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Note

Chosen physical properties of olive cultivars (*Olea europaea* L.)

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A b s t r a c t. The post-harvest physical properties of three olive cultivars (Butko, Kara Sati and Kizil Sati) from North-Eastern Turkey were investigated and are reported here, and their application is also discussed. Bulk density of the cultivars varied between 583.47 (cv. Butko) and 596.69 kg m^{-3} (cv. Kara Sati), and porosity varied from 42.25 to 43.68%, respectively. The fruit firmness of cultivars were the highest in cv. Kizil Sati (109.38 kPa), followed by cv. Kara Sati (72.10 kPa) and cv. Butko (61.31 kPa), respectively.

K e y w o r d s: physical properties, olive (*Olea europaea* L.)

INTRODUCTION

The olive tree is believed to be the first tree grown on Earth. This makes the olive production one of the oldest ones, going back to the first civilisation (Dokuzoguz and Mendilcioglu, 1971). Olive has a great commercial importance in Turkey. It is used for local consumption as well as oil and soap production. Turkey is also one of the important olive oil exporters. Olive growing in Turkey is well established mainly around the Aegean and Mediterranean regions, but also in the Marmara, South-Eastern Anatolia and Black Sea regions (Ercisli, 2004). Olive is gaining more importance in Turkey because of increasing emphasis on health components of olive fruit and oil recently. The Coruh basin, abundant in olive trees, is far away from the biggest markets. However, in the biggest market there is specific consumers demand for olive fruit from the Coruh valley. Therefore, one of the main problems in olive production in the Coruh basin is the crop losses during transportation after harvest. Thus, information with regard to some physical properties such as length, width, geometric mean diameter, sphericity, volume, porosity, bulk density, fruit density, projected area, terminal velocity *etc*. of olive fruit may have more importance for the proper design and constructing equipment and structures for handling, transporting, processing and storing and also for assessing the product quality. For example, bulk and fruit density of agricultural materials play an important role in drying and storage, design of silos and storage bins, separation from undesirable materials, and grading (Mohsenin, 1986). Porosity and surface area affect the resistance to airflow through the bulk material and data on them are necessary in designing the drying process. Angle of repose is a useful parameter for calculation of belt conveyor width and for designing the shape of storage structures. Friction coefficient of various surfaces affects the maximum inclination angle of conveyor and storage bin (Sirisomboon *et al*., 2007; Dash *et al*., 2008; Fathollahzadeh and Rajabipour, 2008; Jahromi *et al*., 2008; Omobuwajo *et al*., 1999).

The physical properties and mechanical behaviour of agricultural materials are well documented for a lot of crops (Baryeh, 2001; Celik *et al*., 2007; Desphande *et al*., 1993; Kibar and Ozturk, 2008; Sirisomboon *et al*., 2007). However, these properties have not been reported extensively for olive in the literature.

This research aimed to investigate the physical properties of olive fruits (*Olea europaea* L.).

MATERIALS AND METHODS

Black-ripe olives (*Olea europaea* cvs. Butko, Kara Sati and Kizil Sati) were hand-picked on 1st December 2007, from trees in the same orchard that received the same cultural practices in the Zeytinlik village in Coruh valley. In this region the growers harvested olive fruits traditionally at black-ripe stages. The fruits were immediately transported to the laboratory in cooled polythene bags and sorted to obtain fruit of uniform size and colour. The analyses were carried out at room temperature of 23°C. All tests were carried out at

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the Biological Material Laboratory in the Agricultural Machinery Department and the Fruit Science Laboratory in the Horticulture Department of Ataturk University, Erzurum, Turkey.

The physical properties of olive cultivars were determined by the standard methods AOAC (1984). Fruit volume and fruit density were determined using the liquid displacement method. Toluene (C_7H_8) was used.

To determine the size of the fruit and pit, one-hundred fruits were selected at random and their two principal linear dimensions, namely length and width (= thickness), were measured by a digital caliper reading to 0.01 mm. Projected area of the olive fruits was determined from pictures taken with a digital camera (Casio Exilim Optical), and then comparing the reference area to a sample area by using the Image Tool for Windows (version 3.00) program. For determining flesh/pit ratio, fruits were cut in half horizontally with a stainless-steel knife and the pits were removed and weighed. The flesh content was calculated by subtracting the pit weight from the whole olive fruit weight. The flesh to pit weight ratio was determined by dividing the flesh mass by the pit mass.

The angle of repose is defined as a kinetic angle with the horizontal at which the material stands when piled. This angle was determined by using a topless and bottomless cylinder of 150 mm diameter and 250 mm height. The angle of repose was calculated by dividing the height of the cone by the radius of the circular plate (Kaleemullah and Gunasekar, 2002).

The friction force was determined by a direct shear test device (Kara *et al*., 1999). The device consists of three main components: a shear box connected to a load cell, a frictional surface with a driving unit, and a PC equipped with a data acquisition system (DAS) to sense and record the frictional force. A frictional surface was placed under a square box with 100 x 100 mm^2 contact area and 40 mm thickness (Zhang *et al*., 1991), and the box was filled with a sample of fruit. The frictional surface was moved horizontally with the aid of the driving unit at a constant velocity of 0.4 mm s^{-1} while a dead load of 5 kg was applied to the top of the fruit sample. The friction force was measured with a load cell and recorded on PC through the DAS. The friction tests were repeated five times.

To determine the terminal velocity a measurement setup was developed. It consists of three components: A vertical tube with a grid in it, a fan connected to a speed control unit and a hot wire anemometer with probe. A small sample of fruits was placed on the grid in the tube and the air velocity was adjusted until the sample suspended in the vertical air stream. The probe of the anemometer was inserted into the air stream through the small hole in the wall of the tube and the air velocity near the location of the fruit suspension was measured to an accuracy of 0.1 m s^{-1} (Song and Litchfield, 1991). The procedure was replicated twenty times.

Fruit firmness was measured at 23°C using a non-destructive firmness device (Aweta Company, The Netherlands).

The external colour of 20 whole fruits was determined with a Minolta Chroma Meter CR-400 (Minolta-Konica, Japan). The chromameter was calibrated to a standard white reflective plate and CIE co-ordinates (L*, a*, b*) were measured to calculate hue angle (α) and chroma (C):

$$\alpha = 360 + \tan^{-1} (b/a) \text{ for } a > 0, b < 0, \quad (1)$$

$$\alpha = \tan^{-1} (b/a) \text{ for } a > 0, b \geq 0, \quad (2)$$

$$C = (a^2 + b^2)^{1/2}, \quad (3)$$

where: +a* represents increasing redness, – a* increasing greenness, +b* increasing yellowness and –b* increasing blueness. The L* value expresses lightness (white=100) or darkness (black=0). Hue describes the visible colour, whereas chroma – the brightness or intensity of the hue (Perkins-Veazie, 1992).

Descriptive statistics was carried out on the three olive cultivars, and the difference between the mean values was investigated by using the Duncan tests.

RESULTS AND DISCUSSION

The determined physical parameters of fruits of Butko, Kara Sati and Kizil Sati olive cultivars are shown in Table 1. The most of the fruit characteristics of the different olive cultivars were found to be statistically important at the 1% level. That means each olive cultivar had its own fruit characteristics.

The cultivar Kizil Sati had the highest L (27.54), a (5.16), b (2.06), and chroma (5.58) values compared to the other cultivars. Hue angle (α) value was somewhat higher in Kara Sati (340.75) than the other cultivars (Table 1). Fruit skin colour is considered to be the most important index of olive external quality and an important consideration to determine maturity of fruits.

The moisture content (w.b.) of Butko, Kara Sati and Kizil Sati olive cultivars were 40.68, 41.71, 47.68%, respectively. Moisture content of olive cultivars was previously reported between 40.49-70.20% (Anonymous, 2005; Proietti and Antognozzi, 1996; Unal and Nergiz, 2003;) in different parts of the world. Our moisture results are within the limits of these studies. The fruit mass, length and width of olive cultivars were 2.46 g, 20.25 mm, 15.37 mm for cv. Butko, 2.41 g, 21.48 mm, 15.11 mm for cv. Kara Sati and 3.15 g, 22.81 mm, 16.39 mm for cv. Kizil Sati (Table 1). It seems that fruit mass and dimensions are important properties that distinguish olive cultivars. The importance of dimensions is in determining the aperture size of machines, particularly in separation of materials as discussed by Mohsenin (1986).

Fruit mass, length and diameter of olive cultivars grown in Turkey was previously reported between 1.76-7.50 g; 17.58-33.60 and 14.91-23.10 mm (Anonymous, 2005; Dokuzoguz and Mendilcioglu, 1971; Kaynas *et al*., 1992).

T a b l e 1. Mean values of physical properties (with the standard deviations) of olive fruits (cvs. Butko, Kara Sati and Kizil Sati)

Properties		Butko	Kara Sati	Kizil Sati	Significant level
Lightness, L		22.29±0.55	25.59±2.19	27.54±1.02	**
Green to red, a		3.16±0.83	2.21±0.61	5.16±0.84	**
Blue to yellows, b		0.11±0.08	-0.82±0.80	2.06±0.81	**
Hue angle, α (°)		2.15±1.98	340.75±15.51	21.12±4.53	**
Chroma, C		3.16±0.83b	2.45±0.74c	5.58±1.07a	*
Moisture (% w.b.)		40.68±0.83b	41.71±0.91b	47.68±1.06a	*
Fruit length (mm)		20.25±1.17c	21.48±2.11b	22.81±1.88a	**
Fruit width or thickness, (mm)		15.37±0.90b	15.11±1.23c	16.39±1.37a	*
Aspect ratio (%)		76.00±4.25a	70.60±4.81c	72.02±4.64b	*
Geometric mean dia (mm)		16.84±0.88b	16.98±1.38b	18.29±1.42a	*
Sphericity (%)		83.26±3.11a	79.25±3.59c	80.31±3.45b	*
Surface area (mm^2)		893.48±94.15b	911.89±149.83b	1057.67±167.57a	*
Projected area (mm^2)		275.90±29.59b	254.69±34.34b	312.98±37.35a	*
Fruit mass (g)		2.46±0.39b	2.41±0.57b	3.15±0.73a	*
Fruit volume (cm^3)		2.33±0.37b	2.28±0.53b	2.97±0.69a	*
Pit length (mm)		13.52±1.07c	14.71±1.69b	15.68±1.41a	**
Pit width (mm)		7.84±0.58c	6.98±0.59b	7.59±0.74a	**
Pit mass (g)		0.50±0.09a	0.41±0.11b	0.49±0.12a	*
Flesh/pit ratio		3.96±0.57c	5.02±1.02b	5.52±1.17a	**
Fruit density (kg m^{-3})		1058.51±12.32a	1033.31±10.96b	1035.64±18.85b	*
Bulk density (kg m^{-3})		596.13±3.75a	596.69±4.90a	583.47±4.89b	*
Density ratio (%)		56.33±0.73b	57.7±0.93a	56.36±1.05b	*
Porosity (%)		43.68±0.73a	42.25±0.93b	43.65±1.05a	*
Angle of repose (deg)		28.37±2.37b	27.55±0.97b	33.83±2.06a	*
Terminal velocity (m s^{-1})		12.05±0.23ab	12.27±0.79a	11.83±0.41b	*
Fruit firmness (kPa)		61.31±10.97c	72.10±10.69b	109.38±10.69a	**
Dynamic coefficient of friction	Steel	0.38±0.01	0.38±0.02	0.36±0.02	ns
	Plywood	0.30±0.02	0.30±0.02	0.32±0.01	ns
	Wood	0.34±0.02 ab	0.32±0.01b	0.38±0.03a	*

*, **significant levels at 5 and 1%, ns – not significant, a-b – letters indicate the statistical difference within rows.

Our fruit mass, fruit length and fruit width results were within the limits of those studies. The variation of fruit mass, fruit length and fruit width of olive fruits could be due to different cultivars, environmental conditions and nutritional status of orchards as well. The pit length and width in mm were between 13.52 (cv. Butko) 15.68 (cv. Kizil Sati) and 6.98 (cv. Kara Sati) and 7.84 (cv. Butko), respectively. Pit mass was the highest in cv. Butko (0.50 g), followed by cv. Kizil Sati (0.49 g) and cv. Kara Sati (0.41 g). Flesh/pit ratio varied from 3.96 (cv. Butko) to 5.52 (cv. Kizil Sati). The higher flesh/pit ratio is a desired fruit property in olive (Dokuzoguz and Mendilcioglu, 1971). The average values of the geometric mean diameter were calculated as 16.84 mm for cv. Butko, 16.98 mm for cv. Kara Sati and 18.29 mm for cv. Kizil Sati (Table 1). Sphericity and aspect ratio of the olive cultivars were 83.26 and 76.00% for cv. Butko and 79.25 and 70.60% for cv. Kara Sati and 80.31 and 72.02% for cv. Kizil Sati. Sphericity is an expression of the shape of a solid relative to that of a sphere of the same volume while the aspect ratio relates the width to the length of the fruit which is indicative of its tendency toward being oblong in shape (Omobuwajo *et al*., 1999). The surface and projected area of olive cultivars were 893.48 and 275.9 mm^2 for cv. Butko, 911.89 and 254.69 mm^2 for cv. Kara Sati, 1057.67 and 312.98 mm^2 for cv. Kizil Sati, respectively. Fruit and bulk density of olive cultivars Butko, Kara Sati and Kizil Sati were between 1 033.31-1 058.51 and 583.47-596.69 kg m^{-3}, respectively. The porosity ranged between 43.68, 42.25, and 43.65% for cv. Butko, Kara Sati and Kizil Sati, respectively (Table 1). The angle of repose of olive cultivars Butko, Kara Sati and Kizil Sati was 28.37, 27.55, 33.83°. The highest coefficient of dynamic friction was obtained on steel, at 0.38 for cv. Butko, 0.38 for cv. Kara Sati and 0.36 for cv. Kizil Sati. In general, the dynamic coefficient was lower on plywood surface. The statistical differences of the cultivars for coefficient of dynamic friction are due to the frictional properties between the fruits and surface materials. The terminal velocity of olive cultivars was the highest in cv. Kara Sati as 12.27 m s^{-1}, followed by cv. Butko at 12.05 m s^{-1} and cv. Kizil Sati at 11.83 m s^{-1}, respectively. In comparison with other fruit species, the dynamic friction of olives was higher than those of sweet cherry (Vursavus *et al.*, 2006) and similar to those of medlar (Haciseferogullari *et al.*, 2005). The dynamic coefficient properties may be important for transportation and separation process of olive fruits.

CONCLUSIONS

1. Fruit colour intensity (chroma) varied from 2.45 (cv. Kara Sati) to 5.58 (cv. Kizil Sati).

2. Fruit mass was between 2.41 (cv. Kara Sati) and 3.15 g (cv.Kizil Sati), and volume – from 2.28 (cv. Kara Sati) to 2.97 cm^3 (cv. Kizil Sati). Pit mass was the highest in cv. Butko (0.50 g), followed by cv. Kizil Sati (0.49 g) and cv. Kara Sati (0.41 g). Flesh/pit ratio varied from 3.96 (cv. Butko) to 5.52 (cv. Kizil Sati). Fruit density varied among the cultivars and was found to be between 1033 (cv. Kara Sati) and 1 059 (cv. Butko) kg m^{-3}.

3. Dimensions varied from 20.25 (cv. Butko) to 22.81 (cv. Kizil Sati) mm in length, and 15.11 (cv. Kara Sati) to 16.39 (cv. Kizil Sati) mm in width. Geometric mean diameter, sphericity and surface area varied from 16.84 (cv. Butko) to 18.29 (cv. Kizil Sati) mm; 79.25 (cv. Kara Sati) to 83.26 (cv. Butko) % and 893 (cv. Butko) to 1058 (cv. Kizil Sati) mm^2.

4. The fruit firmness values of the cultivars were between 61.31-109.38 kPa.

5. The dynamic coefficient of friction on galvanized steel was the highest, followed by wood and plywood surface.

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