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RESEARCH PAPER

Study on physico-chemical properties of selected pigeonpea (*Cajanus cajan* L.) cultivars

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SUMMARY :

The study revealed the distinct variation in physical properties of three cultivars *viz*., Asha, Maruthi and Gulyal at moisture content of 10.47 per cent, 10.40 per cent and 10.13 per cent (d.b), respectively. The mean values for grain size were highest for Maruthi (5.97 mm) and followed by Gulyal (5.74 mm) and Asha (5.42 mm). The average sphericity varied from 0.790 to 0.921. The true density and bulk density were highest for Gulyal (1446 $kgm^{-3}$and 811.7 kgm^{-3}) and followed by Asha (1441 kgm^{-3} and 806.7 kgm^{-3}) and Maruthi (1430 kgm^{-3} and 797.7 kgm^{-3}), respectively. The porosity was found to be 44.8 per cent for Maruthi, 44.0 per cent for Asha and 43.8 for Gulyal. The surface area and volume were highest for Maruthi (1.118 cm^2 and 0.111cm^3) and followed by Gulyal (1.037 cm^2 and 0.099 cm^3) and Asha (0.923 cm^2 and 0.083 cm^3), respectively. The angle of repose was found to be 21.09^0, 20.33^0 and 20.15^0 for Maruthi, Asha and Gulyal, respectively. The protein content was found to be highest in Asha (22.45 %) and followed by Gulyal (22.36 %) and Maruthi (21.04 %). The fat content was found to be highest in Maruthi (1.81 %) and followed by Gulyal (1.67 %) and Asha (1.65 %). The ash content and fibre content was found to be highest in Asha (3.78 % and 1.48 %) and lowest in Gulyal (3.50 % and 1.06 %) and in Maruthi (3.60 % and 1.06 %), respectively. Whereas, the carbohydrates was found to be highest in Maruthi (58.09 %) and followed by Gulyal (57.28 %) and Asha (56.17 %).

KEY WORDS : Physico-chemical properties, Pigeonpea

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Pigeonpea (*Cajanus cajan* L.) is a member of the family Fabaceae. Other common names are arhar, red gram, tur (Hindi/ Gujarathi/ Marathi / Punjabi), togari (Kannada), kandi (Telugu).The cultivation of pigeonpea goes back at least 3000 years. The centre of origin is most likely Asia, from where it travelled to East Africa and by means of the slave trade to the American continent.

In India, split pigeonpea (toor *dhal*) is one of the most popular pulses along with chickpeas, black gram and green gram. Pigeonpea is nutritionally important as it contains high levels of protein and the important amino acids - methionine, lysine and tryptophan.

India is the world's largest producer of pulses and the average productivity lies between 550 to 625 kg/ha (Puspha, 2007). It is estimated that India's population will touch nearly 1,350 million by 2020 AD. The country would need a minimum of 30.3 million tonne of pulses (Masood and Shivakumar, 2008).

In India, the total food grain production is estimated to be around 227.88 million tonne comprising 98.89 million tonne of rice, 77.78 million tonne of wheat, 36.96 million tonne of coarse cereals and 14.25 million tonne of pulses, as per advance estimates of the agriculture ministry (Anonymous, 2008).

Pigeonpea is grown in almost all the states. Larger portion of the area is in the states like Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat, Andhra Pradesh and Tamil Nadu. All together, they occupy 87.89 per cent of area and contribute 86.10 per cent to the total production.

The determination of physical properties of pigeonpea is important for analysis of behaviour of grains during handling, drying, processing, storage and in the design of the machinery for these operations. The bulk density, particle density, porosity, size, shape, sphericity, volume and surface area are some of the important physical properties of food grains. This basic information should be of great value not only to the engineers but also to the food scientists and processors who may exploit these properties for better processing operations (Kanawade *et al.*, 1990).

Since, information on the physico-chemical properties of pigeonpea appears to be lacking in the literature. Therefore, the physico-chemical properties of three pigeonpea varieties *viz.*, Asha (ICP-8863), Maruthi (ICPL - 87119) and Gulyal were selected for this experiment.

EXPERIMENTAL METHODS

Selection of raw material:

Pigeonpea (*Cajanus cajan* L.) varieties *viz.*, Asha (ICPL–87119), Maruthi (ICP–8863) and Gulyal were used in the present study. They were procured from the Agricultural Produce Marketing Committee (APMC), Gulbarga and Regional Research Station (RRS), Raichur. The samples were cleaned, graded and stored in gunny bags until further processing.

Physical properties:

Spatial dimensions:

Physical properties such as length, breadth and thickness were determined in three randomly selected grains of each variety using universal Vernier calipers (Dev *et al.,* 1982).

$$\mathbf{TR = MSR + (VSR \times LC), mm} \qquad \ldots (1)$$

where,

TR = Total reading, mm

MSR = Main scale reading, mm

VSR = Vernier scale reading, mm

LC = Least count (0.02 mm)

Size and sphericity:

The size (D_p) and sphericity (ϕ) of the grains were calculated by using the following formulae (Dev *et al.*, 1982).

$$\mathbf{Size\ (DP) = (LWT)^{1/3}, mm} \qquad .... (2)$$

$$\mathbf{Sphericity\ (\phi)} = \frac{\mathbf{(LWT)^{1/3}}}{L}, \text{ decimal} \qquad .... (3)$$

where,

D_p = Size, mm

ϕ = Sphericity, decimal

L = Length, mm

W = Width, mm

T = Thickness, mm

Volume and surface area:

The grains volume (v) and surface area (S) were calculated by using the following formulae (McCabe *et al.*, 1986).

$$\mathbf{Volume\ (v)} = \frac{\pi}{6}\mathbf{D_P^3}, \text{ mm}^3 \qquad .... (4)$$

$$\mathbf{Surface\ area\ (S)} = \pi\,\mathbf{D_P^2}, \text{ mm}^2 \qquad .... (5)$$

where,

D_p = Size, mm

Bulk density (°$_b$) :

Bulk density was measured with the help of a measuring cylinder of 1000 ml capacity. Grain sample was poured in the measuring cylinder and weighed. The bulk density was expressed as the ratio of mass of the sample and volume occupied by it (Mangaraj *et al*., 2005).

$$\mathbf{Bulk\ density\ (\rho_b)} = \frac{M}{V}, \frac{\mathbf{kg}}{\mathbf{m^3}} \qquad ..... (6)$$

where,

M= Mass of the grain, kg

V= Volume of the grain, m^3

Particle density (°$_p$) :

The particle density was determined by adding a known weight (20 g) of grains in a 100 ml fractionally graduated measuring cylinder containing a fixed volume (50 ml) of kerosene and noting the increase in volume. Kerosene was selected for this purpose as it has a sufficiently high boiling range and is not absorbed by grains (Mohsenin, 1986).

$$\mathbf{Particle\ density\ (\rho_p)} = \frac{M}{V}, \frac{\mathbf{kg}}{\mathbf{m^3}} \qquad ..... (7)$$

where,

M = Mass of sample, kg

V = Increase in volume of kerosene, m^3

Porosity (£):

The porosity of bulk grain was computed from the values of true density and bulk density using the relationship given by Mohsenin (1986) as follows:

$$\textbf{Porosity } (\varepsilon) = \frac{(\rho_p - \rho_b)}{\rho_p} \textbf{ x 100,} \quad ..... (8)$$

where,
ρ_b= Bulk density, kg/m^3
ρ_p=Particle density, kg/m^3

Angle of repose (¯) :

The angle of repose is the angle between the base and the slope of the cone formed on a free vertical fall of the granular material to a horizontal plane (Sahay and Singh, 1994).

$$\theta = \tan^{-1}\left(\frac{\text{height}}{\text{radius}}\right), \text{degrees} \quad ..... (9)$$

Thousand grain weight:

One thousand grains were randomly selected and weight was determined by using digital electronic balance (Essae PG/ FB) reading to 0.001g (Dev *et al*., 1982).

Chemical properties:

Moisture content:

Moisture content of three selected varieties was determined by hot air oven method. This is based on the principle of drying the sample to constant weight in hot air oven (KEMI. KOS-6FD). The moisture content was calculated by using the following formula (AOAC, 1995).

$$\textbf{Moisture content (\%)} = \frac{W_2}{W_1} \textbf{ x 100} \quad .. (10)$$

where,
W_1= Weight of sample, g
W_2= Loss of weight in sample after drying, g

Crude protein:

The crude protein content of three selected varieties was estimated by using Kjeltec™ 2100 system from FOSS analytical AB, Sweden. This is based on the digestion of sample with concentrated H_2SO_4 using $CuSO_2$, $5H_2O$ as a catalyst to convert organic nitrogen to ammonium ions. Then alkali is added and the liberated ammonia is distilled into boric acid solution which is titrated with hydrochloric acid to determine the ammonia absorbed in the boric acid.

The per cent nitrogen was calculated by using the following formula (AOAC, 1995).

$$\textbf{Nitrogen (\%)} = \frac{\textbf{14.01 x V x N x 100}}{\textbf{Wt. x 1000}} \quad ... (11)$$

where,
V = Volume of standard HCL solution, ml
N = Normality of standard HCL solution, mol
Wt. = Weight of sample, g

The crude protein percentage was calculated by multiplying per cent nitrogen with 6.25, considering 16 per cent nitrogen in protein.

Crude fat:

Crude fat content of various sample were estimated by Soxhlet method. The crude fat is extracted with petroleum ether from ground and dried sample. The solvent is removed by evaporation and the residue of crude fat is weighed. The percentage of crude fat was calculated by using the following formula (AOAC, 1995).

$$\textbf{Crude Fat (\%)} = \frac{W_3 - W_2}{W_1} \textbf{ x 100} \quad ... (12)$$

where,
W_1= Weight of sample before drying, g
W_2= Weight of empty flask, g
W_3= Weight of flask with crude fat, g

Total ash:

The total ash content of the sample was the reflections of the total minerals present in the sample. The organic matter was burnt off and the inorganic material was cooled and weighed. Heating was carried out in different stages, first to drive of the water, then to char the product thoroughly and finally to total ash at 550°C in a muffle furnace (Tempo, TI 58 A). The percentage of total ash content was calculated by using the following formula (AOAC, 1980).

$$\textbf{Total Ash (\%)} = \frac{W_2}{W_1} \textbf{ x 100} \quad ... (13)$$

where,
W_1= Weight of the sample, g
W_2= Weight of the ash, g

Crude fibre:

The crude fibre represents the component which is resistant to acid and alkali hydrolyses and therefore, it is commonly determined by sequential hydrolysis by acid and alkali. The fat free sample was treated with boiling sulphuric acid subsequently with boiling sodium hydroxide. The percentage of crude fibre was calculated by using the following formula (AOAC, 1985).

$$\textbf{Crude fibre (\%)} = \frac{W_2 - W_3}{W_1} \textbf{ x 100} \quad ... (14)$$

where,
W_1 = Weight of sample, g
W_2 = Weight of insoluble matter, g
W_3 = Weight of ash, g

Carbohydrates

Carbohydrates are first hydrolysed into simple sugars using dilute hydrochloric acid. In hot acidic medium glucose is dehydrated to hydroxymethyl furfural. This compound forms with anthrone, a green coloured product with maximum absorption at 630 nm. A standard graph was drawn by plotting concentration of the standard on the X- axis versus absorbance on the Y- axis. The amount of carbohydrate present in the sample tube was calculated by using the graph plotted (Hedge and Hofreiter, 1962).

$$\textbf{Carbohydrates} = \frac{\textbf{W}}{\textbf{V}} \textbf{x 100}, \text{ per cent} \quad \text{... (15)}$$

where,
W= Weight of glucose, mg
V= Volume of test sample, ml

EXPERIMENTAL FINDINGS AND ANALYSIS

The results of the present study as well as relevant discussions have been presented under following sub heads:

Physico-chemical properties:

The results of the experiments conducted for determining the various physic-chemical properties of selected pigeonpea varieties *viz.*, Asha, Maruthi and Gulyal are presented in Table 1.

Spatial dimensions:

The maximum length of the grain was recorded in Maruthi (7.55 mm) followed by Asha (6.31 mm) and minimum was recorded in Gulyal (6.24 mm), whereas maximum width (5.88 mm) and thickness (5.16 mm) were recorded in Gulyal followed by Maruthi (5.61 mm and 5.00 mm) and minimum in Asha (5.34 mm and 4.72 mm), respectively. The values in the present investigation were higher than the values of 6.14 mm (length), 4.90 mm (width) and 4.41 mm (thickness) as reported by Mangaraj *et al*. (2005).

This variation in spatial dimensions might be due to variation among varieties or level of maturity at harvesting stage.

Size and sphericity:

The maximum size was recorded in Maruthi (5.97 mm) and minimum in Gulyal (5.74 mm) followed by Asha (5.42 mm). It was observed that, the sphericity had no correlation with size of the grain. Gulyal (0.92) approaches the spherical shape, whereas least value (0.79) recorded in Maruthi. The size and sphericity depended upon the spatial dimensions of the grains.

Table 1 : Influence of varieties on physico-chemical properties of pigeonpea

Physico-chemical properties	Varieties			S.E.±	C.D.
	Asha	Maruthi	Gulyal		
Physical properties					
Length (mm)	6.31	7.55	6.24	0.004**	0.6276
Width (mm)	5.34	5.61	5.88	0.020*	0.4972
Thickness (mm)	4.72	5.00	5.16	0.044*	0.4980
Size (mm)	5.42	5.97	5.74	0.017*	0.4913
Sphericity (decimal)	0.86	0.79	0.92	-	NS
Volume (mm^3)	100.49	97.08	92.41	0.008**	0.0149
Surface area (mm^2)	104.53	102.15	98.85	0.021*	0.1839
Particle density (kgm^{-3})	1441.00	1430.00	1446.00	-	NS
Bulk density (kgm^{-3})	806.70	797.70	811.70	-	NS
Porosity (per cent)	44.00	44.80	43.80	-	NS
Angle of repose (degree)	20.33	21.09	20.15	-	NS
Thousand grain weight (g)	124.00	118.00	122.00	-	NS
Chemical properties					
Moisture content	10.47	10.40	10.13	-	NS
Crude protein	22.45	21.04	22.36	-	NS
Crude fat	1.65	1.81	1.67	-	NS
Total ash	3.78	3.60	3.50	-	NS
Crude fibre	5.48	5.06	5.06	-	NS
Carbohydrate	56.17	58.09	57.28	-	NS

* and ** indicate significance of values at P=0.01 and 0.05, respectively NS=Non-significant

Volume and surface area:

Asha recorded maximum volume (100.49 mm^3) and surface area (10.53 mm^2), whereas Maruthi recorded 97.08 mm^3 volume and 102.15 mm^2 surface area. The minimum volume (92.41 mm^3) and surface area (98.85 mm^2) was recorded in Gulyal. The volume and surface area are interrelated and seems to be directly proportional to each other. The present findings are in conformity with the results of Bhandari *et al.* (1994) who reported that the volume and surface area ranged from 0.07 to 0.09 cm^3 and from 1.01 to 1.93 cm^2, respectively.

Particle and bulk density:

The Maruthi recorded minimum particle density (1430.0 kgm^{-3}) and bulk density (797.70 kgm^{-3}), whereas Asha recorded 1441.0 kgm^{-3} particle density and 806.70 kgm^{-3} bulk density. The maximum particle density (1446.0 kgm^{-3}) and bulk density (811.70 kgm^{-3}) was recorded in Gulyal. These values are in wide variation with the values of particle density (1389 kgm^{-3}) and bulk density (885 kgm^{-3}) reported by Mangaraj *et al.* (2005). It was observed that the particle density and bulk density are directly proportional to each other.

Porosity:

The minimum porosity was observed in Gulyal (43.8 %), whereas the highest porosity (44.8 %) was recorded in Maruthi followed by Asha (44.0 %). The values in the present investigation are higher than those of Mangaraj *et al.* (2005) who reported that the average porosity was 36.1 per cent. This variation might be due to varietal characteristics of pigeonpea.

Angle of repose:

The angle of repose of the Gulyal (20.15°) was similar to that of Asha (20.33°) and these varieties recorded lower angle of repose than Maruthi (21.09°). The results of angle of repose in present study are in good agreement with the range of values reported by Shepherd and Bhardwaj (1986).

Thousand grain weight:

Thousand grain weight (118 g) recorded was least in Maruthi among three varieties. The highest thousand grain weight (124 g) was recorded in Asha and followed by Gulyal (122 g). These results were higher than the findings of Mangaraj *et al.* (2005), who reported that the thousand grain weight for pigeonpea was 96 g. This might be due to varietal characteristics and moisture content of grains.

Proximate composition:

Moisture content:

The moisture content of pigeonpea grains varied among pigeonpea varieties. Asha recorded maximum moisture content (10.47 %) followed by Maruthi (10.40 %) and Gulyal (10.13 %). Literature also reveals that there was a wide variation in the moisture content of pigeonpea. Low values of 7.25 and 9.09 per cent moisture and high value of 11.25 per cent have been reported by Raghuvanshi *et al*. (1992). This might be due to variation in varietal characteristics.

Crude protein:

The crude protein content of Asha (22.45 %) variety was at par with Gulyal (22.36 %) and these varieties were superior to Maruthi (21.04 %). The crude protein values in the present investigation are within the range (19.08 to 27.91 %) as reported by Sood and Dhindsa (1986), Renu and Bhattacharya (1989), Raghuvanshi *et al*. (1992) and Rathnaswamy *et al*. (1973). Variation among varieties might be the cause for variation in crude protein.

Crude fat:

Two varieties namely, Asha (1.65 %) and Gulyal (1.67 %) contained almost same crude fat content. The maximum crude fat content was recorded in Maruthi (1.81 %). The results obtained for the fat content also varied and fell within the range of values as reported by Renu and Bhattacharya (1989) and Raghuvanshi *et al*. (1992).The minimum value of 1.65 per cent was recorded in Asha and maximum was recorded in Maruthi (1.81 %). This might be due to variations in the fertilizer dose applied, soil and climatic conditions during their cropping period.

Total ash:

The total ash content in Gulyal (3.50 %) was the lowest among all the varieties. The highest total ash content (3.78 %) was recorded in Asha followed by Maruthi (3.60 %). These values are in confirmation with reports of Sood and Dhindsa (1986) and Raghuvanshi *et al*. (1992) who reported that the total ash content varied from 2.76 to 4.00 per cent.

Crude fibre:

Two varieties namely, Asha and Gulyal contained crude fibre value of 5.06 per cent, whereas the maximum crude fibre (5.48 %) was recorded in Maruthi variety. The higher values were reported by Raghuvanshi *et al*. (1992). This might be due to variation in variety and application of fertilizer.

Carbohydrates:

Asha variety showed the lowest carbohydrates (56.17 %), whereas Maruthi variety recorded the highest carbohydrates (58.09 %) followed by Gulyal variety (57.28 %). Among the varieties, the carbohydrate content recorded was higher than the values (54.54 to 59.53 %) reported by Raghuvanshi *et al*. (1992). This variation could be due to the difference in agronomic practices, particularly fertilizer application.

Thus it could be concluded that different varieties of pigeonpea showed significant variation in spatial dimensions, size, volume and surface area. Therefore, it becomes necessary to pay outmost attention to the post harvest characteristics of the grain while developing the new varieties.

The variability in physical properties underscores the importance of periodically analyzing representative samples of important varieties of pigeonpea of a particular region.

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