DOI: http://dx.doi.org/10.4314/star.v4i3.29
ISSN: 2226-7522(Print) and 2305-3372 (Online)
Science, Technology and Arts Research Journal
Sci. Technol. Arts Res. J., July-Sep 2015, 4(3): 187-191
Journal Homepage: http://www.starjournal.org/

Original Research

Determination of Some Mechanical Properties of Ugu Seed *(Telfairia occidentalis)* in Relation to the Design of Cracking Machine

Michael Mayokun Odewole[1*], Oluwatosin Adedamola Adesoye [2] and Oluwatosin Adesola Shadare[1]

[1]Department of Agricultural and Biosystems Engineering, Faculty of Engineering and Technology, University of Ilorin, PMB 1515, Ilorin, Kwara State, Nigeria

[2] Department of Mechanical Engineering, Faculty of Engineering and Technology, University of Ilorin, PMB 1515, Ilorin, Kwara State, Nigeria

Abstract

Ugu (*Telfairia occidentalis*) seeds contain valuable oil and other important by-products. Before the oil can be extracted, it has to pass through some processes like depoding, size reduction, cracking etc. The parameters needed in form of engineering properties of the seed to design and construct the processing, storage and handling equipment are not readily available. Therefore, this study was done to determine the following mechanical properties; force at break, energy to break, strain at break and stress at break. Three varieties of seeds (NHTo-1, NHTo-2 and NHTo-3) procured from National Horticultural Research (NIHORT) Institute Ibadan, Nigeria were used. 50 samples from each variety were selected at moisture content 67.734% (wb) and used. Universal Testing Machine (Testometric M500-100AT, 100kN) was used to determine all the mechanical properties. Result showed that the range of mean values at different orientations of diameters were as stated in the brackets: on the major diameter, force at break (28.400±14.064N to 224.857±129.892N); energy at break (0.097±0.044Nm to 0.526±0.481N), strain at break (2.209±0.841% to 11.079±6.672%) and stress at break (0.133±0.069 N/mm² to 1.577± 0.837 N/mm²). On the intermediate diameter, the force at break was (233.667±134.616N to 2043.857±1050,785 N), the energy at break was (0.520±0.054 Nm to 2.604±0.910 Nm), the strain at break was (3.739 ±1.345% to 35.069±10.629%), and stress at break (0.225±0.111 N/mm² to 2.040±0.964 N/mm²). On the minor diameter, the force at break was (53.500± 47.964 N to 363.857±107.606 N); the energy at break was (0.095±0.044 Nm to 1.040 ± 0.548 Nm), the strain at break was (1.909±0.586 to 12.813±3.995 %) and the stress at break was (0.412±0.421 N/mm² to 2.672±0.838 N). NHTo-1 seed variety gave the best crack and did least damage to the kernel on the minor diameter with the mean values of force at break of 53.500±47.964 N.

Article Information

Article History:
Received : 03-06-2015
Revised : 04-09-2015
Accepted : 23-09-2015

Keywords:
Mechanical properties
Varieties
Ugu seed
Force at break
Energy to break
Strain at break
Stress at break

***Corresponding Author:**
Michael Mayokun Odewole

E-mail:
odewole2005@yahoo.com

INTRODUCTION

Fluted pumpkin (*Telfairia Occidentalis*) is popularly called “Ugu” by the Igbo ethnic group of Eastern Nigeria. It is a creeping leafy vegetable that spreads low across the ground with large lobed leaves, and long twisting tendrils (Horsfall and Spiff, 2005; Christian, 2006; Ojiako and Igwe, 2008). In some West African countries (Ghana, Nigeria and Sierra Leone), the vegetable is usually grown for its commercial values (Nkang *et al*., 2003).

Grubben and Denton (2004) reported that the oil from the seed can be used as drying oil for paints and varnishes. In terms of food values, Alegbejo (2012) submitted that the high value of amino acids in Ugu seed is comparable with that of soybean meal with 95% biological value; and the young leaves of the plant contain the anti-nutrients cyanide at 60 mg/100 g dry matter and tannins at 41 mg/100 g dry matter.

An in-depth knowledge of mechanical properties of food, agricultural and other biological materials is very important when dealing with stress distribution under load. These properties are needed when designing size grading machine in electrostatic separation of grain and seed in colour evaluation (Mohsenin, 1970).

Mechanical properties of agricultural, food and other biological materials are those having to do with behavior of materials under applied forces. Mechanical properties are required to design equipment for proper handling, conveying, separation, drying, aeration, storing and processing of agricultural, food and other biological materials.

The seed (Ugu Seed) contains valuable oil and other useful by-products. Before the oil can be extracted, it has to pass through some operations like handling, cracking, separation, size reduction etc. The parameters needed in form of engineering properties of the seed to design and construct effective processing, storage and handling equipment are not readily available. Therefore, the objective of this study was to determine some selected mechanical properties (force, energy, strain and stress) of Ugu seed with particular emphasis on the properties determined at the point of break.

MATERIALS AND METHOD

Experimental Equipment

The equipment used for the study was Universal Testing Machine (Testometric M500-100AT, 100kN) at the National Centre for Agricultural Mechanization, Ilorin-Lokoja, Express Way, Kwara State, Nigeria.

Procurement and Selection of Experimental Materials

The material used was Ugu seeds (*Telfairia Occidentalis*). Matured pods (13 weeks old) containing the seeds were procured from the National Horticultural Research Institute (NIHORT) Ibadan, Nigeria. Three seed varieties were procured for the experiment. The seeds (Figure 1) were classified according to NIHORT standard based on the shape of the pods 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: From left to right (NHTo-1, NHTo-2 & 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. All the seeds were then fairly sun dried and the moisture content was estimated and the average value was 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. Figure 2 and 3 show the seeds before and after drying respectively.

Figure 2: Seeds before drying

Figure 3: Seeds after drying

Determination of Mechanical Properties of Ugu Seeds

The mechanical properties were determined with the aid of a Universal Testing Machine (Testometric M500-100AT, 100kN) at the laboratory of the National Centre for Agricultural Mechanization (NCAM), Ilorin-Lokoja Expressway Kwara State, Nigeria. All the mechanical properties were determined on the principal diameters (i.e. minor, intermediate and major) for each of the seed variety. 50 seeds were used under each variety on the principal diameter.

Figure 4: Major diameter

Figure 5: Minor diameter

Figure 6: Intermediate diameter

RESULTS

Summary of results on major, intermediate and minor diameters for three varieties used are presented in Tables 1, 2 and 3 respectively. Comparison of results between the three varieties(NHTo-1, NHTo-2 and NHTo-3) and on the diameters for energy at break, force at break, strain at break and stress at break are presented in Figures 7, 8, 9 and 10 respectively. From the tables and figures, there were variations in the values of mechanical properties of emphasis i.e energy at break, force at break, strain at break and stress at break. These variations could basically be due to the influence of seed varieties in the sense that, the three varieties may not have the same characteristics even though they are from the same crop family.

Table 1: Summary of determined mechanical properties on major diameter

Properties	NHTo-1	NHTo-2	NHTo-3
Force at Peak (N)	76.545±0.841	163.143±59.575	240.000±123.160
Force at Yield (N)	51.455±23.054	136.571±49.030	99.286±56.588
Force at Break (N)	28.400±14.064	120.857±77.823	224.857±129.892
Deformation at Peak (mm)	1.604±0.561	1.276±0.658	3.461±2.323
Deformation at Yield (mm)	0.786±0.227	0.875±0.412	1.140±0.852
Deformation at Break (mm)	2.209±0.841	1.574±0.633	3.656±2.202
Strain at Peak (%)	1.604±0.561	4.252±2.194	10.489±7.040
Strain at Yield (%)	0.786±0.227	2.916±1.374	3.455±2.582
Strain at Break (%)	2.209±0.841	5.247±2.108	11.079±6.672
Stress at Yield (N/mm²)	0.236±0.104	0.719±0.231	0.678±0.349
Stress at Break (N/mm²)	0.133±0.069	0.634±0.404	1.557±0.837
Stress at Peak (N/mm²)	0.350±0.072	0.859±0.292	1.666±0.801
Young's Modulus (N/mm²)	34.441±10.164	29.850±10.450	22.026±11.271
Energy to Break (Nm)	0.097±0.044	0.17±0.1093	0.526±0.481
Energy to Peak (Nm)	0.073±0.028	0.141±0.097	0.497±0.497
Energy to Yield (Nm)	0.024±0.019	0.074±0.064	0.087±0.116

Table 2: Summary of determined mechanical properties on intermediate diameter

Properties	NHTo-1	NHTo-2	NHTo-3
Force at Peak (N)	304.000±103.116	1978.286±881.598	2069.143±1027.751
Force at Yield (N)	157.000±155.251	1509.714±1130.125	1719.571±1204.114
Force at Break (N)	233.667±134.616	1887.286±831.053	2043.857±1050.785
Deformation at Peak (mm)	3.680±1.303	3.499±1.021	4.060±1.092
Deformation at Yield (mm)	1.350±0.364	2.709±1.360	2.942±1.061
Deformation at Break (mm)	3.739±1.345	3.565±0.967	4.208±1.275
Strain at Peak (%)	3.680±1.303	26.914±7.856	33.830±9.101
Strain at Yield (%)	1.350±0.364	20.842±10.461	24.517±8.840
Strain at Break (%)	3.739±1.345	27.422±7.439	35.069±10.629
Stress at Yield (N/mm²)	0.148±0.136	1.623±1.250	1.679±1.072
Stress at Break (N/mm²)	0.225±0.111	2.003±0.918	2.040±0.964
Stress at Peak (N/mm²)	0.297±0.076	2.101±0.976	2.066±0.941
Young's Modulus (N/mm²)	10.249±7.419	9.034±4.379	6.866±3.302
Energy to Break (Nm)	0.520±0.056	2.551±1.160	2.604±0.910
Energy to Peak (Nm)	0.506±0.054	2.468±1.102	2.517±1.033
Energy to Yield (Nm)	0.127±0.152	1.640±1.422	1.781±1.289

Table 3: Summary of determined mechanical properties on minor diameter

Properties	NHTo-1	NHTo-2	NHTo-3
Force at Peak (N)	89.100±30.079	309.000±182.339	395.714±98.573
Force at Yield (N)	43.700±20.210	181.429±171.908	193.143±85.300
Force at Break (N)	53.500±47.964	233.571±171.267	363.857±107.606
Deformation at Peak (mm)	1.724±0.591	3.447±1.596	4.200±1.324
Deformation at Yield (mm)	0.621±0.276	1.821±1.666	1.513±0.822
Deformation at Break (mm)	1.909±0.586	3.729±1.699	4.356±1.358
Strain at Peak (%)	1.724±0.591	9.071±4.201	12.354±3.894
Strain at Yield (%)	0.621±0.276	4.792±4.385	4.450±2.416
Strain at Break (%)	1.909±0.586	9.813±4.472	12.813±3.995
Stress at Yield (N/mm²)	0.345±0.187	1.573±1.533	1.401±0.581
Stress at Break (N/mm²)	0.412±0.421	2.016±1.522	2.672±0.838
Stress at Peak (N/mm²)	0.695±0.276	2.653±1.580	2.911±0.797
Young's Modulus (N/mm²)	42.640±20.721	26.721±4.391	29.536±10.877
Energy to Break (Nm)	0.095±0.044	0.765±3.409	1.040±0.548
Energy to Peak (Nm)	0.089±0.043	0.694±0.606	0.985±0.520
Energy to Yield (Nm)	0.016±0.012	0.302±0.508	0.195±0.181

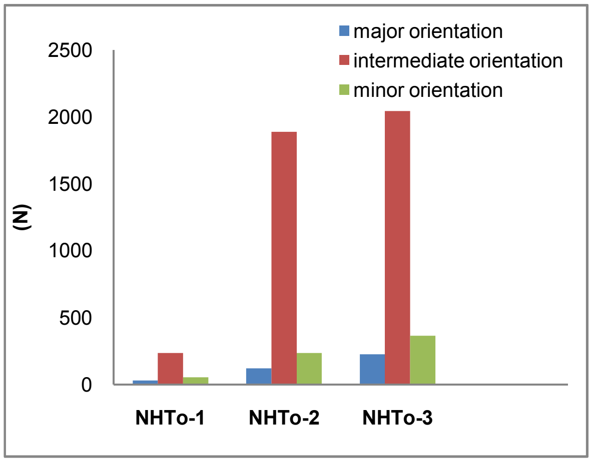

Figure 7: Force at Break Comparison

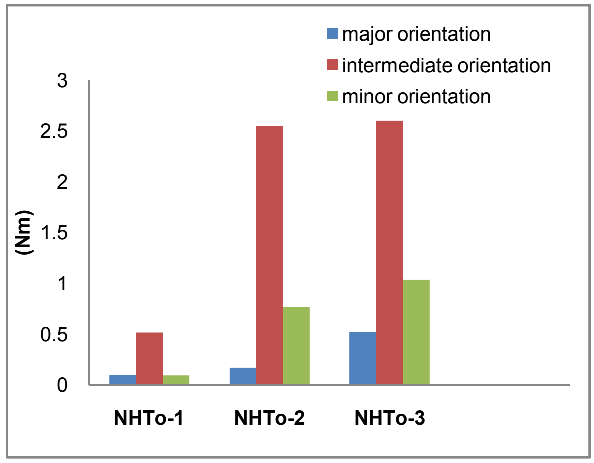

Figure 8: Energy to Break Comparison

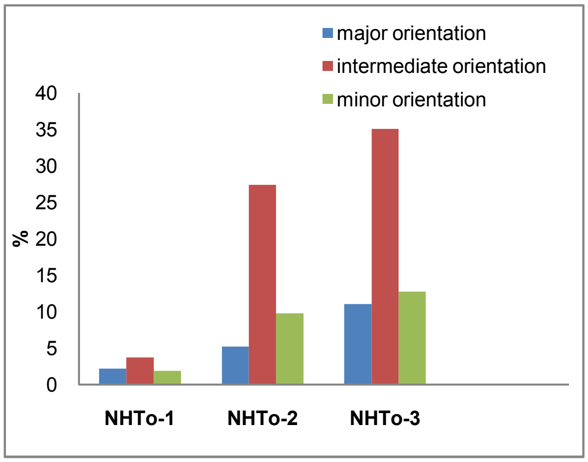

Figure 9: Comparison of strain at break

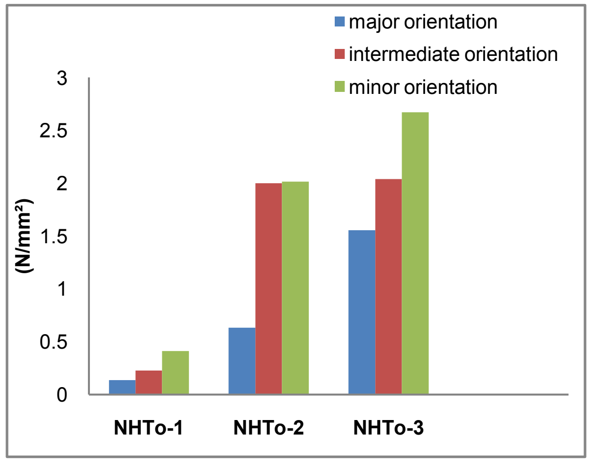

Figure 10: Comparison of stress at break

DISCUSSION

Force at Break

The comparison of the force at break is presented in Figure 7. From the figure, it is clearly seen that the highest values of force at break is noticed at the intermediate diameter for all the three varieties of seed. Although, NHTo-3 variety, required the highest force at break compared to other two varieties (NHTo-1 and NHTo-2). From Tables 1, 2 and 3, NHTo-1 had the lowest force at break on major diameter with mean value of 28.400 ± 14.064 (N) and highest force on the intermediate diameter with a value of 233.667±134.616 (N). This pattern was also noticed for other two varieties with the following mean values (lowest and highest) on major and intermediate diameters respectively: NHTo-2 (120.857± 77.823 (N) and 1887.286±831.053 (N)) and NHTo-3(224.857±129.892 (N) and 2043.857±1050.785 (N)). All the values of force obtained were lower than what Dagwa and Ibhadode (2008) got in the determination of mean rupture force (3174.52±270.70 – 3884.61±878.16 N) for palm kernel shell. The mean fracture force required for breaking palm fruit, kernel and nut were reported to be 0.39N, 11N and 0.92N respectively by Davies (2012); while Owolarafe *et al*. (2007) reported values of 2301N and 1149N for breaking dura and tenera palm kernel varieties. For almond seed, Aktas *et al*. (2007) said the force needed to rupture the seed was between 533.4N and 126.9N.

Energy at Break

Figure 8 shows the comparison of energy to break the seed. From the figure, the highest energy to break was obtained on the intermediate diameter for the three seed varieties with major diameter having the lowest. From Tables 1, 2 and 3, NHTo-1, NHTo-2 and NHTo-3 have the following determined values of energy at break on their diameters respectively: major diameter (0.097±0.044 Nm, 0.170±1.093 Nm and 0.526±0.481Nm); intermediate diameter (0.520±0.056, 2.551±1.160 and 2.604±0.910 Nm); minor diameter (0.095±0.044Nm, 0.765±3.409Nm and 1.040±0.548Nm). Khazaei (2008) reported that the energy required to break almond was 443 MJ.

Strain at Break

The comparison for strain at break of the seed is shown Figure 9. From the figure, the intermediate orientation of the diameter gave highest values of strain at break for all the three varieties of seed. From Tables 1, 2 and 3, NHTo-1, NHTo-2 and NHTo-3 have the following determined values of strain at break on the orientation of their diameters respectively: major (2.209±0.841, 5.247± 2.108 and 11.079±6.672 %), intermediate (3.739±1.345, 27.422±7.439 and 35.069±10.629 %) and minor (1.909±

0.586, 9.813±4.4721 and 12.813±3.995 %). Mayor *et a*l., (2007) reported that the range of failure strain of fresh pumpkin was 0.42-0.71. Also, Sunmonu *et al*., (2015) reported a range of 19.74–38.58 for white and red almond seed.

Stress at Break

From Figure 10, NHTo-1 has the lowest stress at break among the three varieties at all the three orientations of seed diameter. Also, NHTo-3 gave the highest stress at break on the minor orientation of the diameter. From Tables 1, 2 and 3, NHTo-1, NHTo-2 and NHTo-3 have the following determined values of stress at break on the orientation of their diameters respectively: major (0.133±0.069, 0.634±0.404 and 1.557±0.837 N/mm²); intermediate (0.225±0.111, 2.003±0.918 and 2.040±0.964 N/mm²) and minor (0.412±0.421, 2.016± 1.522 and 2.672±0.838 N/mm²).

CONCLUSIONS

The following conclusions were deduced from the determination of the mechanical properties of Ugu Seed; the mean values of mechanical properties (force, energy, strain and stress at break) on the major, intermediate and minor diameters increased from NHTo-1 to NHTo-3.

The ranges of mean values at different orientations of diameters were as stated in the brackets: on the major diameter, the force at break was (28.400±14.064 to 224.857±129.892 N), the energy at break was (0.097± 0.044 Nm to 0.526±0.481Nm), the strain at break was (2.209±0.841 to 11.079±6.672 %) and the stress at break was (0.133±0.069 to 1.577±0.837 N/mm²). On the intermediate diameter, the force at break was (233.667± 134.616 to 2043.857±1050,785 N), the energy at break was (0.520±0.054 to 2.604±0.910 Nm), the strain at break was (3.739 ±1.345 to 35.069±10.629%), and the stress at break was (0.225±0.111 to 2.040±0.964 N/mm²). On the minor diameter, the force at break was (53.500±47.964 to 363.857±107.606 N), the energy at break was (0.095± 0.044 to 1.040±0.548 Nm), the strain at break was (1.909± 0.586 to 12.813±3.995 %), and the stress at break was (0.412±0.421 to 2.672±0.838 N/mm²).

NHTo-1 seed variety gave the best crack and did least damage to the kernel on the minor diameter with the mean values of force at break of 53.500±47.964 N. The implication of this is that when a machine for cracking is to be designed and constructed, ugu seeds should be fed into the cracking medium in such a way that would make them to receive the cracking force of 53.500±47.964 N on their minor diameter orientation.

Conflict of Interest

Authors declared no conflict of interest

Acknowledgements

Authors wish to strongly acknowledge the National Horticultural Research (NIHORT) Institute Ibadan, Nigeria for the classification of seed varieties used and the National Centre for Agricultural Mechanization, Ilorin-Lokoja, Express Way, Kwara State, Nigeria for providing a highly conducive environment for the experiment.

REFERENCES

Aktas, T., Pola, R and Atay, V. (2007). Comparison of Mechanical Properties of some Selected Almond Cultivars with Hard and Soft Shells under Compression Loading. *Journal of Food Engineering*. 30(6): 773-789.

Alegbejo, J.O .(2012). Production, Marketing, Nutritional Value and Uses of Fluted Pumpkin(*Telfairia Occidentalis* Hook. F). *Journal of Biological Science and Bioconsevation* 4: 20-24.

Christian, A. (2006). Studies of Selected Physicochemical Properties of Fluted Pumpkin (*Telfaria Occidentalis* Hook F.) Seed Oil and Tropical Almond (*Terminalia Catappia, L.*) Seed Oil. *Pakistan Journal of Nutrition* 5(4): 306-307.

Dagwa, I.M., and Ibhadode, A.O. (2008). Some Physical and Mechanical Properties of Palm Kernel Shell (PKS). *Botswana Journal of Technology* 17(2): 1019-1593.

Davies, R.M. (2012). Physical and Mechanical Properties of Palm Fruit, Kernel and Nut. *Journal of Agricultural Technology* 8(7): 2147-2156.

Grubben, G.J.H., and Denton, O.A. (2004). Plant Resources of Tropical Africa 2 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* 52: 174-181.

Khazaei, J. (2008). Characteristics of Mechanical Strength and Water Absorption in Almond and its Kernel. *Cerciteria Agronimice in Moldova* 41(1): 37-51.

Mayor, L., Cunha, R.L. and Sereno, A.M. (2007). Relation between Mechanical Properties and Structural Change during Osmotic Dehydration of Pumpkin. *Food Research International* 40: 448-460.

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. *African Journal of Biotechnology* 2(2): 33-39.

Ojiako, O.A. and Igwe, C.U. (2008). The Nutritive, Anti-Nutritive and Hepatotoxic Properties of *Trichosanthes Anguina* (Snake Tomato) Fruits from Nigeria. *Pakistan Journal of Nutrition* 7(1): 85-89.

Owolarafe, O.K., Olabiye, M.T., and Faborode, M.O. (2007). Physical and Mechanical Properties of Two Varieties of Fresh Oil Palm Fruit. *Journal of Food Engineering* 78: 1228-1232.

Schippers, R.R. (2002). African Indigenous Vegetables, an Overview of the Cultivated Species 2002. Revised edition on CD-ROM. National Resources International Limited Aylesford, United Kingdom.

Sunmonu, M.O., Iyanda, M.O., Odewole, M.M and Moshood, A.N (2015). Determination of Some Mechanical Properties of Almond Seeds Related to Design of Food Processing Machine. *Nigerian Journal of Technological Development* 12(1): 22-26.