availability it may be used for bio-diesel. With large scale indigenous growing of this plant species, high commercial exploitation and variation in it characteristic from place to place, some physical attributes of its seeds are expected to be studied.

Physical and engineering properties are important in many problems associated with the design of machines and analysis of the behavior of products during agricultural process operations such as handling, planting, cleaning, sorting, storing and drying [4]. Consequently, many problems associated with design of a specific machine, analysis of the behavior of the product and handling of materials would be solved by availability of information on the engineering properties to machine designer. Although *Thevetia peruviana* (*Apocynaceae*) have potentials in many ways the benefits are not been derived as it has been relegated edge shrubs and ornamental flower hence there is a dearth of information on its engineering properties. This study therefore set out to determine some physical and thermal properties of *Thevetia peruviana* kernel as affected by days of storage with a view to obtaining information useful in handling and processing.

MATERIALS AND METHODS

Matured seeds were collected from different fields in Ibadan, Oyo state Nigeria and the kernel were separated from the fruit using manually threshing method as described by [5] and [6]. Further cleaning was done by hand-picking to get rid of other impurities. They were then packed in desiccators. Sampling was carried out in two stages; firstly, determination of physical and thermal properties of freshly harvested nut, secondly, determination of physical and thermal properties of the same nut at 10 days after harvesting (10*dah*) having being subjected to normal atmospheric condition. The seed moisture content (mc) was determined by low constant temperature oven drying method (*LCTOD*) approved by International Seed Testing Association [7] and [8]. The method is good for species that are rich in oil. Moisture content was computed as;

Moisture content (%, dry basis) =

$$\frac{M_2 - M_3}{M_3 - M_1} \qquad (1)$$

Where, M_1 is the mass of the container (g), M_2 is the mass of the container and seed before oven dry (g) and M_3 is the mass of the bone dried seed and container (g)

Nut dimension of a 100 randomly selected kernel in three perpendicular axes were determined. The perpendicular axes (major – a, intermediate – b and minor – c) were measured at harvest and ten days after harvest using a digital veneer caliper (Carrera Precision model CP8812-T 12-Inch Titanium Digital LCD Calliper Micrometer, United States) having an accuracy of 0.01mm. The geometric mean diameter (GMD) for each replication was computed from a, b, and c using the equation proposed by [9]. The sphericity

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(SPH) of each nut was calculated using the relation reported by [10] as the ratio of GMD to the major diameter. The bulk density (BD) was determined using the mass by volume relationship [11]. The volume was determined by water displacement method and the true density (particle density) (TD) defined as the ratio of the given mass of a matter to its volume was calculated. The porosity (PR) was calculated from the value obtained for bulk density and true density using the relation proposed by [9].

Coefficient of static friction (μ_s) was determined on five structural materials (mild steel sheet, stainless steel sheet, glass surface, plywood surface(parallel to grain and perpendicular to grain) using inclined plane apparatus [12], [13] and [14]. The dynamic angle (θ_d) of repose was determined using the method of [15] and [16]. Specific heat capacity (C_s) of the seed was determined in an adiabatic copper calorimeter, using method of mixture.

RESULTS AND DISCUSSION

Size, shape and density characteristics.

Average moisture content (*mc*) of 28.17% d.b. and 23.88% d.b. were obtained for both *mc* at harvest and 10 days after harvest with equivalent standard deviation of 4.03 and 2.77 (Table 1). Mean major, intermediate and minor diameters for fresh nut were 33.10mm, 17.89mm and 15.34mm while at 10*dah*, mean major, intermediate and minor diameters were 31.38mm, 17.79mm and 15.54mm. Pattern of variability of the dimensions are not the same for both treatment and no regular pattern was obtained for the standard deviation (Table 1). The implication of this is that nuts reduced in all sides as well as sizes which may be associated with reduction in *mc*. The variance and kurtosis analysis of the seed diameter at different parts gave varying results with the highest variance of 8.823 and lowest of 1.532 for fresh seeds. This trend is different from the kurtosis of fresh nuts which has the highest value of 0.572 (b) and the least kurtosis of -0.655 (Table 1). For 10 *dah*, the variance and kurtosis analysis gave the same trends. Highest (6.381) variance was obtained for the diameter at both points a and c as well as highest kurtosis of -0.279 at the same point. Least variance, 1.218 and least kurtosis of -0.680 was obtained for the diameter at point b (Table 1).

The trends of the frequency of recruitment of major, intermediate and minor diameters are the same (Figure 1). The middle frequency classes in each of the cases have higher frequencies for fresh nuts than 10*dah*. For the early (25-29.9, 15-16.9 and 12-13.9) and later (35-39.9, 19-21.9 and 16-17.9) frequencies, 10*dah* have more of the diameter frequencies (Figure 1). The implication of this is that recruitment pattern for each of the major, intermediate and minor diameters are the same. This may not be unconnected with the fact that the 3 parameters were obtained from the same seed. These are background information for characterizing the kernel which are required in designing thevetia's sieving and grading machine.

The skewness and kurtosis analysis for the frequency distribution curve for the 100 readings taken for each dimension shown in Fig. 1 are presented in Table 1. The curves show normal distribution for all the parameters with the peaks being around the means which agrees with earlier results by [17] for five varieties of cowpea, [12] for two African yam bean accessions and [18] for vetch seed. This is an indication that the axial dimensions are relatively uniform and these are useful information in the design of separation and size reduction systems. Skewness characterizes the degree of symmetry of a distribution around its mean. Positive skewness indicates a distribution with an asymmetric tail extending towards more positive values (skewed to the right) and vice versa for negative. Kurtosis characterizes the relative peakedness or flatness of a distribution compared to the normal distribution.

The Geometric Mean Diameter (GMD), sphericity, bulk and true density are 20.07mm, 64.08%, 0.6313gcm^{-3} and 0.928gcm^{-3}; 21.54mm 62.99%, 0.629gcm^{-3},and 0.982gcm^{-3} at harvest and 10dah respectively. Geometric mean of axial dimension as obtained in this result can be used in defining the characteristics dimension for irregular solid. It is also useful in estimation of projected area of particles moving in turbulent or near turbulent region of airstreams, especially with respect to ease of separating of extraneous materials from the nut during cleaning by pneumatic means. The mean sphericity which was found to be 64.08% and 62.99% for both fresh and 10*dah* indicated decrease in the nuts sphericity which is in contrast with [19] who established that sphericity increases with decrease in seed size. However, the simple explanation for this is that the shrinkage over the period of storage may be responsible for the decrease in sphericity. This lower value of sphericity confirmed that the seeds are expected to slide rather than roll. This is a characteristic property required in the design of hopper and chutes and other storage facilities. Effective seed diameter is also suggested to be useful in describing the shape of solid.

The mean value obtained for bulk density for the two observed kernel from this result apparently compared with *Prosopis africana* seed of 899.67kgm^{-3} [4], sorrel seed of 637kgm^{-3} [20] pigeon pea seed of 745kgm^{-3} and pumpkin seed of 472kgm^{-3}. This is an indicator of quality and predicate of breakage susceptibility and hardness study. Similarly, this can also be used to estimate the theoretical capacity of the hopper and silo among others. The true density is a useful attribute in computing product yield and the throughput in processing machinery. The porosity shows the relationship between bulk and true density and the extent of pore space in the seed mass. The average values obtained were 31.14 and 36.10%. This shows that porosity increases with the storage time interval between hence, more gases and liquid are allowed during seed seasoning. By implication, seasoned seed of *Thevetia peruviana* would favour aeration, drying, heating, cooling and distillation operations.

The coefficients of static friction were 0.396 and 0.183 on glass, 0.298 and 0.179 on stainless steel, 0.292 and 0.241 on mild steel, 0.318 and 0.218 on plywood and 0.313 and 0.233 on plywood surface respectively. This would be found useful in hopper design as well as grain outlet for gravity flow to ensure continuous flow of the materials. The dynamic angle of repose is an engineering property that predicts maximum angle of stable slope determined by friction, cohesion and shapes of the particles for both fresh nut and 10*dah.* These are 18.02 and 25.35° for glass, 24.39 and 25.85° on stainless steel, 20.23 and 22.56° on mild steel and 19.80 and 20.87° for plywood surface. These data on angle of repose may be used to design size of conveyor belt for transportation of the material and also useful during transaction, which involve the use of container measurement above the brim. The specific heat capacity of the nut at 80°C for the two observed nut was found to vary from 24.09 - 31.06 kg/kgK and 48.75 - 93.09 kg/kgK respectively. This value is within the range reported for various varieties of *Prosopis africana* seed but higher than that of sorrel seed. The specific heat will be useful in thermal processing of the seeds especially in predicting it thermal behaviors during oil expression.

Mean Character Difference.

No significant differences were obtained for the investigated physical characters (Table 3). The t-statistics,

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0.559, 0.885, -1.00 and -0.978 obtained respectively for the intermediate diameter, minor diameter, geometric mean diameter and sphericity were less than $t_{(198,\ 0.05)}$ = 2.236. The only exception is the major diameter whose t-statistics of -4.385 is less than $t_{(198,\ 0.05)}$ = 2.236. The implication of this result is that though differences were obtained in these measured parameters at the two periods as in line with several other works but these differences are not statistically significant. For coefficient of static friction however statistical t values of -10.874, -4.7968, -3.562, -7.536 and -2.926 obtained for glass, stainless steel, mild steel, plywood along the grain and plywood across the grain were greater than $t_{(38,\ 0.05)}$ = 2.236. Apparently, the observed differences in these variables in both fresh nut and 10dah are not attributable to white noise.

CONCLUSIONS

Some useful engineering properties; physical and thermal characteristics of seasoned *Thevetia peruviana* seed have been determined. These properties have a lot of potentials and are useful for design of processing and handling machineries. Its use and processing has been limited to manual methods which are hazardous. This is a step at commercializing and exploring the full potentials of the seed.

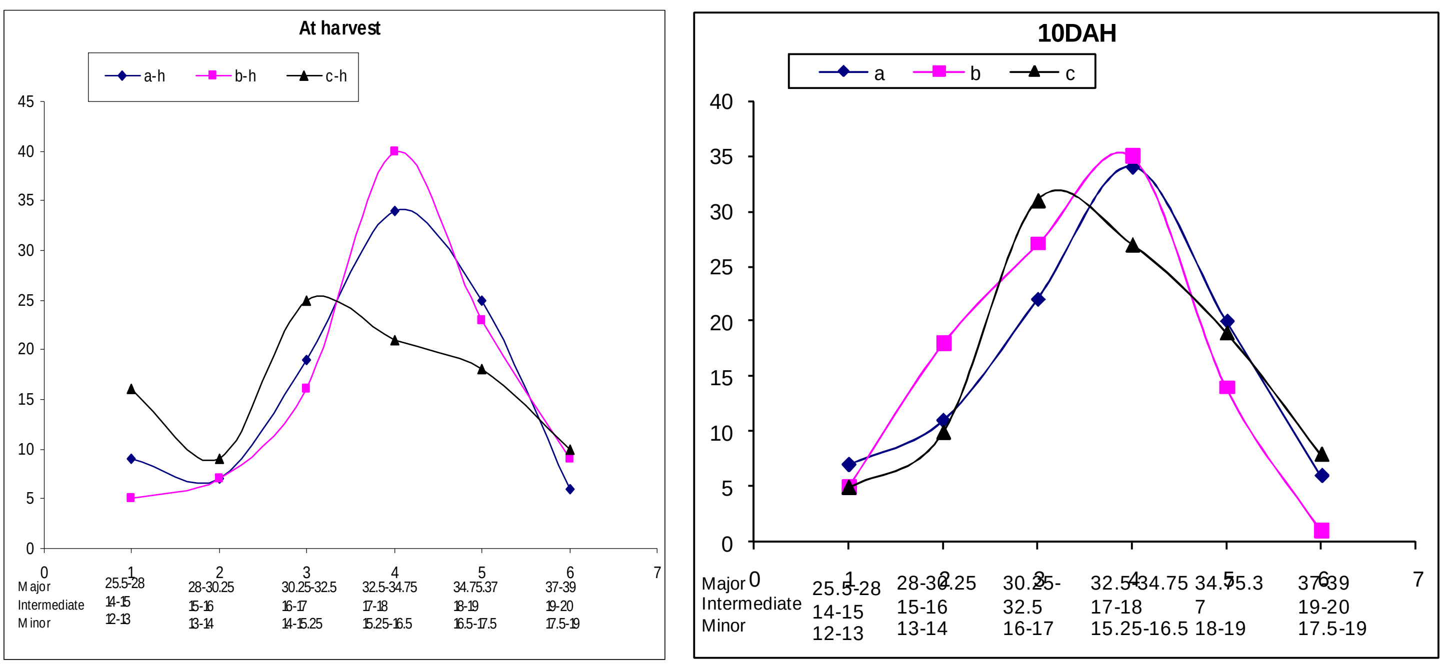

Figure 1. Descriptive statistics of the Major (a), Intermediate (b) and Minor (c) diameter at the 2 Period

Table 1: Physical Properties of fresh and seasoned *Thevetia Peruvian*.J Nut

Nut/Statistics		Parameters								
		a ***(mm)***	b *(mm)*	C *(mm)*	GMD *(mm)*	SPH *(%)*	BD *(gcm^{-3})*	TD *(gcm^{-3})*	PR *(%)*	***Mc*** *(%)*
Fresh	Mean	33.1	17.89	15.34	20.07	64.08	0.6313	0.928	31.14	28.17
	SD	2.97	1.09	1.67	1.38	2.47	0.03	0.10	10.04	4.03
	Maximum	39.00	20.00	19.29	21.33	72.14	0.68	1.06	42.79	20.09
	Minimum	25.50	14.00	12.07	16.4	55.18	0.573	0.725	10.06	20.2
	SE	0.297	0.124	0.165	-	-	-	-	-	-
	Variance	8.823	1.532	2.723	-	-	-	-	-	-
	Kutorsis	0.094	0.572	-0.655	-	-	-	-	-	-
10*dah*	Mean	31.38	17.79	15.54	21.54	62.99	0.629	0.982	36.01	23.88
	SD	2.54	1.24	1.45	2.13	3.23	0.24	0.28	3.19	2.77
	Maximum	36.91	20.4	18.5	23.04	62.91	0.66	1.02	42.43	27.92
	Minimum	25.57	15.5	12.00	16.51	52.97	0.58	0.94	29.55	20.15
	SE	0.253	0.110	0.140	-	-	-	-	-	-
	Variance	6.381	1.218	6.381	-	-	-	-	-	-
	Kutorsis	-0.279	-0.680	-0.279	-	-	-	-	-	-

NB. a, b, c – Diameter; GMD – Geometric Mean Diameter; SPH – Sphericity; BD – Bulk Density; TD – True Density; PR – Porosity; mc – Moisture Content.

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Table 2: Frictional characteristics and thermal properties of fresh and seasoned Thevetia Peruvian.J Nut

COEFFICIENT OF FRICTION	SHC	ANGLE OF REPOSE

NB. PlywoodA –Plywood (parallel to grain); PlywoodB– Plywood(perpendicular to grain) ;SHC-Specific heat capacity at 80^{o}c

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Nut/Statistics	Glass	Stainless Steel	Mild Steel	PlywoodA	PlywoodB		Glass	Stainless Steel	Mild Steel	PlywoodA
FRESH										
Mean	0.396	0.298	0.292	0.313	0.313	28.30	18.0	24.4	20.2	19.8
SD	0.79	0.06	0.52	0.07	0.07	2.72	2.29	3.8	2.49	3.3
Maximum	0.55	0.394	0.384	0.404	0.466	31.07	22.7	30.1	24.2	26.6
Minimum	0.298	0.194	0.213	0.213	0.213	24.10	14.6	18.4	16.4	15.3
10 dah										
Mean	0.183	0.179	0.241	0.218	0.233	68.00	25.9	25.9	22.6	20.9
SD	0.49	0.06	0.62	0.08	0.08	17.55	3.7	4.2	3.3	2.7
Maximum	0.262	0.306	0.344	0.344	0.325	93.09	36.7	26.6	27.8	28.6
Minimum	0.092	0.112	0.118	0.116	0.105	48.75	13.1	15.5	13.1	19.9

Table 3: T-test analysis sample for kernel characteristics

	Variables	Degree of freedom	t-tab
Physical Parameter	Major diameter	198	-4.385**
	Intermediate diameter	198	0.559
	Minor diameter	198	0.885
	Geometric mean	198	-1.000
	Sphericity	198	-0.978
Coefficient of static friction	Glass	38	-10.874**
	Stainless steel	38	-4.797**
	Mild steel	38	-3.562**
	Plywood	38	-7.536**
	Plywood surface	38	-2.926**

** Significant at $p \leq 0.05$

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