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Some compositional and physical characteristics of some Turkish hazelnut (*Corylus avellana* L.) variety fruits and their corresponding oils

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Abstract

Hazelnut (*Corylus avellana* L.) is a popular tree nut worldwide, mainly distributed along the coasts of the Black Sea region of Turkey, southern Europe (Italy, Spain, Portugal, and France), and in some areas of the US (Oregon and Washington). Turkey is the world's largest producer of hazelnuts, contributing ~74% to the total global production. In this study, compositional characteristics of eight different hazelnut varieties grown in the Black Sea Region of Turkey were investigated. The mean total lipid content of hazelnut samples was 66.34%, which the Palas and Ham varieties showed the lowest (65%) and highest (71.03%) values, respectively. Ham variety had the highest (2.44%) ash content while Sivri variety contained the lowest ash values (0.89%). The dry matter of the fruits varied between 91.00-98.80%. Eight fatty acids were identified, among which oleic acid contributed minimum 84.3% to the total, followed by linoleic, palmitic, and stearic acids. Unsaturated fatty acids accounted for 90.2% of the total fatty acids present. The ratios of polyunsaturated/ saturated and unsaturated/saturated fatty acids of hazelnuts varieties were found between 1.15 and 1.94, and 14.1 and 18.3, respectively.

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 (Köksal *et al*., 2006). Hazelnut is being produced in Turkey (79.19%), Italy (11.18%), Spain (6.47%) and United States (2.47%) (Anonymous, 1993; Demir and Beyhan, 2000).Turkey is the world's largest producer of hazelnuts, contributing ~74% to the total global production (Turkish Hazelnut Exporter's Union, 2008).

The Black Sea region of Turkey is most appropriate region for the production of hazelnuts. Most intensive Hazelnut production in Turkey is located in Ordu, Giresun, Sakarya, Samsun, Trabzon and Bolu provinces (Demir and Beyhan ,2000; Çalışkan, 1995). Hazelnut is, therefore, of vital importance to the economy of Turkey. Besides its economic value, hazelnut provides a unique and distinctive flavor as an ingredient in a variety of food products and plays a major role in human nutrition and health (Alasavar *et al.*, 2003a).

Hazelnut varieties of Turkey are classified according to fruit shape and size. These classes are called circular, almond, and sivri. Tombul, palaz, foşa, çakıldak, kalınkara, kargalak, uzunmusa, mincane, cavaca and kan varieties are included in "circular" class. Sivri, incekara, acı hazelnut and kuş hazelnut varieties are included in "sivri" class. Badem, yassi badem and değirmendere varieties are included in "almond" class (Çalışkan, 1995). Hazelnut has found its way into nontraditional foods due to the recognition of its nutritional and nutraceutical properties. Hazelnut is a rich source of of fat (mainly oleic acid), protein, carbohydrate, dietary fiber, vitamins (vitamin E), minerals, phytosterols (mainly â-sitosterol), and antioxidant phenolics. This kind of well balanced food offers protection against diseases (Alphan *et al.*, 1997; Yurttaş *et al*., 2000; Alasalvar *et al*., 2003a).

Due to their organoleptic characteristics, hazelnuts are consumed all over the world, not only as a fruit but also in a diversity of manufactured food products, such as snacks, chocolates, cereals, bakery, dairy, salad, entree, sauce, ice creams, and other dessert formulations (Özdemir and Akıncı, 2004; Amaral *et al*., 2006; Oliveira *et al*., 2008). Hazelnut provides an, excellent source of energy due to its high oil content of approximately 60% (Alasalvar *et al*., 2003b).

Currently, the price of refined Hazelnut oil in

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Turkey is the same as that of virgin olive oil. The positive health effects of fat-soluble bioactives present in hazelnut has been reported (Mercanlıgil *et al*., 2007; Alasalvar *et al*., 2009). 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. Hazelnut oil decreases the cholesterol level in blood and also controls adverse effects of hypertension (Garcia *et al*., 1994; Durak *et al*., 1999; Köksal *et al*., 2006). Nutritional and chemical compositions of hazelnuts are mostly referred to variety, ecology and cultural applications (Köksal, 2002). The aim of this study was to determine some compositional and physical characteristics of hazelnut oils which were obtained from different Turkish hazelnut varieties grown in Black Sea region.

Materials and Methods

Materials

The kernels of Turkish hazelnut (*Corylus avellana* L.) varieties "ham, tombul, kara, sivri, kan, badem and palas" were used in this study. Samples of each variety were obtained from Giresun in Black Sea Region of Turkey. Samples were collected in the year 2009. The hazelnut samples (1 kg each variety as unshelled and ground) were stored at +4°C in polyethylene bags.

Dry matter

Dry matter of hazelnut kernels were determined by drying the samples to a constant weight, in an oven at temprature of 70°C.

Total lipid

Total lipid contents of hazelnut fruits were determined by extracting a known weight of ground fruit sample with petroleum ether, using a Soxhlet apparatus (AOAC, 2000).

Total ash and protein

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. Nitrogen was determined by the micro-Kjeldahl method, described by James (1995) and the percentage nitrogen was converted to crude protein by multiplying by 6.25 (Ayfer *et al*., 1986; Slover and Lanza, 1979).

Free fatty acids and peroxide value

Official Methods of the American Oil Chemists Society (AOCS Ca 5a 40 and Cd 8-531993) were used for the determination of free fatty acid and peroxide values. Results were expressed as % oleic acid and meq O_2/kg oil.

Fatty acid analysis

For the determination of fatty acid composition of the oils, fatty acid methyl esters (FAMEs) were prepared from hazelnut oil and determined by gas chromatography (GC) according to the method described by Slover and Lanza (1979) with minor modifications. FAMEs were prepared using boron trifluoride in methanol (20% of BF_3 in methanol) and extracted with n-hexane and then analyzed by GC (Alasalvar *et al*., 2003a). A Shimadzu (Kyoto, Japan) gas chromatograph, equipped with a flame ionization detector and a split/splitless injector, was employed. Separations were made on a Teknokroma TR-CN100 (Barcelona, Spain) fused-silica capillary column (60 m • 0.25 mm i.d. • 0.20 µm film thickness). The carrier gas was nitrogen, with a flow rate of 1 mL/min. The temperatures of the injector, the detector and the oven were held at 220, 250 and 210°C, respectively. The injection volume was 1 mL. Individual FAME were identified by comparison of the relative retention times of FAME peaks from samples, with those of the standard mixture 37 Component FAME Mix. (Sigma–Aldrich, St. Louis, MO, USA).

Statistical analysis

The data was subjected to an ANOVA using SPSS 10.0 for Windows. Separation of the means was obtained using the Duncan's test, and significant difference was defined as $P < 0.05$. All analyses were conducted in triplicate for each variety.

Results and Discussion

The fatty acid composition and some chemical components of hazelnut varieties were given in Table 1 and Figure 1, respectively. The dry matter content of hazelnut varieties ranged between 91.0% (Badem) and 98.5% (Kan). The crude ash content of hazelnut varieties varied between 0.84% (Sivri) and 2.44% (Ham). Generally, the total lipid contents of the samples were above 45% and were between the values of 65.0% (Ham) and 71.0% (Palas). Protein content of all the varieties were above 15%. Sivri (19.20%) and Badem (18.93%) varieties had the highest while Kara (16.00%) variety had the lowest protein contents. Köksal *et al.* (2006) reported the protein contents of 17 different Turkish hazelnut varieties above 10%.

Ham variety contained higher ash (2.44%) and dry matter (98%) than the other varieties. Badem variety had the lowest (91%) dry matter content

Table 1. Fatty acid compositions of hazelnut oils of seven Turkish varieties

Variety	Palmitic	Miristic	Palmitoleic	Stearic	Oleic	Linoleic	Saturated	Unsaturated
Ham	5.70±0.91* a†	0.18±0.01 a	0.22±0.07 a	0.73±0.05 a	85.47±1.41 c	7.63±0.53 e	6.61±0.22 a	93.30±2.37e
Tombul	4.95±0.76 c	0.15±0.02 c	0.15±0.02 d	0.59±0.06 e	85.12±1.37 d	9.07±0.39 c	5.69±0.39 c	94.22±3.95c
Kara	4.71±0.54 e	0.15±0.01 c	0.21±0.01 b	0.68±0.09 c	84.27±1.01 f	9.98±0.48 b	5.54±0.23 d	94.37±1.95b
Sivri	4.75±0.98 d	0.13±0.01 d	0.22±0.08 a	0.66±0.03 d	86.53±2.55 b	7.71±0.97 d	5.54±0.14 d	94.37±3.23b
Kan	4.71±0.82 e	0.15±0.02 c	0.21±0.03 b	0.69±0.06 b	84.27±2.11 f	9.98±0.41 b	5.54±0.47 d	94.37±2.86b
Badem	4.52±0.79 f	0.16±0.00 b	0.21±0.04 b	0.51±0.02 f	84.51±0.97 e	10.09±0.65 a	5.19±0.26 e	94.72±1.60a
Palas	5.19±0.70 b	0.16±0.01 b	0.18±0.01 c	0.44±0.04 g	87.38±2.30 a	6.65±0.67 f	5.79±0.15 b	94.12±2.54d

*mean value ± standard deviation
†Significant differences in the same row are shown by different lowercase letters [comparison between varieties] (P ≤ 0.05).

Table 2. The ratios of polyunsaturated/ saturated and unsaturated/saturated fatty acids of hazelnuts oils from seven Turkish varieties

Variety	polyunsaturated/ saturated	unsaturated/saturated
Ham	1.16	14.11
Tombul	1.59	16.56
Kara	1.80	17.03
Sivri	1.39	17.03
Kan	1.80	17.02
Badem	1.94	18.25
Palas	1.15	16.26

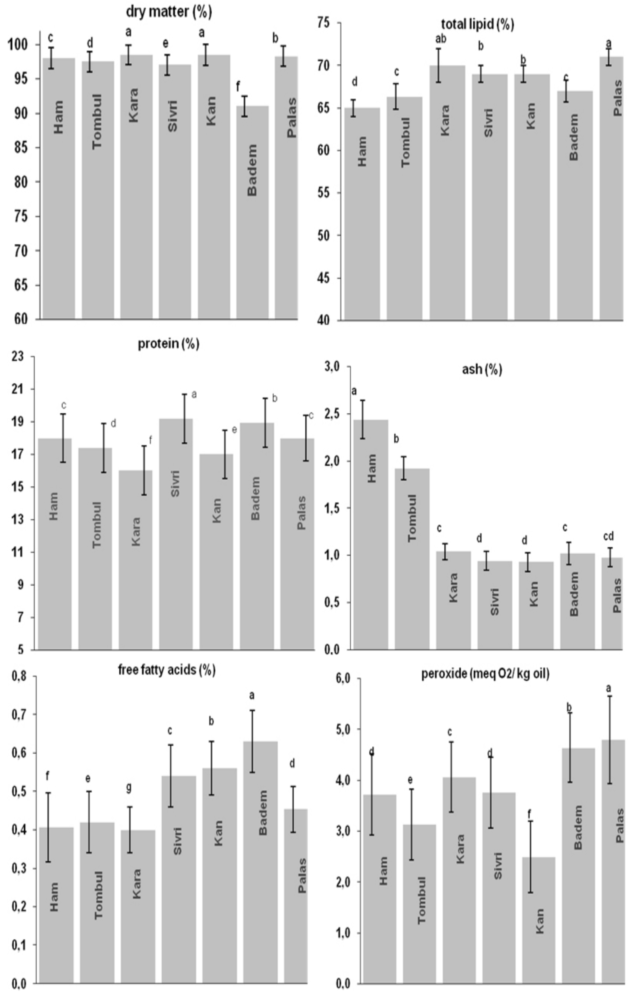

Figure 1. Some chemical constituents of fruits from seven Turkish hazelnut varieties and acidity and peroxide values of their oils

among the other varieties. The ash content of 6 hazelnut varieties from New Zeland were reported between 2.1-2.7% (Oliveira *et al*., 2008). Ham samples showed the lowest (65%) total lipid content, while Palas variety had the highest ratio (71%) of total lipids. Köksal *et al.* (2006) reported the total lipid contents of seventeen different Turkish hazelnut varieties as an average of 61.7%. Savage and Mcneil (1998) compared six different varieties of hazelnut cultivated in New Zealand and found that the total fat content for all shelled hazelnuts ranged between 54.6-63.2%. The total fat contents of 3 hazelnut varieties from Portugal were reported between 56.3-61.6% (Oliveira *et al*., 2008). Kan and Palas varieties showed the lowest (2.50) and highest (4.07) peroxide values respectively. Kara and Ham varieties showed the lowest free fatty acid levels, while Badem variety had the highest level of free fatty acids.

The differences between the oleic acid ratios as the dominant fatty acid in hazelnut oils were not statistically significant. Ham variety showed the highest ratios of myristic (0.18%), palmitoleic (0.22%) and stearic (0.73%) acids and the lowest ratio of palmitic acid (5.70%). Thus, this variety had the highest saturated fatty acids (6.61%) and the lowest unsaturated fatty acids ratios (93.30%). The highest palmitic acid (5.70%) level was belong to the oil of Ham variety and the lowest stearic (0.44%) and linoleic acid (6.65%) levels were determined in Palas samples. Sivri samples had the lowest levels of myristic acid as 0.13. Sivri and Ham varieties showed the highest, while Palas and Tombul samples had the lowest palmitoleic acid ratios. Badem and Ham varieties had the lowest saturated and unsaturated fatty acid contents, respectively. The highest MUFA/ PUFA (monounsaturated fatty acids/polyunsaturated fatty acids) ratio were determined in the oil of Palas variety, while theoil of Badem variety exhibited the lowest ratio of MUF/PUFA.

Badem variety showed the highest ratios (1.94) of polyunsaturated/saturated and unsaturated/saturated, while these ratios were lower in the oils of Ham and Palas varieties when compared to those of other variety oils (Table 2). Hazelnut oil, in terms of its high proportion of unsaturated fatty acids, is much more desirable (Alasalvar *et al.*, 2003b). High levels of monounsaturated fatty acids, mainly oleic acid, in hazelnut oil have been reported to have beneficial effects (Parcerisa *et al*., 1997). On the other hand, Pershern *et al*. (1995) reported that the lower the ratio of unsaturated to saturated fatty acids was, the longer was the shelf life.

These values were comparable with those published previously in the literature for the Tombul, Kara, Palas, Sivri and Kan varieties of hazelnut (Köksal *et al.*, 1993; Alasalvar *et al*., 2003b). Köksal *et al.* (2006) reported the palmitic, palmitioleic, stearic, oleic and linoleic acids in Tombul variety as 82.72%, 8.89%, 4.85% and 2.73%, respectively. Harvest time, farming and drying methods, season, geographical origin, environmental factors, storage and handling conditions, in addition to the variety of hazelnut, were reported to affect the final composition of hazelnut (Alasalvar *et al*., 2003b).

Conclusions

The fruits of Badem variety showed the lowest dry matter, protein contents and MUFA/PUFA ratio, the oil of this variety had the highest free fatty acids and unsaturated fatty acid levels. The oil of Ham variety showed the highest ratios of saturated fatty acids. Ham variety fruits contained the lowest levels of total lipids and the fruits had the highest values of ash among the other varieties. Palas variety was determined to contain the highest total lipid level and MUFA/PUFA ratio.

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