An Investigation into Some Engineering Properties of Dracaena *arborea* Nuts

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Abstract

Meeting the food and energy needs of the ever-increasing population has always being a challenge. Due to this unending demand, there is a need to explore some crops which were hitherto underutilized. Among the plant which could play major role in this crop diversification is *Dracaena arborea.* This study investigates some engineering properties of *Dracaena arborea*, a plant that is currently being underutilized. The result shows that among other properties determined, the $624\ kg/m^3$ and $668\ kg/m^3$ density values at 9.6% and 18% moisture content (mc) values obtained for *Dracaena arborea* compare with those of popular oil seeds. The maximum breaking forces which were 3724N, 4079N, and 7371N for major, minor and intermediate axes respectively, show that the breaking force for intermediate axis would be use in the design of size reduction mechanism. Also, the maximum breaking energy of 34.4 joule was obtained at intermediate axis would be considered when selecting electric motor for the crushing of *Dracaena arborea* nuts.

Keywords: Underutilized crops, *Dracaena arborea*, Dracaena nuts, engineering properties, breaking energy.

1. Introduction

Neglected or underutilized crops have the potential to play a number of roles in the improvement of food security and in combating the negative effects of climate change. Underutilized crops are often indigenous ancient crop species which are still used at some level within the local or international communities but have the potential to contribute further to food and energy source than they currently do (Mayes *et al*., 2011). In this age of bio-based economy, great efforts are now being expended in both basic and applied research to develop useful products from agriculture that replace those form petroleum (Mickeon, 2016). At the global level, over 80 % of the primary energy being consumed is derived from fossil fuels, and roughly 58 % of it is being consumed in the transportation sector (Escobar *et al*., 2008). Due to its risk of depletion, emission of greenhouse gases and environmental degradation are challenges posed by fossil fuel, efforts are now been geared towards alternative source of energy. Among the hitherto underutilized crops that have gained recognition in the recent time are jatropha, castor and jojoba. However, statistics relating to the crop usage reveals that there are arrays of crops that are still being underutilized.

Currently, only about 30 crop species provide 95% of the world's food energy whereas over 7000 species have been known to be used for food and are either partly or fully domesticated. This large array of plant species spans those recognized to be underutilized to those that are recognized as important minor crops. However, with modernization of agricultural practices many have become neglected due to their being held in low esteem and some have been so neglected that genetic erosion of their genepools has become so severe that they are often regarded as lost crops. Underutilized crops are found in numerous agricultural ecosystems and often survive mainly in marginal areas and in recent decades, a number of scientific and economic interests have emerged which focus on lesser-known cultivated species. Underutilized crops are usually considered in relation to their end-use and end-uses are usually grouped into categories: beverage, cereal, oil, spice and flavouring, fruit, vegetable etc. However, the majority of underutilized crops are multipurpose. Probably most underutilized crops for gums, resins, oils and beverages tend to have less than 5–6% of the species with a single use; those for cereals and medicinals somewhat higher, up to 10–11% with predominately a single use; vegetables and tubers up to 16–17% with a single use; and spices and fruits being special categories with about 25% single use (Mayes *et al*., 2011; Williams and Haq, 2002). Among numerous crops that are being grown worldwide or those that grow on their own in the wild is Dracaena.

Dracaena, a genus in the family Agavoideae is one of the most popular and diverse families in the ornamental plant world which compose about 120 species of trees and succulent shrubs (Zona *et al.*, 2014). The discovery of Dracaena in the new world was not made until the waning years of the 19th Century. The first collection of the species now known as *D. americana* and the discovery was made by Carl Thieme in May, 1888 who collected specimens for John Donnell Smith, a prolific botanical explorer of Central America, who distributed the specimens to numerous herbaria. The discovery of Dracaena in Cuba was more recent: The first collections (NY1402323 and NY1402324) were made by John A. Shafer, head horticulturist for the New York Botanical Garden, in eastern Cuba in 1910 and

1911. Unlike most monocots, Dracaenas are evergreen shrubs or trees most frequently characterized by long linear leaves often on unbranched stems or trunks. Mature heights reach from two to over 50 feet. One species, *D. americana*, is indigenous from Mexico to Costa Rica; all other species are native to Africa, India, Madagascar, or islands in the South Pacific. Cultivated species, excluding D. draco that may be grown for its red resin, are grown for their ornamental value (McConnell, *et al*., 2018).

Dracaena had been placed within in the family Liliaceae (Lu and Morden, 2010). Among the characteristics that support this includes a superior ovary; leaves that are not twisted at base; bulbs present; fruits being fleshy, etc. However, this classification is no longer used because Dracaena species are woody and flowers have six stamens, unlike the typical herbaceous Liliaceae. Others have classified Dracaena in the family Agavaceae based on the features of flowers with 6 stamens, paniculate inflorescences, and plants with rosettes of fleshy fibrous leaves (Lu and Morden, 2010; Staples and Herbst, 2005). However, the ovary in Dracaena is superior, unlike other Agavaceae, and this classification is also no longer used. Dracaena has been classified within the family Ruscaceae since 2003 (APGII 2003; Judd *et al*., 2007). However, currently, Ruscaceae is combined into the larger family Asparagaceae based on Angiosperm Phylogeny Group III system (APG 2009) because the research group's conclusion of uniting those confusing families into the same family when they do not show too much distinct from each other in the molecular data. Thus, Dracaena and Pleomeleare replaced into the family Asparagaceae (Lu and Morden, 2010).

Dracaena is a genus of about 120 species of trees and succulent shrubs. Majority of the species are native to Africa, with a few in southern Asia through to northern Australia with teo species in Central America. The common species among those identified by University of Melbourne (2003) are *Dracaena afromontana (dragon tree), Dracaena Americana (Central America dragon tree), Dracaena aletriformis, Dracaena arborea (tree Dracaena), Dracaena aubryana, Dracaena aurea, Dracaena cinabari (Canary Island dragon tree), Dracaena ellenbeckiana (Kedon Dracaena), Dracaena fragrans (stripped Dracaena), Dracaena ombet (Gaabal Elba dragon tree), Dracaena refexa (Song of India), and Dracaena serrulata*. However, the common specie native to Africa is *Dracaena arborea*.

Dracaena are typically propagated by vegetative methods which can incorporate many different processes. The most common types are tip cuttings, stem cuttings, air layers as well as cane production depending on the species. In all methods rooting is relatively easy process for Dracaena (GPN, 2019).

Dracaena is a mainly used owing to its ornamental value, air purification and healing of several health problems. The obvious reason for adopting Dracaena shrubby species such as *D. fragrans*, *D. godseffiana*, *D. braunii* and *D. dermensis* is that most of the species are toxic to pets but not to humans. Other than that, most people use Dracaena mostly for health benefits they offer. Also, Dracaena plant leaves absorb and destroy various organic chemicals through a process known as metabolic breakdown. Dracaena helps in reducing the concentration of formaldehyde, benzene, trichloroethlene, and carbon monoxide. A study conducted in University of Agriculture in Norway concluded that houseplants such as Dracaena can reduce fatigue, sore throats, coughs and a range of other illness related to cold (NCNG, 2016).

Based on the abundance of *Dracaena arborea* in the forests of Ekiti State Nigeria and from literature surveys which reveal lack of research articles on *D. arborea*, this plant was chosen as the plant of interest for this study. Since the long term goal of the research is to design a machine for the processing of Dracaena nuts, the determination of its engineering property would help in the choice of the appropriate techniques for it processing. Also, the engineering property would help bring out the crushing energy requirement towards making decision about energy cost if mechanical method were to be used for expelling oil. This study therefore investigates some engineering properties of Dracaena nuts with a view to have data that will serve as input factor in the design of machine for the processing of the Dracaena nuts. The engineering properties include physical, mechanical, rheological, aerodynamic, hydrodynamic and thermal properties. However, this study focuses on some engineering properties that serve as input factors in the design of Dracaena seed processing machines.

2. Materials and Methods

2.1 *Material Sourcing and Sampling Preparation*

The species of Dracaena used for this study is *Dracaena arborea*. The seeds of *Dracaena arborea* used were sourced from the forests of Ire-Ekiti in Ekiti State, Nigeria. The sampling design used for experimental process was purposive sampling. After harvest fruit harvest, its exocarp and mesocarp were removed leaving only the nut. To test for the physical properties of the nuts were cleaned thereafter sorted into small, medium and large based on the sizes. The Dracaena nuts were then placed under a shed and exposed to air to prevent deterioration and give room for natural drying and some were oven dried. To select the samples for the experiment, four nuts were randomly selected from each of the groups. To test for the mechanical properties, the nuts were compressed along the three orientation – major axis, minor axis and the intermediate axis.

2.2 Physical Properties Determination

The physical properties of *Dracaena arborea* such as arithmetic mean diameter, area, bulk volume, angle of repose, bulk density and moisture content were determined using the methods used are illustrated below.

2.2.1 *Arithmetic mean diameter*

To measure the size of the Dracaena nuts, the seed were placed in the were measured using Vernier calliper. The major, minor, and intermediate lengths were measured and recorded as l, b, t, respectively for the seed being considered.

2.2.2 Determination of area

Since the shape of the Dracaena nuts ranges from spherical to irregular, the surface area of those that are spherical were determined using the Equation 1 below while for those that are of irregular shape, the shape were traced carefully and the traced shape was divided into even number of equal-width strips (width), the ordinates were numbered and each ordinate was measured y_1, y_2, y_3, …, $y_{n+1,}$ Equation 2 was applied in the determination of the area (Stroud and Booth, 2001; BMC, 2019).

$$A=\frac{\pi d^2}{4} \quad \ldots. \qquad 1$$

Where

A= area of object

d = diameter of object.

For nuts with irregular shapes,

$$A = \frac{S}{3}[(F + L) + 4E + 2R] \quad \ldots. \quad 2$$

Where

S = width of each strip

F = sum of first ordinates

L = sum of last ordinates

E = even-numbered ordinates

R = remaining odd-numbered ordinates

2.2.3 Bulk volume determination

In order to determine the volume, water displacement method was used. To do this, water was poured into eureka can up to the discharge outlet level. When water was no longer discharging, the materials wrapped inside a nylon were lowered gently inside eureka can. The water displaced by the materials was collected with a measuring cylinder and the volume of water displaced was taken as the volume of the materials, that is, the Dracaena nuts.

2.2.4 Angle of repose

The material (Dracaena nuts) whose angle of repose was to be determined was placed on the surface of the inclined plane and the upper plate was inclined gradually while the material was observed in order to know when it would slide. The angle at which the slid started was read on the scale. And this procedure was repeated three times.

2.2.4 Bulk density determination

The determination of bulk density is dependent of two parameters. They are mass and volume. To measure the mass, the materials were placed on the plate of the weighting balance and the mass was read on the display unit. The value of the bulk mass and volume were used to determine the bulk density using the relationship in Equation 3 below.

$$\rho = \frac{M}{V} \quad \ldots \quad 3$$

Where

ρ = Bulk density

M = Bulk mass

V = Bulk volume

2.2.5 Moisture content measurement

After the exocarp and mesocarp had been removed, the moisture meter was switched on and the test pins of the moisture meter were inserted into the nut. The moisture content value of the nut was read thereafter on the display unit.

2.3 Mechanical Properties Determination

The universal testing machine (UTM) was used to test the mechanical properties of a given test specimen by exerting tensile, compressive or transverse stresses. The UTM consist of two main parts which are the loading and control unit. For this experiment, M500 – 100AT UTM was used. The loading unit consisted of load frame which has a table where the specimen is placed for compression test, upper crosshead used for clamping one head of the specimen, and the lower crosshead that has screw for height adjustment and tightening; the elongated scale that measures the relative movement of the lower and upper table. The control unit consisted of hydraulic power unit that has an oil pump that provides non-pulsating oil flow to smoothen application of load on the specimen; the load measuring unit that has pendulum dynamometer connected to the piston by pivot lever that deflect based on load applied to the specimen. The range of load can be adjusted by means of a knob. The M500 – 100AT UTM also had control devices that make use of switches to move the crossheads and switch on/off the unit. Testing for the mechanical properties was done by compressing the nuts along the three orientation which were major axis, minor axis and the intermediate axis. For each of the axes, four nuts were selected at random. The nuts were then subjected to load (Plate 1) based on different orientations while each orientation had four replicates.

Plate 1: Dracaena nut under load

3. Results and Discussion

The physical features of *Dracaena arborea* are shown in Plates 2 – 4. Plate 2 shows a young *Dracaena arborea* plant with older ones in the background. In Plate 3 consist of the fruits after they have been detached from the parent plants. The nuts, after they mesocarp have been removed from are shown in Plate 4. Also, the summary of the physical properties measured and those determined which are presented in the Table 1 below.

Plate 2:*Dracaena arborea* plants

Plate 3: *Dracaena arborea* fruits

Plate 4: *Dracaena arborea* nuts

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Table 1: Physical properties of Dracaena nuts

S/N	Parameter	Value	
		$18\% \ m.c.$	$9.6\% \ m.c.$
1	Arithmetic mean diameter, d Major length, l	23.0 - 25.8mm	14.5 – 18.5mm
	Minor length, b	19.0 - 20.2mm	13.7 – 17.3mm
	Intermediate length, t	18.0 – 19.3mm	9.8 – 16.0mm
2	Area, A	$314.2 - 372.1mm^2$	$126.0 - 234.2mm^2$
3	Mass, m	$0.0254kg$	$0.0078kg$
4	Volume, V	$3.80 \times 10^{-5} m^3$	$1.25 \times 10^{-5} m^3$
5	Density, ρ	$668 \ kg/m^3$	$624 \ kg/m^3$
6	Moisture Content, M.C.	$18\% \ m.c.$, d.b.	$9.6\% \ m.c.$, d.b.

The axial compression, cracking energy and other mechanical properties using three orientations are presented below. The mechanical properties obtained for the Dracaena nuts along the major axis are presented in Table 2 while the force-defection curve is shown in Figure 4.1 below. The mechanical properties obtained for the Dracaena nuts along the minor axis are shown in Table 3 while the force-defection curve is presented in Figure 2 below. In Table 4 consists of the mechanical properties obtained for the Dracaena nuts along the intermediate axis while the force-defection curve is shown in Figure 3 below.

Table 2: Compressive force and energy for major axis

Test No	Time of Test	Force @ Peak (N)	Force @ Yield (N)	Force @ Break (N)	Def. @ Peak (mm)	Def. @ Yield (mm)	Def. @ Break (mm)	Strain @ Peak (%)	Strain @ Yield (%)
1	12/5 4:17 PM	2879.700	2879.700	2879.700	7.240	7.240	7.240	38.105	38.105
2	12/5 4:47 PM	2864.000	2864.000	2864.000	8.401	8.401	8.401	44.216	44.216
3	12/5 4:49 PM	4506.000	4506.000	4506.000	7.203	7.203	7.203	37.911	37.911
4	12/5 4:52 PM	4645.200	4645.200	4645.200	7.206	7.206	7.206	37.926	37.926
Min		2864.000	2864.000	2864.000	7.203	7.203	7.203	37.911	37.911
Mean		3723.725	3723.725	3723.725	7.512	7.512	7.512	39.539	39.539
Max		4645.200	4645.200	4645.200	8.401	8.401	8.401	44.216	44.216
S.D.		985.322	985.322	985.322	0.593	0.593	0.593	3.119	3.119
C. of V.		26.461	26.461	26.461	7.888	7.888	7.888	7.888	7.888
L.C.L.		2155.881	2155.881	2155.881	6.570	6.570	6.570	34.577	34.577
U.C.L.		5291.569	5291.569	5291.569	8.455	8.455	8.455	44.502	44.502

Test No	Strain @ Break (%)	Energy to Break (N.m)	Energy to Peak (N.m)	Energy to Yield (N.m)
1	38.105	10.498	10.498	10.498
2	44.216	11.911	11.911	11.911
3	37.911	14.625	14.625	14.625
4	37.926	15.368	15.368	15.368
Min	37.911	10.498	10.498	10.498
Mean	39.539	13.101	13.101	13.101
Max	44.216	15.368	15.368	15.368
S.D.	3.119	2.284	2.284	2.284
C. of V.	7.888	17.436	17.436	17.436
L.C.L.	34.577	9.466	9.466	9.466
U.C.L.	44.502	16.735	16.735	16.735

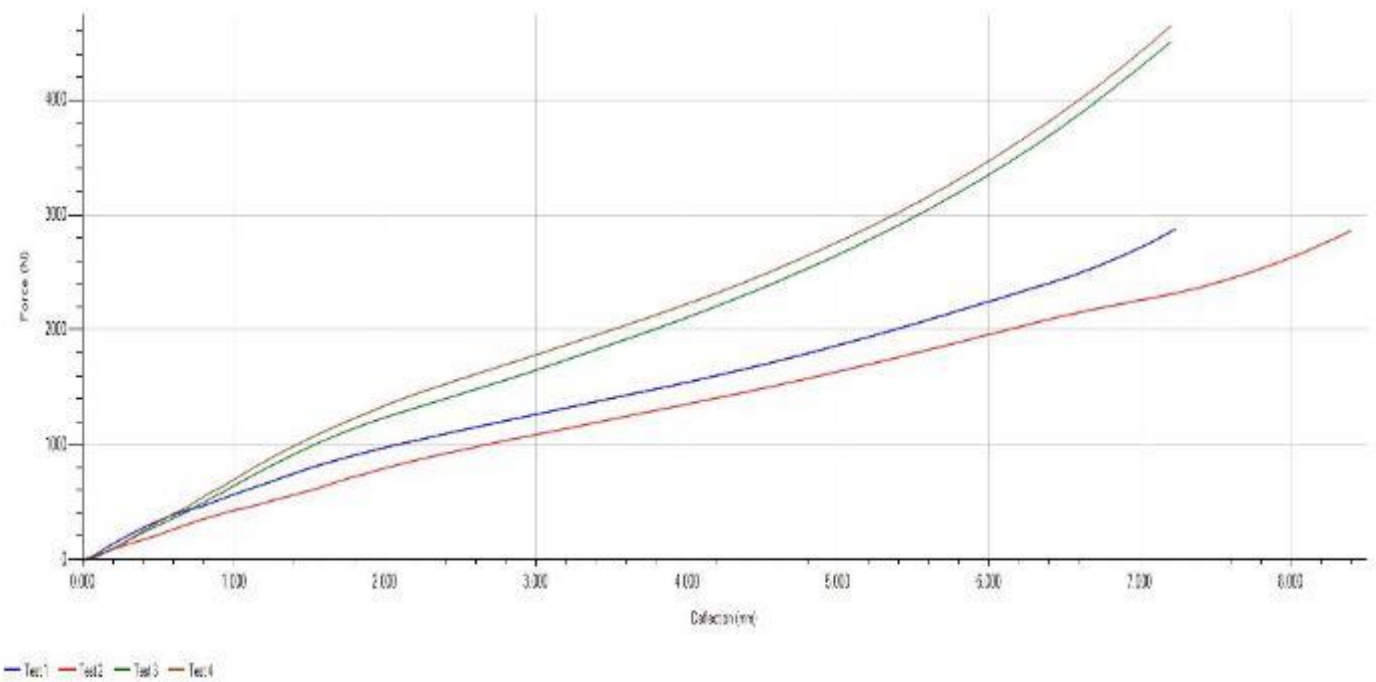

Figure 1: Force-deflection curve along major axis

Table 3: Compressive force and energy for minor axis

Test No	Time of Test	Force @ Peak (N)	Force @ Yield (N)	Force @ Break (N)	Def. @ Peak (mm)	Def. @ Yield (mm)	Def. @ Break (mm)	Strain @ Peak (%)	Strain @ Yield (%)
1	12/5 6:59 PM	3888.000	3888.000	3888.000	5.298	5.298	5.298	34.180	34.180
2	12/5 7:02 PM	4079.000	4079.000	4079.000	5.001	5.001	5.001	32.264	32.264
3	12/5 7:04 PM	3519.000	3519.000	3519.000	5.647	5.647	5.647	36.431	36.431
4	12/5 7:06 PM	2953.000	2953.000	2953.000	5.129	5.129	5.129	33.089	33.089
Min		2953.000	2953.000	2953.000	5.001	5.001	5.001	32.264	32.264
Mean		3609.750	3609.750	3609.750	5.269	5.269	5.269	33.991	33.991
Max		4079.000	4079.000	4079.000	5.647	5.647	5.647	36.431	36.431
S.D.		495.706	495.706	495.706	0.280	0.280	0.280	1.806	1.806
C. of V.		13.732	13.732	13.732	5.314	5.314	5.314	5.314	5.314
L.C.L.		2820.982	2820.982	2820.982	4.823	4.823	4.823	31.117	31.117
U.C.L.		4398.518	4398.518	4398.518	5.714	5.714	5.714	36.865	36.865

Test No	Strain @ Break (%)	Energy to Break (N.m)	Energy to Peak (N.m)	Energy to Yield (N.m)
1	34.180	8.873	8.873	8.873
2	32.264	9.152	9.152	9.152
3	36.431	9.045	9.045	9.045
4	33.089	7.705	7.705	7.705
Min	32.264	7.705	7.705	7.705
Mean	33.991	8.694	8.694	8.694
Max	36.431	9.152	9.152	9.152
S.D.	1.806	0.669	0.669	0.669
C. of V.	5.314	7.697	7.697	7.697
L.C.L.	31.117	7.629	7.629	7.629
U.C.L.	36.865	9.758	9.758	9.758

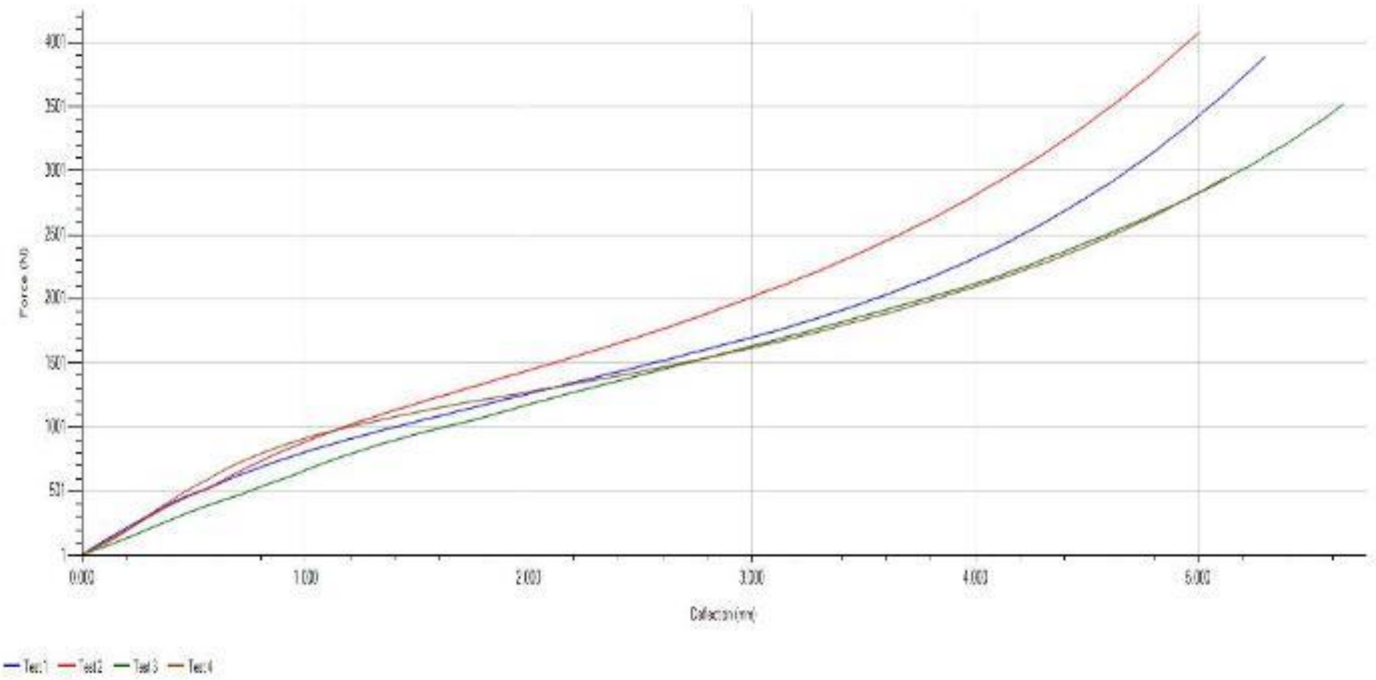

Figure 2: Force-deflection curve along minor axis

Table 4: Compressive force and energy for intermediate axis

Test No	Time of Test	Force @ Peak (N)	Force @ Yield (N)	Force @ Break (N)	Def. @ Peak (mm)	Def. @ Yield (mm)	Def. @ Break (mm)	Strain @ Peak (%)	Strain @ Yield (%)
1	12/5 6:40 PM	5942.000	5897.000	5938.000	10.276	10.037	10.283	51.379	50.184
2	12/5 6:43 PM	7158.000	7158.000	7158.000	11.072	11.072	11.072	55.359	55.359
3	12/5 6:48 PM	7321.000	7321.000	7321.000	11.355	11.355	11.355	56.774	56.774
4	12/5 6:52 PM	4545.000	4545.000	4513.000	8.723	8.723	8.851	43.614	43.614
Min		4545.000	4545.000	4513.000	8.723	8.723	8.851	43.614	43.614
Mean		6241.500	6230.250	6232.500	10.356	10.297	10.390	51.782	51.483
Max		7321.000	7321.000	7321.000	11.355	11.355	11.355	56.774	56.774
S.D.		1287.518	1291.198	1301.895	1.181	1.192	1.122	5.905	5.962
C. of V.		20.628	20.725	20.889	11.403	11.580	10.798	11.403	11.580
L.C.L.		4192.802	4175.695	4160.924	8.477	8.399	8.605	42.386	41.997
U.C.L.		8290.198	8284.805	8304.076	12.235	12.194	12.175	61.177	60.969

Test No	Strain @ Break (%)	Energy to Break (N.m)	Energy to Peak (N.m)	Energy to Yield (N.m)
1	51.414	29.907	29.865	28.455
2	55.359	33.361	33.361	33.361
3	56.774	34.487	34.487	34.487
4	44.254	21.131	20.552	20.552
Min	44.254	21.131	20.552	20.552
Mean	51.950	29.721	29.566	29.214
Max	56.774	34.487	34.487	34.487
S.D.	5.610	6.049	6.324	6.341
C. of V.	10.798	20.354	21.388	21.705
L.C.L.	43.024	20.096	19.504	19.124
U.C.L.	60.877	39.347	39.628	39.303

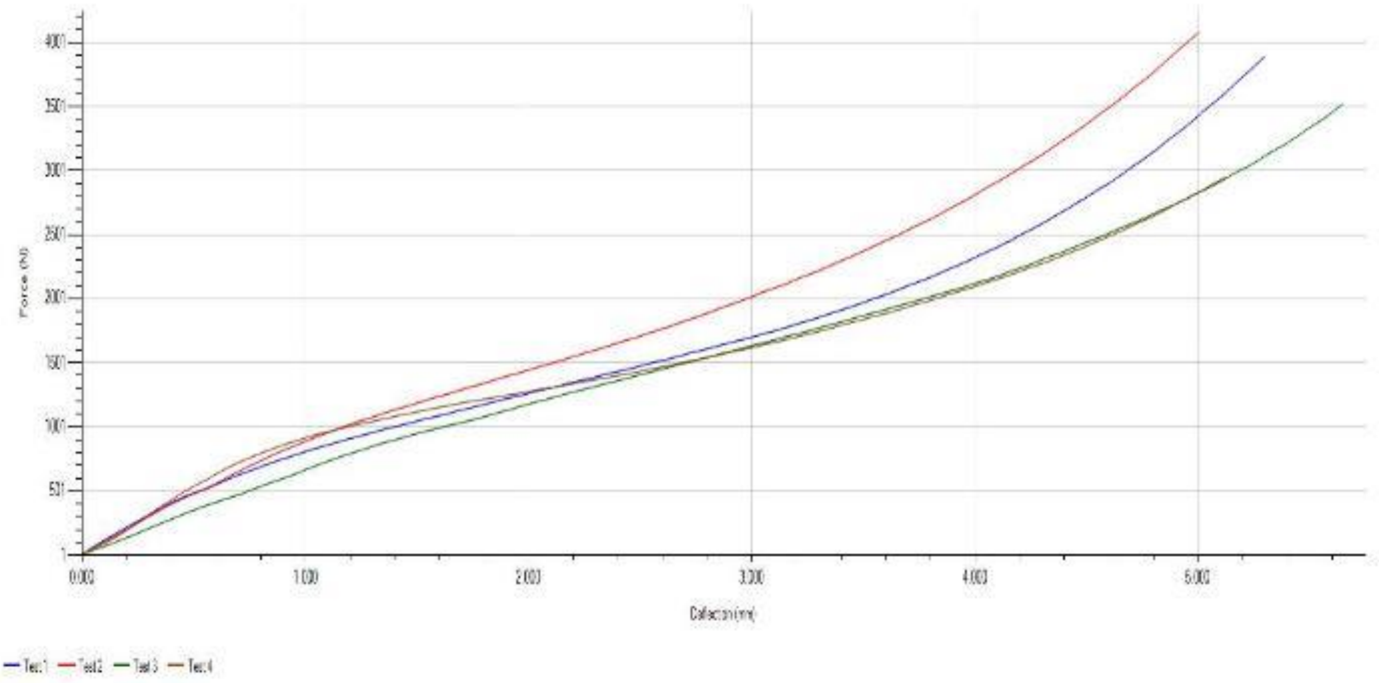

Figure 3: Force-deflection curve along intermediate axis

From study, it was observed that the Dracaena nuts have different shapes ranging from spherical to irregular. Having determined the arithmetic mean diameter, $126.0\ mm^2\ - 234.2mm^2$ and $314.2\ mm^2 -\ 372.1mm^2$ were obtained as the areas of the Dracaena nuts at 9.6% and 18% moisture content (mc), dry basis (d.b.) values. From the results obtained, the $624\ kg/m^3$ and $668\ kg/m^3$ density values at 9.6% and 18% moisture content, values, respectively obtained for Dracaena nuts, when compared to 983 kg/m^3 and 906 kg/m^3 at 8% and 16% mc values obtained by Kibar and Öztürk (2008), and 710 kg/m^3 for palm nuts obtained by Davies (2012) show that *Dracaena arborea* nut has density comparable to those of the popular oil seeds, that is, soybean and palm nut. The maximum breaking forces are 3724N, 4079N, and 7371N for major, minor and intermediate axis respectively. This shows that the breaking force for intermediate axis would be use in the design of size reduction mechanism. Also the highest breaking energy of 34.4 joule would be considered in the selection of electric motor for the size reduction machine.

4. Conclusions and Recommendations

An investigation into some engineering properties of *Dracaena arborea* nuts was carried out. The results shows that *Dracaena arborea* nuts has density comparable to those of popular oil seeds which makes it a potential for being used an oil seed. The maximum breaking forces are 3724N, 4079N, and 7371N for major, minor and intermediate axis respectively show that the breaking force for intermediate axis would be us in the design of size reduction mechanism. Also, the maximum breaking energy of 34.4 joule was obtained at intermediate axis would be considered when selecting electric motor for the crushing of *Dracaena arborea* nuts.

From the research work on an investigation into some engineering properties of *Dracaena arborea*, it is hereby recommended that elaborate studies should be carried out on the agronomical properties of the species of Dracaena in Nigeria with a view to broaden the literature which will serve as the basis for other studies.

References

APG (Angiosperm Phylogeny Group) (2003). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. *Botanical Journal of the Linnean Society*,141: 399–436.

APG (Angiosperm Phylogeny Group) (2009). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Botanical Journal of the Linnean Society*,141: 399–436.

BMC (2019). Area of irregular shapes. Basic-Mathematics.com. www.basic-mathematics.com

Davis, R. M. (2012). Physical and mechanical properties of palm fruit, kernel and nut. *Journal of Agricultural Technology*, 8 (7): 2147 – 2156.

Escobar JC, Lora ES, Venturini OJ, Yāñez EE, Castillo EF, Almazan O (2008) Biofuels: Environment, technology and food security. Renew Sust Energ Rev 13: 1275-1287

GPN (2019). Let's talk dracaena. Greenhouse production News. http://www.gpn.com/article/lets-talk-dracaena/

Kibar H. and Öztürk, T. (2008). Physical and mechanical properties of soybean. *International Agrophysics*. 22 (3) 239 -244.

Lu, P. and Morden, C (2010). Phylogenetics of the plant genera Dracaenaand Pleomele (Asparagaceae). *Journal of Plant Science*, 7: 64–72

Mayes, S., Massawe, J. Alderson, P. G., Roberts, J. A., Azam-Ali, S. N., Hermann, M. (2011). The potential for underutilized crops to improve food security. *Journal of Experimental Botany*, 63 (3): 1075 – 1079.

McConnell, D. B., Chen, J., Henny, R. J., and Everitt, K. C. (2018). Cultural guidelines for commercial production of interiorscape *Dracaena.* Institute of Food and Agricultural Sciences, University of Florida. http://edis.ifas.ufl.edu

Mickeon, T. A. (2016). Industrial oil crops. ScienceDirect, pp 257 – 341.

NCNG (2016). Dracaena – why use dracaena. West Coast Nursery Group. https://www.westcoastnurseries.com/dracaena-why-use-dracaena/

ISSN 2229-5518

Staples G.W. and Herbst D.R. 2005. A Tropical Garden Flora. Bishop Museum Press, Honolulu, Hawaii, USA.

Stroud, K. A., Booth, D. J. (2001). Engineering mathematics. Industrial Press Inc, New York. 5th edition.

University of Melbourne (2003). Sorting Dracaena names. Available at www.plantnames.unimelb.edu.au/Sorting/Dracaena.html

Williams, J.T. and Haq, N. (2002). Global research on underutilized crops. An assessment of current activities and proposals for enhanced cooperation. *ICUC*, Southampton, UK.

Zona, S., Álvarez Dezayas, A., Orellana, R., Oviedo, R., Jestrow, B. and Francisco-Ortega, J. (2014). Dracaena L. (Asparagaceae) in the New World: Its History and Botany. *Su Historia Y Botánica*, Vieraea 42:219-240. https://www.researchgate.net/publication/274139621_Dracaena_L_Asparagaceae_in_the_New_World_Its_History_and_Botany/link/551732520cf2d70ee2772a62/download