Selected Engineering Properties of Fluted Pumpkin (*Telfaria occidentalis*) Seeds

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***Abstract*—Fluted pumpkin is a tropical vine grown in West Africa as a vegetable and for its edible seeds. The main objective of this study is to determine some engineering properties of fluted pumpkin seeds to serve as a guide to engineers in design in post harvest machines for the crop. Fluted pumpkin pods were locally obtained and the seeds were extracted, cleaned and sorted. Average values of surface area, sphericity, bulk density, true density and porosity are 533.38mm^2, 0.47, 0.94 kg/m^3, 1.15 kg/m^3 and 17.55%. The coefficient of friction determined on five different structural materials (galvanized steel, mild steel, stainless steel, plywood and glass) gave least value on glass (0.477) and highest on plywood (0.577). Average maximum compressive stress (N), compressive strain at maximum compressive stress (Mm/Mm), energy at maximum compressive stress and compressive load at maximum compressive stress was obtained as 0.11675, 0.09093, 0.03356 and 18.62010 respectively. The mean load at maximum compressive stress (N), extension at maximum compressive stress (mm), compressive extension at break (mm) and load at break (N) was obtained as -18.62010, -2.76240, 3.33498 and 14.16960 respectively also, mean extension at break standard (mm), energy at break (J), compressive stress at yield and the compressive load at yield was obtained as -3.33498, 0.04252, 0.07585 and 12.09619 respectively. The engineering properties are essential engineering data in the design of agro-processing machines in postharvest handling of Fluted Pumpkin seeds.**

Keywords—fluted pumpkin, surface area, sphericity, porosity, coefficient of friction, compressive strenght.

I. Introduction

Fluted pumpkin, *(Telfairia occidentalis)* is a tropical vine grown in West Africa as a vegetable and for its edible seeds. Common names for the plant include Fluted pumpkin, Fluted gourd, *Krobonko*, *Gonuge*, *Costillada* and most Nigerians call it *Ugwu*. It occurs in the forest zone of West and Central Africa, most frequently in Benin, Nigeria and Cameroon [1] and it is a popular vegetable all over Nigeria. It has been suggested that it originated in South-east Nigeria and was distributed by the *Igbo* tribe in Nigeria, who have cultivated this crop since time immemorial. The seed of fluted pumpkin has high protein and fat, and can therefore contribute to a well-balanced diet [2]. *Telfairia occidentalis* is traditionally used by an estimated 30 to 35 million people in Nigeria, including the *Efik, Ibibio,* and *Urhobo*. It is noted to have healing properties and was used as a blood tonic, to be administered to the weak or ill. It is endemic to Southern Nigeria, and was an asset to International food trades of the Igbo tribe [3]. The seed has nutritive and calorific values which make them necessary in diets and good sources of edible oils and fats [4]. Apart from the domestic use of oils and fats as cooking oils, they also find wide application as sources of oleo-chemicals [2].

The composition of the seed per 100g edible portion is: water 6.2g, energy 2280 kJ (543 kcal), protein 20.5g, fat 45.0g, carbohydrate 23.5g, fibre 2.2g, Ca 84mg, P 572mg [5]. Other sources recorded a protein content of 28–37% and an oil content of 42–56% of the dry matter. The seeds are high in essential amino acids (except lysine) and can be compared with soya bean meal with 95% biological value. The fruit pulp has a protein content of about 1.0%. The main constituents of the seed oil are oleic acid (37%), stearic and palmitic acid (both 21%), linoleic acid (15%) as reported by [5].

The major sources of edible oils in Nigeria include peanut, oil palm, soybean etc, these oils are used mainly as cooking oils, for the production of soap, margarine, and cosmetics [6]. With increasing demand, which has led to importation of cooking oils, there is need to source for local oil-bearing-seeds which can be used in production of oils, both for consumption and industrial applications. Fluted pumpkin is a major source of vegetable that contain protein and high in potassium, iron and crude fat which can be further developed to increase world edible vegetable oil production. There is the need for development of processing machines for post-harvest handling of fluted pumpkin seeds and the design of these machines is dependent on some engineering properties of the crop hence, the importance of this study. The engineering properties of biomaterials include; physical, mechanical, thermal, optical etc which constitutes an important and essential data for design of machines, products, equipment, structures, processes and controls [7]. [8] studied some physical properties of *Telfaria occidentalis* however, there is need to study some other engineering properties of the seed relevant to design of postharvest machines Thus, the main objective of this study is to determine the physical properties of Fluted Pumpkin seeds.

II. MATERIALS AND METHODS

A. *Materials*

Pods of fluted pumpkin (*Telfairia occidentalis*) seeds were obtained at Engineering Bus Stop along Federal College of Agriculture, Abeokuta Road, Ibadan, Oyo State, Nigeria. The seeds were thoroughly cleaned and foreign materials discarded. The pod and seed of fluted pumpkin are presented in Plate 1a and b. Other materials used include; Repose Box, Moisture Meter, Vernier Caliper, Weighing Scale, Co-efficient of friction plane, ruler, measuring cylinder.

Plate 1: Fluted Pumpkin a- Pod, b- Seeds

B. *Measurement of Engineering Properties of Fluted Pumpkin Seeds*

i. **Surface Area:** Surface area "A" was determined in accordance with methods reported by [7], [9], [10], [11], [12] as:

$$A = \pi Dg^2 \quad ...(1)$$

Where: Dg is the geometric mean of the length, width, and thickness.

ii. **Sphericity:** computed in reference to [7], [9], [10] using Equation 2

$$S = \frac{(LWT)^{1/3}}{L} \quad ...(2)$$

Where: L, W, T represents Length, width and thickness in mm respectively

iii. **Bulk and True Density:** bulk density was determined by filling an empty 1000ml graduated cylinder with the seed and weighed [7]. The weight of the seeds was obtained by subtracting the weight of the cylinder from the weight of the cylinder and seed. To achieve uniformity in bulk density the graduated cylinder was tapped 10 times for the seeds to consolidate as reported by [13]. Equation 3 was used for computation of bulk density.

$$Pb = \frac{Ws}{Vs} \quad ...(3)$$

Where: Pb is the bulk density in kg m^3, Ws is the weight of the sample in kg; and Vs is the volume occupied by the sample in m^3.
The seeds were then poured into the can and the volume of water displaced was measured using a 50ml measuring cylinder. The process was replicated 10 times and the true density taken as the average of the 10 replications was calculated for each reading as reported by [13]:

$$Pt = \frac{Ws}{Vw} \quad ...(4)$$

Where: Pt is the true density in k/gm^3; and Vw is the volume of water displaced in m^3.

iv. **Porosity:** this was calculated from the values of bulk and true densities using the following relationship:

$$\varepsilon = \frac{Pt-Pb}{Pt} \quad ...(5)$$

All parameters remains as earlier defined

v. **Coefficient of Static Friction:** this was determined with respect to five structural materials; Galvanized Steel, Mild Steel, Stainless Steel, Plywood and Glass using an inclined plane apparatus as described by [14]. The table was gently raised and the angle of inclination to the horizontal at which the sample started to sliding was read off the protractor attached to the apparatus [13]. The tangent of this angle was reported as coefficient of friction. Equation 6 was used for the computation of the coefficient of friction.

$$\theta = Tan\ \alpha \quad ...(6)$$

Where: α is the angle of inclination on the plane and θ is the coefficient of Static friction

vi. **Mechanical Properties (Compressive Strength):** Structural properties of biological tissues are usually determined through some form of mechanical testing (e.g., tensile tests, compressive tests, bending and torsion tests). Seed Samples were picked at random and were all taken to Centre for Energy Research and Development (CERD), Obafemi Awolowo University, Ile –Ife, for Compressive Strength Test on Instron Machine equipped with a 500N compression load cell as shown in Plate 2 where samples were placed for compression loading test which include elasticity modulus and maximum force. The samples were placed on the fixed plate and loaded with moving speed.

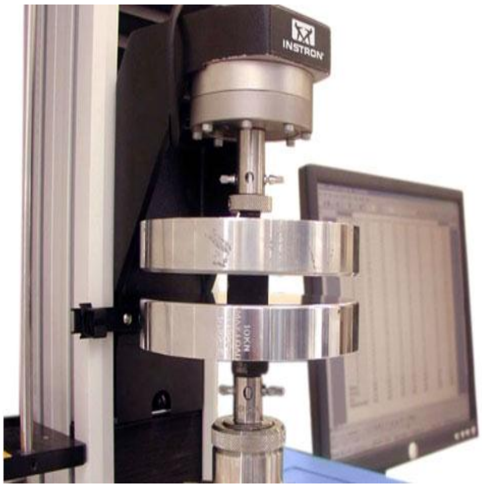

Plate 2: Instron Compressive Testing Machine.

III. Results And Discusions

The physical properties of Fluted Pumpkin seeds was determined in accordance with ASABE standard method of evaluation of engineering properties, the results obtained is presented in Tables 1 – 4 and Figures 1 – 2.

Table 1: Some Engineering Properties of Fluted Pumpkin Seeds

Properties	No. of Samples	Min. (mm)	Max. (mm)	Mean Value (mm)
Surface area (mm^2)	100	420.54	660.51	533.38
Sphericity (decimal)	100	0.46	0.48	0.47
Bulk Density(kg/m^3)	100	0.76	0.85	0.94
True Density(kg/m^3)	100	0.87	1.01	1.15
Porosity (%)	100	15.02	18.55	17.55

Min. – Minimum and Max. - Maximum

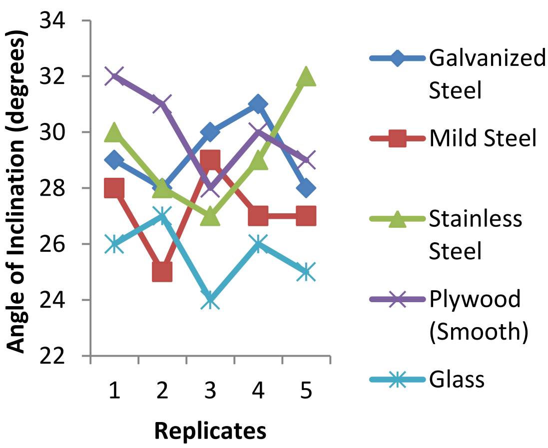

Figure 1: Angle of Inclination obtained on different Structural Materials

Table 2: Compressive Stress of Fluted Pumpkin Seeds

S/N	Max. Compressive Stress	Compressive Strain at Maximum Compressive Stress (Mm/Mm)	Energy at Max. Compressive stress (J)	Compressive load at Max. Compressive stress (N)
1	0.10519	0.07968	0.01993	16.77598
2	0.14286	0.14582	0.06562	22.78359
3	0.10221	0.04729	0.01512	16.30073
Ave	**0.11675**	**0.09093**	**0.03356**	**18.62010**
S.D.	**0.02266**	**0.05022**	**0.02787**	**3.61351**

Table 3: Load at Maximum Compressive Stress of Fluted Pumpkin Seeds

	Load at Maximum Compressive stress (N)	Extension at Maximum Compressive stress (mm)	Compressive extension at Break (Standard) (mm)	Load at Break (Standard) (N)
1	-16.77598	-2.42063	2.62969	-14.80731
2	-22.78359	-4.42994	5.06963	-19.29863
3	-16.30073	-1.43663	2.30562	-8.40288
Ave	**-18.62010**	**-2.76240**	**3.33498**	**-14.16960**
S.D.	**3.61351**	**1.52564**	**1.51096**	**5.47579**

Table 4: Extension at Break and Compressive Load at Yield

	Extension at Break (mm)	Energy at Break (J)	Compressive stress at Yield (Zero Slope) (MPa)	Compressive load at Yield (Zero Slope) (N)
1	-2.62969	0.02279	0.03833	6.11269
2	-5.06963	0.07869	0.13420	21.40224
3	-2.30562	0.02609	0.05501	8.77363
Ave	**-3.33498**	**0.04252**	**0.07585**	**12.09619**
SD	**1.51096**	**0.03136**	**0.05122**	**8.16836**

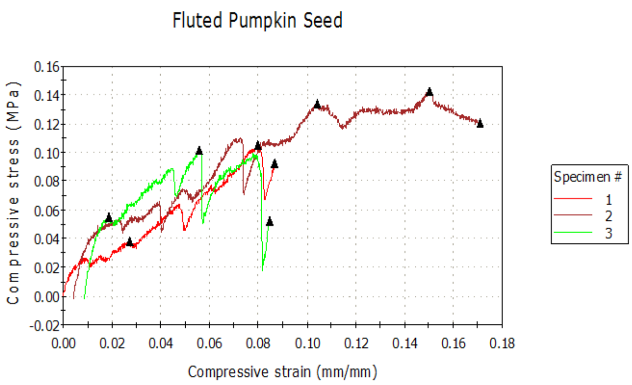

Figure 2: Young Modulus of Elasticity of Fluted Pumpkin Seeds

A. Discussion

Average values of surface area, sphericity, bulk density, true density and porosity are 533.38mm^2, 0.47, 0.94 kg/m^3, 1.15 kg/m^3 and 17.55%. Average values of surface area, sphericity, bulk density, true density and porosity are 533.38mm^2, 0.47, 0.94 kg/m^3, 1.15 kg/m^3 and 17.55%The coefficient of friction determined on five different structural materials (galvanized steel, mild steel, stainless steel, plywood and glass) gave average angle of inclination (and friction coefficient) as 29.24^0(0.559), 27.04^0(0.510), 29.04^0 (0.555), 30.00^0 (0.577) and 25.52^0 (0.477), these values are in tandem with [8] in their study on some physical properties of *Telfaria occidentalis* as affected by moisture content.

Bulk density has been reported to have practical applications in the calculation of thermal properties in heat transfer problems, in determining Reynolds number in pneumatic and hydraulic handling of materials and in predicting physical structure and chemical composition [15].

Sphericity value of most agricultural produce has been reported to range between 0.32 and 1.00 [7], [15]. Sphericity values obtained are in tandem with findings reported by [16] for *Ronghai lablab* and *Highworth Ronghai* seeds, [17] for *egusi* melon seed.

The coefficient of friction of seeds is required in the design of silos and hopper for processing machines, least value was obtained on glass while the highest was obtained on plywood, this implies that the seeds will slide easily on glass while there will be more friction on wood. A similar trend was reported by [18] for two cultivars of paddy grains and [12] for ginger rhizomes. Least static coefficient of friction may be owing to smoother and more polished surface of the glass than the other materials used, similar trend that was reported by [19], [20], [21].

The Mechanical properties of Fluted Pumpkin seeds results test shows that the Maximum compressive stress (N) ranges from 0.10221 to 0.14286 and the mean value obtain was 0.11675N, the Compressive Strain at Maximum Compressive Stress (mm/mm) ranges from 0.04729 to 0.14582 and the mean value was 0.09093 mm/mm, Energy at Maximum Compressive stress (J) ranges from 0.01512 to 0.06562 and the Mean Value was 0.03356 and Compressive load at Maximum Compressive stress (N) ranges from 16.30073 to 22.78359 and the Mean Values is 18.62010.

Load at Maximum Compressive stress (N) ranges from -16.30073 to -22.78359 where the Mean Value is -18.62010, Extension at Maximum Compressive stress (mm) ranges from -1.43663 to -4.42994 where the Mean Value is -2.76240, Compressive extension at Break (mm) 2.30562 to 5.06963 where the Mean Value is 3.33498 and Load at Break (N) ranges from -8.40288 to -19.29863 and the Mean Value is -14.16960.

Extension at Break Standard (mm) for Fluted Pumpkin seeds ranges from -2.30562 to -5.06963 and the Mean Value is -3.33498, the Energy at Break (J) ranges from 0.02609 to 0.07869 and the mean value is 0.04252, the Compressive stress at Yield ranges from 0.05501 to 0.13420 and the mean value is 0.07585and the Compressive load at Yield ranges from 8.77363 to 21.40224 and the Mean Value is 12.09619.

IV. CONCLUSION

Some Engineering Properties of *Telfairia occidentalis* seed was investigated at 12% moisture content. The values of surface area, sphericity, bulk density, true density and porosity ranged from 420.54 – 660.51 mm^2, 0.46-0.48mm, 0.76 - 0.85kg/m^3, 0.76 - 0.85 kg/m^3, 15.02% - 18.55%, the coefficient of friction measured on glass was 0.45^0 – 0.51^0, galvanized steel 0.53^0 – 0.60^0, mild steel 0.47^0 –0.55^0, stainless steel 0.51^0 - 0.63^0, plywood 0.53^0-0.63^0, maximum compressive stress 0.102 – 0.105N, compressive load at maximum compressive stress 16.30 – 22.78N, energy at break 0.078 – 0.026J. The mean load at maximum compressive stress (N), extension at maximum compressive stress (mm), compressive extension at break (mm) and load at break (N) was obtained as -18.62010, -2.76240, 3.33498 and 14.16960 respectively also, mean extension at break standard (mm), energy at break (J), compressive stress at yield and the compressive load at yield was obtained as -3.33498, 0.04252, 0.07585 and 12.09619 respectively. The engineering properties are essential engineering data in the design of agro-processing machines in postharvest handling of Fluted Pumpkin seeds.

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