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Physical and Mechanical Properties of "Egusi" Melon (*Citrullus colocynthis lanatus* var. *lanatus*) Fruit

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ABSTRACT

The aim of the present work is to determine the physical and mechanical properties of Egusi melon fruits. These properties are required for the purpose of mechanizing the harvest and post harvest operations of the fruits, such as storage, transportation, processing and packaging. This paper presents some of these properties in relation to the "Egusi" fruit and how they were determined and values obtained. It uses have been identified in medicine, cosmetics and as a biodiesel feedstock. Basic dimensions and mass were determined with a digital gauge and scale with accuracy 0.01 mm and 0.01 g, respectively. Maximum length, width, thickness and mass of 100 samples were 12.86 cm, 12.53 cm, 15.52 cm and 1031.5 g, respectively. Arithmetic and Geometric mean diameters were between 5.68-13.63 and 5.58-13.22 cm while mean Bulk and True densities were 404.98 and 1074.6 kg m^{-3} on 3 and 6 runs, respectively. The sphericity and aspect ratio were about 1, with average packaging coefficient on 5 separate runs of 33.49. The average vertical and horizontal weight to break the fruit was 121.23 and 74.09 kg, respectively. These findings will guide Egusi harvesting machine design and also gives information on loading capacity in transportation and storage of the harvested fruit prior to processing.

Key words: Egusi fruit, packaging coefficient, vertical and horizontal loading of fruit, basic dimensions

INTRODUCTION

Melons are generally under Cucurbitaceae family. The species are same; the only major difference is the variety, which classifies the melons as either "edible" or "inedible". The seed kernel is being used in West African countries as soup ingredient, or snack when roasted. Its oil and methyl esters have been proved to meet the biodiesel qualities (Gusmini *et al*., 2004; Solomon *et al*., 2010). These kernels are covered with a shell which is usually removed before processing to any use. It is a good source of amino acids such as arginine, vitamins B1, Vitamins B2, niacin, tryptophan and methionine and minerals such as zinc, iron, potassium, phosphorus, sulphur, manganese, calcium, lead, chloride and magnesium Onyeike and Acheru (2002). Eugene and Gloria, 2002 concluded in their research that the seed kernel contains 50 and 30% oil and proteins, respectively.

Physical and mechanical properties are often required for designing harvest and post harvest handling and processing deices as well as transportation for agricultural products. Physical and mechanical properties data of "egusi" fruit are necessary for harvest and various post harvest operations such as packaging, transportation, sorting, storage, grading and so on. A careful review of literature showed no results for the fruit's properties, Bande *et al.* (2012a) worked on the properties of the seeds of egusi. Similar results were presented on different types of oranges by Topuz *et al.* (2005). Investigations on physical properties of areca nut kernels, such as size, shape, roundness, sphericity, 1000 kernel mass, bulk density, porosity, angle of repose, static coefficient of friction and kinetic coefficient of friction was also reported by Kaleemullah and Gunasekar (2002). Similar works have been reported on the physical properties of fruits such as plum (Ertekin *et al.*, 2006) and gumbo fruit (Akar and Aydin, 2005), Iranian oranges (Tabatabaeefar *et al.*, 2000). To develop technologies for fruits processing and mechanical handling, knowledge of the properties of fruit involved is important. In this study, physical and mechanical properties of egusi fruit, such as length, width, thickness, mass, fruit density, bulk density, porosity, packaging coefficient, geometric and arithmetic mean diameters, sphericity, surface area, aspect ratio, vertical and horizontal fruit breaking force and skin punching force were determined.

MATERIALS AND METHODS

"Egusi" melons (Fig. 1) were grown in Malaysia for the first time on a 20 m by 10 m plot and a harvest of over 1000 fruits was made. They were manually harvested and transported to the laboratory for experiments. One hundred fruits (100) fruits were randomly selected to conduct these tests. Moisture level was maintained as the fruits were placed in an air-conditioned room at 16°C until equipment was ready.

Basic dimensions: Basic dimensions (Length, Width and Thickness) were measured using vertical digital scale (Mitutoyo, series 193) with accuracy of 0.001 mm, as in Aviara and Haque (2000) and Visvanathan *et al.* (1996). Mass of fruits was determined using digital scale with accuracy of 0.001 g (Mitutoyo). Arithmetic mean diameter (D_a), Geometric mean diameter (D_g), sphericity (ω) and surface areas (S_a) were calculated by using Eq. 1-4:

$$D_a = (L+W+T)/3 \tag{1}$$

$$D_g = (LWT)^{1/3} \tag{2}$$

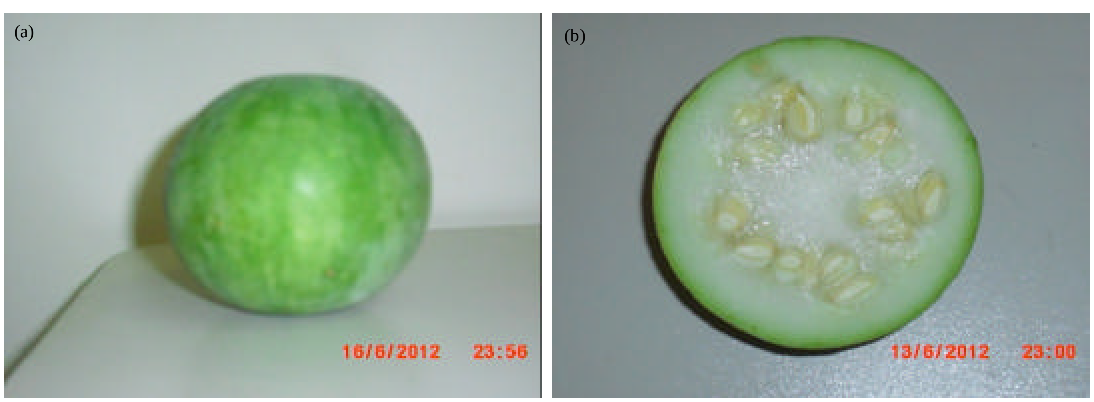

Fig. 1(a-b): Egusi melon (a) Whole fruit and (b) Horizontally cut fruit

$$\omega = D_g/L \quad (3)$$

$$S_a = \pi D_g^2 \quad (4)$$

where, L is the length of fruit, W is the width of fruit, T is the thickness of fruit. Similar relations were used by Baryeh (2001), Bande *et al.* (2012b) and Kabas *et al.* (2005).

Bulk and true densities: Bulk density of the fruit was obtained using standard test weight procedure by filling an empty box of predetermined weight and re-weighted. The bulk density was calculated from the mass of fruit and volume of the container, as in Singh and Goswami (1996); Suthar and Das (1996). Volume of the cylindrical container was calculated from equation 5 and Bulk density was obtained from Eq. 6:

$$V_b = \pi r^2 h \quad (5)$$

$$\rho_b = W_s / V_b \quad (6)$$

where, r, h, W_s is the radius, height, weight of the container, respectively and V_b volume of the beaker.

True density of the fruit was determined as ratio of fruit mass to volume of displaced water as in Dutta *et al.* (1988). This was obtained by measuring the amount of water displaced by immersion of fruit. Equation 7 uses the values of bulk and true densities to evaluate the porosity of the fruit as in Jain and Bal (1997).

$$\varepsilon = 1-(\rho_b/\rho_t)\times 100 \quad (7)$$

where, ε, ρ_b and ρ_t is the porosity, bulk density and true density, respectively.

Packaging coefficient: Packaging coefficient is defined by the ratio of the total volume of fruit packed to the volume of box and calculated by Eq. 8:

$$\beta = V_t/V_{box} \quad (8)$$

where, β is parking coefficient, V_t is the total volume of fruits and V_{box} is box volume.

Mechanical properties: Mechanical properties of the fruit is determined by subjecting the fruit to loading in different orientations and crushed between the swindles of a Texture Profile Analyzer (TPA), with load cell of 30 kg at test speed of 2 mm sec^{-1} until breakage of the fruit was achieved. The vertical and horizontal forces were obtained by Instron machine, 100 kN, with feed speed of 2 mm sec^{-1}. This was similarly reported in the works of Akaaimo and Raji (2006), Baumler *et al.* (2006), Olaniyan and Oje (2002) and Bande *et al.* (2012a).

RESULTS AND DISCUSSION

Readings were taken on fresh fruits by randomly selecting 100 fruits samples for the basic dimensions. Properties such as length, thickness, width, mass and derivatives like arithmetic and geometric mean diameters, surface area, aspect ratio and sphericity were deduced from them. The results showed that the maximum length, width and thickness were 12.86, 12.53 and 15.52 cm, while the mean values were 9.29, 9.16 and 10.57 cm, respectively. These dimensions are important in machine design and transportation or fruit sorting, as discussed by Rafiee *et al.* (2007).

The sphericity of the samples was close to one, indicating that the fruits were almost spherical in shape. This is an important parameter, especially in packaging. The arithmetic and geometric mean diameters were in the range of 5.68 to 13.63 and 5.58 to 13.22, respectively. Surface area of the sample fruits was in the range 97.90 to 549.18 with aspect ratio almost one. Bulk density was determined to be between 369.23 and 445.72 kg m^{-3} while true density was between 993.48 and 1237.82 kg m^{-3}.

Egusi fruits compared to bergamot as in Rafiee *et al.* (2007), indicated that the masses of the egusi fruit is higher than the bergamot but the basic dimensions are smaller, indicating than the densities of egusi fruit is higher. True densities of bergamot were between 620 to 740 kg m^{-3} and that of egusi was between 993 to 1237 kg m^{-3} as seen in the results. Similarly, the sphericity of bergamot was less than that of egusi fruit. A comparison was made to oranges in the work of Topuz *et al.* (2005).

Another important parameter is the packaging coefficient. This is important for space requirement either in storage or transportation. The study revealed that it was in the range of 28.18 to 43.54. Packaging coefficient of egusi fruit was higher than the bergamot and oranges, as reported by Rafiee *et al.* (2006). These results are summarized in Table 1.

Some mechanical properties of Egusi fruit were also determined, such as vertical and horizontal crushing forces (Fig. 2, 3). These properties are important in bulk transportation and packaging. It gives information of how much load can the fruit withstand without crushing. Figure 2 (vertical loading of fruit) indicates that specimen 1 and 2 where crushed to the extension of about 27 mm before rupture, under crushing force of 1300 and 950 N, respectively. Sample 3 ruptured at 37 mm under 1300 N. In Fig. 3, the horizontal loading of fruit, sample 1 ruptured at 27 mm under 780 N while sample 2 ruptured at 28 mm under 810 N. Similarly, sample 3 ruptured at 26 mm under 580 N. Similar reports were made by Baumler *et al.*

Table 1: Physical properties of Egusi fruit

Property	No. of replicates	Maximum	Minimum	Mean	SD
Length (cm)	100	12.86	5.73	9.29	1.67000
Width (cm)	100	12.53	5.69	9.16	1.67000
Thickness (cm)	100	15.52	5.62	10.57	2.90000
Mass (g)	100	1031.60	103.50	407.20	219.030
Arithmetic mean diameter	100	13.63	5.68	9.67	2.07000
Geometric mean diameter	100	13.22	5.58	9.42	1.98000
Sphericity (%)	100	1.00	0.97	1.00	0.03600
Surface area (cm^2)	100	549.18	97.90	291.19	117.970
Aspect ratio	100	0.99	0.97	0.99	0.00900
Bulk density (kg m^{-3})	3	445.72	369.23	404.98	38.4900
True density (kg m^{-3})	6	1237.82	993.48	1074.60	93.1200
Packaging coefficient	5	43.54	28.18	33.49	6.27000

Table 2: Mechanical properties of Egusi fruit

		Mass (kg)				Extension (mm)			
Property	Rep.	Max.	Min.	Mean	SD	Max.	Min.	Mean	SD
Vertical loading	3	133.95	97.93	121.23	20.37	35.47	26.86	29.94	4.790
Horizontal loading	3	82.81	59.60	74.09	12.64	27.32	25.57	26.29	0.914

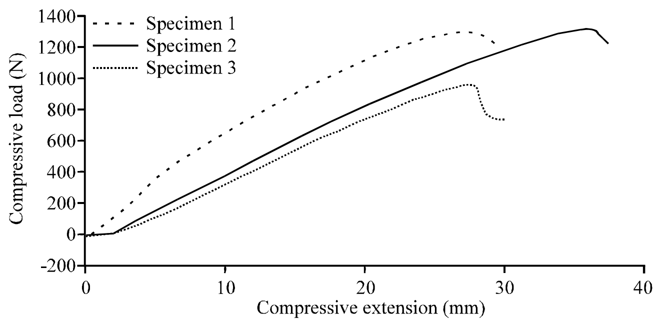

Fig. 2: Vertical loading response of the fruit

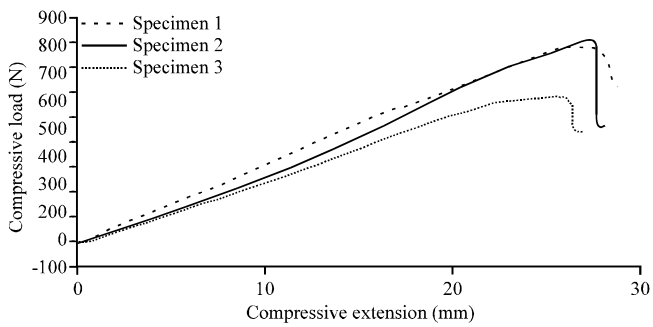

Fig. 3: Horizontal loading response of the fruit

(2006) on safflower seeds. The results showed that, on three replications, the average vertical weight required to crush the fruit was 121.23 kg, while the horizontal was 74.09 kg (Fig. 2, 3) as shown in Table 2.

CONCLUSIONS

Conclusions drawn from the investigations revealed that the length of Egusi fruit was in the range of 5.73-12.86 cm while the width was between 5.69-12.53 cm and 5.62-15.52 in thickness. Mass was in the range of 103.5-1031.5 g, while bulk and true densities were in the range of 369.23-445.72 and 993.48-1237.82 kg m^{-3}, respectively. Packaging coefficient was between 28.18 and 43.54 and sphericity and aspect ratio were around one, with the average vertical and horizontal weight to break the fruit at 121.23 and 74.09 kg, respectively.

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