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Chemical composition of oils from wild almond (*Prunus scoparia)* and wild pistachio (*Pistacia atlantica)*

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RESUMEN

Composición química de aceites de almendras *(Prunus scoparia)* y pistachos silvestres *(Pistacia atlantica)*

El objetivo de este estudio fue determinar la composición en ácidos grasos, esteroles, triglicéridos, así como tocoferoles, fenoles totales y pigmentos de aceites de almendras y pistachos silvestres prensados en frío. Triglicéridos (TAG), tocoferoles y pigmentos se analizaron mediante HPLC, los ácidos grasos y esteroles mediante cromatografía de gases, y los fenoles totales espectrofotométricamente. Los principales ácidos grasos de ambas especies fueron los ácidos oleico, linoleico y palmítico. Las especies de TAG predominantes son SLL + OLP (21,83%) en el pistacho silvestre y OOO (47,27%) en almendras silvestre. Feofitina a es un pigmento importante en los aceites de pistacho silvestre. No se detectó pigmentos en los aceites de almendras silvestres. Los fenoles totales fueron 57,6 mg kg^{-1} y 45,3 mg kg^{-1} en los aceites de pistacho silvestre y de almendra silvestre respectivamente.

PALABRAS CLAVE: Aceite de almendra Silvestre – Aceite de pistachio – Aceite prensado en frío – Ácidos grasos – Esteroles – Fenoles Totales – Triacilgliceroles – Tocoferoles.

SUMMARY

Chemical composition of oils from wild almond *(Prunus scoparia)* and wild pistachio *(Pistacia atlantica)*

The aim of this study was to determine the fatty acids, sterols and triacylglycerol compositions as well as the amount of tocopherols, total phenols and pigments wild almond and cold pressed wild pistachio oils. Triacylglycerols, tocopherols and pigments were analyzed with HPLC, fatty acids and sterols with gas chromatography, and total phenols photometrically. The main fatty acids in both samples were oleic, linoleic and palmitic acids. The most predominant TAG species are SLL + PLO (21.83%) in wild pistachio oil and OOO (47.27%) in wild almond oil. Pheophytin a was the major pigment in wild pistachio oil. There were no pigments detected in wild almond oil. Total phenols were 57.6 mg kg^{-1} oil for wild pistachio and 45.3 mg kg^{-1} oil for wild almond oil.

KEY-WORDS: Cold pressed oil – Fatty acid – Sterol – Tocopherol – Total phenol – Triacylglycerol -– Wild almond oil – Wild pistachio oil.

1. INTRODUCTION

A large quantity of oils and fats, whether for human consumption or for industrial purposes, is presently derived from plant sources and because of this, interest in newer sources of edible oils has recently grown. No oil from a single source has been found to be suitable for all purposes because oils from different sources generally differ in their composition. Tree nuts and their oils contain several bioactive and health promoting components. Dietary consumption of tree nut oils may have even more beneficial health effects than the consumption of whole tree nuts, possibly due to the suppressing of dietary carbohydrates and more a concentrated content of unsaturated lipids and/or other components present in the oil extracts. (Hu and Stampfer, 1999). Vegetable oils are mainly constituted by triacylglycerol (95-98%) and complex mixtures of minor compounds (2-5%) of a wide range of chemical nature (Aluyor *et al*., 2009). The minor components include mono and diglycerides, free fatty acids, tocopherols, sterols, carotenoids and polyphenols. Tocopherols act as antioxidants and are required to protect cells against oxidative damage by free radicals (Foster *et al*., 2009). Tocopherols and carotenoids improve oil stability and thus oils naturally rich in these constituents are preferred (Warner and Frankel, 1987; Frankel, 1991). Phenols can act as antioxidants and reduce the risk of cancer and cardiovascular diseases (Burton, 1994; Burton and Traber, 1990; Ferreira *et al*., 2007). Sterols are essential components of cell membranes that play a role in controlling membrane fluidity and permeability. These compounds have a similar structure to cholesterol. When they are present in foods, they can inhibit the absorption of cholesterol resulting in a reduction in low-density lipoprotein (LDL). This improves the cholesterol profile and can help to reduce the risk of developing coronary heart diseases (CHD) (Warner and Frankel, 1987).

Conventional vegetable oil extraction is carried out by pressing or solvent extraction. Solvent oil extraction is the most efficient method; however, its application presents some industrial disadvantages such as emissions of volatile organic compounds into the atmosphere, high operation costs and poor quality products caused by high processing temperatures (Uquiche *et al*., 2008). Cold pressing is simple, ecological and does not require much

energy (Álvarez-Ortí *et al*., 2012). The cold-pressing procedure involves neither heat nor chemical treatments. The consumption of cold-pressed oils may improve human health and may prevent certain diseases (Siger *et al*., 2008).

Almonds and pistachios are grown as orchard crops, are highly nutritious and hav sites and have evolved throughout southwest and Central Asia from Turkey and Syria into the Caucasus Mountains, through Iran, and into the deserts of the Tian-Shan and Hindu Kush Mountains of Tajikistan, Uzbekistan, and Afghanistan (Browicz and Zohary, 1996). Iran is optimally situated for growing almond trees. Nearly 20 of the wild species have been reported from Iran (Gorttapeh *et al.,* 2006). *Prunus Scoparia* is one of them, which grows in the Kerman Province of Iran. The fruits of wild almond and pistachio trees are used by natives for food after peeling and grinding them. In spite of the wide distribution of wild almond and pistachio trees with fruits of high nutritional value and low cost, they have not been used for industrial applications. Although numerous studies have been reported on the chemical characteristics of commercial almond and pistachio species, there are few which deal with the chemical composition of wild almond and pistachio species. Furthermore, this is the first time that a complete chemical analysis of cold pressed wild pistachio oil and wild almond oil (solvent extracted) is determined including sterols, TAGs, tocopherols, fatty acids, phenols and pigment assessment (Yousfi *et al*., 2002; Yousfi *et al*., 2005; Benhassaini *et al*., 2007; Farhoosh and Tavakoli., 2008; Ozcan *et al*., 2011).

2. MATERIALS AND METHODS

2.1. Samples

Wild pistachio *(Pistacia atlantica)* seeds were gathered in September from three locations in Iran including the provinces of Fars, Isfahan and Kohkeloye Boyerahmad and were mixed equally. Wild almond (*Prunus Scoparia*) seeds were collected in October from the Kerman Province in Iran. The outer skin was manually peeled and then the nuts were dried at room temperature in the shade for 1 week for both samples. The moisture content of the air-dried nuts at room temperature was calculated by the difference in weight of about 5 g kernel samples before and after further drying at 105 °C for 3 h.

2.2. Reagents and standards

All chemicals and solvents used in this study were of analytical grade and were purchased from Sigma, BDH and Merck chemical companies.

2.3. Oil extraction

Oil was obtained from wild almond by solvent extraction. Powdered wild almond (200 g) was extracted with 600 mL hexane at room temperature with vigorous shaking for 3 h in a flask covered with aluminum foil. Then, the mixture was filtrated under a vacuum. The solvent was removed by rotary evaporation at 35 °C. Extraction was carried out in triplicate.

The oil of wild pistachio seeds was obtained by pressing 5 kilograms of seeds by means of a cold press machine (PR500, Germany). The screw speed was at 35 rpm. This operation was carried out three consecutive times and fine particles were removed from the oil by filtration. Additionally, before each analysis, these filtered crude oils were centrifuged in a centrifuge Kokusan (model H-11n, Tokyo, Japan) at 4000 rpm for 15 minutes.

Experiments were carried out in triplicate immediately after oil extraction; otherwise, extracted oil samples were stored at 3 °C for one week.

2.4. Analytical methods

The analysis was carried out in triplicate. The values of different parameters were expressed as the mean ± standard deviation

2.5. Fatty acid analysis

The separation of fatty acid methyl esters (FAMEs) was done using 0.05 g of oil sample according to the method of Arena *et al.,* (2007) and analyzed by capillary column GC/FID according to the method of Givianrad *et al.,* (2011). A YoungLin gas chromatograph (model 6000 South Korea), equipped with a split-splitless mode injection system, flame-ionization detector, and TR-CN 100 High polar (60m × 0.25mm, 0.25µm) column was used for FAME analysis. The gas chromatographic conditions were: injection port temperature (250 °C), initial oven temperature (100 °C), heating rate (2 °C min^{-1}), final temperature (200 °C), detector port temperature (280 °C), hydrogen gas flow rate (30 mL min^{-1}), air flow rate (300 mL min^{-1}), and hydrogen gas carrier flow rate (1 mL min^{-1}). The injection volume was 1 µL.

2.6. Sterol analysis

The unsaponifiable fractions were extracted after an alkaline hydrolysis of wild pistachio and wild almond oil samples and the sterols were isolated from the other constituents by thin-layer chromatography according to the method of Givianrad *et al*., (2011). Trimethylsilyl ether derivatives (TMSE) of sterols were synthesized by adding anhydrous pyridine with a mixture of hexamethyldisilane-trimethylchlorosilane (99:1, v/v) to each dried sample; afterwards, the composition of the sterol fraction was determined using Young-Lin gas chromatograph (Model 6000 South Korea) supplied with a flame ionization detector (FID) and capillary column (60 m × 0.32 mm i.d.; 0.25 µm film thickness). The carrier gas was hydrogen at 1 mL

min^{-1} and 1:20 split ratio. The injector and detector temperatures were 300 and 320 °C, respectively and Oven Temperature was 250 °C. Peak identification was carried out by comparing retention times to those of standards.

2.7. Triacylglycerols (TAG) analysis

TAGs were separated by RP-HPLC (model Young Lin Acme 9000). Wild pistachio and wild almond oil samples were dissolved in HPLC-grade acetone, filtred by a syringe filter and injected into a C18 Column (25 cm ×4.6 mm i.d., 5 µm particle size, Tracer excel 120 ODSA). Elution was conducted at a flow rate of 1.5 mL/min with acetonitrile and acetone (40:60). The column was equilibrated at room temperature and the effluent monitored with a refractive index detector.

2.8. Tocopherol analysis

Wild pistachio and wild almond oil samples were dissolved in acetone (1:10), filtered by a syringe filter (0.22 µ) and 20 microliter injected into a C18 lichrosphere RP-100 (250 mm × 4.6 mm, 5 µm) column and guard column (4.6 × 1.5 mm) equipped with a UV detector at 295 nm. The mobile phase was acetonitrile: methanol: water (47.5, 47.5, 5 v/v) at a flow rate of 1 mL min^{-1}.

2.9. Pigment analysis

Each sample was extracted by liquid-phase distribution (LPD) between N, N-dimethyl formamide (DMF) and hexane, according to the method described by Giuffrida *et al.,* (2007). The DMF was evaporated in a rotary evaporator, dissolved in methanol, and analyzed by HPLC. Separation was performed using a C18 Column (25 cm × 4.6 mm i.d., 5 µm particle size, Tracer excel 120 ODSA) and elution was performed at a flow rate of 1.0 mL min^{-1} at room temperature. The mobile phase was a mixture of methanol and water (8:2, v/v) containing 0.025% ammonium acetate and 0.05% triethylamine as phase A and methanol and acetone (1:1, v/v) as phase B. The pigments were eluted according to solvent gradient as follows: 0-10 min, 75% A, 25% B, 10-14 min, 50% A, 50% B, 14-21 min 20% A, 80% B, 21-40 min, 0% A, 100% B, 40-50 min 75% A, 25% B

2.10. Total Phenolic Contents

Phenolic compounds were extracted from the oils in a hexane solution with water and methanol (40/60, v/v) 3 times. The three extracts were combined, and evaporated to dryness in a rotary evaporator. Samples were dissolved in 1 mL methanol and placed in a 25 mL test tube followed by the addition 1 mL of Folin-Ciocalteu reagent and 2 mL Na_2CO_3 (7.5%) respectively. The final volume was brought up to 7 mL with deionized water, and the solution was allowed to stand for 2 h at ambient temperature (about 22 °C). The total phenol content was determined colorimetrically at 750 nm, and expressed as gallic acid equivalents (Zengin *et al*., 2011).

3. RESULTS AND DISCUSSION

3.1. Fatty acid composition

Oil yield was 15.32± 0.6% and 45.34± 0.95% for wild pistachio and wild almond oil, respectively, on a dry weight basis. The moisture of the samples was 15.2 ± 1.5% and 8.9 ± 0.9 for wild pistachio oil and 11.1 ±1.1 and 6.3 ± 2.1 for wild almond oil before and after drying, respectively.

Table 1 shows the fatty acid composition of wild pistachio and wild almond seed oils. The main fatty acids from the studied samples were oleic, linoleic and palmitic acids. In both studied edible oils, the most abundant fatty acid was oleic acid. It represented 51% in wild pistachio and 67% in wild almond seed oils. The seed oils of wild pistachios and wild almonds contained high percentages of linoleic acid (about 30% for wild pistachio and about 22% for wild almond oil). They also contain saturated fatty acids especially palmitic and stearic acids. The latter was poorly represented with about 3% for both oils. Indeed, this fatty acid is constantly

Table 1
Fatty acid compositions of wild pistachio and wild almond seed oils (mean ± standard error (SE), %)

Fatty acids	Pistacia atlantica	Wild almond
Myristic $C_{14:0}$	0.15 ± 0.12	
Palmitic $C_{16:0}$	13.12 ± 0.21	6.94 ± 0.11
Palmitoleic $C_{16:1}$	2.04 ± 0.10	0.30 ± 0.03
Margaric $C_{17:0}$	0.07 ± 0.02	
Heptadecenoic $C_{17:1}$	0.09 ± 0.02	
Stearic $C_{18:0}$	2.78 ± 0.17	3.30 ± 0.12
Oleic $C_{18:1}$	50.65 ± 0.82	67.18 ± 0.72
Linoelaidic $C_{18:2}$	0.04± 0.15	
Linoleic $C_{18:2}$	29.76± 0.30	22.13 ± 0.42
α-Linolenic $C_{18:3}$	0.59 ±0.08	0.15 ± 0.02
Arachidic $C_{20:0}$	0.17 ± 0.06	
Gondoic $C_{20:1}$	0.32 ± 0.02	
Behenic $C_{22:0}$	0.18 ± 0.04	
Lignoceric $C_{24:0}$	0.04 ± 0.02	
SFA[a]	16.51	10.24
MUFA[b]	53.10	67.48
PUFA[c]	30.39	22.28

[a] SFA, saturated fatty acid
[b] MUFA, monounsaturated fatty acid
[c] PUFA, polyunsaturated fatty acid

solicited for the biosynthesis of oleic acid. C17:0 and C17:1 fatty acids presented in wild pistachios are known to be found in animals, but they can only be detected in plants in very small amounts (Satil *et al*., 2003).

The polyunsaturated (PU) and monounsaturated (MU) and saturated (SA) fatty acids amounted to about 30%, 53% and 17%, respectively for wild pistachio seed oil and about 22%, 67% and 10% for wild almond seed oil. The ratio of unsaturated / saturated fatty acids of wild pistachio seed oil was 5.1 and 8.8 for wild almond seed oil. Results of this study on oleic acid levels in wild pistachios are comparable to those reported by Tsantili *et al*., (2010) (52%) and Arena *et al*., (2007) (55%) for commercial pistachios from Iran. The oleic acid contents of wild almonds from the current study was comparable to those reported by Moayedi *et al*. (2011) (68%), Maguire *et al.* (2004) (69.2%) and Miraliakbari and shahidi (2008) (69.9%) for commercial and domestic almonds. Low contents of saturated fatty acids and high contents of monounsaturated oleic acid are highly favorable for human nutrition. Monounsaturated fatty acid-rich oils prevent cardiovascular diseases and they are less exposed to oxidization (Kocyigit *et al*., 2006). According to the results of this study, wild pistachio and wild almond seed oils are regarded as oleic-linoleic oil because oleic acid is most abundant, followed by linoleic acid and it may be used as edible cooking or salad oil.

3.2. Sterol composition

Phytosterols are of a great interest due to their antioxidant activity and impact on health (Maestro-Durán and Borja-Padilla, 1993). Table 2 shows the sterol composition of the seed oils of wild pistachios and wild almonds. In these oils, the marker was β-sitosterol, which constituted about 88% and 91% in wild pistachio and wild almond seed oils, respectively. In most plants such as nuts (walnuts, almonds, peanuts, hazelnuts and the macadamia nuts), β-sitosterol is also the most abundant sterol. Among the different phytosterols, β-sitosterol has been most intensively investigated with respect to its beneficial and physiological effects on health. β-sitosterol lowers cholesterol levels (Pegel, 1997), enhances immunity (Nieman, 1994), and has anti-inflammatory, antipyretic and anti-carcinogenic effects (prostate essentially) (Klippell, 1997; Kritchevsky and Shirley, 2005).

Table 2
Sterol composition of wild pistachio and wild almond seed oil (mean ± standard error (SE), %)

Constituent	Wild pistachio	Wild almond
Cholesterol	0.44 ± 0.02	0.21 ± 0.01
Campesterol	4.35 ± 0.04	3.49 ± 0.06
Stigmasterol	0.98 ± 0.02	0.41 ± 0.03
β-sitosterol	87.73 ± 0.16	91.32 ± 0.14
Δ^5-avenasterol	2.28 ± 0.04	3.52 ± 0.05
Δ^7-avenasterol	1.04 ± 0.06	0.26 ± 0.06
$\Delta^{5,24}$-stigmastadienol	1.19 ± 0.02	0.29 ± 0.03
Others	1.59	0.50

The next major components were campesterol in wild pistachio seed oil and Δ^5-avenasterol in wild almond seed oil, where they reach about 4% of the total sterols. Δ^5-avenasterol accounted for about 2% in pistachio oil. Each of the $\Delta^{5,24}$stigmastadienol, Δ^7-avenasterol and stigmasterol amounted to about 1% of the total amount of sterols in wild pistachio oil and about 0.3%, 0.3% and 0.4%, respectively in wild almond seed oil. Cholesterol, which is specific to animal lipids, is present at low levels in most vegetable oils. It was found at about 0.4% for wild pistachio oil and 0.2% for wild almond oil.

The total sterol contents in wild pistachio and wild almond seed oils were 2164.5 mg kg^{-1} and 2084.5 mg kg^{-1} oil, respectively. These values were higher than those determind by Miraliakbari and Shahidi (2008) and Abidi (2001) for the solvent-extracted oils of almonds, Brazil nuts, hazelnuts, pecans, pine nuts, pistachios and walnuts (800 to 1600 mg Kg^{-1} oil).

3.3. TAG composition

The fatty acid composition can be used to evaluate the stability and the nutritional quality of fats and oils, but not always their functional properties. The type and the amounts of the various TAG species in the oil are important as well because they determine the final physical and functional properties of the oils (Jahaniaval *et al*., 2000). Table 3 shows the TAG composition of wild pistachio and wild almond oils. The most predominant TAG species are SLL+PLO (21.83%) and then SOL+POO (16.56%), OOLn+ PLL (15.68%), OOO (14.07%) and SOO (13.72%) in wild pistachio oil and OOO (47.27%), POO+SOL (26.25%), OOL+PLnP (10.67%) in wild almond oil. Where the P, Palmitic; S, Stearic; O, Oleic; L, Linoleic; Ln, Linolenic; Po, Palmitoleic TAG profiles determined in wild almond oil present good similarity with that of olive oil (Abaza *et al*., 2002). The Studied oils are clearly distinguishable from sunflower oil because of its poor levels of LLL (Noor Lida *et al.,* 2002). The internal position is occupied either by oleic acid (both oils) or linoleic acid (pistachio oil), making these two fatty acids biologically easily available. Oleic acid is an important element in reducing cardiovascular diseases and linoleic acid constitutes an essential fatty acid that helps prevent physiological problems (López Alonso and García Maroto, 2000). In both seed oils TAGs with ECN of 48 were dominant (30.63% in wild pistachio and 76.32% in wild almond), followed by triacylglycerols with ECN of 46 (27.65% in wild pistachio and 15.36% in wild almond).

Table 3
Triacylglycerol composition of wild pistachio and wild almond seed oil (mean ± standard error (SE), %)

Triacylglycerol species	ECN[a]	TAG[b] Content, Wild pistachio	TAG[b] Content, Wild almond
LLL + PoLL	42	0.55 ± 0.02	0.10 ± 0.03
OLLn	42	0.10 ± 0.03	
OLL + PoOL	44	7.04 ± 0.18	1.21 ± 0.16
OOLn + PLL	44	15.68 ± 0.15	1.37 ± 0.14
PLnP + OOL	46	5.82 ± 0.82	10.67 ± 0.79
SLL + PLO	46	21.83 ± 0.41	4.69 ± 0.39
OOO	48	14.07 ± 0.92	47.03 ± 1.34
SOL + POO	48	16.56 ± 0.87	26.25 ± 1.32
PLP + POP	48		3.04 ± 0.02
SOO	50	13.72 ± 060	4.89 ± 0.55
POS + SLS	50	4.31 ± 0.14	0.40 ± 0.08
SOS	52	0.09 ± 0.01	
PPP	54	0.23 ± 0.06	

[a] ECN, equivalent carbon number (carbon number - 2 × number of double bonds)
[b] TAG, Triacylglycerol

3.4. Tocopherol composition

Tocopherols and tocotrienols are naturally occurring constituents found in vegetable oils in varying amounts. The presence of these compounds is important in relation to oil stability and nutritional labeling. Besides, consumption of these oils is recommended thanks to their beneficial effects on health (Gliszczynska-Swigło and Sikorska, 2004). Because of the critical role of tocopherols in nutrition and their relative instability, qualitative and quantitative analysis is very important. To the authors' knowledge, this is the first time that the tocopherol compositions of wild almond and cold press wild pistachio oils have been evaluated. Table 4 shows the tocopherol contents of wild pistachio and wild almond seed oils. Relatively high level of tocopherols in wild pistachio cold press oil (409.97 mg kg^{-1} oil) and wild almond oil (487.92 mg kg^{-1} oil) were determined. The total tocopherols were more than the amounts of those Miraliakbari *et al*., (2008) and Kornsteiner *et al.,* (2006) reported for commercial pistachio and almond when the oil was extracted with different solvents such as 218.5 to 298 mg kg^{-1} for pistachio and 170.6 to 273 mg kg^{-1} oil for almond, respectively. The tocopherol contents in nuts (Brazil nuts, hazelnuts, pecans, pine nuts and walnuts) were obtained from 106.8 to 321.9 mg kg^{-1} oil (Miraliakbari *et al*., 2008). α-tocopherol was found in its highest concentration in wild pistachio and wild almond fruit oils. It was 379.68 mg kg^{-1} oil for wild pistachio and 446.92 mg kg^{-1} oil for wild almond. α-tocopherol was not detected in commercial pistachios (Kornsteiner *et al.,* 2006), but Maguire *et al*., (2004) mentioned that α-tocopherol was the most dominant tocopherol in almonds, peanuts, hazelnuts and macadamias. It ranged from 9.4 (peanuts) to 186.4 μg g^{-1} oil (almonds). α-tocopherol acts as a radical-chain breaking antioxidant in membranes, lipoproteins and foods as the main function of α-tocopherol (Tsantili *et al*., 2010). This ability allows for reducing the risk of cancer and cardiovascular diseases (Burton, 1994; Burton and Traber, 1990). However, not only α-tocopherol but also other tocopherol forms are recently considered to be of biological importance (Wagner *et al*., 2004). (γ + β)-tocopherol and δ-tocopherol amounts were 20.70 and 9.59 mg kg^{-1} oil in wild pistachio, and 35.40 and 5.60 mg kg^{-1} oil in wild almond seed oils, respectively.

Table 4
Tocopherol composition of wild pistachio and wild almond seed oil

Tocopherols	Content, mg kg^{-1} oil, Wild pistachio	Content, mg kg^{-1} oil, Wild almond
α-tocopherol	379.68 ± 0.92	446.92 ± 1.02
(γ + β)-tocopherol	20.70 ± 0.04	35.40 ± 0.10
δ-tocopherol	9.59 ± 0.02	5.60 ± 0.04
Total	409.97	487.92

(γ + β)-tocopherols were the most abundant tocopherols in commercial pistachios, ranging from 100 to 434 mg kg^{-1} oil. In walnuts, pecans, Brazil nuts, pines, peanuts and cashews (γ + β)-tocopherols were also the major tocopherols. In commercial almond (γ + β)-tocopherol ranged from 5 to 104 mg kg^{-1} oil. Traces of δ-tocopherol (<40 mg kg^{-1} extracted oil) were found in cashews, hazelnuts, peanuts, pecans, pines, pistachios and walnuts (Kornsteiner *et al*., 2006).

3.5. Pigment content

The wild almond and wild pistachio oil samples were also investigated with regard to chlorophyll and carotenoid pigments. The total amount was marginal for wild almond. This result is comparable to those reported for almonds, Brazil nuts, cashews, hazelnuts, macadamias, peanuts, pecans, pines and walnuts that reported the abcence of carotenoids, α- and β-carotene, zeaxanthin, lutein, cryptoxanthin and lycopene, carotenes in these oils (Kornsteiner *et al*., 2006). As shown in table 5, the major component in wild pistachio oil was pheophytin a (12.02 mg kg^{-1}), followed by luteoxanthin (10.41 mg kg^{-1}). Neoxanthin (0.15 mg kg^{-1}), violaxanthin (0.23 mg kg^{-1}), lutein (5.2 mg kg^{-1}), lutein isomers (1.2 mg kg^{-1}), chlorophyll a (1.19 mg kg^{-1}), chlorophyll a' (0.92 mg kg^{-1}) and pheophytin a' (1.46 mg kg^{-1}) were also present.

Lutein and chlorophyl values are significantly lower than those in pistachio nuts (*Pistacia vera*) of different geographic regions (Bellomo and Fallico, 2007).

Chlorophyll and carotenoid play key roles in photosynthesis. Animals cannot synthesize chlorophylls and carotenoids, thus they must obtain them from foods. Several reports have demonstrated that plant pigments play important roles in health (Maguire *et al*., 2004). Carotenoids have antioxidant activity, which protects cells and tissues from free radicals and singlet oxygen. Other beneficial actions of carotenoids include enhancement of the immune response, protection against solar radiation, inhibition of some cancers and prevention of degenerative and cardiovascular diseases (Miraliakbari and Shahidi, 2008).

Table 5
Levels of wild pistachio pigment, mg kg-1

Constituent	Value
Neoxanthin	0.15 ± 0.02
Violaxanthin	0.23 ± 0.03
Luteoxanthin	10.41 ± 0.04
Lutein	5.20 ± 0.07
Lutein isomers	1.20 ± 0.02
Chlorophyll a	1.19 ± 0.06
Chlorophyll a'	0.92 ± 0.01
Pheophytin a	12.02 ± 0.03
Pheophytin a'	1.46 ± 0.02
Total chlorophylls	17.21
Total carotenoids	14.80

3.6. Total phenolic content

The total phenol contents of wild pistachio and wild almond oils are expressed as their equivalent gallic acid in mg per kg oil. They reached 57.6 mg kg^{-1} oil for wild pistachio and 45.3 mg kg^{-1} oil for wild almond oil. Moayedi *et al.,* (2011) reported for regular almond a value of 37.7 mg kg^{-1} oil, which is slightly inferior to ours, whereas Miraliakbari and Shahidi (2008) mentioned a total phenol content of 158 mg kg^{-1} oil for commercial pistachio, obviously lighter than what we put in evidence in this research.

A direct relationship has been found between the content of total phenolics and the antioxidant capacity of plants (Ferreira *et al*., 2007). Phenolic acids have been widely investigated as potential models for the development of new primary antioxidants, which can prevent or delay *in vitro* and/or *in vivo* oxidation processes (Siquet *et al*., 2006).

4. CONCLUSIONS

A large quantity of oils and fats is presently derived from plant sources and because of this, interest in newer sources of edible oils has recently grown. Nuts contain a diverse group of compounds that enhance the nutritional value of the human diet. Almond and pistachio nuts and their oils contain several bioactive and health-promoting components but they remain expensive. The fruits of wild almonds and pistachios are used by natives for food. In spite of awide distribution of wild almonds and pistachios with high nutritional value and low cost, they have not been used for industrial applications. Improved knowledge of the composition of wild pistachio and wild almond seed oils would assist in efforts to achieve industrial applications of these plants. Data about wild almond and cold pressed wild pistachio seed oils are very few. Tocopherols and sterols in these seed oils may be of nutritional importance for possible applications in food. More studies are required to evaluate a possible risk of antinutritional components from these sources, which was outside the scope of this study.

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