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Geometric properties of groundnut kernels

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ABSTRACT

The length, width, thickness or diameter of kernels of four Bangladeshi groundnut (*Arachis hypogaea*) varieties viz. Basanti, Maischar, Jhinga and Tridana were evaluated and found to be different. Kernels of each variety were classified small, medium and large on the basis of length and diameter. Kernel shapes of all varieties were prolate spheroids. The surface area and volume of kernels were determined by different formulae and compared with the measured values. Different formulae were found valid for different varieties but not for all the varieties. These findings can provide the information that could be helpful for development of new processing machines or modification and adaptation of the available standard processing machines for the selected groundnut varieties.

Key words: *Arachis hypogaea*, groundnut kernels, geometric size, shape, surface area, volume.

INTRODUCTION

Groundnut (*Arachis hypogaea L.*) is an important oil and protein producing crop in the world. For handling, processing and storing of groundnut kernels, their geometric properties need to be known (Kaleemullah 1992). A property, which is almost inelastic to the variation in the function of the machinery and constantly needed for the processing of the product is the geometric property. The form and dimensions of the holes in sieves used in the cleaning and grading of groundnut, are functions of shape and size of the kernels.

Agricultural materials pose special problems in determining their physical properties because of their diversity of shape, size, moisture content and maturity levels (Waziri and Mittal 1983). Mostafa (1971) assumed elliptical model for the prediction of the surface area and volume of apples, oranges, lemons and carrots. The model gave good agreement with apples but not with carrots. Chuma *et al.* (1984) determined the surface area and volume of soybeans from the coordinates using Langrange's interpolation formula and Simpson's rule considering the shape of the grain cylindrical, spherical and elliptical. Murthy *et al.* (1986) calculated the surface area and volume of paddy grains assuming them as cono-elliptical cylinders. Kaleemullah (1992) treated groundnut kernel as oval shaped. No detailed study on size and shape of groundnut kernels to classify and to calculate the surface area and volume is available. Therefore experiments were undertaken for the determination of geometric shape and size parameters of groundnut kernels and to test the available formulae in determining the surface area of groundnut kernels belonging to different varieties.

MATERIALS AND METHODS

This study was conducted in Postharvest Process Engineering Laboratory of Bangladesh Agricultural Research Institute (BARI), Gazipur during 1998. The kernels were randomly taken out from a heap of each of the four selected varieties Basanti (DG-2), Maischar (Dhaka-1), Jhinga (ACC-2) and Tridana (DM-1) which were grown in the BARI farm in Rabi season 1997-98. All parameters were measured at the safe storage moisture content (Basanti 9.66%, Maischar 9.80%, Jhinga 10.16% and Tridana 9.56%, dry basis). The length, breadth (major diameter) and thickness (minor diameter) of 100 kernels of each variety were measured by a slide caliper of least count 0.01 mm. The average diameter of kernel was calculated by arithmetic mean of breadth and thickness (Ackali and Guven 1990).

Dimensional classification was done by calculating the average dimension (X) and the associated standard deviation (σ_x). Small, medium and large size groundnut kernels were so defined that their specific dimension (x) satisfies the following inequalities, respectively:

Small size group : $x < (X-\sigma_x)$ (1)

Medium size group : $(X_x\text{-}\sigma) < x < (X+\sigma_x)$ (2)

Large size group : $x > (X+\sigma_x)$ (3)

The percentage of each group in a given set was determined by using probability function. If f(x) designates the probability of coming across with the groundnut kernels, the dimensions of which are less than a given x value defined on the integral $x_0 \leq x \leq x_n$, then it is evaluated by means of the density function y(x) as such:

$$P(x) = \frac{\int_{x_0}^{x} y\,dx}{\int_{x_0}^{x_n} y\,dx} \qquad (4)$$

Geometric model

The simplest method of determining the geometric shape of groundnut kernel is visual observation and it is considered as oval shape (Kaleemullah 1992). Murthy *et al.* (1986) considered the shape of grains conoelliptical cylinders to calculate the surface area and volume as:

$$S = \frac{13}{11}(B+T) \qquad (5)$$

$$V = \frac{\pi}{6}\ L.B.T. \qquad (6)$$

Chuma *et al.* (1984) determined surface area and volume of soybean by following empirical formula and suggested that this formula is valid for other grains similar to soybean.

$$S = 4.19\, L^{0.53} B^{0.81} T^{0.52} \qquad (7)$$
$$V = 0.81\, L^{0.73} B^{1.24} T^{0.83} \qquad (8)$$

Ackali and Guven (1990) considered groundnut being composed of a cylinder of finite length in the middle and two hemispheres of the same cylinder radius at the ends and developed formula to determine surface area (A) and volume (V) of a groundnut kernel by using the following relationship:

$$A = D\left(L + \frac{D}{2}\right) \qquad (9)$$

$$V = \frac{\pi D^2}{4}\left(L - \frac{D}{3}\right) \qquad (10)$$

Where, S, V, L, B, T and D represent the surface area, volume, length, breadth, thickness and diameter of groundnut kernels, respectively. The surface area and volume of groundnut kernels were measured experimentally. The surface area of kernel was determined by peeling the bran carefully and measuring the traced outlines of the bran by a planimeter. The volume of kernel was determined by water displacement method as performed by Mohsenin (1970). The measured surface area and volume of kernel were compared with that obtained by formulae given by Murthy *et al.* (1986), Chuma *et al.* (1984), and Ackali and Guven (1990).

RESULTS AND DISCUSSION

The length frequencies of different varieties of groundnut kernels are shown in Fig. 1. Kernel lengths of Basanti, Maischar, Jhinga and Tridana ranged 11-21 mm, 9-15 mm, 9-14 mm and 8-15 mm, respectively. The highest frequencies of kernel length for Maischar, Jhinga and Tridana were 12 mm but for Basanti it was 17 mm. The diameters of all groundnut kernels ranged from 5 to 11 mm (Fig.2). The kernel diameters of Basanti, Maischar, Jhinga and Tridana were in the range of 8-11mm, 6-10 mm,

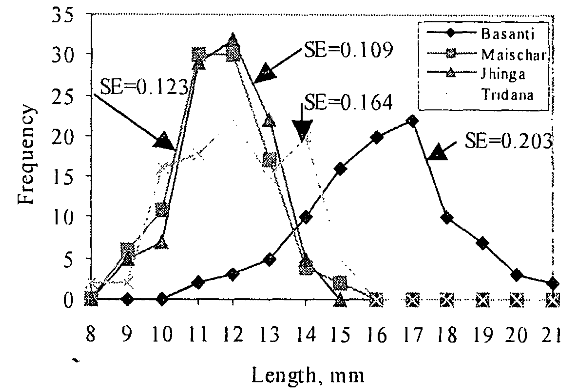

Fig. 1. Length frequency of groundnut kernels.

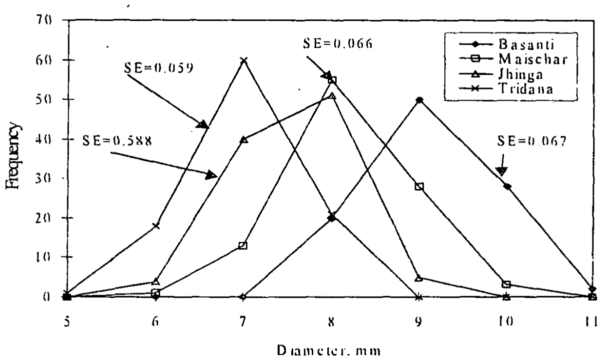

Fig. 2. Diameter frequency of groundnut kernels

6-9 mm and 5-8 mm, respectively. The highest diameter frequencies observed in all varieties were in the range of 7-9 mm.

The geometric dimensions and shape of different varieties of groundnut kernels are presented in Table 1. Kernels of variety Basanti recorded the highest length, width, thickness and diameter. The length and width of varieties Maischar and Jhinga were similar but the thickness and diameter of Jhinga were lower than that of Maischar. Lowest width, thickness and diameter were found for variety Tridana but its length was lower than that of Basanti but higher than that of Maischar and Jhinga. The standard deviations indicate that variations of kernel lengths were higher than that of width, thickness and diameter. The ratio of width and length of Basanti and Tridana and also of Maischar and Jhinga were almost same. So the shape of Basanti and Tridana, and Maischar and Jhinga were similar. Overall shape

Table 1. Geometric dimensions and shapes of groundnut kernels of different varieties.

Variety	Length (L), mm	Width (B), mm	Thickness (T), mm	Diamter $(D = \frac{B+T}{2})$ mm	$\frac{\text{Width}}{\text{Length}}$	Shape
Basanti	16.31 (1.32)	9.60 (0.82)	8.73 (0.73)	9.17 (0.67)	0.59	Prolate spheroid
Maischar	11.73 (1.23)	8.78 (0.75)	7.74 (0.80)	8.26 (0.66)	0.75	Prolate spheroid
Jhinga	11.83 (1.09)	8.78 (0.79)	6.44 (0.99)	7.62	0.74	Prolate spheroid
Tridana	12.09 (1.64)	7.23 (0.59)	6.77 (0.63)	7.00 (0.59)	0.60	Prolate spheroid

The dimensions are means of 100 kernels. The figures in parentheses indicate standard deviation.

of all varieties were prolate spheroid.

Kernels were classified as small, medium and large size according to their length and diameter (Table 2). It is observed from the table that for each variety of groundnut kernels, their size was different from each other because of their differences in length and diameter. In case of Basanti, Jhinga and Tridana, more than 50% of kernels had medium length and diameter but in case of Moischar more than 50% of kernels were classified as large according to length. According to diameter they were of medium size (Table 3).

The measured and calculated surface area and volume of different types of groundnut kernels by different formulae are presented in Table 4 and Table 5, respectively. The surface area and volume of Basanti, Maischar and Tridana groundnut kernels calculated by formulae of Murthy *et al.* (1986) and Chuma *et al.* (1984) formula were much closer to measured value than that of Ackali and Guven (1990) formula. In case of Tridana variety, surface area and volume calculated by Ackali and Guven (1990) formula was closer to measured value than other methods. The reason might be that the length of Tridana kernels was much higher than its diameter and thickness. The least percent errors were observed, on the basis of measured value, in Murthy *et al* (1986) formula and Chuma *et al* (1984) formula for Basanti, Chuma *et al* (1984) formula for Maischar and Jhinga, and Ackali and Guven (1990)

Table 2. Size classification of selected groundnut kernels.

Variety	Dimension	Small size, mm	Medium size, mm	Large size, mm
Basanti	Length (L)	L < 14.28	14.28 ≤ L ≤ 18.34	L > 18.34
	Diameter (D)	D < 8.5	8.50 ≤ D ≤ 9.84	D > 9.84
Maischar	Length (L)	L < 10.50	10.50 ≤ D ≤ 9.84	L > 12.96
	Diameter (D)	D < 7.60	7.60 ≤ D ≤ 8.92	D > 8.92
Jhinga	Length (L)	L < 10.74	10.74 ≤ L ≤ 12.93	L > 12.93
	Diameter (D)	D < 7.03	7.03 ≤ D ≤ 8.21	D > 8.21
Tridana	Length (L)	L < 10.45	10.45 ≤ L ≤ 13.73	L > 13.73
	Diameter (D)	D < 6.42	6.42 ≤ D ≤ 7.60	D > 7.60

Table 3. Probability of length and diameter of groundnut kernels.

Variety	Probability of length (%)			Probability of diameter (%)		
	Small	Medium	Large	Small	Medium	Large
Basanti	20	68	12	08	62	30
Maischar	17	25	58	13	56	31
Jhinga	14	59	27	40	55	05
Tridana	20	55	25	19	61	20

Table 4. Measured and calculated surface area of groundnut kernel and percent error.

Variety	Measured surface area, mm^2	Murthy *et al.* (1986) formula	Chuma *et al.* (1984) formula	Ackali and Guven (1990) formula	Percent error, $\frac{(S_c - S_m) \times 100}{S_m}$		
					Murthy *et al.*	Chuma *et al.*	Ackali and Guven
Basanti	382.50	353.32	354.64	609.87	07.63	07.28	59.44
Maischar	274.80	229.01	260.21	411.56	16.66	05.31	49.77
Jinga	260.30	213.06	237.93	374.40	18.15	08.59	43.83
Tridana	320.60	200.03	210.72	342.84	37.61	34.28	06.94

S_m = measured surface area, mm^2 and S_c = calculated surface area, mm^2

Table 5. Measured and calculated volume of groundnut kernel and percent error.

Variety	Measured Volume, mm^2	Murthy *et al.* (1980) formula	Chuma *et al.* (1984) formula	Ackali and Guven (1990) formula	Percent error, $\frac{(V_c - S_m) \times 100}{S_m}$		
					Murthy *et al.*	Chuma *et al.*	Ackali and Guven
Basanti	664.40	715.71	620.35	875.29	07.72	06.63	31.74
Maischar	448.50	417.38	436.56	481.02	06.93	02.66	07.25
Jinga	336.75	357.33	341.64	423.66	04.33	01.47	25.81
Tridana	360.80	309.85	284.04	375.48	14.12	21.27	04.07

V_m = measured volume, mm^3 and V_c = calculated volume, mm^3

formula for Tridana. Jindal *et al* (1974) reported that the difference between measured and calculated surface area of wheat, corn and soybean was 2.8-6.5%. Hence, one formula is not applicable to calculate surface area and volume of all varieties of groundnut kernels because of their dissimilarities in size and shape.

CONCLUSIONS

The length, width, thickness or diameter of groundnut kernels was found different for different varieties. Kernels of each variety were classified small, medium and large on the basis of length and diameter. Kernel shapes of all varieties were prolate spheroids. The surface area and volume of kernels were determined by different formulae and compared with the measured values. Different formulae were found valid for different varieties but not for all the varieties. These findings can provide the information that could be helpful for development of new processing machines or modification and adaptation of the available standard processing machines for the selected groundnut varieties.

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