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A Study on Physical Properties of Okra Seed: *Abelmoschus esculentus* (L.)

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Physical properties of any seed are vital information for the development of its metering mechanism, 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 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^{-3} and 1.07 g cm^{-3}, respectively. The average volume of one okra seed was 108 mm^{-3}. The average angle of repose of okra seeds was 28.65°, which ranged from 27° to 30°. The study also inferred that the roundness of the seed was 78.2% ranging from 68.4% to 89.5% whereas the sphericity of the seed was 87.9% ranging from 82.4% to 95.8%. The porosity of bulk of okra seeds was 49.1%, which varied between 43.9% and 55.0%. The average weight of 1000 okra seeds varied between 53.2 g and 57 g with an average value of 55.16 g.

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

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1. INTRODUCTION

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

The physical properties of okra are the primary data set required for the development of its metering mechanism (a mechanism that delivers seeds or fertilizers from the hopper at selected rates). This data can also be used for designing of its handling, processing and storage structures. Separation of unwanted material from seeds is easy through oscillating chaffers when size, shape, and density of the seed are known [8]. The angle of repose affects the design of mass flow structures. In drying and aeration systems for seeds, bulk density and porosity play a significant role as these properties control the amount of hindrance caused by airflow [9]. This study was aimed to assess physical properties of okra seeds, which includes size, shape, bulk density, and true density, angle of repose, porosity, and weight of one thousand seeds.

2. MATERIALS AND METHODS

2.1 Sample Preparation

The variety of the okra seed was *Varsha Uphar,* and it was locally available. 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 the seed sample was determined by oven drying method. Three samples of seed taken in aluminum boxes were weighted and placed in hot air oven at 105°C [10]. The moisture content of the seeds was found to be 6.58% on dry basis.

2.2 Determination of Physical Properties

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

2.3 Size of Okra Seed

Seed size is the one of the primary property of seed that is of primary requirement for any seed handling system. The cell size of a metering system also depends on it. The seed size is specified by its length, width, and thickness. The measurements in these three dimensions were taken by using a micrometer having a least count of 0.1 mm. The dimension of 10 randomly selected seeds was measured.

2.4 Shape

The shape of seed is essential to design parameter of flow structures and metering mechanisms. The shape of the seed is expressed by its roundness and sphericity. The roundness of seed, R_p is calculated by the formula [11]:

$$R_p = \frac{A_p}{A_c} \times 100$$

where, R_p = Roundness, %
A_P = Projected area, mm^2
A_c = Area of the smallest circumscribing circle, mm^2

The projected area of the seed was measured using a testing setup which included a thirteen-megapixel camera, glass slab, camera stand and graph paper. Experimental setup used for this is depicted in Fig. 1.

Image of the seed is then processed with the help of computer and projection of seed on a graph was created (Fig. 2). Graph paper acts as reference scale in the image taken. The projected area was calculated by graphical method. The area of a smallest circumscribing circle was calculated by taking the largest axial dimension of the seed at natural rest position as the diameter of the circle. The procedure was repeated for 10 seeds selected randomly. The

mean was taken as the characteristic value of roundness.

The sphericity of seeds, φ is calculated by using the following relationship [11]:

$$\varphi\ (\%) = \frac{(LWT)^{\frac{1}{3}}}{L}\ x\ 100$$

where, L = Length of seed, mm
W = Width of seed, mm
T = Thickness of seed, mm

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

Length of seed, a = Longest intercept, mm
Width of seed, b = Longest intercept normal to a, mm
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.

2.5 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^{-3}. The box was filled with okra seeds without compaction and then its weight was measured. The bulk density was calculated as follows:

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

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

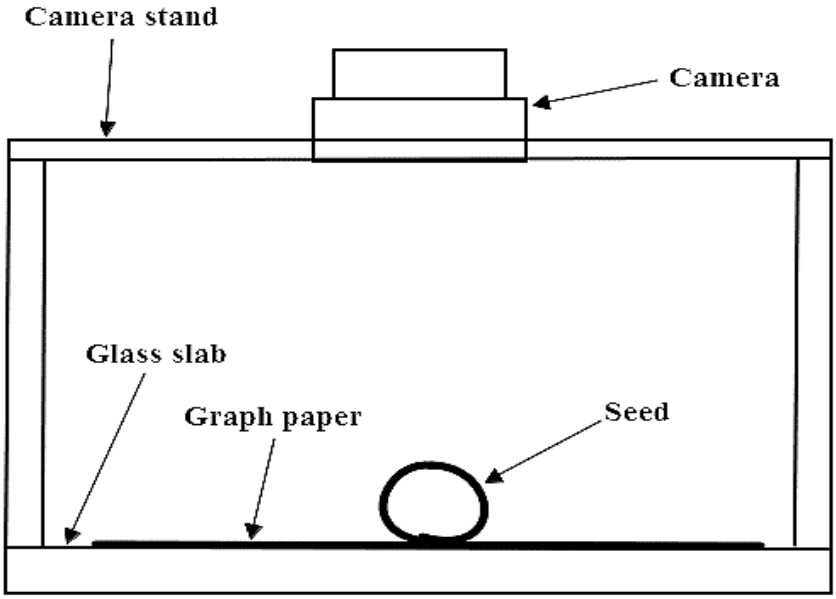

Fig. 1. Schematics of an experimental setup for finding projection of seed on graph paper

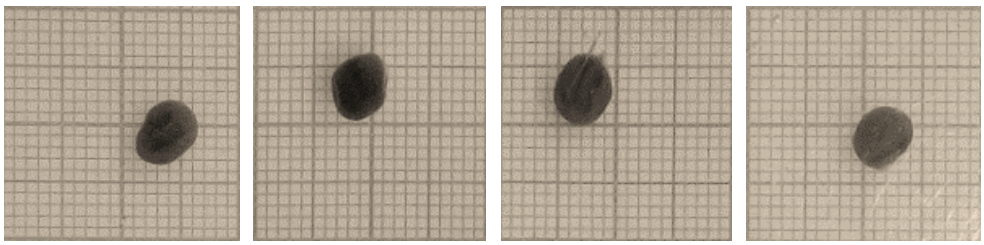

Fig. 2. Projection of okra seed on graph paper

2.6 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 is 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 a 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.

2.7 Angle of Repose

The angle of repose is the angle between the base and the slope of cone (Fig. 1) formed on a free vertical fall of the grain mass to a horizontal plane [13]. The slope of base of the seed flow structures is based on the average angle of repose of seeds to ensure free flow of seed [14]. Three readings were taken with the help of protractor and average was reported.

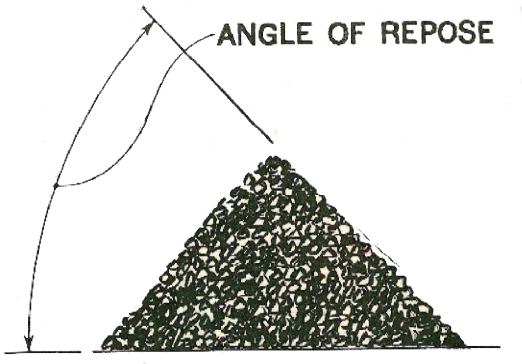

Fig. 3. Angle of repose

2.8 Porosity

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

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

Bulk density and true density values obtained from previous experiments were used to calculate the per cent porosity of the seed.

2.9 Weight of 1000 Seed

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

3. RESULTS AND DISCUSSION

Based on the experiments conducted in the laboratory for each mentioned property of okra seed, the results are as follows:

3.1 Bulk Density

Bulk density of okra seed varied between 0.51 gcm^{-3} and 0.57 g cm^{-3} at seed moisture content of 6.58% on dry basis. The average value of bulk density of the seed was 0.54 g cm^{-3}. The coefficient of variation of bulk density was 4.55%. Kushwaha et al. [15] reported bulk density of okra seeds as 0.58 g cm^{-3} at 11.2% moisture content (dry basis) of okra seed whereas Sahoo and Srivastava [16] reported it as 0.59 g cm^{-3} at 8.16% moisture content on dry basis.

3.2 Volume and True Density

The mean volume of okra seeds was 108 mm^{-3} and it varied in range from 99 mm^{-3} to 110 mm^{-3}. The mean true density of okra seed was 1.07 g cm^{-3} which ranged between 1 g cm^{-3} and 1.07 g cm^{-3}. The coefficient of variation of true density was 5.14%. Kushwaha et al. [15] reported true density of okra as 1.2 g cm^{-3} at 11.2% moisture content (d.b.). At 8.16% moisture content on dry basis, Sahoo and Srivastava [16] reported 1.10 g cm^{-3} as true density of the okra seeds.

3.3 Angle of Repose

The average angle of repose for okra seeds was found to be 28.65° which ranged from 27° to 30° with coefficient of variation as 3.08%. Kushwaha et al. [15] reported angle of repose of okra seed as 28.70° at the 11.2% moisture content (d.b.) whereas Sahoo and Srivastava [16] reported 27.60° as angle of repose of okra seed at 8.16% moisture content (d.b.).

3.4 Length, Width, Thickness and Geometrical Mean Diameter

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

length, width and thickness of the seed were found to be 5.73 mm, 4.83 mm and 4.49 mm, respectively (Fig. 4). The average geometrical mean diameter of the seed was 4.98 varying in range from 4.84 to 5.09 with 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 mm, 4.71 mm and 4.59 mm, respectively at the 8.16% moisture content (dry basis) of okra seed. Kushwaha et al. [15] reported geometrical mean diameter of okra seed as 4.9 mm.

3.5 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% (Fig. 5). 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

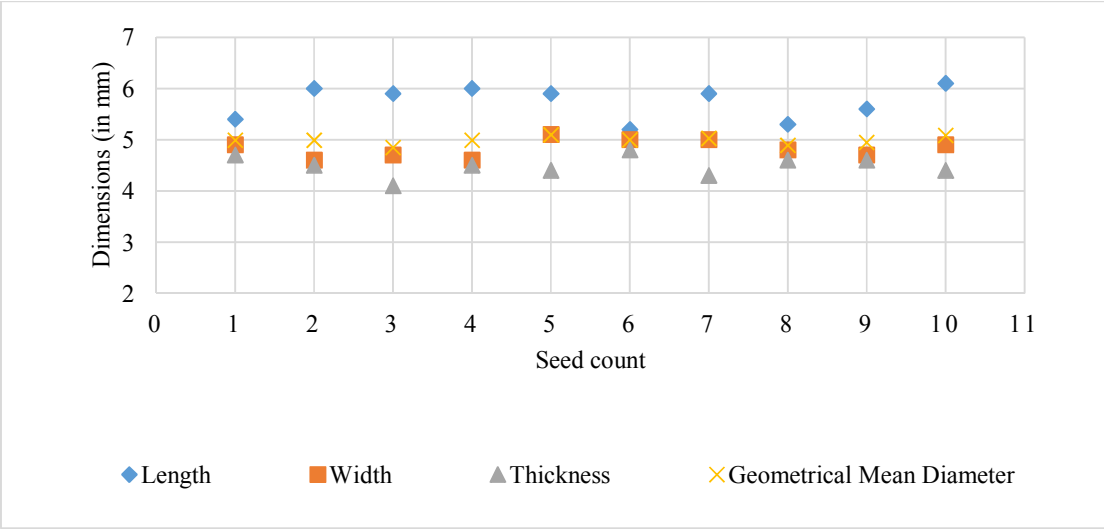

Fig. 4. Size variation of okra seeds

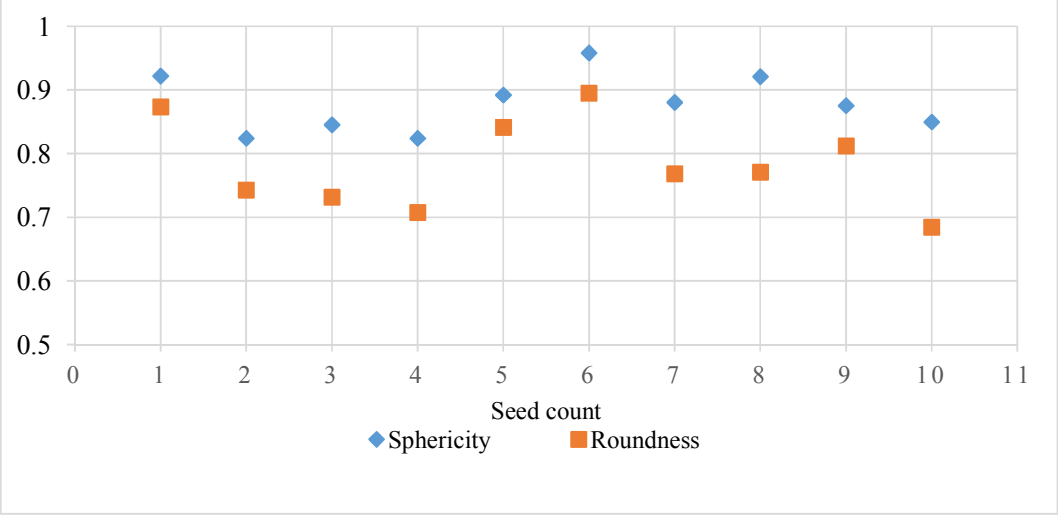

Fig. 5. Shape variation of okra seeds

roundness and sphericity as 79.3% and 86.4%, respectively.

3.6 Porosity

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

3.7 Weight of 1000 Seeds

The average weight of 1000 okra seeds varied from 53.2 g to 57 g with an average value of 55.16 g. The coefficient of variation of weight of 1000 seeds of okra seed was 2.86%. Sahoo and Srivastava [16] reported weight of 1000 okra seeds as 65.78 g.

4. CONCLUSION

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

1. 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.
2. The bulk density and true density of okra seeds was 0.54 g cm^{-3} and 1.07 g cm^{-3}, respectively. The volume of the okra seed was found to be 108 mm^{-3}. The average angle of repose of okra seeds was 28.65° varying between 27° to 30°.
3. The study also concluded that the roundness of the seed was 78.2% ranging from 68.4% to 89.5% whereas the sphericity of the seed was 87.9% ranging from 82.4% to 95.8%.
4. The porosity of okra seed was 49.1% varying between 43.9%-55.0%. The average weight of 1000 seeds varied between 53.2 g and 57 g with average a value of 55.16 g.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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