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Note

Some physical properties of pomegranate cv. Eksinar

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A b s t r a c t. Several physical properties such as porosity, geometric mean diameter, surface area, fruit mass and dimensions, fruit volume, coefficient of static friction, projected area, skin colour, aril colour, aril dimensions and aril ratio, which are imperative to characterise the fruits of pomegranate cv. Eksinar with a view to understand the properties that may affect the design of machines to handle their processing, were determined. The average fruit mass, length, width and thickness of cv. Eksinar were determined as 206.4 g; 62.4, 76.9, and 71.8 mm, respectively. On four different surfaces, static friction coefficient values were between 0.21 (galvanized steel sheet) and 0.25 (plywood). The aril ratio and 1 000 arils mass were 64% and 276 g, respectively.

K e y w o r d s: *Punica granatum*, pomegranate, physical properties

INTRODUCTION

Pomegranate is considered an excellent tree for growing in arid or semiarid zones due to its resistance to drought conditions. It is now widely cultivated in the Mediterranean, in tropical and subtropical areas. It can be encountered as regular plantations in Egypt, Morocco, Spain, Tunisia and Turkey (Mars, 1996). Turkey is one of the native lands of pomegranate, and it has been cultivated in the Mediterranean region, Southern Anatolia and Northeast part of Turkey since ancient times. Numerous types and forms are well adapted to different agroecological conditions. Fruits produced in traditional orchards are not appropriate for the modern market (Ercisli, 2004).

The edible part of the pomegranate is called arils. The fruit is consumed fresh or can be processed into juice, syrup (grenadine), jams, or a type of wine. In Northern India, a major use of the wild fruits is for the preparation of 'anardana' – the juice sacs being dried in the sun for 10 to 15 days and then sold as a spice (Kingsly *et al*., 2006). It is also widely used for traditional medicinal purposes.

The determination of physical properties of agricultural materials is important to design machines and processes for harvesting, handling and storage of these materials and requires understanding for converting these materials into food and feed. For horticultural materials (fruits, vegetables, grapes), dimensions (length, diameter, thickness) are widely used properties to describe them. Fruit physical dimensions, particularly shape, are very important in sorting and sizing, and determine how many fruits can be placed in shipping containers or plastic bags of a given size (Keramat Jahromi *et al*., 2008). Fruit skin colour is an attribute that determines consumers behaviour and it is accepted as one of the most important external quality parameters (Ercisli *et al*., 2007). Fruit volume, shape and density are important to design fluid velocities for transportation (Mohsenin, 1986). Fruits being a solid material, surface areas must be known for accurate modelling of heat and mass transfer during cooling and drying. Porosity, which is the percentage of air space in particulate solids, affects the resistance to air flow through bulk solids (Keramat Jahromi *et al.*, 2008). On the other hand, knowledge of frictional properties of fruits is needed for design of handling equipment (Mohsenin, 1986).

A lot of studies on physical properties of different fruit species and cultivars such as kiwifruit (Celik *et al.,* 2007), orange (Topuz *et al*., 2005), sweet cherries (Vursavus *et al*., 2006), date (Keramat Jahromi *et al*., 2008), cactus pear (Kabas *et al*., 2006), persimmon (Celik and Ercisli, 2008), hazelnut (Aydin, 2002) and barberry (Fathollahzadeh and Rajabipour, 2008) have been reported.

The physical properties of pomegranate can be important for design of equipments for processing, transportation, sorting, separating and also packing. Currently used system has been designed without taking these criteria into consideration, the resulting designs lead to inadequate applications.

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This results in a reduction in work efficiency, an increase in product loss. Therefore, determination and consideration of these criteria have an important role in designing of these equipments.

There is not enough published work relating to physical properties of pomegranate. Hence, the aims of this research were to investigate the physical properties of pomegranate cv. Eksinar sampled from Yusufeli district of NE Turkey.

MATERIALS AND METHODS

Fruits of the well known pomegranate cv. Eksinar used in this study were harvested manually from Yusufeli district in Northeast Region of Turkey during harvest season of 2006. Harvested fruits were transferred to the laboratory in polythene bags to reduce water loss during transport. The fruits were cleaned in an air screen cleaner to remove all foreign matter such as dust, dirt and chaff, as well as immature and damaged fruits. Measurements were made immediately after harvest. Fifty fruits were individually analyzed for each physical characteristic. The linear dimensions, length (L), width (W), and thickness (T), were measured by using a digital caliper gauge with a sensitivity of 0.01 mm (Fig. 1). The measurement of length was made on the polar axis of fruit *ie* between the apex and stem. The maximum width of the fruit, as measured in the direction perpendicular to the polar axis, is defined as the diameter. Geometric mean diameter (Dg) and surface area (S) were determined according to Mohsenin (1986). Volume (V) of fruit was measured by the liquid displacement method. Toluene (C_7H_8) was used, rather than water, because water is absorbed by the fruits (Aydin, 2003). Projected area (P) with two major axes (x, y) of the pomegranate was determined from images taken by a digital camera (Olympus C-990), and then comparison of the reference area to a sample area was performed using the Sigma Scan Pro 5 program. Fruit mass (M_f) was measured by using a digital balance with a sensitivity of 0.001 g.

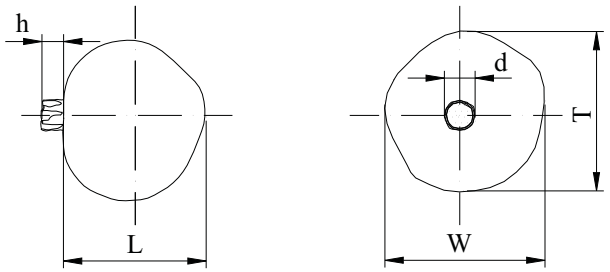

Fig. 1. Dimensions of pomegranate, front view (left) and side view (right).

Porosity ε was calculated by using bulk and fruit density (Mohsenin, 1986). Coefficient of static friction (μ_s) was measured by a friction device having rubber, plywood, polyethylene and galvanized steel surfaces. For this measurement, the material was placed on the surface that was then gradually raised by the screw. Vertical and horizontal height values were read from the ruler when the material started sliding over the surface, and then using the tangent value of the angle so that the coefficient of friction was found (Nimkar and Chattopadhyay, 2001).

Skin and aril apparent colour of 50 pomegranates was measured by using a CR-400 Chromometer (Konica Minolta, Japan) represented as. L* a* b* value. Colour values for each fruit were computed as means of three measurements taken from opposite sides at the equatorial region of the fruit (Perkins-Veazie, 1992).

Skin firmness was measured at 23°C using a drill-mounted penetrometer (0-150 N cm^{-2}). For skin firmness measurement, the apparatus directly penetrated the external surface. Three measurements were made per fruit at right angles to each other on paired areas on the equator of the fruit.

RESULTS AND DISCUSSION

The results of physical properties of pomegranate cv. Eksinar are presented in Table 1. According to the results, the fruit mass of cv. Eksinar varied from 154.4 to 289.5 g with average of 206.4 g. It can be said that cv. Eksinar has medium fruit size. It is well known that fruit mass within the same pomegranate cultivar is very variable. Same pomegranate shrubs produce small to medium fruits, and even very big fruits (Tibet and Onur, 1999). The medium fruit mass of pomegranate is very important because it affects yield and attracts consumer preference. It is a generally emphasized and desired trait of all developed cultivars, except for situations involving special purposes. In several previous studies, fruit mass of pomegranate cultivars was found between 150 and 568 g (Al-Maiman and Ahmad, 2002; Ercan *et al*., 1992; Kazankaya *et al*., 2003; Ozkan, 2005; Yilmaz *et al*., 1992). Our fruit mass results are within these limits. On the other hand, average fruit length, width and fruit volume of cv. Eksinar were determined as 62.4 mm, 76.9 mm and 211.7 cm^3, respectively (Table 1). Some studies conducted on fruit length, width and volume of pomegranate cultivars ranged from 61 to 91, 36 to 104 mm and 100 to 300 cm^3 (Al-Maiman and Ahmad, 2002; Kazankaya *et al*., 2003; Tibet and Onur, 1999; Yilmaz *et al*., 1992), which supports our findings. The importance of dimensions is in determining the aperture size of machines, particularly in separation of materials as discussed by Mohsenin (1986). These dimensions can be used in designing machine components and parameters. For example, they may be useful in estimating the number of fruits to be engaged at a time.

T a b l e 1. Some physical properties of pomegranate cv. Eksinar

Properties	Values			Standard deviations
	Min	Max	Mean	
Porosity, ε (%)	26.9	50.5	43.1	5.6
Geometric mean diameter, D_g (mm)	63.8	79.0	70.1	4.2
Surface area, S (mm^2)	12 813	19 611	15 496	77
Fruit length, L (mm)	52.9	75.0	62.4	5.1
Fruit width, W (mm)	60.6	85.9	76.9	5.3
Fruit thickness, T (mm)	63.4	81.4	71.8	4.4
Fruit mass, M_f (g)	154.4	289.5	206.4	38.0
Fruit volume, V (cm^3)	150.9	295.8	211.7	38.4
Fruit firmness (N cm^{-2})	110.3	134.8	122.1	0.7
Projected area, P (mm^2)				
x-axis	5 526	9 061	6 939	882
y-axis	6 204	1 0175	8 048	1 030
Skin colour				
L*	42.4	62.1	53.8	4.8
a*	22.3	40.3	32.6	5.0
b*	18.6	35.8	28.7	3.8
Aril colour				
L*	14.6	23.7	19.2	2.5
a*	11.7	20.5	15.8	2.7
b*	3.5	7.9	5.8	1.2
Aril length (mm)	8.4	11.4	10.0	0.7
Aril width (mm)	5.3	8.8	6.3	0.6
Aril thickness (mm)	3.9	6.3	5.2	0.5
Aril geometric mean diameter (mm)	6.1	7.7	6.9	0.4
Numbers of aril per fruit	368	618	502	79
Total aril mass per fruit (g)	108	182	138	21
1000 aril mass (g)	228	321	276	29
Aril ratio (%)	51	70	64	5
Coefficient of static friction, μ_S				
Galvanized steel sheet	0.12	0.31	0.21	0.04
Rubber	0.13	0.34	0.23	0.05
Plywood	0.06	0.34	0.25	0.06
Polyethylene	0.15	0.29	0.22	0.03

The average value of the geometric mean diameter was calculated as 70.1 mm for cv. Eksinar (Table 1). Mean surface area of cv. Eksinar fruit was 15 496 mm^2. The porosity ranged between 26.96 and 50.58% and average porosity was 43.13%. Fruit porosity property may be useful in the separation and transportation of the fruits by hydrodynamic means.

Results of analysis showed that the surface of materials had an effect on values of the static coefficient of friction. The highest coefficient of static friction was obtained on plywood, at 0.25, and followed by rubber, polyethylene and galvanized steel sheet, at 0.23, 0.22 and 0.21, respectively. Similar results were found in almond (Aydin, 2003) and cactus pear (Kabas *et al*., 2006). These properties may be useful in the separation process and the transportation of the fruits.

Average skin firmness of cv. Eksinar was 122.1 N cm^{-2} at harvest time. Skin colour of pomegranate cv. Eksinar was determined as L value 53.8, a value 32.6 and b value 28.7 (Table 1). The L is indicating 0:black and 100:white. The average projected areas in mm^2 were 6 939 on x-axis and 8 048 on y-axis.

As it was mentioned before, consumed part of pomegranate is called aril. In this study we reported some physical properties of arils of cv. Eksinar as well (Table 1). 1000 aril mass, length, width and thickness of arils were 276 g, 10.0, 6.3 and 5.1 mm (Table 1). The averages of L, a and b values of arils of pomegranate cv. Eksinar were estimated as 19.2, 15.8 and 5.8. The visible aril colour of this cultivar was pink. Pomegranate cultivars has dark red, red, pink, or even white aril colour (Ozkan, 2005). According to these results, a values were found to be lower in comparison to previous research. However, it was shown that L and b were similar to the earlier results (Poyrazoglu *et al*., 2002). The average aril ratio, number of arils per fruit and total aril mass per fruit of cv. Eksinar were determined as 64%, 502 and 138 g, respectively (Table 1). The mean geometric aril diameter value was 6.9 mm. In comparision with previous studies, average aril ratio values of different pomegranate cultivars were between 41-79% (Kazankaya *et al*., 2003; Ozkan, 2005; Tibet and Onur, 1999).

CONCLUSIONS

1. Average fruit porosity of pomegranate cv. Eksinar was 43.1%.

2. Fruit mass and volume were between 154.4 to 289.5 g and from 150.9 to 295.8 cm^3.

3. Fruit dimensions varied from 52.9 to 75.0 mm for length, 60.6 to 85.9 mm for width and 63.4 to 81.4 mm for thickness. Average geometric mean diameter of fruit and aril were 70.1 and 6.9 mm, respectively.

4. Fruit firmness values were between 110.3 and 134.8 N cm^{-2}.

5. Average static coefficient of friction on plywood was the highest.

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