Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLVIII
Broj 3, 2023.
Strane: 51 – 64

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLVIII
No. 3, 2023.
pp. 51 – 64

UDK: 581.48:641.15

Original scientific paper
Originalni naučni rad
DOI: 10.5937/PoljTeh2303051O

ENGINEERING PROPERTIES OF *Dioclea Reflexa* (*Hook F.*) SEED RELEVANT TO MACHINE PROCESSING AND BULK HANDLING

Olakunle Olukayode[*1], Abraham Aworinde[2], Wasiu Adedeji[1], Kehinde Fayemiwo[3]

[1]*Department of Mechanical Engineering, Osun State University, Osogbo, Nigeria*
[2] *Department of Mechanical Engineering, Covenant University, Ota, Nigeria*
[3]*Department of Chemical Engineering, Osun State University, Osogbo, Nigeria*

Abstract: Interest is growing in the utilization of fringe plant materials such as *Dioclea reflexa* seed to cater for the need of growing global population. It has demonstrated potentials for a wider use as human food, and as industrial raw material. This research focused on determines the engineering properties of the seed that will be useful in the design or selection of industrial machinery for its processing and bulk handling. Four types of tests were carried out on the seeds: geometric, gravimetric, frictional and mechanical tests. Results revealed that the seed's mean geometric diameter was 25.84mm at 5.60 % (w.b.) moisture content. The individual seed average mass, true density and bulk density were 7.76g, 948.5kg·m^{-3} and 558.5kg·/m^3 respectively. Among the surfaces tested, glass has the lowest coefficient of friction (0.221) while wood has the highest (0.424). Seed orientation during compression test has effect on fracture force, deformation, toughness as well as energy absorbed. Variation of mechanical properties along axes of orientation in quasi-static compression of the seeds showed that major axis has the highest mean fracture force, mean deformation to fracture, and mean fracture energy at 1.38kN, 3.05mm and 2.10J respectively. However, the axis with the highest strength is the minor axis at 1.01kNmm^{-1}. From energy efficiency point of view, when designing machine for cracking the seeds, provision must be made for the seeds to be oriented in such a way that the applied cracking force will impact the seeds along their major axis.

Key words: *Marble Vine, Dioclea reflexa, seed physical properties, seed mechanical properties, uni-axial compression test*

[*1]Corresponding Author. Email: olakunle.kayode@uniosun.edu.ng

INTRODUCTION

The ever-increasing global population is making governments and researchers to continue looking for alternative resources in addition to the traditional ones to meet the material needs of this growing population. In this context, seeds that, hitherto, are on the fringe of human utilization but which can boost food production as well as serve as industrial raw materials are worthy of being studied. One example of such fringe seeds as far as human consumption or use is concerned is the *Dioclea Reflexa* seeds. This seed has several vernacular names, such as Sea purse, Sea beans, Marble vine, Horse eye, Bonkele (Lingala), Ukpo (Igbo, South-East Nigeria) and Agba-arin (Yoruba, South-West Nigeria) [1].The species *Dioclea reflexa Hook* belong to *Leguminosae* family and placed in *Papilionaceae* sub-family [2]. *Dioclea reflexa* is native to west-central tropical Africa, Caribbean and tropical region of South America. Propagation is by seeds.

Several researchers had carried out research into pharmaceutical properties of the seed. Study had shown that the *Dioclea reflexa* seeds contain alkaloid and glycosides, which are of pharmacological significance and its high levels of carbohydrates, crude protein and moisture content, could serve as supplementary sources of essential nutrient to man and livestock [3]. *Dioclea reflexa* holds the potential to be used in development of functional foods and in therapeutic applications to promote health [1]. Research also shows that *Dioclea reflexa* seeds contain substances with potent capacity to protect the kidney and blood from oxidative and related injuries under acute and chronic toxicological conditions [4]. Moreover, the seed flour was reported to have anti diabetic properties [5] as well as strong antioxidant properties [6]. It has been recommended that adequate intake of antioxidant through the consumption of anti- oxidant rich foods can prevent the development of oxidative stress.

Reported, [7] that *Dioclea reflexa* oil could act as a good domestic and industrial substitute for conventional oils, while its oil seed cake could be a source of protein in livestock production. Research by [8] confirmed the functional, pasting, nutritional and sensory qualities of wheat based biscuit supplemented with *Dioclea reflexa* seed flour. Still on possible industrial applications, the high saponification and iodine values of *Dioclea reflexa* oil suggest its possible utilization in alkyd resin, shoe polish, liquid soap and shampoo production, while it natural gum has a potential as food and pharmaceutical additive [2, 9, 10].

In most research work reviewed about determination of pharmaceutical and or nutritional values of *Dioclea reflexa* seeds, the seeds preparation for laboratory tests usually involved manual cracking of the hard husk while the seeds are milled using laboratory grinders or laboratory mortar and pestle [5,6,9]. This method of preparation is suitable for laboratory research involving relatively small quantities of seeds. Obviously, this method will be highly impractical and inefficient when dealing with large quantities of seeds as raw materials in industrial processing. A good understanding of the physical properties of raw agricultural material is very crucial for accurate design of machines and processes in the food chain from harvest to shop shelf [11].

[12] investigated the influence of moisture content on some physical properties of *Dioclea reflexa* seed as well as effect of both moisture content and seed orientation during uni-axial quasi-static loading using universal tensile machine to determine some of its mechanical properties.

Properties investigated in relation with moisture contents were seed's linear dimensions, geometric mean diameter, sphericity, surface area, rupture force and rupture energy. However, information are lacking on the seed's other engineering properties such as Eccentricity index, Flatness Index, Aspect Ratio, seed true density, bulk density, porosity, coefficient of frictions between the seed and more common engineering material surfaces, strength, and magnitude of seed deformation before onset of rupture. Therefore, this study aim to provide information on these parameters as related to *Dioclea reflexa* seeds. These set of data will provide relevant information about the seed that will be very crucial in designing machinery for its bulk handling and processing.

MATERIAL AND METHODS

Dioclea reflexa seeds used in this study was sourced from the local seed market located at Oja-Oba (Lat. 7.766º N, Long. 4.555º E) in Osogbo, Nigeria. On arrival at the laboratory, 100 mature seeds were randomly selected from the purchased pile. While the rest were preserved in jute sack placed in a well ventilated space. Some samples of the seeds were sent for identification at the Department of Plant Science, Osun State University Osogbo, Nigeria, the result of which was positive. Four types of tests as related to engineering properties were carried out on the seeds: geometric, gravimetric, frictional and mechanical tests.

Determination of the geometrical properties

For the geometrical and morphological properties, three linear dimensions were identified for the seed: the major diameter or length (L), intermediate diameter or width (W) and minor diameter or thickness (T) as depicted in Figure 1. The linear dimensions of each of the selected 100 seeds were measured using a digital electronic Vernier caliper (Mitutoyo, Japan) with an accuracy of ±0.02mm. The arithmetic mean diameter, geometric mean diameter, seed volume, and seed surface area were determined using Equations (1) to (4) [13-14]

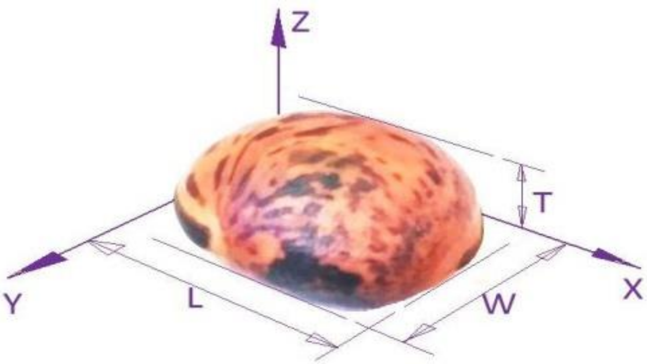

Figure 1: Three perpendicular dimensions of *Dioclea reflexa* seeds; length (L), width (W) and thickness (T).

$D_a = \frac{L+W+T}{3}$ …………………….. (1)

$D_g = (LWT)^{1/3}$ ………………………(2)

$V = \frac{\pi\ (LWT)}{6}$ ……………………….(3)

$A_s = \pi\ (D_g)^2$ (4)

Where D_a is the arithmetic mean diameter (mm), D_g is the geometric mean diameter (mm); V is the seed volume (mm^3), and A_s is the surface area (mm^2). To further detail the geometric properties of the seeds, sphericity which is the degree of roundness of the seeds, Eccentricity index, Flatness Index, and Aspect Ratio were determined using Equations (5) to (8) below (13,15, 16]:

$$\Phi = \frac{D_g}{L} \quad (5)$$

$$EI = \frac{L}{W} \quad (6)$$

$$FI = \frac{L+W}{2T} \quad (7)$$

$$AR = \frac{L}{T} \quad (8)$$

Where Φ is the degree of Sphericity, EI is the Eccentricity index, FI is the Flatness Index, and AR is Aspect Ratio.

Determination of the Gravimetric properties

The moisture content of the *Dioclea reflexa* seeds used in this study was determined by the oven drying method specified in the Association of Officiating Agricultural Chemists [17] The samples' moisture content on a wet basis (w.b.) was calculated using Equation (9). The moisture content (*MC*), was defined based on a wet basis as:

$$MC_{WB}\ (\%) = \frac{M_W - M_D}{M_W}\ X\ 100 \quad (9)$$

where MC_{wb} is the moisture content on a wet basis of the *Dioclea reflexa* seeds (% w.b.); M_W is the initial weight of the *Dioclea reflexa* seeds (g); M_D is the weight of the *Dioclea reflexa* seeds after drying (g).

Seed weight was determined for 15 randomly selected seeds from the original 100 seeds and each seed weigh individually on electronic weighing balance (Ohaus Corp, Pine Brook, NJ, USA) with readability of 0.0001 g. The true density (ρ_t) was determined as the ratio between the mass of the *Dioclea reflexa* seeds samples and the true volume of the samples using the expression in Equation (10) as:

$$\rho_t = \frac{M_S}{V_S} \quad \text{……………..(10)}$$

Where,
Ms is the mass of the seeds sample (kg) and
Vs is the volume (m^3) of the sample determined using the displacement method.

This procedure was repeated for five different sets of seeds samples. The bulk density (ρ_b) was determined by first weighing a cylindrical vessel of known volume. Then the container was filled with the seeds until their level just reached the level of the container rim. The mass of the vessel and the seeds were then weighed and the bulk density calculated [13], using Equation (11):

$$\rho_b = \frac{M_{sv} - M_v}{V_v} \qquad \text{...................(11)}$$

where M_{SV} is the mass of seeds and container (kg), M_V is the mass of the vessel only (kg) and V_V is the volume of the vessel (m^3). From the results of Equations (10) and (11), the porosity (ε) was calculated [13] from the values of the bulk and true densities using the relationship in Equation (12) as:

$$\varepsilon = \left(1 - \frac{\rho_b}{\rho_t}\right) \text{x } 100 \qquad \text{.....................(12)}$$

where, ρ_b is the bulk density (kg·m^{-3}),
ρ_t is the true density (kg·m^{-3}).

Determination of static coefficients of friction

Coefficient of static friction between the seeds and some representative surfaces were determined experimentally by using the tilted plate method described by many researchers [18]. A hollow cardboard cylinder opened at either ends filled with the seeds was placed on the surface of a plate made from the material of interest and the cardboard cylinder was slightly raised to ensure that only the seeds has contact with the plate surface. After this, the plate was gradually raised at one end and rotates about a hinge at the other end. The angle of inclination with the horizontal at which the sample initiated its sliding was read off a protractor with a sensitivity of one degree. The tangent of the angle in which sliding was initiated is the coefficient of static friction [18-19]. This procedure was repeated five times for each material surfaces tested. Five material surfaces, namely wood, galvanized steel sheet, mild steel sheet, aluminum sheet, and glass were tested.

Determination of the mechanical properties

Using the American Society of Agricultural and Biological Engineers -ASAE S368.4 [20] standard as a guide in determining the mechanical properties of the *Dioclea reflexa* seeds, uni-axial compression tests were carried out on the seeds using the Universal Testing Machine (Haida International, China) controlled by a micro-computer (Figure 2).

The S368.4 standard was developed especially for determining the mechanical properties of food material of convex shape such as fruits and vegetables, seeds, and grains.

The force-deformation curve, which is an output of the test, was frequently used in the study of physical properties of seeds and grain [11]. There are four basic values that can be obtained from this uni-axial compression test: force (maximum load), deformation (displacement), slope (ratio of force to deformation i.e. stiffness modulus), and area under the force/ deformation curve (energy absorbed, i.e. Toughness). The loading rate was $0.1 kN \cdot sec^{-1}$. The placement of the seeds on the plate of the machine was based on orientation along the three axis identified for the seed, that is; along the axis of the major, intermediate and minor diameters respectively as shown in Figure 3.

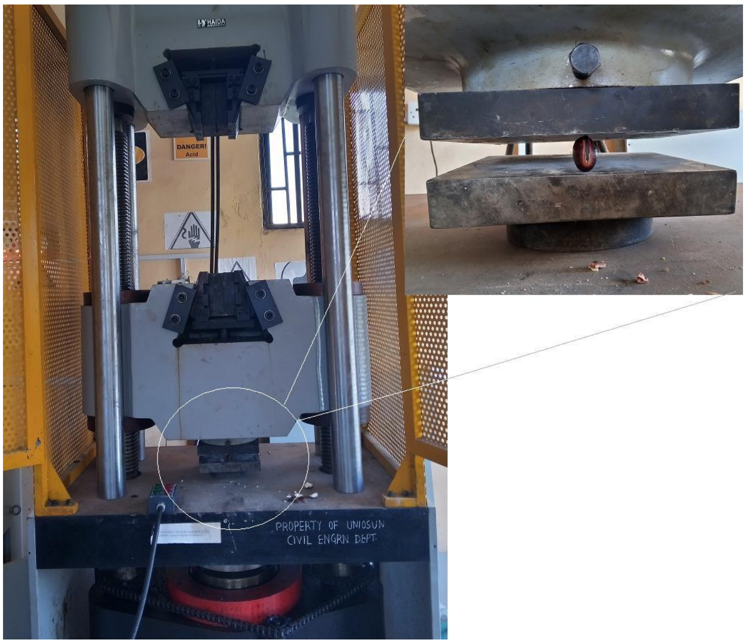

Figure 2. Placement of seed between the platens of Haida International- Mechanical Universal Testing Machine used in compression tests.

Ten seeds were tested for each orientation. The compression test was run for each seed until rupture occurred. The onset of seed rupture was announced by a popping sound. As the compression commenced and progressed, the computer in response to the compression of each seed automatically plotted a load deformation curve. From the Load-deformation curve, fracture force (F) in kN and deformation (d) in mm to rupture was determined. The slope of the Load- deformation curve gives the stiffness value for the seed in $kN \cdot mm^{-1}$. The energy absorbed (Toughness, E_T) by the seed sample at rupture was determined by calculating the area under the force-deformation curve up to the rupture point from the following Equation (13):

$$E_T = \frac{Fd}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (13)$$

Where, F is the fracture force (kN),
d is the deformation (mm)

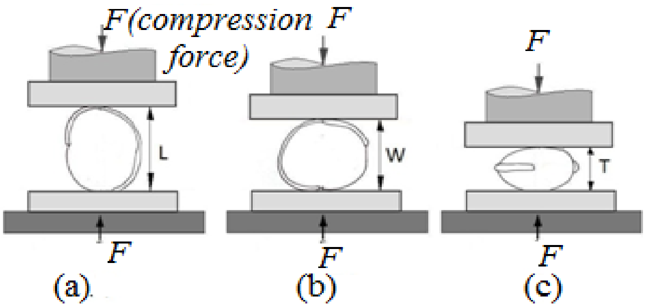

Figure 3. Orientations of the seeds on the universal testing machine (a) along major diameter, (b) along intermediate diameter and (c) along minor diameter.

Statistical analysis

The data obtained from the tests, measurements and experiments as detailed in the previous sub-sections were subjected to descriptive statistical analysis. Range (maximum "Max" and minimum "Min"), average, and standard deviation (SD), were calculated by using Microsoft Excel (2007) spreadsheet. In addition, t-test was used to determine if there is significant difference between the mean values obtained for mechanical properties.

RESULTS AND DISCUSSION

The initial moisture content of the *Dioclea Reflexa* seeds was found to be 5.60 % (wet basis). This value is within the normal values for the seed in post-harvest storage [12]. The results for geometric, gravimetric, frictional and mechanical tests carried out on the seeds are as presented in the subsequent sub-sections.

Geometrical properties

The geometric properties of *Dioclea Reflexa* seed is shown in Table 1. The average length, width and thickness were 30.91, 26.91 and 20.81mm respectively with mean geometric diameter of 25.84mm. The average sphericity, eccentricity and flatness indices as well as aspect ratio were 83.7%, 1.15, 1.39 and1.49 respectively. The mean volume and surface areas respectively were 9136.58mm^3 and 2101.37mm^2. The values of the linear dimensions will be useful in the design of sorting machine especially those employing perforated holes to do the sorting. The sphericity value implies that *Dioclea Reflexa* seed has a very high degree of roundness when compared with a sphere.

These indicate that the seed has propensity to roll rather than slide on the processing surfaces and this property is important in the design of hoppers and belts for handling and conveying operations respectively.

The surface area value is an important parameter in designing dryers for the seeds if needed in further processing. The seed's volume can be used to determine the number of seeds a specific space can accommodate, especially for seed packaging.

Generally, the physical properties such as size, volume, density, porosity and surface area of agricultural materials are critical data in design problems associated with development of machines for processing or analysis of such materials [13]. Compared with more common edible seeds, the length, width, thickness and sphericity for pecan (*Carya illinoinensis*) is 54.3, 25.1, 23.2mm and 58.38% respectively at 10.36 % (d.b.) moisture content [21]; for Hazel nut (*Corylus avellana*)(Kargalak cultivar) 25.08, 21.20, 21.20mm and 89.51% respectively [22]; and for pistachio nut (*Pistacia vera*), 19.6, 10.1, 11.3mm, and 82% respectively at 7.1 % (w. b.) moisture content [23]. For *Mucuna Sloanei*, a related seed, the major diameter, minor diameter, intermediate diameter and the sphericity, ranged from 25.61 to 32.52 (mm); 17.84 to 20.66 (mm); 24.24 to 30.18 (mm); and 0.82 to 0.89 respectively (moisture content 10.5 to 16.87% (db) across its two varieties studied by [24].

Table 1. Geometric properties of *Dioclea reflexa* seed*

	Min.	Max.	Average	SD
Major Diameter, L [mm]	25.0	35.3	30.909	1.6900
Intermediate Diameter, W [mm]	23.0	30.2	26.912	1.582
Minor Diameter, T [mm]	18.4	24.0	20.807	1.1974
Arithmetic mean diameter [mm]	23.57	28.40	26.209	1.1111
Geometric Mean Diameter [mm]	23.3	28.08	25.843	1.0799
Volume (mm^3)	6701.01	11357.91	9136.58	1149.53
Surface area (mm^2)	1705.76	2477.42	2101.37	175.66
Sphericity (%)	75.0	94.0	83.7	2.98
Eccentricity index	1.00	1.35	1.1498	0.0634
Flatness index	1.15	1.63	1.3934	0.0938
Aspect ratio	1.19	1.84	1.4873	0.1121

**For 100 randomly selected mature seeds, SD= Standard Deviation*

Gravimetric properties

The gravimetric properties of the seeds are as presented in Table 2. The individual seed average mass was 7.76g, the true density was 948.5$kg \cdot m^{-3}$ and bulk density was 558.5kgm^{-3}. The density ratio and porosity was calculated as 1.72 and 41.86% respectively. These values are very useful in designing conveyance for the seeds during industrial processes. It also has impact on power rating of processing machines since the more bulky, the more power requires in moving the seeds around in processing.

For comparison, the individual seed average mass for pecan nut (*Carya illinoinensis*) was 9.76g at 10.36 % (d.b.) moisture content [21] and for Hazel nut (*Corylus avellana*) (Kargalak cultivar) was 4.15g [22].

Table 2. Gravimetric properties of *Dioclea reflexa* seed

	Min.	Max.	Average	SD
Individual Seed Mass (g)*	6.5803	10.1859	7.7582	0.8223
Seed (True) Density ($kg{\cdot}m^{-3}$)†	914.95	970.20	948.50	29.48
Bulk Density ($kg{\cdot}m^{-3}$) †	516	615	551.5	43.96

**for 15 randomly selected seeds, †for 5trials,* SD= *Standard Deviation*

Coefficients of friction

The coefficients of friction between *Dioclea Reflexa* seeds and some representative surfaces commonly found in food processing machines and storage compartments are as depicted in Table 3. The glass surface (Coefficient of friction 0.221) presented the lowest coefficient of friction while wood (0.424) has the highest. For comparison, coefficient of friction between Mexican pink pinion (*Pinus pinea L.*) and glass was 0.45 and plywood 0.35 at 7.58% moisture content [25]. Coefficient of friction is an indication of how easy it is for the seeds to slide on an inclined surface as well as determining whether a seed will roll instead of sliding. If the coefficient of friction is relatively high, rolling might be a preferred form of motion for the seeds when being fed to a chute.

Table 3: Coefficients of friction of *Dioclea reflexa* seed on selected surfaces

	Aluminum	Glass	Wood	Galvanized Steel	Mild Steel
Mean	0.250	0.221	0.424	0.251	0.360
S.D.	0.0431	0.0245	0.0381	0.0497	0.0083

SD= Standard Deviation

Mechanical properties

The mechanical properties of *Dioclea Reflexa* seeds are as presented in Table 4 and the typical load-deformation curves for each seed orientation was as shown in Figure 4. Of the three possible orientations of the seed in compression testing, fracture force is consistently higher for major axis orientation (i.e. along length) while it is lowest for minor axis orientation (i.e. along thickness). There is significant difference at 0.05% between fracture force along the major axis and of the other two axes. However, though that of intermediate axis was slightly higher than that of the minor axis, there is no significant difference (at 0.05%) between the two.

In deformation, similar trend was observed with deformation highest (average 3.05mm) along major axis and lowest (0.95mm) along the minor axis. There is significant difference between the three axes in term of deformation at 0.05%.

Table 4. Mechanical properties of *Dioclea reflexa* seed

	Orientation								
	Major Axis			Intermediate Axis			Minor Axis		
	Min	Max	Mean (SD)	Min	Max	Mean (SD)	Min	Max	Mean (SD)
Fracture force (kN)	1.10	1.60	1.38 (0.19)	0.55	1.45	0.98 (0.27)	0.55	1.40	0.94 (0.26)
Deformation to fracture (mm)	2.40	4.00	3.05 (0.45)	0.70	3.50	1.47 (0.79)	0.70	1.40	0.95 (0.25)
Strength ($kN{\cdot}mm^{-1}$)	0.29	0.63	0.46 (0.09)	0.29	1.07	0.77 (0.24)	0.61	1.57	1.01 (0.25)
Energy absorbed (J)	1.50	2.71	2.1 (0.41)	0.19	1.75	0.75 (0.46)	0.25	0.98	0.47 (0.25)

SD= Standard Deviation

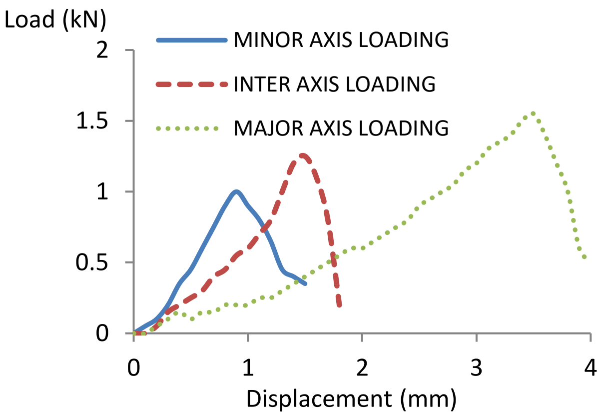

Figure 4. Typical Load-deformation curves for *Dioclea reflexa* seed under uni-axial compression test.

The seeds have greatest strength along the minor axis. This is because though fracture force is lowest along this particular axis, its deformation is also the least among the three axes. The converse is also true for major axis which has the greatest fracture force and deformation. This implies that there is greater resistance to deformation along minor axis when compared with the other two.

For comparison, *Mucuna flagellipes* nut, a biological relative of *Dioclea Reflexa* seed, at 3.38% moisture content (dry basis) exhibits a rupture forces of 685N and 420N respectively for lateral and longitudinal loading of the seeds and at 10.7% moisture content (d.b.) rupture forces of 365N and 1215N respectively for lateral and longitudinal loading of the seeds.

These shows that moisture level as well as seed orientation during compression tests has influence on rupture forces for the Mucuna *flagellipes* nut with the force decreasing for lateral orientation and increasing for longitudinal orientation as moisture content increases [26].
Moreover, for acorn nuts, [27] reported the rupture force values of 367.84, 480.53, and 401.19N for loading on lateral, vertical and thickness axes respectively at a moisture content of 5.48% (d.b.). Thus orientating has an obvious effect on the value of rupture force.

CONCLUSION

The high sphericity value of *Dioclea Reflexa* seed indicate that the seed has propensity to roll rather than slide on the processing surfaces of processing machines, however the bulk density and porosity are well within the range of common well established food grade seeds. Seed orientation during compression test was shown to have effect on fracture force, deformation, toughness as well as energy absorbed. This is similar to trends observed for similar agricultural materials. Fracture force, deformation to fracture and fracture energy were highest for loading along the major axis with the minor axis having the lowest corresponding values. However, in term of seed strength under compressive load, the minor axis has the highest value while the major axis has the lowest value. From energy efficiency point of view, when designing machine for cracking the seeds, provision must be made for the seeds to be oriented in such a way that the applied cracking force will impact the seeds along their minor axes.

BIBLIOGRAPHY

[1] Ajatta M.A., Akionla S.A., Otolowo D.T., Awolu O.O. Omoba O.S., & Osundahunsi O.F. 2019. Effect of Roasting on the Phytochemical Properties of Three Varieties of Marble Vine *Dioclea Reflexa*) using Response Surface Methodology. *Preventive Nutrition and Food Science.* 24(4): pp.468-477.

[2] Akinyede A.I., Fagbemi T.N., Osundahunsi O.F., & Aluko R.E. 2016. Physicochemical Composition and Oil Characterization of *Dioclea reflexa* and *Monodora myristica* Seeds. *Applied Tropical Agriculture*, 21 (3): pp.1-11.

[3] Ajayi I.A., (2014). Oil Content and Fatty Acid Composition of *Dioclea reflexa* Seeds. *IOSR Journal of Applied Chemistry (IOSR-JAC)* , 7(I). pp.68-73

[4] Atawodi S.E., & Iliemene, U.D. 2014. Effects of Methanolic Extract of *Dioclea reflexa* Hook F Seed on some Haematological and Kidney Function Parameters in Rats following Single or Repeated Carbon Tetrachloride Intoxication. *British Biotechnology Journal*, 4(12): pp.1253-1262.

[5] Adepoju-Adeyinka G.K., & Balogun O.M. 2014. Exploration of the anti-diabetic effect of the matured seeds of Dioclea reflexa. *Journal of Medicinal Plant Research*, 8(20): pp.811-813.

[6] Iliemene U.D., &Atawodi S.E. 2014. In vivo anti-oxidant and hepatoprotective effects of methanolic extract of dioclea reflexa seed in rats following acute or chronic liver injury. Bangladesh J. Pharmacol 2014; 9: pp.112-117. *A Journal of the Bangladesh Pharmacological Society (BDPS).* ISSN: 1991-0088.

[7] Yusuf A.A., & Lasisi A.A. 2006. Compositional Analysis of Horse Eye (*Dioclea reflexa*) Seed Flour and its Cake. *Agricultural journal*, 1(1): pp.25-31.

[8] Akoja S.S., & Coker O. 2019. Evaluation of Functional, Proximate and Sensory Qualities of Breads Based On Blends of *Dioclea Reflexa* and Wheat Flour. JBook of Proceedings of 4th National Development Conference of The School of Pure and Applied Science, The Federal Polytec. Ilaro, Ogun State, Nigeria. December, 2 – 5t: pp.254-262

[9] Oyeleke G.O., Afolabi O., Olayiwola O.A., & Adetoro R.O. 2012. Oil quality characteristics and effects of temperature variations on some functional properties of horse eye (*Dioclea reflexa*) seed flour. *IOSR Journal of Environmental Science, Toxicology and Food Technology,* 2(2): pp.38-42.

[10] Mbah,C.C., Samali,A., Aboh, M.I., Ogbonna,J.I., Builders, P.F., Attama, A.A., & Ofoefule, S.I. 2022. Preliminary investigation of Dioclea reflexa seed gum as a food and potential pharmaceutical excipient. *German Journal Pharm. Biomaterials* 1(4): pp. 27-37. https://doi.org/10.5530/gjpb.2022.4.17

[11] Dobrzański B., & Stępniewski A. (2013. Physical Properties of Seeds in Technological Processes. In book: Advances in Agrophysical Research. http://dx.doi.org/10.5772/56874

[12] Olukayode, O.; Alade, E.I.; & Oyelami, S. 2022. Effect of moisture contents and compression axes on some physical and mechanical properties of *Dioclea reflexa* seed. *Journal of Applied Life Sciences and Environment***,** 55 (2), pp.189-200. https://doi.org/10.46909/alse-552057.

[13] Mohsenin N.N. 1986. Physical properties of plant and animal materials. New York, Gordon and Breach Science Publishers.

[14] Gongora, I.G.; Dunoyer, A.T.; & Garcia-Zapateiro, L.A. 2018. Physical, Chemical and Biological Properties of Maize Variety Fr-28. *Contemp. Eng. Sci*., 11, pp.257–268.

[15] Cervantes E., Martín J.J., & Saadaoui E. 2016. Updated Methods for Seed Shape Analysis. *Scientifica* (Hindawi Publishing Corporation). Volume 2016, Article ID 5691825, 10 pages, http://dx.doi.org/10.1155/2016/5691825.

[16] Jahanbakhshi, A.; Abbaspour–Gilandeh, Y.; Ghamari, B.; & Heidarbeigi, K. 2019. Assessment of physical, mechanical, and hydrodynamic properties in reducing postharvest losses of cantaloupe (*Cucumis melo var. Cantaloupensis*). *Journal of Food Process Engineering*. 42, 1-8. https://doi.org/10.1111/jfpe.13091.

[17] AOAC. 2016. Official methods of analysis of the AOAC, 20th Edition, Association of Officiating Analytical Chemists, Washington DC.

[18] Fayed M.I.A., El-Shal M.S. & Omar O.A. (2020). Determination of some apricot seed and kernel physical and mechanical properties. *AgricEngInt:CIGR Journal*, (22) 4, pp.229-237. http://wwwcigrjournal.org

[19] Mirzabe, A. H., Hajiahmad, A., & Asadollahzadeh, A. H. 2021. Moisture-dependent engineering properties of arugula seed relevant in mechanical processing and bulk handling. *J. Food Process Eng* 44, e13704. https:// doi. org/ 10. 1111/ jfpe. 13704.

[20] ASAE (American Society of Agricultural and Biological Engineers - S368.4). 2008. Test of Food Materials of Convex Shape. Revised, Dec. 2000, Reaffirmed..

[21] Kabas O., & Vladut V. 2015. Determination of Some Engineering Properties of Pecan (*Carya illinoinensis*) for New Design of Cracking System. Article in Erwerbs-Obstbau (Springer*).* DOI: 10.1007/s10341-015-0255-5.

[22] Ercisli S., Ozturk I., Kara M., Kalkan F., Seker H., Duyar O., & Erturk,Y. 2011. Physical properties of hazelnuts. *International Agrophysics*., 25: pp.115-121

[23] Polat, R., Gezer, I., Guner, M., Dursun, E., Erdogan, D, Blim, H.C. 2006. Mechanical harvesting of pistachio nuts. Journal of Food Engineering, 79. pp. 1131-1135.

[24] Ide, P.E., Eze, P.C., & Offor, B.C.2019. Effect of Moisture Content on the Physicomechanical Properties of *Mucuna sloanei. International Journal of Scientific Engineering and Research*, 7, pp.91-96.

[25] Pensamiento-Nin˜o, C.A., Herna´ndez-Santos, B., Herman-Lara, E., Jua´rez-Barrientos, J. M., Martı´nez-Sa´nchez, C.E., Ramı´rez-Rivera, E.J., & Rodrı´guez-Miranda, J. 2019. Physical, mechanical, functional and chemical properties of Mexican pink pinion (*Pinus pinea L*.). *J Food Sci Technol* 56(2):763–774. https://doi.org/10.1007/s13197-018-3536-9

[26] Aviara N.A., Onuh O.A., & Ehiabhi S.E. 2012. Influence of moisture content and loading orientation on some mechanical properties of *Mucuna flagellipes* nut. *Research in Agricultural Engineering,* 58 (2): pp. 66–72.

[27] Fos'hat M., Etemad V., Gharibzahedi S.M.T., & Ghahderijani M. 2011. Physical, Mechanical and Aerodynamic Properties of Acorn (*Quercus Luber l.*) as Potentials for Development of Processing Machines. Australian Journal of Crop Science. 5(4): pp.473-478.

INŽINJERSKE OSOBINE SEMENA *Dioclea Reflexa* (*Hook. F.)* RELEVANTNE ZA UPOTREBU MAŠINE KOD ZAPREMINSKE PRERADE

Olakunle Olukayode[1], Abraham Aworinde[2], Wasiu Adedeji[1], Kehinde Fayemiwo[3]

[1]*Department of Mechanical Engineering, Osun State University, Osogbo, Nigeria*
[2] *Department of Mechanical Engineering, Covenant University, Ota, Nigeria*
[3]*Department of Chemical Engineering, Osun State University, Osogbo, Nigeria*

Apstrakt: Raste interesovanje za korišćenje sporednog biljnog materijala kao što je seme *Dioclea reflexa* da bi se zadovoljile potrebe rastuće globalne populacije. *Dioclea reflexa* ima potencijale za širu upotrebu kao ljudska hrana i kao industrijska sirovina.
Ovo istraživanje fokusirano na utvrđivanje inženjerskih osobina semena koje će biti od koristi u projektovanju ili izboru industrijskih mašina za njegovu preradu i rukovanje velikim količinama semena u toku prerade.
Na semenu *Dioclea reflexa* su sprovedena četiri tipa ispitivanja: geometrijska, gravimetrijska (zapreminska), frikciona i mehanička.
Rezultati pokazuju da je srednji geometrijski prečnik semena bio 25,84 mm pri 5,60 % sadržaja vlage. Prosečna masa pojedinačnog semena, prava gustina (zapremina) i nasipna gustina imaju vrednost 7,76g, 948,5 kgm^{-3} i 558,5 kg/m^3 respektivno.

Kod ispitivanja uticaja površina na trenje, staklo ima najmanji koeficijent trenja (0,221), dok drvo ima najveću vrednost (0,424).
Orijentacija semena tokom testa kompresije utiče na silu loma, deformaciju, žilavost kao i na apsorbovanu energiju. Varijacije mehaničkih osobina u pravcu ose orijentacije u kvazistatičkoj kompresiji semena su pokazale da glavna osa (x) ima najveću srednju silu loma, srednju deformaciju kao i lom i srednju energiju loma pri 1,38 kN, 3,05 mm i 2,10 J respektivno. Međutim, osa orjentacije zrna sa najvećom čvrstoćom je mala osa (y) sa vrednosti 1,01 $kNmm^{-1}$.
Sa stanovišta energetske efikasnosti, prilikom projektovanja mašine za deformaciju (lom), mora se predvideti da seme bude orijentisano na takav način da primenjena sila deformacije utiče na seme duž njihove glavne ose.

Ključne reči: *Marable loza, Dioclea reflexa, fizička svojstva semena, mehanička svojstva semena, jednoosni test kompresij.e*

Prijavljen:
***Submitted*: 08.06.2023.**
Ispravljen:
Revised: **15.07.2023.**
Prihvaćen:
***Accepted*: 26.08.2023.**