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Changes in sugars, acids and fatty acids in naturally parthenocarpic date plum persimmon (*Diospyros lotus* L.) fruit during maturation and ripening

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Abstract The date plum persimmon fruit (*Diospyros lotus* L., fam: Ebenaceae) is cultivated throughout northern of Turkey for its edible fruits. Sugars and organic acids were measured during fruit maturation and ripening using HPLC. The analyses showed that fructose and glucose were the main sugars accumulated in the fruit pulp. Fructose and glucose increased up to 43,552.8 mg. 100 g^{-1} fw and 35,450.8 mg.100 g^{-1} fw respectively during fruit ripening. Sucrose content remained relatively low and decreased during ripening. The major organic acids found in date plum fruit were citric and malic acids, which increased through the immature and midripe maturity, and then the levels decreased in the overripe fruit. Palmitic acid (16:0), palmitoleic acid (16:1), stearic acid (18:0), oleic acid (18:1) and linolenic acid (18:3) were among the major fatty acids determined by GC throughout the maturation and ripening of the fruits. The levels of these fatty acids were found to be significantly different (P=0.05) between the three maturity stages. The fruits displayed the level of linoleic acid (0.7%) in low and α-linolenic acid (17.8%) in higher quantities, and the combined levels of linoleic and α-linolenic acid comprised ~19% (120.1 $\mu g.g^{-1}$ dw) of the total fatty acid content in the over ripened fruit. These results show that naturally parthenocarpic date plum fruits have high levels of sugars and organic acids and moderate levels of fatty acids that significantly changed during maturation and ripening. This information can be used by nutritionalists and food technologists to improve the nutrition of local people and develop food products that would be beneficial to human health.

Keywords *Diospyros lotus* · Date plum persimmon fruit · Parthenocarpy · Sugars · Acids · Fatty acids · Ripening

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Introduction

The genus *Diospyros* L. (fam: Ebenaceae) which comprises two species (*D. lotus* L. and *D. kaki* L.) is native in Balkans, Caucasia to China and Japan where the date plum persimmon (*D. lotus* L.) is native and naturalized. In Turkey, date plum persimmon is widely cultivated throughout northeast and southeast Anatolia for its edible fruits. The fruits of date plum persimmon is yellow or bluish-black. The globose fruits ranges between 1.5 and 2 cm in diameter [1]. In contrast to the Japanese persimmon (*D. kaki* L.), the date plum persimmon fruit is consumed as the fruit overripes or largely as dried form in the winter season.

Knowledge of the qualitative and quantitative distribution of the characteristic sugars and organic acids in fruits or fruit products is an important aspect of product

quality. Free sugars, organic acids and fatty acid esters are among the natural components of many fruits and vegetables that play an important role in determining their nutritive value [2].

The effects of maturation and ripening on the composition of free sugars, organic acids, and lipid compositions have been extensively studied in many important fruits such as strawberry [2], persimmon [3] and apple [4]. These changes are caused by a series of concerted biochemical and physiological processes [5]. Understanding the changes in fruit phytochemistry during maturation and ripening will help in improving the quality and nutritional content of fruit. The date plum can have drupe (seeded fruits) and parthenocarpic (seedless fruits) either on the same tree or on separate trees. The parthenocarpic date plum has mature fruits that range from 1to1.5 cm in diameter and are less juicy than the drupe type. Because of the abundance of seeds in drupe fruit, the natural parthenocarpic fruits are more preferable for consumption.

The fruit chemical composition of the drupe (non-parthenocarpic) date plum persimmon—free sugars [6] in sun dried, non-volatile [7] and phenolic [8] acids in fruits during development and maturation by GC/GC-MS have been previously reported. In fact, both very large and juicy persimmon (*D. lotus* L. and *D. kaki* L.) fruits contain 1–10 large flattened seeds [1]. Our observation have revealed that date plum persimmon fruit tree has naturally parthenocarpic forms in its natural habitats in rare cases, and the parthenocarpic fruits are preferred for harvesting and consumption among the people who live in these regions. The cultivation and preferential consumption of naturally parthenocarpic date plum fruit have necessitated the study of the compositions of the main nutrients in the fruit. The aim of this work was to asses sugar and organic acid profile of this naturally parthenocarpic date plum persimmon (*D. lotus*) fruit by the simple and rapid HPLC method. We also report free fatty acid composition of the fruit lipid using a large scaled fatty acid standard by GLC.

Materials and methods

Fruit material

Naturally parthenocarpic date plum (*Diospyros lotus* L.) fruits were harvested in 2002 from fourteen 30–35-year-old trees around Trabzon, in northeast Anatolia, Turkey (500–600 m over sea level). Fruits were harvested at seven different maturation stages (Table 1). Fruits were harvested on 258 (15 September), 278, 285, 292, 299, 306 and 313th (9 November) day of the year (DOY). At each harvest 0.5 kg fruits were gathered in triplicate from all 14 trees. Fruits were harvested in the early morning and maintained below 12 °C till they were in the laboratory. In the laboratory, all fruits were immediately weighed frozen in liquid nitrogen, and then used for analyses.

Sugar and organic acid extraction

Ethanolic extracts of sugars and organic acids were prepared from freshly harvested fruits. Ten gram fresh fruit sample from randomly chosen six fruits were weighed and treated with liquid N_2 for 5 min and blended in the dark with 95% ethanol for 3–5 min, at the maximum speed of a blender. The homogenate was vacuum-filtered through Whatman No. 1 filter paper and the residue was washed three times with 80% ethanol. The filtrates were combined and adjusted to 5 $ml.g^{-1}$ of fresh weight (FW) with ethanol [9].

HPLC analysis for sugars and organic acids

Sugars and organic acids were analyzed in a Hewlett-Packard 1090 liquid chromatograph equipped with a photodiode array detector (HPLC-DAD) and a Waters 410 differential refractometer (Millipore) connected in series. Data were processed by means of Hewlett-Packard 85-B computing system and a Beckman Analogue Interface Module 406 and a Gold V.711 software, respectively. Isocratic separations of the compounds were made on a stainless steel Ion-300 (300 mm × 7.8 mm, 10 μm column), containing a cation-exchange polymer in the ionic hydrogen form, with an IonGuard GC801 guard column (Interaction, San Jose, CA), and thermostated at 23 °C. The mobile phase utilized for the elution consisted of a filtered (0.22 μm nylon) and degassed solution of 0.0085N H_2SO_4 and a flow rate of 0.4 $ml.min^{-1}$. UV detection at 195 and 245 nm, the refractive index detector was used at sensitivity setting 16×, and the injection volume was 20 μl [9].

Lipid extraction

Samples of finely ground powder of mesocarp (1 g) in triplicate were weighed and extracted with chloroform:methanol (2:1, v/v) [10] and a saline (NaCI, 0.9%) was added at a rate of 20% of the extraction volume. The mixture was shaken and centrifuged (IEC HN-SII Benchtop Centrifuge, International Equipment Company, Needham Heights, MA, USA) at 1000 rpm for 5 min to allow phase development. The bottom (organic) layer was collected and filtered. The total extracted lipid material was recovered after the solvent was removed in a stream of nitrogen. The samples were dissolved in anhydrous chloroform. Sixteen microgram of triheptadecanoin (containing three molecules of heptadecanoic acid; 17:0) and a 0.1 ml aliquot of the lipid sample were transferred to a 15 ml teflon-lined screw tube. Fatty acid methyl esters were obtained using 14% (w/v) boron trifluoride (BF_3) in methanol [11]. After removing the solvent in nitrogen gas, the sample was mixed with 0.5 ml of the BF_3 reagent and placed in a warm bath at 100 °C for 30 min. After cooling, saline (NaCI, 0.9%) and hexane were added and the fatty acids methyl esters were extracted into hexane. A mixture of known fatty acid methyl ester standards was used to calibrate the gas chromatograph and to identify the fatty acid methyl ester peaks.

Gas chromatography of fatty acid methyl esters

Aliquots (1–2 μl) of the hexane solution containing the fatty acid methyl esters were analyzed using a Hewlett-Packard 5890 Series II gas chromatograph (Hewlett-Packard, Palo Alto, CA) equipped with a fused-silica capillary column (Omegawax; 30 m × 0.32 mm i.d., Supelco, Bellefonte, PA) and a flame-ionization detector. The injector temperature was set at 200 °C, detector at 230 °C, oven at 120 °C initially, then 120–205 °C at 4 °C min^{-1}, and then held at 205 °C for 18 min. The carrier gas was helium (99.999%) and the flow rate was approximately 50 $ml.s^{-1}$. Electronic pressure control in the constant flow mode was used. The fatty acids were reported as the average of three determinations conducted on three independent assays. The internal standard (heptadecanoic acid, 17:0) and a calibration mixture of fatty acid standards (GLC-68, Nu-Check, Elysian, MN, USA) were used to identify and quantify the fatty acids in the various lipid extracts [12].

Table 1 Sugar and organic acid composition (mg.100 g^{-1} fw) of naturally parthenocarpic date plum persimmon (*D. lotus* L.) fruit at various stages of maturation and ripening. [Analysis of variance was used for comparisons. Means in rows followed by different letters on superscript are significant at P=0.05[a]

Compounds	Immature			Midripe		Ripe	
	258*	278	285	292	299	306	313
Sucrose	393.3 c (±30.6)	300.6 b (±26.6)	370 c (±27.3)	243.8 a (±19.7)	379.5 c (±36.6)	284.4 ab (±16.2)	296 b (±6.9)
Glucose	13,491.3 a (±84.1)	21,046.9 b (±63.1)	23,804.5 c (±175.4)	27,686.8 d (±119.6)	35,408.8 g (±180.3)	28,081.4 e (±11.3)	30,319.4 f (±7.1)
Fructose	15,289.3 a (±79.4)	23,371.7 b (±39.2)	28,074.8 c (±96.1)	34,140.6 e (±53.2)	43,552.8 g (±55.8)	33,855.2 d (±35.1)	34,529.5 f (±82.1)
G/F	0.9 b (±0.0)	0.9 b (±0.0)	0.9 b (±0.0)	0.8 a (±0.0)	0.8 a (±0.0)	0.8 a (±0.0)	0.9 b (±0.0)
Σsugar	2,917.4 a (±96.1)	4,419.2 b (±88.7)	52,249.8 c (±160.7)	62,071.2 d (±123.7)	79,383.1 f (±132.7)	62,220.1 d (±11.7)	65,144.9 e (±95.5)
Citric acid	610.3 a (±10)	1,035.3 c (±14.3)	1,082.9 c (±2.7)	1,018 c (±88.2)	1,915.6 e (±78.9)	1,209 d (±5.5)	930 b (±26.5)
Malic acid	464 a (±3.5)	1026 d (±22.5)	1,503.5 f (±35.3)	1,445.9 f (±67.9)	1,361.2 e (±14.8)	929.4 c (±59.3)	589.2 b (±58.9)
MA/CA	0.8 b (±0.1)	1 c (±0.0)	1.2 d (±0.0)	1.4 d (±0.1)	0.7 b (±0.0)	0.8 b (±0.1)	0.6 a (±0.1)
Σacid	1,074.3 a (±11.6)	2,061.4 c (±20.1)	2,586.4 d (±32.9)	2,463.9 d (±149.4)	3,276.7 e (±93.5)	2,138.5 c (±58.3)	1,519.2 b (±84.2)

Notes: G/F; Glucose/fructose ratio. Σsugar is the sum of sucrose, glucose and fructose. MA/CA; malic acid/citric acid ratio. Σacid is the sum of citric and malic acid

[a] Values, means of three independent extractions and determinations for each sampling (n=6)

* Days of year (DOY)

Statistical analysis

A completely random experimental design was run in triplicate for each development stage. The data presented are the means of three separate extractions and determinations. Data on free sugars, organic acids, and fatty acids compositions were evaluated by analysis of variance, using the general linear procedure, a package program of the Statistical Analysis System (SAS Institute Inc., Cary, NC, USA). Duncan's Multiple Range Test was employed to determine the statistical significance of differences among the means. All comparisons were made at 5% (P=0.05) level of significance.

Results and discussion

The levels of free sugars, organic acids and fatty acids in naturally parthenocarpic date plum fruit varied significantly (P=0.05) during maturation and ripening. A 55-day of fruit maturation period was constituted beginning from 258 to 313 DOYs at 20-day intervals between 258 and 278 DOYs and seven-day intervals through 278 to 313 DOYs. The state of fruit maturity ranging between 258 and 285 DOYs was characterized unripe, 292 and 299 was midripe, 306 and 313 was ripe and overripe, respectively. Our observations shown that as the fruit maturation progressed, the greenish pulp of unripe fruit at earliest (258 DOY) state changed into brownish-blackish in the ripe and overripe fruits of date plum persimmon at the stages where the fruits are consumed by the local people in the region.

Effect of ripening on sugar composition

Sucrose, fructose and glucose were the three major soluble sugars in naturally parthenocarpic date plum fruits. Glucose and fructose levels were at high levels in the mid-late stages of fruit maturation and ripening. The level of sucrose remained relatively low during maturation, although in fruits at immature maturity (258 DOY), the fruits had 393 mg sucrose.100 g^{-1} fw. Glucose content in the immature fruit of date plum was 13,491 mg. 100 g^{-1} fw at 258 DOY, and the content increased gradually to its highest level (35,450.8 mg.100 g^{-1} fw) towards to the end of October (Oct 26 at 299 DOY). However, when the fruits reached to overripe maturity, the level of glucose was 30,319 mg.100 g^{-1} fw at 313 DOY. The unripe fruit contained the lowest level of flesh fructose (15,289 mg.100 g^{-1} fw) at 258 DOY, and then the level increased continually through the maturity, reaching a maximum level of 43,552.8 mg.100 g^{-1} fw at 299 DOY in the midripe fruit. Similar to glucose, the overripe (313 DOY) fruit had lower levels of fructose 34,529 mg.100 g^{-1} fw than that of the ripe (306 DOY) fruit. The glucose/fructose (G/F) ratios did not remarkably change during maturation and ripening (Table 1), although significantly (P=0.05) varied between 292 and 306 DOYs.

Total sugar content (as the sum of individual sugars) significantly increased (P=0.05) from 258 DOY, reaching a maximum at 299 DOY (79,383.1 mg.100 g^{-1} fw). The levels of total sugars then declined in over-ripe fruit (Table 1).

Soluble sugars have an important role in the sensorial properties of fruits and also contribute to their nutritive

value. The compositional trends of free sugars during fruit development, maturation and ripening have been characterized in many fruits. Senter et al. [3] reported an increase in both fructose and glucose levels throughout fruit development and maturation in several Japanese persimmon cultivars, although it seemed to be cultivar specific. For example cv. 'Kijiro' had fairly constant levels of sugar during ripening, while cv. 'Fuyu' increased from 9 to 24 g.100^{-1} fw (from immature to rioe stage). However, in this experiment, the naturally parthenocarpic persimmon fruit displayed a continual increase in the level of glucose and fructose until the ripe stage at which the fruit was moderately soft. These levels remained low through the late stages of ripening (306 and 313 DOYs). The sucrose levels were fairly low throughout maturation and ripening period.

Effect of ripening on organic acid composition

The major organic acids of parthenocarpic date plum fruit were malic and citric acids, which significantly changed during maturation and ripening. The level of citric acid reached its maximum on 29 DOY, while malic acid peaked at 285 DOY. Following these peaks, the levels of organic acids declined with ripening.

The ratio of malic to citric acid (MA/CA) increased until 292 DOY and then declined with ripening and maybe it is a criterion for the separation of immature and ripe fruit during fruit maturation of date plum. Total acid content (sum of the individual organic acids), peaked at 285 DOY and then the content gradually declined, except the level at 299 DOY, remaining low in the ripe fruit (1,519.2 mg.100 g^{-1} fw) (Table 1).

The nature and the concentration of organic acids are important factors influencing the organoleptic properties of the fruit [13]. In general, Japanese persimmon fruits showed an increase in their malic acid contents and a decrease in citric acid content during maturation (except cv. 'Ichi Kijiro' and 'Aizumi' in which the citric acid content remained constant during development) [3]. In this study, we have shown that a steady increase was determined in the levels of both citric and malic acids from immature fruit through a peak, then significantly declinies in the overripe fruit. This was also observed by Senter et al. [3] in Japanese persimmon in which the same acids were also determined in lower quantities in ripe fruits than in the immature and mid-ripe fruits.

Malic acid, a key intermediate in CAM metabolism, is also a substrate in respiration and is one of the most abundant organic acid found in fruits [14]. In some fruits such as tomatoes, apples, grapes, and pears, malic acid accumulates in the first developmental stage then decreases by about 50% during ripening due to respiration [15–17]. This may also occur in date plum fruits during ripening. Similarly, Senter et al. [3] also showed that the decline in the level of malic acid during maturation and ripening in Japanese persimmon can be attributed to the increase in respiration during ripening.

Effect of ripening on fatty acid composition

Eighteen different fatty acids in date plum fruit were determined during the maturation and ripening period (Table 2). Palmitic acid (16:0), palmitoleic acid (16:1), stearic acid (18:0), oleic acid (18:1) and linolenic acid (18:3) were among the major fatty acids quantified and (P=0.05) changed significantly throughout fruit maturation and ripening. The levels of palmitic acid, oleic acid (plus 18:1n-9 and 18:1n-7) and linolenic acids generally increased during maturation. The levels of palmitoleic acid (3.5 μg.g^{-1} dw) rapidly increased from the most immature fruit at 258 DOY and then increased to reach its maximum in the overripened fruit (207 μg.g^{-1} dw). Stearic acid remained relatively stable, although it reached its highest level (25 μg.g^{-1} dw) at the first stage of ripe maturity. The levels of linoleic acid in maturing and ripening fruit were relatively stable in midripe fruits.

The total levels of minor fatty acids (C12:0, C14:0, C14:1, C15:0, C20:0, C20:1n-9, C20:2n-6, C20:3n-3, C22:0, C22:1n-9 and C24:0) were added and reported as 'Other Acids' in Table 2. This data show that the highest levels of these fatty acids were ~46 μg.g^{-1} dw in the mid ripe and ripe fruits. Figure 1 illustrates the total fatty acids (as the sum of all individual fatty acids), saturated and unsaturated fatty acid in date plum fruit during maturation and ripening. The results show significant (P=0.05) changes during maturation and ripening, especially with the transition in fruits at the midripe and ripe fruits (292–313 DOY).

Fruits have characteristic fatty acid compositions and profiles during development and ripening. In general, the C16:0 (palmitic acid), C16:1 (palmitoleic acid), C18:1 (oleic acid), C18:2 (linoleic acid) and C18:3 (linolenic acid) are the most predominant and abundant fatty acids in fruits during the development, maturation and ripening process, but generally, the levels and proportions of these acids depend on the type of fruit.

The relationship between human diet and the increasing frequency of lifestyle diseases among the populations in industrialized countries is clear [18]. Omega-3 (n-3) fatty acids are essential for human diet [19, 20]. In addition to the polyunsaturated fatty acids, linoleic acid (C18:2n-6) and α-linolenic acid (C18:3n-3), have been shown to be essential for the human diet but they cannot be synthesized *in vivo* [20, 21]. This study has shown that there are low levels of linoleic acid (0.7%) and higher levels of α-linolenic acid (17.8%), of the total fatty acid content in date plum fruit. The combined levels of these two acid consisted of ~19% of the total fatty acid content (120 μg.g^{-1} dw) in the overripened fruits of naturally parthenocarpic persimmon fruit. In addition, the fatty acids, 16:1 (207 μg.g^{-1} dw, 34%), 16:0 (113 μg.g^{-1} dw, 19%) and 18:1 (109 μg.g^{-1} dw, 18%) acids were present individually in higher proportion than that of linoleic acid (C18:2n-6) and α-linolenic acid (C18:3n-3) levels in the overripe fruits harvested in November. These acids may play roles similar to linoleic and α-linolenic acid by using conversion reactions to maintain homeostasis in the hu-

Table 2 Fatty acid composition ($\mu g.g^{-1}$ dry wt) of naturally parthenocarpic date plum persimmon (*D. lotus* L.) fruit. Results are expressed as the means ±SD of three separate extractions and determinations. For comparisons among the means analysis of variance was used. Means in rows followed by different letters are significant at P=0.05[a]

Fatty acid	Immature			Midripe		Ripe	
	258*	278	285	292	299	306	313
12:0	ND[b]	0.2±0.0 a	ND	0.3±0.1 ab	0.3±0.0 a	ND	0.4±0.0 b
14:0	1.5±0.1 a	4.9±0.4 b	3±0.6 ab	8.7±0.5 c	7.3±1.5 c	11.4±1.8 d	14.6±0.4 e
14:1	0.7±0.0 e	0.2±0.0 b	ND	0.2±0.0 a	0.5±0.0 d	0.5±0.0 d	0.4±0.0 c
15:0	0.8±0.0 c	0.4±0.0 a	0.7±0.1 bc	1.4±0.0 d	0.4±0.0 a	0.5±0.1 ab	2.5±0.1 e
16:0	17.8± 2.2 a	40.8±2.3 b	32.5±8.0 b	63.1±0.9 c	66.3±5.4 c	72.3±6.8 c	113±2.9 d
16:1	3.5±0.5 a	32.5±1.9 b	35.3±9.8 b	93.7±2.9 c	103.3±1.6 c	136±2.4 d	207.2±9.8 e
18:0	15.2±1.4 ab	14.6±0.3 b	10.3±1.5 a	18.4±0.1 b	17.7±0.8 ab	25.1±2.7 c	17.1±0.0 ab
18:1n-9	11.6±1.8 cd	9.3±0.1 bc	5.6±0.4 a	7.5±0.1 ab	9.0±2.2 bc	11±0.6 cd	12.1±0.1 d
18:1n-7	5.8±1.1 a	25.3±1.2 b	24.3±6.6 b	51.1±0.1 c	60.4±0.2 d	62.9±1.7 d	96.9±2.7 e
18:2n-6	6.3±0.9 b	9.7±0.4 c	3.9±1.2 a	4.0±0.1 a	3.6±0.4 a	3.3±0.3 a	4.4±0.1 a
18:3n-3	18.8±2.7 a	69.5±2.7 c	48.3±1.2 b	74.7±2.1 c	80.4±1.3 c	79.1±1.2 c	108±5.1 d
20:0	1.2±0.3 a	2.5±0.0 b	3.1±0.7 b	4.7±0.0 c	4.7±0.0 c	5.2±0.9 c	8.8±0.2 d
20:1n-9	0.4±0.1 a	0.9±0.2 cd	0.4±0.0 a	0.5±0.0 ab	0.7±0.1 bc	1.1±0.2 d	0.5±0.0 ab
20:2n-6	0.1±0.0 a	0.4±0.1 c	0.1±0.0 a	0.3±0.0 b	0.2±0.0 b	0.0±0.0 a	0.2±0.0 b
20:3n-3	0.7±0.1 a	1.0±0.3 ab	0.8±0.3 a	1.5±0.0 bc	1.9±0.1 c	1.4±0.4 b	1.5±0.0 bc
22:0	1.7±0.4 a	2.1±0.1 a	2.0±0.2 a	4.0±1.7 abc	5.5±2.3 bc	3.3±0.1 ab	5.9±0.1 c
22:1n-9	3.3±0.6 ab	2.9±0.0 a	2.5±0.2 a	3.0±0.5 a	3.6±0.9 ab	4.4±0.7 b	2.9±0.4 a
24:0	13.3±2.4 b	5.7±0.3 a	6.5±1.2 a	6.4±0.7 a	6.8±0.2 a	5.5±0.1 a	7.9±0.2 a
∑Other acids	23.7	21.2	19.1	43.6	31.9	33.3	45.6

* Days of year (DOY)
[a] Values, means of three independent extractions and determinations for each sampling (n=6)
[b] ND; not detected

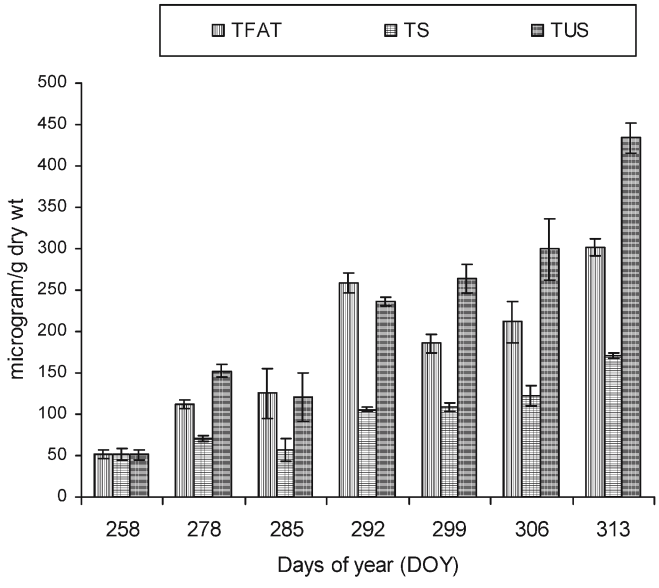

Fig. 1 Changes in the total fatty acid (TFAT), saturation (TS) and unsaturation (TUS) of naturally parthenocarpic date plum persimmon (*D. lotus* L.) fruit during maturation and ripening. The *bars* on the graphs indicate mean ± SD

man body [20, 21]. Even though the levels of these two essential fatty acids are not as high as those in other well-known sources such as olive oil, consuming ripe date plum would significantly contribute to the polyunsaturated fatty acid requirement in the diet.

The methodology used in this study for the separation of both sugars and organic acids in a single injection was adapted from Pérez et al. [3]. This analytical HPLC method was fairly simple and was found to be reliable.

The importance and benefits of Japanese persimmon fruit (*Diospyros kaki*) in human consumption have been attributed to the hypocholesterolemic and antioxidant effects of the fruit [22]. Gorinstein et al. [22–24] have suggested that the antioxidant effect of this fruit is of mainly due to its phenolics. Phenolics can exert an antioxidant effect and prevent development of atherosclerosis [23, 25, 26]. The same effects may be attributed to the date plum fruit. It is well known that the ripening process of both persimmon fruits (*D. kaki* and *D. lotus*) continues during overripening on the trees and after harvest [8, 23]. This physiological process leads to significant changes in the phytochemistry of these fruits, especially on the fruit phenolics. Gorinstein et al. [23] showed significant changes in the phenolic profile of ripening Japanese persimmon (*D. kaki)* and similar changes have been previously reported in drupe (seeded) fruits of persimmon (*D. lotus*) during fruit development [8]. This is the first report on the nutritional content of naturally parthenocarpic date plum fruit.

The inherent absence of seeds in parthenocarpic date plums significantly aids the ease of consumption and processing. Hence, further research on the chemical composition of this fruit for other nutritional information should enable horticulturalists and food technologists to select parthenocarpic date plums with improved nutritional quality. This information will assist food technologists and nutritionalists in recommending the fruit largely for human consumption directly or as additives in food products due to its high sugar content or acids. However, more investigations similar to those conducted

with the Japanese persimmon which has shown the major hypocholesterolemic and antioxidant effects of persimmon fruit [22–24] need to be conducted with the date plum (*D. lotus* L.).

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