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**Original Research Article** 

# A study on physical properties of okra seed: *ABELMOSCHUS ESCULENTUS* (L.)

#### 4 Abstract

5 Physical properties of any seed is vital information for development of its metering mechanism, 6 processing and storage system. An experiment was conducted to evaluate physical properties of okra seed of variety 'Varsha Uphar'. The study revealed that the average value of length, width, thickness 7 8 and geometrical diameter of okra seed were 5.73 mm, 4.83 mm, 4.49 mm and 4.98 mm, respectively. The bulk density and true density okra seeds were found to be 0.54 g cm<sup>-3</sup> and 1.07 g cm<sup>-3</sup>, 9 respectively. The average volume of one okra seed was 108 mm<sup>-3</sup>. The average angle of repose of 10 11 okra seeds was  $28.65^\circ$ , which ranged from  $27^\circ$  to  $30^\circ$ . The study also inferred that the roundness of 12 the seed was 78.2% ranging from 68.4% to 89.5% whereas the sphericity of the seed was 87.9% 13 ranging from 82.4% to 95.8%. The porosity of bulk of okra seeds was 49.1%, which varied between 14 43.9% and 55.0%. The average weight of 1000 okra seeds varied between 53.2 g and 57 g with an 15 average value of 55.16 g.

16 Keywords: Okra, seed properties of okra, roundness, sphericity of seeds, density.

#### 17 Introduction

18 Okra, commonly known as lady finger, is one of the important vegetable crops in India. In world 19 scenario, it occupies first position in okra production (65.94% of total production) followed by 20 Nigeria [1]. It was sown in 5.04 lacs hacatres in India during 2014-15 resulting into a production of 21 5.7 million metric tonnes [2]. Okra is consumed in form of its immature finger-like green pods. These 22 green pods are the important constituents of diet in developing countries. Its major nutrients are 2.2% 23 protein, 9.7% carbohydrate and 1.0% fibre [3]. It is also rich source of vitamin C (30 mg/100 g), 24 calcium (90 mg/100 g) and iron (1.5 mg/100 g) content [4]. The stems and roots of this vegetable are 25 used to clean cane-juice while making juggary [5]. Because of its high mucilage content, it is 26 beneficial in curing peptic ulcer, reducing the pains and haemorrhoid effects [6]. In an experiment, its 27 mucilage had been used as alternative to blood plasma [7].

28 The physical properties of okra is the primary data set required for development of its metering 29 mechanism. This data can also be used for designing of its handling, processing and storage 30 structures. Separation of unwanted material from seeds is easy through oscillating chaffers when size, 31 shape and density of the seed are known [8]. The angle of repose affect the design of mass flow 32 structures. In drying and aeration systems for seeds, bulk density and porosity play a very important 33 role as these properties control the amount of hindrance caused to air flow [9]. This study was aimed 34 to assess physical properties of okra seeds, which includes size, shape, bulk density, and true density, 35 angle of repose, porosity and weight of one thousand seeds.

#### 36 Materials and Methods

# 37 Sample preparation

The okra seed was procured from local market. The variety of the okra seed was *Varsha Uphar*. The sample seeds were cleaned from foreign material, damaged seeds and impurities by manual picking and then passing through a metal screen having square pores of size 10mm. The moisture content of 41 the seed sample was determined by oven drying method. Three samples of seed taken in aluminum

42 boxes were weighted and placed in hot air oven at 105°C [10]. The moisture content of the seeds was

43 found to be 6.58% on dry basis.

# 44 Determination of physical properties

45 Seed properties essential for development of the metering, processing and storage systems, were 46 identified and determined. The properties identified are discussed below-

# 47 Size of okra seed

48 Seed size is the one of the basic property of seed that is of primary requirement for any seed handling

- 49 system. The cell size of metering system also depends on it. The seed size is specified by its length,
- 50 width and thickness. The measurements in these three dimension were taken by using a micrometer

51 having a least count of 0.1 mm. The dimension of 10 randomly selected seeds were measured.

# 52 Shape

53 The shape of seed is important design parameter of flow structures and metering mechanisms. The

shape of the seed is expressed by its round  $\mathbf{x}$  ericity. Roundness of seed,  $R_p$  is calculated by

55 formula [11]:



56 where,  $R_p$  = Roundness, %

57 
$$A_P$$
 = Projected area, mm<sup>2</sup>

58  $A_c$  = Area of the smallest circumscribing circle, mm<sup>2</sup>

59 The projected area of the seed was measured using a testing setup which included a thirteen

60 megapixel camera, glass slab, camera stand and graph paper. Experimental setup used for this is

61 depicted in Fig. 1.



62 63

Fig. 1: Schematics of experimental setup for finding projection

64 of seed on graph paper

Image of the seed is then processed with the help of computer and projection of seed on graph is created (Fig. 2). Graph paper acts as reference scale in the image taken. The projected area is calculated by graphical method. The area of smallest circumscribing circle is calculated by taking the largest axial dimension of the seed at natural rest position as the diameter of the circle. The procedure 71 72

69 was repeated for 10 seeds selected randomly. The mean was taken as the characteristic value of 70 roundness.

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Fig. 2: Projection of okra seed on graph paper

73 The sphericity of seeds,  $\varphi$  is calculated by using the

by using the tionship [11]:  

$$\varphi(\%) = -$$

74 where, L = Length of seed, mm

75 W = Width of seed, mm

76 
$$T = Thickness of seed, mm$$

Assuming that volume of solid is equal to the volume of tri-axial ellipsoid with intercepts a, b, c andthat the diameter of circumscribed sphere is longest intercept of the ellipsoid,

- 79 Length of seed, a = Longest intercept, mm
- 80 Width of seed, b = Longest intercept normal to a, mm

81 Thickness of seed = Longest intercept normal to both a and b, simultaneously

The procedure was repeated for ten seeds selected randomly. The mean was taken as the characteristic value of sphericity.

#### 84 Bulk density

Bulk density of the seeds is used for seed storage structures designs. Bulk density of seed was measured using an aluminum box having a volume of 120 cm<sup>-3</sup>. The box was filled with okra seeds

87 without compaction and then its weight was measured. The bulk density was calculated as follows:

Bulk Density 
$$(\frac{g}{cm^{x} 10} = \frac{\text{Weight of seed sample (g}}{\text{Volume of sample box (cm}^3)})$$

88 The procedure was repeated ten times and the average bulk density of the seed was reported.

# 89 Volume and true density

The volume of the seed plays an important role in cell design of seed metering mechanisms. The volume and true density of seed are determined by toluene ( $C_7H_8$ ) displacement method. Toluene was used instead of water because it is absorbed by seeds to a lesser extent. The volume of toluene displaced was found by immersing a weighted quantity of okra seeds in in a graduated glass jar containing known volume of toluene [12]. True density is the ratio of weight of the sample to the volume of the toluene displaced. Observations were taken for ten samples and the mean was calculated separately for volume and true density of seeds.

# 97 Angle of repose

98 The angle of repose is the angle between the base and the slope of cone formed on a free vertical fall 99 of the grain mass to a horizontal plane [13]. The slope of base of the seed flow structures is based on 100 the average angle of repose of seeds to ensure free flow of seed [14]. Three readings were taken with 101 the help of protractor and average was reported.

# 102 **Porosity**

103 The porosity of seed is calculated using the following expression [13]:

Porosity (%) = 
$$\left(1 - \frac{\text{Bulk density}}{\text{True Densty}}\right) \times 100$$

104 Bulk density and true density values obtained from previous experiments were used to calculate the

105 per cent porosity of the seed.

# 106 Weight of 1000 seed

107 The weight of single seed was determined by randomly selecting 1000 seeds of okra and then108 weighing them one by one. A precision weighing balance having least count of 0.001 g was used.

# 109 Results & Discussion

# 110 **1. Bulk density**

Bulk density of okra seed varied between 0.51 gcm<sup>-3</sup> and 0.57 g cm<sup>-3</sup> at seed moisture content of 6.58% on dry basis. The average value of bulk density of the seed was 0.54 g cm<sup>-3</sup>. The coefficient of

6.58% on dry basis. The average value of bulk density of the seed was 0.54 g cm<sup>-1</sup>. The coefficient of

variation of bulk density was 4.55%. Kushwaha et al. [15] reported bulk density of okra seeds as 0.58

114 g cm<sup>-3</sup> at 11.2% moisture content (d.b.) of okra seed whereas Sahoo and Srivastava [16] reported it as

115  $0.59 \text{ g cm}^{-3}$  at 8.16% moisture content on dry basis.

# 116 **2. Volume and true density**

The mean volume of okra seeds was 108 mm<sup>-3</sup> and it varied in range from 99 mm<sup>-3</sup> to 110 mm<sup>-3</sup>. The mean true density of okra seed was 1.07 g cm<sup>-3</sup> which ranged between 1 g cm<sup>-3</sup> and 1.07 g cm<sup>-3</sup>. The coefficient of variation of true density was 5.14%. Kushwaha et al. [15] reported true density of okra as 1.2 g cm<sup>-3</sup> at 11.2% moisture content (d.b.). At 8.16% moisture content on dry basis, Sahoo and

121 Srivastava [16] reported  $1.10 \text{ g cm}^{-3}$  as true density of the okra seeds.

# 122 **3. Angle of repose**

123 The average angle of repose for okra seeds was found to be 28.65° which ranged from 27° to 30° with

124 coefficient of variation as 3.08%. Kushwaha et al. [15] reported angle of repose of okra seed as 28.70°

125 at the 11.2% moisture content (d.b.) whereas Sahoo and Srivastava [16] reported 27.60° as angle of

126 repose of okra seed at 8.16% moisture content (d.b.).

# 127 4. Length, width, thickness and geometrical mean diameter

128 The dimension of okra seed were taken with the help of a micrometer. The average values of length,

129 width and thickness of the seed were found to be 5.73 mm, 4.83 mm and 4.49 mm, respectively (Fig.

- 130 3). The average geometrical mean diameter of the seed was 4.98 varying between 4.84 to 5.09 with
- 131 coefficient of variation as 1.55% (Fig. 3). Sahoo and Srivastava [16] reported average geometrical

- mean diameter of the seed as 4.98 and the average length, breadth and thickness of the seed as 5.92
- 133 mm, 4.71 mm and 4.59 mm, respectively at the 8.16% moisture content (dry basis) of okra seed.
- 134 Kushwaha et al. [15] reported geometrical mean diameter of okra seed as 4.9 mm.





Fig. 3: Size variation of okra seeds

#### 137 **5. Shape of the okra seed**

Shape of seed is represented by its roundness and sphericity. The average value of roundness of the seed was 78.2% ranging from 68.4% to 89.5% with coefficient of variation as 9.03%. The mean sphericity of the seed was recorded as 87.9%, which ranged between 82.4% and 95.8% with coefficient of variation as 5.10%. Sahoo and Srivastava [16] reported the roundness of okra seed as 77.7% and sphericity of okra seed as 74.4% at 8.16% moisture content (d.b.) whereas Kushwaha et al. [15] reported roundness and sphericity as 79.3% and 86.4%, respectively.





145



# 146 **6. Porosity**

147 The mean value of porosity of okra seed was 49.1% varying between 43.9% and 55.0% with 148 coefficient of variation as 6.79%. Kushwaha et al. [15] found porosity of okra seed as 49.1%. Sahoo 149 and Srivastava [16] reported porosity of okra seed as 46.3%.

# 150 **7. Weight of 1000 seeds**

151 The average weight of 1000 okra seeds varied from 53.2 g to 57 g with an average value of 55.16 g.

152 The coefficient of variation of weight of 1000 seeds of okra seed was 2.86%. Sahoo and Srivastava

153 [16] reported weight of 1000 okra seeds as 65.78 g.

#### 154 Conclusion

The study of experiments conducted on okra seeds (*Varsha Uphar*) at 6.58% moisture content on drybasis revealed the following conclusions:

- The length, width, thickness and geometrical diameter of okra seed were 5.73 mm, 4.83 mm,
   4.49 mm and 4.98 mm, respectively.
- 159
  2. The bulk density and true density of okra seeds was 0.54 g cm<sup>-3</sup> and 1.07 g cm<sup>-3</sup>, respectively.
  160 The volume of the okra seed was found to be 108 mm<sup>-3</sup>. The average angle of repose of okra
  161 seeds was 28.65° varying between 27° to 30°.
- 162 3. The study also concluded that the roundness of the seed was 78.2% ranging from 68.4% to
  163 89.5% whereas the sphericity of the seed was 87.9% ranging from 82.4% to 95.8%.
- 164
  4. The porosity of okra seed was 49.1% varying between 43.9%-55.0%. The average weight of
  165
  1000 seeds varied between 53.2 g and 57 g with average a value of 55.16 g.

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