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Determination of Biochemical Properties and Fatty Acid Composition of New Walnut (*Juglans regia*) Genotypes

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Abstract: Walnuts (*Juglans regia* L.) of 14 new genotypes were selected according to late leafing time, fruit quality and high yield in native population in Niksar-Turkey. Crude protein, total oil and ash contents of walnut kernels ranged from 17.09-23.89 %, 62.80-73.05 %, and 1.36 %-2.20 % respectively. Phosphorous contents of kernels were found in the range of 230.65-344.40 mg 100 g^{-1}, potassium 163.92-308.86 mg 100 g^{-1}, sodium 7.94-22.53 mg 100 g^{-1}, copper 2.25-3.64 mg 100 g^{-1}, iron 2.21-4.32 mg 100 g^{-1}, zinc 1.97-5.48 mg 100 g^{-1}, manganese 0.91-4.39 mg 100 g^{-1}. Differences in chemical properties and fatty acid contents were determined. Polyunsaturated especially linoleic acid was found predominant. Oleic, linolenic, palmitic and stearic acids were other main fatty acids in oil of walnut kernels. Also, 13 different fatty acids were determined by at small quantities. Total PUFA content changed between 58.77 % and 77.39 %.

Keywords: Walnut, mineral contents, fatty acids

Yeni Ceviz Genotiplerinin Kimyasal İçerikleri ve Yağ Asitleri Bileşenlerinin Belirlenmesi

Öz: Geç yapraklanma, meyve kalitesi ve yüksek verim esas alınarak Niksar ceviz popülasyonundan 14 genotip seçilmiştir. İç cevizde ham protein, total yağ ve kül içeriği sırasıyla 17.09-23.89 %, 62.80-73.05 %, 1.36-2.20 % arasında belirlenmiştir. Fosfor içeriği 230.65-344.40 mg 100 g^{-1} arasında, potasyum içeriği 163.92-308.86 mg arasında, sodyum içeriği 7.94-22.53 mg arasında, bakır içeriği 2.25-3.64 arasında, demir içeriği 2.21-4.32 arasında, çinko içeriği 1.97-5.48 arasında, manganez içeriği 0.91-4.39 arasında tespit edilmiştir. Genotiplerin kimyasal içerikleri ve yağ asitleri kompozisyonları arasında farklılıklar belirlenmiştir. Çoklu doymamış yağ asitleri içinde linoleik asit dominant bulunmuştur. İç ceviz yağında, ana yağ asitleri oleik, linolenik, palmitik ve stearik asitlerdir. Ayrıca eser miktarlarda 13 farklı yağ asidi de tespit edilmiştir. Total ÇDYA içeriği % 58.77 ile % 77.39 arasında belirlenmiştir.

Anahtar kelimeler: Ceviz, mineral içerikleri, yağ asitleri

1. Introduction

Walnuts are accepted dense and rich foods since ancient times so that it was called '*Jovis glans'* in the meaning of fruit of god Jupiter. *Juglans regia* L. trees can be found the native in a wide area from central Asia, Iran to the eastern part of Turkey (McGranahan and Leslie 1990). Turkey is an important walnut producer country in the world (FAOSTAT 2014). In Turkey, kernel walnuts are used in bakery and confectionary in making bread, cakes, ice creams and especially 'baklava' production as important special food.

In the world today, some fruits like walnuts becoming popular due to their positive health effect. Health benefits of walnuts are generally attributed to their chemical composition. Depending on genetic of the tree and environmental factors walnuts generally contain 60 % oil, 12-19 % protein and 2-4 % ash, 65 % of this oil composed of polyunsaturated fatty acids (Savage et al. 2001; Savage 2001; Prasad 1994).

As well as containing omega 3 and omega 6 fatty acids, walnuts contain significant amounts of antioxidants such as vitamin E, vegetable

proteins, dietary fibers, vitamins B12, B 1, phytosterols, polyphenols, minerals such as phosphorous, potassium, magnesium, iron and copper (Pereria et al. 2008; Venkatachalam et al. 2006; Maguire et al. 2004; Amaral et al. 2003; Sze-Tao et al. 2000).

Although walnuts are rich in fat, a meaningful correlation between nut consumption and reduced incidence of heart and artery diseases has been reported in large epidemiological studies (Torobian et al. 2009). Regular walnut consumption shows the cardio protective effect and lowers blood total plasma cholesterol and low-density-lipoprotein (LDL) cholesterol levels. This positive health effect thought to be a result of high unsaturated fatty acid contents of walnut oil. Results of many researches support daily consumption of walnut in certain amounts (Torobian et al. 2009; Griel and Kris-Etherton 2006).

Oil content and fatty acid profile of walnut oil are also important for consumers that expect health benefits such as lowering blood LDL concentrations. Consumers of today have increasing interest on nutritional attributes and origin of fruits. Cultivars that show variation aspect of oil and high rate of stable fatty acids are also important for breeders.

Cultivar based and market survey analyses to demonstrate nutritive quality were implemented by researchers. Generally, proximate mineral contents and fatty acid composition of walnut cultivars or genotypes from different origins have been reported separately. But the production of wild or semi-cultivated trees that offered to markets or food industry has not been investigated. In this research main and important nutritional components and oil attributes of walnuts were investigated together for genotypes among wild and semi-cultivated walnut trees. In this study, 14 new selected walnut genotypes from important walnut production area of Turkey were characterized. The main aim of this study was to determine biochemical properties and fatty acid composition of new genotypes.

2. Materials and Methods

2.1. Plant material and preparation of samples

In this study, 14 new selected walnut genotypes were used. These genotypes were selected according to nut quality, late leafing time and tolerant to spring frost. Trees of genotypes were grown under natural rainfall (averaging 420 mm/year) and not fertilized. Nut samples were collected at optimum harvest dates. The nuts 5 kg per tree handpicked from the tree, after nuts were hulled, dried at 41 ± 2 °C approximately for two days and were shelled manually. The walnut kernels were put in plastic bags and frozen to -18 °C until the analyses.

2.2. Chemical Analyses

All chemical analyses were performed according to standard AOAC methods in duplicate. Dry and well-chopped walnut kernels were extracted with *n*-hexane in a Soxhlet apparatus for 8 hour and crude oil content was determined according to standard AOAC method (948.22). Crude protein of samples was determined by the Kjeldahl method of AOAC (950.48). Total protein contents were calculated as percent by using a conversion factor of 5.30. Ash of samples was determined by incinerating in a muffle furnace at 525 °C until white ash is obtained according to the gravimetric method of AOAC 950.49 (AOAC 1995). Phosphorous contents were determined according to AOAC method 986.24 by using UV spectrophotometer. Potassium, sodium, copper, iron, zinc and manganese contents of samples were determined by using flame atomic absorption spectrophotometer after ashing 1.0 g sample in a muffle furnace at 550 °C for 5-7 hours until a grey ash residue was obtained. Results reported as mg.100 g^{-1} (AOAC 1995).

2.2.1. Fatty Acid Analyses

All extractions were conducted in duplicate by using 4.0 g finely chopped walnut. Fatty acid analyses were carried out using the IUPAC II.D.19 method (IUPAC 1979). Fatty acids of the kernel oils were analyzed using a Perkin Elmer

Auto System XL gas chromatograph (Perkin-Elmer, Eacosfield, UK) equipped with an SP-2330 column and a flame ionization detector. Separation of fatty acid methyl esters was achieved using a fused silica capillary column (30 m x 0.25 mm x 0,20 μm film thickness). The oven temperature was set at 120 °C for 2 min, then increased to 220 °C with a ramp rate of 58 °C min $^{-1}$ and then held for 15 min. The injector and detector temperatures were maintained at 240 and 250 °C, respectively. The carrier gas was 10 psi helium with a split ratio of 1/50. The air and hydrogen pressures were 338 and 45 mL min $^{-1}$ respectively. Results were expressed as the percentage of fatty acid with respect to the total fatty acids. Fatty acid analyses were conducted in duplicate.

3. Results and Discussion

3.1. Crude Protein, Total Oil and Ash Contents

Crude protein and total oil contents of walnut kernels ranged from 17.09-23.89 %, 62.80 -73.05 % respectively and listed in Table 1. Crude protein values of walnut vary widely due to genetic and environmental effect. Calculation of crude protein using different conversion factor (4.38, 5.30, 5.40 or 6.25) is another variation source.

Table 1. Crude protein, total oil, ash contents (%) and mineral contents (mg 100 g -1) of kernels of fourteen new walnut (*Juglans regia* L.) genotypes

Çizelge 1. *On dört yeni ceviz (Juglans regia L.) genotipinin ceviz içlerinin ham protein, toplam yağ, kül (%) ve mineral içerikleri (mg 100 g -1)*

Content	Content									
	Crude protein (NX5.3)	**Total oil**	**Ash**	**Phosphorous (P)**	**Potassium (K)**	**Sodium (Na)**	**Copper (Cu)**	**Iron (Fe)**	**Zinc (Zn)**	**Manganese (Mn)**
60NL2	21.65	62.80	2.08	280.80	259.89	15.56	3.11	3.35	2.38	1.57
60NL5	23.38	71.60	1.70	308.10	239.51	8.15	3.12	3.09	5.48	4.31
60NL7	17.09	73.05	1.36	252.90	254.65	17.53	3.17	2.70	3.22	2.23
60NL10	17.29	64.28	1.70	292.20	212.36	17.30	3.29	2.96	2.26	0.91
60NL13	19.71	69.02	1.44	296.20	232.00	15.27	2.76	2.21	3.16	1.12
60NF32	20.07	65.87	1.75	270.60	238.73	9.73	2.83	3.01	4.29	3.11
60NF34	23.89	69.05	1.74	298.80	236.70	10.30	3.64	3.08	2.97	2.20
60NF44	22.39	69.84	1.84	230.65	163.92	22.53	3.46	4.04	3.38	4.39
60NL53	21.23	66.62	2.20	330.60	308.86	19.10	2.73	2.72	1.97	2.65
60NF58	20.59	70.68	1.90	298.80	254.28	17.38	2.70	2.98	2.82	1.63
60NF59	20.90	70.37	2.14	330.45	297.22	16.58	2.85	3.03	3.81	1.96
60NL61	19.01	68.20	1.72	263.40	262.19	13.21	3.34	2.67	3.22	0.92
60NF81	18.84	68.35	1.88	293.40	225.61	10.53	3.32	4.32	2.73	1.84
60NF84	23.88	67.63	2.14	344.40	267.43	7.94	2.25	2.95	5.19	2.72
Mean	20.71	68.38	1.83	292.24	246.67	14.37	3.04	3.08	3.35	2.25

Each value is the average of duplicate determinations

Walnut protein values determined between 12.2 % and 19.24 % in different studies by the different conversion factor. Amaral et al (2003) found oil values of six French cultivars grown in Portugal between 12.2-15.2 % (N x 5.30). Savage (2001) determined crude protein contents of walnut grown in New Zealand between 13.6-18.1 % (Nx6.25). Pereira et al. (2008) have also investigated the proximate composition of six French cultivars and found crude protein values between 15.42-18.03 % (Nx4.38). Caglarirmak (2003) determined protein contents of four new Turkish selections between 13.16-14.63 % (Nx5.40). Crude protein contents of genotypes from eastern Anatolia found in a range between 12.11-23.43 % (Yarılgaç et al. 2003), and genotypes from western Anatolia in a range between 15.17-19.24 % (Nx5.30) (Özkan and Koyuncu 2005).

Crude protein quantities of samples are slightly higher when compared other researcher's reports. 60NL7 genotype showed lowest value with 17.09 % content when 60NF34 was the highest with 23.89 %. Higher protein contents can be an advantage of origin and result of genetic superiority.

Studies by many researchers have shown that total oil of walnuts varied between 52-70 %.

Mean value of 67.84 % in the range of 62.80 % (60NL2) and 73.05 % (60NL7) obtained from walnut samples in this research (Table 1). Pereira et al. (2008) determined oil contents of three cultivars (Franquette, Lara and Marbot) grown in Portugal between 68.83 % and 72.14 %. Özkan and Koyuncu (2005) determined oil content of walnut genotypes originated from Turkey between 61.97-70.92 %. Savage (2001), reported oil amounts of New Zealand grown American, European cultivars and New Zealand selections. Total oil values differed between 62.6-70.3 % in that study. Sze-Tao and Sathe (2000) determined 66.90 % mean oil content in market surveyed walnuts. Özcan (2009) found 64.2 % mean oil value in the population surveyed walnut samples in Turkey. Maguire et al. (2004) determined 50.8 % oil content in walnut samples derived from local food markets. The oil content of the walnut varieties selected from the Çankırı region varied between 43.16 and 58.68 % (Ünver et al. 2016). Our results were generally similar with previously reported walnut oil amounts from the different part of the world, different cultivars or genotypes.

Average ash content was 1.84 % in this research and values varied narrowly between 1.36-2.20 % (Table 1). Generally, ash contents were differed widely in previously reported researches. Ash contents of walnut kernels varied in the range of 1.26 % (Özkan and Koyuncu 2005) and 4.26 % (Pereira et al. 2008) in that reports.

3.2. Mineral Contents

Mineral compositions of walnut genotypes were listed also in Table 1. Phosphorous contents of genotypes were found in the range of 230.65-344.40 mg 100 g^{-1}. Potassium contents were found between 163.92-308.86, sodium 7.94-22.53 mg 100 g^{-1}. The amount of other minerals (mg 100 g^{-1}) determined in the range of 2.25-3.64 for copper, 2.21-4.32 for iron, 1.97-5.48 for zinc, 0.91-4.39 for manganese.

Studies on the determination of walnut mineral contents showed that there were significant differences in amounts. That can be related to various geological origins, genotypes-cultivars, climate and soil conditions and tree fertilization. Lavedrine et al. (2000) reported the mineral composition of walnuts originated from France and California. According to their findings, walnut contains (as mg 100 g^{-1}) phosphorous between 308-335, potassium 358-487, sodium 0.3-6.7, copper 1.2-1.5, iron 1.8-2.9, zinc 1.2-1.9, manganese 1.1-4.3. Cultivar samples derived in that study were from professional orchards and cultivated in similar conditions so that internal within the same mineral values were narrow. Determined average and range mineral values of new Turkish walnut cultivars and selections from different origins by Caglarirmak (2003) were (mg 100 $g^{-1)}$ 316.0 (280-380) for phosphorous, 270 (230-340) for potassium, 1.01 (0.50-1.34) for copper, 2.90 (2.46-3.33) for iron, 2.01 (1.1-2.45) for zinc, 2.46 (1.51-3.85) for manganese.

In our study, average phosphorous and potassium quantities were found lower than many of previously reported data (Özcan 2009; Caglarirmak 2003; Lavedrine et al. 2000) and book reviews (Prasad 1994). Sodium values were slightly higher when compared other reports. But levels of iron, copper, zinc and manganese minerals were similar (Özcan 2009; Lavedrine et al. 2000).

Differences in mineral contents in other researches has been reported a result of origin, genotype and different environmental factors such as climate and soil. Origins, environmental factors, and cultural practices such as irrigation and fertilization did not fully represent in reports. Mineral absorption of trees greatly affected by soil pH, so walnut kernels could show wide variations. Acidic soils enhance Cu and Mn absorption. Inversely chalky soils could affect absorption of iron. Fertilizer applications in orchards by enriching soil nutrition could result from differences in contents of walnut kernels. In our study, samples were collected from different genotypes from sites that have different soil types and not fully cultivated.

3.3. Fatty Acid Composition

The fatty acid compositions of 14 different genotypes were given in Table 2.

Table 2. Fatty acid content (%) of kernels of fourteen new walnut (*Juglans regia* L.) genotypes
Çizelge 2. *On dört yeni ceviz (Juglans regia L.) genotipinin ceviz içlerinin yağ asidi içerikleri (%)*

Fatty acid name and molecular structure	**60NL2**	**60NL5**	**60NL7**	**60NL10**	**60NL13**	**60NF32**	**60NF34**
Myristic C14:0	0.031 ± 0.001	0.027 ± 0.001	0.022 ± 0.001	0.026 ± 0.001	0.024 ± 0.001	0.031 ± 0.001	0.025 ± 0.000
Pentadecanoic C15:0	-	-	-	-	-	0.023 ± 0.002	-
Palmitic C16:0	7.116 ± 0.006	7.185 ± 0.008	6.653 ± 0.007	6.982 ± 0.008	7.233 ± 0.001	7.585 ± 0.003	6.352 ± 0.001
Palmiteloic C16:1	0.074 ± 0.001	0.081 ± 0.000	0.069 ± 0.001	0.066 ± 0.001	0.078 ± 0.002	0.084 ± 0.001	0.082 ± 0.000
Heptadecanoic C17:0	0.047± 0.000	0.049 ± 0.000	0.048 ± 0.000	0.264 ± 0.217	0.056 ± 0.000	0.052 ± 0.000	0.047 ± 0.001
Heptadecenoic C17:1 cis-10	0.374 ± 0.010	0.323 ± 0.006	0.365 ± 0.022	0.232 ± 0.232	0.415 ± 0.002	0.301 ± 0.002	0.334 ± 0.004
Stearic C18:0	2.146 ± 0.008	1.907 ± 0.005	2.288 ± 0.023	2.874 ± 0.006	2.438 ± 0.002	1.941 ± 0.000	1.910 ± 0.004
Elaidic C18:1n9t	-	-	0.028 ± 0.001	0.011 ± 0.011	0.023 ± 0.001	0.027 ± 0.000	-
Oleic C18:1n9c	18.412 ± 0.000	27.822 ± 0.004	12.828 ± 0.001	16.744 ± 0.003	17.661 ± 0.003	12.426 ± 0.002	32.090 ± 0.008
Linoleaidic C18:2n6t	-	-	-	-	-	0.023 ± 0.001	-
Linoleic C18:2n6c	59.010 ± 0.005	52.762 ± 0.001	65.520 ± 0.005	59.169 ± 0.011	60.925 ± 0.001	64.696 ± 0.010	48.859 ± 0.004
Linolenic C18:3n6 g	0.052 ± 0.000	0.041 ± 0.001	0.052 ± 0.001	0.056 ± 0.000	0.043 ± 0.000	0.053 ± 0.001	0.039 ± 0.000
Arachidic C20:0	0.083 ± 0.003	0.085 ± 0.003	0.080 ± 0.002	0.098 ± 0.001	0.091 ± 0.001	0.081 ± 0.000	0.092 ± 0.001
Linolenic C18:3n3 a	12.320 ± 0.002	9.368 ± 0.003	11.765 ± 0.001	13.130 ± 0.004	10.728 ± 0.001	12.376 ± 0.002	9.842 ± 0.002
Eicosenoic C20:1n9 cis-11	0.262 ± 0.010	0.292 ± 0.001	0.203 ± 0.012	0.255 ± 0.001	0.220 ± 0.001	0.224 ± 0.013	0.260 ± 0.011
Eicosadienoic C20:2 cis 11.14	0.049 ± 0.001	0.028 ± 0.000	0.055 ± 0.002	0.055 ± 0.000	0.041 ± 0.001	0.054 ± 0.002	0.035 ± 0.000
Heicosanoic C21:0	-	-	-	0.012 ± 0.012	-	-	-
Behenic C22:0	0.027 ± 0.001	0.034 ± 0.002	0.028 ± 0.001	0.029 ± 0.000	0.028 ± 0.001	0.027 ± 0.000	0.035 ± 0.001
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Fatty acid name and molecular structure (continued)	**60NF44**	**60NL53**	**60NF58**	**60NF59**	**60NL61**	**60NF81**	**60NF84**	**Mean**
Myristic C14:0	0.026 ± 0.000	0.040 ± 0.013	0.030 ± 0.000	0.028 ± 0.001	-	0.027 ± 0.002	0.032 ± 0.006	0.028
Pentadecanoic C15:0	-	-	-	0.011 ± 0.011	-	-	0.021 ± 0.001	0.018
Palmitic C16:0	6.693 ± 0.004	6.966 ± 0.007	6.610 ± 0.004	6.098 ± 0.009	5.962 ± 0.004	7.139 ± 0.004	6.766 ± 0.000	6.810
Palmiteloic C16:1	0.067 ± 0.001	0.088 ± 0.001	0.072 ± 0.000	0.071 ± 0.001	0.072 ± 0.001	0.066 ± 0.001	0.097 ± 0.000	0.076
Heptadecanoic C17:0	0.048 ± 0.000	0.044 ± 0.000	0.046 ± 0.000	0.051 ± 0.001	0.050 ± 0.000	0.052 ± 0.001	0.051 ± 0.001	0.065
Heptadecenoic C17:1 cis-10	0.337 ± 0.012	0.311 ± 0.006	0.319 ± 0.016	0.336 ± 0.011	0.272 ± 0.026	0.455 ± 0.016	0.286 ± 0.016	0.333
Stearic C18:0	2.091 ± 0.012	1.820 ± 0.006	2.006 ± 0.016	1.927 ± 0.009	1.795 ± 0.025	2.529 ± 0.020	1.943 ± 0.016	2.115
Elaidic C18:1n9t	0.024 ± 0.001	0.025 ± 0.001	0.025 ± 0.001	0.011 ± 0.011	-	-	0.028 ± 0.001	0.022
Oleic C18:1n9c	17.042 ± 0.000	16.030 ± 0.000	17.303 ± 0.001	24.285 ± 0.001	25.655 ± 0.013	17.987 ± 0.001	16.877 ± 0.002	19.512
Linoleaidic C18:2n6t	-	-	0.011 ± 0.011	0.022 ± 0.001	-	-	0.011 ± 0.011	0.017
Linoleic C18:2n6c	60.430 ± 0.003	59.242 ± 0.004	61.986 ± 0.010	57.556 ± 0.013	56.397 ± 0.005	59.542 ± 0.002	62.547 ± 0.013	59.189
Linolenic C18:3n6 g	0.054 ± 0.000	0.051 ± 0.001	0.048 ± 0.001	0.039 ± 0.000	0.040 ± 0.000	0.050 ± 0.000	0.047 ± 0.001	0.047
Arachidic C20:0	0.070 ± 0.003	0.067 ± 0.001	0.074 ± 0.000	0.071 ± 0.000	0.062 ± 0.002	0.085 ± 0.000	0.075 ± 0.002	0.080
Linolenic C18:3n3 a	12.828 ± 0.001	15.036 ± 0.002	11.167 ± 0.003	9.182 ± 0.001	9.383 ± 0.002	11.700 ± 0.001	10.941 ± 0.002	11.412
Eicosenoic C20:1n9 cis-11	0.223 ± 0.001	0.197 ± 0.008	0.231 ± 0.002	0.255 ± 0.000	0.263 ± 0.004	0.274 ± 0.000	0.214 ± 0.011	0.241
Eicosadienoic C20:2 cis 11.14	0.044 ± 0.000	0.058 ± 0.000	0.051 ± 0.001	0.040 ± 0.001	0.054 ± 0.001	0.071 ± 0.001	0.044 ± 0.002	0.048
Heicosanoic C21:0	-	-	-	-	-	-	-	0.012
Behenic C22:0	0.026 ± 0.001	0.029 ± 0.001	0.024 ± 0.000	0.022 ± 0.000	-	0.026 ± 0.000	0.026 ± 0.000	0.028
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Each value of fatty acid concentrations is the average of duplicate determinations, (-) not detected

Major fatty acids were linoleic (C18:2n6c), oleic (C18:1n9c) and linolenic (C18:3n3a), palmitic (C16:0) and stearic (C18:0) with mean of 59.19 %, 19.51 %, 11.41 %, 6.81 %, 2.12 % respectively (Table 2). Besides these five main fatty acids heptadecenoic, eicosenoic amounts were determined under 1 % and myristic, pentadecanoic, palmiteloeic and myristic acids were observed at trace amounts.

Fatty acid composition of walnut oil has been reported to differ mainly with variety, location, climate and cultural treatments such as fertilization and irrigation during growth (Amaral et al. 2003; Sze-Tao et al. 2000). Linolenic and palmitic acid contents were strongly affected by crop year (Martinez et al. 2006). The main fatty acids found in walnuts are linoleic (18:2n:6), linolenic (18:3n-3), oleic (18-1n-9) (Özcan 2009; Martinez et al. 2006; Doğan and Akgül 2005). Total unsaturated fatty acid (UFA) content is about 65 % in oil of walnut cultivars and these acids especially polyunsaturated (PUFA) acids can be oxidated in a short time (Savage 2001). As oleic acid concentrations increase, the stability of oil increase and this provides much longer storage life. Walnuts that contain the high rate of stable oils can be useful for the food industry for different end use. Fatty acid composition of oil is important for rancidity, flavour and taste (Zwarts et al. 1999).

Amaral et al. (2003) investigated walnut oils from seven countries around the world and in their study SFA ranged between 8.2-10.8 %, MUFA 13.7-22.5 %, PUFA 69.1-76.3 %. In different studies, lack of detection of some fatty acids, walnut oils that have high proportions of C16:0 and C18:1 and low proportions of C18:0 were reported (Tsamouris et al. 2002; Özkan and Koyuncu 2005).

Ünver et al. (2016) determined fatty acid content of 8 walnut types between 50.83 and 60.77 % for linoleic acid, 16.14 and 26.44 % for oleic acid, 5.42 and 7.29 % for palmitic acid, 11.08 and 14.25 % for linolenic acid and 1.70 and 2.55 % for stearic acid and, the total amount of PUFA found between 65.45 and 74.47 %.

Pereira and et al. (2008) analyzed fatty acid composition of Franquette, Lara, Parisienne and Mayette walnut cultivars. The linoleic acid content was changed from 55.51 % in cv. Franquette to 60.30 % in cv. Lara. Oleic acid content was ranged from 14.92 % (cv. Franquette) to 20.22 % (cv. Lara) followed by linolenic acid, from 13.2 % (cv. Parisienne) to 17.61 % (cv. Mayette). Palmitic fatty acids contents found between 5.95–6.61 % and stearic acids 2.70–3.07 %. MUFA were present in percentages ranging from 15.16 % (cv. Lara) to 20.53 % (cv. Franquette).

PUFA were the main fatty acid group in walnut oil of extracted from genotypes ranging from 58.78 % (60NF34) to 77.39 % (60NL7) (Table 2). Total monounsaturated fatty acids (MUFA) content of oils ranged from 13.06 (60NF32) to 32.76 % (60NF34) and saturated fatty acids (SFA) were the minor group ranging from 7.87 % (60NL61) to 10.29 % (60NL10). Total UFA (PUFA+MUFA) contents of genotypes were over than 90 % except genotype 60NF10. When considering MUFA, 60NF34 and 60NL5 genotypes showed higher contents than others because of their higher oleic acid concentrations. In this study, genotypes are rich with PUFA, especially with linoleic acid.

Dublin's Glory variety from New Zealand (Zwarts et al. 1999), Franquette variety from Argentina (Martinez et al. 2006), and 32.YS.119-097 (Özkan and Koyuncu 2005) genotypes from Turkey were reported with their high oleic acid contents.

The values obtained in this study were generally in agreement with previously reported fatty acid ranges. Much differentiation can be seen in oleic, linoleic and linolenic acid concentrations but generally similar levels of fatty acids were observed in many studies (Özcan 2009; Pereira et al. 2008; Venkatachalam et al. 2006; Akça et al. 2006; Martinez et al. 2006; Maguire et al. 2004). In general terms, the obtained results were in agreement with the observed in Portuguese samples and other geographical origin such us Italy. The high oleic acid contents of two genotypes 60NF34 (32.09 %)

and 60NL5 (27.82 %) are noteworthy in this study. These genotypes have clearly higher oleic acid contents. Fatty acid composition of some genotypes in this study is suitable for maximum health benefit due to high UFA content and some are suitable for long term usage due to high oleic contents. Observed variability in fatty acid composition can be attributed to genetic variability.

4. Conclusions

The results of this study presented here show that genotypes from Turkey have a sufficient and important nutritive value for human consumption. Fatty acid profiles of genotypes are distinctive, healthy and useful for different purposes. Among genotypes, there are suitable genotypes for health consumption with high PUFA contents and also for long term storage. Variability in fatty acid composition of walnut genotypes especially higher oleic acid contents for oil stability showed us that can be possible to breed walnut varieties for long time storage.

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