GIDA (2017) 42 (2): 155-162
doi: 10.15237/gida.GD16062

Research / Araştırma

FATTY ACID PROFILES AND MINERAL CONTENTS OF WALNUTS FROM DIFFERENT PROVINCES OF VAN LAKE

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Received / Geliş Tarihi: 09.06.2016
Received in revised form / Düzeltilerek Geliş Tarihi 02.09.2016
Accepted / Kabul Tarihi 10.10.2016

Abstract

In this study some physical and chemical properties of walnut genotypes grown in 5 different regions around Van Lake (Eastern Anatolia) harvested during ripening period have been determined. The average kernel ratios of ripe fruits from Adilcevaz, Ahlat, Edremit, Çatak and Hakkari found to be 45.7, 45.0, 42.2, 43.1 and 38.4%, respectively. The oil contents of fruits considerably increased during ripening and ranged between 65.7 and 70.7% in ripe walnuts. Linoleic acid was the most abundant fatty acid in walnut followed by oleic acid. The unsaturated fatty acids contents of samples remarkably increased during ripening. The tocopherol contents of walnuts considerably increased during ripening. The initial and final total tocopherol contents of samples varied between 8.3-18.5 and 121.9-135.4 mg/100 g oil, respectively. Potassium was the most abundant mineral in ripe walnuts followed by Mg and Ca. The results showed that these genotypes were promising walnut types and selection researches should be carrying out to produce standard walnut types from this genotypes.

Keywords: Walnut, fatty acid composition, tocopherol, minerals.

VAN GÖLÜ ÇEVRESİNDEKİ FARKLI BÖLGELERDEN ELDE EDİLEN CEVİZLERİN YAĞ ASİDİ BİLEŞİMLERİ VE MİNERAL İÇERİKLERİ

Özet

Bu çalışmada olgunlaşma süresince Van Gölü çevresinde yer alan 5 farklı bölgeden temin edilen ceviz genotiplerinin bazı fiziksel ve kimyasal özellikleri belirlenmiştir. Adilcevaz, Ahlat, Edremit, Çatak ve Hakkari'den temin edilen olgun cevizlerin ortalama iç oranları sırasıyla, %45.7, 45.0, 42.2, 43.1 ve 38.4 olarak bulunmuştur. Olgunlaşma süresince cevizlerin yağ içerikleri önemli oranda artmış ve olgun cevizlerde yağ içeriği %65.7 ile %70.7 arasında değişmiştir. Cevizlerde baskın yağ asidi linoleik asit olurken, onu oleik asit takip etmiştir. Örneklerin doymamış yağ asidi içeriği olgunlaşma süresince belirgin düzeyde artmıştır. Cevizlerin tokoferol içerikleri de olgunlaşma süresince önemli ölçüde artmıştır. Örneklerin başlangıç ve son toplam tokoferol içerikleri sırasıyla, 8.3-18.5 ve 121.9-135.4 mg/100g yağ arasında değişmiştir. Olgun cevizlerde baskın mineral potasyum olurken onu sırasıyla, Mg ve Ca izlemiştir. Elde edilen sonuçlar, 5 farklı bölgeden elde edilen genotiplerin ümitvar ceviz tipleri olduğunu ve bu genotiplerden standart ceviz çeşitlerinin oluşturulması için seleksiyon çalışmaları yapılması gerektiğini göstermiştir.

Anahtar kelimeler: Ceviz, yağ asidi bileşimi, tokoferol, mineral.

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INTRODUCTION

Turkey is one of the leading countries in walnut production. The agricultural statistics data shows that Turkey is in the forth rank in walnut production after China, Iran and United States (1). Walnut is naturally spread in many regions in Turkey, especially in East Anatolia (Bitlis, Van and Hakkari) (2). Walnut fruit is generally used as a dried nut, and also added to several food formulations for its nutty flavour. Walnut is a rich source of oil, minerals and tocopherols. It has a high oil content which can vary from 59 to 72% depending on the cultivar, location and irrigation rate (3, 4). Walnut is well known because of its high polyunsaturated fatty acids (PUFA) content. Major fatty acid of walnut is linoleic acid (52.2-60.2%), followed by oleic (16.3-29.7%), linolenic (8.8-15.2%), palmitic (5.3-7.2%) and stearic acid (1.8-2.7%). PUFA (C18:2 and C18:3) is the main group of fatty acids in walnut oil, ranging from %61.8 to 75.3% (4). It is known that higher intake of PUFA decrease the risk of coronary heart disease by reducing blood pressure, total and LDL cholesterol (5). However, high PUFA content limits the shelf life of walnuts due to susceptibility of PUFA to oxidation. Oxidation results an undesirable rancid taste, and is the most important quality parameter decreasing economic value of walnut (6). On the other hand, walnut has rich antioxidant content. Walnut has the highest tocopherol content among popular seeds and fruits. High tocopherol content protects walnut oil against oxidation and also has some positive health effects (7, 8). Tocopherol contents of five different walnut varieties grown in Turkey were analyzed by Bakkalbaşı et al. (9). The amount of α-, γ-, δ- and total tocopherol ranged from 9.7 to 14.1, 298.8 to 470.0, 10.1 to 26.0 and 321.3 to 505.3 mg/kg walnut, respectively. Vaidya and Eun (10) reported that α-, γ-, δ- and total tocopherol content of walnut oil was 15.3, 258.1, 41.5 and 314.9 µg/g oil, respectively. γ-Tocopherol was the major tocopherol isomer in walnut. Recently, several studies showed that γ-tocopherol detoxifies lipophilic electrophiles such as reactive nitrogen oxide species, possess anti-cancer and anti-inflammatory activity, and protects against cardiovascular disease (11, 12).

Walnut is also considered as a good source of mineral compounds. Walnut contains high amount of potassium, phosphorus and magnesium. Cosmulescu et al. (13) declared that K, Mg, Ca, Mn, Fe, Zn and Cu contents of different walnut cultivars grown in Romania ranged from 387.3 to 444.4, 264.7 to 272.3, 62.8 to 72.9, 10.5 to 18.1, 5.4 to 5.9, 3.2 to 4.1 and 2.9 to 3.5 mg/100 g, respectively. Mineral compositions of 20 promising walnut types selected from Bahçesaray (Van, Turkey) were also found to be 296-632 mg/100g for K, 64-118 mg/100g for Ca, 102-168 mg/100g for Mg, 266-539 mg/100g for P, 1.0-2.7 mg/100g for Cu, 1.9-5.1 mg/100g for Mn, 2.8-14.0 mg/100g for Fe and 2.0-4.4 mg/100g for Zn (14).

Walnut contains several important chemical compounds such as fatty acids, tocopherols and minerals that may affect nutritional and economic value of walnut. Fatty acid, tocopherol and mineral contents of walnut are influenced by several factors such as cultivar, origin, climate, applied cultural practice and harvesting time. In this study, some physical and chemical properties of walnut genotypes grown in some regions around Van Lake during ripening period have been investigated.

MATERIALS AND METHODS

Materials

In this study, for pomologic properties 5 promising walnut selections were collected from 5 different regions of Van Lake (Adicevaz, Ahlat, Edremit, Hakkari and Çatak). The oil contents, fatty acid compositions, total tocopherol and mineral contents of genotypes with the highest yield have been studied during ripening period (1st July, 15th July, 3rd August, 17th August and 25th September).

Fruit Characteristics

Pomological properties such as nut weight, kernel weight, kernel ratio, nut length, suture, diameter, shell thickness, shell roughness (easy, medium, hard), kernel colour (light, tawny, dark) and shell colour (light, tawny, dark) were determined in five matured walnut genotypes from each region (15).

Chemical Analysis

The oil, fatty acids and mineral contents of walnut samples were determined according to AOAC (16). For gas-chromatographic (GC) analysis, fatty acids methyl esters (FAME) were prepared by dissolving 0.4 g oil in 4 ml of isooctane and methylated in 0.2 ml 2 M methanolic KOH. FAMEs were analyzed in a Hewlett Packard 6890 series GC with split injection of 1:20, donated with Hewlett Packard 7673 auto-injector, Flame Ionization Detector (FID) and Chrompack CP-Sil 88 column (50 m x 0.25 mm ID, 0.2 µm film thickness) (Chrompack, Middelburg, The Netherlands). The column was operated isothermally at 177 °C. The injector and detector temperatures were 250 and 250 °C, respectively. He was used as carrier gas. FAMEs were identified by using Standard FAMEs (47885-U, Supleco, Bellafonte, PA) and were quantified according to their percentage area.

Minerals were determined directly in the ash solution (dry ashing at 550°C) by atomic absorption spectrometry (ATI Unicam-929). All reagents and samples were prepared in double distilled water. Standard mineral solutions were freshly prepared from 1000 ppm stock solutions and a linear calibration curve was used.

Chromatographic analyses for tocopherols were carried out using an Thermofinnigan HPLC system that consisted of an P4000 quaternary pump, AS3000 autosampler, SCM1000 degasser and UV6000 photodiode array detector. The method described by AOCS (Official Method No: Ce 8-89) was used for HPLC, with slight modifications (17). The extracted walnut oil (1 g) was diluted with HPLC grade *n*-hexane. Diluted oil was filtered through a syringe filter (0.45 µm polytetrafluoroethylene) and analyzed by HPLC. Separation of tocopherols was carried out using a Phenomenex normal-phase silica column (250 mm x 4.6 mm ID, particle size of 5 mm). The mobile phase was a mixture of *n*-hexane and isopropanol (99:1, v/v). Elution was performed at a solvent flow rate of 1 mL/min with an isocratic program. Detection was made at 295 nm and column oven temperature was 30 °C. The compounds appearing in chromatograms were identified on retention times and spectral data by comparison with standards (α-, β-, γ- and δ-tocopherol, Sigma-Aldrich Co.). Total tocopherol content was calculated in walnuts as sum of the tocopherol isomers. All the chemical analyses were performed in duplicate.

Statistical Analysis

Data from 5 replications for pomologic parameters and data from 2 replications for chemical analysis were analyzed by two-way analysis of variance using SPSS 20.0 for Windows program. Significance level was established at $P<0.05$.

RESULTS AND DISCUSSION

Fruit Characteristics

Nut weight, kernel weight, kernel ratio, nut length, suture, nut diameter, shell thickness, shell roughness, kernel colour and shell colour of 5 walnut genotypes from 5 region of Van Lake are given in Table 1. Different genotypes from each region showed different fruit characteristics. The average nut weight and kernel ratios of 5 walnut genotypes from Adilcevaz, Ahlat, Edremit, Çatak and Hakkari were 10.2, 9.8, 10.0, 8.8, 9.6 g and 45.7, 45.0, 42.2, 43.1 and 38.4%, respectively. Shell roughness, kernel colour and shell colour of walnut genotypes from Ahlat and Çatak were easy, light and light-tawny. The pomological parameters of ripe fruits from different regions of Van Lake did not show significant ($P>0.05$) difference (except nut length). Pomologic properties of samples tested in this study showed good correlation with data previously reported for the walnut genotypes grown in Turkey (15, 18).

Chemical Properties

Oil Content

The changes in oil contents and fatty acid compositions of walnuts harvested from 5 different regions in Van Lake during maturation are given in Table 2. The oil contents of samples considerably increased during maturation. The oil contents of walnuts harvested from Adilcevaz, Ahlat, Edremit, Çatak and Hakkari regions significantly increased from 8.2 to 69.6, 3.2 to 69.6, 8.9 to 65.7, 6.1 to 70.7 and 6.2 to 70.1%, respectively during 1st (initial) and 5th (final) sampling intervals ($P<0.05$). However, the difference among oil contents of samples from different regions found to be insignificant ($P>0.05$). Walnuts from Edremit

Table 1. Pomologic properties of walnut genotypes harvested from the Van Lake province (n=5)

Pomologic Properties	Regions of Van Lake				
	Adilcevaz	Ahlat	Edremit	Çatak	Hakkari
Nut Weight (g)	10.2±2.1	9.8±1.2	10.0±1.2	8.8±1.1	9.6±2.4
Kernel Weight (g)	4.7±1.3	4.4±0.5	4.2±0.7	3.8±0.5	3.7±1.3
Kernel Ratio (%)	45.7±8.6	45.0±4.6	42.2±9.4	43.1±2.5	38.4±6.3
Nut Length (mm)	35.0±2.2	38.0±4.2	35.9±2.2	31.2±2.7	32.6±3.6
Suture (mm)	29.5±4.4	29.8±0.7	29.9±2.2	28.1±1.5	30.4±2.3
Diameter (mm)	31.5±2.1	29.5±1.0	30.7±2.8	29.7±1.6	30.5±1.8
Shell Thickness (mm)	1.4±0.4	1.5±0.1	1.9±0.5	1.4±0.2	1.8±0.4
Shell Roughness	E-M	E	H	E	M-H
Kernel Colour	T	L	T-D	L	L-T
Shell Colour	T	L-T	L	L-T	L-D

Means± Standard Deviation
D: Dark, E: Easy, H: Hard, L: Light, M: Medium, T: Tawny.

(65.7%) showed the lowest and those from Çatak had the highest (70.7%) oil contents. Koyuncu et al. (19) reported that the oil contents of Yalova-1 and Yalova 2 genotypes regularly increased during ripening and reached to 65.9 and 65.5%, respectively. The oil contents of samples harvested from Ahlat, Hakkari and Çatak were higher than those of Yalova-1 and Yalova-2. The oil contents of different walnut varieties (Yalova-1, Yalova-3, Şebin, Bilecik and Kaman-5) grown in Turkey, harvested in 2004 and 2005 ranged from 61.2 to 72.6 % (4). The oil contents of Combe Persian and Lake Persian walnuts reported by Li et al. (20) were 59 and 61%, respectively.

Table 2. Fatty acid composition and total tocopherol contents of walnut samples collected from Van Lake province (n=2)

Region	Harvesting date	Total Tocopherol[1]	Oil (%)	Fatty acid methyl esters (%)					
				C16:0	C18:0	C18:1	C18:2	C18:3	SFA/UFA
Adilcevaz	July 1st	14.2±0.2	8.2±0.1	9.6±0.1	3.6±0.1	14.1±0.1	63.3±0.1	9.2±0.1	0.15±0.0
	July 15th	19.2±0.2	14.5±0.4	8.1±0.1	2.2±0.0	15.2±0.1	64.2±0.3	9.7±0.2	0.12±0.0
	August 3rd	49.7±0.6	42.2±0.3	6.9±0.1	1.9±0.1	25.0±0.1	60.1±0.1	7.2±0.1	0.10±0.0
	August 17th	102.7±3.1	53.0±1.1	5.2±0.1	1.1±0.1	28.7±0.2	55.8±0.2	9.8±0.1	0.07±0.0
	Sep. 25th	129.5±4.0	69.6±2.0	4.3±0.1	1.0±0.0	29.2±0.2	55.8±0.1	9.9±0.1	0.06±0.0
Ahlat	July 1st	8.3±0.1	3.2±0.0	9.8±0.1	3.8±0.1	16.8±0.1	56.8±0.2	12.3±0.1	0.16±0.0
	July 15th	14.2±0.3	12.4±0.2	7.5±0.1	2.6±0.1	18.3±0.1	60.0±0.2	12.4±0.1	0.11±0.0
	August 3rd	51.5±0.5	40.4±1.6	6.6±0.1	1.2±0.1	20.2±0.2	60.3±0.2	10.5±0.1	0.09±0.0
	August 17th	109.8±4.1	56.0±2.5	6.3±0.1	1.0±0.0	25.2±0.1	55.6±0.2	12.0±0.0	0.08±0.0
	Sep. 25th	130.2±5.0	69.6±2.4	5.1±0.1	1.0±0.0	29.8±0.1	52.0±0.3	12.7±0.2	0.07±0.0
Edremit	July 1st	18.5±0.8	8.9±0.3	8.1±0.1	3.9±0.1	18.5±0.0	60.1±0.2	9.1±0.1	0.14±0.0
	July 15th	28.4±0.4	15.2±0.5	8.0±0.1	2.8±0.1	20.1±0.1	58.7±0.2	9.8±0.1	0.12±0.0
	August 3rd	56.4±0.5	41.2±0.7	6.7±0.1	2.8±0.0	21.2±0.1	59.9±0.2	9.8±0.1	0.11±0.0
	August 17th	84.2±1.6	50.2±0.5	6.5±0.0	2.6±0.1	28.0±0.1	56.0±0.7	8.0±0.1	0.10±0.0
	Sep. 25th	121.9±2.7	65.7±1.4	5.9±0.1	2.4±0.0	29.8±0.0	52.9±0.2	9.7±0.1	0.09±0.0
Çatak	July 1st	12.2±0.3	6.1±0.1	8.7±0.1	3.9±0.1	11.8±0.1	60.0±0.7	8.7±0.1	0.16±0.0
	July 15th	18.6±0.5	12.9±0.4	7.5±0.1	2.9±0.1	14.1±0.0	63.0±0.2	12.5±0.1	0.12±0.0
	August 3rd	49.9±0.6	45.5±0.5	5.9±0.1	2.0±0.0	22.4±0.1	58.0±0.1	11.6±0.1	0.09±0.0
	August 17th	96.2±2.0	59.0±1.4	5.7±0.1	1.8±0.0	24.2±0.1	55.9±0.2	10.9±0.0	0.08±0.0
	Sep. 25th	135.4±4.2	70.7±0.9	5.7±0.1	1.6±0.1	24.3±0.1	55.5±0.4	13.1±0.1	0.08±0.0
Hakkari	July 1st	12.5±0.4	6.2±0.1	8.2±0.1	4.0±0.0	12.08±0.1	64.2±0.3	11.6±0.1	0.14±0.0
	July 15th	18.7±0.3	11.1±0.1	7.5±0.1	2.0±0.0	14.89±0.1	63.7±0.2	11.8±0.1	0.11±0.0
	August 3rd	56.3±0.3	48.2±0.5	6.7±0.1	1.6±0.0	18.16±0.1	64.7±0.2	9.0±0.1	0.09±0.0
	August 17th	112.8±2.8	51.2±0.6	5.9±0.1	1.7±0.0	25.88±0.2	56.7±0.3	9.7±0.1	0.08±0.0
	Sep. 25th	133.3±2.0	70.1±0.5	4.9±0.0	1.6±0.1	26.92±0.2	55.7±0.1	11.1±0.0	0.07±0.0

Means± Standard Deviation
[1] mg/100g oil.

FAME

The FAME profiles of walnut samples during maturation are presented in Table 2. Linoleic acid was the most abundant fatty acid found in walnut oil followed by oleic, linolenic, palmitic and stearic acids. While palmitic, stearic and linoleic acids showed decreasing trend during maturation, oleic acid increased throughout the ripening period. The linolenic acid contents of samples showed irregular change in a narrow range. Samples from Adilcevaz, Hakkari and Çatak showed higher linoleic acid contents than samples from Ahlat and Edremit. Walnuts from Çatak had higher linolenic acid contents (13.1%) followed by those from Ahlat and Hakkari (12.7 and 11.1%, respectively). The linoleic and linolenic acids contents of Yalova-1 and Yalova-4 genotypes were 58.2, 10.8% and 59.0, 10.8%, respectively (15). Doğan et al. (21) noted that the walnut genotypes contained 65.6% oil, 5.8% palmitic acid, 0.2% palmitoleic acid, 2.7% stearic acid, 18.7% oleic acid, 59.9% linoleic acid, 14.2% linolenic acid, 0.3% arachidic acid and 0.2% gadoleic acid. Among fatty acids only linolenic acid showed significant difference in samples obtained from different regions ($P<0.05$). The fatty acid compositions of samples significantly changed during ripening period ($P<0.05$).

The SFA/UFA which represents the total fatty acid composition of each sample as a single data showed decreasing trend throughout the maturation period (Table 2). The SFA/UFA ratios of walnut samples from Adilcevaz, Ahlat, Edremit, Çatak and Hakkari regions during ripening reduced from 0.15 to 0.06, 0.16 to 0.07, 0.14 to 0.09, 0.16 to 0.08 and 0.14 to 0.07, respectively. This shows that the unsaturated fatty acid contents of walnuts increased during ripening. Lower SFA/UFA may be evaluated as higher nutritional content regarding to fatty acid composition of food (22). The linoleic, oleic and linolenic acids contents and SFA/UFA ratios of walnuts from Erzincan (Eastern Turkey) reported by Özrenk et al. (23) varied between 43.2-53.2%, 26.2-38.6%, 8.9-15.1% and 0.08-0.10, respectively. Linoleic acid ranging from 43.2% to 53.2% was the most abundant fatty acid in 15 pomologically selected walnut genotypes grown in Erzincan (Eastern Turkey), followed by oleic and linolenic acids (31.9% and 11.5%, respectively) (23).

Total Tocopherol

Walnut has the highest tocopherol contents among popular seeds and fruits (24). Tocopherols and tocotrienols are fat-soluble antioxidants with vitamin E activity. Vitamin E is mainly consists of four tocopherols (α-, β-, γ- and δ-) and four tocotrienols (α-, β-, γ- and δ-). Vitamin E acts as an important antioxidant against oxidative modification of LDL, which is accepted as an initial event in pathogenesis of atherosclerosis (25). The total tocopherol contents of walnut samples are given in Table 2. The tocopherol contents of walnuts significantly increased during ripening ($P<0.05$). The initial and final tocopherol contents of samples varied between 8.3-18.5 and 121.9-135.4 mg/100 g oil, respectively. Samples from Çatak showed the highest tocopherol content followed by those from Hakkari. There were no significant differences ($P>0.05$) in tocopherol contents of ripe walnut samples harvested from different regions. The total tocopherol contents (α-, γ- and δ-) of walnut reported by Gunstone et al. (24) was 160.8 mg/100 g oil. The range of α-, γ- and δ-tocopherol for 15 promising walnuts noted by Özrenk et al. (23) varied between 1.8-6.8, 32.8-146.4 and 2.3-12.4 mg/kg oil, respectively.

Mineral Contents

The mineral contents of walnut samples showed irregular changes during ripening (Table 3.). The mineral contents of samples varied depending on their genotype, region and harvesting time. K was the most abundant mineral in ripe walnuts followed by Mg, Ca and Na. Minerals showed different trends during ripening. Some minerals increased, some reduced and others varied in a narrow range. In ripe fruits, those from Ahlat had the highest K and Zn contents (319 and 7.9 mg/100 g, respectively) and samples from Adilcevaz showed the highest Mg, Ca and Na contents (173, 143 and 16.9 mg/100 g, respectively). Samples from Adilcevaz showed the highest and those from Edremit had the lowest final Na contents. The Ca contents of walnuts reported by Lavedrine et al. (26) and Çağlarırmak (27) varied between 58-91 and 67-105.5 mg/100 g, respectively.

The Cu contents of ripe samples from Adilcevaz, Ahlat, Edremit, Çatak and Hakkari were 2.3, 2.4, 1.3, 2.1 and 3.2 mg/100 g, respectively. The Cu

contents for walnut reported by Lavedrine et al. (26) and Çağlarırmak (27) ranged between 1.1-1.5 and 0.5-1.3 mg/100 g, respectively. The Fe contents of ripe fruits varied between 2.6 and 8.4 mg/100 g. Walnuts from Ahlat showed highest and those from Adilcevaz had the lowest Fe contents. The Fe contents of walnuts from Adilcevaz, Edremit, Hakkari and Çatak agreed with the results reported by Lavedrine et al. (26) and Çağlarırmak (27). The Mn contents of ripe walnuts ranged between 3.3 and 6.0 mg/100 g. Co and Ni were the least abundant minerals in ripe walnuts varied between 0.1-0.6 and 0.2-0.6 mg/100 g, respectively. Except Cu, Fe and Mg, the other minerals contents of walnut samples from 5 regions of Van Lake were found significantly different (P<0.05). The mineral contents of walnut samples showed significant variation (P<0.05) during ripening period (except the Na content of samples from Çatak). Factors such as climate variations, soil type, agricultural practice or others may lead to seasonal variations in walnut composition.

CONCLUSIONS

Turkey is one of the leading countries in walnut production in the world. Walnut is a rich source of essential fatty acids and tocopherols. The data obtained in this study showed that the tested walnut genotypes have comparable properties to nationally and internationally selected kinds. Walnut genotypes with superior pomologic properties and compositions may be valuable for future nutritional breeding efforts.

Acknowledgment

The authors wish to thank The Yüzüncü Yıl University Research Fund (Project No: 2003-ZF-YL013) for the financial supports.

Table 3. Mineral compositions of walnut samples collected from Van Lake province (n=2)

Regions	Harvesting date	Minerals (mg/100g)				
		Ca	Co	Cu	Fe	K
Adilcevaz	July 1st	144.6±2.0	0.7±0.0	3.0±0.1	10.1±0.2	238.3±10.3
	July 15th	136.3±1.4	0.7±0.1	3.6±0.0	11.7±0.4	283.8±16.0
	Aug. 3rd	149.8±6.1	0.6±0.0	4.4±0.1	6.8±0.2	179.4±8.8
	Aug. 17th	130.4±5.5	0.3±0.0	3.0±0.0	7.5±0.5	204.3±6.4
	Sep. 25th	142.9±6.2	0.2±0.0	2.3±0.0	2.6±0.1	288.8±4.8
Ahlat	July 1st	91.2±2.7	Tr	4.9±0.1	7.8±0.1	255.9±8.1
	July 15th	93.3±4.8	Tr	5.7±0.0	11.9±0.2	242.8±1.0
	Aug. 3rd	115.8±3.4	0.2±0.0	4.0±0.1	9.1±0.4	202.4±5.9
	Aug. 17th	118.6±2.3	0.2±0.0	3.4±0.0	24.5±1.3	240.5±6.5
	Sep. 25th	134.4±5.4	0.6±0.1	2.4±0.1	8.4±0.9	319.4±5.1
Edremit	July 1st	141.3±7.1	0.2±0.0	5.6±0.1	19.4±0.9	198.2±7.6
	July 15th	162.3±3.8	0.3±0.0	5.3±0.1	20.4±0.3	207.7±3.0
	Aug. 3rd	150.8±5.7	0.3±0.0	2.5±0.1	11.3±0.8	240.3±4.0
	Aug. 17th	162.4±5.5	0.1±0.0	2.7±0.1	8.5±0.3	401.4±17.7
	Sep. 25th	115.9±5.2	0.3±0.0	1.3±0.1	3.9±0.0	306.6±5.8
Çatak	July 1st	138.5±4.2	0.5±0.0	5.4±0.3	12.6±0.5	103.9±3.0
	July 15th	144.8±7.3	0.5±0.1	4.8±0.2	10.7±0.8	126.4±6.9
	Aug. 3rd	146.9±6.7	0.6±0.1	4.5±0.4	10.4±0.3	211.4±10.8
	Aug. 17th	82.8±5.0	0.2±0.0	3.8±0.4	8.8±0.2	234.6±6.8
	Sep. 25th	101.0±5.5	0.3±0.0	2.1±0.0	4.2±0.3	251.4±4.0
Hakkari	July 1st	138.5±5.5	0.4±0.0	4.4±0.1	12.6±0.6	363.5±19.7
	July 15th	142.4±7.8	0.3±0.0	5.0±0.5	10.9±0.3	396.3±25.8
	Aug. 3rd	110.5±6.9	0.3±0.0	5.8±0.1	6.0±0.2	398.5±17.3
	Aug. 17th	101.5±2.3	0.4±0.0	3.6±0.1	3.8±0.1	262.3±18.1
	Sep. 25th	130.4±3.7	0.1±0.0	3.2±0.2	5.8±0.1	282.4±4.1

Means± Standard Deviation
Tr: Trace.

Table 3 Continued

Regions	Harvesting date	Minerals (mg/100g)				
		Mg	Mn	Na	Ni	Zn
Adilcevaz	July 1st	41.3±0.9	2.4±0.1	23.9±0.9	0.9±0.0	2.0±0.0
	July 15th	63.2±0.8	3.9±0.1	26.6±0.6	0.9±0.0	3.0±0.1
	Aug. 3rd	126.8±1.7	4.4±0.1	29.4±0.7	0.7±0.0	5.6±0.1
	Aug. 17th	175.8±1.8	3.8±0.0	37.7±0.5	0.4±0.0	5.1±0.1
	Sep. 25th	173.1±0.8	3.3±0.1	16.9±0.1	0.5±0.0	4.8±0.0
Ahlat	July 1st	70.9±3.8	4.1±0.1	10.0±0.1	0.1±0.0	3.1±0.1
	July 15th	90.3±4.1	3.6±0.2	8.8±0.4	0.2±0.0	3.4±0.0
	Aug. 3rd	130.8±4.5	3.8±0.1	9.2±0.3	0.2±0.0	4.5±0.1
	Aug. 17th	173.2±4.2	5.1±0.2	9.8±0.8	0.9±0.0	7.0±0.2
	Sep. 25th	143.8±5.0	3.5±0.1	8.7±0.3	0.2±0.0	7.9±0.3
Edremit	July 1st	166.4±4.5	2.5±0.1	8.1±0.3	0.4±0.0	4.7±0.2
	July 15th	178.2±3.3	4.5±0.1	7.6±0.1	0.4±0.0	5.8±0.1
	Aug. 3rd	158.7±2.1	5.5±0.2	7.3±0.3	1.0±0.1	7.3±0.4
	Aug. 17th	123.6±5.1	7.4±0.5	8.1±0.4	0.9±0.1	6.3±0.5
	Sep. 25th	118.3±1.1	4.1±0.2	5.4±0.2	0.4±0.1	4.7±0.3
Çatak	July 1st	96.6±5.8	5.6±0.2	9.2±0.6	0.7±0.1	5.2±0.3
	July 15th	123.2±6.2	5.9±0.2	8.9±0.5	0.7±0.0	6.5±0.2
	Aug. 3rd	136.4±6.8	7.5±0.4	8.6±0.3	0.8±0.0	6.5±0.3
	Aug. 17th	124.5±7.1	8.7±0.4	8.0±0.2	0.8±0.0	6.4±0.1
	Sep. 25th	117.5±3.7	6.0±0.5	8.4±0.1	0.4±0.1	5.9±0.1
Hakkari	July 1st	134.5±9.5	4.3±0.3	20.0±1.4	0.2±0.0	2.3±0.1
	July 15th	135.5±5.7	4.6±0.2	17.7±0.6	0.6±0.1	3.0±0.1
	Aug. 3rd	190.2±8.9	5.3±0.3	18.2±0.3	0.5±0.0	3.2±0.1
	Aug. 17th	179.4±11.2	7.0±0.3	11.5±0.1	0.8±0.1	2.8±0.1
	Sep. 25th	115.3±5.1	4.2±0.2	14.2±0.1	0.6±0.0	5.2±0.2

Means± Standard Deviation
Tr: Trace.

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