Available online at www.sciencedirect.com

SCIENCE DIRECT®

Food Chemistry 99 (2006) 509–515

Food Chemistry

www.elsevier.com/locate/foodchem

Nutrient composition of hazelnut (*Corylus avellana* L.) varieties cultivated in Turkey

A. İlhami Köksal [a,*], Nevzat Artik [b], Atilla Şimşek [c], Nurdan Güneş [a]

[a] *Ankara University, Faculty of Agriculture, Department of Horticulture, 06100 Ankara, Turkey*
[b] *Ankara University, Faculty of Agriculture, Department of Food Engineering, 06100 Ankara, Turkey*
[c] *Karadeniz Technical University, Faculty of Ordu Agriculture, Department of Food Engineering, Ordu, Turkey*

Received 17 January 2005; received in revised form 8 August 2005; accepted 8 August 2005

Abstract

In this study, chemical composition of the 17 different hazelnut varieties grown in the Black Sea Region of Turkey was investigated. The main fatty acids in hazelnut varieties were oleic (79.4%), linoleic (13.0%) and palmitic acid (5.4%). The ratios of polyunsaturated/saturated and unsaturated/saturated fatty acids of hazelnuts varieties were found to be between 1.23 and 2.87, and 11.1 and 16.4, respectively. The average niacin, vitamin B_1, vitamin B_2, vitamin B_6, ascorbic acid, folic acid, retinol and total tocopherol contents of hazelnut kernels were 1.45 mg/100 g, 0.28 mg/100 g, 0.05 mg/100 g, 0.5 mg/100 g, 2.45 mg/100 g, 0.043 mg/100 g, 3.25 mg/100 g and 26.9 mg/100 g, respectively. The amount of the essential amino acids, mostly as arginine (2003 mg/100 g) and leucine (1150 mg/100 g), and the non-essential amino acids, mostly as glutamic acid (2714 mg/100 g) and aspartic acid (1493 mg/100 g) were also determined in the hazelnut varieties. Mineral compositions of the hazelnut varieties, e.g., K, Mn, Mg, Ca, Fe, Zn, Na and Cu were (averagely) measured as 863 mg/100 g, 186 mg/100 g, 173 mg/100 g, 5.6 mg/100 g, 4.2 mg/100 g, 2.9 mg/100 g, 2.6 mg/100 g and 2.3 mg/100 g, respectively.

Keywords: Aminoacids; *Corylus avellana* L.; Hazelnuts; Minerals; Vitamins

1. Introduction

Turkey has growing conditions suitable for cultivating high quality varieties of hazelnuts. Furthermore, Anatolia is genetic origin of hazelnut as well as the natural extension area of the most valuable wild species and the main source of cultivated varieties (Ayfer, Türk, & Eriş, 1997; Köksal, 2002). Turkey is the main hazelnut-producing country, supplying 65% of the world's total production. She is followed by Italy, Spain and the USA. In addition, Turkey is the largest exporter of hazelnuts which account for 12% of its foreign trade earnings (Anonymous, 2001). So, hazelnut is a very important horticultural product for Turkey's economy.

Hazelnut kernels are consumed as natural, blanched and roasted or their products, such as sliced, chopped, flour, oil and hazelnut butter, in the world in order to provide flavour in dairy, bakery, confectionery, candy and chocolate products. Eighty percent of the hazelnut kernels are processed in chocolate manufacture, 15% in confectionery, biscuit and pastry manufacture, 5% is consumed without any further processing (Anonymous, 1995).

Hazelnuts play a major role in human nutrition and health due to their very special nutritional value. One hundred grammes of hazelnut provides 600–650 kcal (Alphan, Pala, Açkurt, & Yilmaz, 1997; Garcia, Ağar, & Streif, 1994; Mehlenbacher, 1990; Richardson, 1997). Hazelnut kernel includes carbohydrate at 10–22% (Bonvehi & Cool, 1993; Botta, Gianotti, Richardson, Suwanagul, & Sanz, 1994; Mashev & Kabatrzhikov, 1978). It also includes organic acids but in small quantities and the most abundant organic acid in hazelnut kernel is malic acid (Botta et al.,

* Corresponding author. Tel.: +90 312 596 13 10; fax: +90 312 317 91 19.
E-mail address: ikoksal@agri.ankara.edu.tr (A. İlhami Köksal).

0308-8146/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodchem.2005.08.013

1994). Celluloses and pectins in hazelnut are available at a rate of 1–3% (Baysal, 1996). The protein content of hazelnut kernel changes between 10% and 24%. It has been reported that 22% of daily protein requirement in the human diet could be supplied by consuming 100 g of hazelnut in a day (Pala, Açkurt, Löker, Yıldız, & Ömeroğlu, 1996). Hazelnut kernels are a good source of fat (50–73%) and contain unsaturated fatty acids (linoleic, linolenic, oleic acids, palmitic and stearic), essential for human health (Garcia et al., 1994). Hazelnut oil decreases the cholesterol level in blood and also controls adverse effects of hypertension (Durak et al., 1999). Besides their rich mineral content, hazelnut kernels are among valuable sources of necessary vitamins, such as vitamins B_1, B_6, niacin and α-tocopherol. There is growing, although inconclusive, evidence that α-tocopherol, the active form of vitamin E, helps to lower the risk of certain chronic diseases, such as heart disease (Iannuzzi et al., 2002), type 2 diabetes (Dhein et al., 2003), hypertension (Boshtam, Rafiei, Sadeghi, & Sarraf-Zadegan, 2002), and cancer (Venkateswaran, Fleshner, & Klotz, 2002) and that it may combat some of the negative effects associated with aging (Grodstein, Chen, & Willett, 2003). α-Tocopherol may also be protective against cognitive decline and Alzheimer's disease (Martin, 2003). However, nutritional and chemical composition of hazelnuts are mostly referred to variety, ecology and cultural applications (Köksal, 2002). The aim of this study is to determine the composition of different Turkish hazelnut cultivars growing in the East Black Sea Region of Turkey.

2. Materials and methods

2.1. Materials

The kernels of 17 Turkish hazelnut (*Corylus avellana* L.) varieties, such as "Acı", "Cavcava", "Çakıldak", "Foşa", "İncekara", "Kalınkara", "Kan", "Karafındık", "Kargalak", "Kuş", "Mincane", "Palaz", "Sivri", "Tombul", "Uzunmusa", "Yassıbadem" and "Yuvarlakbadem", were used in this study. Samples of each variety were obtained from the Hazelnut Research Institute in Giresun, located in the East Black Sea Region of Turkey during the 2002 harvest season. The hazelnut samples (3 kg for each variety as unshelled and milled) were stored at −20 °C in polyethylene bags prior to analyses.

2.2. Methods

The moisture of samples was determined by drying at 103 ± 2 °C until they reached constant weight (Anonymous, 1978). Total fat was extracted with *n*-hexane (60 °C) for 6 h using a Soxhlet extractor and fatty acid composition was analysed by gas chromatography (Thermo Quest, 2000) with a flame ionisation detector (FID). N_2 was used as carrier gas at a flow rate of 1 ml/min. For separation of the fatty acids, a fused silica capillary column (23.30 m × 0.25 mm × 25 μm film thickness) was used and the temperature of the column, detector and injection was set at 240 °C. Fatty acids were identified by comparison with retention times of external standards (AOCS, 1990). Total ash was determined by drying of the samples for 12 h at 75 °C in an oven and then transferring the crucible to a muffle furnace. The temperature was gradually raised to 550 °C, and the samples were ashed for 24 h to a white colour. Protein was determined by the micro Kjeldahl method. Protein content was calculated as total N × 6.25 (James, 1995). Free amino acids were determined using high performance liquid chromatography (HPLC) (Shimadzu LC 10 ADVP, SCL 10 AVP). HPLC was performed with a hypersil ODS column (200 × 2.1 mm, ID 5 μm), and photodiode array (PDA) detector (Shimadzu, SPD 10 AVP) at 226 nm. Two different solvents, namely solvent (A), buffer solution of 0.03 M sodium acetate (pH 7.2 + 0.5% THF) and solvent (B), buffer solution 0.1 M sodium acetate: ACN (1:4), were gradually used at 0.45 ml/min flow rate. Column temperature was set at 40 °C (Shuster, 1988). Soluble and insoluble vitamins were determined by HPLC. For the analysis of vitamin B_1, B_2, B_6, folic acid, biotin, ascorbic acid and niacin, a SUPELCO Discovery C_{18} column (150 × 4.6 mm, ID 5 μm) and PDA detector at 220 nm were used. The column temperature was 35 °C. Mobile phase was K_2HPO_4/methyl alcohol (99/1) at 1 ml/min flow rate and column pressure was 92 kgf (Rizollo, Baldo, & Polesella, 1991). For the determination of insoluble vitamins, such as retinol and tocopherols (α-tocopherol, γ-tocopherol and δ-tocopherol), *n*-hexane/isopropanol (99:1) at a flow rate 1 ml/min, was used as mobile phase. Vitamins were separated with a Lichrosorb Si_{60} (250 × 4 mm, ID 5 μm) column at 35 °C (Yao, Dull, & Eitenmiller, 1992). Determination of mineral content of hazelnut varieties was carried out by atomic absorption (Varian Spectr AA-400 Plus Atomic Absorption Spectrophotometer). Phosphorus was spectrophotometrically analysed in the form of vanadium phosphomolybdate (James, 1995).

All analyses were conducted in triplicate for each variety.

3. Results and discussion

The moisture content of hazelnut varieties ranged between 2.49% ("Karafındık") and 5.25% ("Cavcava") (Table 1).

Generally, the total fat content of the samples was above 50% and was between the values of 56.07% and 68.52% (Table 1). "Cavcava", which had the highest moisture content, had the lowest fat within all varieties and "Mincane", "Palaz", "Yuvarlak Badem", "Foşa" and "Kargalak" followed this variety. While oleic acid was the dominant fatty acid (74.2–82.8%) in all varieties, linolenic acid was found in the lowest quantity (0.03–0.08%). The varieties including oleic acid at more than 80% were "Kan", "Kargalak", "Yassı Badem" and "Çakıldak". Linoleic acid was the sec-

Table 1
Fatty acid contents of hazelnut (*Corylus avellana* L.) varieties

Variety	Moisture (%)	Total oil (%)	Fatty acids (g/100 g)						P	U	S	P/S	U/S
			Palmitic C16:0	Palmitooleic C16:1	Stearic C18:0	Oleic C18:1	Linoleic C18:2	Linolenic C18:3					
Cavcava	5.25	56.07	5.87	0.22	2.37	78.8	12.7	0.069	12.7	91.7	8.2	1.55	11.2
Çakıldak	4.86	60.67	4.89	0.32	2.15	80.7	11.9	0.059	12.0	92.9	7.0	1.70	13.2
Foşa	4.46	59.50	5.62	0.37	1.70	79.0	13.2	0.074	13.3	92.6	7.3	1.82	12.7
İncekara	4.27	60.75	5.67	0.32	1.76	79.5	12.7	0.073	12.7	92.5	7.4	1.71	12.5
Kalınkara	4.14	68.52	5.71	0.42	2.42	79.5	11.9	0.067	12.0	91.8	8.1	1.47	11.3
Kan	3.41	63.05	5.72	0.32	2.30	81.8	9.82	0.053	9.87	91.9	8.0	1.23	11.5
Karafındık	2.49	67.75	5.62	0.28	2.37	78.9	12.8	0.058	12.9	92.0	7.9	1.61	11.5
Kargalak	4.39	59.57	4.89	0.42	0.86	81.0	12.7	0.067	12.8	94.2	5.7	2.23	16.4
Kuş	4.41	61.25	5.69	[a]	0.87	79.9	13.5	0.076	13.6	93.4	6.5	2.07	14.3
Mincane	4.71	57.95	5.02	0.38	1.90	82.8	9.89	0.029	9.92	93.0	6.9	1.43	13.5
Palaz	4.76	57.65	4.87	0.34	2.13	77.6	15.0	0.076	15.1	92.9	7.0	2.15	13.3
Sivri	4.78	63.89	4.72	0.42	2.49	79.2	13.2	a	13.2	92.8	7.2	1.83	12.9
Tombul	4.63	64.60	5.17	0.48	1.75	77.8	14.8	0.054	14.8	93.0	6.9	2.14	13.5
Uzunmusa	4.17	61.75	5.70	0.46	1.41	78.8	13.6	0.069	13.6	92.8	7.1	1.92	13.1
Yassı Badem	3.56	63.48	4.87	0.28	1.43	81.1	12.2	0.046	12.3	93.6	6.3	1.95	14.9
Yuvarlak Badem	4.61	58.3	5.66	0.36	0.87	74.2	18.73	a	18.7	93.4	6.5	2.87	14.3
Minimum	2.49	56.07	4.72	0.22	0.86	74.2	9.82	0.029	9.87	91.7	5.7	1.23	11.1
Maximum	5.25	68.52	5.87	0.48	2.49	82.8	18.7	0.076	18.7	94.2	8.2	2.87	16.4
Mean	4.29	61.66	5.36	0.36	1.80	79.4	13.0	0.062	13.1	92.8	7.1	1.85	13.1
SD	0.70	3.4	0.4	0.1	0.6	2.0	2.1	0.013	2.06	0.69	0.69	0.39	1.41

U, unsaturated fatty acid (C16:1 + C18:1 + C18:2 + C18:3); S, saturated fatty acid (C16:0 + C18:0); P, polyunsaturated fatty acid (C18:2 + C18:3).
[a] Unidentifiable result with analysis.

Table 2
Vitamin content of hazelnut (*Corylus avellana* L.) varieties

Variety	Soluble vitamins (mg/100 g)							Insoluble vitamins (mg/100 g)				
	Vitamin B_1	Vitamin B_2	Folic acid (μg/100 g)	Vitamin B_6	Biotin	Niacin	Ascorbic acid	Retinol	α-Tocopherol	γ-Tocopherol (μg/100 g)	δ-Tocopherol	Total tocopherol
Acı	0.106	0.057	[a]	0.421	a	1.602	2.86	1.21	22.2	a	2.29	24.5
Cavcava	0.349	0.041	76	0.686	a	0.804	1.61	2.21	26.7	a	2.45	29.2
Çakıldak	0.124	0.062	38	0.389	a	0.918	1.89	4.96	25.8	a	1.38	27.2
Foşa	0.472	0.049	39	0.472	a	1.12	2.03	9.06	23.8	a	1.12	24.9
İncekara	0.243	0.047	a	0.446	a	1.71	2.94	4.62	26.4	a	1.16	27.5
Kalınkara	0.184	0.041	a	0.305	a	1.41	2.86	2.22	27.1	a	2.62	29.8
Kan	0.145	0.053	82	0.716	a	1.39	1.38	3.79	29.8	a	2.52	32.3
Karafındık	0.172	0.051	44	0.349	a	1.90	2.77	3.48	23.1	a	0.52	23.6
Kargalak	0.396	0.048	24	0.691	a	1.20	1.96	1.7	20.3	a	3.41	23.8
Kuş	0.544	0.057	a	0.544	a	1.10	1.41	2.36	19.0	a	0.7	19.7
Mincane	0.168	0.053	56	0.631	a	2.01	2.78	2.21	21.0	0.98	1.54	22.6
Palaz	0.361	0.048	a	0.644	a	1.41	2.96	1.58	25.8	a	1.76	27.5
Sivri	0.132	0.061	9	0.216	a	1.54	2.63	2.79	27.0	a	1.28	28.3
Tombul	0.199	0.067	19	0.344	a	1.61	2.88	2.95	38.4	0.61	3.08	41.4
Uzunmusa	0.204	0.058	26	0.614	a	1.81	2.71	1.79	28.4	1.62	2.68	31.1
Yassı Badem	0.309	0.041	a	0.466	a	1.71	3.00	2.38	18.6	0.38	0.97	19.6
Yuvarlak Badem	0.580	0.058	61	0.580	a	1.39	2.93	5.99	17.2	1.23	0.75	17.9
Minimum	0.106	0.041	9	0.216		0.804	1.38	1.21	17.2	0.38	0.52	17.9
Maximum	0.580	0.067	82	0.716		2.01	3.00	9.06	38.4	2.98	3.41	41.4
Mean	0.276	0.052	43	0.501		1.45	2.45	3.25	24.7	1.36	1.78	26.5
SD	0.151	0.008	24	0.151		0.340	0.59	1.98	5.09	1.03	0.90	5.63

[a] Unidentifiable result with analysis.

ond most abundant fatty acid in the samples and its range was between 9.82% and 18.7%. Palmitic, stearic and palmitoleic acids followed this. The kernels of "Cavcava", "Tombul"and "Sivri" had the highest level of palmitic (5.87%), palmitoleic (0.48%) and stearic (2.49%) acids, respectively (Table 1). The fatty acid profiles of all investigated varieties were consistent with data on Turkish hazelnut varieties (Baş, Ömeroğlu, Türdü, & Aktaş, 1986; Botta et al., 1994; Garcia et al., 1994; Mehlenbacher, 1990; Özdemir, Topuz, Doğan, & Karkacıer, 1998; Özdemir et al., 2001; Parcerisa, Richardson, Rafecas, Condony, & Boatella, 1998). The ratio of unsaturated/saturated as mean fatty acid was 13.1 (Table 1). Due to the high ratio of unsaturated/saturated fatty acids found in hazelnut, its addition to processed food can improve the nutritional quality of the manufactured food (Bonvehi & Cool, 1993; Ebrahem, Richardson, Tetley, & Mehlenbacher, 1994). Moreover, the highest concentration of oleic and linoleic acid in hazelnut kernels allows oxidative rancidity to occur (Kinderlerer & Johnson, 1992). The ratio of polyunsaturated/saturated (P/S) fatty acids was 1.23–2.87 in a variety of hazelnut. Diet proposals tend to reduce total amount of fats and cholesterol and to achieve a ratio of polyunsaturated/saturated fatty acids greater than 1 and this depends upon amount of vitamin E (Ebrahem et al., 1994; Hong & Shin, 1978).

The niacin, vitamin B_1, vitamin B_2, vitamin B_6, folic acid and ascorbic acid contents of the hazelnut varieties were (averagely) found to be 1.45 mg/100 g, 0.276 mg/100 g, 0.052 mg/100 g, 0.501 mg/100 g, 43 μg/100 g and 2.45 mg/100 g, respectively (Table 2). The highest levels of niacin (2.01 mg/100 g), vitamin B_1 (0.580 mg/100 g), vitamin B_2 (0.067 mg/100 g), vitamin B_6 (0.716 mg/100 g) and ascorbic acid (3.00 mg/100 g) were determined in the kernels of "Mincane", "Yuvarlak Badem", "Tombul", "Kan" and "Yassı Badem" varieties, respectively. "Kan" was the most significant variety, based on either folic acid or vitamin B_6 contents. Biotin was an unidentified vitamin in all varieties. The mean values of the insoluble vitamins, such as retinol, α-, γ- and δ-tocopherol were determined to be 3.25 mg/100 g, 24.7 mg/100 g, 1.36 μg/100 g and 1.78 mg/100 g, respectively. The kernels of "Tombul" variety contained α-tocopherol (38.4 mg/100 g) at a higher level than the others. There is some evidence that α-tocopherol contents of Turkish hazelnut varieties are between 29.0 mg/100 g and 41.3 mg/100 g (Açkurt, Özdemir, Biringen, & Löker, 1999; Alphan et al., 1997; Parcerisa et al., 1998; Richardson, 1997).

In this research all of the hazelnut varieties had protein contents above 10% (Table 3). The N × 6.25 content oscillates between 17.4 g/100 g and 20.8 g/100 g. The protein was mostly composed of non-essential amino acids such as glutamic and aspartic acids (Table 3). In all hazelnut varieties, glutamic acid was determined as the most common non-essential amino acid, followed by aspartic acid. The kernels of "Mincane" variety had the highest glutamic acid content as 3475 mg/100 g. The other varieties, following this, were "Kalınkara" "Uzunmusa" and "İncekara". Based on the mean values, tyrosine was found at the lowest level for all hazelnut varieties.

In all hazelnut varieties, however arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine and valine were determined as the essential amino acids, and arginine and leucine were found as the most abundant (Table 4). Arginine and leucine levels in the samples ranged between 1187 mg/100 g and 2322 mg/100 g,

Table 3
Non-essential amino acid contents of hazelnut (*Corylus avellana* L.) varieties

Variety	Protein (%)	Non-essential amino acids (mg/100 g)						
		Alanine	Aspartic acid	Glutamic acid	Glycine	Proline	Serine	Tyrosine
Acı	16.6	714	1672	2855	632	624	621	414
Cavcava	20.8	662	489	2196	571	529	574	517
Çakıldak	19.4	724	1462	2689	513	526	494	483
Foşa	15.8	762	1648	3147	658	618	865	590
İncekara	16.3	631	1678	3215	648	542	627	428
Kalınkara	11.7	764	1579	3265	679	613	719	597
Kan	17.0	718	1578	2941	715	617	732	487
Karafındık	15.6	748	1697	2715	516	627	725	436
Kargalak	15.2	731	1697	2697	686	538	627	463
Kuş	16.8	741	615	2815	625	672	748	442
Mincane	20.0	825	1687	3475	724	819	716	489
Palaz	18.0	638	1487	2575	624	567	1002	432
Sivri	18.7	683	1627	2982	722	624	748	487
Tombul	17.5	716	1675	2767	679	539	1082	436
Uzunmusa	17.0	712	1528	3247	644	513	616	428
Yassı Badem	17.9	812	1612	2914	613	514	718	452
Yuvarlak Badem	20.8	718	1649	2764	675	579	614	417
Minimum	11.7	631	489	2196	513	513	494	414
Maximum	20.8	825	1697	3475	724	819	1082	597
Mean	17.4	724	1493	2836	643	592	719	471
SD	2.30	52.4	362	667	63.1	76.1	149	54.9

Table 4
Essential amino acid contents of hazelnut (*Corylus avellana* L.) varieties

Variety	Essential aminoacids (mg/100 g)								
	Arginine	Histidine	Izoleucine	Leucine	Lysine	Methionine	Phenylalanine	Threonine	Valine
Acı	2127	542	567	1124	424	148	582	434	684
Cavcava	1763	385	318	1169	389	146	576	474	618
Çakıldak	1864	521	627	1187	378	124	568	425	657
Foşa	2306	393	674	1025	474	189	718	474	768
İncekara	2265	512	567	1217	479	182	542	467	618
Kalınkara	2218	398	689	1197	447	149	749	517	807
Kan	2178	367	618	1269	481	159	767	502	624
Karafındık	1979	413	568	1215	402	178	724	423	616
Kargalak	2184	389	624	1271	469	148	557	432	642
Kuş	1187	392	497	1179	427	148	561	448	671
Mincane	2249	393	548	1165	519	149	765	484	627
Palaz	1274	590	573	924	386	179	578	416	785
Sivri	2148	382	483	1085	489	163	728	468	617
Tombul	2146	377	519	1030	468	150	678	497	629
Uzunmusa	1867	382	624	1249	514	189	563	478	618
Yassı Badem	2322	348	565	1149	517	171	579	427	656
Yuvarlak Badem	1965	315	492	1093	395	169	598	492	633
Minimum	1187	315	318	924	378	124	542	416	616
Maximum	2322	590	689	1271	519	189	767	517	807
Mean	2003	418	562	1150	454	162	637	462	663
SD	334	75.4	86.9	94.1	47.8	18.6	85.4	31.6	62.7

924 mg/100 g and 1271 mg/100 g, respectively. But, based on the mean values of the samples, methionine (162 mg/100 g) was the most insignificant amino acid. As a result of this research, hazelnut seems to be a good source of protein and also amino acids and for this reason its use in the human diet should be considered. Our findings are parallel results of Baş et al. (1986).

The average ash content of the hazelnut varieties was found to be 2.34% (Table 5). The minimum and maximum values, based on this parameter, ranged between 1.87% (''Kalınkara'') and 2.72% (''Cavcava''). Differences among the hazelnut varieties were observed, based on the mineral compositions (Table 5). According to Ayfer, Uzun, and Baş (1986) and Baş et al. (1986), the mineral composition of hazelnut kernels depended, not only on the variety, but also on the growing conditions such as soil and geographical condition. In this study, while the existence of nine elements was determined in all hazelnut varieties, K

Table 5
Mineral contents of hazelnut (*Corylus avellana* L.) varieties

Variety	Total ash (%)	Mineral elements (mg/100 g)								
		K	P	Ca	Mg	Fe	Cu	Mn	Zn	Na
Acı	2.22	1036	340	204	208	4.3	2.2	3.6	2.7	2.16
Cavcava	2.72	886	331	161	152	3.7	2.8	7.7	3.2	2.63
Çakıldak	2.60	1470	335	224	224	5.1	2.6	10.0	4.4	2.42
Foşa	2.25	1052	339	172	176	4.8	2.6	8.4	3.1	2.22
İncekara	2.41	506	246	175	152	3.9	1.8	4.3	2.9	2.04
Kalınkara	1.87	914	233	65	144	4.0	2.0	2.4	2.2	2.62
Kan	2.13	750	285	101	168	3.3	2.2	3.5	2.3	2.79
Karafındık	1.90	776	325	194	160	5.1	2.5	7.5	3.0	2.66
Kargalak	2.37	928	202	158	144	3.6	1.7	2.5	2.4	2.26
Kuş	2.30	706	239	180	176	3.8	2.3	3.1	2.4	2.71
Mincane	2.43	1002	285	214	184	5.0	2.5	4.0	3.3	2.37
Palaz	2.61	1014	370	328	200	4.9	3.2	7.7	3.4	2.32
Sivri	2.30	920	270	129	184	4.0	2.2	3.4	2.6	3.81
Tombul	2.43	814	288	217	168	4.2	2.3	7.7	2.7	3.19
Uzunmusa	2.34	872	288	234	160	4.2	2.3	7.0	3.6	2.31
Yassı Badem	2.42	382	228	174	144	3.2	2.0	4.8	2.2	2.42
Yuvarlak Badem	2.46	640	272	230	192	3.6	2.2	7.6	2.7	2.72
Minimum	1.87	382	202	65	144	3.2	1.7	2.4	2.2	2.04
Maximum	2.72	1470	370	328	224	5.1	3.2	10.0	4.4	3.8
Mean	2.34	863	287	186	173	4.2	2.3	5.6	2.9	2.6
SD	0.20	243	47.7	58.6	23.7	0.6	0.4	2.4	0.6	0.4

was predominant, followed by P, Ca and Mg. K, Mg, Fe, Mn and Zn levels of "Çakıldak" hazelnut variety were higher than the others. Ca, P and Cu levels were higher in the samples of "Palaz". Na levels of "Sivri" and "Tombul" varieties were higher than those of the other varieties. The presence of Fe, Zn and Cu, and a high K/Na ratio, make hazelnut interesting for human diets, and especially for electrolyte balance (Fennema, 1985). The mineral elements found in this study are similar to those reported by Ayfer et al. (1986), Baş et al. (1986), Pala et al. (1996), Özdemir et al. (1998) and Özdemir et al. (2001) for Turkish hazelnut varieties.

As a result of this study, hazelnut is a valuable horticultural product, based on its beneficial nutrient composition, especially for human health. However, certain growing conditions and cultural management techniques affecting the nutritional value of hazelnut varieties will be the subject of further research projects.

References

Açkurt, F., Özdemir, M., Biringen, G., & Löker, M. (1999). Effects of geographical origin and variety on vitamin and mineral composition of hazelnut (*Corylus avellana* L.) varieties cultivated in Turkey. *Food Chemistry, 65*, 309–313.

Alphan, E., Pala, M., Açkurt, F., & Yilmaz, T. (1997). Nutritional composition of hazelnuts and its effects on glucose and lipid metabolism. *Acta Horticulturae, 415*, 305–310.

Anonymous (1978). *Unshelled hazelnuts (filberts), TS-3074*. Ankara: Institute of Turkish Standards.

Anonymous (1995). Fındık Ekonomik Raporu, Fiskobirlik, Giresun.

Anonymous (2001). *Agricultural product profiles*. Available from http://www.igeme.gov.tr/tur/foyler/tarim/frame.htm.

AOCS (1990). *Officals methods and recommended practices of the American oil chemist's society* (5th ed.). IL, USA: American Oil Chemist Society.

Ayfer, M., Uzun, A., & Baş, F. (1986). *Türk Fındık* Çeşitleri, Karadeniz Fındık İhracatçılar Birliği, Ankara.

Ayfer, M., Türk, R., & Eriş, A. (1997). Chemical composition of Değirmendere hazelnut and its importance in human nutrition. *Acta Horticulturae, 415*, 51–53.

Baş, F., Ömeroğlu, S., Türdü, S., & Aktaş, S. (1986). Önemli fındık çeşitlerinin bileşim özelliklerinin saptanması. *Gıda, 11*, 195–203.

Baysal, A. (1996). *Beslenme*. Hatipoğlu Yayınevi. Ankara. 494 p.

Bonvehi, J. S., & Cool, F. V. (1993). Oil content, stability and fatty acid composition of the main varieties of Catalonian hazelnut (*Corylus avellana* L.). *Food Chemistry, 48*, 231–241.

Boshtam, M., Rafiei, M., Sadeghi, K., & Sarraf-Zadegan, N. (2002). Vitamin E can reduce blood pressure in mild hypertensives. *International Journal of Vitamin and Nutrition Research, 72*, 309–314.

Botta, R., Gianotti, C., Richardson, D., Suwanagul, A., & Sanz, C. L. (1994). Hazelnut variety organic acids sugars and total lipid fatty acids. *Acta Horticulturae, 351*, 693–699.

Dhein, S., Kabat, A., Olbrich, A., Rosen, P., Schroder, H., & Mohr, F. W. (2003). Effect of chronic treatment with vitamin E on endothelial dysfunction in a type I in vivo diabetes mellitus model and in vitro. *Journal of Pharmacology and Experimental Therapeutıcs, 305*, 114–122.

Ebrahem, K. S., Richardson, D. G., Tetley, R. M., & Mehlenbacher, S. A. (1994). Oil content, fatty acid composition and vitamin E concentration of hazelnut varieties, compared to other types of nuts and oil seeds. *Acta Horticulturae, 351*, 685–692.

Fennema, O. R. (1985). *Food chemistry* (2nd ed.). 270 Madıson Avenue, New York: Marcel Dekker, Inc., 991 p.

Durak, İ., Köksal, İ., Kaçmaz, M., Büyükkoçak, S., Çimen, B. M. Y., & Öztürk, H. S. (1999). Hazelnut supplementation enhances plasma antioxidant potential and lowers plasma cholesterol levels. *Clinica Chimica Acta, 284*, 113–115.

Garcia, J. M., Ağar, I. T., & Streif, J. (1994). Lipid characteristics of kernels from different hazelnut varieties. *Turkish Journal of Agricultural and Forestry, 18*, 199–202.

Grodstein, F., Chen, J., & Willett, W. C. (2003). High-dose antioxidant supplements and cognitive function in community-dwelling elderly women. *American Journal of Clinical Nutrition, 77*, 975–984.

Hong, H., & Shin, H. (1978). Lipid components of hazelnut oil. *Korean Journal of Food Science and Technology, 10*, 361–365.

Iannuzzi, A., Celentano, E., Panico, S., Galasso, R., Covetti, G., Sacchetti, L., et al. (2002). Dietary and circulating antioxidant vitamins in relation to carotid plaques in middle-aged women. *American Journal of Clinical Nutrition, 76*, 582–587.

James, G. S. (1995). *Analytical chemistry of foods*. London: Blackie Academic and Professional (pp. 117–120).

Kinderlerer, J. L., & Johnson, S. (1992). Rancidity in hazelnuts due to volatile aliphatic aldehydes. *Journal of Science and Food Agriculturae, 58*, 89–93.

Köksal, A. I. (2002). *Turkish hazelnut cultivars*. ISBN: 975-92886-1-3. 136 p.

Martin, A. (2003). Antioxidant vitamins E and C and risk of Alzheimer's disease. *Nutrition Reviews, 61*, 69–73.

Mashev, N. P., & Kabatrzhikov, L. G. (1978). Chemical composition and nutritonal value of hazelnut kernels. *Food Science and Technology Abstracts, 10*, 11154.

Mehlenbacher, S. A. (1990). Hazelnuts (*Corylus*). In J. N. Moore, & J. R. Ballington (Eds.), *Genetic resources of temperate fruit and crops 1* (pp. 791–820). Wageningen, The Netherlands.

Özdemir, F., Topuz, A., Doğan, U., & Karkacıer, M. (1998). Fındık çeşitlerinin bazı fiziksel ve kimyasal özellikleri. *Gıda, 23*, 37–41.

Özdemir, M., Açkurt, F., Kaplan, M., Yıldız, M., Löker, M., Gürcan, T., et al. (2001). Evaluation of new Turkish hybrid hazelnut (*Corylus avellana* L.) varieties: fatty acid composition, α-tocopherol content, mineral composition and stability. *Food Chemistry, 73*, 411–415.

Pala, M., Açkurt, F., Löker, M., Yıldız, M., & Ömeroğlu, S. (1996). Fındık çeşitlerinin bileşimi ve beslenme fizyolojisi bakımından değerlendirilmesi. *Turkish Journal of Agriculture and Forestry, 20*, 43–48.

Parcerisa, J., Richardson, D. G., Rafecas, M., Condony, R., & Boatella, J. (1998). Fatty acid, tocopherol and sterol content of some hazelnut varieties (*Corylus avellana* L.) harvested in Oregon (USA). *Journal of Chromatography A, 805*, 259–268.

Richardson, D. G. (1997). The health benefits of eating hazelnuts: Implications for blood lipid profiles, coronary heart disease, and cancer risks. *Acta Horticulturae, 415*, 295–297.

Rizollo, A., Baldo, C., & Polesella, A. (1991). Application of high performance liquid chromatography to the analysis of niacin and biotin in Italian almond cultivars. *Journal of Chromatography, 553*, 187–192.

Shuster, R. (1988). Determination of amino acids in biological, pharmaceutical plant and food samples by HPLC. *Journal of Chromatography, 431*, 271–284.

Venkateswaran, V., Fleshner, N. E., & Klotz, L. H. (2002). Modulation of cell proliferation and cell cycle regulators by vitamin E in human prostate carcinoma cell lines. *Journal of Urology, 168*, 1578–1582.

Yao, F., Dull, G., & Eitenmiller, R. (1992). Tocopherol quantification by HPLC in pecans and relationship to kernel quality during storage. *Journal of Food science, 57*, 1195–1197.