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A study on physical properties of pomegranate (*Punica granatum* L., Punicaceae) fruits

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Abstract
Fresh pomegranate fruits (cv. *Bhagva*) were procured from the Horticultural farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The physical properties such as weight, volume, true density, bulk density, moisture content, sphericity of pomegranate fruits were measured. These data are required in research and development of various equipment. The physical properties of pomegranate fruit such as length, width, thickness, size and sphericity ranged from 69.70 to 90.86, 65.11 to 82.87, 63.02 to 83.17, 66.82 to 83.74 and 83.56 to 97.26 %. The weight, volume, true density and bulk density of pomegranate fruits ranged from 149.502 to 252.530 g, 150.156 to 254.450 cc, 0.916 to 1.058 and 0.621 to 0.693g/cc, whereas, the average values are 193.515±30.977 g, 192.890±30.054cc, 1.003±0.038 and 0.654±0.028 g/cc respectively. The true density of pomegranate aril was found to be 1046.030 kg/m^3. The aril and peel moisture content of fresh pomegranate fruit ranged from 79.75 to 82.90 % and 69.90 to 72.56 %, whereas, the average values of moisture content of aril and peel were 81.38±0.1.16 and71.47±0.83 respectively. Peel thickness ranged from 4.61 to 7.59 mm whereas its mean value was 5.85 mm ±0.87 on opposite sides of peel pieces of selected fruits. The aril, juice and peel content of pomegranate fruits on whole fruit weight basis ranged from 51.51 to 55.66 %, 44.69 to 48.51 % and 37.25 to 40.21 %, whereas, the average values of aril, juice and peel contents are 53.87±1.24, 46.06±1.19 and 38.92±0.97 %, respectively.

Keywords: pomegranate, weight, volume, true density, bulk density, moisture content, sphericity, Peel thickness

Introduction
Pomegranate (*Punica granatum* L., Punicaceae) is an ancient, beloved plant and fruit. The pomegranate and its usage are deeply embedded in human history and utilization is found in many ancient human cultures as food and as a medical remedy. Despite this fact, pomegranate culture has always been restricted and generally considered as a minor crop. Recent scientific findings corroborate traditional usage of the pomegranate as a medical remedy and indicate that pomegranate tissues of the fruit, flowers, bark, and leaves contain bioactive phytochemicals that are antimicrobial, reduce blood pressure, and act against serious diseases such as diabetes and cancer. These findings have led to a higher awareness of public to the benefits of the pomegranate fruit, particularly in the western world and consequently to a prominent increase in the consumption of its fruit and juice. The development of industrial methods to separate the arils from the fruit and improvement of growing techniques resulted in an impressive enlargement of the extent of pomegranate orchards and value addition of pomegranate. At the global level, India is the world's largest producer of pomegranates, followed by Iran (Varmudy, 2011) [1]. In India, Maharashtra is the leading producer of pomegranates followed by Karnataka, Andhra Pradesh, Gujarat and Tamil Nadu. To a smaller extent; it is also grown in Rajasthan and Himachal Pradesh (Horticulture at a glance, 2017) [2]. *Ganesh, Mridula, Ruby, Arakta and Bhagwa* are some of the important varieties of pomegranate grown in India. Due to its high nutritive value, therapeutic properties, antioxidant capacity, potentially bioactive compounds and consumer appeal, pomegranate is considered as a 'Super fruit' and a food medicine. As per the demand of processed products of pomegranate, the standardization of process technology of pomegranate juice extraction is highly required to produce qualitative products. This need is feasible to be fulfilled with the knowledge of the physical properties of pomegranate fruits. Therefore, the present study was carried out to study the physical properties of pomegranate fruits.

Materials and Method

Selection and procurement of pomegranate fruits

This research work was conducted in the Department of Post-Harvest Technology, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, District Mehsana, during the year 2016-17. The required quantity of fully matured and ripen fresh pomegranate fruits (cv. *Bhagva*) was procured from the Horticultural farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during the month of July, 2016. Twenty trees were randomly selected and twenty fruits were randomly procured from selected trees. After discarding the immature, sunburned, cracked, infected and bruised fruits, 50 kg of fresh and fully ripen pomegranates were collected.

Measurement of physical properties of pomegranate fruits shape and size

The principal dimensions of pomegranate fruits in terms of length, breadth and thickness were measured using a vernier caliper (Mitutoyo, Japan; Least count: 0.1 mm). The triaxial dimensions of 50 fruits randomly selected from the bulk of pomegranate fruits were measured. The average value of 50 observations was reported. The method of measuring the size and sphericity of fruit was used as formula shown below (Mohsenin, 1986) [3].

$$\text{Size (Geometric Mean Diameter)} = (abc)^{1/3} \ldots \quad (1)$$

$$\text{Sphericity} = (abc)^{1/3} \div a$$

Where,
a = length of pomegranate fruit, cm
b = breadth of pomegranate fruit, cm
c = thickness of pomegranate fruit, cm

Weight, volume, true density and bulk density

Weight of individual selected fruits was determined using a standard laboratory electronic balance (SCALE-TEC, Model: SAB303, Range: 0.01 – 500 g) with a sensitivity of 0.01 g. The volume of fruit was determined by the simple technique of toluene displacement. (Mohsenin, 1986) [3]. the sample was first weighed on the scale in air and then dipped into toluene by means of a sinker rod. The second reading of the scale with the sample submerged minus the weight of the container and toluene is the weight of displaced toluene which was used in the following expression to calculate the volume:

$$True\ Volume\ of\ sample\ (m^3) = \frac{Weight\ of\ displaced\ toluene\ (kg)}{Weight\ density\ of\ toluene\ (kg/m^3)} \ldots\ldots \quad (2)$$

Knowing the weight in air and the volume, the true density of the sample is then obtained by the ratio of weight to volume.

$$True\ density\ (kg/m^3) = (Weight\ (kg))/(Volume\ (m\text{^}3) \ldots \quad (3)$$

The volume of ten selected pomegranate fruits was measured by toluene displacement method (Mohsenin, 1986) [3]. The mean values of weight and volume were used to calculate the true density of pomegranate fruits.

For Bulk density measurement a perfect rectangular wooden box was taken and its volume was determined by multiplying length with width and height (l x b x h) and then the box was completely filled with sample. The weight of the sample required to fill the box was recorded and the bulk density was determined using the following relationship:

$$Bulk\ Density\ (kg/m^3) = \frac{Weight\ of\ sample\ in\ container\ (kg)}{Volume\ of\ wooden\ box\ (m^3)} \ldots\ldots \quad (4)$$

Moisture content of aril and peel

5-150 °C, Res.- 0.1 °C, Accuracy ± 1 °C) as described by Ranganna (1999) [4]. The arils and peels of freshly harvested pomegranate were kept in a single layer in the *petri* dishes and then the dishes were placed inside a hot air oven at 70 ± 1 ºC for 18 hr or till the samples attained the constant weight. The samples were cooled in desiccators and weighed. The difference in initial and final weights of the samples was taken as the water removal. The moisture content of pomegranate arils and peels was calculated by dividing the weight of water removed by the total weight of the sample and expressed in per cent wet basis as.

$$Mwb = (Wi - Wf)/(Wi\ )\ x\ 100 \ldots \quad (5)$$

Where,
Wi = initial weight of sample, g
Wf = final weight of sample, g

Determination of percentage of aril, juice and peel

Aril, Juice and Peel percentage with respect to whole fruit weight was measured separately for ten fruits as per method utilized by Sadeghi (2010) [5]. Juice was extracted by juice extractor (Maharaja White line-Smart chef FP-100) and it was filtered through muslin cloth. Peel thickness was measured by taking sample peel from opposite side of ten selected fruits using a vernier caliper (Mitutoyo, Japan; Least count: 0.1 mm).

$$Juice\ yield\ (\%) = \frac{Weight\ of\ juice}{Weight\ of\ fruit} X\ 100 \ldots \quad (6)$$

$$Pomace\ (\%) = \frac{Weight\ of\ pomace}{Weight\ of\ fruit}\ X\ 100 \ldots \quad (7)$$

After the extraction of the juice the pomace consisting of seed and rag (non edible portion) was weighed and expressed on percentage basis.

Results and Discussion

Physicochemical properties of pomegranate fruits

Measurement of shape and size of pomegranate fruits

The results revealed that the length, width and thickness range from 69.7 to 90.86, 65.11 to 82.87 and 63.02 to 83.17 mm respectively. The average value of length, width and thickness were found to be 82.29 ±4.46, 72.72 ± 4.13 and 73.38 ± 4.59 mm respectively. Similar results for length, width and thickness of pomegranate fruits has also been reported by Riyahi *et al.* (2011) [6]. The average values of size and sphericity were also found as 75.97 ± 3.81mm and 0.925 ± 0.03 respectively.

Measurement of weight, volume and density of pomegranate fruits

Weight and volume of ten (10) pomegranate fruits (*Punica granatum* L.) cv. *Bhagva* were measured as per the method described above. The results of weight, volume and true density of pomegranate fruits are presented in Table 1, true density of aril in table 2 and bulk density of pomegranate fruit in Table 3.The results shows that the weight, volume and density of pomegranate fruits ranges from 149.502 to 252.530 g, 150.156 to 254.450 cc and 0.916 to 1.058 g/cc, respectively

and average values are 193.515±30.977 g, 192.890± 30.054cc and 1.003 ± 0.038g/cc respectively. The true density of pomegranate aril was 1046.030 kg/m^{3}whereas bulk density of pomegranate fruit was 654.88 kg/m^3. Similar results for weight, volume and density of pomegranate fruits have also been reported by Akbarpour *et al.* (2009) [7], Tarighi*et.al.* (2011) [11] and Lam (2013) [9].

Moisture content determination of aril and peel of pomegranate fruits

The moisture content of aril and peel of ten pomegranate fruits (*Punica granatum L.*) cv. *Bhagva* were measured as per method described above. The obtained results are presented in Table 4. It is evident from the results that the aril and peel moisture content ranges from 79.75 to 82.90 % and 69.90 to 72.56 % respectively, the average values are 81.38 ± 1.16 and 71.47 ± 0.83 respectively. Peel thickness ranges from 4.61 to 7.59 mm whereas its mean value was found 5.85 mm.

Table 1: Weights, Volume and Density of pomegranate fruits

Sr. No.	Fruit weight(g)	Fruit volume(cc)	True Density(g/cc)
1	174.345	190.245	0.916
2	252.530	254.45	0.992
3	206.005	205.215	1.004
4	149.502	150.156	0.996
5	207.899	205.45	1.012
6	171.602	168.05	1.021
7	219.010	213.45	1.026
8	158.895	162.458	0.978
9	205.510	199.98	1.028
10	189.850	179.45	1.058
Min	149.502	150.156	0.916
Max	252.530	254.450	1.058
Mean	193.515	192.890	1.003
SD	30.977	30.054	0.038

Table 2: True densities of pomegranate arils

Sr. No.	Weight of Sample(kg)	Displaced Volume(ml)	True Density(kg/m^3)
1	0.07	67	1044.776
2	0.076	73	1041.096
3	0.078	75	1040.000
4	0.069	66	1045.455
5	0.072	68	1058.824
Mean			1046.030

Table 3|: Bulk density of pomegranate fruits

Sr. No	Weight of Sample(kg)	Volume of container(ml)	Bulk Density(kg/m^3)
1	2.98	0.00430	693.02
2	2.67	0.00430	620.93
3	2.88	0.00430	669.77
4	2.81	0.00430	653.49
5	2.74	0.00430	637.21
Mean			654.88

(79.6 to 82.2 per cent) reported by Singh *et al.* (2003) [10] for different genotypes of pomegranate. Akbarpour *et al.* (2009) [7] also recorded peel thickness ranged from 1.60 to 6.01 mm which is coinciding to our results.

Determination of aril, juice and peel percentage in pomegranate fruits

Aril, Juice and Peel component of ten pomegranate fruits were measured as per method described in Para 3.3.4. The results of aril, juice and peel content are presented in Table 4. It is evident from the table that the aril, juice and peel content of pomegranate fruits on whole fruit basis ranges from 51.42 to 55.27 %, 44.66 to 48.52% and 37.26 to 40.19 % respectively, and average values are 53.81 ±1.24, 46.10 ± 1.20 and 38.90 ± 0.99% respectively. Similar results for aril, juice and peel content of pomegranate fruits has also been reported by Tehranifar *et al.* (2010) [11] and Akhtar *et al.* (2013) [12].

Table 4: Moisture content of peel and aril and thickness of peel of pomegranate fruits

Sr. No.	Peel M. C. (%)	Aril M. C. (%)	Peel thickness (mm)
1	71.50	80.20	6.51
2	72.56	81.56	4.61
3	71.50	82.40	7.59
4	69.90	79.90	6.43
5	72.10	82.90	5.53
6	70.50	81.35	5.57
7	71.50	79.75	5.59
8	71.20	80.90	6.32
9	72.50	82.60	5.42
10	71.40	82.20	4.96
Min	69.90	79.75	4.61
Max	72.56	82.90	7.59
Mean	71.47	81.38	5.85
SD	0.83	1.16	0.87

Conclusions

The physical properties of pomegranate fruit such as length, width, thickness, size and sphericity ranged from 69.7 to 90.86, 65.11 to 82.87, 63.02 to 83.17, 66.82 to 83.74 and 83.56 to 97.26 mm, whereas, the average values of above mentioned parameters are 82.29 ±4.46, 72.72 ± 4.13, 73.38 ± 4.59 75.98 ± 3.81 and 92.40 ± 3.03 mm respectively. The weight, volume, true density and bulk density of pomegranate fruits ranged from 149.502 to 252.530 g, 150.156 to 254.450 cc, 0.916 to 1.058 and 0.621 to 0.693g/cc, whereas, the average values are 193.515±30.977 g, 192.890±30.054cc, 1.003±0.038 and 0.654±0.028 g/cc respectively for the above indicated parameters. The true density of pomegranate aril was 1046.030 kg/m^3. The aril and peel moisture content of fresh pomegranate fruit ranged from 79.75 to 82.90 % and 69.90 to 72.56 %, whereas, the average values of moisture content of aril and peel are 81.38±0.1.16 and 71.47±0.83 respectively. Peel thickness ranged from 4.61 to 7.59 mm whereas its mean value was 5.85 mm on opposite sides of peel pieces of selected fruits. The aril, juice and peel content of pomegranate fruits on whole fruit weight basis ranged from 51.51 to 55.66 %, 48.51 to 44.69 % and 37.25 to 40.21 %, whereas, the average values of aril, juice and peel contents are 53.87±1.24, 46.06±1.19 and 38.92±0.97 %, respectively. Thus, the physical properties of pomegranate fruit and arils can be useful in the study and design of various agricultural equipment concerned with cleaning, grading, sorting, transporting and packaging etc.

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