

Determination of Selected Physical Properties of Fluted Pumpkin Seed (*Telfairia Occidentalis*) Related to Machine Design

M. M. Odewole^{1*}, O.A. Adesoye², O. Adeyinka-Ajiboye³ and O.A. Shadare³

¹Department of Food Engineering, Faculty of Engineering and Technology, University of Ilorin, P.M.B 1515 Ilorin, Kwara State, Nigeria

²Department of Mechanical Engineering, Faculty of Engineering and Technology, University of Ilorin, P.M.B 1515 Ilorin, Kwara State, Nigeria

³Department of Agricultural and Biosystems Engineering, Faculty of Engineering and Technology, University of Ilorin, P.M.B 1515 Ilorin, Kwara State, Nigeria

E- mail: ^{1*} odewole2005@yahoo.com, Phone Number: ^{1*}+2348050453697

Abstract

Some engineering parameters needed in the form of physical properties of fluted pumpkin seed to design, construct and analyse processing, storage and handling machines/facilities are not readily available. Therefore, this study was done to determine the following physical properties of the seed for three different varieties: size (major diameter, intermediate diameter and minor diameter), mass, surface area, volume, density and geometric mean diameter. Mature pods (13 weeks old) were procured from the National Horticultural Research Institute (NIHORT) Ibadan, Nigeria and were classified as NHTo-1, NHTo-2 and NHTo-3 by NIHORT. One hundred (100) seed samples were selected from each variety after sun drying to an average moisture content of 67.734% (wb). In summary, the following range of mean values ($\pm$ standard deviation) of results were obtained: major diameter (29.968 ± 2.146 mm – 37.320 ± 2.867 mm); intermediate diameter (9.184 ± 2.061 mm – 31.020 ± 3.892 mm); minor diameter (5.421 ± 3.757 mm – 37.156 ± 2.859 mm); mass (0.992 ± 0.236 g – 7.870 ± 1.318 g); volume (4.400 ± 1.653 mm³– 8.399 ± 0.600 mm³) $\times 10^3$); density (0.136 ± 0.125 g/mm³– 2.010 ± 0.827 g/mm³) $\times 10^{-3}$); surface area (1013.16 ± 534.552 mm² – 1584.788 ± 197.61 mm²), and geometric mean diameter (22.267 ± 1.402 – 25.359 ± 2.873 mm). The values of physical properties obtained are relevant in designing machines for the handling, processing, packaging and storage of fluted pumpkin seeds.

Keywords: Physical properties, engineering parameters, varieties, fluted pumpkin seed.

Introduction

Fluted pumpkin (*Telfairia occidentalis*) is a plant that is usually called “ugu” among the Igbo ethnic group in the Eastern part of Nigeria. It is a creeping leafy vegetable that spreads low across the ground with large lobed leaves, and long twisting tendrils (Syndenham, 1985; Horsfall and Spiff, 2005; Christian, 2006; Ojiako and Igwe, 2008). The plant is of commercial importance and it is grown in West Africa with Nigeria, Ghana and Sierra Leone as the major producers (Nkang *et al.*, 2003). The oil from the seed can be used as drying oil for paints and varnishes (Grubben and Denton, 2004); and for the treatment of prostrate and bladder problems in men (Odewole *et al.*, 2015). Alegbejo (2012) reported that *Telfairia* (ugu) seeds are high in essential amino acids (except lysine) and are comparable with that of soybean meal with 95% biological value. Generally, proper knowledge and understanding of the engineering properties of food, agricultural and other biological materials is very important when dealing with stress distribution under load and designing of grading machines (Mohsenin, 1970). Some of these engineering properties are: physical, mechanical, thermal, electrical, rheological and aerodynamic. Relevant engineering properties of materials are very important parameters in the design of machines and structures for the handling, transporting, processing, storage and packaging of needed products. These properties are the foundation of any engineering and related operations to be imposed on any raw material for some specific purposes.

The seed of the fluted pumpkin plant contains valuable oil and other useful by-products. Before the oil can be extracted, it has to pass through some specific unit operations such as harvesting, cleaning, drying, handling, cracking, separation and size reduction. Some of the engineering parameters needed in the form of physical properties of the seed for the development of effective handling, processing and storage systems are not readily available. Therefore, the objective of this study was to determine selected physical properties (size i.e., major, intermediate and minor diameters); mass, surface area, volume, density and geometric mean of the fluted pumpkin seed.

Materials and Methods

Experimental Equipment

The following list of equipment was used for the study: digital Vernier caliper (zoom classic 150 mm, accuracy: ± 0.02 mm, India), digital weighing balance (OHAUS CL Series, Model CL 201, China) and a glass measuring cylinder with accuracy of 0.001mm.

Procurement and Selection of Experimental Materials

Three varieties of mature pods (13 weeks) of fluted pumpkin seeds were procured at the National Horticultural Research Institute (NIHORT) Ibadan, Nigeria. The needed seeds were classified (Figure 1) according to NIHORT standard based on the shape of the pod which were NHTo-1(pointed at both ends), NHTo-2(flat at point of attachment to the vine) and NHTo-3(flat at both ends).



Figure 1: The three varieties of Fluted Pumpkin Used (From left to right: NHTo-1, NHTo-2 and NHTo-3)

Seed Preparation

The external coat (pods) of the seed was removed manually with the aid of a sharp knife in order to get seeds needed for the experiment. After this, all the seeds were fairly sun dried to an average moisture content of 67.734 % (wb). All foreign materials such as dust, stones, immature and broken seeds as well as bad seeds were separated by hand picking and the best seeds with no external observable defects were selected for the experiment. Figures 2 and 3 show the seeds before and after drying respectively.



Figure 2: Seeds before drying



Figure 3: Seeds after drying

Determination of the Physical Properties of the seed

One hundred (100) good seeds were randomly selected from each of the three varieties (NHTo-1, NHTo-2 and NHTo-3) and 100 runs of each physical property were done, after which the mean values of each selected physical property were estimated.

Size Determination

The sizes of the seed were determined using a digital vernier caliper (zoom classic 300 mm). The principal diameters; major diameter (a), intermediate diameter (b) and minor diameter (c) were measured by placing each seed in between the lower jaws of the digital vernier caliper.

Geometric Mean Diameter (D_g)

The geometric mean diameter was determined from the major and minor diameters according to Mohsenin (1970) using equation 1.

$$D_g = (a.b.c)^{\frac{1}{3}} \quad (1)$$

where:

D_g = Geometric mean diameter (mm)

a = major diameter (mm)

b = intermediate diameter (mm); and

c = minor diameter (mm)

Mass Determination

The mass (in gram) of each seed was determined placing each seed on the digital weighing balance and recording each value.

Surface Area Determination

The surface area (S_a) was determined using equation (2) cited by (Sacilik et al., 2003)

$$S_a = \pi(D_g)^2 \quad (2)$$

where:

Sa = surface area (mm²)

D_g = Geometric mean diameter (mm)

Volume Determination

The volume of each seed was determined using water displacement method. A standard graduated measuring cylinder was filled with water to a specific level. Each seed was gently dropped into the measuring cylinder holding the water. The difference between the initial level of water (before dropping the seed) and final level of water (after dropping the seed) was taken as the volume of each seed.

Density Determination

The apparent or true density was determined using the ratio of mass to volume.

$$\text{Density (g/mm}^3\text{)} = \frac{\text{Mass (g)}}{\text{volume(mm}^3\text{)}} \quad (3)$$

Results and Discussion

A summary of all the determined physical properties (size (major, intermediate and minor diameters), mass, volume, density, surface area and geometric mean diameter) is presented in Tables 1, 2 and 3 for NHTo-1, NHTo-2 and NHTo-3 respectively.

Size

The of size of the seeds in terms of minor, intermediate and major diameters are as presented in parts of Table 1 for NHTo-1, Table 2 for NHTo-2 and Table 3 for NHTo-3. From the tables, it is clearly seen that NHTo-1 has the highest major and intermediate diameters as well as lowest minor diameter. Also, the mean values with standard deviation are 37.320 ± 2.867 mm and 31.02 ± 3.892 mm on the major and intermediate diameters respectively, while the lowest mean value on minor diameter is 5.421 ± 3.757 mm for NHTo-1. For NHTo-2 with the mean values of 33.979 ± 2.061 mm for major diameter, 9.184 ± 2.061 mm for intermediate diameter and 37.156 ± 2.586 mm for minor diameter. NHTo-3 has the mean

values of 29.768 ± 2.146 mm, 11.217 ± 1.254 mm and 32.696 ± 5.200 mm for major, intermediate and minor diameters respectively.

For castor nut, Olaoye (2000) reported values of 16.0 ± 1.8 mm for *Ojji* variety for major diameter, 12.2 ± 0.6 mm for intermediate diameter and 7.2 ± 0.3 mm for minor diameter; for *Evahura* variety, values of 16.3 ± 1.1 mm for major diameter, 12.4 ± 2.9 mm for intermediate diameter and 7.3 ± 0.5 mm for minor diameter were observed and *Asbowu* variety had, values of 10.6 ± 1.9 mm for major diameter, 8.2 ± 0.7 mm for intermediate diameter and 5.1 ± 0.4 mm for minor diameter were reported at moisture content range of 4.94% to 5.62%. Sunmonu *et al.*, (2016) respectively determined the major, intermediate and minor diameters of red almond seeds to be 0.08mm, 0.08mm and 0.09mm and 0.07 mm, 0.10 mm and 0.07mm for white almond seeds. Size as a property/parameter determined in this study can be used in material separation and setting of the dimension required for easy movement of seeds from hoppers/other retaining containers into handling and processing machines, or in and out of storage structures.

Mass

The determined mass for each variety of the fluted pumpkin seeds are presented in parts of Tables 1, 2 and 3. NHTo-3 has the highest mass with mean value of 7.870 ± 1.318 g followed by NHTo-2 with 6.143 ± 1.461 g and NHTo-1 with 0.992 ± 0.236 g. Variation in mass among varieties could be due to possible inherent physiological differences that could exist in biological materials irrespective of whether they are in the same class/group or not. All these values obtained were not up to what Idowu *et al.*, 2012 got (between 860 g to 1600g) when the thousand seed mass method was used to determine the mass properties of sand seed box (*Hura crepitans*) under different moisture content which ranged from 9.3 to 52.4%. The value of mass obtained in the current study can be used in determining the maximum load of seeds that handling, transporting, storage and processing machines/systems can withstand without failure. It can also be used in machine performance evaluation operation and material balance analysis.

Density

Tables 1, 2 and 3 have the results of determined density for NHTo-1, NHTo-2 and NHTo-3 varieties respectively. The mean values from Tables 1, 2 and 3 are: $0.136 \pm 0.125 \text{ g/mm}^3 \times 10^{-3}$, $1.479 \pm 0.523 \text{ g/mm}^3 \times 10^{-3}$ and $2.010 \pm 0.827 \text{ g/mm}^3 \times 10^{-3}$ for NHTo-1, NHTo-2 and NHTo-3 respectively. The trend observed in terms of differences in values could be due to the effect of management practices at the growing stage of the pod and genetic make-up of each variety. Oje and Ugbor (1991) reported that the average density value for oil bean seed was 1.12 g/cm^3 under moisture condition of 4.5 % (db). Also, Oje (1993) stated that more than 85% of the locust beans pod and seeds had densities between 1.12 and 1.35 g/cm^3 higher than 1.0 g/cm^3 and also 90% of the pods had their densities below 0.95 g/cm^3 for Locust pods and seeds. The usefulness of the determined density is in the area of material separation, especially when water is to be used as the medium of separation. It is also applicable in failure analysis of storage structures.

Surface Area

Furthermore, as seen in parts of Table 1, 2 and 3, the surface area of each seed varied for each variety with NHTo-2 having the largest area of average value $584.788 \pm 197.616 \text{ mm}^2$ then NHTo-3 with $1564.65 \pm 196.293 \text{ mm}^2$ and NHTo-1 with $1013.168 \pm 534.552 \text{ mm}^2$. Variation in surface area could be due to intrinsic factors like genetic make-up of each variety and extrinsic factors like the prevalent agronomical conditions of location of origin. Olalusi and Bolaji (2011) reported that the surface area of bush mango increased with moisture increase. However, this study (on fluted pumpkin seed) did not vary the moisture content of seed varieties for the purpose of determining their physical properties. Surface area values determined are needed during the drying operation of the seed in order to determine the adequate space required for drying, and the estimation of the rate of heat transfer and in the study of drying kinetics of the seed.

Volume

Parts of Tables 1, 2 and 3 show the determined volume of each variety of the seed. From the tables, the mean values are $8.399 \pm 6.000 \text{ mm}^3 \times 10^3$; $4.480 \pm 1.485 \text{ mm}^3 \times 10^3$; $4.400 \pm 1.653 \text{ mm}^3 \times 10^3$ respectively for NHTo-1, NHTo-2 and NHTo-3. Idowu *et al* (2012) reported a value of 758 to 1098.91 mm^3 for sand box seeds (*Hura crepitans*) at moisture

content of an average value of 9.3 to 52.4% (wb). Meanwhile, Olaoye (2000) reported values for three varieties of castor nut: *Ojji*, *Evahura* and *Asbowu* as $1.49 \pm 0.18 \text{ cm}^3$, $1.72 \pm 0.19 \text{ cm}^3$ and $0.81 \pm 0.05 \text{ cm}^3$ respectively. Volume as a physical property obtained in this study can be used to determine the capacity of hopper, storage and packaging facilities.

Geometric Mean Diameter

Tables 1, 2 and 3 show the results of the geometric mean diameter. NHTo-1 has the highest mean value of $25.359 \pm 1.402 \text{ mm}$ followed by NHTo-2 and NHTo-3 respectively with the mean values of $22.430 \pm 1.362 \text{ mm}$ and $22.267 \pm 1.402 \text{ mm}$. All the values of geometric mean diameter obtained were close to the 20.34mm obtained by Olatunji *et al.*, (2011) for *thevetia peruviana* seed. In the work of Idowu *et al* (2012), it was reported that the value of geometric mean diameter of sand box seed (*Hura crepitans*) was between 12.89 to 15.39 mm.

Table 1: Summary of Determined Physical Properties for NHTo-1

Physical Properties	Range	Mean *	Standard deviation(±)
Major diameter(mm)	32.000 - 43.000	37.320	2.867
Intermediate diameter(mm)	20.000 - 38.000	31.020	3.892
Minor diameter(mm)	0.050 - 14.500	5.421	3.757
Mass (g)	0.367 - 1.721	0.922	0.236
Volume(mm^3) $\times 10^3$	6.589 - 9.664	8.399	0.600
Density(g/mm^3) $\times 10^{-3}$	4.000 - 11.000	8.460	1.740
Surface area (mm^2)	183.400 - 2138.400	1013.168	534.552
Geometric mean diameter(mm)	7.640 - 18.570	25.359	2.873

* Mean of 100 seeds

Table 2: Summary of Determined Physical Properties for NHTo-2

Physical Properties	Range	Mean *	Standard deviation ($\pm$)
Major diameter(mm)	29.910 - 37.970	33.797	2.189
Intermediate diameter(mm)	5.360 - 14.950	9.184	2.061
Minor diameter(mm)	31.060 - 42.220	37.156	2.586
Mass (g)	1.130 - 8.830	6.143	1.461
Volume($(\text{mm}^3) \times 10^3$)	2.000 - 8.000	4.480	1.485
Density($\text{g}/\text{mm}^3 \times 10^{-3}$)	0.226 - 2.887	1.479	0.523
Surface area (mm^2)	1181.150 - 2168.050	1584.788	197.616
Geometric mean diameter(mm)	19.390 - 26.670	22.430	1.362

* Mean of 100 seeds

Table 3: Summary of Determined Physical Properties for NHTo-3

Physical Properties	Range	Mean *	Standard deviation ($\pm$)
Major diameter(mm)	22.780 - 32.890	29.768	2.146
Intermediate diameter(mm)	8.760 - 14.280	11.217	1.254
Minor diameter(mm)	3.530 - 38.160	32.696	5.200
Mass (g)	4.230 - 11.000	7.870	1.318
Volume($(\text{mm}^3) \times 10^3$)	2.000 - 9.000	4.400	1.653
Density($\text{g}/\text{mm}^3 \times 10^{-3}$)	0.867 - 3.975	2.010	0.827
Surface area(mm^2)	1125.770 - 1919.760	1564.651	196.293
Geometric mean diameter(mm)	18.930 - 24.720	22.267	1.402

* Mean of 100 seeds

Conclusion

In conclusion, the following range of mean values ($\pm$ standard deviation) of results were obtained: major diameter (29.968 ± 2.146 mm – 37.320 ± 2.867 mm); intermediate diameter (9.184 ± 2.061 mm – 31.020 ± 3.892 mm); minor diameter (5.421 ± 3.757 mm – 37.156 ± 2.859 mm); mass (0.992 ± 0.236 g – 7.870 ± 1.318 g); volume (4.400 ± 1.653 mm³– 8.399 ± 0.600 mm³) $\times 10^3$); density (0.136 ± 0.125 g/mm³– 2.010 ± 0.827 g/mm³) $\times 10^{-3}$); surface area (1013.16 ± 534.552 mm² – 1584.788 ± 197.61 mm²), and geometric mean diameter (22.267 ± 1.402 – 25.359 ± 2.873 mm). The values of physical properties determined are relevant for designing machines for the handling, processing, packaging and storage of fluted pumpkin seeds.

References

- Alegbejo, J.O. (2012). Production, marketing, nutritional value and uses of fluted pumpkin (*Telfairia occidentalis* Hook. F). Journal of Biological Science and Bioconservation, Vol: 20-24.
- Christian, A. (2006). Studies of selected Physico-chemical properties of fluted pumpkin (*Telfaria occidentalis* Hook F.) Seed oil and tropical almond (*Terminalia catappia*, L.) seed oil. Pakistan J. Nutr., 5 (4):306 – 307.
- Grubben, G.J.H and Denton,O.A. (2004). Plant resources of Tropical Africa vegetables. PROTA Foundation, Wageningen, Netherlands. Backhuys Publishers, Leiden, Netherlands CTA, Wageningen Netherlands. Pp 668.
- Horsfall, M.J. and Spiff, I.A. (2005). Equilibrium sorption study of A13+, CO2+ and Ag+ in aqueous solution by Fluted Pumpkin (*Telfaria occidentalis* Hook F) Waste Biomass. Acta Chemistry of Slovia.
- Idowu, D.O.; Abegunrin T.P. and Ola, F.A. (2012). Measurement of some (*Hura Crepitans*). Agricultural and biology journal of north America, Vol 3(8): 318-325.
- Mohsenin N.N (1970). Physical properties of plant and animal materials. Gordon and Breach science publisher, New York. Vol. 1:1-742.
- Nkang. A., Omokaro. D., Egbe A. and Amanke, G. (2003) Variations in fatty acid proportion during desiccation of *Telfairia Occidentalis* seeds harvested at physiological and agronomic maturity. Afr. J. Biotechnol, 2 (2): 33 – 39.

- Odewole, M.M., Sunmonu, M.O., Obajemihi, O.I and Owolabi, T.E (2015). Extraction of Oil from Fluted Pumpkin Seed (*Telfairia Occidentalis*) by Solvent Extraction Method. Annals. Food Science and Technology (AFST) Journal. Vol. 16(2): 372-378.
- Oje, K and Ugbor, E.C., (1991). Some physical properties of oil bean seed. Journal of Agricultural Engineering research. Vol.50:305-313.
- Oje, K, (1993). Locust bean pods and seeds; some physical properties of relevant to dehulling and seed processing. Journal of food science and technology. Vol. 30(4): 233-255.
- Ojiako, O.A. and Igwe, C.U. (2008). The nutritive, anti-nutritive and hepatotoxic properties of *Trichosanthes anguina* (Snake tomato) fruits from Nigeria. Pakistan J. Nutr. Vol.7 (1): 85– 89.
- Olalusi, A.P. and Bolaji, O.T. (2011): Moisture level effect on some engineering properties of bush mango nut. Electronic journal of Environmental Agricultural and Food Chemistry. Vol. 10(8):2759-2777.
- Olaoye, J.O. (2000). Some physical properties of castor nut relevant to the design of processing equipment. Journal of Agricultural Engineering research. Vol. 77(1):113-118.
- Olatunji, O.M., Akor, A.J and Akintayo, C.O (2011). Analysis of Some Physio-Chemical Properties of Milk Bush (*Thevetia peruviana*) Seed. Electronic Journal of Environmental, Agricultural Food Chemistry. Vol. 10(2): 1952-1957.
- Sacilik, K. Ozturk, B and Keskin R (2003). Some physical properties of hemp seed. Biosystems Engineering. Vol.86 (2): 191-198.
- Sunmonu, M.O., Iyanda, M.O., Odewole, M.M., Ajala, E.O., Moshood, A.N and Aduba, J.J (2016): Determination of Some Physical Properties of Almond Seed Related to the Design of Food Processing Machine. Nigerian Journal of Pure and Applied Sciences (NJPAS).. Vol 29(1): 2730-2740. DOI: <http://dx.doi.org/10.19240/njpas.2016.A13>
- Sydenham, D. (1985). Success in vegetable production. 1st edition. Macmillan London, p.23.