

# Physical and Mechanical Properties of Talaja Red Onion Cultivar

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## To cite this article:

Mukesh Dabhi, Nagin Patel. Physical and Mechanical Properties of Talaja Red Onion Cultivar. *Bioprocess Engineering*. Vol. 1, No. 4, 2017, pp. 110-114. doi: 10.11648/j.be.20170104.13

**Received:** April 8, 2017; **Accepted:** April 22, 2017; **Published:** August 21, 2017

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**Abstract:** The physical and mechanical properties of the onion crop were determined for the Talaja Red variety. The linear relationship was observed between polar diameter and equatorial diameter and also weight of the bulbs. The shape of the onion crop may be considered oval to spherical. The mean bulk density onion was observed 548 kg/m<sup>3</sup>. The coefficient of friction for galvanized iron, mild steel, aluminum and plywood was found 0.42, 0.39, 0.45 and 0.32 respectively. Also, the angle of repose for galvanized iron, mild steel, aluminum and plywood was found 23, 21, 24 and 17 respectively.

**Keywords:** Onion Bulbs, Physical, Mechanical, Properties, Coefficient of Friction

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## 1. Introduction

Onion (*Allium Cepa L.*) is the important vegetable crop, grown almost all over the country, which is seasonal in production, but required round the year. The onion export from India has increased drastically in last sixty years and gone up from 0.04 million tones in year 1953-54 to 1.55 million tones MT in year 2011-12, an increase by 38.97 times. The total value of the export has also gone up from Rs. 1.06 crores to Rs. 2141.43 crores in the same period, touching a peak export of 18,73,002 MT in 2009-10. Unit value of onion export is increasing drastically due to excess demand for Indian onion in the international markets. Onion has gained an important commercial position in the crop sector of India. The area of onion growing is increased from 0.83 million hectares to 1.08 million hectares during 2008-09 to 2011-12. In the year 2011-12, the production of onion in India was 17.51 million tones, of which 1.56 million tones were produced in Gujarat. Onions grown in India are very much in demand in gulf countries and Singapore, Malaysia, Sri Lanka and Bangladesh because of strong pungency. Each country has demand of different size of onion. To satisfy the countries, it is important to apply the proper post harvest technologies for onion. For onion bulbs, it has to be well sorted, graded

and packed. To achieve such operations, information about physical and mechanical properties is required.

The information about the physical properties of onion is very important to understand the behaviour of the onion during post harvest operations such as harvesting, transporting sorting, grading, packaging and storage. Many researchers were carried out research on the physical and engineering properties of onion, garlic and other many agricultural products. Bahnasawy et al (2004) and Rani (2006) studied the physical and mechanical properties of onion [7] [11]. They studied the equatorial and polar diameter as well as crushing load, penetration load, shear strength, coefficient of static friction etc for onion. Bahnasawy (2007) also studied some physical and mechanical properties of garlic [6]. He studied the linear dimensions, shape index and surface area, friction angle, coefficient of static friction, etc for garlic. Akbari (1997) studied the physical properties of Talaja white variety. He studied the linear dimensions, shape and bulk density [3].

Abdel-Ghaffar and Hindey (1984) tested four sizes (small, medium, large, and extra-large) of an Egyptian onion (Abo-Fatla variety) [2]. They found that the mean polar diameters

were 40.45, 47.00, 47.94, and 52.40 mm and the mean equatorial diameters were 39.07, 50.03, 56.00 and 60.40 mm for the same previous order. The mean mass, bulb density and bulk density were 177 g, 0.976 g/cm<sup>3</sup>, and 0.586 g/cm<sup>3</sup>, respectively.

## 2. Experimental Procedures

The most popular onion cultivar Talaja Red was brought from the Mahuva Market. The moisture content value was 85.23±0.48. The bulb was inspected and used to measure the linear dimensions, mass, bulb density, coefficient of friction and angle of repose.

### Apparatus and procedure

#### 2.1. Moisture Content

To determine the moisture content, the onion bulbs were cut in thin slice of 1-2 mm, weighed and oven dried to constant weight at 60±2°C [5].

#### 2.2. Linear Dimensions

There are two categories of onion bulb diameter; polar diameter and equatorial diameter. Polar diameter is the distance between the onion crown and the point of root attachment to the onion. Equatorial diameter is the maximum width of the onion in a plane perpendicular to the polar diameter. The equatorial diameter ( $D_e$ ), polar diameter ( $D_p$ ), and thickness ( $T$ ), of each 150 bulbs were measured with a caliper reading to 0.01 mm. The geometric mean diameter ( $D_{gm}$ ), and cross-sectional areas ( $A_{cs}$ ) of the bulbs were calculated using the following relationships given by [8], as follows:

$$\text{Geometric mean diameter (Dgm)} = (D_e D_p T)^{1/3}, \text{ cm} \quad (1)$$

$$\text{Arithmetic mean diameter (Dam)} = \frac{(D_e + D_p + T)}{3}, \text{ cm} \quad (2)$$

$$\text{Cross sectional area (Acs)} = \frac{\pi (D_e + D_p + T)^2}{4 \cdot 9}, \text{ cm}^2 \quad (3)$$

#### 2.3. Shape Index

Shape index is used to evaluate the shape of onion bulbs and it is calculated according to the following equation [1]:

$$\text{Shape index} = \frac{D_e}{\sqrt{D_p + T}} \quad (4)$$

The onion bulb is considered an oval if the shape index >1.5, on the other hand, it is considered spherical if the shape index <1.5.

#### 2.4. Individual Bulb Weight

A total of 150 bulbs were drawn randomly and their individual weight was measured by an electronic balance

having least count of 0.01 g.

#### 2.5. Size Distribution

Size distribution pattern of harvested onion bulbs selected for analysis was determined to decide the usual size of the bulbs. It was done on the basis of polar diameter and unit mass of the bulbs. The size distribution was classified in to three categories as small (<40 mm), medium (40 to 60 mm) and large (>60 mm) based on the polar diameter.

#### 2.6. Bulk Density

To determine the bulk density, onion bulbs were filled in a box of 5899 x 10<sup>-6</sup> m<sup>3</sup> volume without undue pressure and its weight was measured on an electronic balance having least count of 0.01g. The bulk density was calculated as weight of material per unit volume.

#### 2.7. Co-efficient of Friction and Angle of Repose

The coefficient of friction is the ratio of the force required to slide the bulb over a surface divided by the normal force pressing the bulb against the surface. The coefficient of friction was determined between onion bulbs and different surfaces such as Galvanized Iron sheet, Mild Steel sheet, Aluminium sheet and plywood. The material surface was fastened to tilting table. A frame made with square wooden bars was placed on the surface. The frame was filled with bulbs. The table was tilted slowly manually until movement of the whole bulb mass. The coefficient of friction was the tangent of the slope angle of the table measured with a protractor.

The angle of repose for Talaja Red onion bulbs was determined as per the procedure described by [8].

Statistical analysis was carried out according to [11]. Analysis of variance for the data of Tables 4 and 5 was applied followed by LSD (at 0.05) to carry out the multiple comparison. Mean, standard deviation (SD) and coefficient of variation (CV) for the data of tables, were calculated.

## 3. Results and Discussions

### 3.1. Physical Properties

#### 3.1.1. The Equatorial and Polar Diameters, and Shape Index

Table 1 shows the mean values, standard deviation and coefficient of variation of equatorial and polar diameters and shape index of onion bulbs. It shows that the mean equatorial and polar diameters were 55.80±10.49 and 44.72±7.40 mm, respectively. The coefficient of variation of the equatorial diameter value was higher than that of polar diameter. The mean of shape index was estimated 5.60±0.63 for the onion bulbs. According to [1] the onion bulb is considered an oval if the shape index > 1.5, on the other hand, it is considered spherical if the shape index < 1.5. Hence, the shape index of Talaja Red variety can be regarded as oval.

Table 1. The mean equatorial diameter, polar diameter and shape index.

Parameter	Equatorial diameter (mm)	Polar diameter (mm)	Shape index
Maximum	74.96	60.05	6.93
Minimum	36.67	29.32	4.43
Mean	55.80	44.72	5.60
SD	10.49	7.40	0.63
CV(%)	18.79	16.55	11.29

3.1.2. Geometrical Mean Diameter ( $D_{gm}$ ), Arithmetic Mean Diameter ( $D_{am}$ ), Cross Sectional Area ( $A_{cs}$ ) and Mass of Onion

The geometrical mean diameter, arithmetic mean diameter, cross sectional area and unit mass of onion was measured for 150 randomly selected onion bulbs. The geometrical mean diameter of onion bulbs was varied from 33.59 to 69.14 mm with a mean value of  $51.12 \pm 8.63$  mm and arithmetic mean

diameter was varied from 33.75 to 69.49 mm with a mean value of  $51.45 \pm 8.76$  mm. The value of cross sectional was varied from 894.16 to 3790.65 mm<sup>2</sup> with a mean value of  $2137.80 \pm 723.13$  mm<sup>2</sup>. The unit mass of onion bulb was ranged between 17 and 146 g. Table 2 shows the mean values, standard deviation and coefficient of variation of the  $D_{gm}$ ,  $D_{am}$ ,  $A_{cs}$  and mass of the onion.

Table 2. Geometrical mean diameter ( $D_{gm}$ ), arithmetic mean diameter ( $D_{am}$ ), cross sectional area ( $A_{cs}$ ) and mass of onion.

	$D_{gm}$ (mm)	$D_{am}$ (mm)	$A_{cs}$ (mm <sup>2</sup> )	Mass (g)
Maximum	69.14	69.49	3790.66	146.00
Minimum	33.59	33.75	894.16	17.00
Mean	51.12	51.45	2137.80	63.20
SD	8.63	8.76	723.13	33.38
CV(%)	16.88	17.03	33.83	52.81

The variation in weight of onion bulbs with respect to equatorial diameter and polar diameter is shown in Fig. 1 and 2 respectively.

The best-suited equation for variation in weight with equatorial diameter was observed as,  $Y = -7E-06X^5 + 0.002X^4 - 0.22X^3 + 11.814X^2 - 313.14X + 3285.5$  with the highest  $R^2$  value as 0.9529 suggesting the polynomial variation with order 5 in equatorial diameter with weight.

Similarly, the variation in weight with polar diameter was also found exponential with the best suited equation as  $Y = 4.2373e^{0.0573X}$  with the highest  $R^2$  value of 0.6276.

3.1.3. Size Distribution

It was found from the 150 samples that the equatorial diameter of onion bulb was varied from 36.67 to 74.96 mm while polar diameter from 29.32 to 60.05 mm. The best-suited equation for variation in equatorial diameter with polar diameter was observed as,  $Y = 2.4656X^{0.8192}$  with the highest  $R^2$  value as 0.5536 suggesting the power of 0.8192 variation in equatorial diameter with polar diameter (Fig. 3).

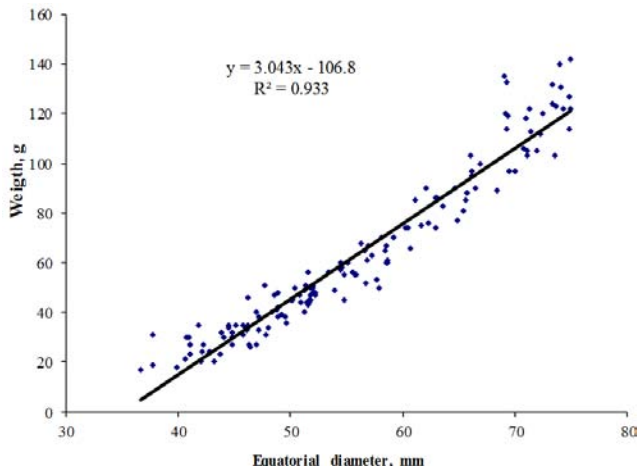


Figure 1. Variation of weight with equatorial diameter.

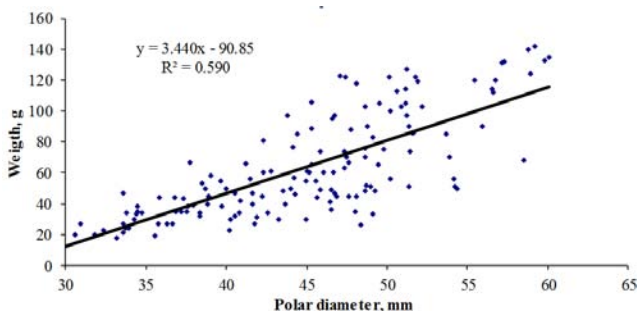


Figure 2. Variation of weight with polar diameter.

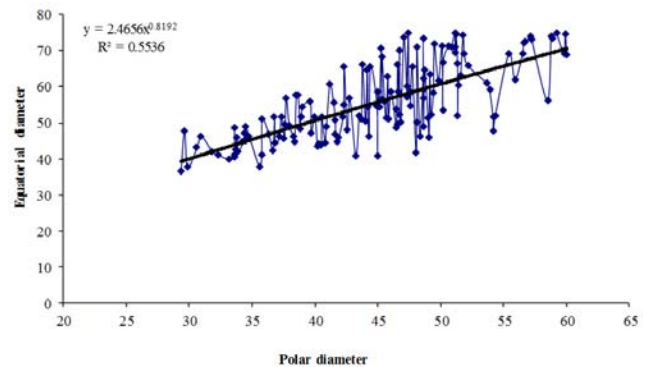


Figure 3. Sizing Map.

The variation of polar diameter suggesting three category of size as (i) below 40 mm (ii) 40 to 60 mm and (iii) above 60 mm. Moreover these categories of size were also found suitable for the commercial application [4].

### 3.1.4. Bulk Density

The bulk density of onion bulbs were measured as described in section 3.2.5 and data are reported in Table 3. The bulk density of the onion bulbs of different sizes, i.e., small, medium and large were determined for the Talaja red variety of onion having 85.23 per cent moisture content (w.b.). The results obtained are the mean values of four

replications. The Table 3 revealed that as the size of onion bulb increased, the bulk density decreased. This phenomenon was similar to that observed in different sizes of grains of the same variety. As the size of onion bulbs increased, its bulk porosity increased which ultimately resulted in reduction in bulk density. The mean value of bulk density for small (below 40 mm), medium (40-60 mm) and large (above 60 mm) size of onion was found to be 552, 548 and 545 kg/m<sup>3</sup>, respectively. Akbari (1997) reported 677 kg/m<sup>3</sup> bulk density for Talaja Local White variety of onion [3]. The variation might be due to difference in the variety of the onion.

**Table 3.** Mean value of bulk density for different of onion size.

Size of onion bulb, mm	Bulk density, kg/m <sup>3</sup>
Below 40 (small)	552
40-60 (medium)	548
Above 60 (Large)	545
Mean	548

### 3.2. Frictional Properties of Onion Bulbs

The coefficient of friction and angle of repose are the important parameters to measure the level of friction characteristics. Hence, these parameters were determined under gravity flow for different surfaces such as galvanized

iron, mild steel, aluminum and ply wood as described in 3.3.1. The coefficient of friction for galvanized iron, mild steel, aluminum and plywood was found 0.42, 0.39, 0.45 and 0.32 respectively. Also, the angle of repose for galvanized iron, mild steel, aluminum and plywood was found 23, 21, 24 and 17 respectively.

**Table 4.** Coefficient of friction under gravity flow for different surfaces.

Surface Tested	Coefficient of friction	Angle of repose (degree)
GI Sheet	0.42	23
MS Sheet	0.39	21
Aluminum Sheet	0.45	24
Plywood	0.32	17

## 4. Conclusion

This work focuses on some physical and mechanical properties of Talaja Red cultivar of the onion bulbs. The physical properties were equatorial and polar diameters, shape index, mass, bulk density. The mechanical properties were the angle of repose and coefficient of friction.

The equatorial and polar diameters ranged from 36.67 to 74.96 and 29.32 to 60.05 with CV 18.79% and 16.55% respectively.

The Talaja Red onion bulbs are oval in shape.

The geometric mean diameter ( $D_{gm}$ ) ranged from 33.59 to 69.14 mm, the arithmetic mean diameter ( $D_{am}$ ) ranged from 33.75 to 69.49 mm, and the cross-sectional of area ( $A_{cs}$ ) ranged from 894.16 to 3790.66 mm<sup>2</sup> and mass ranged from 17 to 146 g.

The bulk density ranged from 545 to 552 kg/m<sup>3</sup>.

The coefficient of friction ranged from 0.32 to 0.45 with highest value for Aluminum sheet.

The angle of repose ranged from 17 to 24 degree with highest value for Aluminum sheet.

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