



## ENGINEERING PROPERTIES OF ULTRASONIC TREATED AFRICAN EKKI WOOD (*LOPHIRA ALATA*) SEED

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### Abstract

Some selected engineering properties of ultrasonic treated seeds of *Lophira alata* were determined in this study. The dimension of *Lophira alata* seeds in the three principal axes (namely, length, width, and thickness) and its geometric diameter, sphericity, porosity, bulk and true densities were determined. The crushing force of the seed was also established. The mean values obtained for the seeds of *Lophira alata* in the three principal axes (namely, length, width, and thickness) were 14.42, 9.31 and 9.23mm for small seed size; 15.72, 9.52 and 9.48 mm for medium seed size and 17.09, 9.23 and 9.14mm for large seed size while geometric mean and arithmetic mean diameters were 10.72 and 10.99 mm; 11.21 and 11.57 mm; 11.28 and 11.82 mm respectively for the three sizes. The sphericity was also found to have mean values of 0.74, 0.71 and 0.66 for the three sizes respectively. The unit true density has mean values of 1.22, 1.18 and 1.19 kg/m<sup>3</sup> respectively for small, medium and large seed sizes. However, the Ultrasonic Treated Seed (UTS) has a range of 0.67 to 0.74kg/m<sup>3</sup> while Non-Ultrasonic Treated Seed (NUTS) has a range of 0.69 to 0.71 kg/m<sup>3</sup> for bulk density. The mean values of crushing force ranged from 0.15 to 0.3kN and 0.3 to 0.5kN both UTS and NUTS respectively. In conclusion the data derived could be useful in processing *Lophira alata* seeds.

Keywords: *Lophira alata* Seed, treatment, sizes, shapes and crushing force.

### Introduction

*Lophira alata* popularly known as azobe plant and African ekki wood is a monoecious plant which produces oil bearing seeds. It is known as aba in Igbo, akufo/ekki in Yoruba and namijin kadai in Hausa (Abderamane *et al.*, 2011; Ajiboye *et al.*, 2014). It is a plant commonly found in the tropical rainforests of Africa, including the forests of Sierra Leone, Nigeria, Gabon, Uganda and Sudan. It has much similarity as *Lophira lanceolata*; however, the two plants thrive in different habitats (Persinos and Quimby, 1968; Palanti *et al.*, 2015).

There is high demand for the wood of *Lophira alata* for timber production thus endangering the plant with little being reported on reforestation of the plant. More so, all the parts of *Lophira alata* plant such as seeds, flower, stem and bark find its use in ethnomedicine for treatment of ailment such as toothaches, headaches, cough, infertility and diarrhoea (Baldé *et al.*, 2015). However, with less focus on the utilization of *Lophira alata* seed for industrial purposes; it has been discovered that this seed is a potential replacement edible oil-bearing seeds having unfavorable competition with direct human consumption. The oil of this seed has been reported to be highly medicinal as a remedy for myriads of ailments. It also finds its application in production of soap and medicine (Nonviho *et al.*, 2015). It was reported to be unsafe for culinary use, even though it is usually mixed with other edible oil as filler and consume by some African countries. Furthermore, extraction of oil from *Lophira alata* seed is gaining research interest with little being done on exploitation on other pretreatment techniques such ultrasonics. The application of ultrasonic in food processing is gaining research interest in the area of oil extraction, cleaning and improvement of organoleptic properties of food. In recent times ultrasonic effects have been applied to food processing and pre-harvest treatments which seeds are subjected to in order to improve their viability. Cavitation initiated by ultrasonic waves enhances the flow of oil from cell matrices, thus facilitating the extraction with minimized alteration in

oil characteristics. Ultrasonic treatment of oil-bearing seeds has been discovered to enhance oil yield with little or no change to oil quality (Thilakarathna *et al.*, 2022). This study aims to determine some engineering properties of ultrasonic treated *Lophira alata* seeds in relation to their further processing.

## 2.0 Materials and Methods

### 2.1 Determination of Sizes and Shapes

The sizes (*viz.* length, breadth and thickness) *Lophira alata* was measured using a digital vernier caliper (Mitutoyo 200 mm, Instrument, reading to 0.01 mm). The dimension of *Lophira alata* seeds were determined using a total number of eighty-one seeds which was sorted into three parts *i.e.*, small, medium and large seeds. The sphericity, geometric and arithmetic mean diameters were computed using equations 1 to 3. Figures 1 and 2 show some *Lophira alata* seeds as measured using a vernier caliper.

$$S = \frac{(abc)^{1/3}}{a} \quad 1$$

$$GMD = (abc)^{1/3} \quad 2$$

$$AMD = \frac{a+b+c}{3} \quad 3$$

Where

- GMD is geometric mean diameter
- AMD is arithmetic mean diameter
- a is the seed length
- b is the seed breadth
- c is the seed thickness



Figure 1: Measurement of dimension of *Lophira alata* seeds using a vernier caliper



Figure 2: *Lophira alata* seeds

## 2.2 Determination of Seed Unit and Bulk Densities

The unit density of *Lophira alata* seed was determined by obtaining the mass of the seed using a digital weigh balance reading to 0.1 g, while the seed unit volume was determined by liquid displacement method using a measuring cylinder. The volume of the liquid displaced was computed from the difference between the initial and final volumes. This was carried out using eighty-one seeds altogether. The unit density was found using equation 4. The bulk density was found by filling some *Lophira alata* seeds in a cylindrical container of a known volume. The ratio of mass of seeds contained in the container to container's volume was computed as the bulk density as shown in equation 5 (Aremu and Fadele, 2011).

$$\text{Unit Density} = \frac{\text{Unit Mass}}{\text{Unit Volume}} \quad 4$$

$$\text{Bulk Density} = \frac{\text{Bulk Mass}}{\text{Bulk Volume}} \quad 5$$

## 2.3 Determination of Crushing Force

The crushing force of *Lophira alata* was determined using a Universal Test Machine (Techquipment SN1000). This was determined following American Society for Testing and Materials standards (ASTM, 2008). The seeds were ultrasonically treated in a water bath at room temperature ( $28 \pm 2^\circ\text{C}$ ) for 60, 120, 180, 240 and 300s. This was also repeated without ultrasonic treatment for the same period. Figures 3a and 3b show *Lophira alata* seed under loading.



Figure 3a and 3b: *Lophira alata* seed under loading using a UTM (Techquipment SN1000)

## 3.0 Results and Discussion

Some engineering properties of *Lophira alata* in relation to effect of ultrasonic treatment were established. Physical properties of sizes and shapes of *Lophira alata* with bulk and unit densities were discussed as follow.

### 3.1 Sizes and Shapes of *Lophira alata* Seeds

Sizes and shapes of *Lophira alata* seeds were obtained in three categories viz. small, medium and large sizes based on the seed length as shown in Tables 1 – 3 at a moisture content of 9.66% (w.b.). The small size *Lophira alata* was established to have an average length, breadth and thickness of 14.42, 9.31 and 9.23mm respectively. The geometric and arithmetic mean diameters were found to have mean values of 10.72 and 10.99 mm respectively while the sphericity was 0.74. The medium size *Lophira alata* was also found to have an average length, breadth and thickness of 15.72, 9.52 and 9.48 mm respectively. The geometric and arithmetic mean diameters were found to have mean values of 11.21 and 11.57 mm respectively while the sphericity was 0.71. Similarly, the large size of *Lophira alata* seed was found to have an average length, breadth and thickness of 17.09, 9.23 and 9.14mm respectively. The geometric and arithmetic mean diameters were found to have mean values of 11.28 and 11.82 mm respectively while the sphericity was 0.66.

**Table 1: Sizes and Shapes of Small Size *Lophira alata* Seeds**

Property	Number of Seed	Min	Max	Mean	SD
Length (mm)	27	11.32	15.19	14.4163	0.81541
Breadth (mm)	27	7.45	11.60	9.3081	1.04292
Thickness (mm)	27	7.50	11.19	9.2319	1.06172
Sphericity	27	0.66	0.85	0.7448	0.05584
Geometric Mean Diameter	27	9.06	12.44	10.7245	0.88220
Arithmetic Mean Diameter	27	9.42	12.56	10.9854	0.81205

**Table 2: Sizes and Shapes of Medium Size *Lophira alata* Seeds**

Property	Number of Seed	Min	Max	Mean	SD
Length (mm)	27	15.21	16.22	15.7189	0.30901
Breadth (mm)	27	7.41	12.04	9.5174	1.15258
Thickness (mm)	27	7.61	11.98	9.4822	1.13640
Sphericity	27	0.60	0.83	0.7137	.05853
Geometric Mean Diameter	27	9.68	13.18	11.2136	.88095
Arithmetic Mean Diameter	27	10.29	13.30	11.5728	.74344

**Table 3: Sizes and Shapes of Large Size *Lophira alata* Seeds**

Property	Number of Seed	Min	Max	Mean	SD
Length (mm)	27	16.32	19.07	17.0904	0.68489
Breadth (mm)	27	7.79	10.72	9.2300	0.85986
Thickness (mm)	27	8.09	10.79	9.1407	0.72035
Sphericity	27	0.57	0.73	0.6608	0.03995
Geometric Mean Diameter	27	10.42	12.52	11.2814	0.62391
Arithmetic Mean Diameter	27	11.01	12.88	11.8204	0.53987

It can be depicted from the values obtained that the seed length insignificantly affects the breadth and thickness of *Lophira alata* seed. The sorting of the seeds was carried out based on seed length which invariably does not determine the breadth and thickness as shown in Tables 4 and 5. Olajide and Igbeka (2003) reported average values of 8.54, 3.55 and 6.93 mm for length, breadth and thickness of groundnut respectively which is less than that of *Lophira alata* seeds.

**Table 4: Analysis of Variance for Seed Breadth of Various Sizes**

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	1.192496	2	0.596248	0.566869	0.569618	3.113792
Within Groups	82.04253	78	1.051827			
Total	83.23502	80				

**Table 5: Analysis of Variance for Seed Thickness of Various Sizes**

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.688365	2	0.844183	0.862132	0.426245	3.113792
Within Groups	76.37606	78	0.97918			
Total	78.06442	80				

### 3.2 Unit and Bulk Seed Densities *Lophira alata*

The unit bulk density of *Lophira alata* seeds were found to have mean values of 1.22, 1.18 and 1.19 kg/m<sup>3</sup> respectively for small, medium and large seed sizes. It was established that the seeds size does not significantly influence the densities of *Lophira alata* seed as shown in Table 6.

**Table 6: Analysis of Variance for Effects of Seed Sizes with Unit Density**

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	0.01628	2	0.00814	0.14464	0.86557	3.113792
Within Groups	4.38884	78	0.05627			
Total	4.4051	80				

**Table 7: Effect of Seed Sizes on Unit Density**

Unit Density (kg/m <sup>3</sup> )	Number of Seed	Min.	Max	Mean	SD
Small Size	27	0.87	1.80	1.22	0.227
Medium Size	27	0.60	2.00	1.18	0.276
Large Size	27	0.89	1.80	1.19	0.203

Furthermore, the relationship between unit density and seed size is an indication that the seed size might not have any influence on its bulk density. However, the effect of ultrasonic treatment of *Lophira seed* on bulk density was determined and found to be insignificant. Figure 4 relationship among bulk densities of ultrasonic treated seeds in water, water treated and non-treated seed. Ultrasonic Treated Seed (UTS) has a range of 0.67 to 0.74kg/m<sup>3</sup> while Non-Ultrasonic Treated Seed (NUTS) has a range of 0.69 to 0.71 kg/m<sup>3</sup>.

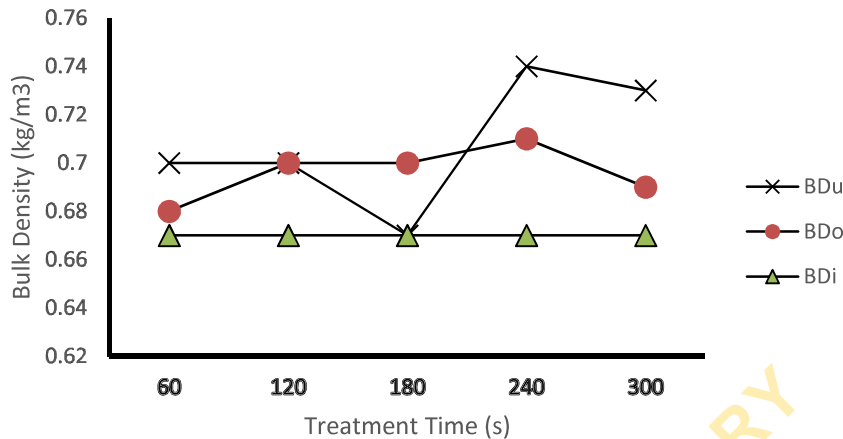


Figure 4: Variation of bulk densities of *Lophira alata* seeds with treatment time

### 3.3 Crushing Force of *Lophira alata*

The effect of ultrasonic treatment on the crushing force of *Lophira alata* seed was also found to follow a sinusoidal trend while non-treated seed was quadratic. The crushing force for ultrasonically treated seeds ranges from 0.15 to 0.3kN while non-ultrasonic treated seeds range from 0.3 to 0.5kN as shown in Figure 5. It is noteworthy that ultrasonic treatment of *Lophira alata* seeds enhanced its cavitation. Haruna et al. (2023) reported the compressive force necessary to initiate oil expulsion from *Lophira alata* seed to be 3.29kN which far greater than the crushing force obtained.

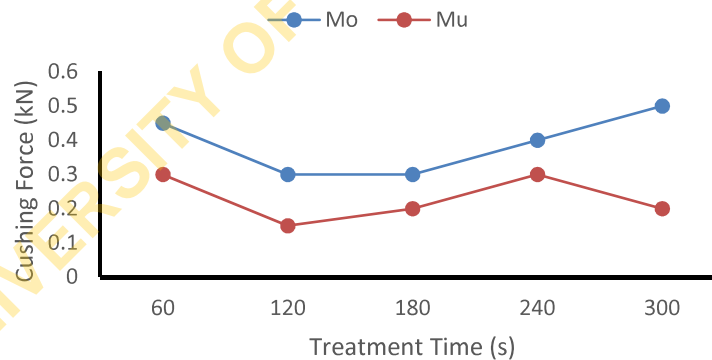


Figure 5: Variation of crushing force the treatment time

### Conclusions

The engineering properties of *Lophira alata* established in this study in relation to ultrasonic treatment reveals the significance of pretreatment on crushing and compressive force necessary to induce oil expression. Furthermore, the dimension of *Lophira alata* seeds in the three principal axes (namely, length, width, and thickness) and its geometric diameter, sphericity, porosity, bulk and true densities were established. The unit density was found to be insignificantly affected by ultrasonic treatment. The bulk density was also established. The engineering properties obtained could be useful in development of processing machines for *Lophira alata* seeds

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