



(RESEARCH ARTICLE)



## Determination of selected physical properties of three varieties of shelled and unshelled melon seeds

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### Abstract

The physical properties of shelled and unshelled melon seeds for three different varieties: *C. cucurbita*, *C. vulgaris* and *C. lanatus* were investigated at the moisture contents of 5.3, 5.1 and 6.0% dry basis respectively. The axial dimension, mean diameter, sphericity, surface area, porosity, true and bulk density, angle of repose, coefficient of friction of the three varieties of melon seeds were determined using standard methods. The results obtained from the study revealed that length, width, thickness, arithmetic and geometric diameter, sphericity, surface area and 1000 unit mass ranged from 12.81-14.50 mm, 7.02-8.42 mm, 2.22-2.49 mm, 7.36-8.31 mm, 5.84- 6.54 mm, 0.47- 0.53, 134.64-192.23 mm<sup>2</sup> and 94.0- 110.0g respectively. Sphericity was 0.41, 0.41 and 0.36 for shelled *C. lanatus*, *cucurbita* and *c. vulgaris*, while the values for unshelled varieties are 0.43, 0.42 and 0.41 respectively. Surface area was 116 mm<sup>2</sup>, 139 mm<sup>2</sup> and 180 mm<sup>2</sup> for shelled *C. lanatus*, *cucurbita* and *C. vulgaris*, while the values for unshelled varieties are 186 mm<sup>2</sup>, 205 mm<sup>2</sup> and 283 mm<sup>2</sup>. One thousand unit mass was 89.6g, 82.2g and 95.8g for shelled *C. lanatus*, *cucurbita* and *C. vulgaris*, while the values for unshelled varieties are 98g, 94g, and 110g respectively. Angle of repose was 26.3°, 25.4° and 26.1° for shelled *C. lanatus*, *cucurbita* and *C. vulgaris*, while the values for unshelled varieties are 23.6°, 20° and 23.5° respectively. Bulk density was 458 g/mm<sup>3</sup>, 389 g/mm<sup>3</sup> and 423 g/mm<sup>3</sup> for shelled *C. lanatus*, *cucurbita* and *C. vulgaris*, while the values for unshelled varieties are 543 g/mm<sup>3</sup>, 405 g/mm<sup>3</sup>, and 446 g/mm<sup>3</sup> respectively. Finally porosities of 34.8%, 47.9% and 48.5% were obtained for shelled *C. lanatus*, *cucurbita* and *C. vulgaris*, while the values for unshelled varieties are 37.3%, 53.7% and 48.5% respectively.

**Keywords:** Unshelled; Shelled; Physical; Properties; Melon; Moisture; Content

### 1. Introduction

Melon (*Citrulus species*) is one of the most popular vegetables crops in Africa. Melon is a tendril climbing herbaceous crop. [1] reported that 100,000 and 488,000 metric tons were produced in Nigeria for the year 1992 and 1997 respectively. The seed belongs to the family of cucumber. Melon, locally called "Egusi" (*Citrulus colocynthis*: *Citrulus vulgaris* and *Cucurbita spp.*) are used as food source, in medicine, engineering and cosmetics. *Egusi* has excellent genetic diversity, vegetative and reproductive characteristics. Some of the species are edible and grown in most parts of the world [2]. It is a creepy growing plant that covers a large area when properly grown, and as such control weeds, thereby improving soil fertility. Kernels of this seeds can be roasted and used extensively for cooking purposes, either as a soup additive or as cooking oil source. Recently, it has been proved to be a feed stock for bio-fuel [3]. It is a good source of amino acid such as arginine vitamins B, and the oil content is over 50%. It contains other important mineral nutrients. The processing operations for *egusi* are predominantly traditional and done manually. Traditional processing methods are time consuming and laborious. The condition prevalent at this level of processing is generally unsanitary and inherently unhygienic. This processing method has been generally designed without taking into consideration the physical properties of melon and as such the resultant system leads to reduction in processing efficiency and increased product losses [4, 5].

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The knowledge of physical of biomaterials like melon, is fundamental because it facilitates the design and development of equipment for harvesting, handling, conveying, cleaning, delivering, separation, packing, storing, drying, mechanical oil extraction and processing of such materials [6, 7]. It is also essential for design of equipment for planting, aeration and dehulling [8]. These are necessary so that the component requirement for a successful dehulling without grinding the kernel, which is soft in nature, can be developed. Therefore, the development of the machine will address the problems of traditional method of processing such as high labor demand drudgery, low through put, time consumption etc. and it will ensure clean and hygienic product.

Determination of the physical properties of agricultural bio-material is often problematic because of their diversity of shape, size and moisture content and maturity level. Recent scientific developments have improved the handling and processing of bio-materials through mechanical and thermal devices, but little is known about the basic physical characteristics of these materials [9]. Such basic information is not only important to engineers but also to food scientists and processors, plant and animal breeders, and other scientists involved in handling and processing (such as transportation, drying dehulling cleaning etc) and design of post-harvest machines.

Melon are full of nutrients; the seeds are high, in protein and oil contents. Analysis made on melon by [10] indicates that melon seeds consist about 50% of oil (edible) by weight, 37.4% of protein, 2.6% of fibre, 3.6% ash and 6.4% of moisture. The oil content of the seed is made of unsaturated fatty acids, which are linoleic (35%) and oleic (15%), and 50% saturated fatty acid, which are stearic and palmitic acids. The presence of unsaturated fatty acid makes melon nutritionally desirable and suggests a possible hypocholesterolemic effect (lowering of food cholesterol). The melon seed has a lot of advantages among which are oil for margarine production, shortening and cooking oil, cake for livestock feed etc. The seed contains alphanatocopherol (vitamin E. component) that helps to maintain young and smooth skin. It also contains stearic, linoleic, palmitic, and oleic acids, which are important in protecting the heart. *Egusi* seeds are used to make soups that are very popular throughout Africa. Apart from that, the seeds are generally used in many West Africa Cuisines.

Dry melon seeds are often eaten as snack. It is widely used to make paste for spreading on bread. The seeds can also be good substitute for baby food. At times, the seeds are blend with honey and water that produces a kind of liquid, which can be used for feeding children if breast milk is not available. They are resilient to pests, so farmers often intercrop this plant with other plants [10]. The objectives of this research work is to determine some selected physical properties of three varieties of shelled and unshelled melon seeds as they affect their processing.

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## 2. Material and methods

A sample size of 100 seeds of three species of melon (*C. vulgaris*, *C. lanatus* and *Cucurbita*) each were used, the samples were bought from Umuahia market and stored in a container at room temperature for two days, to allow uniformity of moisture distribution. Some samples of each variety of the melon seeds were also manually shelled and also used for the tests. The size and principal axes of the seeds (minor, intermediate and major) were determined using a Digital Caliper of precision 0.01mm and model Greprufte Sicurhele (GS).

The weights of the seeds were determined using a Digital Scale of maximum measurement of 400g and approximate error of 0.1g. Other instruments used in the engineering properties determination include oven (moisture content determination) T-square and meter rule (angle of repose), aluminum foil (surface area), thermometers calibrated beaker, electric boiling ring (water) graphs etc.

### 2.1. Methods of experiments

The three varieties of melon studied were labeled as samples A, B and C. Where A is commonly known as white *Egusi* "*Colocynthis citrullus lanatus*, sample B is commonly known as "Ahu" *Cucurbita* and Sample C is commonly known as Water Melon *Citrullus vulgaris*. Each of these experiments was carried out on both the shelled and unshelled melon samples to determine their properties.

#### 2.1.1. Roundness

Tracing method was used; the trace of the seed was done on graph paper, and the area estimated by counting the squares in the graph. Roundness was determined using the relationship as described by [6] as;

$$\text{Roundness} = \frac{AP}{AC} \quad (1)$$

$AP$  = largest projected area of the seed in rest position

$AC$  = area of smallest circumscribing circle. (Mohsenin 1986)

### 2.1.2. Shape

This was determined using descriptive term, from the physical characteristics of the seed, matched with the Charted Standards [6].

### 2.1.3. Sphericity

The sphericity was determined, using the expression.

$$\text{Sphericity} = \left( \frac{bc}{a^2} \right)^{1/3} \quad (2)$$

Where

$a$  = longest intercept (major diameter)

$b$  = Longest intercept normal to "a"

$c$  = Longest intercept normal to a and b

### 2.1.4. Surface area

A paper foil method was used to determine this. The seeds were carefully wrapped with the foil paper, and then the boundary of the seeds as seen on the foil paper was placed and traced on graph paper. The surface area estimated by counting the squares in the graph.

### 2.1.5. Volume

The volume of the seed was determined using Archimedes principle which states that the volume of an object when immersed in water is equal to the amount of water displaced by that object. The volume of the displaced water when the samples were put in a measuring cylinder were recorded.

### 2.1.6. Bulk density

Archimedes principle was also used. Here a known volume of cylinder was used and the weight of the seed sample was taken and recorded, and the density was determined using the expression.

$$\text{Density} = \frac{m}{v} \quad (3)$$

Where,  $m$  = mass of samples, and  $v$  = volume of samples

### 2.1.7. Solid density

This was determined using a gravity bottle and the expression as described by Davis (2010) was used.

$$\text{Solid density} = \frac{M_2 - M_1}{(M_4 - M_1) - (M_3 - M_2)} \quad (4)$$

$M_1$  = Weight of empty density bottle (g)

$M_2$  = Weight of density bottle with samples

$M_3$  = Weight of density bottle with samples filled with water

$M_4$  = Weight of density bottle with water only (g)

2.1.8. Bulk porosity

Bulk porosity was determined using the expression as described by Mohsenin (1986) [6]

$$\text{Porosity} = 1 - \frac{\text{bulk.density}}{\text{solid.density}} \times 100 \tag{5}$$

2.1.9. Moisture content

The moisture content of the samples was determined using the oven method. The weight of the samples and empty cans were measured before drying and also the weight of the cans and samples after oven drying at a temperature of 105°C for 24hours.

The moisture content of the seed can be determined using the relationship below:

$$\text{MC(wet basis)} = \frac{W_w - W_d}{W_w} \times 100 \tag{6}$$

$$\text{MC(dry basis)} = \frac{W_w - W_w}{W_d} \times 100 \tag{7}$$

$W_w$  = weight of wet sample (g)

$W_d$  = Weight of dried sample (g)

2.1.10. Angle of repose

The tilting method was used. In this method, the sample was placed on a stainless steel plate and tilted until they began to flow. The angle of inclination of the plate from the horizontal before the samples began to flow was recorded as the angle of repose of the *egusi* samples.

3. Results and discussion

Some physical properties of the three varieties of melon are shown in Table 1.

**Table 1** Summary of some physical properties of three varieties of shelled and unshelled melon seeds.

Parameter	No of samples	<i>C. lanatus</i>		<i>Cucurbita</i>		<i>Vulgaris C</i>	
		shelled	unshelled	Shelled	unshelled	shelled	unshelled
Length (mm)	100	12.5	14.5	13.1	16.3	15.1	20.5
Width (mm)	100	7.7	8.6	5.8	7.4	6.0	8.9
Thickness (mm)	100	1.4	1.9	2.1	2.6	1.7	3.9
Arithmetic mean diameter (mm)	100	6.84	7.68	6.38	7.36	7.45	8.31
Geometric mean (mm)	100	5.36	6.16	5.43	5.84	5.36	6.25
Volume mm <sup>3</sup>	100	135	170	142	182	183	213
Sphericity	100	0.41	0.43	0.41	0.42	0.36	0.41
Surface area (mm <sup>2</sup> )	100	116	186	139	205	180	283
1000 unit mass (g)	1000	89.6	98.0	82.2	94.0	95.8	110 .0
Angle of repose (°)	100	26.3	23.6	25.4	20.0	26.1	23.5
Bulk density g/mm <sup>3</sup>	100	458	543	389	405	423	446
Porosity (%)	100	34.8	37.3	47.9	53.7	44.3	48.5
Moisture content	100	6.13	5.97	6.18	5.38	5.36	5.08

The figures of the shelled and unshelled varieties of the melon seeds are shown in figures 1 to 6.



**Figure 1** *C. Curcubita* (Unshelled)



**Figure 2** *C. Curcubita* (Shelled)



**Figure 3** *C. Lanatus* (Unshelled)



**Figure 4** *C. Lanatus* (Shelled)



**Figure 5** *C. Vulgaris* (Unshelled)



**Figure 6** *C. Vulgaris* (Shelled)

The highest axial dimensions were observed from *C. vulgaris*, 20.5, 8.9 and 3.9 mm related to length width and thickness respectively for the unshelled samples, while the shelled samples had 15.1, 6.0 and 1.7 mm length, width and thickness respectively. *C. lanatus* had the lowest values of length, width and thickness. The knowledge of axial dimensions of agricultural materials is pertinent in the sense that separation of biomaterial as a unit processing operation is hinged on axial dimensions. *C. Vulgaris* had the highest geometric and arithmetic mean diameters values of 6.25 and 6.31 mm respectively.

*C. vulgaris* had the highest surface area of 213 mm<sup>2</sup>, while the least surface area recorded was for *C. lanatus* 186 mm<sup>2</sup> for unshelled melon sample, *C. vulgaris* shelled melon sample had highest surface area of 180 mm<sup>2</sup> while the least surface area recorded was for *C. lanatus* (116 mm<sup>2</sup>). Investigation made by [11], showed that surface area for shelled and unshelled watermelon ranged from 182.96-225.03 mm<sup>2</sup> and 182.51-220.45 mm<sup>2</sup> respectively. The maximum sphericity value was observed for *C. lanatus*, 0.43 followed by *C. cucurbita*, 0.42. The minimum sphericity was noticed to

be *C. vulgaris*, 0.41. According to [12], and [13], any grain, fruit and seed is considered as spherical when the sphericity value is above 80 and 70%, respectively. Therefore, it can be concluded that melon seeds are not spherical based on the sphericity values obtained. *C. vulgaris* had the highest 1000-unit mass value of 110 g while the least value 94 g was recorded for *C. cucurbita*. It was observed that the highest porosity was *C. vulgaris*, 53.7 % while the least porosity value was shown as *C. lanatus*, 37.3%. This can be furthered explained from obtained result that aeration through the seeds will be more pronounced in *C. vulgaris* (53.7%) compared to *C. lanatus* (37.3%). The result of true and bulk densities and angle of repose for the three varieties of melon studied showed that, *C. lanatus* had the highest bulk density 543 kg/m<sup>3</sup> and followed by *C. vulgaris* 446 kg/m<sup>3</sup>. The mean true density values ranged from 816.09 to 847.47 kg/m<sup>3</sup> for the three varieties.

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#### 4. Conclusion

The following conclusions are drawn from the research on some engineering properties of three varieties of melon seeds (*C. lanatus*, *C. vulgaris* and *C. cucurbita*) at moisture content of 6.0%, 5.1% and 5.4% dry basis respectively: The mean length, width, thickness, arithmetic and geometric mean diameter, sphericity, surface area, 1000 unit mass, for the three varieties of melon were in these ranges, 12.81-14.50mm, 7.02-8.42mm, 2.22-2.49mm, 7.36-8.31mm, 5.84-6.25mm, 0.47-0.53, 131.64- 192.23 mm<sup>2</sup>, 94-110g respectively.

The mean porosity, true and densities, angle of repose were investigated for the three varieties were 37.3-53.7, 816.09-847.47kg/m<sup>3</sup>. 405.0 - 543kg/m<sup>3</sup> and 29.3-36 respectively.

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#### Compliance with ethical standards

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##### *Disclosure of conflict of interest*

We (Etoamaihe Ukachi Julius and Ezeh Elyon) the authors of the article “Determination of selected physical properties of three varieties of shelled and unshelled melon seeds” wish to state that there are no conflicts of interests in this our research article.

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