Some Nutritional Characteristics of Fruit and Oil of Walnut (*Juglans regia* L.) Growing in Turkey

Mehmet Musa ÖZCAN*[+]

Department of Food Engineering, Faculty of Agricultural, Selcuk University, 42031 Konya, TURKEY

ABSTRACT: *Walnut (Juglans regia L.) were evaluated for some physical properties and chemical composition. Ripe fruits were determined for moisture (2.71 %), crude protein (14.6 %) crude fibre (1.8 %) ash (1.57 %), crude energy (576 Cal) ether soluble extract (24.71 %), nut (10.5 g) and kernel (5.09 g) veights. Relative density, refractive index, free fatty acids, peroxide value, saponification number, unsaponifiable matter were established in the walnut oil. The main fatty acids identified by gas chromatography were palmtic (6,4 %) oleic (13.4 %), linoleic (55,3 %) and linolenic (8,7 %) acids. The mineral contents of walnuts were established by using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). Contents of A1, Ca, Fe, K, Mg, Mn, Na, P, Se and Zn were also determined in the fruits. The work attempts to contribute to knowledge of the nutritional properties of walnut kernels. The fruits were found to be rich in protein, oil, fibre, unsaturated fatty acids and minerals. These results may be useful for the evaluation of dietary information.*

KEY WORDS: *Walnut, Juglans regia L., Proximate composition, Fatty acid composition, Minerals.*

INTRODUCTION

Walnut (*Juglans regia* L) a member of Juglandaceae family is one of the finest nuts of temperate regions. It is the oldest cultivated fruit in the world and grown spontaneously almost all over Turkey [1-3]. Also, oil yielding crop plants are very important for economic growth of the agricultural sector. The oilseeds containing unusual fatty acids are industrially important, as they are used in protective coatings, dispersants, pharmaceuticals, cosmetics, soaps and a variety of synthetic intermediates as stabilizers in plastic formulations [4,5].

Walnut production is expected to gradually rise in the next 3-5 years, as new trees with improved varieties reach bearing age and as acreage is increcsed. Per capita consumption is relatively stable in Turkey. Fifty percent of production is consumed on- form and the remainder is marketed. Most of the marketed walnuts are consumed whole, with only a limited amount being processed [6].

Ripe walnuts are mostly eaten as dessert nuts or used in cakes, desserts and confectionery of all kinds from ice cream to Baklava. The walnut plant has a high nutritional value and high quality wood. In turkey, walnut has a special value in Turkish foods and is very common in traditional Turkish foods. Although walnuts are rich in fat, a diet supplemented with walnuts had a beneficial

* *To whom correspondence should be addressed.*
+ *E-mail: mozcan@selcuk.edu.tr*
1021-9986/09/1/57 6/$/2.60

effect on blood lipids, lowering blood cholesterol and lowering the ratio of serum concentrations of low deroity lipoprotein:high density lipoprotein by 12 % [7,8]. Walnut kernels generally contained about 60 % oil [9] but this can vary from 52 to 70 % depending on the cultivar, location grown and irrigation rate [2,3,8,10-12]. Most nuts are rich in oleic acid while walnuts are also high in two polyunsaturated fatty acids linoleic acid and α-linolenic acids. The major fatty acids found in walnut oil are oleic, linoleic and linolenic acids [3,8,13]. The fatty acid profile of walnut oil varies between cultivars. It is important to a identify these differences in locally grown cultivars and to identify which fatty acids give the best nutritional qualities [10,13].

More recently, *Abbey et al.* [14] have shown that the supplementation of a background diet (based on a reference Australian diet) with 68 g of walnuts/day reduced the total and low-density lipoprotein cholesterol by 5 and 9 %, respectively. These reductions would have some positive effect in reducing the risk of coronary heart disease. So, it has a very importtant place in public nutritional habits. Few published studies have been carried out on the quality and fruit properties such as chemical composition and fatty acid contents of walnuts growing in Turkey [2,3,15-18]. Walnut oil, which is cold pressed from the meat of dried walnuts, has a strong and distinctive walnut flavor. It is generally used as a flavoring for baked goods and for some sauces. It can provide a bold flavor to salad dressing or it can be added to mildly flavored oils to create a subtle taste [19].

The aim of this study was to establish the some physical and chemical properties, fatty acid composition and mineral contents of walnut growing in Konya (Doğanhisar).

MATERIAL AND METHODS

Material

Walnut fruit was collected from walnut trees growing in Konya (Doğanhisar) in October 2005 and a final sample of about 3 kg was randomly taken. After harvest, shells of walnut fruit were removed and dried at ambient temperature in air condidions. The fruit were stored in + 4 ^{o}C until the analyses.

Chemical analysis

The nut and kernel weights of 100 fruits were determined. The chemical and physical properties (moisture, crude protein, crude oil, crude fibre, ash, relative density, refractive index, free fatty acids, peroxide value, saponification number, unsaponifiable matter) were analysed according to AOAC methods [20,21]. Nitrogen was established by Kjeldahl analyses, multiplied by 6,25 and determined as protein.

The total fat content was determined in accordance with AOAC [22] method. The oil for fatty acid analysis was extracted from the kernels using a small hand- held cold press. The oil was placed in screw-capped test tubes and flushed with N_2 gas and stored at 4 ^{o}C until analysis commenced the following day. Crude oil was obtained from finely crushed walnuts (ca 20g) extracted with petroleum ether (Merck- Darmstadt) in a Soxhlet apparatus; the remaining solvent was removed by vacuum distillation. The extracted oil was stored at 4 ^{o}C in tubes with anhydrous sodium sulphate.

About 100 mg of the sample was heated under reflux and saponified with 5 mL of ethanolic potassium hydroxide solution (20 % wlv) for 2 h. The unsaponifiable matter was extracted three times with 15 mL of petroleum ether, and the extracts were combined and evaporated in a rotary evaporater at 40 ^{o}C under reduced pressure. The unsaponifiable residue was weighed [23]. For peroxide value, a known weight of walnut oil was dissolved in a mixture of acetic acid/ chloroform (3:2 v7v), and a saturated solution of KI (1 mL) was then added. The liberated iodine was titrated with sodium thiosulphate solution (0,05 m) in the presence of starch as indicater. For the free oil acidity, a known werght of walnut oil was dissolved in a mixture of diethyl ether/ ethanol (1:1 v/v). The mixture was titrated of phenolphthalein as indicator.

Determination of fatty acids

Fatty acid composition for walnut samples was determined using a modified fatty acid methyl ester method as described by *Hışıl* [24]. The oil was extracted three times for 2 g air-dried seed sample by homo-genization with petrolium ether. The oil samples (50-100 mg) was converted to its fatty acid methyl esters (FAME). The methyl esters esters of the fatty acids (1 µl) were analysed in a gas chromotography (Shimadzu GC-2010) equipped with a flame ionising deterctor (FID), a fused silica capillary column (60 m x 0.25 mm i.d.; film thickness 0.20 micrometer).

It was operated under the following conditions: oven temperature program, 90 °C for 7 min. Raised to 240 °C at a rate 5 °C/min and than kept at 240 °C for 15 min); injector and detector temperatures, 260 and 260 °C; respectively, carrier gas, nitrogen at flow rate of 1,51 mL/min; split ratio, 1/50 μL/min.

A Standard fatty acid methyl ester mixture (Sigma Chemical Co.) was used to identify sample peaks. Commercial mixtures of fatty acid methyl esters were used as reference data for the relative retention times [21]. Quantitative analyses of the fatty acids were performed using the heptadecanoic acid methyl ester as internal standard. The results are mean values of three replicates.

Determiation of mineral contents

About 0,5 g of dried and ground walnut fruit was put into burnig cup with 15 mL of pure NHO_3. The sample was incinerated in a MARS 5 microwave oven (CEM corporation Manufactura) at 200 °C. Distilled deionized water and ultrahigh-purity commercial acids were used to prepare all reagents, standards, and walnut samples. After digestion treatment, samples were filtrated through whatman No 42. The filtrates were collected in 50 mL Erlenmayer flasks [2] and analysed by ICP-AES (Varian). The mineral contents of the samples were quantified against standard solutions of known concantrations which were analyzed concurrently [25].

Working conditions of ICP-AES:

Instrument: ICP-AES (Varian-Vista

RF Power: 0,7-1,5 kw (1,2-1,3 kw for Axial)

Plasma gas flow rate (Ar): 10,5-15 L/min. (radial) 15 " (axial)

Auxilary gas flow rate (Ar) :1,5 "

Viewing height: 5-12 mm

Copy and reading time: 1-5 s (max.60 s)

Copy time: 3 s (max. 100 s)

Statistical analyses

The statistical package programmes as Minitab [26] and Mstat C [27] were used for multivariative variance analysis test at ($p<0,05$) and Duncan test.

RESULTS AND DISCUSSION

The physical and chemical properties of walnut kernel are shown in table 1. Nut and kernel weight, moisture, ash, crude protein, crude oil, crude fibre, crude energy and ether-soluble extract values of fruit were established. Crude protein, crude oil and crude fibre contents were lower than those for Esterhazy, Rex, Meyric, 150, 151 and 153 varieties reported by *Savage* [8] and for 32.YS.060, 32.YS.023, 32.YS.097, 32.YS.031, 32.YS.075, 32.YS.098 and 32.YS.051 genotypes reported by *Özkan* and *Koyuncu* [3]. Nut and kernel weights were determined as 8.1 g and 3.51 g, respectively. Nut and kernel weights of walnuts varied between 8.43 g to 11.09 g and 4.35 g to 6.32 g, respectively [3]. Previous studied reported as 3.46-4.22 g, and nut weight as 8.15-14.95 g [2]. Proximate compounds (%) were: protein (13.77), ash (1.81), moisture (2.98), fat (62.84) [2].

Table 1: Physical and chemical properties of walnut fruit.

Properties	Values
Whole Nut weight / a walnut (g)	10.5±1.3**
Kernel weight /a walnut (g)	5.09±0.8
Moisture (%)	2.71±0.71
Ash (%)	1.57±0.03
Crude protein* (%)	14.6±1.1
Crude oil (%)	64.2±2.6
Crude fibre (%)	1.8±0.6
Energy (Cal)	576±7.1
Ether-soluble extract (%)	24.71±1.63

**Nx6.25, **Mean±standard deviation.*

The extracted walnut oil was yellowish in colour. Physical and chemical properties of oil are given in table 2. A relative density was found as 0.9721, and higher than the value reported by *Özcan* and *Seven* [28] for peanut kernel oil (0.954-0.955 d20) and by *Özcan* [29] for terebinth fruit oil (0.9742 d20). The unsaponifiable matter content was 4.7 g/kg, lower than that of terebinth fruit (15.7 g/kg) [29], and higher than that of peanut kernel oil (0.27-0.99 g/kg) [28]. The peroxide value was 1.04 meq/kg oil, lower than generally recommended for commercial edible crude vegetable oils (≤10) [30].

The fatty acid composition of walnut kernel oil was determined by gas chromatograpy (table 3). Linoleic acid (55.3 %) was present in the highest concentrion, followed by oleic (13.4 %), linolenic (8.7 %) and palmitic (6.4 %) acids. Palmitoleic, and stearic acids were present in minor amounts. Saturated fatty acids accounted for

approximately 6.05 % of total fatty acids. Linoleic acid contents of walnut kernel were determined between 56 to 59 % [31]. Palmitic, stearic, oleic, linoleic and linolenic acid contents of walnut oil were established as 7.22 %, 1.07 %, 28.51 %, 52.46 % and 10.50 %, respectively [18]. *Özkan* and *Koyuncu* [3] that the contents of the main fatty acids of walnut genotypes were 5.24-7.62 % palmitic, 2.56-3.67 % stearic, 21.18-40.20 % oleic, 43.94-60.12 % linoleic and 6.91-11.52 % linolenic. *Zwarts et al.* [13] reported as 6.7-8. 2 % palmitic, 1.4-2.5 % stearic, 13.8-33.0 % oleic, 49.3-62.3 % linoleic and 8.0-14.2 % linolenic acids. The oleic acid content of walnut oil was lower than that of walnut oil reported by *Zwarts et al.* [13], *Özkan* and *Koyuncu* [3] and *Koyuncu* and *Aşkın* [18]. The walnut fatty acid composition shows high contents of linoleic acid and linolenic acid which are beneficial to human health and linoleic acid and especially linoleinic acid play important roles for human health regarding the cardio vascular system [3,7,14,32].

These results are comparable to data previously reported in the literature [10-12]. Nuts and oils intended to be cooked may require a low polyunsaturated fatty acid content, as polyunsaturated fatty acids have a higher tendency to char [33].

There is no doubt that walnuts can contribute to a healthy diet [13]. *Sabate et al.* [7] showed that the inclusion of 84 g of walnuts per day in the diets of health men for a period of 8 weeks significantly reduced their blood cholesterol levels provided that their diets were adjusted to keep the total fat intake to reasonable levels. The results of the experiment presented here show that Turkish walnuts have a similar composition profile.

The mineral contents of walnut kernels were determined by ICP-AES (table 4) and found to be excellent. Walnut kernels were found to be rich in some minerals such as Ca (1108.6 mg/kg), K (4627.6 mg/kg), P (3621.9 mg/kg), Na (44.7 mg/kg) Mn (46.3 mg/kg and Mg (1089.9 mg/kg). *Çağlarırmak* [2] reported as 280-380 mg/100 g P, 230-340 mg/100 g K, 81-99 mg/100 g Mg and 67-105.5 mg/100 g Ca in fresh walnut kernels. Our results were found higher compared with mineral values reported by *Çağlarırmak* [2]. Also, K, P, Na and Se and Mg concentrations were higher than that of terebinth (*P.terebinthus*) (Na, 906.64 mg/kg; K, 1364.19 mg/kg; P, 801.88 mg/kg; Mg,318.39 mg/kg) [29].

Calcium is the major component of bone and assists

Table 2: Physical and chemical properties of walnut oil.

Properties	Values
Relative density (d20)	0.9761±0.0012*
Refractive index (nD20)	1.446±0.003
Acidity (oleic,%)	0.43±0.12
Peroxide value (meq/kg)	1.04±0.23
Saponification number	161.4±7.14
Unsaponifiable matter (g/kg)	4.7±0.73

** Mean±standard deviation.*

Table 3: Fatty acid compositions of walnut oil.

Properties	Values
Palmitic	6.4±0.4
Palmitoleic	0.1±0.0
Stearic	1.7±0.1
Oleic	13.4±0.3
Linoleic	55.3±1.1
Linolenic	8.7±0.7

Mean±standard deviation.

Table 4: Mineral contents of walnut kernel.

Minerals	Values (mg/kg)
Al	5.8±1.0*
B	58.8±16.2
Ba	5.9±2.4
Ca	1108.6±13.7
Co	0.24±0.08
Cr	8.9±0.7
Cu	3.8±2.2
Fe	32.4±4.3
K	4627.6±34.7
Li	0.68±0.06
Mg	1089.9±26.3
Mn	46.3±6.5
Na	44.7±7.8
Ni	2.4±0.6
P	3621.9±11.2
Se	15.7±2.9
Sr	2.4±0.6
Zn	26.4±3.2

** Mean±standard deviation.*

in teeth development [34]. The Mg, Fe and P levels are adequate. Some inorganic elements which may contribute to biological processes, but which have not been established as essential are bromine, cadmium, lead and lithium [35,36]. Cadmium and lead are best known for their toxicological properties. Decreasing of these toxic element contents is an advantage. The highest mineral contents were P, K, Ca, Mg, Na and Fe. This work attempts to contribute to knowledge of the nutritional properties of these seeds. In addition, knowledge of the mineral contents, as condiments at various baked products is of great interest.

CONCLUSIONS

The differences in physical properties of fruits having about the same size were probably due to environmental conditions in conjunction with the analytical methods used [37]. In addition, moisture, crude protein, ash, crude fibre and crude oil contents of fruits are affected chiefly by variety and growth conditions. Walnut oil has a higher content of linoleic, linolenic and oleic acids and there are a health composition for nutrition [3,8,13]. These findings may be useful for dietary information, which requires prior knowledge of the nutritional composition of edible wild fruits and nuts. The high protein and oil contents and the pleasent taste suggest that this fruit can be of use in the food industry. The consumption of walnut fruits is rising around the world owing to the increasing popularity of natural products. According to results, it could be said that walnut kernels have a rich source of a number of important that provide a very useful effect on human health.

Acknowledgements

This work was supported by Selçuk Üniversity Scientific Research Project (S.Ü.-BAP, Konya-TURKEY).

Received : 14th April 2007 ; Accepted : 8th July 2008

REFERENCES

[1] Şen, S.M., Ceviz Yetiştiriciliği, Eser Matbaası, p. 109-229, Samsun-Turkey (1986).

[2] Çağlarırmak, N., Biochemical and Physical Properties of Some Walnut Genotypes (*Juglans regia* L.)., *Nahrurg/Food*, **47**(1), 28 (2003).

[3] Özkan, G., Koyuncu, M.A., Physical and Chemical Comparision of Some Walnut (*Juglans regia* L.) Genotypes Grown in Turkey, *Grasas y Aceites*, **56**(2), 142 (2005).

[4] Hosamani, K. M., Sattigeri, R. M., Industrial Utilization of Rivea Ornata Seed Oil: A Moderate Source of Vernolic Acid, *Ind. Crops Prod.*, **12**, 93 (2000).

[5] Eganathan, P., Subramanian, H.M.SR, Latha, R., Srinivasa Rao, C., Oil Analysis in Seeds of Salicornia Brachiata, *Industrial Crops and Products,* **23**, 177 (2006).

[6] Anonymous, Available in : http:// www. herbalgram. org/youngliving/commissione/Monograp/Monograph_0370.html (2006).

[7] Sabate, J., Fraser, G.E., Burke, K., Knutsen, S.F., Benett, H., Linstead, K.D., Effects of Walnuts on Serum Lipid Levels and Blood Pressure in Normal Men, *New Ergl. J. Med.*, **329**, 603 (1993).

[8] Savage, G.P., Chemical Composition of Walnuts (*Juglans regia* L.) Grown in New Zealand, *Plant Foods for Human Nutrition*, **56**, 75 (2001).

[9] Prasad, R.B.N. "Walnut and Pecans, In : Encysclo-Paedia of Food Science, Food Technology and Nutrition", pp. 4828-4831, London: Academic Press (1994).

[10] Greve, C., Mc Granahan, G., Hasey, J., Synder, R., Kelly, K., Gold Hamerer, D., Labavitch, J., Variationin Polyunsaturated Fatty Acids Composition of Persian Walnut, *J. Am. Soc. Hart. Sci.*, **117**, 518 (1992).

[11] Garcia, J. M., Agar, I. I., Streit, J., Lipid Characterization in Kerrels from Different Walnut Cultivars, *Turk. J. Agric. For.*, **18**, 195 (1994).

[12] Beyhan, O.E., Kaya, I., Şen, S.M. Doğan, M., Fatty Acid Composition of Walnut (*Juglans regia* L.) Types Selected in Darende, *Turk. J. Agric. For.*, **19**, 299 (1995).

[13] Zwarts, L., Savage, G.P., McNeil, B.L., Fatty Acid Content of New Zealand-Grown Walnuts (*Juglans regia* L.), *Interrational Journal of Food Sciences and Nutrition*, **50**, 189 (1999).

[14] Abbey, M., Noaks, M., Belling, G.B., Nestel, P.J., Partial Replacement of Saturated Fatty Acids with Almonds or Walnuts Lowers Total Plasma Cholesterol and Low-Density Lipoprotein Cholesterol., *Am. J. Clin. Nutr.*, **59**, 995 (1994).

[15] Olez, H., Marmara Bölgesi Cevizlerinin (*Juglans regia* L.) Seleksiyon Yoluyla ıslahı Üzerine Araştırmalar., Yalova Bahçe Kültürleri Araştırma Merkezi Dergisi, **4**, 1 (1971).

[16] Şen, S.M., Kuzeydoğu Anadolu ve Doğu Kardeniz bölgesi cevizlerinin seleksiyon yoluyla ıslahı üzerinde araştırmalar., *Doğa Bilim Dregisi*, **7**, 163 (1983).

[17] Şen, S.M., Beyhan, O., A Study on the Selection of Darende Walnut, *Acta Hort.*, **311**, 57 (1993).

[18] Koyuncu, M., Aşkın, M.A., Van Gölü çevresinde yetiştiriciliği yapılan bazı ceviz tiplerinin depolanması üzerine çalışmalar, T*urk. J. Agric. Ferest.*, **23**, 785 (1999).

[19] Anonymous, Available in http://www. hormel.com/ templates/knowledge (2006).

[20] AOAC. Official Methods of Analysis, 14th Ed., *Assoc. Offic. Anal. Chem., Arcingten*, VA (1984).

[21] AOACS, Official Methods and Recommended Practices. Vol. 1, 4th Ed. American Oil Chemists Society, Champaign, II (1990).

[22] AOAC, Official Methods of Analysis, *Assoc. Offic. Anal. Chem., Arcingten*,VA (1995).

[23] Küsmenoğlu, Ş., Toker, G., Başer, K.H.C., Koca, Composition of the Fruit Oils of *Capparis* Species, Acta Pharm. Turc. XXXIX:55-57 (1997).

[24] Hışıl, Y., Instrumental Analysis Techniques, Ege Univ. Engineer Fac. Publ. No. 55, Bornova-İzmir. (in Turkish) (1998).

[25] Skujins, J., Handbook for ICP-AES (Varian-Vista), A Short Guide to Vista Series ICP-AES Operation, *Varian Int. AG*, *Zug*,Version 1-0, Switzerland (1998).

[26] Minitab, Minitab Referance Manual (Release 7.1), Minitab Inc. State Coll., PA (1991).

[27] MSTAT-C, Mstat User's Guide : Statistics (Version 5th Ed.), Michigan State University, Michigan (1980).

[28] Özcan, M., Seven, S., Physical and Chemical Analysis and Fatty Acid Composition of Peanut, Peanut Oil and Peanut Butter from ÇOM and NC-7 Cultivars, *Grasas Y Aceites*, **54** (1),12 (2003).

[29] Özcan, M., Characteristics of Fruit and of Terebinth (*Pistacia terebibthus* L.) Growing Wild in Turkey, *Jourrol of the Huience of Food and Agriculture*, **84**, 517 (2004).

[30] TSE., Analysis Methods of Vegetable Oil. TS 894, Turkish Standard Institute, Ankara (1971).

[31] Ruggeri, S., Cappelloni, M., Gambelli, L., Nicoli, S., Carvovak, E., Chemical Composition and Nutritive Value of Nuts Grown in Italy, *Ital. J. Food Sci.*, **10**, 243 (1998).

[32] Cunnane, S.C., Ganguli, S., Menard, C., Liede, A.C., Hamadeh, M.J., Chen, Z., Wolever,T.M.S., Jerkins, D.J.A., High Linolenic Acid Flaxseed *(Linum usitatissimum)*: Some Nutritional Properties in Humans, *Br. J. Nutr.,* **69**, 443 (1993).

[33] Gunstone, F. D., Norris, F. A., Lipids in Foods: Chemistry, Biochemistry and Technology 1st Ed., Oxford, Pergamon (1983).

[34] Brody, T., Nutritional Biochemistry, San Diego, CA: Academic Pres (1994).

[35] Macrae, R., Robinson, R.K. Sadler, M.J. (Eds.), Encyclopaedia of Food Science, Food Technology and Nutrition, Vol. 5, pp. 3126-3131, Academic Press INC., San Diego, CA, (1993).

[36] Macrae, R., Robinson, R.K. Sadler, M.J. (Eds.), Encyclopaedia of Food Science, Food Technology and Nutrition, Vol. 7, pp. 4593-4600, Academic Press INC., San Diego,CA, (1993).

[37] Guil, J. L., Gimenez, J. J., Torija, M. E., Mineral Nutrient Composition of Edible Wild Plants, *J. Food Compositon and Analysis*, **11**, 322 (1998).