African Journal of Agricultural Research Vol. 5(17), pp. 2379-2385, 4 September, 2010
Available online at http://www.academicjournals.org/AJAR
ISSN 1991-637X ©2010 Academic Journals

Full Length Research Paper

Some chemical composition of walnut (*Juglans regia* L.) selections from Eastern Turkey

Ferhad Muradoglu[1]*, H. Ibrahim Oguz[2], Kenan Yildiz[3] and Hüdai Yilmaz[1]

[1]Department of Horticulture, Faculty of Agriculture, Universty of Yuzuncu Yil, 65080 Van, Turkey.
[2]Professional High School of Kahta, Adiyaman Universty, Adiyaman, Turkey.
[3]Department of Horticulture, Faculty of Agriculture, Universty of Gaziosmanpaşa,Tokat, Turkey.

Accepted 10 May, 2010

The aim of this study was to determine the chemical and mineral contents of eighteen walnut genotypes which were newly selected from Hizan (Bitlis) located in Eastern Anatolia. The protein, total fat, total oil (saturated and unsaturated oil) compositions and mineral contents were investigated. It was found that the average value for protein was 18.1% and for total fat was 58.2%. Saturated fatty acids composition values were less than the values of monounsaturated fatty acids composition and polyunsaturated fatty acids composition in all genotypes. Among the identified fatty acids, linoleic acid (50.58 - 66.60%) was the predominant fatty acid followed by oleic acid (14.88 - 28.71%) and linolenic acid (9.16 -16.42%) in all genotypes. The other fatty acids were found in trace contents. The minimum and maximum macronutrient contents of walnut were determined as mg100 g^{-1} for K (911.0 - 684.3), P (434.7 - 356.2), Ca (756.7 - 388.2), Mg (444.0 - 330.8) and Na (48.9 - 26.1) while minimum and maximum micronutrient contents of walnut were determined for Fe (6.6 - 4.3), Cu (2.8 - 1.8), Mn (5.7 - 2.7) and Zn (4.3 - 2.7). The potassium contents were found to be higher than those of the other minerals in all kernels of the walnuts.

Key words: Fatty acids, mineral contents, walnut.

INTRODUCTION

Turkey is supposed to be one of the origin centers of walnut (*Juglans regia* L.). with 172.572 tones annual walnut productions, Turkey comes after China (503.000) and United States of America (290.300) Anonymous (2007). Walnuts are grown naturally in almost all over Turkey with suitable climate and geographic conditions for growth. Particularly, in the valleys of big rivers and on the slope of the hills, very rich walnuts populations were born and many genotypes from these populations have been selected. Located in eastern Anatolia, Hizan (Bitlis) province presents microclimatic conditions for walnut cultivars. This microclimatic zone results from the mild effects of Lake Van and Suphan Mountain. Hizan country is surrounded by high mountains and has the valley of river and the slope of hills. Therefore, Hizan can be rich in native genetic resource for walnut population. From pre-agriculture times to the present day, nuts have been eaten as part of the human diet, providing macronutrients and micronutrients, as well as other bioactive constituents.

Nuts are a rich source of unsaturated fatty acids, vitamin E, fiber, magnesium, potassium (Dreher et al., 1996). Compared with most other nuts, which contain mostly monounsaturated fatty acids (MUFA), walnuts are highly enriched in omega-6 and omega-3 polyunsaturated fatty acids (PUFA), which are essential dietary fatty acids (Amaral et al., 2003). This situation makes walnuts unique for a healthy diet. Many studies suggest that frequent consumption of nuts may provide some protection against coronary heart disease (Hu et al., 1998; Prineas et al., 1993) and cations, such as magnesium and potassium, may improve blood pressure (Elin, 1993). Replacement of dietary saturated fats with either monounsaturated fatty acids (MUFAs) or polyunsaturated fatty acids (PUFAs) decreases plasma total and LDL-cholesterol concentrations (Dattilo and Kris-Etherton, 1992). Chemical and mineral contents of walnuts can vary

*Corresponding author. E-mail: muradogluf@yyu.edu.tr. Tel/Fax: 432 2251331.

by variety, genotype, ecology, technical and cultural practices, climate, and soil conditions.

The objective of this study was to determine fatty acids and macro-micro mineral contents in newly selected eighteen walnuts genotypes from Hizan (Bitlis), eastern Anatolia Region.

MATERIALS AND METHODS

Plant materials and sampling

The study was conducted in the native walnut population of Bitlis (Hizan) province located in eastern Anatolia of Turkey. Walnut samples were collected from central Hizan (Bitlis) where walnut has been widely cultivated for the past years. Walnut samples were randomly taken from trees during 2002 - 2004 years. At the end of the second year, eighteen genotypes were selected and identified for chemical and mineral contents. All walnuts genotypes were harvested between 4 and 13 October. After harvest, walnut fruits were immediately transported to the laboratory and held in an oven (UL60, Memmert, Germany) for 3 days at 30°C. And then, the fruits were stored in the shell, closed in plastic bags, and frozen to -20°C, until the analyses.

Chemical analysis

Moisture content was analyzed and calculated according to the methods given by the Turkish Standard Institute (Anonymous, 1991). A kjeldal digestion method for protein analysis (Nx6.25) and a muffle furnace for ash content analysis in kernel samples of walnut genotypes were use (AOAC, 1990). Total ash was determined by drying of the sample for 24 h at 105°C in an oven and then transferring the crucible to a muffle furnace. The temperature was gradually raised to 600°C and the samples were ashed for 10 - 12 h to a white colour. Oil content was determined by extraction from 10 g dried, ground kernels per replicate with petroleum ether using a soxhlet apparatus at 45 - 50°C for 8 - 9 h. The oil content was detected as the difference in weight of dried kernel sample before and after the extraction (AOCS, 1989).

Fatty acid composition

The oil was saponified by the usual procedure according to standard IUPAC, (1998) methods. Fatty acids were esterified by 10% (v/v) BF3-MeOH as reagent. The fatty acids methylesters (FAMEs) of total lipid were obtained by transmethylation (AOAC, 1990). The FAMEs were analyzed by gas chromatography (Agilent 6890N) with a flame ionization detector (FID). He: 2.0 ml/dk. H_2:45 ml/dk and air: 450 ml/dk were used as carrier gas with DB-23 capillary column (60 m x 0.25 mm x 0.25 µm film thickness). The colon temperature was run at 120°C (5 min). 15°C/min. The injection temperature was 250°C and detector was at 260°C. The rate of split was 1/10.

Mineral composition

For determination of mineral content, kernel samples were ashed at 500°C and dissolved in 4 ml 3NHCl solution (Kaçar, 1972), then atomic absorption was carried out on these solutions (Varian Techtron Model AAS 1000, Varian Associates, Palo Alto, CA). The minerals (Fe, Cu, Zn, Mn, Mg, Ca, Na and K) were determined by an atomic absorption spectrophotometer. The samples, which were digested in an acid solution, were passed through the AAS system using different lamps, and calibrated with related minerals in different concentrations for different micronutrients. Phosphorus concentrations of samples were determined according to Vanado molibdo phosphoric-yellow colour method using spectrophotometer (Specord 40, AnalyticJena Ag, Germany). The values of K, P, Ca, Mg, Fe, Cu, Mn, Zn, and Na were determined as mg 100 g^{-1}.

RESULTS AND DISCUSSION

The results obtained from proximate composition of walnut genotypes were shown in Table 1. Fat was the highest constituent in all the samples, the total fat content of samples was 50% and was between the values of 49.8% (HW-6) and 66.1% (HW-7). Moisture and ash contents had lower values. Moisture content was the highest in 2.7% (HW-8) and the lowest in 1.1% (HW-7), while ash content was the highest in 2.8% (HW-8) and lowest in 1.5% (HW-13). These values were similar to the results reported by some researchers (Amaral et al., 2003; Muradoğlu, 2005). The total oil contents were from 62.3 to 66.5% and ash value from 1.8 to 2.1% for six cultivars of walnuts by Amaral et al. (2003). Muradoğlu, (2005) recorded that the total oil contents were from 51.6 to 67.0%, and the ash value was between 1.0 and 2.5% for fifty genotypes of walnut. Oil contents of this study were lower than those reported by other researchers (Savage, 2001; Pereira et al., 2008). They reported total oil contents from 62.6 to 70.3% (Savage, 2001), and from 78.83 to 82.4% (Pereira et al., 2008).

Protein contents of kernel showed a wide variation depending on genotypes, ranging from 12.8% (HW-5) to 22.3% (HW-18) (Table 1). These values were similar to the results reported by Amaral et al. (2003); Muradoğlu (2005), Mitrovic et al. (1997) and Savage (2001) who reported 12.2 -15.2, 13.9 - 23.3,13.0 - 16.11 and 13.6 - 18.0% crude protein contents respectively. According to literature Ravai, 1992; Payne, 1985; Feinberg et al., 1987; Klepping et al., 1989; Souci et al., 1994), walnuts contain high levels of potassium (390 - 700 mg 100 g^{-1}, phosphorus (310 - 510 mg 100 g^{-1}) and magnesium (90 - 140 mg 100 g^{-1}), and lower sodium (1 - 15 mg 100 g^{-1}). In the present study, eighteen walnut genotypes contained potassium between 519 and 911 mg 100 g^{-1} and phosphorus between 299.1 and 434.7 mg 100 g^{-1}. Calcium contents of kernels showed a prominent variation, ranging from 170.5 (HW-1) to 756.5 mg 100 g^{-1} (HW-2) (Table 2). The calcium content in walnuts genotypes (as reported) ranged from 58 - 91 mg 100 g^{-1} (Lavedrine et al., 2000), 640 - 1180 mg/kg (Koyuncu et al., 2002). Our values of calcium were considerably higher than those reported by Lavedrine et al., 2000. In Hartley and Franquette walnut cultivars and in some selected walnut genotypes (Koyuncu et al., 2002). Magnesium, and sodium levels ranged from 236 (HW-3) - 444 mg 100 g^{-1} (HW-17), and 15.1 (HW-17) - 48.9 mg 100 g^{-1} (HW-2). Magnesium and sodium contents of this study were

Table 1. Proximate compositions of walnut (*Juglans regia* L.) genotypes.

Genotypes	Moisture %	Total ash %	Protein %	Total oil %
HW-1	1.6 ± 0.03	1.9 ± 0.23	16.0 ± 1.21	57.4 ± 1.52
HW-2	1.2 ± 0.05	1.8 ± 0.09	19.6 ± 0.21	65.2 ± 1.30
HW-3	1.3 ± 0.13	2.0 ± 0.31	17.0 ± 1.25	62.3 ± 0.50
HW-4	2.6 ± 0.06	2.1 ± 0.11	20.4 ± 1.31	51.1 ± 2.80
HW-5	1.6 ± 0.20	2.2 ± 0.04	12.8 ± 0.20	59.9 ± 1.33
HW-6	1.8 ± 0.06	1.9 ± 0.20	15.5 ± 1.34	49.8 ± 0.86
HW-7	1.1 ± 0.16	1.8 ± 0.05	17.8 ± 1.17	66.1 ± 1.38
HW-8	2.7 ± 0.22	2.8 ± 0.22	20.6 ± 0.69	65.7 ± 0.90
HW-9	1.3 ± 0.09	1.8 ± 0.14	17.1 ± 1.34	59.9 ± 1.22
HW-10	1.5 ± 0.05	1.9 ± 0.29	18.0 ± 0.30	55.1 ± 0.47
HW-11	1.7 ± 0.18	2.4 ± 0.07	17.1 ± 0.24	62.2 ± 1.20
HW-12	2.1 ± 0.14	2.5 ± 0.23	21.1 ± 1.93	52.0 ± 1.80
HW-13	1.5 ± 0.06	1.5 ± 0.21	20.7 ± 1.08	57.9 ± 0.47
HW-1 4	1.5 ± 0.14	2.0 ± 0.23	17.6 ± 0.27	62.8 ± 0.80
HW-15	1.9 ± 0.06	2.2 ± 0.14	17.5 ± 0.77	49.3 ± 1.22
HW-16	1.4 ± 0.03	1.8 ± 0.40	15.4 ± 0.80	62.3 ± 0.27
HW-17	2.0 ± 0.08	2.1 ± 0.41	19.8 ± 0.69	51.0 ± 0.47
HW-18	2.0 ± 0.12	2.6 ± 0.04	22.3 ± 1.29	58.8 ± 1.50
Minimum	1.1 ± 0.16	1.5 ± 0.21	12.8 ± 0.20	49.8 ± 1.22
Maximum	2.7 ± 0.22	2.8 ± 0.22	22.3 ± 1.29	66.1 ± 1.38
Mean	1.5	1.1	18.1	58.2
SD	2.8	2.7	4.4	4.5

Table 2. Macro element content of walnut (*Juglans regia* L.) genotypes.

Genotypes	Macro elements (mg 100 g^{-1})				
	Potassium (K)	Phosphorus (P)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)
HW-1	600.0	358.5	170.5	236.0	41.3
HW-2	602.0	299.1	756.7	422.0	48.9
HW-3	594.0	303.7	202.5	236.0	43.0
HW-4	735.0	355.0	285.5	258.0	39.1
HW-5	632.0	381.5	238.7	282.0	45.4
HW-6	625.0	303.1	312.3	286.0	47.2
HW-7	525.0	305.4	502.3	275.0	21.4
HW-8	911.0	434.6	371.5	438.0	18.5
HW-9	763.0	356.0	268.0	346.0	17.6
HW-10	820.0	337.0	723.0	443.0	15.4
HW-11	849.0	420.2	264.7	422.0	20.2
HW-12	852.0	363.3	224.7	328.0	16.2
HW-13	553.0	311.2	223.4	311.0	15.5
HW-1 4	616.0	434.7	386.4	319.0	16.2
HW-15	734.0	414.1	672.7	375.0	16.7
HW-16	519.0	306.9	286.1	268.0	15.2
HW-17	740.0	375.2	704.0	444.0	15.1
HW-18	647.0	351.9	394.1	265.0	16.8
Minimum	519.0	299.1	170.5	236	15.1
Maximum	911.0	434.7	756.7	444	48.9
Mean	684.3	356.2	388.2	330.8	26.1
SD	119.7	46.7	196.5	74.9	13.4

Table 3. Micro element content of walnut (*Juglans regia* L.) genotypes.

Genotypes	Micro elements (mg 100 g^{-1})			
	Iron (Fe)	Copper (Cu)	Manganese (Mn)	Zinc (Zn)
HW-1	2.8	1.7	2.1	2.4
HW-2	5.3	1.7	3.8	3.0
HW-3	6.6	0.9	1.2	2.0
HW-4	4.5	0.8	2.2	4.0
HW-5	5.5	0.5	2.5	2.1
HW-6	5.3	2.5	5.7	3.3
HW-7	5.2	2.6	2.0	2.5
HW-8	4.0	2.4	2.8	4.3
HW-9	2.9	1.9	3.3	2.6
HW-10	3.6	1.9	1.3	1.5
HW-11	4.0	1.2	1.9	2.2
HW-12	4.3	2.5	2.5	3.5
HW-13	3.8	1.5	4.1	2.1
HW-1 4	4.7	1.6	3.0	2.5
HW-15	3.3	1.9	2.9	3.1
HW-16	3.6	2.0	2.3	2.4
HW-17	3.5	1.6	2.3	3.0
HW-18	4.5	2.8	2.0	2.9
Minimum	2.8	0.5	1.2	1.5
Maximum	6.6	2.8	5.7	4.3
Mean	4.3	1.8	2.7	2.7
SD	1.0	0.7	1.1	0.7

generally higher than those reported by many studies in different walnut varieties. Iron, Copper, Manganese and Zinc contents were between 2.8 (HW-1) - 6.6 mg 100 g^{-1}(HW-3), 0.5 (HW-5) and 2.8 mg 100 g^{-1}(HW-18), between 1.2 (HW-3) and 5.7 mg 100 g^{-1} (HW-6) and between 1.5 (HW-10) and 4.3 mg 100 g^{-1}(HW-8) respectively (Table 3). Copper, Manganese and Zinc contents were similar to values reported by other researchers (Souci et al., 1994; Lavedrine at el., 2000; Koyuncu et al., 2002). It is well known that elemental composition and also pH of soil greatly affect mineral absorption by plant. Such as, acidic soils enhance Cu and Mn absorption. Inversely, chalky soils have been shown to lower iron absorption. So content of elemental composition of walnuts can be influenced by genotype, cultivar, different ecology and different soil.

Results related to fatty acids compositions of eighteen walnut genotypes are given in Tables 4 and 5. The fatty acids compositions of walnut genotypes ranged from 5.81 to 9.23% saturated fatty acids (SFA_s); from 15.13 to 29.97% monounsaturated fatty acids ($MUFA_s$) and from 62.85 to 78.15 polyunsaturated fatty acids ($PUFA_s$). Among the identify SFA_s palmitic acids were the predominant fatty acids (between 3.79% for HW-5 and 5.98% for HW-16) followed by stearic acids (1.46 - 2.63%). The other SFA_s such as Myristic 0.04 - 0.66% and Arachidic 0.07 - 0.31% were found in low concentrations in all walnuts genotypes (Table 5). The major fatty acids identified as a $PUFA_s$ was linoleic acid in all walnut genotypes. Its amounts ranged between 66.60% (HW-6) and 50.58% (HW-16). The other $PUFA_s$ linolenic was found between 9.12 and 16.42% (Table 4). Oleic acid was the second primary MUFA in these genotypes. Percentage of oleic acids was between 14.88% (HW-6) and 28.71% (HW-18). Followed by Palmitoleic 0.14 - 1.69% and Gadoleic acids 0.00 - 0.16% (Table 4). In general terms, the obtained results were in agreement with those observed in other geographical origin such as Portugal (Amaral et al., 2003; Pereira et al., 2008), Italy (Ruggeri et al., 1998). Canada (Li et al., 2007) and New Zealand (Zwarts et al., 1999). It was realized that the proportions of fatty acids change among genotypes. The fatty acids profile of walnuts genotypes generally exhibits a dominance of two classes, $MUFA_s$ and $PUFA_s$ (Table 4). Among walnuts genotypes, HW-18 had the highest level of $MUFA_s$ (29.97%) and HW-6 gave the highest $PUFA_s$ (78.15%). The highest PUFA/SFA ratio was obtained from 12.40% HW-1 whereas the lowest values were found to be 6.94 HW-16. Walnuts have high amounts of omega-6 and omega-3 PUFA, which are essential dietary fatty acids. Epidemiological and clinical studies suggest that omega-3 PUFA may have a significant role in the prevention of coronary heart disease and showed that the inclusion of walnut consumption in the diet had a significant

Table 4. Unsaturated fatty acids content of walnut (*Juglans regia* L.) genotypes.

Genotypes	Unsaturated fatty acids (%)						
	Palmitoleic acid C16:1	Oleic acid C18:1	Gadoleic acid C20:1	Total MUFA	Linoleic acid C18:2	Linolenic acid C18:3	Total PUFA
HW-1	0.36 ± 0.01	21.81 ± 0.60	0.00 ± 0.00	22.17	60.51 ± 1.55	11.51 ± 0.01	72.02
HW-2	0.93 ± 0.00	20.87 ± 0.40	0.08 ± 0.01	21.88	59.71 ± 1.41	10.78 ± 0.02	70.49
HW-3	1.05 ± 0.01	25.10 ± 0.41	0.14 ± 0.01	26.29	54.15 ± 0.95	12.91 ± 0.01	67.06
HW-4	1.65 ± 0.01	15.99 ± 0.30	0.08 ± 0.00	17.72	65.73 ± 1.55	10.47 ± 0.00	76.20
HW-5	1.36 ± 0.00	23.56 ± 0.25	0.01 ± 0.00	24.93	58.53 ± 1.10	10.39 ± 0.02	68.92
HW-6	0.14 ± 0.01	14.88 ± 0.50	0.11 ± 0.01	15.13	66.60 ± 1.35	11.55 ± 0.02	78.15
HW-7	1.69 ± 0.02	15.33 ± 0.25	0.06 ± 0.00	17.08	62.85 ± 1.80	12.84 ± 0.01	75.69
HW-8	1.61 ± 0.01	19.74 ± 0.19	0.02 ± 0.00	21.37	60.74 ± 1.05	9.92 ± 0.00	70.66
HW-9	0.93 ± 0.01	24.22 ± 0.32	0.02 ± 0.00	25.17	51.68 ± 1.23	16.42 ± 0.03	68.10
HW-10	1.06 ± 0.00	17.85 ± 0.40	0.08 ± 0.00	18.99	58.41 ± 1.20	15.19 ± 0.01	73.60
HW-11	1.23 ± 0.01	17.68 ± 0.30	0.04 ± 0.00	18.95	61.54 ± 1.08	12.75 ± 0.00	74.29
HW-12	1.42 ± 0.02	25.33 ± 0.20	0.16 ± 0.01	26.91	54.10 ± 0.90	12.12 ± 0.03	66.22
HW-13	1.50 ± 0.01	18.46 ± 0.18	0.04 ± 0.00	20.00	59.05 ± 1.35	12.91 ± 0.00	71.96
HW-1 4	1.12 ± 0.01	18.12 ± 0.22	0.12 ± 0.01	19.36	59.58 ± 1.40	13.96 ± 0.02	73.54
HW-15	0.95 ± 0.00	23.26 ± 0.33	0.14 ± 0.01	24.35	56.66 ± 0.50	11.80 ± 0.04	68.46
HW-16	0.76 ± 0.00	25.94 ± 0.20	0.07 ± 0.00	26.77	50.58 ± 1.60	13.48 ± 0.03	64.06
HW-17	1.03 ± 0.01	24.42 ± 0.22	0.10 ± 0.00	25.55	55.64 ± 0.91	10.98 ± 0.02	66.62
HW-18	1.17 ± 0.01	28.71 ± 0.26	0.09 ± 0.00	29.97	53.69 ± 1.70	9.16 ± 0.01	62.85
Minimum	0.14 ± 0.01	14.88 ± 0.50	0.00 ± 0.00	15.13	50.58 ± 1.60	9.16 ± 0.01	62.85
Maximum	1.69 ± 0.02	28.71 ±0.26	0.16 ± 0.01	29.97	66.60 ± 1.35	16.42 ± 0.03	78.15
Mean	0.77	25.26	0.05	22.37	57.10	10.34	70.49
SD	0.57	4.88	0.06	4.07	4.82	1.66	4.29

Table 5. Saturated fatty acids content of walnut (Juglans regia L.) genotypes.

Genotypes	Saturated fatty acids (%)					
	Myristic acid C14:0	Palmitic acids C16:0	Stearic acid C18:0	Arachidic acid C20:0	Total SFA	PUFA/SFA
HW-1	0.04 ± 0.01	4.04 ± 0.22	1.66 ± 0.21	0.07 ± 0.00	5.81	12.40
HW-2	0.66 ± 0.02	4.70 ± 0.39	2.26 ± 0.18	0.10 ± 0.02	7.72	9.13
HW-3	0.35 ± 0.00	4.26 ± 0.17	2.03 ± 0.15	0.10 ± 0.01	6.74	9.95
HW-4	0.32 ± 0.01	4.22 ± 0.39	1.46 ± 0.14	0.15 ± 0.02	6.15	12.39
HW-5	0.31 ± 0.01	3.79 ± 0.35	1.79 ± 0.25	0.26 ± 0.03	6.15	11.21
HW-6	0.36 ± 0.00	4.34 ± 0.12	1.92 ± 0.20	0.20 ± 0.02	6.82	11.46
HW-7	0.30 ± 0.01	4.55 ± 0.31	2.36 ± 0.31	0.09 ± 0.00	7.30	10.37

Table 5. Saturated fatty acids content of walnut (Juglans regia L.) genotypes (Continued).

Genotypes	Saturated fatty acids (%)					
	Myristic acid C14:0	Palmitic acids C16:0	Stearic acid C18:0	Arachidic acid C20:0	Total SFA	PUFA/SFA
HW-8	0.34 ± 0.01	5.02 ± 0.17	2.32 ± 0.17	0.31 ± 0.03	7.99	8.84
HW-9	0.34 ± 0.01	4.25 ± 0.08	1.99 ± 0.10	0.16 ± 0.02	6.74	10.10
HW-10	0.34 ± 0.00	4.88 ± 0.35	2.18 ± 0.09	0.09 ± 0.01	7.49	9.83
HW-11	0.24 ± 0.00	4.59 ± 0.26	1.80 ± 0.21	0.17 ± 0.01	6.80	10.93
HW-12	0.30 ± 0.00	4.66 ± 0.14	1.91 ± 0.19	0.16 ± 0.01	7.03	9.42
HW-13	0.34 ± 0.01	5.44 ± 0.45	2.13 ± 0.25	0.17 ± 0.01	8.08	8.91
HW-1 4	0.27 ± 0.02	4.73 ± 0.21	2.02 ± 0.09	0.21 ± 0.02	7.23	10.17
HW-15	0.38 ± 0.01	4.50 ± 0.40	2.26 ± 0.21	0.20 ± 0.01	7.34	9.33
HW-16	0.46 ± 0.01	5.98 ± 0.18	2.63 ± 0.18	0.16 ± 0.01	9.23	6.94
HW-17	0.49 ± 0.01	5.12 ± 0.40	2.10 ± 0.13	0.22 ± 0.02	7.93	8.40
HW-18	0.43 ± 0.00	4.51 ± 0.33	2.03 ± 0.07	0.30 ± 0.02	7.27	8.65
Minimum	0.04 ± 0.01	3.79 ± 0.35	1.46 ± 0.14	0.07 ± 0.00	5.81	6.94
Maximum	0.66 ± 0.02	5.98 ± 0.18	2.63 ± 0.18	0.31 ± 0.03	9.23	12.40
Mean	0.24	4.28	1.85	0.19	7.21	9.91
SD	0.28	0.33	0.26	0.31	0.81	1.41

protective benefit with respect to fatal and nonfatal coronary heart diseases events (Davis et al., 2007).

In this study, many walnut genotypes had higher contents of phosphorus, calcium, magnesium, iron, sodium and unsaturated fatty acids (linoleic, linolenic) which may con tribute to its nutritional improvement effort.

REFERENCES

Amaral JS, Casal S, Pereira J, Seabra R, Oliveira B (2003). Determination of sterol and fatty acid compositions, oxidative stability, and nutritional value of six walnut (*Juglans regia* L.) cultivars grown in Portugal. J. Agric. Food Chem., 51: 7698-7702.

Anonymous (1991). Turkish Standard Institute TS 1276/Mart. Ankara.

Anonymous (2007). FAO htpp://faostat.fao. org/site/339/default.aspx.

AOAC (1990). Official Methods of Analysis. 15th AOAC İnternational. Washington. DC.

AOCS (1989). Offical Methods and Recommended Practices of The American Oil Chemistry's Society. Champaign., (Method Ce-66).

Dattilo AM, Kris-Etherton PM (1992). Effects of weight reduction on blood lipids and lipoproteins: a meta-analysis. Am. J. Clin. Nutr., 56: 320-328.

Davis L, Stonehouse W, Loots DT, Mukuddem-Petersen J, Van Der Westhuizen F, Hanekom SJ, Jerling JC (2007). The effects of high walnut and cashew nut diets on the antioxidant status of subjects with metabolic syndrome. Eur. J. Nutr., 46: 155-164.

Dreher ML, Maher CV, Kearney P (1996). The traditional and emerging role of nuts in healthful diets. Nutr. Rev., 54: 241-5.

Elin RJ (1993). Is the magnesium content of nuts a factor for coronary heart disease? Arch. Int. Med., 153: 779-780.

Feinberg M, Favier JC, Ireland-Ripert J (1987). Repertoire general des aliments (INRA), Technique et documentation. Ed. Lavoisier, Paris, France, p. 189.

Hu FB, Sampfer MJ, Manson JE, Rimm EB, Colditz GA, Rosner BA, Speizer FE, Hennekens CH, Willett WC (1998). Frequent nut consumption and risk of coronary heart disease in women: prospective cohort study. Br. Med. J., 317: 1341-1345.

IUPAC (1998). International Union of Pure and Applied Chemistry. Standard Methods and Applications. Marcel Dekker. New York.

Kaçar B (1972). Chemical analyze of plant and soil. II. Plant analyze Ankara University, faculty of Agriculture Press p. 453 Practice guide, p. 155 Ankara p. 635.

Klepping J, Guilland JC, Fuchs F, Marcer I, Houard-Malval M (1989). Recueil de donnees sur la composition des aliments, CEIV, Roche, Neuilly Sur Seine, p. 128.

Koyuncu F, Koyuncu MA, Erdal İ, Yavic A (2002). Chemical Composition of fruits of some walnut (*J. regia* L) Selections Gida 27(4): 247-251.

Lavedrine F, Ravel A, Villet A, Ducros V, Alary J (2000). Mineral composition of two walnut cultivars originating in France and California. Food Chem., 68: 347-351.

Li L, Tsao R, Yang R, Kramer JKG, Hernandez M (2007). Fatty acid profiles, tocopherol contents, and antioxidant activities of heartnut (*Juglans ailanthiofolia var. cordiformis*) and Persian walnut (*Juglans regia* L.). J. Agric. Food Chem., 55: 1164-1169.

Mitrovic M, Stanisavljevic M, Danjanovic JG (1997). Biochemical composition of fruits of some important walnut cultivars and selections. Proc. III. İnt. Walnut Congress Acta Hortcult. 442: 205-207.

Muradoğlu F (2005). Selection of promosing genotypes in native walnut (*Juglans regia* L.) populations of Hakkari central and Ahlat (Bitlis) districht, and genetic diversty. PhD Thesis,. Yüzüncü Yil University, Turkey.

Payne T (1985). California walnuts and light food. Cereal Foods World. 30: 215-218.

Pereira JA, Oliveira I, Sousa A, Ferreira ICFR, Bento A, Estevinho L (2008). Bioactive properties and chemical composition of six walnut (*Juglans regia* L.) cultivars. Food Chem. Toxicol., 46: 2103-2111.

Prineas RJ, Kushi LH, Folsom AR, Bostick RM, Wu Y (1993). Walnuts and serum lipids. New Engl. J. Med., 329: 359-360.

Ravai M (1992). Quality characteristics of califonia walnuts. Cereal Foods World, 37: 362-366.

Ruggeri S, Cappelloni L, Gambelli S, Carnovale E (1998). Chemical composition and nutritive value of nuts grown in Italy. Ital. J. Food Sci., 3: 243-252.

Savage GP (2001). Chemical composition of walnuts (*Juglans regia* L.) grown in New Zealand. Plant Foods Hum. Nutr., 56: 75-82.

Souci SW, Fachmann W, Kraut H (1994). Food composition and nutrition tables. Medpharm, CRC Press, Stuttgart, pp. 955-956.

Zwarts L, Savage GP, McNeil DL (1999). Fatty acid content of New Zealand-grown walnuts (*Juglans regia* L.). Int. J. Food Sci. Nutr., 50: 189-194.