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Note

Physical and chemical properties of persimmon fruit

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A b s t r a c t. Physical and chemical properties of persimmon fruit (cv. Fuyu) were determined. The plywood surface offered the maximum coefficient of static friction, followed by chipboard and galvanized metal. The skin and flesh firmnesses of persimmon fruits along Y-axis were higher than the X-axis.

K e y w o r d s: persimmon, physical properties, chemical properties

INTRODUCTION

Persimmon (*Diospyros kaki Thunb.*) is rich in vitamin A, calcium, potassium, tannic acid and antioxidant phenolic compounds. China is ranked first in the World with 1 655 000 t of persimmon production (Liu *et al.,* 2007). Turkey produces about 20 000 t of persimmon annually (Ercisli and Akbulut, 2009). Persimmon is successfully cultivated in the Mediterranean and the Northern Anatolia regions of Turkey. 'Fuyu' is the most comman variety grown in Turkey due to its taste and appeal.

Several researchers have investigated the physical, chemical and mechanical characteristics of different persimmon varieties *eg* Mopan, Harbiye and Hachiya (Candir *et al.*, 2009; Celik and Ercisli, 2008; Liu *et al*., 2007). However, no detailed study on some of the physicochemical and mechanical characteristics of persimmon cv. Fuyu has been adequately carried out.

The aim of this study was conducted to investigate the size dimension, sphericity, fruit mass, volume, fruit and bulk densities, colour characteristics (L^*, a^*, b^*), coefficient of static friction, total soluble solid content, titratable acidity, pH, total phenolic, antioxidant activity and total sugar and firmness of persimmon fruits.

MATERIALS AND METHODS

Persimmon fruits (cv. Fuyu) were hand harvested from Ordu Province located in the Black Sea region during the harvest season, on 15 November 2008. Harvested fruits were transferred to the laboratory in polyhthene bags to reduce water loss during transport. One hundred fruits were randomly selected to determine the persimmon fruit size. The length and width were measured using a dial-micrometer to an accuracy of 0.01 mm. The fruit mass of persimmon was measured using a digital electronic balance with a resolution of 0.01 g. The geometric mean diameter, sphericity (Φ), volume, true (fruit) and bulk densities of persimmon fruits were determined by standard methods (Celik and Ercisli, 2008, 2009; Mohsenin, 1970). The projected area was measured by a digital planimeter (Placom Roller-Type, KP90N). The measurement along X-, and Y- axes was determined according to the method of Razavi and Parvar (2007). The coefficient of friction is defined as tangent value of the angle of (slope) between sliding surface and vertical and horizontal planes (Celik and Ercisli, 2008). The experiment was conducted using friction surfaces of plywood, chipboard and galvanized metal.

The colour of persimmon fruits in terms of L^*, a^*, b^* values was determined using a Minolta colourimeter (CR-3000 Model). L^* denotes the lightness or darkness; a^* is green or red; and b^* is blue or yellow colour of the samples. The colour was measured at three points of each sample. Measurements were conducted on the skin, flesh, core and two sides of cut surface along the longitudinal axis (Jha *et al.,* 2006). The colour measurements of persimmon samples were computed as the means of three replications.

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The chemical composition and pH of persimmon fruit was determined by standard methods (AOAC, 1984). The total soluble solid content (TSSC) was determined by a digital refractometer (Kyoto Company, Kyoto, Japan). Titratable acidity (TA) was measured by titration with 0.1 N NaOH. Total phenolic (TP) content was measured by the Singleton and Rossi (1965) procedure. Gallic acid was used as a standard. The results were expressed as mg gallic acid equivalent in kg fresh mass basis (GAE/kg f.m.). The total antioxidant activity (TAA) was estimated by two standard procedures, FRAP and TEAC assays, as suggested by Ozgen *et al.* (2006). The ferric reducing ability of plasma (FRAP) was determined according to the method of Benzie and Strain (1996). The individual sugars of persimmon cv. Fuyu fruits pulp (5 g) were diluted with purified water and homogenizated for extraction. The homogenate was centrifuged at 6000 r.p.m. for 5 min. Supernatants were filtered through a 0.45 µm membrane filter before HPLC analysis, and the mobile phase solvents were degassed before using. All the samples and standards were injected three times, and mean values were used. Analysis of sugars was performed according to the method described by Bartolome *et al.* (1995).

For the firmness measurement, a biological material test device (Zwick/Roell, Instruction Manual for Materials Testing Machines/BDO-FB 0.5 TS) was used. For the skin and flesh firmness measurements, the apparatus was directly inserted into the external surface (Celik and Ercisli, 2008). The firmness of persimmon fruits was measured using by a 7.9 mm diameter stainless steel probe. The skin firmness was measured at 20 mm min^{-1} test speed and 22.5 mm puncture depth. During the flesh firmness tests, the operating conditions were 10 mm min^{-1} and 8 mm puncture depth (Razavi and Parvar, 2007). Persimmon fruit samples were penetrated along X- and Y- axes to determine the skin and flesh firmness.

RESULTS AND DISCUSSION

The length, width, geometric mean diameter and fruit mass of persimmon ranged from 44.5 to 55.4, 65.6 to 81.7, 57.4 to 71.5 mm; 106.6 to 202.9 g, respectively. About 74% of the persimmon fruits have a length ranging from 44.0 to 52.6 mm, about 87% width ranging from 65.7 to 76.4 mm, about 73% fruit mass ranging from 100.0 to 168.9 g, respectively (Fig. 1). The correlation coefficients between *L/W*, *L/M, L/*D_g, *L/*ϕ and *L/V* were statistically significant (Table 1). The sphericity, bulk and fruit densities and fruit volume of persimmon fruits ranged from 1.25 to 1.33; 496.6 to 580.4 kg m^{-3}; 737.3 to 1 010 kg m^{-3} and 21.3 to 48.2%, and 100.2 to 193.7 mm^3, respectively.

The projected area along X-, Y-axes and spread area varied from 25.4 to 32.1 cm^2; 35.1 to 45.3 cm^2 and from 317.0 to 375.1 cm^2 kg^{-1}, respectively. The projected area along X- and Y- axes and spread area of persimmon (cv. Hachiya) were reported as 4.93, 4.59 mm^2 and 79.7 m^2 kg^{-1} (Celik and Ercisli, 2008). The results of determination of the coefficients of static friction of persimmon fruits on various surfaces were compared. The coefficients of static friction were greater on plywood compared to the other friction surfaces (Table 2). The mean coefficient of static friction on galvanized steel, rubber, plywood and polyethylene have

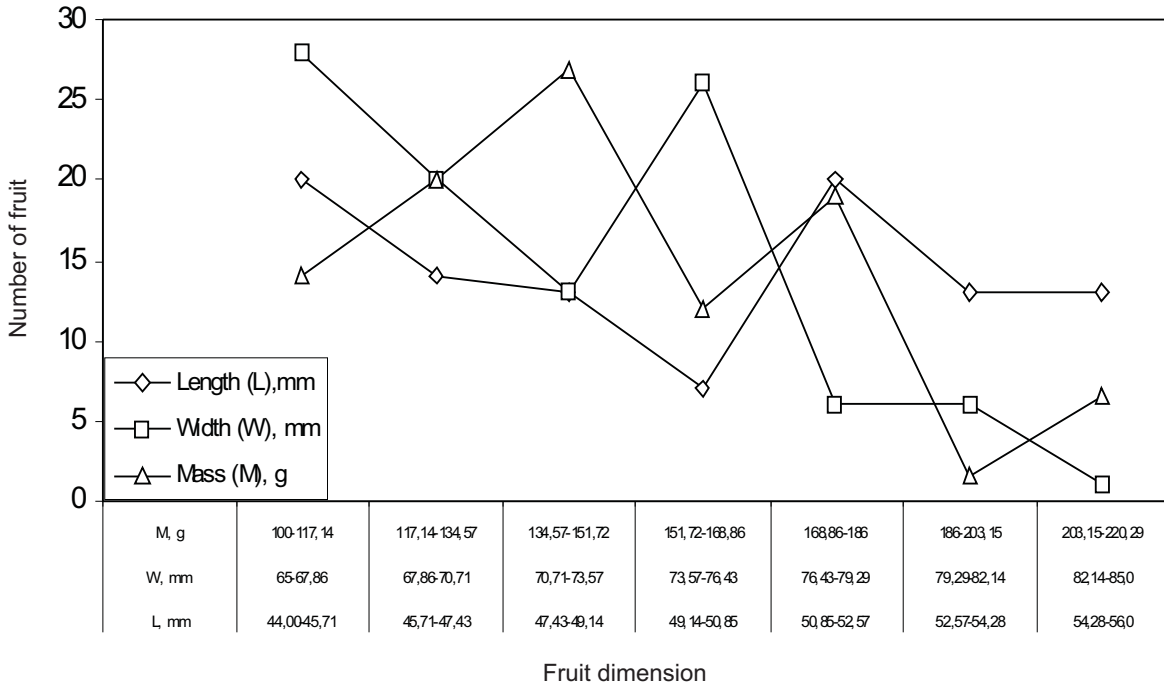

Fig. 1. Frequency distribution curves of persimmon fruit length, width and fruit mass.

T a b l e 1. The correlation coefficient between paramters of persimmon fruit (98 degrees of freedom)

Particulars	Ratio	Correlation coefficient (R)
L/W	0.690	0.874 *
L/M	0.340	0.895 *
L/Dg	0.784	0.950 *
L/φ	0.390	-0.557 *
L/V	0.363	0.942 *

*Significant at 1% level.

T a b l e 2. Physical characteristics of persimmon fruit

Physical characteristics	Mean	SD
Length (mm)	49.8	3.6
Width (mm)	72.2	4.4
Geometric mean diameter (mm)	63.5	4.0
Sphericity, ϕ	1.28	0.03
Fruit mass (g)	146.1	27.9
Bulk density (kg m^{-3})	540.8	29.9
Fruit density (kg m^{-3})	932.7	111
Volume (mm^3)	137.2	26.2
Spread area (m^2 kg^{-1})	342.7	29.6
Projected area (cm^2)		
X-axis	28.9	2.8
Y-axis	38.8	3.7
Static coefficient of friction		
Chipboard	0.31	0.02
Galvanized metal	0.30	0.04
Plywood	0.31	0.02

been reported as 0.17, 0.16, 0.18 and 0.18, which were lower than those obtained in this study (Celik and Ercisli, 2008).

The mean skin colour (*L*, a*, b**) values of persimmon fruits are presented in Table 3. The values of *L*, a*, b** varied from 88.9 to 95.2; 33.7 to 45.4 and 85.2 to 94.7, respectively. The flesh (bottom of skin) colour (*L*, a*, b**) values ranged from 94.6 to 103.9; 10.4 to 24.1; 68.4 to 77.1, respectively. The *L*, a*, b** values on core of fruits ranged between 105.0 to 118.9; 7.34 to 9.37 and 52.1 to 74.0, respectively. Corresponding *L*, a*, b** values for two sides of fruit cores varied between 89.3 to 103.2; 7.67 to 16.1 and 60.5 to 79.2, respectively.

Persimmon contains (in 100 g fresh fruit): water - 80.3 g; protein - 0.58 g, total lipids - 0.19 g, total carbohydrates - 18.6 g; total dietary fibre up to 1.48 g, a high concentration of antioxidants like ascorbic acid (up to 7.5 mg), carotenoids, some minerals, polyphenols and a specific group of polyphenols/tannins (Young and How, 1986).

The chemical and mechanical characteristics of persimmon fruit are presented in Table 4. The total soluble solid content, titratable acidity and pH of persimmon fruit ranged from 11.5 to 11.6%; 0.12 to 0.12 g 100 g^{-1} and 5.52 to 5.58, respectively. Celik and Ercisli (2008) reported that the average total soluble solids, pH, titratable acidity of persimmon cv. Hachiya fruits were 17.1, 5.40, and 2.06%, respectively. The pH obtained was similar to pH reported in the literature. The total soluble solid, sugar and titratable acidity contents were similar to the findings of previous reports (Candir *et al.,* 2009; Celik and Ercisli, 2008).

The total sugar content of persimmon was 16.3 g/100 g, whereas fructose and glucose contents were 6.13 and 10.2 g 100 g^{-1}, respectively (Table 4). The total phenolic content of persimmon cv. Fuyu was 3293 mg GAE/g f.m. Chen *et al*. (2008) reported that the content of the total phenolic was 32.3 mg/100 g d.w. for persimmon cv. Mopan. The total antioxidant activity (TAA) was 9.75 mmol TE/g f.m., whereas TEAC and FRAP 8.57 and 1.18 mmol TE/g f.m., respectively. The total antioxidant activity of persimmon cv. Mopan was obtained as 328.0 ($\times 10^{-3}$ mmol 100 g^{-1} d.m.) (Chen *et al*., 2008). Some researchers reported persimmon as one of the most bioactive fruits, especially in polyphenols and tannins (Chen *et al.,* 2008). In this study, the persimmon cv. Fuyu possesses high contents of total polyphenols and a high antioxidant potential.

The skin firmness of persimmon fruits punctured along X- and Y- axes ranged from 17.7 to 31.2 and 6.19 to 12.0 N, respectively. Flesh firmness of persimmon fruits at X- and Y- axes varied from 24.0 to 41.0 N (X-axis) and 6.15 to 17.1 N (Y-axis), respectively. Celik and Ercisli (2008) found the skin and flesh firmness of cv. Hachiya as 59.4 and 36.3 N cm^{-2}, respectively. Flesh firmness at harvest is also an important criterion to maintain quality during the postharvest period. The flesh firmness of persimmon cv. Harbiye decreased during fruit growth and reached 51-54 N in the third week of October (Candir *et al.,* 2009).

T a b l e 3. Colour characteristics of persimmon fruit

Parameter	Skin		Flesh		Core		Two sides of core	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
L	91.8	2.4	99.7	4.2	98.2	5.2	112.3	6.3
a	39.8	4.4	17.0	5.6	12.8	3.5	8.5	0.7
b	89.3	3.5	73.0	4.2	67.2	7.1	63.8	7.8

T a b l e 4. Chemical and mechanical characteristics of persimmon fruit

Parameter	Mean	SD
pH	5.5	0.03
TSSC (%)	11.5	0.06
TA (g 100 g^{-1})	0.12	0.0004
TP (mg GAE/g fw)	3 293	271.5
Total antioxidant activity		
TEAC (mmol TE/g fw)	8.6	0.28
FRAP (mmol TE/g fw)	1.18	0.43
Sugars (g 100 g^{-1})		
Fructose	6.1	0.15
Glucose	10.2	0.30
Sucrose*	–	–
Total	16.3	0.44
Mechanical characteristics		
Skin firmness (X-axis) (N)	20.9	5.2
Skin firmness (Y-axis) (N)	32.2	7.0
Flesh firmness (X- axis) (N)	9.0	2.3
Flesh firmness (Y-axis) (N)	11.1	4.1

*none detected.

CONCLUSIONS

1. The correlation coefficients between physical parameters of persimmon fruits (*L/W, L/M, L/D_g, L/ϕ* and *L/V*) were significant. The coefficient of static friction was greater on plywood as compared to the chipboard and galvanized metal surfaces.

2. The projected areas along X-axis were lower than along Y-axis. The skin colour characteristics of persimmon fruit such as *L*, a*, b** were lower than the flesh, core and the two sides of fruit cores section.

3. Total soluble solid content, titratable acidity, pH were similar to the findings of previous reports, whereas, persimmon cv. Fuyu was characterised by higher contents of total polyphenols and a higher antioxidant potential relative to the values reported in the literature.

4. Flesh firmness is an important criterion to maintain quality during the postharvest period. The skin and flesh firmness of persimmon fruits punctured along Y-axis were higher than Y- axis.

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