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Study on physical properties of chickpea

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Abstract
The physical properties of seeds are essential for the design of equipment for handling and planting the kernels in precise manner. A study was conducted to investigate physical properties of chickpea seeds at different levels of moisture content 16.41-25.65% (d.b.). The average value of length, width and thickness varied from 8.27-9.39 mm, 6.16-7.02mm and 5.59-6.62mm respectively. Geometric mean diameter and sphericity varied 6.57-7.58 mm and 79.55– 80.77 percent, respectively. Average value of bulk density and true density varied from 722.02 to 689.05 kgm^{-3} and 875.09 to 850.51 kgm^{-3} respectively. The angle of repose ranged between 22.34 to 25.52°. The roundness of chickpea ranged between 0.77 to 0.80, seed weight 230.81 to 248.11 respectively.

Keywords: Chickpea seeds, physical properties. seed variety, sphericity, true density, India

Introduction
Chickpea (*Cicer arientimum* L.) also known a 'chana' or 'bengal gram' belongs to leguminous family. It is third most commonly consumed legume in world (Singh, 1988; Singh, 1990). It is a major pulse crop in the Indian subcontinent and several other countries. It forms an important source of protein in the Indian vegetarian diet. The chickpeas are a good source of protein and carbohydrate and its protein quality is better than other legumes such as pigeon pea, black gram and green gram, it is used as an edible seed as well as for making flour. This crop is broadly divided into two categories viz. Desi and Kabuli according to the colour, seed size and taste. India is the leading producer and consumer of chickpea in the world. Normally it accounts for around 40% of India's total pulses crop production of 12-15 million tons. Major producing states are Madhya Pradesh, Uttar Pradesh, Rajasthan and Maharashtra. Chickpea annual production was 10,461.215 tons, harvest area was 11,551.857 ha and yield 905.50 kg ha^{-1} in the word. (Maurya and Kumar, 2018). The geometric properties such as size and shape, seed weight, bulk density, sphericity, angle of repose, moisture content roundness and true density are the most important for physical properties.

Materials and Methods
Selection of the Variety
A variety of the chickpea were selected for this study. JG-11 was recommended by Agricultural University Raichur, because this variety covers a major area under chickpea in Raichur region and JG-11 is commercially available variety which cover more area compare to other non-recommended verities in Raichur.
The grains were procured from the seed market in Raichur. The chickpea grains were cleaned manually in order to remove the impurities such as dust, stone, and sticks, immature and damaged kernels. The study was carried out in the laboratory of processing and food engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur.

1. Geometric Mean Diameter
To determine average seed size, 10 seeds were randomly picked and their three linear dimensions namely, length (L), width (W) and thickness (T) were measured using a digital Vernier calliper (Fig.1) with an accuracy of 0.05mm. The size and shape of the seeds were useful in deciding the size and shape of orifice of metering mechanism for the selected seeds used for this study. It was calculated by using formula.

$$= (L \times W \times T)^{1/3} \quad \text{... (1)}$$

Fig 1: Measuring length, width and thickness

2. Seed Weight

For determination of average weight of 1000 seeds, a random sample of thousand seeds was selected and weighed on the electronic weighing balance having sensitivity of 0.01g. The experiment was replicated ten times to determine average value of 1000 seeds weight (Mohsenin, 1986) [4].

3. Bulk Density

An empty container (150mL) was weighed using a digital balance to the nearest 0.0001g. The container was filled with a sample and the material was slightly compacted to ensure absence of large void spaces. The container and the sample were then weighed. Ten replications were carried out. The bulk density (Varnamkhasti *et al.*, 2008) [9] of sample was calculated from the following given equation.

$$\text{Bulk density, kg m}^{-3} = \frac{\text{M, kg}}{\text{V, m}^3} \quad \ldots. (2)$$

Where,
M = Mass of the seed sample. kg
V = Volume of sampler, m^3

4. True Density

The true density is defined as the ratio between the mass of seeds and the true volume of the seeds and determined using the toluene (C_7H_8) pycnometer method. The true density of the seeds calculated by using the following relation (Mohsenin, 1970) [5].

$$\text{True density} = \frac{\text{Weight of seeds, kg}}{\text{Volume of seeds excluding void space, cm}^3} (\text{kg m}^{-3}) \quad \ldots(3)$$

5. Sphericity

The sphericity is defined as the ratio of the surface area of a sphere with the same volume as the seed to the surface area of the seed. This measurement was determined using the following equation (Mohsenin, 1986) [4].

$$\Phi = \frac{(L \times W \times T)^{1/3}}{L} \quad \ldots. (4)$$

Where,
Φ= Sphericity
L = Length, mm
W = Width, mm
T = Thickness, mm

6. Angle of Repose

The apparatus used for measuring dynamic angle of repose consisted of a funnel with an adjustable throat opening mounted on a stand. A circular plate, with two centring arms, was mounted in the funnel below the adjustable throat. The funnel was filled with seeds by keeping its adjustable throat closed. The throat was fully opened to allow free flow of seeds over and around the plate mounted beneath the funnel. At the end of process, a heap-cone of the seed was formed on the plate. From the heap cone, base diameter and height of cone were measured. The angle of repose (Fig.2) was calculated using the following relationship (Nimkar and Chattopadhyay, 2001) [6].

$$\theta = \tan^{-1}\left(\frac{h}{r}\right) \quad \ldots. (5)$$

Where,
θ = Angle of repose, degrees
h= Height of heap, m
r = Radius of heap, m

Fig 2: Apparatus used for angle of repose by using a Vernier calliper.

7. Moisture Content of Seeds

Moisture content of seeds were determined by hot air oven method. Seed samples were weighed and oven dried at 105^0C for 24 hours. The weight of the dried samples was recoded. The seed moisture content on dry basis (per cent) was calculated using the following expression (Gupta and Das, 2000) [2].

$$MC(\%) = \frac{w_1 - w_2}{w_2} \times 100 \quad \ldots. (6)$$

Where,
MC = Moisture content, %
W_1 = Initial weight of sample, g
W_2 = Dried weight of sample, g

8. Roundness

Roundness was calculated by using the formula (Gautam *et al.* 2016) [1].

$$\text{Roundness} = \frac{[(W/L) + (T/L) + (T/W)]}{3} \quad \ldots. (7)$$

Where,
W = Width of grain seed, mm
L = Length of grain seed, mm
T = Thickness of seed, mm

Results and Discussion

The average values of the three principal dimensions of a maize kernel namely, length, width and thickness were determined. These values at different moisture contents are presented in Table 1. The average length, width and thickness of the chickpea varied from 8.87 to 6.62 mm, 6.13 mm, respectively as the moisture content increased from 16.41 to 25.65% d.b The geometric mean diameter ranged from 6.57 to 7.58 mm as the moisture content increased from 16.41 to 25.65% d.b, respectively. The length, width, thickness and geometric mean diameter of the chickpea was found to increase linearly with increase in the moisture content.

1000 Kernel Weight

From the (Fig. 3), it is observed that the 1000 kernel weight increased linearly from 230.81 to 248.11 g as the moisture content increased from 16.41 to 25.65% d.b.

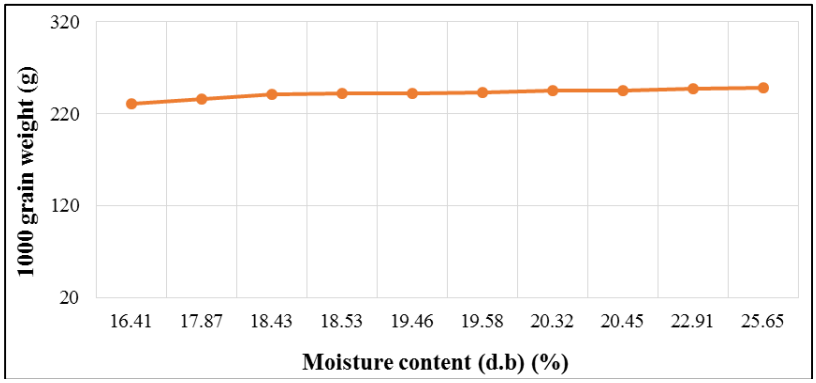

Fig 3: Effect of moisture content on 1000 grain weight of chickpea

Bulk and True Density

The bulk density and true density of the chickpea at different moisture levels varied from 722.02 to 689.05 kg m^{-3} and 875.09 to 850.51 kg m^{-3} with the moisture range of 16.41 to 25.65% d.b respectively. A nonlinear increase in bulk density and true density was observed for different moisture levels. This increase in true density (Fig. 4) may be due to the higher rate of increase in mass than the volumetric expansion of the kernels. The bulk density (Fig. 5) of the chickpea kernel decreases with increase in the moisture content from 16.41 to 25.65% d.b. Similar trend was reported for ground nut kernels (Mohsenin, 1970) [5].

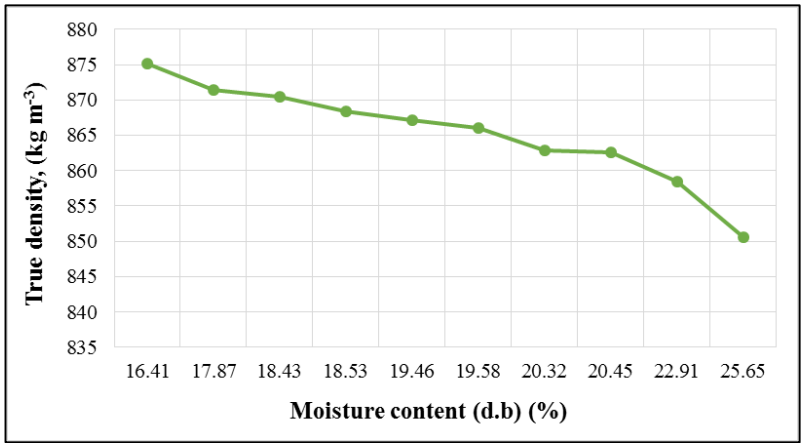

Fig 4: Effect of moisture content on true density of chickpea

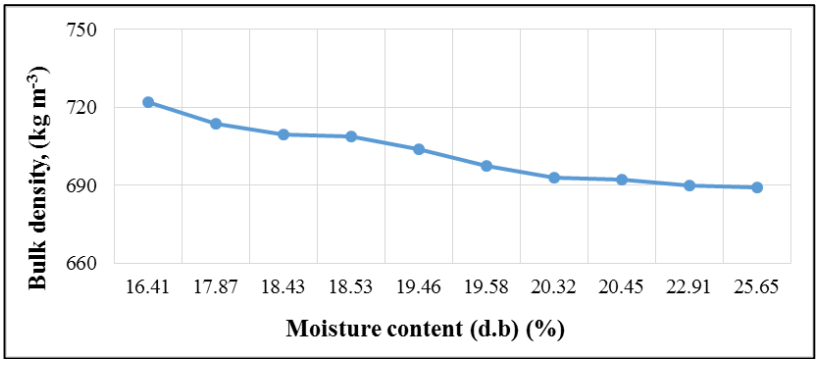

Fig 5: Effect of moisture content on bulk density of chickpea

Angle of Repose

The angle of repose for chickpea varied from 22.34 to 25.52^0 respectively, at different levels of moisture content. Both the angle of repose for chickpea increased with increase of moisture content from 16.41 to 25.65% d.b. The increase in angle of repose (Fig. 6) with moisture content may be due to the surface tension which holds the surface layer of moisture surrounding the particle together with the aggregate of grain. The relationship can be expressed using the following equation (5).

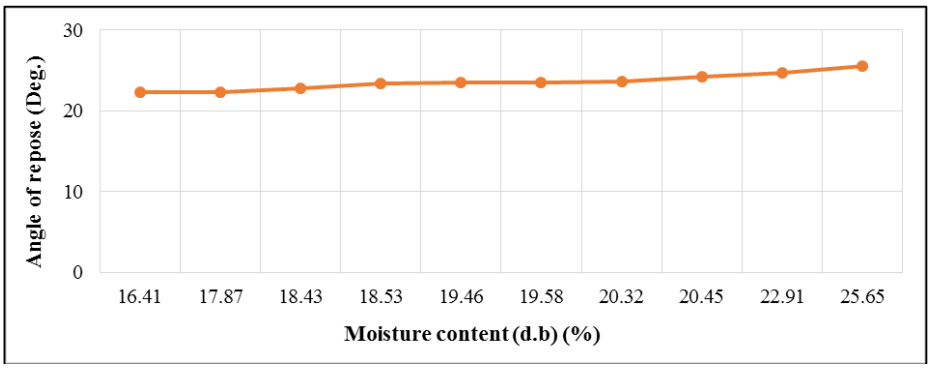

Fig 6: Effect of moisture content on angle of repose of chickpea

Roundness

Roundness for chickpea varied from 0.77 to 0.80 respectively, at different levels of moisture content. The average value found was 0.78.

Conclusion

The length, width and thickness, of gram were determined and found to be increased linearly with the increase of moisture content. Whereas, Bulk density, and true density decreases with increase of moisture content. As moisture content increases, mass of 1000 grains also increases and similarly, angle of repose and sphericity, increases with the increase of moisture content.

Table 1: Physical properties of chickpea seeds

Sample No.	MC (d.b) (%)	Length (mm)	Width (mm)	Thickness (mm)	Geometric mean diameter	Sphericity (%)	1000 grain weight (g)	Bulk density, (kg m^{-3})	True density, (kg m^{-3})	Angle of repose, (Deg.)	Roundness
01	16.41	8.27	6.16	5.59	6.57	79.55	230.81	722.02	875.09	22.34	0.77
02	17.87	8.54	6.27	5.68	6.72	78.74	236.54	713.57	871.43	22.35	0.76
03	18.43	8.75	6.3	5.93	6.88	78.72	240.95	709.55	870.40	22.85	0.80
04	18.53	8.81	6.45	6.02	6.99	79.38	242.38	708.65	868.34	23.36	0.78
05	19.46	8.85	6.56	6.14	7.09	80.11	242.42	703.95	867.21	23.51	0.79
06	19.58	8.89	6.73	6.21	7.189	80.86	243.71	697.43	866.07	23.57	0.79
07	20.32	8.98	6.86	6.24	7.27	80.96	244.85	693.04	862.91	23.62	0.79
08	20.45	9.1	6.93	6.43	7.40	81.33	245.52	692.05	862.65	24.23	0.80
09	22.91	9.21	6.97	6.51	7.47	81.17	246.93	690.05	858.43	24.69	0.80
10	25.65	9.39	7.02	6.62	7.58	80.77	248.11	689.05	850.51	25.52	0.80
Average	19.96	8.87	6.62	6.13	7.11	80.15	242.22	701.93	865.30	23.60	0.78

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