International Journal of Emerging Engineering Research and Technology
Volume 8, Issue 1, 2020, PP 23-29
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

Some Physical Properties of Okra Fruits and Seeds

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ABSTRACT

Some of the engineering properties of okra seeds and fruit studied were: geometric dimension such as length, width, thickness, arithmetic and geometric mean diameter, volume, 1000 unit mass, square mean diameters, surface area, sphericity and equivalent mean diameter. that are relevant to design and manufacturing of equipment for processing and preservation of the fruits and seeds. The mean values of aspect ratio and sphericity of okra seeds and fruit indicated that the shape tends towards being spherical and expected to roll than slide. The results obtained will form a database that will be valuable in the design of systems for handling and processing of okra seeds and fruit.. 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: *axial dimensions, sphericity, crop, bulk density, angle of repose.*

INTRODUCTION

Okra *Abelmoschus esculentus* L. (Moench) is ranked as the second main fruit and vegetable produced is the world Adejumo, 2015). It is an annual herb. The crop in commonly called ladies finger, okra, bhindi, or gumbo (Carney and Richard, 2009, Dhaliwal, 2010 and Kumar *et al*., 2013). Okra is rated as one the important vegetable and is a native to Africa. This crop is mainly grown in tropical, subtropical, and warm temperate climates in different countries from Africa to Asia, Southern Europe, and America (Ndunguru and Rajabu, 2004, Naveed et al., 2009 and Saifullah and Rabbani, 2009). In Nigeria, Okra is sold in virtually all the markets. It is ranked second best vegetable in order of importance in Nigeria while in Ghana the crop is rated fourth most popular vegetable (Adejumo *et al*., 2013).

Many researchers have described okra as multipurpose crop owing to the varied use of its leaves, buds, flowers, pods, stems, and seeds. (BeMilleret al., 1993 and Sengkhamparn et al., 2010) This crop is very rich in nutrients that are critical to human health like vitamins, carbohydrates, potassium, calcium, dietary fiber, and unsaturated fatty acids polyphenolic compounds, carotene, folic acid, thiamine, riboflavin, niacin, vitamin C, oxalic acid, and amino acids and also of bioactive chemicals. The database on the medicinal potential related to okra have been reported by many scientists such as cardioprotective, renal protective, neuro protective, anticancer, analgesic, antiulcer, antibacterial, and anti fatigue.

Singh *et al*., (2017) reported that okra has potential to reduce hemorrhoid effects, pains, and curing peptic ulcer.

The processing operations of okra are still predominantly achieved through manual methods. Dadali *et al*. (2005) reported the economic, health and nutritional benefits of okra. The traditional methods of processing okra is laborious, time consuming and huge losses, the various processing operations are characterized with high degree of unhygienic conditions such as contamination with dust, ash, soil, sand particles and insects infestation and is weather dependent (Dadali *et al*., 2005). According to Doymaz (2005) and Wankhale *et al*., (2012) reported three drying techniques such as open sun drying, solar drying and hot air drying.

MATERIALS AND METHODS

Sample Preparation and Moisture Content Determination

The freshly harvested okra fruit and transverse section of sliced okra pod (Fig. 1 and 2) were

cleaned manually to remove all foreign materials such as dust, dirt, broken and immature ones. The sample was packed inside polythene bags and air sealed.

Geometric Properties

To determine mean of okra fruits and seeds dimension, 100 okra fruits and seeds were randomly selected and their three namely, length (*L*), width (*W*) and thickness (*T*) were measured using digital vernier caliper with an accuracy of 0.01 mm. The mean length of okra fruits and seeds were determined 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 okra fruits and seeds were calculated by using the following relationships (Galedar *et al*., 2008 and Mohsenin, 1986, Koocheki *et al*., 2007 and Milani, 2007, Mc Cabe *et al*., 1986 and Lorestani *et al*., 2012).

Figure1. *Picture of freshly harvested Okra*

Figure1. *Transverse section of sliced Okra pod*

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

$$Dg = (LWT)^{1/3} \quad (2)$$

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

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

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

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

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

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

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

The volume (V) of okra fruits and seeds were evaluated using the toluene displacement method (Demir et al., 2002).The 1000 unit mass of okra fruits and seeds determined using precision electronic balance to an accuracy of 0.01g. To evaluate the 1000 unit mass for fruits and nut, 50 randomly selected samples were weighed and multiplied by 20 to give the mass of 1000 fruit and nut. The experiment was replicated ten times.

Gravimetric of Okra Fruit and Seeds

The bulk density (ρb) of okra fruits and seeds were evaluated using the technique adopted by Garnayak *et al.* 2008.

$$\rho b = \frac{\text{Mass of bulk seeds}}{\text{Volume of bulk seeds}} \quad (11)$$

The true density of okra fruits and seeds was evaluated using the water displacement method (Kabas *et al*. 2007). Water displacement method was used for okra fruits and seeds because of its low water absorption characteristic. The porosity of the bulk okra fruits and seeds were evaluated from the values of the bulk density and true density based on the relationship given by Mohsenin (1986).

$$\varepsilon\,(\%) = \left(1 - \frac{\rho b}{\rho t}\right)100 \quad (12)$$

The static coefficient of friction was determined with respect to five structural materials namely: galvanized iron sheet, rubber sheet, plywood sheet, iron sheet in accordance with Davies and Mohammed (2011).The angle of repose was determined based on the method used by Davies and El-Okene (2009).

Results and Discussion

The geometrical characteristics of okra seeds and fruit such as length, width, thickness, 1000 unit mass, arithmetic and geometric mean diameter, sphericity, volume and surface area for okra seeds and fruits were investigated and presented in Table 1. The mean length, width and thickness of okra fruit were 8.08 cm, 2.66 cm and 2.50 cm with coefficient of variation of 11.2, 7.5 and 6.1% respectively. The average length, width and thickness of okra seeds were 0.57 cm, 0.55 cm and 0.50 cm with coefficient of variation of 9.74, 8.62 and 7.95% respectively. Davies and Mohammed (2004) reported the average length, width and thickness of soursop seeds were 13.25±0.65 mm, 8.97±0.87 mm and 5.63±0.12 mm respectively. The average length, width and thickness of *simarouba* fruit were 21.26 mm, 13.81 mm and 11.03 mm (Dash *et al*., 2008).

Information on dimensional characteristics of any biomaterial like seed and fruit shapes is pertinent due to their horticultural research purposes. It involves species descriptions for plant variety rights or species registers (Beyer *et al*., 2002 and Jannatizadek *et al*., 2008). These parameters are significant in the determination of consumer preference and evaluation of heritability of fruit shape traits (White *et al*., 2002). The arithmetic and geometric mean diameter of okra seeds and fruits were 0.54 cm and 4.29 cm with correlation variation of 8.7% and 8.2%. Koocheki *et al.* (2007). The arithmetic and geometric mean diameter of okra seeds and fruits were 0.52 cm and 4.21 cm with correlation variation of 7.23% and 6.83%. Evaluation of arithmetic and geometric mean diameters for Kolaleh, Ghemez and Ghemez (three species of watermelon seeds) ranged between 6.89 and 8.24 mm, 8.37 and 10.79 mm and 7.61 and 9.28 mm. Davies (2012) reported geometric and arithmetic mean diameters of palm fruit that ranged between 21.36 to 29.23 mm and 20.80 to 27.80 mm.

The average surface area of okra fruits and seeds was 44.74 cm^2 and 0.91 cm^2 with correlation variation of 13.7%. Davies and Mohammed (2014) reported that the surface area of *Soursop* seeds differed from 195.10±7.73 mm^2 to 385.05±4.75 mm^2. The mean surface area of okra fruits was 339.31 mm^2 with correlation variation of 14.37%. The mean surface area of gbafilo fruits varied between 1584.80 to 2455.90 mm^2 (Davies and Zibokere, 2011). The parameter is used in the assessment of spray coverage, residues removal, respiration rate, light reflectance, and colour. It has effect on the rate of reaction during biochemical processes. The volume of okra seeds and fruits were 61.22 cm^3 and 339.31 cm^3 with correlation variation of 15.3% and 15.61%. The average sphericity of okra seeds and fruits were 47.0% and 95.06%. The sphericity of three species of melon seeds was obtained for *C. lunatus*, 53%, *C. edulis*, 47% and *C. vulgaris*, 45% (Davies, 2009). Bal and Mishra 1988 and Garnyak 2008 recommended any grain, fruit and seed with sphericity value more than 70% is assumed to be spherical. Therefore, it can be concluded that okra seeds and fruits are spherical. The average aspect ratio of okra fruit and seed were 32.92% and 96.49% with their respective correlation variation of 10.8 and 9.15%. The obtained result is an indication that the okra seeds will roll but fruit will rather slide than roll.

Table1. *Geometrical properties of okra fruit and seed*

Properties	Sample no	Fruit			Seed	
		Mean	Coefficient variation (%)	Standard deviation	Mean	Coefficient variation (%)
Length (cm)	100	8.08	11.2	0.47	0.57	9.74
Width (cm)	100	2.66	7.5	0.63	0.55	8.62
Thickness (cm)	100	2.50	6.1	0.55	0.50	7.95
Arithmetic mean Diameter (cm)	100	4.41	8.7	0.82	0.54	7.23
Geometric mean Diameter (cm)	100	3.77	8.2	0.85	0.51	6.83
Equivalent diameter (cm)	100	4.04	9.65	0.28	0.52	9.61
Sphericity (%)	100	47.52	7.9	0.84	54,6	5.56
Aspect ratio (%)	100	32.92	10.8	0.53	96.49	9.15
Surface area (cm^2)	100	44.74	13.7	0.65	0.91	14.37
Volume (cm^3)	100	61.22	15.3	1.64	417.07	15.61

Table2. *Gravimetric properties of okra fruit and seed*

Properties	Seeds		Fruit	
	Mean	Coefficient of variation (%)	Mean	Coefficient of variation (%)
1000 -Unit mass (g)	93.54	4.75	11352.78	12.63
Bulk density kg/m3	463.84	10.52	146..58	9.38
True density kg/m3	739.41	8.27	289.31	3.81
Porosity (%)	37.27	2.33	49.33	5.85

Table3. *Frictional properties of okra fruit and seeds*

Properties	Fruits		Seeds	
	Average	Standard deviation	Mean	Standard deviation
Angle of repose (o)	28.93	0.345	25.76	0.237
Coefficient of static friction				
Aluminum steel	0.376	0.242	0.347	3.67

Stainless steel	0.334	0.340	0.332	7.43
Galvanised iron sheet	0.439	0.236	0.411	4.52
Plastic sheet	0.457	0.315	0.421	5.41
Plywood sheet	0.451	0.345	0.423	5.36

This is useful information in the design of hoppers. The mean 1000 unit mass of okra seeds and fruits were 95.54 g and 11352.78 g with their respective correlation variation of 17.1 and 15.02%. The average 1000 unit mass of bitter kola nut varied from between 3087.02 and 4200.35 g (Davies and Mohammed, 2013). Many researchers reported 1000 unit mass of different seeds and fruits such as japtropha seed and kernel, arigo seed, simarouba fruit and kernel, maize, red gram, wheat, green gram, chickpea, faba bean, pigeon pea were 1322.41 g, 688 g, 1124.7 g, 1120 g, 330.26 g, 268.30 g, 102 g, 346 g, 30.15 g, 120 g and 75 g (Shephered and Bhardwaj, 1986, Dulta *et al*., 1998, Tabatabaeefar, 2003 and Dash *et al*., 2008).

True and bulk densities and porosity okra seeds and fruits Table 2. The porosity of okra seeds and fruits were 37.27 and 49.33%. The air circulation through the products will be more prominent in okra fruits compared to its seeds. The bulk densities of okra fruit and seed were 146.58 kg/m^3 and 289.31 kg/m^3. The true densities of okra fruit and seed were 463.84 and 739.41 kg/m^3 The corresponded average values of true and bulk densities for hog plum fruits and nuts were 1023.51, 652.90, 431.48 and 837.70 kgm^{-3} (Davies, 2015). Information on the coefficient of static friction of biomaterial is important in the design of pneumatic conveying systems, screw conveyors as well as hoppers.

Conclusion

- The mean length, width and thickness of okra fruit were 8.08 cm, 2.66 cm and 2.50 cm.
- The average length, width and thickness of okra seed were 0.57 mm, 0.55 mm and 0.50 mm.
- The average surface area of okra seeds was 88.72 mm^2 with correlation variation of 13.7%.
- The mean sphericity and aspect ratio of okra seeds and fruits were 47.0%, 9506%, 32.92% and 96.49%
- The mean 1000 unit mass of okra seeds and fruits were 95.54 g and 11352.78 g with their respective correlation variation of 17.1 and 15.02%.
- The bulk and true densities of okra fruit and seed were 146.58 kg/m^3. 289.31 kg/m^3, 463.84 and 739.41 kg/m^3.
- The porosity of okra seeds and fruits were 37.27 and 49.33%.

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Citation: *Davies, Rotimi Moses, "Some Physical Properties of Okra Fruits and Seeds", International Journal of Emerging Engineering Research and Technology, 8(1), 2020, pp. 23-29.*