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Research Note

Studies on Some Engineering Properties of Peanut Pod and Kernel

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ABSTRACT

Physical properties viz. dimension (D_1, D_2, D_3), arithmetic mean diameter (AMD), geometric mean diameter (GMD), square mean diameter (SMD), equivalent diameter (EQD), sphericity (Sp) and aspect ratio (AR) of nine different varieties of peanut and its kernel were determined at the moisture content of 4.5±1% db. Dimensions D_1,D_2,D_3 varied between 16.8-34.6, 11.04-14.9, 11.0-14.4 mm for peanut pod, and 11.9-19.8, 8.03-11.65 and 6.82-9.96 mm for peanut kernel, respectively. AMD, GMD, SMD and EQD were 15.9-21.2, 14.6-19.4, 26.1-34.9 and 18.9-25.2 mm for peanut pod and 8.9-13.5, 8.7-12.8, 15.2-22.8 and 10.9-16.4 mm for peanut kernel, respectively. Sp and AR ranged between 0.6-0.7 and 0.4-0.7 for peanut pod and its kernel, respectively. Bulk density for peanut pod and its kernel were 199-329 and 443-619 g/ml, respectively. Thousand kernel mass of nine varieties studied were lowest for M4 (158 g) and highest for IC2 (1594 g) for peanut pod, and lowest for S1 (446 g) and highest for IC2 (784) varieties for peanut kernel. The oil content in peanut kernel ranged from 41.8-57.7 per cent.

Peanut (*Arachis hypogaea* L.) is one of the principal oilseed crops. India is the second largest producer of peanut in the world with a share of 18% (USDA, 2009). Peanuts are rich source of edible oil (43-55%) and protein (25-28%). About two-third of the world's peanut production is crushed for oil and the remaining is consumed directly or as an ingredient in food (Bunting *et al.*, 1985). It has two cotyledons and the germ covered with a thin skinned testa, which vary in colour from red to brown purple depending upon the genotype. Testa contributes about 4-5% of the kernel weight, while cotyledons of peanut kernel range between 92-94%, and germ constitutes around 3-4 per cent. The testa and oil content contribute to the colour of peanut, and tannins and catechol derivatives are responsible for the colour of peanut testa.

Physical properties play an important role in handling, processing and storage of agricultural commodities (Masoumi and Tabil, 2003). Such properties of many nuts and grains such as minor millets (Balasubramanian and Viswanathan, 2010), pearl millet (Jain and Bal, 1997) gorgonnut (Jha and Prasad, 1993), neem nut (Visvanathan *et al.*, 1996), cashew nut (Balasubramanian, 2001), bambara groundnut (Baryeh, 2001) and arecanut (Kaleemullah and Gunasekar, 2002) have been determined by researchers. Agrawal *et al* (1973) described the shape of peanut with one or two kernels as ellipsoid, double ellipsoid and cassinoid. Olajide and Igbeka (2003) reported the principal axial dimension of pea nuts as 8.54, 3.55 and 6.93 mm, respectively. So far, the researchers have focused only on peanut kernels for product development. However, the whole peanut and kernel are potentially valuable products which can be subjected to industrial processing. Thus, the present study was undertaken to determine the physical properties of different peanut varieties.

MATERIALS AND METHODS

Nine peanut varieties *viz.*, M13 (M1), M-335 (M2), M548 (M3), M522 (M4), SG84 (S1), SG99 (S2), ICGV00401 (IC1), ICGV00440 (IC2), ICGV-99083 (IC3), nomenclature in bracket indicating code number, were obtained from the Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana, India. Sample lots were cleaned to remove broken, immature and unhealthy seeds. The pods were manually dehulled to remove the outer layer and separate the kernels. Broken, immature kernels were then removed. The moisture content was determined (AACC, 2000), and samples conditioned to 4.5% moisture content (d.b). The conditioned samples were packed in double layer low density polyethylene bags (90µm thick), and stored at ambient temperature (28 ± 2 °C) for further studies in 3 replications (Sharma *et al.*, 2009).

Dimension

Major (D_1), intermediate (D_2) and minor (D_3) dimensions

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were measured using a digital vernier caliper (least count 0.01mm, Mitutoyo, Japan) for both peanut and kernel.

Arithmetic mean diameter (AMD), geometric mean diameter (GMD), square mean diameter (SMD), equivalent diameter (EQD), sphericity (Sp), and aspect ratio (AR) for both peanut and its kernel were calculated using the following equations (Mohsenin, 1986):

$$AMD = \frac{D_1 + D_2 + D_3}{3} \quad \ldots (1)$$

$$GMD = \sqrt[3]{D_1 D_2 D_3} \quad \ldots (2)$$

$$SMD = \sqrt[2]{D_1 D_2 + D_2 D_3 + D_3 D_1} \quad \ldots (3)$$

$$EQD = \frac{AMD + GMD + SMD}{3} \quad \ldots (4)$$

$$Sp = \frac{GMD}{D_1} \quad \ldots (5)$$

$$AR = \frac{D_2}{D_1} \quad \ldots (6)$$

Major dimension was used to calculate the volume (V_t) and surface area (S) of a single grain (Jain and Bal, 1997) as below:

$$V_t = \frac{\pi\, GMD^2\, D_1^2}{6\,(2D_1 - GMD)} \quad \ldots (7)$$

$$S = \frac{\pi\, GMD\, D_1^2}{2D_1 - GMD} \quad \ldots (8)$$

Shape Factor

Shape factor (λ) based on volume and surface area of grain was determined (McCabe and Smith, 1984) as:

$$\lambda = \frac{b}{a} \quad \ldots (9)$$

Where,

$$a = \frac{V_t}{D_2^3} \text{ and } b = \frac{S}{6D_2^2} \quad \ldots (10)$$

Thousand Kernel Mass

About one kilogram of peanut was divided in 10 equal portions. Thousand kernel mass (TKM) of peanut pod and its kernel was randomly picked from each portion, and separately weighed using a digital electronic balance (least count 0.01g, Citizen Balance, Mumbai).

Bulk Density

Bulk density (BD) was calculated as the ratio of mass of peanut and kernels to volume of the container (Balasubramanian and Viswanathan, 2010).

$$BD = \frac{M}{V} \quad \ldots (11)$$

Colour

Hunter colour values of peanut and its kernel was recorded as L = lightness (0= black, 100 = white), a (-a= greenness, +a = redness), b (-b = blueness, +b = yellowness) using colour meter (M/s. Hunter Associate Laboratory Inc, Reston, VA, USA; model NR-3000).

Oil Content

Oil content was determined by extracting 5 g sample with hexane for 2 h in a soxhlet apparatus (Pelican Equipments, Chennai, India). The solvent was evaporated by heating at 80 °C, and the oil content weighed. Increase in weight of the tared flask after complete evaporation of hexane indicated the weight of oil content in the sample.

RESULTS AND DISCUSSION

Dimension

The major dimension (D_1) for peanut pod and kernel was 34.6 mm and 19.8 mm for variety IC2, and was lowest for variety IC1 (16.8 mm) and variety S1 (11.9 mm) for peanut pod and kernel, respectively (Table 1). Intermediate dimension (D_2) of peanut (14.9 mm) was highest for variety M3 and kernel (11.65 mm) for variety IC3, whereas it was lowest for variety S1 for peanut pod (11.04 mm) and kernel (8.03 mm). Minor dimension (D_3) was highest for peanut pod (14.4 mm) and kernel (9.96 mm) for the variety IC2, whereas the same was lowest for peanut pod (11.0 mm) and kernel (6.82 mm) for variety S1. The highest dimensions of peanut were thus of variety IC3 as compared to other varieties.

The AMD of peanut ranged between 15.9 and 21.2 mm, whereas that of kernel ranged between 8.9 and 13.5 mm. The GMD of peanut pod ranged between 14.6 and 19.4 mm, which were close to the value cited by Aydin (2006). The GMD of kernel ranged between 8.7 and 12.8 mm. The SMD of peanut and its kernel was highest for variety IC2 and minimum for variety S1 and M1. The EQD was highest for variety M1 for peanut pod and IC2 for kernel. The EQD of peanut and its kernel was lowest for variety S1.

Table 1. Physical properties of peanut and kernel

Variety	Code		Dimension (mm) D_1	D_2	D_3	AMD (mm)	GMD (mm)	Vt (mm^3)	S (mm^2)	SMD (mm)	EQD (mm)
M13	M1	P	33.7±2.7	14.50±1.1	14.30±1.2	20.8± 1.2	19.1±1.1	2094± 42	913±10	34.1±1.9	24.7±1.4
		K	18.2±1.5	11.23±0.6	9.68±0.6	12.5±0.9	12.4±0.4	47± 03	416± 08	22.1±0.8	15.8±0.6
M335	M2	P	29.5±1.8	12.70±0.9	12.70±1.2	18.3± 0.7	16.8±0.5	1537± 41	736±17	30.1±0.9	21.7±0.7
		K	17.2±0.7	9.56±1.7	8.20±0.4	11.6± 0.9	11.1±1.1	145± 13	324± 9	19.6±1.8	14.1±1.3
M548	M3	P	33.4±1.9	14.90±1.5	13.00±0.9	19.9± 0.9	18.0±0.8	1636± 47	794±25	32.5±1.6	23.5±1.1
		K	16.5±1.8	8.51±0.4	7.97±0.5	11.0± 0.7	10.4±0.5	99± 14	285±13	18.4±1.0	13.3±0.8
M522	M4	P	31.9±1.3	13.90±0.9	13.80±0.7	19.9± 0.8	18.3±0.8	2058± 62	888±21	32.8±1.3	23.7±0.9
		K	17.1±1.6	9.97±0.8	8.33±0.7	11.8± 0.2	11.2±0.2	152± 12	332±14	19.9±0.2	14.3±0.2
SG84	S1	P	25.6±1.9	11.04±0.6	11.00±0.5	15.9± 0.6	14.6±0.6	905± 63	523±19	26.1±1.2	18.9±0.8
		K	11.9±1.3	8.03±0.6	6.82±1.1	8.9± 0.8	8.7±0.9	102± 11	202±13	15.2±1.5	10.9±1.1
SG99	S2	P	30.0±0.7	12.30±0.5	12.30±0.7	18.1± 0.4	16.5±0.4	1334± 52	681±15	29.7±0.7	21.4±0.5
		K	15.6±1.3	9.81±0.5	7.56±0.5	11.8± 0.5	11.1±0.5	189± 09	329±11	19.5±0.8	14.1±0.6
ICGV00401	IC1	P	16.8±1.3	13.50±0.7	13.10±0.7	19.9± 1.3	18.0±0.8	1652± 37	796±17	32.5±1.7	23.4±1.3
		K	17.9±3.6	10.23±0.6	9.17±0.6	12.4± 1.1	11.8±0.8	196± 08	375±09	20.9±1.6	15.1±1.2
ICGV00440	IC2	P	34.6±2.4	14.7±0.9	14.40±0.8	21.2± 1.1	19.4±0.9	2153± 34	936±10	34.9±1.7	25.2±1.2
		K	19.8±1.9	10.77±0.4	9.96±0.6	13.5± 0.9	12.8±0.7	209± 12	437±11	22.8±1.4	16.4±0.9
ICGV99083	IC3	P	30.8±1.7	12.60±1.0	13.50±0.9	19.0± 0.9	17.4±0.8	1502± 36	737±23	31.2±1.5	22.5±1.1
		K	19.1±2.3	11.65±1.1	8.90±1.0	13.2± 1.1	12.5±0.8	201± 13	416±11	22.3±1.6	16.0±1.2

* P = Peanut pod, k = Kernel

Table 2. Gravimetric properties, colour and oil content of peanut pod and kernel

Variety	Code		Sp	AR	λ	TK W(g)	BD (g/cm^3)	Hunter colour value L	a	b	Oil content (%)
M13	M1	P	0.6 ±0.03	0.4 ±0.03	1.05 ±0.7	1198 ± 17	209 ± 7	41.60 ± 0.3	7.2 ± 0.1	19.9 ± 0.2	-
		K	0.7 ±0.04	0.6 ±0.07	3.30 ±0.6	674 ± 60	619 ± 8	42.21 ± 0.4	16.5 ± 0.1	21.7 ± 0.2	50.8 ± 0.07
M335	M2	P	0.6 ±0.03	0.4 ±0.03	1.01 ±0.7	1011± 16	199 ± 2	33.10 ± 0.7	6.1 ± 0.1	15.7 ± 0.1	-
		K	0.6 ±0.07	0.6 ±0.10	4.40 ±1.8	520±27	443± 2	34.24 ± 0.4	13.7 ± 0.2	20.97 ± 0.5	52.4 ± 0.45
M548	M3	P	0.6 ±0.02	0.4 ±0.02	1.10 ±0.7	391 ± 15	239 ± 3	42.70 ± 0.1	4.9 ± 0.1	17.7 ± 0.1	-
		K	0.6 ±0.04	0.5 ±0.05	4.21 ±1.1	508 ± 48	589 ± 9	23.41 ± 0.2	14.9 ± 1.7	12.9 ± 0.1	52.9 ± 1.39
M522	M4	P	0.6 ±0.02	0.4 ±0.02	0.99 ±0.7	158 ± 19	270 ± 7	40.50 ± 0.7	9.1 ± 0.2	29.3 ± 0.4	-
		K	0.7 ±0.07	0.6 ±0.09	3.99 ±1.3	739 ± 48	587 ±13	44.27 ± 3.6	10.9 ± 2.3	18.1 ± 1.3	57.4 ± 0.10
SG84	S1	P	0.6 ±0.03	0.4 ±0.03	1.06 ±0.7	643 ± 13	291 ± 1	42.90 ± 0.2	6.9 ± 0.1	22.9 ± 0.3	-
		K	0.7 ±0.06	0.7 ±0.08	2.92 ±0.9	446 ± 34	600 ±11	23.92 ± 2.8	6.6 ± 0.1	10.6 ± 1.5	57.7 ± 0.22
SG99	S2	P	0.6 ±0.01	0.4 ±0.02	1.05 ±0.7	1589 ± 15	329 ± 5	52.20 ± 0.9	6.4 ± 0.1	27.7 ± 0.3	-
		K	0.7 ±0.03	0.6 ±0.03	2.92 ±0.4	700 ± 03	597 ± 3	43.17 ± 0.1	9.7 ± 1.4	21.9 ± 1.4	51.8 ± 2.89
ICGV00401	IC1	P	0.6 ±0.04	0.4 ±0.05	1.05 ±0.9	643 ± 27	209 ± 7	44.10 ± 0.3	6.8 ± 0.1	20.6 ± 0.2	-
		K	0.7 ±0.11	0.6 ±0.18	3.72 ±1.4	729 ±26	547 ± 3	37.90 ± 0.2	18.0 ± 0.2	22.5 ± 0.1	50.3 ± 3.34
ICGV00440	IC2	P	0.7 ±0.02	0.4 ±0.03	1.04 ±0.7	1594 ± 21	242 ±13	42.40 ± 0.6	8.8 ± 0.2	23.2 ± 0.5	-
		K	0.7 ±0.03	0.5 ±0.03	3.83 ±0.7	784 ± 44	566 ± 6	39.95 ± 0.2	16.0 ± 0.1	20.4 ± 0.3	41.8 ± 4.02
ICGV99083	IC3	P	0.6 ±0.02	0.4 ±0.02	1.03 ±0.7	1447 ± 37	220 ± 7	33.10 ± 0.2	6.1± 0.1	15.7 ± 0.3	-
		K	0.7 ±0.03	0.6 ±0.07	4.09 ±0.8	669 ± 41	614 ± 8	31.80 ± 0.1	15.5 ± 0.3	16.8 ± 0.4	43.9 ± 2.71

* P = Peanut pod, k = Kernel

Volume and Surface Area

The volume (V_t) of single peanut and its kernel was highest for variety IC2. The surface area of single grain for peanut pod (936.0 mm^2) and kernel (437 mm^2) was highest for IC2 variety.

Sphericity, Aspect ratio and Shape factor

The sphericity and aspect ratio of kernel was nearly same (0.6-0.7) for the nine varieties. The sphericity and aspect ratio of more than 70% implied that peanut was more as spherical, and tend to rather roll than slide (Dutta *et al.*, 1988). The low value of aspect ratio indicated the tendency to slide than to roll. It was observed that the sphericity of small sized seeds showed the highest sphericity (0.6-0.7). The shape factor for the all nine varieties of peanut pod and kernel was almost same.

Thousand Kernel Mass and Bulk Density

Thousand kernel mass ranged between 158 g and 1594 g for pod and 446-784 g for kernel. Bulk density of peanut pod was maximum for S2, and minimum for M2 variety. Bulk density of kernel varied between 443 and 619 g/ml.

Oil Content and Colour

Variety S1 exhibited maximum and IC2 minimum oil content. The L-value ranged between 33.1 and 52.2 for peanut pod and 23.41 and 44.27 for kernel. The a-value ranged between 4.9 and 9.1 for peanut, and between 6.6 and 16.5 for kernel. The b -value ranged between 15.7 and 29.3 for peanut, and 10.6 and 22.5 for kernel (Table 2).

CONCLUSIONS

Principal dimensions D_1, D_2 , D_3 of peanut ranged between 16.8 and 34.6, 11.04 and 14.9, 11 to 14.4 mm while that of kernel ranged between 11.9 and 19.8, 8.03 and 11.65, 6.82 and 9.96 mm. Shape factor of kernel varied from 2.92 to 4.39, whereas for peanut it was almost same for all the nine varieties. The volume of single grain of peanut and its kernel varied from 905 to 2153 and 47 to 209 mm^3, respectively. The surface area of a single grain of peanut and kernel varied from 523 to 936 and 202 to 437 mm^2, respectively. The bulk density of peanut varied from 199 to 329 kg/m^3, whereas it varied from 443 to 619 kg/m^3 for its kernel. The oil content of kernel varied from 41.8 to 57.7%, and was highest for the variety S1.

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