ISSN: 2347-4688, Vol. 5, No.(3) 2017, Pg. 381- 386

Current Agriculture Research Journal

www.agriculturejournal.org

A Study on Physico-Mechanical Properties of Onion Varieties Under Koppal District, (Karnataka)

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Abstract

The physico-mechanical properties of four popular cultivable onion varieties i.e., Ballari red, Arka kalyan, Satara (local verity), Kalasa (local variety) in Koppal (Karnataka)were studied to form an important database for designing of storage structures, cleaning, grading, sorting and harvesting equipments. The equatorial diameter of all size category Ballari red onion variety ranged from 4.01 to 8.35 cm, polar diameter ranged from3.82 to 6.62 cm and thickness of Ballari red onion variety ranged from 1.25 to 2.51 cm where as the lowest values of equatorial diameter was observed in Kalasa (local variety) i.e., 3.2 to 7.12 cm, polar diameter ranged from 2.89 to 5.12 cm and thickness from 1.22 to 2.01 cm, respectively. Shape index of three out of four was oval in shape. The geometric mean diameter (Dgm) and arthematic mean diameter (Dam) of large, medium and small size verities as Ballari red, Arka kalyan, Satara, Kalasa had 2.65 to 5.09, 2.5 to 4.58, 2.35 to 4.43 and 2.23 to 4.13 cm, respectively. The highest mean value of bulk density from 678.9 to 390.42 kg/cm^3 was observed in Ballari red onion followed by Arka kalyan of 662.7to 390.42 kg/cm^3, Satara 628.4 to 390.23 kg/cm^3, Kalasa 618.59 to 385.24 kg/cm^{3}and highest mean value of angle of repose which was observed in Ballari red i.e, 37^o (large size) and lowest was observed 20.90^o in Kalasa (small size) variety.

Article History

Received: 19 July 2017
Accepted: 23 November 2017

Keywords:

Angle of repose, Arithmetic Mean Diameter (Dam), Crushing load, Geometric Mean Diameter (Dgm), Mechanical properties, Moisture content, Physical properties.

Introduction

India place world's second most largest producer of onion (*Alliumcepa*L.) and China being at top followed by USA, Turkey, Pakistan, Iran, Indonesia, Vietnam and Myanmar. India produces about 13 per cent of total world's onion product and ranked second after

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To Link to this Article: http://dx.doi.org/10.12944/CARJ.5.3.18

China. In India 1.0 million hectare (mha), onion is grown with the production of 15.1 million tones (mt) and productivity of 14.2 t/ha[1].The overall onion export from India was 203 lakh tones (lt) in the year 2015-16. In India vegetable production occupies 10.5 percent and Maharashtra (28.9 %) placed highest in production[2]. In Karnataka the total onion cultivation area is 1.90 lakh hectares (lha) with a production of 2.5 mt and productivity of 13.6 t/ha[2]. In Koppal, agriculture is the main resource and it plays important role in the economic development of the district and has an area 14,329 ha with of onion production 49,529 mt (Anonymous, 2016) and has 24 percent share of agriculture in GDDP (Gross District Domestic Product). The knowledge of physico-mechanical properties of onion are required for (a) cleaning, grading and sorting machines design (b) prediction of total surface chemical applied (c) during thermal processes to depict heat and mass transfer (d) during handling process to quantify damage caused due to bruise and abrasion.

Studies on physico-engineering properties of most agricultural products were carried out for the designing of grading and pulpers[3,4,5,6]. So, the knowledge on density, size and crushing strength are necessary[7] and for designing of handling system and grading equipment the physico-mechanical properties are also required[8]. In milling process of rice grains the shape index and coeffcient of contact surface had significant effect on the percentage broken and rupture force[3].

The physico-mechanical properties of three onion varieties viz., Agri found Dark Red, Pusa Red and NP-53 were studied. Pusa Red verities were larger in size when compared with the other two varieties[9]. In all three varieties the cutting force was increased with neck diameter. The mean length was varied from 30.85 to 36.68 mm and the number of leaves ranged from 8 to 10 for all three varieties of the onion crop, respectively. The pusa red variety was denser (270kg/m^3) when compared with other two varieties. The mean values of co-efficient of static friction were found 0.43, 0.41 and 0.41, respectively for all the three onion varieties and it had inverse relationship with equatorial diameter.

Roundness and sphericity were important parameters that determine the geometric shape of agriculture products[10]. The current study focus on to determine the physico-mechanical properties viz moisture content, geometric mean diameter, arithmetic mean diameter, volume, mass, density, angle of repose and crushing load which form an important database for four popular grown onion varieties viz Ballari red, Arka kalyan, Satara (local variety), Kalasa (local variety). This information is required to analyze the behavior of the product during the post harvest operations such as cleaning, curing, transportation, sorting, grading, packaging, storage and designing of harvesting equipments. This data is also helpful in food processing operations.

Materials and Methods

Most commonly cultivable onion varieties at Koppal district (Karnataka) were surveyed and brought from the local market and categorized into small (< 4cm), medium (4 to 7 cm) and large (> 7cm) size, respectively. The physico-mechanical properties of onion were measured.

Linear Dimensions

Equatorial Diameter (De)

Equatorial diameter is the maximum width of the onion in a plane perpendicular to the polar diameter. The equatorial diameter was measured by digital vernier calipers of 0.01 mm least count[11].

Polar Diameter (Dp)

Polar diameter is the distance between the onion crown and the point of root attachment to the onion. The polar diameter was measured by digital vernier calipers of 0.01 mm least count[11].

Thickness (T)

It was measured as the dimension between equatorial and polar diameter surfaces of onion bulbs which was smaller than other two dimensions.

Shape Index

The shape index of the onion bulb is the ratio of the equatorial diameter and square root of the product of polar diameter and thickness of onion bulbs. Shape index was used to assess the shape of onion bulbs[11]. If the shape index >1.5 then it was considered as oval and if the shape index <1.5 then it was considered as spherical.

$$Shape\ index = \frac{D_e}{\sqrt{D_p * T}} \quad ...(1)$$

Geometric Mean Diameter (Dgm)

It was calculated from a number of linear dimensions viz., polar diameter (Dp), equatorial diameter (De), and thickness (T) of the sample. It is the cube root of the product of linear dimensions Dp, De and T.

$$D_{gm} = (D_e * D_p * T)^{0.333} \quad ...(2)$$

Where,

D_{gm}- Geometrical mean diameter, cm
De - Equatorial diameter of onion, cm
Dp - Polar diameter of onion, cm
T - Thickness of onion, cm

Arithmetic Mean Diameter (Dam)

It is the sum three linear dimensions namely equatorial diameter, polar diameter and thickness of the sample divided by the total number of linear dimensions. The linear dimensions were measured using digital vernier calipers of 0.01mm least count[11].

$$D_{am} = \frac{D_e * D_p * T}{3} \quad ...(3)$$

Where,

D_{am}-Arithmetic mean diameter, cm
De – Equatorial diameter of onion, cm
Dp- Polar diameter of onion, cm
T - Thickness of onion, cm

Physico-Mechanical Properties

The Physico-mechanical properties are important during the handling of material for filling in bags, storage and designing of harvesting equipments.

Moisture Content (MC)

Moisture content is the basic parameter for all the properties studied of onion bulb. The fresh onions skins were removed manually. Which were sliced into 1 mm thick and placed on perforated metal trays and dried at 55 °C in hot air oven till a constant weight[12]. The observations were recorded and it was calculated by the following equation[13].

$$M_{wb} = \frac{W_1 - W_2}{W_1} X\ 100 \quad ...(4)$$

Where,

M_{wb}-Moisture content, per cent wet basis
W_1- Initial weight of the sample, g
W_2- Final weight of the sample, g

Bulk Density (BD)

It indicates the weight of the sample per unit volume and variation of densities tends to cause the undesirable stratification as bags or bins are filled. The porous nature of some agricultural materials presents a number of problems in volume and density measurement[14]. It was determined by filling onion bulbs of known volume of steel container and it was weighed. The ratio between the mass and volume (10 x 10 x 10 cm) was calculated as bulk density. The average value of bulk density was reported by repeating the experiments in thrice.

Bulk density (kg/m^3) = Weight of onion in Kg / Volume of container, $m^3 \times 100$ ...(5)

Angle of Repose

It was calculated by placing the samples at the center of the horizontal platform. The platform was inclined by rotating the handle at minimum speed, until the samples begins to roll. At this point, angle of inclination of the platform was recorded. For next sample, the platform was placed into the initial horizontal position. Experiment was repeated in thrice[11].

Crushing Load (CL)

It implies onion sample partial or complete destruction. The sample was placed on a horizontal plate then crosshead of apparatus was brought into contact with the sample then a compression force was applied by adding weights or loads until permanent destruction was found and loads were recorded[11].

Results and Discussions

Leaner Dimensions

The Equatorial & Polar Diameters

The average value of equatorial diameter of bigger size verities was 8.35 cm (Ballari red), 7.53 cm (Arka kalyan), 7.35 cm (Satara) and 7.12 cm (Kalasa) where as polar diameter 6.62 cm (Ballari red), 5.75 cm (Arka kalyan), 5.42 cm (Satara) and 5.12 cm (Kalasa), respectively. In medium size category, the equatorial diameter was observed as 6.85 cm (Ballari red), 6.52 cm (Arka kalyan), 6.24 cm (Satara) and 5.89 cm (Kalasa), where as polar diameter 5.71 cm (Ballari red), 5.01 cm (Arka

Table 1: The average values of linear dimension of different size onion varieties

	Large size						Medium size						Small size					
Parameters Verities	**De (cm)**	**Dp (cm)**	**T (cm)**	**Shape index**	**Dgm (cm)**	**Dam (cm)**	**De (cm)**	**Dp (cm)**	**T (cm)**	**Shape index**	**Dgm (cm)**	**Dam (cm)**	**De (cm)**	**Dp (cm)**	**T (cm)**	**Shape index**	**Dgm (cm)**	**Dam (cm)**
Ballari Red	8.35	6.62	2.51	2.04	5.09	5.83	6.85	5.71	1.95	2.07	4.18	4.84	4.01	3.82	1.25	1.84	2.65	3.03
Arka Kalyan	7.53	5.75	2.32	2.06	4.58	5.2	6.52	5.01	1.82	2.16	3.85	4.45	3.98	3.21	1.26	1.98	2.5	2.82
Satara	7.53	5.42	2.29	2.08	4.43	5.02	6.24	5.02	1.75	2.1	3.75	4.34	3.52	3.11	1.21	1.82	2.35	2.61
Kalasa	7.12	5.12	2.01	2.22	4.13	4.75	5.89	4.89	1.86	1.95	3.72	4.21	3.21	2.89	1.22	1.71	2.23	2.44
SE±m	0.001	0.003	0.002	0.001	0.001	0.004	0.012	0.006	0.001	0.001	0.024	0.004	0.012	0.006	0.001	0.006	0.001	0.001
CD (P=0.05)	0.028	0.106	0.092	0.04	0.03	0.119	0.207	0.152	0.058	0.052	0.292	0.119	0.206	0.149	0.024	0.143	0.053	0.045
CV	0.194	0.983	2.104	1.011	0.347	1.213	1.715	0.516	1.644	1.308	4.044	1.417	2.098	2.432	1.035	4.158	1.138	0.863

Table 2: The average values of physical properties of different size onion varieties

	Large size				Medium size				Small size			
Parameters Verities	**MC (%)**	**Angle of Repose(°)**	**BD (Kg**	**CL (N) /m³)**	**MC (%)**	**Angle of Repose(°)**	**BD (Kg/ m³)**	**CL (N)**	**MC (%)**	**Angle of Repose(°) m³)**	**BD (Kg/**	**CL (N)**
Ballari Red	85.25	37.5	678.9	842.52	81.72	32.7	555.82	592.12	82.11	25.5	391.42	425.7
Arka Kalyan	85.12	34.39	662.7	832.4	80.16	30.1	545.86	582.4	81.07	22.75	390.42	415.6
Satara	85.14	32.1	628.4	821.32	80.26	29.5	547.82	582.5	80.14	21.6	390.23	405.12
Kalasa	82.12	31.7	618.59	819.7	80.12	28.6	532.12	576.74	80.01	20.9	385.24	398.4
SE±m	0.101	3.75	4.052	2.188	0.003	2.917	0.724	0.581	0.028	1.833	2.81	0.591
CD (P= 0.05)	0.598	3.646	3.79	2.785	0.099	3.216	1.602	1.435	0.317	2.549	3.156	3.085
CV	0.376	5.559	0.311	0.178	0.065	5.806	0.156	0.13	0.208	6.422	0.43	0.398

CV is the coefficient of variation (%).

kalyan) 5.02 cm (Satara) and 4.89 cm (Kalasa), diameter was higher in Ballari red variety in all respectively. In case of small size category similar the three sizes when compared to other varieties trend was observed. The mean value of equatorial (Table 1).

Thickness

The lowest mean value of thickness was observed in Kalasa (local variety) of small size category 1.22 cm where as the highest was observed in Ballari red of large size category 2.51cm.

Shape Index

From the table 1, it was observed that the shape index values were >1.5 cm for all four varieties of three size category onions. All four varieties were regarded as oval shape[11]. The highest mean value of shape index was observed in Kalasa of large size category 2.22 cm followed by Satara 2.13 cm, Arka kalyan 2.06 cm, Ballari red 2.04 cm where as lowest was observed 1.71 cm in Kalasa (local variety) of small size category followed by 1.82 cm (Satara), 1.84 cm (Ballari red), 1.98 cm Arka kalyan, respectively.

Geometric Mean Diameter (Dgm) and Arithmetic Mean Diameter (Dam),

The Dgm and Dam mean values pertaining to all three size category range from 2.65 to 5.09 cm (Ballari red), 2.5 to 4.58 cm (Arka kalyan), 2.35 to 4.43 cm (Satara) and 2.23 to 4.13 cm (Kalasa), respectively (Table 1).

Physico-Mechanical Properties

Moisture Content and Angle of Repose

The angle of repose was affected by the moisture content. As the value of moisture content increases the value of angle of repose will also increases[14]. The same trend was observed in all the four varieties of all three size categories, the highest mean value of moisture content 85.25 % and angle of repose 37.5° observed in Ballari red of big size category where as lowest mean value of moisture content 80.01 % and angle of repose 20.90° was observed in Kalasa of small size variety followed by Satara (80.14 % & 21.60°), Arka kalyan (81.07 % & 22.75°) and Ballari red (82.11 % & 25.50°). In medium size category, the highest mean value of moisture content was recorded in Ballari red 81.72 % and lowest was in Kalasa 80.12 % whereas the similar trend was observed in case of angle of repose

Bulk Density

For designing of silos, cleaning equipments and storage bins the values of bulk density are required[14]. The highest mean value of bulk density was observed in Ballari red variety 678.90 kg/cm^3 (big size), 555.82 kg/cm^3 (medium size), 391.42 kg/cm^3 (small size), and lowest value where observed in Kalasa local variety 618.59 kg/cm^3 (big size), 532.12 kg/cm^3 (medium size), 385.24 kg/cm^3 (small size).

Crushing Load

As onion bulb size of four varieties of all three size categories increased the crushing load also increased. Ballari red onion of all three size category, the average crushing load was between 425.70 to 842.52 N, 415.60 to 832.40 N for Arka kalyan 405.12 to 821.32 N for Satara and for Kalasa ranged 398.40 to 819.70 N. These results were similar to the Egyptian onion cultivars[11].

Conclusion

Physical and mechanical properties of four commonly grown onions in Koppal district, Karnataka were studied and the following conclusions were made:

- The equatorial diameter of all size Ballari red onion variety ranged from 4.01 to 8.35 cm ,polar diameter ranged from 3.82 to 6.62 cm and thickness ranged from 1.25 to 2.51 cm where as the lowest values of equatorial diameter was observed in Kalasa (local variety) i.e., 3.2 to 7.12 cm, polar diameter ranged from 2.89 to 5.12 cm and thickness from 1.22 to 2.01 cm, respectively.
- Onions of different size were observed in oval shape.
- Dgm and Dam of all three size category range from 2.65 to 5.09 cm (Ballari red), 2.5 to 4.58 cm (Araka kalyan), 2.35 to 4.43 cm (Satara) and 2.23 to 4.13 cm (Kalasa), respectively.
- The highest mean value of bulk density from 390.42to 678.9 kg/cm3 was observed in Ballari red onion followed by Arka kalyan 390.42 to 662.7 kg/cm3, Satara 390.23to 628.4 kg/cm3, Kalasa 385.24 to 618.59 kg/cm3 and highest mean value of angle of repose which was observed in Ballari red i.e, 37o (large size) and lowest was observed 20.90o in Kalasa (small size) variety.
- Onion bulb size is directly proportional to crushing load. The highest crushing load ranged from 425.70 to 842.52 N in Ballari red onions and lowest was 398.40 to 819.70 N for Kalasa variety.

On the basis of current study on onion varieties, it has been observed that the different size of Ballari red onion variety is superior to all other varieties, followed by Arka kalyan, Satara and Kalasa. Therefore, it will be easy to develop cleaning, sorting, grading, packaging, harvesting equipments and this data is helpful in processing operations.

Acknowledgement

All the authors are grateful to the University of Horticulture Sciences, Bagalkot, Karnataka for providing basic infrastructure and financial support to carry out the present research work.

References

1. Sunitha, B., Sujatha, G., Girish, B., Kiran, B. Raj and Ramana, M.V. Determination of Physical Properties of Onions (*Arkakirthiman). Internat. J. Proc. And Post Harvest Technol.,* ***7***(1): 36-41,(2016).
2. Kaveri, G. and Thirupathi, V., Studies on Geometrical and Physical Properties of Co 4 onion bulb. *International Journal of Recent Scientific Research;* ***6***(3): 2897-2902, (2015).
3. Abd Alla, H. S., Radwan, S. M. and El-Hanfy, E. H. Effect of Some Physical Properties of Rice Grains on Milling Quality. *Misr J. Agr. Eng;* ***12***(1): 143–155, (1995).
4. Kukelko, D. A., Jayas, D. S., White, N. D. G. and Britton, M. G. Physical Properties of Canola (Rapeseed) Meal. *Can. Agric. Eng. J;* ***30***(1):61–64, (1988).
5. Mohsenin, N. N. Physical Properties of Plant and Animal Materials. New York: Gordon and Breach; 51–87, (1970).
6. Muir, W. E. and Sinha, R. N. Physical Properties of Cereal and Oilseed Cultivars Grown in Western Canada. *Can. Agric. Eng. J;* ***30***(1): 51–55, (1988).
7. Gosh, B. N. Physical properties of the different grades of Arabica Beans. Trans. ASAE, 9(3):592–593, (1969).
8. Chandrasekar, V and Viswanathan, R. Physical and Thermal Properties of Coffee. *J. Agric. Eng. Res;* ***73***: 227–234, (1999).
9. Vijaya Rani, Sharma, T.R. Singh, and Narendra. Testing and Evaluation of Vegetable Seed Extractor forBrinjal (*Solanum melongena*). *Horticultural Science Haryana Agricultural University J. Res;* ***30***(2): 19-24, (2002).
10. Waziri, A.N. and Mittal, J.P. Design Related Physical Properties of Selected Agriculture Products. *Agric. Mechanization in Asia, Africa and Latin America;* ***14***(1): 59-62, (1983).
11. Bahnasway A.H, El-Haddad Z.A, El-Ansary MY and Sorour HM. Physical and Mechanical Properties of Some Egyptian Onion Cultivars. *Journal of Food Engineering;* ***62***: 255–261, (2004).
12. Abhayawick, L. Laguerre J.C, Tauzin, V and Duquenoy, A. Physical properties of three onion varieties as affected by the moisture content. *Journal of Food Engineering;* ***55:*** 253–262, (2002).
13. AOAC. Fruits and fruit products. In: *Official Methods of Analysis of the Association of Official Analytical Chemists.* Vol. II. Arlington, Virginia (USA) ; 910-928, (1990)
14. Sahay K.M and Singh. K.K. 1994. Unit Operation of Agricultural Processing. Vikas Publishing House PVT Limited. Noida, Uttarpradesh, India. Pp.374.
15. http://nhm.nic.in/Archive/Onion.pdf