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Engineering Properties of Three Varieties of Melon Seeds as Potentials for Development of Melon Processing Machines

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Abstract: To develop appropriate technologies for processing agricultural products, it is pertinent to have the full knowledge of the engineering properties of the biomaterial. The engineering properties of melon seeds for three different varieties: *C. edulis, C. vulgaris and C. lanatus* were investigated at the moisture content of 6.25, 6.33 and 5.21% 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 method. The result 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, 134.64-192.23mm² and 94.0- 110.0g respectively. The static coefficient of friction was determined for four frictional surfaces, namely, glass, plywood, galvanized steel and concrete. The highest coefficient of friction was observed in concrete surface for all the three varieties of melon investigated. The ratio of length to width, length to thickness and length to mass were equally investigated.

Key words: Axial dimension, engineering properties, melon and moisture content

INTRODUCTION

Melon is a tendril climbing herbaceous crop. Oloko and Agbetoye (2006) reported that 100,000 and 488,000 metric tones of melon were produced in Nigeria for the year 1992 and 1997 respectively. The seed *C. lanatus* had been reported to contain an average about 22g of protein, 30g of fat and 11g of carbohydrate and as well as good quantities micronutrients per 100g sample. Melon contain between 30-50% by weight of oil and offer valuable sources of vegetable oil for local and export trade (Oloko and Agbetoye, 2006). Melon has about 60% protein content that enriches the diet of the consumer. The melon pod has an almost spheroidal external shape and ellipsoidal seed cavity (Oloko and Agbetoye, 2006; Odigbo, 1977; Makanjuola, 1978). Odigbo (1977) and Oloko and Agbetoye (2006) reported unshelled melon seeds having major diameter about 12 mm, minor diameter 2.3 mm, intermediate diameter 8 mm and 1000 unit mass 150g.

In defiance of its economic potential of melon little is known about the physical properties. The processing operations are predominantly done manually. The traditional processing is time consuming and laborious, the condition prevalent at this level is generally unsanitary and inherent unhygienic conditions. The knowledge of engineering properties of melon like any other biomaterial 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 agricultural products, their physical properties have to be known (Mohsenin, 1980; Aviara *et al*., 1999). Presently, the equipment used in processing melon have been generally design without taken into cognizant the physical properties of melon which include the size, mass, bulk density, true density, sphericity, porosity, coefficient of static friction and angle of repose and resultant systems leads to reduction in working efficiency and increased product losses (Manuwa and Afuye, 2004; Razari *et al*., 2007). The engineering properties have been studied for various agricultural products by other researchers such as soybean (Manuwa and Afuye, 2004), caper fruit (Sessiz *et al*., 2005) cocoa bean (Bart-plange and Baryeh, 2003), pigeon pea (Shepherd and Bhardwaj, 1986), locust bean seed (Ogunjimi *et al*., 2002), wheat (Tabatabaeefa, 2003) and pistachio nut and its kernel (Razari *et al*., 2007).

Investigation was therefore carried out to determine the engineering properties of melon seeds such as axial dimension, geometric and arithmetic mean diameter, sphericity, surface area, unit mass, 1000 grain mass, true volume, true and bulk densities, porosity, angle of repose and static coefficient of friction of melon seeds in order to develop appropriate equipment that will alleviate laborious nature experience in processing the crop.

MATERIALS AND METHODS

The three varieties of melon were bought from Yenegoa market in Bayelsa state, Niger Delta, Nigeria on 12th January 2009. The sample were selected and cleaned manually. It was ensured that the seeds were free of dirt,

broken ones and other foreign materials. The seeds were kept in the room temperature for five days. Moisture content was immediately measured on arrival. The experiments were conducted for the three varieties of melon: *C. edulis*, *C. vulgaris* and *C. lanatus* at the moisture content of 6.25, 6.33 and 5.21% dry basis respectively. All the tests were conducted in the Agro-processing laboratory, Department of Agricultural Engineering, Niger Delta University, Bayelsa State, Nigeria.

For this experiment, 100 melon seeds were randomly selected, the length, width and thickness and mass of melon seeds were measured using a micrometer screw gauge with a reading of 0.01mm. The average diameter was calculated by using the arithmetic mean and geometric means of the three axial dimensions. The arithmetic mean diameter and geometric mean diameter of the melon seeds were calculated according to Galedar *et al.* (2008), Mohsenin, (1980).

The sphericity was calculated based on Koocheki *et al.* (2007), Milani (2007). The surface area was found by the following relationship given by McCabe *et al.* (1986). The aspect ratio was calculated by applying the following relationships given by Maduako and Faborode, 1990. The unit volume of 100 individual melon seed was calculated as cited by Galedar *et al.* (2008)

The 1000 unit mass was determined using precision electronic balance to an accuracy of 0.01g. To evaluate the 1000unit mass, 50 randomly selected melon seeds were weighed and multiplied by 20. The reported value was a mean of 20 replications. The bulk seeds were put into a container with known mass and volume (500ml) from a height of 150mm at a constant rate Bulk density was calculated from the mass of bulk seeds divided by the volume containing mass (Garnayak *et al.*, 2008). The true density was determined using the unit values of unit volume and unit mass of individual seed and calculated using the following relationship by Burubai *et al.* (2007). The porosity of the bulk seed was computed from the values of the true density and bulk density of the seed by using the relationship given by Mohsenin (1980).

The static coefficient of friction for melon seed determined with respect to four test surfaces namely plywood, galvanized iron sheet, concrete and glass. A glass box of 150mm length, 100mm width and 40mm height without base and lid was filled with sample and placed on an adjustable tilting plate, faced with test surface. The sample container was raised slightly (5–10mm) so as not to touch the surface. The inclination of the test surface was increased gradually with a screw device until the box just started to slide down and the angle of tilt was measured from a graduated scale. For each replicate, the sample in the container was emptied and refill with a new sample (Joshi *et al.*, 1993). The static coefficient of friction was calculated based on this equation, (Mohsenin, 1980).

The filling or static angle of repose with the horizontal at which the material will stand when piled. This was determined using topless and bottomless cylinder of 0.15m, diameter and 0.25m height. The cylinder was placed at the centre of a raise circular plate having a diameter of 0.35m and was filled with melon seeds. The cylinder was raised slowly until it formed a cone on a circular plane. The height of the cone was measured and the filling angle of repose was calculated based on the following relationship established by (Karababa, 2006; Kaleemullah and Gunaseka, 2002).

RESULTS AND DISCUSSION

Some engineering properties of the three varieties of melon are shown in Table 1. These engineering properties investigated at specific moisture content for the three varieties of melon: *C. edulis*, C. vulgaris and *C. lanatus* at 6.25, 6.33 and 5.21% dry basis respectively. Statistically the three varieties of melon were significantly different 0.05 level. The highest axial dimension was observed from *C. vulgaris*, 14.50, 8.47 and 2.49mm related to length width and thickness respectively. *C. lanatus* had the lowest values of length, width and thickness. The corresponding values of axial dimensions for melon seed as reported by Odigbo (1977) average values for length, width and thickness at moisture content of 8.31% dry basis were 12.0, 8.0 and 2.3mm respectively. The measured values and the corresponding values indicated that these values were significant different at 5% level. According to El-Sayed *et al.*, (2001) reported mean values of length, width and thickness of three different varieties of watermelon namely Sarakhay 15.60±1.065, 9.190±0.691 and 3.107 ± 0.385, for Kolaleh 13.455±0.933, 8.401±0.633, 2.912± 0.281 while for Red 18.972±0.956, 10.72± 0.59 and 2.988±0.315. The corresponding average dimension values of African nutmeg as reported by Burubai *et al.* (2007) for length, width and thickness were 16.68, 11.52 and 9.98mm respectively. Comparative analyses of the calculated melon and corresponding values of watermelon indicated that the highest values of width and thickness for melon was lower than the lowest values watermelon in term of width and thickness values. Furthermore, the length of Sarakhay and Red varieties for watermelon were of higher values compared to the highest values obtained from the study. The knowledge of axial dimension of any agricultural materials is pertinent in the sense that separation of biomaterial as a unit processing operation is hinged on axial dimensions. The mean geometric and arithmetic mean diameter, sphericity and surface area, 1000unit mass, and volume were determined. *C. vulgaris* had the highest geometric and arithmetic mean diameters values of 6.25 and 6.31mm respectively. The corresponding values for watermelon as reported Koocheki *et al.* (2007) were 6.89 and 8.24mm for

Kolaleh, 8.37 and 10.79mm for Ghemez and 7.61 and 9.28mm for Sarakhsi at moisture content of 5.02, 4.75 and 4.55% wet basis. *C. vulgaris* had the highest surface area 161.28mm² and the least surface area recorded was *C. edulius* 141.63mm². As per investigation made by El-Sayed *et al.* (2001) and Koocheki *et al.* (2007) for watermelon ranged from 182.96-225.03 mm² and 182.51-220.45mm² respectively. The maximum value was observed for *C. lunatus*, 0.53 followed by *C. edulis*, 0.47. The minimum sphericity was noticed to be *C. vulgaris*, 0.45. Galedar *et al.*, (2008) reported sphericity for pistachio nut at moisture content of 5.83% and kernel at moisture content of 6.03% were 69.34 and 72.59% respectively. According to Bal and Mishra (1988), and Garnayak *et al.* (2008) considered any grain, fruit and seed as spherical when the sphericity value is above 80 and 70%, respectively. Therefore, it can be concluded that melon seeds were not spherical based on the sphericty values obtained were less than 0.7-0.8. *C. vulgaris* had the highest 1000 unit mass value of 110g while the least value 94g was recorded for *C. edulis*. The corresponding values reported for japtropha seed and kernel, arigo seed, simarouba fruit and kernel, maize, red gram, wheat, green gram, chickpea, faba bean, pigeon pea were 1322.41, 688, 1124.7(±111.3), 1120(±52.54), 330.26(±29.35), 268.30(±0.002), 102(±0.06), 346g, 30.15g, 120g and 75g respectively (Sirisomboon *et al.*, 2007; Dash *et al.*, 2008; Fraser *et al.*, 1978; Dutta *et al.*, 1988; Shepherd and Bhardwaj, 1986; Tabatabaeefa, 2003). It was observed that the highest porosity was *C. vulgaris,* 53.7 % while the least porosity value was shown as *C. lanatus,* 37.3%. El-Sayed *et al.* (2001) reported the mean value of porosity for watermelon, for the three varieties studied; for sarakhey, 51.68%, for kolaleh, 39.14% and for red, 47.80%. Analysis of variance revealed the statistical different in the porosity of melon seed calculated and that reported watermelon seeds. The values obtained for porosity is solely dependent on the true and bulk density. 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%).

A glance look at Table 2 showed the result of true and bulk densities, angle of repose and coefficient of friction for the three varieties of melon studied. *C. lanatus* had the highest bulk density 543kg/m3 and followed by *C. vulgaris* 446 kgm^{-3}. The mean true density values ranged from 816.09 to 847.47kgm^{-3} for the three varieties. The corresponding values for true and bulk densities for nutmeg and simarouba fruit and kernel were 836.54, 488.76, 622.27 and 727.27 kgm^{-3}. The true and bulk densities values of melon seeds, nutmeg and simarouba were significantly difference at 0.05 level (Burubai *et al.*, 2007). The coefficient of static friction on the tested surfaces namely: glass, plywood, galvanized steel and concrete significantly difference at 0.01 probability level. On the glass surface, the static coefficient of friction values of *C. vulgaris* was found to be the highest while C. *edulis* was the lowest. On galvanized metal sheet surface, the static coefficient of friction of *C. edulis* was recorded the lowest while *C. lanatus* observed as the highest. On concrete surface melon seeds experience the highest static coefficient of friction compared to all other tested surfaces. Tabatabaeefa (2003) observed similar trend in the static coefficient of friction of wheat. He recorded lowest static coefficient of friction on glass surface, followed by galvanized iron and lastly plywood.

Table 1: Some physical properties of melon seeds.

Properties	No of sample	*C. edulis*	*C. vulgaris*	*C. lanatus*
Length (mm)	100	12.81	14.50	13.37
Width (mm)	100	7.02	8.47	7.22
Thickness (mm)	100	2.22	2.49	2.44
1000unit mass (g)	50	94.0	110.0	98.0
Arithmetic mean diameter(mm)	100	7.36	8.31	7.68
Geometric mean diameter (mm)	100	5.84	6.25	6.18
Sphericity	100	0.47	0.45	0.53
Surface area (mm)	50	134.64	161.28	142.23
Volume(mm^3)	100	154.83	198.74	167.46
Moisture content (%)		6.25	6.33	5.21

Table 2: Gravimetric and frictional properties of the studied melon varieties.

Bulk density kgm^{-3}	405	446	543
True density kgm^{-3}	816.29	847.47	839.29
Porosity %	53.7	48.5	37.3
Angle of repose	36º	29.7º	33º
Coefficient of static friction			
Glass 0.32	0.35	0.30	
Plywood	0.51	0.57	0.56
Galvanized metal	0.43	0.41	0.46
Concrete	0.56	0.65	0.61

Table 3: Dimensional parameters ratios of the three varieties of melon seeds.

Varieties	Parameters	Ratio
C. edulis	L/W	1.82
	L/T	5.77
	L/M	136.3
C. edulis	L/W	1.71
	L/T	5.82
	L/M	131.9
C. lanatus	L/W	1.85
	L/T	5.48
	L/M	136.4

The experimental result of angle of repose for the three varieties of melon seeds ranges from 29.7º- 36º. The highest mean value of repose observed with *C. edulis*, while the least was *C. vulgaris*. The corresponding angle of repose for simarouba fruit and kernel is lower than jatropha seed and kernel. While pistachio nut and kernel were less than melon seeds (Sirisomboon *et al.*, 2007; Galedar *et al.*, 2008).

The correlation statistics, for example L/W, L/T and L/M with respect to dimensional properties of three varieties of melon tested revealed statistical difference at 0.05level as shown Table 3. According to the observed results, the maximum and the minimum L/W value were found with *C. lanatus* and *C. vulgaris* with mean value being the same 1.85 and 1.71. The maximum and minimum of L/T value were found to be *C. vulgaris* and *C. lanatus* with average values of 5.82 and 5.48 respectively. The highest and lowest of L/M was observed with *C .lanatus* and *C. vulgaris* with average value of 136.4 and 131.9. Furthermore, the axial dimension relationship in *C. vulgaris* L/W and L/T showed statistical difference at 0.05 probability level.

CONCLUSION

The following conclusions are drawn from the investigation on the some engineering properties of three varieties of melon seeds (*C. edulis*, *C. vulgaris* and *C. lanatus*) at moisture content of 6.25%, 6.33% and 5.21% dry basis respectively:

The mean length, width, thickness, arithmetic and geometric mean diameter, sphericity, surface area, 1000unit mass, for the three varieties of melon were in these range, 12.81-14.50mm, 7.02-8.42mm, 2.22-2.49mm, 7.36-8.31mm, 5.84-6.25mm, 0.47-0.53, 131.64-192.23mm2, 94-110g respectively.

The mean porosity, true and densities, angle of repose were investigated for the three varieties. The obtained results were 37.3-53.7, 816.09-847.47kg/m3. 405.0-543kg/m3 and 29.3-36º.

The coefficient of static friction of melon was determined for four different surfaces namely, glass, plywood, galvanized steel and concrete. Concrete surface was observed to be the highest coefficient of static friction for the three varieties.

The observed highest values for L/W and L/T were *C. lanatus* and *C. vulgaris*.

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