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Some Physical and Mechanical Properties of Pear Fruits and Seeds

Davies, R.M

Department of Agricultural and Environmental Engineering, Niger Delta University, P.M.B 071, Yenagoa, Bayelsa State, Nigeria.

***Corresponding Author:** *Davies, R.M, Department of Agricultural and Environmental Engineering, Niger Delta University, P.M.B 071, Yenagoa, Bayelsa State, Nigeria.*

ABSTRACT

Some engineering characteristics of pear fruits and seeds were conducted at 70.63% for fruit and 42.71% dry basis for seed. Some engineering of avocado pear were studied: length, width, thickness, arithmetic and geometric mean diameter, volume, 1000 unit mass, square mean diameters, surface area, sphericity, equivalent mean diameter and compressive force that are pertinent to design and manufacturing of equipment for processing and preservation of the fruits and seeds. The mean values of aspect ratio and sphericity of avocado fruits and seeds indicated that the shape tends towards being spherical and expected to roll than slide. The results of rupture, bioyield, yield and compressive forces and well as modulus of elasticity of avocado fruit and seeds showed that there was significant difference between two different orientations at $P < 0.05$. Avocado pear fruit and seed have more strength on the longitudinal orientations during loading compared to lateral orientations. The results obtained will form a database that will be valuable in the design of systems for handling and processing of pear fruits and seeds. Stainless steel as construction material had the lowest dynamic and static coefficient of friction. Hence, suitable as construction material for the production of food processing machines.

Keywords: *Rupture force, axial dimensions, sphericity, bulk density, angle of repose*

INTRODUCTION

The avocado (*Persea Americana*) is a tropical fruit plant, a family of Lauraceae and Perseal genus [1, 2, 3]. Avocado pear fruits are very rich and contain some nutritive substances and equally have enormous medicinal values. The colour of the skin of ripe avocado fruits turned purplish black. The whole avocado fruit comprises of edible flesh 65%, seed is 20% and the skin is 15%.

The fat content is between 71 to 88% of their total calories. The seeds of avocado pear possess anti insecticidal, anti-fungicidal and anti-microbial properties. Avocado has many medicinal and health benefits which includes blood serum cholesterol levels, good source of vitamin B6, vitamin C, Folate and copper, vitamin E, vitamin D and vitamin K [4]. The fruit contain dietary fiber, 75% insoluble and 25% soluble fiber and also a good source of potassium [4, 5].

Avocado skin is very useful as antibiotic, for removal of intestinal tract of parasites, and also for treating diarrhea and dysentery [5]. Avocado pears consists of vital nutrients such as carbohydrates, sugar, soluble and insoluble fiber. Avocado pear is rich in vitamin E, a good source antioxidants, and glutathione [3, 4, 5].

Immediately, avocado pear fruit ripe deterioration commences. It is imperative to process the fruit to different types of food products that ensuring longer shelf life [4, 5]. This will eventually enhance development of innovative processing plants, creation of new jobs, and improving the profits of both farmers and processors [6, 7]. USDA (2009) [4] reported that crude fibre of avocado pear was 6.70 g. According to USDA [4] crude fibre contents from agricultural crops were reported such as 2.2g (pear), 1.7g (orange), 0.7g (melon), 1.9g (kiwi), 0.7g (Grape), 1.1g (Banana), 2.8g (Lemon). The crude fibre content is essential component of any diet and also enhances digestion. Crude fibre content is considered as critical in analyzing animal feeds [7, 8]. 100g of avocado pear yielded 7.4g of carbohydrate content as compared to other fruits like melon 5.5g, lemon 9.32g, strawberries 5.7g, apple 11.8g, banana 23.2g and orange 8.5g [4]. The investigation into engineering properties of biological materials play a major role in assessing the quality of the products, dipping the post harvest losses due to transportation and other mechanical handling during processing of the products, storage and packaging system [9, 10, 11, 12].

Many researchers have conducted studies on the physical and mechanical properties of diverse fruit crops like orange [9, 10, 13, 14], gumbo fruit varieties [15], doum palm fruit [16], cherry [17], wild mango fruit [18], sweet cherry [19], minneola fruits, strawberry [21], sea buckthorn fruit [22], tomato [23] and gbafilo [24].

Some database have been established on physical and mechanical properties of fruit such as; kiwifruit [25], pear [26], apple [27], jujube fruit [28], hawthorn fruit [11], orange [14], olive fruits [21] and scolymus [12], palm fruit [30].

Presently, handling and processing the avocado pear fruit and seed achieved by using traditional techniques. This method is synonymous with drudgery and post harvest losses. Innovative technology in handling and processing the fruit using appropriate machinery based on engineering properties database developed.

Design of the equipment for cleaning, grading, and separation require accurate information of the size distribution of avocado pear is important.

Investigation of bulk and true densities, porosity of any agricultural materials is imperative for the design of equipment associated to aeration, separation equipment, drying, storage, and transport systems.

Investigation into flow ability of grain, seed and fruit is determined through the angle of repose. The objective of this study was therefore to determine the engineering characteristics of avocado pear.

Materials And Method

Sample Preparation

The avocado pear fruits (Fig. 1) used for this research were purchased Swali market Yenagoa, Bayelsa State, Nigeria.

Samples were cautiously selected to avoid premature, pitted, soft and ripe fruit ones.

Thus, only mature amd healthy fruits were chosen for the conduct of this experiment. Fifty avocado pear were randomly selected.

Figure1. *Avocado pear fruits*

Figure 2. *Avocado pear seeds*

Geometric and Gravimetric Properties

To determine pear fruits and seeds dimensions, 50 fruits were randomly and cautiously chosen and their three axial dimensions that is, length (*L*), width (*W*) and thickness (*T*) were measured using digital Vernier Caliper with precision of 0.01 mm. The mean length of avocado pear fruits and seeds were investigated using the three axial dimensions. The arithmetic mean diameter (D_a), geometric mean diameter (D_g), sphericity (Φ), surface area S, aspect ratio R_a of Velvet tamarind were calculated by using the following relationships [31,32, 33, 34, 35].

$$Da = \frac{L + W + T}{3} \quad (1)$$

$$Dg = (LWT)^{0.333} \quad (2)$$

$$Dsm = \left(\frac{lW + WT + LT}{3}\right)^{0.5} \quad (3)$$

$$De = \frac{Da + Dg + Dsm}{3} \quad (4)$$

$$\Phi = \frac{\sqrt[3]{(LWT)}}{L} \quad (5)$$

$$Ra = \frac{W}{L}100 \quad (6)$$

$$As = \frac{\pi B L^2}{(2L - B)} \quad (7)$$

$$V = \frac{\pi B^2 L^2}{6(2L - 3)} \quad (8)$$

$$B = (LW)^{0.5} \quad (9)$$

The volume (V) of pear fruits and seeds were evaluated using the toluene displacement method [36]. The 1000 unit mass of pear fruits and seeds determined using precision electronic balance to an accuracy of 0.01g. To evaluate the 1000 unit mass for fruits and seed, 50 randomly chosen samples were weighed and multiplied by 20 to give the mass of 1000 fruit and seed. The experiment was replicated ten times.

Mechanical Properties

The investigation on hardness of the fruits and seeds were necessary in order to determine required forces that acted through the three dimensions length, width and thickness to rupture the fruits and seeds under compression. An electronic Universal Testing Machine with precision was 0.01 N. was used for the test. Individual sample was placed on desired section and preferred speed of loading and force was applied force until it ruptured.

Each sample was loaded between two parallel plates of the machine with the load applied along the three dimensions length, width and thickness at a deformation speed of 10 mm min-^{1}.

The following mechanical characteristics were determined rupture force, yield force, bioyield force, compressive force and modulus of elasticity.

Result and Discussion

A summary for measured and calculated physical characteristics of avocado pear fruit with the coefficient of variations were shown in Table 1. The mean length, width and thickness of avocado fruit varied between 93.50 and 132.50 mm, 74.61 and 86.92 mm, 71.30 and 82.12 mm at 70.63% moisture content dry basis.. According to Sharifi et al., [10] the length, width and thickness of orange were quoted to be varied between 77.93 and 90.40 mm, 70.62 and 85.03 mm and 69.15 and 84.39 mm. The axial dimensions such as length, width and thickness of *simarouba* fruit were 21.26 mm, 13.81 mm and 11.03 mm [37]. The mean length, width and thickness of date palm fruit were 41.06±2.02 mm, 19.24±2.66 mm and 16.65±1.23 mm [38].

These parameters are pertinent in the design of aperture sizes used in processing machines for cleaning, sorting, grading and packaging operations [39].

Square mean diameter and equivalent diameter of avocado pear fruit ranged between 18.49 and 6.82 mm and 59.16 and 73.33 mm. Arithmetic and geometric mean diameters of avocado pear fruit varied between 79.8 and 100.47 mm and 79.23 and 98.10 mm.

The sphericity of avocado pear fruit ranged from 0.58 to 0.75 while its aspect ratio varied between 0.66 and 0.80. The obtained values showed that avocado pears have the higher possibility of rolling than sliding. This falls within the reported sphericity and aspect ratio for most of the grains, fruits and seeds [40].

Table 1. *Geometrical properties of avocado fruit and seed*

Part of fruit	Properties	No. of Samples	Maximum	Minimum	Mean
Fruit	Length (mm)	10	132.50	93.50	113.00
	Width (mm)	10	86.92	74.61	80.75
	Thickness (mm)	10	82.12	71.30	76.65
	Arithmetic mean diameter (mm)	10	100.47	79.8	90.13
	Geometric Mean Diameter (mm)	10	98.10	79.23	88.77
	Sphericity (%)	10	75.27	57.99	63.16
	Square Mean Diameter (mm)	10	21.43	18.49	19.99
	Equivalent Diameter (mm)	10	73.33	59.17	66.30
	Aspect Ratio (%) Ra	10	65.58	79.79	71.46
	Surface Area(mm^2)	10	30239.36	19722.69	24756.82
Seed	Length(mm)	10	69.80	46.00	57.90
	Width(mm)	10	59.80	43.30	51.55
	Thickness (mm)	10	50.50	40.90	45.70
	Arithmetic Mean Diameter(mm)	10	60.03	43.4	51.71
	Geometric Mean Diameter(mm) Dg	10	59.51	43.35	51.47
	Sphericity	10	86.63	60.32	75.27
	Square Mean Diameter (mm)	10	15.29	12.36	13.85
	Equivalent Diameter (mm)	10	44.94	33.03	39.02
	Aspect Ratio (%)	10	94.13	85.67	89.04

	Surface Area(mm^2)	10	11128.54	5904.53	8325.72

The assessment of dimensional properties of any agricultural produce are critical in creating database for engineering design and manufacturing equipment for sorting, cleaning, grading, sizing, packaging and handling operations such as conveying and discharge from chutes for any grain, fruit and seed [30]. These parameters determine the natural resting position of any fruits, grains and seeds. Surface area of avocado pear fruit varied from 19722.69 to 30239.36 mm^2. Other researchers have reported surface area of gbafilo fruit and kernel spread between 1584.80 and 2455.90 mm² and 737.37 to 1378.90 mm² respectively [31]. Surface area is significant in determining shape of fruit, seed and grain. It was found that surface area of avocado pear fruit was higher than that reported gbafilo fruit, simarouba fruit and date fruits [24, 37, 38]. The volume of avocado pear fruit ranged from 260432.33 to 493329.57 mm^3 as shown in Table 2. 1000 unit mass of avocado pear fruit varied between 181517.30 and 312341.70g. The practical relevance of this characteristic is in the design of equipment for cleaning using aerodynamic forces, separation, conveying and elevating unit operations.

Table 2. *Gravimetric properties of avocado fruit and seed*

Part of fruit	Properties	No. of Samples	Mean	Coefficient of variation
Fruit	Unit mass (g)	20	217.23	5.74
	1000 unit Mass (g)	20	195510.80	6.48
	Volume (mm^3)	20	366258.8	4.37
	Bulk density	20	794.63	13.64
	True density	20	1037.38	15.75
	Porosity	20	0.34	12.48
Seed	Unit mass (g)	20	54.63	8.98
	1000 unit mass(g)	20	49342.56	7.48
	Volume(mm^3)	20	61566.11	4.35
	Bulk density	20	685.47	3.46
	True density	20	984.49	7.41
	Porosity	20	0.31	16.39

The mean bulk and true densities of avocado pear fruit were 794.63 and 1037.38 kg m^{-3} respectively. This is an indication that avocado pear fruit is heavier than water. These parameters are helpful in the design of cleaning, separation and transportation of the fruit using hydrodynamic ways.

The average porosities recorded for fruit and seed of avocado pear were 34.0% and 31% respectively. This is an indication that there will be substantial volume of voids between the fruits [40, 41, 42].

Summary of the results of the compression test on avocado pear fruit were shown in Table 3. Under longitudinal loading, the rupture, bioyield, yield and compressive forces of the avocado pear fruit were 49.87 (10.47) N, 41.72 (7.86) N, 35.83 (12.47) N and 48.37 (4.60) N, accordingly.

On the lateral orientation, the rupture, bioyield, yield and compressive forces of the avocado pear fruit were 42.52 (54.3) N, 35.60 (9.65) N, 31.97 (8.74) N and 48.37 (4.60) N. There was significant difference between two different orientations at $P < 0.05$. Based on the obtained mean values of bioyield, yield, rupture and compressive forces, the avocado pear fruit have more strength on the longitudinal axis during loading compared to lateral axis. Lesser force was required to rupture the fruits at the longitudinal orientation compared to lateral orientation. Thus, losses due postharvest handling of layers of fruits during transportation could be dipping if fruits are arranged in vertical orientation.

A cursory look at the results of rupture, bioyield, yield and compressive forces of avocado seeds showed that there was significant difference between two different orientations at $P < 0.05$.

The angle of repose for fruit and seed were 22.63± 3.21° and 20.45±4.54° as shown in Table 4. For avocado pear fruit, the static coefficient of friction of aluminum steel, stainless steel, galvanised iron sheet, plastic sheet and plywood sheet were 0.425 ±0.032, 0.362 ± 0.058, 0.451 ±0.086, 0.476 ±0.026 and 0.489±0.022 (Table 3). Both fruit and seed of avocado pear revealed that dynamic coefficient of friction for four surfaces studied showed that plywood had the highest dynamic and static coefficient of friction among all the surfaces. Stainless steel recorded lowest dynamic and static coefficient of friction.

Table 3. *Mechanical Properties of Avocado fruits and seeds of on length, width and thickness*

Properties	Loading Orientations	No of Samples	Fruit	Coefficient of variation (%)	Seed	Coefficient of variation (%)
Rupture Point (N)	Vertical	10	49.87	10.76	1897.21	7.41
	Horizontal	10	42.52	5.43	1696.47	12.76
Yield force	Vertical axis	10	41.72	7.86	1665.36	11.54
	Horizontal	10	35.60	9.65	1598.69	6.32
Bioyield force (N)	Vertical	10	35.83	12.47	1539.06	9.31
	Horizontal	10	31.97	8.74	1503.87	7.65
Compressive force(N)	Vertical	10	55.04	6.43	2367.54	5.05
	Horizontal	10	48.37	4.60	2264.62	5.21
Modulus of elasticity (N/mm2)	Vertical	10	0.63	7.97	12.53	5.32
	Horizontal	10	0.49	8.48	10.26	6.51

Table 4. *Frictional properties of avocado pear fruit and seed*

Properties	Fruits		Seeds	
	Average	Coefficient Variation (%)	Average	Coefficient Variation (%)
Angle of repose (^{o})	22.63	3.21	20.45	4.54
Coefficient of static friction				
Aluminum steel	0.425	3.28	0.397	3.67
Stainless steel	0.362	0.058	0.531	7.43
Galvanised iron sheet	0.451	0.086	0.419	4.52
Plastic sheet	0.476	2.64	0.292	5.41
Plywood sheet	0.489	2.15	0.434	5.36
Coefficient of dynamic friction				
Aluminum steel	0.401	8.35	0.368	5.19
Stainless steel	0.347	6.37	0.321	2.42
Galvanised iron sheet	0.393	8.04	0.368	5.70
Plastic sheet	0.456	7.49	0.292	3.67
Plywood sheet	0.454	5.68	0.416	2.54

CONCLUSION

The physical and mechanical properties of avocadro pear fruits and seeds were evaluated. The mean values of aspect ratio and sphericity of avocado fruits and seeds indicated that the shape tends towards being spherical and expected to roll not slide. The results of rupture, bioyield, yield and compressive forces and well as modulus of elasticity of avocado fruit and seeds showed that there was significant difference between two different loading orientations at $P < 0.05$. Avocado pear fruit and seed can withstand more strength on the longitudinal orientations during loading compared to its lateral orientations. Losses due to postharvest handling of layers of fruits during transportation could be dipping if fruits are arranged in vertical orientation via packaging system. The results obtained will form a database that will be valuable in the design of systems for handling, processing and packaging of pear fruits and seeds. Stainless steel as construction material had the lowest dynamic and static coefficient of friction.

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