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**Bhawna S Shirsat**
Assistant Professor, Department of Agricultural Engineering, COA, Dr. BSKKV, Dapoli, Maharashtra, India

**Correspondence:**
**Bhawna S Shirsat**
Assistant Professor, Department of Agricultural Engineering, COA, Dr. BSKKV, Dapoli, Maharashtra, India

# Studies on some physical properties of chickpeas

## Bhawna S Shirsat

**Abstract**
The chickpea (*Cicer arietinum* L.), also called Bengal gram is an important pulse crop of the pea family (Fabaceae), commonly grown for its nutritious seeds. The present work was done to study some physical properties of various types of chickpeas (Kabuli, dark red gram and light red gram) procured from the local market of Dapoli. The average moisture content was found to be 8.18, 6.91 and 7.31% (wet basis). Geometric properties *viz*., length, breadth, thickness, geometric mean diameter, sphericity, roundness and aspect ratio were determined and found to be in the range of 7.02-13.51 mm, 5.08-9.65 mm, 4.77-8.99 mm, 5.54-10.24 mm, 69.49-94.67%, 0.71-0.94 and 0.59-0.93 for Kabuli, dark red gram and light red gram, respectively. The 1000 seed weights were found to be in the range of 519.06, 167.09, and 162.30 g, respectively. The gravimetric and frictional properties such as bulk density, true density, porosity and angle of repose were 815.79-845.26 kg/m$^3$, 1481.48-1666.67 kg/m$^3$, 43.16-51.05 % and 23.09-26.38°, for Kabuli, dark red gram and light red gram, respectively. The result of this study will help in the design and construction of the processing, sorting, grading and handling equipment.

**Keywords:** Chickpea, *Cicer arietinum*, sphericity, roundness

## 1. Introduction
Pulses play an important role in the supply of food needed in human society in developing countries. The chickpea (*Cicer arietinum* L.), also called Bengal gram is an important pulse crop of the pea family (Fabaceae), commonly grown for its nutritious seeds. Globally, India ranks first in the area and production of chickpea followed by Pakistan, Iran, and Australia in the area and Australia and Myanmar in production. In India, the total productivity of chickpeas is about 995 kg/ha (FAO STAT, 2014). During the twelfth plan (2012-16), the area and production of the chickpea or gram are about 87.62 lakh hectares and 82.15 lakh tonnes, respectively. More than 90% production of gram comes from seven states such as Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, Uttar Pradesh, and Chhattisgarh. Maharashtra ranks second *i.e*., 21.83 lakh tonnes or 11.89% of total production (Anonymous, 2015-16) [1].
Chickpea is a good source of protein and carbohydrates and it has higher protein content (20-22%) than other pulses such as pigeon pea, green gram, and black gram. It also supplies some minerals (calcium, magnesium, potassium, zinc, iron, and phosphorus), fibers, and vitamins like niacin and thiamine. Chickpea is rich in nutritionally important unsaturated fatty acids such as oleic acid and linoleic acid (Sastry *et al*. 2013) [8].
The information on the physical properties of chickpeas is important in the design and construction of the equipment used for processing, sorting, separation, storage, and transportation. These properties are also helpful during the processing and handling of agricultural materials to set the equipment's operational parameters for efficient operations. The physical properties are relevant to the mechanization of processing to increase its utilization as a food resource. The agricultural practices such as harvesting, cleaning and processing of this seed depend largely on traditional methods which are not practical for large-scale production. Therefore, increasing production, minimizing seed damage, and reducing crop losses require designing efficient processing and handling equipment (Sawant *et al*. 2009) [2] there is limited research that has been done on the physical properties of chickpeas. The objective of this study was taken to study some physical properties of different varieties of chickpeas.

## 2. Material and Method

The seeds of chickpea were procured from the local market of Dapoli. The measurements of all physical properties were taken in the Laboratory of the Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. BSKKV, Dapoli. The methods adopted for the determination of physical properties are given below.

### 2.1 Moisture content

The moisture content of chickpeas was determined by the oven-drying method. The samples from seed samples were weighed and oven dried at 105°C for 24 hours. The weight of the dried sample was recorded and moisture content was determined as per the standard method of analysis (ISTA, 1993) [4]. The moisture content was expressed as% (wet basis) or % (dry basis). The moisture content was determined by using the following equation:

$$\text{Moisture Content (\%)} = \frac{\mathbf{w_2 - w_3}}{\mathbf{w_2 - w_1}} \quad \ldots (1)$$

Where,
$W_1$ = Weight of empty sample box, g
$W_2$ = Weight of empty dish + sample before drying, g
$W_3$ = Weight of empty dish + sample after drying, g

### 2.2 Axial dimensions

Chickpeas of different types were randomly selected for measuring the axial dimensions. Length (L), width (B) and thickness (T) of each seed of chickpea were measured using a Vernier caliper (0.01 mm accuracy) as per. A hundred observations were made to get average values of length, width and thickness of the chickpeas.

### 2.3 Geometric Mean Diameter

The geometric mean diameter (GMD) was determined using measured axial dimensions such as length, width and thickness. It was determined using the following formula described by Mohsenin (1986) [6].

$$\text{GMD} = \sqrt[3]{(L \times \text{B} \times \text{T})} \quad \ldots(2)$$

Where,
L = length of the chickpea, mm
B= width of the chickpea, mm
T = thickness of the chickpea, mm

### 2.4 Sphericity

Sphericity (ϕ) Sphericity is the ratio of the diameter of a sphere of the same volume as that of the particle and the diameter of the smallest circumscribing sphere or generally the largest diameter of the particle (Mohsenin, 1986) [6].

$$\text{Sphericity } (\phi) = \frac{\sqrt[3]{(L \times B \times T)}}{L} \quad \ldots(3)$$

Where,
L = length of the chickpea, mm
B= width of the chickpea, mm
T = thickness of the chickpea, mm

### 2.5 Roundness

Roundness is the measure of the sharpness of the corner of the solid materials. It was determined by using the following expression (Gautam *et al*. 2016) [2].

$$\text{Roundness} = \frac{[(\text{B/L}) + (\text{T/L}) + (\text{T/B})]}{3} \quad \ldots(4)$$

Where,
L = length of the chickpea, mm
B= width of the chickpea, mm
T = thickness of the chickpea, mm

### 2.6 Aspect Ratio

The aspect ratio is the ratio of the width of the seeds to the length of the seeds into 100. The aspect ratio (Ra) of the chickpea seeds was determined as recommended by using the equation:

$$\text{Ra} = \frac{\text{B}}{L} \ldots \quad \ldots(5)$$

Where,
Ra= Aspect ratio
L = Length, mm
W = Width, mm

### 2.7 Bulk Density

The bulk density was determined as the ratio between the mass of chickpea seeds in a container to its volume. The seeds of chickpea were filled in a measuring cylinder of volume 1000 $cm^3$ and the mass of contents was determined.

$$\text{Bulk Density} = \frac{\text{Weight of the sample,g}}{\text{The volume of the cylinder,cm}^3} \quad \ldots(6)$$

### 2.8 True Density

The true density of the chickpea seeds was determined by the Platform scale method (Mohsenin, 1986) [6]. It was determined by adding a known weight of seed sample in a 100 ml fractionally graduated measuring cylinder having a fixed volume of toluene and recording the increase in volume. The true density of the chickpea was determined by taking 10 replications and calculated using the following expression.

$$\text{True Density} = \frac{\text{Weight of the sample (kg)}}{\text{The true volume of the sample (m}^3\text{)}} \quad \ldots(7)$$

### 2.9 Porosity

Porosity is the percentage of the volume of voids in the test sample at given moisture content. It was calculated as the ratio of the difference in the true and bulk densities to true plant density and determined by the expression as reported by Sawant *et al*. (2009) [2]:

$$\text{Porosity \%} = 1 - \frac{\text{Bulk density}}{\text{True density}} \times 100 \quad \ldots(8)$$

### 2.101000 seed weight

1000 seed weight of the chickpeas was measured on randomly selected 1000 seeds and weighing them using anelectronic weighing balance (least count: 0.001 g) and weight was recorded in grams. The experiment was replicated ten times to determine the average 1000 seed weight (Mohsenin, 1986) [6].

### 2.11Angle of Repose

The angle of repose was determined using an experimental set-up. The chickpea seeds filled in a grain holder were allowed to fall on a circular plate of known diameter and a

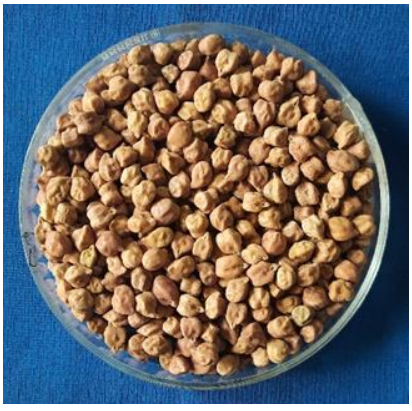
heap of the sample was noted. From the known diameter and height of the heap, the angle of the repose was calculated by using the following formula:

$$\Theta = \tan^{-1}\left(\frac{2H}{D}\right) \quad \ldots(9)$$

Where,
Θ = Angle of repose in °,
H = Height of the heap in cm,
D = Diameter of the heap in cm

A) Kabuli

B) Dark red gram



C) Light red gram

**Fig 2.1:** Different types of Chickpeas

## 3. Results and Discussion

### 3.1 Moisture content

The initial moisture content of the turmeric rhizomes was determined by the oven drying method and the average moisture content was found by 8.18, 6.91 and 7.31% (wb) for Kabuli, dark red gram and light red gram, respectively. The moisture content of the product determines the shelf life and the keeping quality of the turmeric.

### 3.2 Axial dimensions and sphericity

The mean and standard deviation of axial dimensions i.e. length, width and thickness, geometric mean diameter and sphericity of three varieties of chickpeas are given in Table 1. The average value of length of Kabuli, dark red gram and light red gram were found to be 11.14 mm, 8.10 mm and 8.50 mm, respectively. Similarly, the average values of width and thickness were found to be 8.65, 5.92, 5.99 mm and 8.06, 5.56, 5.78 mm, respectively. The above observations for axial dimensions are in agreement with the findings of Sastry *et al*. (2013) [8], and Ghamari *et al*. (2014) [3].

The mean value of geometric mean diameter was calculated to be 9.18 mm, 6.43 mm and 6.65 mm, respectively. The sphericity of the Kabuli, dark red gram and light red gram were determined to be 82.71%, 79.53% and 78.34%, respectively. A similar trend was reported by Sastry *et al*. (2013) [8] for different types of chickpea seeds.

### 3.3 Roundness and aspect ratio

The calculated values of roundness and aspect ratio were the average of 100 seeds of chickpeas are shown in Table 1. The mean values of roundness were observed to be0.81, 0.79 and 0.78 with a standard deviation of 0.04, 0.03 and 0.02 for Kabuli, dark and light red gram, respectively. The mean values of aspect ratio for these three types of chickpeas were calculated to be0.78, 0.73 and 0.71, respectively. The results of roundness and aspect ratio are similar to the findings of Jaliliantabar and Lorestani (2012) [5], respectively.

### 3.1 1000 seed weight

The 1000 seed weights of Kabuli, dark and light red grams were determined to be 519.96 g, 167.09 g and 132.30 g with a standard deviation of 8.11, 2.64 and 2.06, respectively.

### 3.2 Bulk density

The bulk density of Kabuli, dark red gram and light red gram were observed in the range of 831.58 to 836.84 kg/m$^3$, 836.84 to 845.26 kg/m$^3$ and 815.79 to 826.32 kg/m$^3$, respectively. The mean value and standard deviation of bulk density were calculated to be 831.58, 841.16, 820.53 kg/m$^3$ and 2.12, 3.38, 2.99, respectively for three types of chickpeas.

### 3.5 True density

The true density of Kabuli, dark red gram and light red gram was observed in the range of 1481.48 to 1538.46 kg/m$^3$, 1481.48 to 1600.00 kg/m$^3$ and 1600.00 to 1666.67 kg/m$^3$, respectively. The mean value and standard deviation of bulk density were calculated to be 1487.18, 1545.07, 1633.33 kg/m$^3$ and 18.02, 33.97, 35.14, respectively for three types of chickpeas. These results are similar to the findings of Sastry *et al*. (2013) [8] for different types of chickpeas.

### 3.6 Porosity

The mean values of porosity of the Kabuli, dark red gram, and light red gram were found to be 43.87%, 45.54% and 49.74% with a standard deviation of 0.59, 1.16 and 1.06, respectively.

### 3.7Angle of repose

The angle of repose was found to be 24.66, 25.15 and 25.13°with a standard deviation of 1.05, 0.4, 0.78, for Kabuli, dark red gram, and light red gram, respectively. The results of the angle of repose are similar to the findings of Nikoobin *et al*. (2007) [7] for red grams.

## 4. Conclusion

The present investigation was conducted on the physical properties of different types of chickpeas. These properties can be very useful in the design and construction of post-harvest handling and sorting machines as well as processing machines. The knowledge of physical properties is also essential in post-harvest operations like material handling, processing, storage and transportation. These physical properties are very important to characterize any biological material.

**Table 1:** Physical properties of different types of chickpeas

| Physical Properties | No. of observations | Kabuli | | Dark red gram | | Light red gram | |
|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD |
| Length, mm | 100 | 11.14 | 0.87 | 8.1 | 0.51 | 8.5 | 0.52 |
| Width, mm | 100 | 8.65 | 0.48 | 5.92 | 0.42 | 5.99 | 0.22 |
| Thickness, mm | 100 | 8.06 | 0.48 | 5.56 | 0.32 | 5.78 | 0.25 |
| Geometric mean dimension, mm | 100 | 9.18 | 0.46 | 6.43 | 0.35 | 6.65 | 0.28 |
| Sphericity, % | 100 | 82.71 | 4.16 | 79.53 | 2.62 | 78.34 | 2.44 |
| Roundness | 100 | 0.81 | 0.04 | 0.79 | 0.02 | 0.78 | 0.02 |
| Aspect ratio | 100 | 0.78 | 0.07 | 0.73 | 0.05 | 0.71 | 0.03 |
| Bulk density, kg/m$^3$ | 10 | 831.58 | 2.12 | 841.16 | 3.38 | 820.53 | 2.99 |
| True density, kg/m$^3$ | 10 | 1487.18 | 18.02 | 1545.07 | 33.97 | 1633.33 | 35.14 |
| Porosity, % | 10 | 43.87 | 0.59 | 45.54 | 1.16 | 49.74 | 1.06 |
| 1000 seed weight, g | 10 | 519.96 | 8.11 | 167.09 | 2.64 | 162.3 | 2.06 |
| Angle of repose, ° | 10 | 24.66 | 1.05 | 25.15 | 0.4 | 25.13 | 0.78 |
| Moisture content | 3 | 8.18 | 0.17 | 6.91 | 0.25 | 7.31 | 0.18 |

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