ELSEVIER

Food Chemistry 65 (1999) 309–313

Food Chemistry

Effects of geographical origin and variety on vitamin and mineral composition of hazelnut (*Corylus avellana* L.) varieties cultivated in Turkey

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Received 18 May 1998; received in revised form; accepted 20 August 1998

Abstract

The effects of variety and geographical origin on vitamin and mineral composition of eight different varieties of hazelnut cultivated in the Black Sea Region of Turkey were studied. The mean contents of niacin, vitamin B_1, vitamin B_2, vitamin B_6 and α-tocopherol were 1.81 ± 0.28, 0.30 ± 0.07, 0.10 ± 0.01, 0.240 ± 0.05, and 35.53 ± 3.82 mg/100 g, respectively. The mean contents of iron, zinc, copper, magnesium, manganese, calcium, potassium and sodium were 2.32 ± 0.21, 1.95 ± 0.25, 0.65 ± 0.29, 144 ± 14.86, 6.09 ± 4.17, 83.5 ± 5.14, 637 ± 105.33 and 0.70 ± 0.10 mg/100 g, respectively. Vitamin and mineral compositions of the varieties were not significantly different from each other. Geographical region differences did not significantly affect α-tocopherol, iron, manganese and calcium contents of the samples. Zinc, manganese, and sodium levels of Akçakoca samples were higher than for the other regions. Correlation analysis showed that α-tocopherol content correlated strongly with minerals (manganese, sodium, zinc, potassium) and vitamin B_6. © 1999 Elsevier Science Ltd. All rights reserved.

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

1. Introduction

Hazelnuts are of great economic importance to Turkey and annual production is about 500,000 tons. Their total export revenue is about one billion US dollars. Besides their economic value, hazelnuts provide a definite flavor to food products and play a major role in human nutrition and health (Woodroof, 1975; Labell, 1983; Mattson, 1989; Elvevol et al., 1990; Nicolosi et al., 1990; Mehlenbacher, 1991; Labell, 1992; Ebrahem & Richardson, 1994; Garcia et al., 1994; Alphan et al., 1996; Pala et al., 1996).

Hazelnuts are susceptible to rancidity due to their high fat content. Unsaturated fatty acids, α-tocopherol and mineral contents such as iron, manganese and copper are involved in rancidity. Several studies indicate that fat and mineral compositions of hazelnuts are affected by variety, geographical origin, harvest year, climate and the methods of cultivation (Parcerisa et al., 1995; Pershern et al., 1995). Researches on vitamin and mineral composition of hazelnut varieties cultivated in Turkey with respect to geographical origin and variety are limited. Therefore, this study was planned and carried out to determine the effects of geographical region and variety on vitamin and mineral compositions of Turkish hazelnut varieties. Eleven samples cultivated in four different geographical districts (Akçakoca, Ordu, Giresun, Trabzon) corresponding to the varieties Tombul, Palaz, Foşa, Mincane, Çakıldak, Sivri, Kalınkara, Sivri and Karafındık, were analyzed.

2. Materials and methods

2.1. Sampling

Eleven samples corresponding to eight commonly grown varieties of hazelnut (*Corylus avellana* L.) were collected by experts from trees cultivated in four geographical districts of the Black Sea Region of Turkey (The varieties Mincane, Çakıldak, Karafındık and Foşa from Akçakoca; Palaz and Çakıldak from Ordu; Sivri, Tombul and Kalınkara from Giresun; Sivri and Mincane from Trabzon). Samples in their unshelled state were

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PII: S0308-8146(98)00201-5

kept at room temperature for at most 2 weeks until analyses were performed. All reagents were of analytical grade. All analyses were conducted in triplicate.

2.2. Chemical analysis

Vitamins B_1, B_2 and niacin levels were determined by using a Technicon Autoanalyser A II according to the standard methods of the instrument. For the analysis of vitamin B_6 a microbiological method of AOAC (1990) was performed; α-tocopherol was determined by the Emmerie–Engel color reaction using a spectrophotometer (AOAC, 1990). Mineral analysis were carried out by Atomic Absorption Spectrophotometer (Hitachi 180-50) according to standard AOAC method (AOAC, 1990).

2.3. Statistical analysis

One way analysis of variance (ANOVA), multiple range least significant difference (LSD) test and correlation analyses were carried out by using a statistical package program (SPSS ver. 5.0) for $p<0.05$ significance level.

3. Results and discussion

Vitamin and mineral compositions of hazelnuts were shown in Tables 1–3, with respect to variety and geographical region. The mean values of niacin, vitamins B_1, B_2, B_6 and α-tocopherol content of the samples were 1.81, 0.30, 0.10, 0.240 and 35.53 mg/100 g, respectively. Significant differences between vitamin contents of varieties were observed (Table 1). Niacin, vitamins B_1, B_2, and B_6 levels of the samples were significantly changed according to geographical region; however, there were no significant changes observed between α-tocopherol levels (Table 3). The highest levels of niacin, vitamin B_1, and vitamin B_2 were determined in the samples of Ordu. Samples from the Akçakoca region were high in vitamin B_2 and vitamin B_6, while samples of the Trabzon region were highest in vitamin B_6. The results are comparable with those given by Ayfer et al. (1986), Baş et al. (1986), Mehlenbacher (1991) and by Pala et al., (1996) for Turkish hazelnut varieties. α-Tocopherol contents were also comparable with the results given by Ebrahem and Richardson (1994); Parcerisa et al., (1995) and Savage et al. (1997) for American, Spanish and New Zealand hazelnut varieties, respectively. It was reported that, α-tocopherol contents of Spanish hazelnut varieties were not significantly dependent on geographical area; in contrast significant changes were observed according to the harvest year (Parcerisa et al., 1995).

Mineral compositions are of interest due to their prooxidant activity and health benefits (Parcerisa et al., 1995; Pershern et al., 1995; Alphan et al., 1996). Significant differences were observed between mineral compositions of the samples (Table 2). Iron, manganese and calcium levels of hazelnuts were not affected by geographical region. Zinc, copper, manganese, calcium, and sodium levels were high in the samples of Akçakoca (Table 3). Potassium and magnesium levels of the samples from the Ordu region were highest. The lowest copper level was determined in samples of the Giresun region. However, there were no significant differences observed in the levels of iron between the geographical regions. Mineral compositions of our results were also supported by the results given by Ayfer et al., (1986),

Table 1
Vitamin composition (mg/100 g) of Turkish hazelnut varieties[1]

Region	Variety	Niacin	Vitamin B_1	Vitamin B_2	Vitamin B_6	α-Tocopherol
Akçakoca	Karafındık	1.798 ± 0.098bc	0.304 ± 0.013bcd	0.093 ± 0.002abc	0.199 ± 0.022bc	41.2 ± 0.10f
	Çakıldak	1.956 ± 0.271c	0.277 ± 0.016abc	0.104 ± .0006cd	0.285 ± 0.015e	NA[2]
	Mincane	1.629 ± 0.024abc	0.216 ± 0.005a	0.086 ± 0.003ab	NA	NA
	Foşa	1.922 ± 0.071c	0.298 ± 0.015bcd	0.104 ± 0.012cd	0.266 ± 0.015e	29.12 ± 0.10a
Ordu	Çakıldak	1.855 ± 0.175bc	0.300 ± 0.003bcd	0.097 ± 0.003bc	NA	35.17 ± 0.14d
	Palaz	2.371 ± 0.514d	0.444 ± 0.033e	0.096 ± 0.011bc	0.211 ± 0.010c	32.87 ± 0.13c
Trabzon	Sivri	1.511 ± 0.151a	0.237 ± 0.052ab	0.084 ± 0.005a	0.241 ± 0.011d	36.57 ± 0.51e
	Mincane	1.810 ± 0.032bc	0.331 ± 0.006cd	0.094 ± 0.003abc	0.318 ± 0.008f	30.20 ± 0.11b
Giresun	Sivri	1.747 ± 0.021abc	0.347 ± 0.028d	0.109 ± 0.009d	0.171 ± 0.012a	NA
	Tombul	1.576 ± 0.019ab	0.275 ± 0.020abc	0.097 ± 0.008cd	0.187 ± 0.008ab	30.56 ± 0.14b
	Kalınkara	1.762 ± 0.064abc	0.316 ± 0.115cd	0.100 ± 0.009cd	0.278 ± 0.009e	32.54 ± 0.14c
Mean		1.81 ± 0.28	0.30 ± 0.07	0.10 ± 0.01	0.240 ± 0.05	35.53 ± 3.82
p		< 0.0022	< 0.0002	< 0.0080	< 0.00001	< 0.00001

[1] Each value is a mean ± standard deviation of three determinations. Values in the same column with different lower-case letters (a–h) are significantly different at $p<0.05$.
[2] NA; not available.

Table 2
Mineral composition of Turkish hazelnut varieties (mg/100 g)[1]

Region	Variety	Iron	Zinc	Copper	Magnesium	Manganese	Calcium	Potassium	Sodium
Akçakoca	Karafındık	2.30 ± 0.09bc	2.44 ± 0.04d	0.10 ± 0.02g	142.64 ± 3.96bc	1.99 ± 0.02a	82.28 ± 1.17ab	686.24 ± 9.50de	0.86 ± 0.04e
	Çakıldak	2.05 ± 0.18a	2.18 ± 0.08c	0.86 ± 0.03ef	142.24 ± 4.39bc	2.92 ± 1.43b	92.46 ± 3.30d	735.26 ± 11.74e	0.80 ± 0.04c
	Mincane	2.60 ± 0.02d	1.82 ± 0.04b	0.90 ± 0.01fg	118.09 ± 9.36a	15.85 ± 0.60g	82.76 ± 5.52ab	624.27 ± 57.96c	0.84 ± 0.01de
	Foşa	2.23 ± 0.23abc	1.85 ± 0.22b	0.62 ± 0.12c	140.89 ± 5.54b	11.22 ± 0.05f	85.88 ± 7.58bc	611.77 ± 19.05c	0.81 ± 0.05cd
Ordu	Çakıldak	2.15 ± 0.05ab	2.09 ± 0.06c	0.74 ± 0.04cd	154.42 ± 12.00c	1.77 ± 0.04a	80.63 ± 2.81ab	894.72 ± 72.63f	0.63 ± 0.02ab
	Palaz	2.54 ± 0.12d	2.11 ± 0.02c	0.77 ± 0.03de	177.22 ± 15.42d	5.90 ± 0.40d	82.58 ± 1.37ab	602.07 ± 10.44bc	0.66 ± 0.03b
Trabzon	Sivri	2.41 ± 0.07cd	2.06 ± 0.12c	0.80 ± 0.03def	140.82 ± 0.34b	4.92 ± 0.33c	89.53 ± 1.71cd	532.58 ± 4.63a	0.62 ± 0.02ab
	Mincane	2.05 ± 0.05a	1.81 ± 0.08b	0.83 ± 0.18def	140.42 ± 5.40b	3.34 ± 0.28b	79.06 ± 1.00a	553.23 ± 22.67ab	0.62 ± 0.01ab
Giresun	Sivri	2.40 ± 0.13cd	1.63 ± 0.03a	0.16 ± 0.01a	143.33 ± 2.33bc	7.72 ± 0.24e	80.86 ± 4.46ab	636.66 ± 8.45cd	0.61 ± 0.01a
	Tombul	2.56 ± 0.08d	1.77 ± 0.02ab	0.32 ± 0.01b	137.51 ± 1.76b	8.45 ± 0.02e	78.83 ± 2.50a	526.72 ± 11.55a	0.62 ± 0.01ab
	Kalınkara	2.24 ± 0.12abc	1.71 ± 0.07ab	0.17 ± 0.01a	141.96 ± 3.44b	4.61 ± 0.28c	83.76 ± 3.03abc	609.05 ± 14.04c	0.61 ± 0.02a
Mean		2.32 ± 0.21	1.95 ± 0.25	0.65 ± 0.29	143.59 ± 14.86	6.09 ± 4.17	83.51 ± 5.14	637.14 ± 105.33	0.70 ± 0.10
p		< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.0031	< 0.00001	< 0.00001

[1] Each value is a mean ± standard deviation of three determinations. Values in the same column with different lower-case letters (a–g) are significantly different at $p < 0.05$.

Table 3
Statistical data: mean ($\bar{x}$)[1], standard error of mean (SE) and significance level for vitamin and mineral composition

	Akçakoca	Ordu	Trabzon	Giresun		
	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	SE	p
Niacin	1.824a	2.113b	1.658a	1.695a	0.050	0.0074
Vitamin B_1	0.274a	0.372b	0.284a	0.313ab	0.012	0.0191
Vitamin B_2	0.097ab	0.096ab	0.089a	0.102b	0.002	0.0613
Vitamin B_6	0.250ab	0.211a	0.279b	0.212a	0.010	0.0354
α-Tocopherol	35.17a	34.01a	33.39a	31.56a	0.780	NS[2]
Iron	2.30a	2.35a	2.23a	2.40a	0.037	NS
Zinc	2.07b	2.10b	1.94b	1.70a	0.043	0.0006
Copper	0.843b	0.753b	0.818b	0.216a	0.051	< 0.00001
Magnesium	136.0a	165.8b	140.6a	140.9a	2.59	0.0001
Manganese	8.00b	3.84a	4.13ab	6.92ab	0.731	NS
Calcium	85.85b	81.61ab	84.30ab	81.15a	0.894	NS
Potassium	663.4ab	748.4c	542.9a	590.95a	18.34	0.0007
Sodium	0.828b	0.642a	0.622a	0.613a	0.012	< 0.00001

[1] Each value is a mean of three determinations. Values in the same column with different lower-case letters (a–c) are significantly different at $p < 0.05$.
[2] NS, not significant.

Baş et al. (1986) Pala et al. (1996) and Özdemir (1985) for Turkish hazelnut varieties. Similar results were also found by Parcerisa et al., (1995) for Spanish hazelnuts. According to geographical regions, significant changes were observed for manganese and copper in Spanish hazelnut (Parcerisa et al., 1995).

Correlation analyses of the samples were also carried out between mineral and vitamin compositions (Table 4). Zinc positively correlated with copper ($p = 0.001$) and potassium ($p = 0.012$) but negatively correlated with manganese ($p = 0.032$). Zinc, copper and potassium correlated positively with sodium ($p = 0.008$, 0.029, < 0.0001, respectively). There was no significant relation observed between the levels of iron, magnesium and manganese and other minerals. Calcium and vitamin B_2 were not correlated with any of the parameters; therefore they were excluded from Table 4. Niacin content correlated positively with magnesium ($p < 0.0001$). Vitamin B_1 correlated positively with magnesium ($p < 0.0001$) and niacin ($p < 0.0001$). Vitamin B_6 correlated negatively with iron ($p = 0.001$) and zinc ($p = 0.023$). α-Tocopherol correlated positively with zinc ($p < 0.0001$), copper ($p = 0.019$) and potassium ($p = 0.018$) but negatively with manganese ($p = 0.001$) and vitamin B_6 ($p = 0.049$).

Strong correlation was observed between α-tocopherol and minerals (manganese, sodium, zinc, potassium) and vitamin B_6. These correlations suggest that soil

Table 4
Correlation between vitamin and mineral composition

		Zinc	Copper	Magnesium	Manganese	Potassium	Sodium	Niacin	Vitamin B_1	Vitamin B_6	α-Tocopherol
Iron	r[1]	0.0454	−0.1035	0.2261	0.2355	−0.1574	−0.088	0.0317	0.1086	−0.6692	0.1212
	p[2]	NS[3]	NS	NS	NS	NS	NS	NS	NS	0.001	NS
Zinc	r		0.6618	0.2817	−0.4691	0.539	0.56	0.1745	0.1074	−0.4938	0.8249
	p		0.001	NS	0.032	0.012	0.008	NS	NS	0.023	< 0.0001
Copper	r			0.2202	−0.4029	0.3211	0.4765	0.1844	0.112	−0.0444	0.5083
	p			NS	NS	NS	0.029	NS	NS	NS	0.019
Magnesium	r				−0.0539	0.1689	−0.116	0.7209	0.7022	−0.2788	0.0192
	p				NS	NS	NS	< 0.0001	< 0.0001	NS	NS
Manganese	r					−0.2725	0.0623	0.0596	−0.0833	−0.09	−0.6773
	p					NS	NS	NS	NS	NS	0.001
Potassium	r						0.7724	0.327	0.2555	−0.1533	0.5106
	p						< 0.0001	NS	NS	NS	0.018
Sodium	r							0.1038	−0.0663	−0.2353	0.4166
	p							NS	NS	NS	NS
Niacin	r								0.7678	−0.0617	−0.1277
	p								< 0.0001	NS	NS
Vitamin B_1	r									−0.0136	−0.1275
	p									NS	NS
Vitamin B_6	r										−0.435
	p										0.049
α-Tocopherol	r										
	p										

[1] r, correlation coefficient.
[2] p, probability of significance.
[3] NS, not significant.

composition and uses of fertilizers influence vitamin and mineral composition, which consequently contributes stability and quality of hazelnuts. Parcerisa et al. (1995) stated that composition of soil, uses of fertilizers and irrigation affect the mineral and vitamin compositions of hazelnuts and consequently influence the stability and quality of the product. On the other hand, variety has a minor affect on the vitamin and mineral compositions of hazelnuts. Our results showed that vitamin and mineral compositions of Turkish hazelnuts are also strongly influenced by variety, but according to the geographical regions, levels of α-tocopherol, iron, manganese and calcium did not significantly change.

References

Alphan, E., Pala, M., Açkurt, F., & Yılmaz, T. (1996). Nutritional composition of hazelnuts and its effects on glucose and lipid metabolism. *Acta Horticulturae, 445*, 305–310.

AOAC (1990). *Official methods of analysis of the Association of Official Analytical Chemists* (15th ed.). Washington, DC: Association of Official Analytical Chemists.

Ayfer, M., Uzun, A., & Baş, F. (1986). *Türk fındık çeşitleri*. Ankara: Black Sea Hazelnut Exporters Union.

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

Ebrahem, K. S., & Richardson, D. G. (1994). Oil content, fatty acid composition, and vitamin E concentration of 17 hazelnut varieties, compared to other types of nuts and oils seeds. *Acta Horticulturea, 351*, 685–692.

Elvevol, E. O., Moen, P., Olsen, R. L., & Brox, J. (1990). Some possible effects of dietary monounsaturated fatty acids in cardiovascular disease. *Artheriosclerosis, 81*, 71–74.

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

Labell, F. M. (1983). Hazelnut paste provides sweet, delicate flavor. *Food Processing, 44*, 80–84.

Labell, F. M. (1992). Hazelnuts supply flavor and crunch. *Food Processing, 53*, 52–54.

Mattson, F. H. (1989). A changing role for dietary monounsaturated fatty acids. *Journal of the American Dietetic Association, 89*, 387–391.

Mehlenbacher, S. A. (1991). Hazelnuts (*Corylus*). *Acta Horticulture, 290*, 791–836.

Nicolosi, R. J., Stucchi, A. F., Kewal, M. C., Hensesig, L. K., Hegstein, P. M., & Schefer, E. J. (1990). Effect of dietary fat saturation and cholesterol on LDL composition and metabolism. *Arteriosclerosis, 10*, 119–128.

Özdemir, M. (1985). Elemental analysis of hazelnut kernels and shells by spark source mass spectrometry. *Z. lebensmittel Untersuchung.und Forschung, 180*, 289–292.

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

Parcerisa, J., Boatella, J., Codony, R., Farran, A., Garcia, J., Lopez, A., Rafeces, M., & Romero, A. (1993a). Influence of variety and geographical origin on the lipid fraction of hazelnuts (*Corylus avellane* L.) from Spain: I. Fatty acid composition. *Food Chemistry, 43*, 411–414.

Parcerisa, J., Rafeces, M., Castellote, A. I., Codony, R., Farran, A., Garcia, J., Lopez, A., Romero, A., & Boatella, J. (1993b). Influence of variety and geographical origin on the lipid fraction of hazelnuts (*Corylus avellane* L.) from Spain: II. Triglyceride composition. *Food Chemistry, 50*, 245–249.

Parcerisa, J., Rafeces, M., Castellote, A. I., Codony, R., Farran, A., Garcia, J., Lopez, A., Romero, A., & Boatella, J. (1995). Influence of variety and geographical origin on the lipid fraction of hazelnuts (*Corylus avellane* L.) from Spain: III. Oil stability, tocopherol content and some mineral contents. *Food Chemistry, 53*, 71–74.

Pershern, A. S., Breene, W. M., & Lulai, E. C. (1995). Analysis of factors influencing lipid oxidation in hazelnuts (*Corylus* sp.). *Journal of Food Processing and Preservation, 19*, 9–25.

Savage, G. P., McNeil, D. L., & Dutta, P. C. (1997). Lipid composition and oxidative stability of oils in hazelnuts (*Corylus avellane* L.) grown in New Zealand. *Journal of the American Oil Chemists Society, 74*, 755–759.

Woodroof, J. G. (1975). *Tree nuts, production, processing, products* (2nd Ed.). Westport, CT: Avi Publishing Company.