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Evaluation of new Turkish hybrid hazelnut (*Corylus avellana* L.) varieties: fatty acid composition, α-tocopherol content, mineral composition and stability

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Abstract

Five new hybrids (T. Kolon, H190, H260, H262, H580) of Turkish hazelnut varieties were evaluated in terms of total oil, fatty acid composition, α-tocopherol, unsaturated/saturated ratio, stability index and mineral in comparison with five commercial Turkish hazelnut varieties (Tombul, Palaz, Mincane, Foşa and Çakıldak). Significant differences in total oil, fatty acid composition, stability index, α-tocopherol content and mineral composition were observed between varieties. The highest stability index values were observed in commercial Tombul (6.29), Foşa (5.93) and Palaz (5.42) varieties. No significant advantage of new hybrid varieties over commercial varieties was observed in terms of stability of hazelnuts.

Keywords: Hazelnut composition; Rancidity; *Corylus avellana* L

1. Introduction

Hazelnut production in Turkey is about 500,000 t, 75% of which is exported with a total annual revenue of one billion US$. Besides their economic value, hazelnuts provide a definite flavor to food products and plays a major role in human nutrition and health (Alphan, Pala, Açkurt & Yılmaz, 1996; Ebrahem, Richardson, Tetley & Mehlenbacher, 1994; Elvevol, Moen, Olsen & Brox, 1990; Garcia, Agar & Streif, 1994; Labell, 1983; Labell, 1992; Mattson, 1989; Mehlenbacher, 1991; Nicolosi, Stucchi, Kewal, Henesig, Hegstein & Schefer, 1990; Pala, Açkurt, Löker, Yıldız & Ömeroğlu, 1996; Özdemir & Devres, 1999; Villarroel, Biolly, San-Martin & Estrada, 1997; Woodroof, 1975).

Composition affects many quality factors of hazelnuts,such as color development, internal browning and susceptibility to rancidity (Özdemir, Seyhan, Bakan, Ilter, Özay & Devres, 2000; Özdemir & Devres, 1999). Variety, location, composition of soil, uses of fertiliser and irrigation affect the fatty acid, mineral and vitamin composition of hazelnuts and consequently influence the stability and quality of the product (Açkurt, Özdemir, Biringen & Löker, 1999; Baş, Ömeroğlu, Türdü & Atkaş, 1986; Bonvehi & Coll, 1993; Parcerisa, Boatella et al., 1993a, Parcerisa, Rafeces et al., 1995a; Savage, McNeil & Dutta, 1997). Unsaturated fatty acids, anti-oxidants, such as α-tocopherol, and mineral components, such as iron, manganese and copper, are involved in rancidity. Therefore, varieties having low unsaturated/saturated ratios, and which are low in pro-oxidant components, rich in anti-oxidant components and low in enzymatic activities, are preferred, because they minimise post-harvest quality losses, packaging and refrigeration costs (Açkurt et al., 1999; Özdemir & Devres, 1999; Parcerisa, Boatella et al., 1993a; Parcerisa, Rafeces et al., 1993b; Pershern, Breene & Lulai, 1995; Parcerisa & Rafeces, 1995a). Currently cultivated commecial varieties and new varieties, from breeding

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studies, must therefore be evaluated in terms of technological and nutritional properties such as oil stability; vitamin, mineral, sugar and amino acid composition, and also physical properties (% kernel,% pellicle removal, etc.). Previously, compositions of major commercial Turkish hazelnut varieties were studied by Baş et al. (1986) and Açkurt et al. (1999). Moreover, Ayfer et al. (1986) and Çalişkan (1995) reported physical properties of the major commercial Turkish hazelnuts. There are no studies on compositional and physical properties of new Turkish hybrid varieties. Therefore, in this study, five new hybrids of Turkish hazelnut varieties were evaluated, in comparison with five major commercial Turkish hazelnut varieties, in terms of total oil content, fatty acid composition, α-tocopherol, unsaturated/saturated ratio, stability index, and mineral composition.

2. Materials and methods

2.1. Sampling

New hybrid hazelnut varieties (T. Kolon, H190, H260, H292, H580) and commercial Turkish hazelnut varieties (*Corylus avellana* L.) (Tombul, Palaz, Mincane, Foşa, Çakıldak) were supplied from the Hazelnut Research Institute (1998 harvest season; Giresun, Turkey). Samples in their unshelled state were kept in a refrigerator until analyses were performed. All reagents were of analytical grade. All analyses were conducted in triplicate.

2.2. Chemical analysis

Moisture analysis was carried out according to the method of Turkish Standards (TS 3075; TSE, 1978). Oils were extracted from the samples as described in IUPAC (1979), using light petroleum ether (b.p. 40–60°C). The extracted oils were kept at −30°C until analysed. The fatty acid methyl esters of total lipids were obtained by direct transmethylation (AOCS, 1990). For chromotographic analyses of fatty acids, a Philips Pye Unicam PU 4500 gas chromatograph, equipped with a flame ionisation detector, was used. α-Tocopherol was determined by the Emmerie-Engel color reaction using a spectrophotometer (AOAC, 1990). Mineral analyses were carried out with an atomic absorption spectrophotometer (Hitachi 180-50) according to a standard AOAC method (AOAC).

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 version 5.0) for $P<$ 0.05 significance level.

3. Results and discussion

Fatty acid composition and antioxidant components such as α-tocopherol, affect susceptibility to rancidity, as do the amount of pro-oxidants, water activity, temperature and enzyme activity (Bonvehi & Coll, 1993; Bonvehi & Rosuo, 1996; Botta & Giovanni, 1996; Garcia et al., 1994; Parecerisa, Boatella et al., 1995b; Parcerisa, Rafeces, et al., 1995a). Total oil content, fatty acid composition, α-tocopherol, unsaturated/saturated ratio and stability index of samples are shown in Table 1. Palmitic ($C_{16:0}$), stearic ($C_{18:0}$), oleic ($C_{18:1}$), and linoleic ($C_{18:2}$) acids were identified in the oils of the varieties. ANOVA indicated that there were significant differences in total oil content and fatty acid compositions between varieties ($P<0.0001$), as shown in Table 1. Moreover, the LSD test showed that hybrid T. Kolon, H190 and H260 varieties and Mincane variety contained

Table 1
Moisture (%), total oil (g/100 g, db), fatty acid composition (% of total oil), vitamin E (mg/100g, db), unsaturated/saturated ratio and stability index of commercial Turkish hazelnuts and their new hybrids[a]

	Variety	Moisture	Total Oil	Palmitic Acid	Stearic Acid	Oleic Acid	Linoleic Acid	Unsat/sat	Vitamin E	Stability Index
Commercial	Tombul	7.9±0.02f	68.6±0.15b	7.8±0.12cd	3.8±0.18d	76.1±0.24a	12.3±0.52bc	7.6±0.20 a	47.9±1.31e	6.3±0.34e
	Palaz	8.1±0.15g	69.4±0.19cd	8.3±0.38e	3.1±0.72cd	75.7±1.51a	12.9±0.73cd	7.8±0.58a	42.1±0.84bc	5.4±0.52d
	Mincane	6.5±0.25c	70.8±0.23f	8.0±0.20de	3.2±0.38cd	77.7±0.40bc	11.1±0.27b	8.0±0.24ab	29.8±0.47a	3.8±0.15a
	Foşa	7.7±0.06ef	69.4±0.42cd	7.6±0.48c	2.9±0.43bc	76.9±0.51ab	12.7±0.29cd	8.6±0.28bc	50.8±0.08f	5.9±0.20e
	Çakıldak	8.4±0.08h	67.1±0.27a	6.6±0.23a	2.8±0.39bc	76.9±0.39ab	13.8±0.14d	9.7±0.51d	41.0±1.97b	4.2±0.06ab
New hybrids	T. Kolon	7.0±0.09d	70.1±0.20e	6.8±0.12ab	3.2±0.45cd	76.4±1.52ab	13.6±1.54d	9.0±0.44cd	46.3±1.27de	5.2±0.16cd
	H190	5.9±0.10a	70.8±0.02f	6.9±0.18b	2.5±0.44b	76.9±0.67ab	13.6±0.81d	9.6±0.63d	40.1±4.40b	4.2±0.53ab
	H260	6.2±0.07b	72.0±0.09g	7.6±0.07c	1.8±0.34a	78.5±0.33c	12.2±0.07bc	9.7±0.47d	45.4±0.04de	4.7±0.23bc
	H292	8.1±0.05g	69.1±0.28c	6.6±0.11ab	2.9±0.14bc	79.1±0.46c	11.3±0.48b	9.4±0.03d	44.7±1.03cd	4.7±0.12bc
	H580	7.6±0.13e	69.8±0.46de	6.7±0.13ab	3.3±0.18cd	80.7±0.63d	10.1±0.27a	9.1±0.16cd	39.9±0.08b	4.4±0.09b
	P	0.0001	0.0001	0.0001	0.001	0.0001	0.0001	0.0001	0.0001	0.0001

[a] 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 $P<0.05$.

significantly more oil (> 70 g/100 g, db) than the other varieties (Table 1). Except for H260, hybrids contained similar amounts of palmitic acid which was generally lower than commercial Turkish hazelnut varieties (Table 1). Hybrid H260 contained significantly less stearic acid (1.8±0.3% of total oil) than the other varieties, (2.5–3.8% of total oil; Table 1). Oleic acid constituted the major fraction of unsaturated fatty acids. Hybrids H292 and H580 contained significantly more oleic acid (around 79% of total oil) than the other varieties (Table 1). The range of oleic acid was 75.7–80.7 (% of total oil) while the range of linoleic acid was 10.0–13.8 (% of total oil). Moreover, α-tocopherol contents were significantly different ($P < 0.0001$) between varieties as shown in Table 1. Foşa (50.8±0.1 mg/100 g, db) and Tombul (47.9±1.3 mg/100 g, db) had notably high α-tocopherol content (Table 1).

Stabilities of commercial and new hybrid hazelnut varieties were evaluated by fatty acid composition and α-tocopherol content. The unsaturated/saturated ratio (ratio of the sum of unsaturated fatty acids to the sum of saturated fatty acids), previously used by Pershern et al. (1995), showed a significant difference between varieties ($P < 0.0001$) and commercial varieties Tombul, Palaz Mincane and Foşa had significantly lower unsaturated/saturated ratios than other varieties (Table 1). The lower the ratio, the longer was the shelf life. A stability index (α-tocopherol×saturated fatty acids/unsaturated fatty acid) was also used in prediction of stability of hazelnut varieties. Commercial varieties Tombul (6.29), Foşa (5.93) and Palaz (5.42), showed significantly higher stability index value. Among all the varieties, Mincane (3.75) showed the lowest stability index due its lowest α-tocopherol content (Table 1).

Minerals are of interest due to their pro-oxidant activity and health benefits (Alphan et al., 1996; Pala et al., 1996; Parcerisa, Rafeces et al., 1995a; Pershern et al., 1995). Significant differences were observed between mineral composition of the varieties ($P < 0.0001$; Table 2). Iron, copper and manganese are involved in lipid oxidation and linoleic acid biosynthesis pathway (Parcerisa, Rafeces et al., 1995a). Among Tombul, Palaz and Foşa varieties, the ones with higher stability indices, Foşa had the lowest iron, copper and manganese contents. From a nutritional point of view, hazelnut is a good plant source of iron, magnesium, calcium and zinc. In addition to calcium, potassium and low levels of sodium aid regulation of blood pressure (Pala et al., 1996). Mineral compositions tally with the results given by Açkurt et al. (1999); Baş et al. (1986), and Özdemir (1985) for Turkish hazelnut varieties.

Correlation analysis was also carried out for total oil, fatty acids, α-tocopherol and minerals (Table 3). Total oil content negatively correlated with zinc ($P < 0.0001$) and calcium (0.019). Palmitic acid and stearic acid negatively correlated with unsaturated/saturated ratio. Oleic acid is negatively correlated with linoleic acid ($P < 0.005$) as also found by Parcerisa, Boatella et al., (1993a) for Spanish hazelnuts. Manganese positively correlated with zinc ($P < 0.02$) and calcium ($P < 0.002$). Zinc positively correlated with calcium ($P < 0.03$). Although there was no correlation between fatty acids, α-tocopherol and minerals, Açkurt et al. (1999) reported a strong correlation between α-tocopherol and some minerals (manganese, sodium, zinc, potassium) in Turkish hazelnut varieties from different locations. The correlations given in the study suggest that compositional differences due to variety, composition of soil and cultural practices such as uses of fertiliser and irrigation may affect stability and subsequently quality of hazelnuts (Açkurt et al., 1999; Bonvehi & Coll, 1993; Parcerisa, Boatella et al., 1993a; Parcerisa, Boatella et al., 1993a; Parcerisa, Rafeces et al., 1995a).

This study indicates that there was a significant difference in total oil, fatty acid composition, stability index, α-tocopherol content and mineral composition between

Table 2
Mineral composition of commercial Turkish hazelnuts and their new hybrids (mg/100g, db)[a]

	Variety	Iron	Copper	Manganese	Potassium	Zinc	Sodium	Magnesium	Calcium
Commercial	Tombul	4.3±0.17cd	2.1±0.06cd	2.2±0.14c	485±2.21c	2.7±0.05de	3.6±0.47c	190±1.32b	208±7.65c
	Palaz	3.6±0.08ab	1.2±0.04bcd	2.5±0.03d	496±0.94c	2.6±0.18d	1.8±0.07a	216±7.36de	212±3.06c
	Mincane	4.4±0.50d	2.1±0.07cd	1.4±0.07a	415±13.83a	2.3±0.07a	2.1±0.29ab	167±9.98a	152±1.14b
	Foşa	3.4±0.22a	1.7±0.17a	1.6±0.03ab	489±16.02c	2.6±0.04d	1.8±0.19a	208±8.06cd	115±13.15a
	Çakıldak	4.3±0.22cd	2.0±0.19bcd	2.6±0.12d	430±1.68ab	2.9±0.03e	2.5±0.50ab	225±0.88e	225±13.08d
New hybrids	T. Kolon	4.2±0.13cd	2.2±0.06d	2.5±0.03d	440±4.82b	2.6±0.01cd	2.1±0.64ab	185±2.03b	153±4.07b
	H190	3.9±0.08bc	1.9±0.00ab	1.7±0.11b	530±18.15d	2.4±0.03bc	3.9±0.56c	202±6.18c	122±2.41a
	H260	3.5±0.07ab	2.0±0.17bc	1.7±0.01b	479±6.93c	2.4±0.08ab	1.9±0.07a	220±0.50e	120±2.08a
	H292	4.4±0.07d	1.7±0.03a	3.1±0.29e	494±0.91c	2.7±0.15de	2.2±0.02ab	209±1.01cd	244±1.02d
	H580	3.9±0.40bc	1.7±0.03a	1.8±0.08b	441±16.21b	2.7±0.07d	2.7±0.40b	184±3.10b	147±4.74b
	P	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

[a] 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 $P < 0.05$.

Table 3
Correlation between total oil, vitamin E, fatty acids and minerals of commercial Turkish hazelnuts and their new hybrids

		Linoleic acid	Unsaturated/ saturated	Zinc	Calcium
Total oil	R^a			−0.9002	−0.7191
	P			0.0001	0.019
Palmitic acid	r		−0.7760		
	P		0.008		
Stearic acid	r		−0.7092		
	P		0.022		
Oleic acid	R	−0.7998			
	P	0.005			
Manganese	R			0.7174	0.8449
	P			0.020	0.002
Zinc	R				0.6818
	P				0.030

[a] r, correlation coefficient.

the varieties. However, commercial Tombul (6.29), Foşa (5.93) and Palaz (5.42) varieties had significantly higher stability indices than the other commercial or new hybrid varieties. So it can be concluded that there is no significant advantage of new hybrid varieties over commercial varieties in terms of stability. Nevertheless, further research on the physical and other chemical (vitamin, amino acid, sugar, sterol and triglyceride composition, enzymatic) properties of new hybrids (over harvest year and cultivation locations) are recommended for better evaluation of the new hybrids.

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