JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY

Quantitation of Fatty Acids, Sterols, and Tocopherols in Turpentine (*Pistacia terebinthus* Chia) Growing Wild in Turkey

BERTRAND MATTHÄUS*,† AND MEHMET MUSA ÖZCAN‡

Institute for Lipid Research, Federal Research Center for Nutrition and Food, Piusallee 68/76, 48147 Münster, Germany, and Department of Food Engineering, Faculty of Agriculture, University of Selcuk, 42031 Konya, Turkey

The chemical composition (fatty acids, tocopherols, and sterols) of the oil from 14 samples of turpentine (*Pistacia terebinthus* L.) fruits is presented in this study. The oil content of the samples varied in a relatively small range between 38.4 g/100 g and 45.1 g/100 g. The dominating fatty acid of the oil is oleic acid, which accounted for 43.0 to 51.3% of the total fatty acids. The total content of vitamin E active compounds in the oils ranged between 396.8 and 517.7 mg/kg. The predominant isomers were α- and γ-tocopherol, with approximate equal amounts between about 110 and 150 mg/kg. The seed oil of *P. terebinthus* also contained different tocotrienols, with γ-tocotrienol as the dominate compound of this group, which amounted to between 79 and 114 mg/kg. The total content of sterols of the oils was determined to be between 1341.3 and 1802.5 mg/kg, with β-sitosterol as the predominent sterol that accounted for more than 80% of the total amount of sterols. Other sterols in noteworthy amounts were campesterol, Δ5-avenasterol, and stigmasterol, which came to about 3−5% of the total sterols.

KEYWORDS: Fatty acids; *Pistacia terebinthus*; sterols; tocopherols; turpentine

INTRODUCTION

Pistacia terebinthus, belonging to the family Anacardiaceae, is an annual plant that is widely distributed in western and southern Turkey and other Mediterranean countries in the Middle East and southern Europe (*1*). The turpentine tree is broad, bushy, and deciduous and grows slowly to a height and spread of 25 to 30 feet. In Turkey, the species *terebinthus* is found growing on dry rocky slopes and hillsides or in pine forests, particularly in the Taurus mountain, from just above sea level to 1600 m. The fruits have been used as an appetizer in human nutrition in southern Turkey, but also in baking of special village breads and as coffee substituent either before or after roasting. In folk medicine, the fruits are used in the treatment of gastralgia (internally), rheumatism, cough (externally), eczema, diarrheic, throat infections, asthma, and stomach ache. Additionally, some effect is described as a stimulant, diuretic, antitussive, astringent, antipyretic, and antibacterial (*2*−*7*).

Some studies have been carried out to characterize the chemical composition of the seed oil and the physical properties of the fruits (*5*, *7*−*12*). Pistachio nuts are well-known as a popular snack food, and they are used to prepare different varieties of sweet and savory foods. Another species of Pistacia that has importance in commerce and has a wide range of uses in food preparation is the pistachio nut (*P. vera*) (*13*). The nuts have beneficial nutraceutical properties and are useful for human health (*14*−*16*). Satil et. al (*17*) described the fatty acid composition of some pistachio varieties from *Pistatica vera*, but no information is available about the tocopherol and sterol composition of *P. terebinthus*.

The aim of the present study was to investigate the chemical properties of the ripe fruits of *P. terebinthus* collected from several regions in Turkey concerning the fat content and the composition of fatty acids, vitamin E active components, and sterols.

MATERIALS AND METHODS

Plant Material. About 20 turpentine (*P. terebinthus*) fruits/sampling were collected by hand from plants growing wild in several locations of Turkey in August, 2002. The average temperature in August was 28−35 °C. Because no meteorological stations were available at the different locations, the information about rainfall is not possible. Fruits were cleaned in an air screen cleaner to remove immature and broken fruits, dried by air condition, and then stored in polypropylene bags at room temperature. Voucher specimens were deposited at the herbarium of the Department of Food Engineering, Faculty of Agriculture, Selcuk University, Konya-Turkey. Each sample was analyzed as the whole nut, without the shell.

Reagents. Petroleum ether (40−60°) was of analytical grade (>98%; Merck, Darmstadt, Germany). Heptane and *tert*-butyl methyl ether were of HPLC grade (Merck, Darmstadt, Germany). Tocopherol and tocotrienol standard compounds were purchased from CalBiochem (Darmstadt, Germany). Betulin, β-sitosterol, campesterol, and stigmasterol were obtained from Aldrich (Munich, Germany).

* Corresponding author. Tel.: ++49 (0) 251 48167-14. Fax: ++49 (0) 251 519275. E-mail: bertrand.matthaus@bfel.de.
† Federal Research Center for Nutrition and Food.
‡ University of Selcuk.

10.1021/jf060990t CCC: $33.50
Published on Web 08/29/2006

Oil Content. The oil content was determined according to the method ISO 659:1998 (*18*). About 2 g of the seeds were ground in a ball mill and extracted with petroleum ether in a Twisselmann apparatus for 6 h. The solvent was removed by a rotary evaporator at 40 °C and 25 Torr. The oil was dried by a stream of nitrogen and stored at −20 °C until used.

Fatty Acid Composition. The fatty acid composition was determined following the ISO standard ISO 5509:2000 (*19*). In brief, one drop of the oil was dissolved in 1 mL of *n*-heptane, 50 μg of sodium methylate was added, and the closed tube was agitated vigorously for 1 min at room temperature. After addition of 100 μL of water, the tube was centrifuged at 4500 g for 10 min and the lower aqueous phase was removed. Then 50 μL of HCl (1 mol with methyl orange) was added, the solution was shortly mixed, and the lower aqueous phase was rejected. About 20 mg of sodium hydrogen sulfate (monohydrate, extra pure; Merck, Darmstadt, Germany) was added, and after centrifugation at 4500 g for 10 min, the top *n*-heptane phase was transferred to a vial and injected in a Varian 5890 gas chromatograph with a capillary column, CP-Sil 88 (100 m long, 0.25 mm ID, film thickness 0.2 μm). The temperature program was as follows: from 155 °C; heated to 220 °C (1.5 °C/min), 10 min isotherm; injector 250 °C, detector 250 °C; carrier gas 36 cm/s hydrogen; split ratio 1:50; detector gas 30 mL/min hydrogen; 300 mL/min air and 30 mL/min nitrogen; manual injection volume less than 1 uL. The peak areas were computed by the integration software, and percentages of fatty acid methyl esters (FAME) were obtained as weight percent by direct internal normalization.

Tocopherols. For determination of tocopherols, a solution of 250 mg of oil in 25 mL of *n*-heptane was directly used for the HPLC. The HPLC analysis was conducted using a Merck−Hitachi low-pressure gradient system, fitted with a L-6000 pump, a Merck−Hitachi F-1000 fluorescence spectrophotometer (detector wavelengths for excitation 295 nm, for emission 330 nm), and a D-2500 integration system. The samples in the amount of 20 μL were injected by a Merck 655-A40 autosampler onto a Diol phase HPLC column 25 cm × 4.6 mm ID (Merck, Darmstadt, Germany) used with a flow rate of 1.3 mL/min. The mobile phase used was *n*-heptane/*tert*-butyl methyl ether (99 + 1, v/v) (*20*).

Sterols. The sterol composition of the oils was determined following ISO\FIDS 12228:1999 (E) (*21*). In brief, 250 mg of oil was saponified with a solution of ethanolic potassium hydroxide by boiling under reflux. The unsaponifiable matter was isolated by solid-phase extraction on an aluminum oxide column (Merck, Darmstadt, Germany) on which fatty acid anions were retained and sterols passed through. The sterol fraction was separated from unsaponifiable matter by thin-layer chromatography (Merck, Darmstadt, Germany), re-extracted from the TLC material, and afterward, the composition of the sterol fraction was determined by GLC using betulin as internal standard. The compounds were separated on a SE 54 CB (Macherey−Nagel, Düren, Germany; 50 m long, 0.32 mm ID, 0.25 μm film thickness). Further parameters were as follows: hydrogen as carrier gas, split ratio 1:20, injection and detection temperature adjusted to 320 °C, temperature program, 245 °C to 260 °C at 5 °C/min. Peaks were identified either by standard compounds (β-sitosterol, campesterol, stigmasterol) by a mixture of sterols isolated from rapeseed oil (brassicasterol) or by a mixture of sterols isolated from sunflower oil (Δ7-avenasterol, Δ7-stigmasterol, and Δ7-campesterol). All other sterols were identified by GC-MS for the first time and afterward by comparison of the retention time.

Each method was carried out in triplicate for each sample. The mean values were given in the tables, without the standard deviation, because this value would represent only the deviation of the method and not the variation of the appropriate sample.

RESULTS AND DISCUSSION

Oil Content. The oil content of 14 samples of *P. terebinthus* seeds from different locations in Turkey varied in a relatively small range from 38.4 (*P. terebinthus*-7) to 45.1% (*P. terebinthus*-5), with a mean value of 41.2% (**Table 1**). This was in good agreement with results reported by Özcan (*22*). For seeds from *P. terebinthus*, the oil content as one characteristic feature of oilseeds seems to be relatively stable against environmental influences resulting from different locations of cultivation. The variation of the oil content in dependency on the location of cultivation was only small.

Table 1. Origin and Oil Content of 14 Samples of *Pistacia terebinthus*

sample	origin	oil content [g/100 g]
P. terebinthus 1	Konya (Balcilar-Taskent)	42.0
P. terebinthus 2	Mugla	38.5
P. terebinthus 3	Hatay (Yayladagi)	39.7
P. terebinthus 4	Karaman (Ermenek)	40.9
P. terebinthus 5	Mersin (Silifke)	45.1
P. terebinthus 6	Kahramanmaras	41.9
P. terebinthus 7	Antalya (Beskonak-Manavgat)	38.4
P. terebinthus 8	Mersin (Sakizköy-Mut)	41.5
P. terebinthus 9	Izmir (Hisarköyü)	40.7
P. terebinthus 10	Antalya (Akbasköyü-Serik)	40.9
P. terebinthus 11	Mersin (Erdemli)	42.2
P. terebinthus 12	Antalya (Armutlu-Akseki)	40.1
P. terebinthus 13	Antalya (Alanya)	43.1
P. terebinthus 14	Antalya (Kepez)	42.6
mean value		**41.2**
standard deviation		**1.8**

In comparison to pistachio nuts (*Pistacia vera*), which present an important commodity of Turkey, the oil content of *P. terebinthus* is remarkably lower. For these nuts, the oil content accounted for nearly 60% (*17*).

Nevertheless, the high oil content of *P. terebinthus* seeds is comparable to several commonly used oilseeds such as rapeseed or soybeans. Therefore, considering the oil content, *P. terebinthus* seeds could be interesting for a commercial processing of the oil from an economical point of view.

Fatty Acid Composition. The fatty acid compositions of oil from *P. terebinthus* seeds are summarized in **Table 2**. The oil contained fatty acids commonly present in seed oils, such as saturated fatty acids like palmitic acid or stearic acid and unsaturated fatty acids like oleic, linoleic, or linolenic. Therefore, the fatty acid composition of *P. terebinthus* seed oil has only a minor chemotaxonomic value (*23*). Nevertheless, the fatty acid composition of seed oils is an interesting point with regard to the further use of the seeds or the oil.

The fatty acid composition of turpentine oil was similar to that reported previously (*22*). Most predominate in the oil of *P. terebinthus* seeds is oleic acid, with amounts between 43.8% (*P. terebinthus*-12) and 51.3% (*P. terebinthus*-8), with a mean value of 46.9% for the 14 different samples. Only in seeds collected in Antalya (Alanya) and Mersin (Sakizköy-Mut), respectively, was more then 50% of oleic acid found in the oil. In the more common used species *P. vera* the content of oleic acid is clearly higher (*17*). This oil consists of nearly 60% oleic acid, which is comparable to rapeseed oil.

As another quantitatively interesting unsaturated fatty acid, the oil contained linoleic acid in a range from 19.0 to 25.9%, with a mean value of 21.7%. In the case of linoleic acid, the variation was smaller and only the oil of two seeds (*P. terebinthus*-2 and *P. terebinthus*-3) consisted of about 25% linoleic acid. In all the other seed oils, the amount of linoleic acid was significantly lower ($P = 0.01$). Comparing the amount of linoleic acid in the seed oil of the two species *P. terebinthus* and *P. vera*, this fatty acid is more present in *P. terebinthus*, while in *P. vera*, the amount ranged between 14.7 and 17.8% (*17*). The most conspicuous difference between the seed oils of *P. terebinthus* and *P. vera* is the high concentration of palmitoleic acid (16:1Δ9) in *P. terebinthus*, which ranged

Table 2. Fatty Acid Composition (Percent) of Seed Oils from *Pistacia terebinthus*[a]

sample	palmitic acid 16:0	palmitoleic acid 16:1 Δ9	stearic acid 18:0	oleic acid 18:1 Δ9	*cis*-vaccenic acid 18:1 Δ11	linoleic acid 18:2 Δ9,12	linolenic acid 18:3 Δ9,12,15	eicosanoic acid 20:0	eicosenoic acid 20:1 Δ11	behenic acid 22:0	lignoceric acid 24:0
Pt 1	21.9	3.5	2.2	47.7	3.4	19.7	0.7	0.2	0.2	0.0	0.1
Pt 2	22.0	2.4	2.2	44.7	2.4	24.7	0.7	0.2	0.2	0.0	0.0
Pt 3	20.8	2.5	2.1	44.8	2.3	25.9	0.7	0.2	0.2	0.1	0.0
Pt 4	21.3	3.2	2.3	49.2	3.1	19.5	0.7	0.2	0.2	0.1	0.0
Pt 5	22.2	3.5	1.9	48.5	3.1	19.4	0.7	0.1	0.2	0.0	0.0
Pt 6	20.6	4.2	1.8	47.4	4.0	20.4	0.6	0.1	0.2	0.1	0.1
Pt 7	21.8	3.3	2.3	44.0	3.2	23.7	0.8	0.2	0.2	0.1	0.0
Pt 8	20.4	2.9	2.2	51.3	2.7	19.0	0.6	0.2	0.2	0.0	0.0
Pt 9	19.3	2.0	2.0	48.8	2.3	23.9	0.9	0.1	0.2	0.0	0.0
Pt 10	23.5	3.5	2.1	43.9	3.3	22.1	0.7	0.2	0.2	0.0	0.0
Pt 11	21.4	3.9	1.9	47.8	3.0	20.8	0.7	0.1	0.2	0.0	0.0
Pt 12	23.1	3.6	2.1	43.8	3.2	22.5	0.8	0.2	0.2	0.1	0.1
Pt 13	20.5	2.8	1.8	50.4	2.8	20.1	0.7	0.1	0.2	0.1	0.0
Pt 14	22.9	3.5	2.2	44.5	3.1	22.1	0.8	0.2	0.2	0.1	0.0
mean value	**21.6**	**3.2**	**2.1**	**46.9**	**3.0**	**21.7**	**0.7**	**0.2**	**0.2**	**0.1**	**0.0**
standard deviation	**1.2**	**0.6**	**0.2**	**2.6**	**0.5**	**2.2**	**0.1**	**0.0**	**0.0**	**0.1**	**0.0**

[a] Abbreviation: *Pt* = *Pistacia terebinthus*.

Table 3. Tocopherol, Tocotrienol, and Plasochromanol-8 Composition (mg/kg) of Seed Oils from *Pistacia terebinthus*[a]

sample	α-T	α-T3	β-T	γ-T	β-T3	P8	γ-T3	δ-T	δ-T3	total amount
P. terebinthus 1	116.4	20.5	3.0	122.9	0.0	6.6	91.0	6.6	29.8	396.8
P. terebinthus 2	140.7	35.7	3.8	145.7	0.0	8.0	81.6	7.3	24.4	447.2
P. terebinthus 3	147.8	26.3	3.6	155.1	3.7	6.3	96.8	0.0	36.8	476.4
P. terebinthus 4	137.6	27.0	3.4	143.0	1.5	4.9	89.4	7.2	39.9	453.9
P. terebinthus 5	121.9	27.9	2.7	113.3	0.0	0.0	111.7	8.6	36.0	422.1
P. terebinthus 6	150.7	36.8	4.6	146.7	4.5	5.8	113.5	11.3	43.7	517.7
P. terebinthus 7	127.9	62.7	3.5	143.2	4.1	7.3	100.5	10.7	36.8	496.6
P. terebinthus 8	130.6	23.1	2.4	130.4	2.3	5.6	78.5	11.3	32.0	416.2
P. terebinthus 9	133.2	28.3	3.6	128.7	0.0	8.5	89.6	13.8	35.0	440.8
P. terebinthus 10	140.0	69.6	3.4	134.5	4.8	5.7	114.1	4.9	40.2	517.3
P. terebinthus 11	124.4	35.1	2.5	149.5	0.0	5.0	112.3	8.0	47.5	484.3
P. terebinthus 12	140.9	59.2	3.2	121.0	4.1	6.0	110.2	9.3	38.0	492.0
P. terebinthus 13	143.7	29.2	3.5	150.8	3.4	5.9	110.1	11.6	39.0	497.3
P. terebinthus 14	131.9	65.0	2.3	113.5	4.2	5.3	100.3	4.9	33.6	461.0
Mean value	**134.9**	**39.0**	**3.2**	**135.6**	**2.3**	**5.8**	**100.0**	**8.3**	**36.6**	**465.7**
Standard deviation	**10.0**	**17.2**	**0.6**	**14.1**	**2.0**	**2.0**	**12.4**	**3.5**	**5.7**	**37.9**

[a] Abbrevations: T = tocopherol; T3 = tocotrienol; P8 = plastocromanol-8.

between 2.0% (*P. terebinthus*-2) to 4.2% (*P. terebinthus*-6), with a mean value of 3.1%. This fatty acid is known in most commonly used vegetable oils, but also in seed oils of wild plants in amounts clear below 1%, and also in *P. vera*, only 0.1% was found (*17*). Interesting sources for this fatty acid are the oil of seeds from Macadamia (*Macadamia integrifolia*) and Sea buckthorn (*Hippophae rhamnoides*), containing about 20 and more than 40%, respectively (*24*).

Nutritionally unfavorable is the high content of saturated fatty acids, consisting of palmitic acid, which amounted to between 19.3% (*P. terebinthus*-9) and 23.5% (*P. terebinthus*-10), with a mean value of 21.6% and stearic acid, which was found in a very small range between 1.8% (*P. terebinthus*-6) and 2.3% (*P. terebinthus*-7), with a mean value of 2.1%. With amounts between 14.1% and 16.1%, *P. vera* usually contains clearly less saturated fatty acids than *P. terebinthus*. Nevertheless, possibly depending on the climatic conditions, in some cases, remarkably higher values can be found (28.1%) in seed oils of *P. vera* when the temperature is too low (*17*). Even if the number of samples tested in this investigation was small, the result shows clearly that the dependency of the fatty acid composition of the different samples on the location of growing is comparatively small. The variation of the fatty acid composition is comparable to the variation given for other commonly used oilseeds in the Standard of the Codex Alimentarius (*25*).

Vitamin E. In addition to the fatty acid composition, the composition of vitamin E active compounds is an important characteristic feature to describe the identity of vegetable oils. Additionally, these compounds have some importance in nutrition because they are known to have an antioxidative activity, which protects the oil against oxidative deterioration; additionally, a biological activity exists, which protects cells against oxidative stress. The group of vitamin E active compounds comprises, in addition to the tocopherols, four tocotrienols and plastochromanol-8, which also have antioxidative and biological activities, but less than the tocopherols.

In comparison to other edible vegetable oils, the amount of tocopherols was lower in the seed oil of *P. terebinthus* (**Table 3**). The concentration in the different seed oils ranged from 396.8 mg/kg (*P. terebinthus*-1) to 517.7 mg/kg (*P. terebinthus*-6), with

Table 4. Sterol Composition (mg/kg) of Seed Oils from *Pistacia terebinthus*[a]

	chol	brass	camp	stig	7-camp	5.23-stigma*	chlero*	**β-sitost**	sito*	5-aven*	5.24-stigma*	7-stig	7-aven	total amount
Pt 1	10.2	0.0	80.6	39.8	3.5	17.0	3.6	1185.2	16.3	53.4	22.4	10.5	7.9	1450.5
Pt 2	8.3	0.0	73.5	42.6	10.6	16.4	0.0	1096.8	14.3	39.3	21.1	10.9	7.6	1341.3
Pt 3	15.7	8.6	79.4	44.0	0.0	17.6	0.0	1327.0	17.9	66.7	28.1	12.7	10.2	1627.9
Pt 4	8.9	0.0	78.7	37.6	4.8	18.3	0.0	1252.9	16.0	46.3	25.1	17.2	11.2	1517.0
Pt 5	11.4	0.0	86.8	57.0	4.3	17.0	0.0	1138.5	17.5	55.1	23.6	11.3	9.8	1432.3
Pt 6	13.1	0.0	114.2	54.8	4.7	19.9	0.0	1411.4	20.9	74.1	24.6	12.7	11.3	1761.6
Pt 7	19.2	23.9	125.0	47.0	0.0	21.3	0.0	1418.9	19.6	70.6	28.4	17.6	11.0	1802.5
Pt 8	15.2	12.7	74.0	42.5	0.0	19.8	0.0	1276.4	19.3	50.6	22.4	19.8	8.2	1561.0
Pt 9	14.4	0.0	76.0	38.5	0.0	17.5	0.0	1257.4	18.3	37.9	19.3	14.6	9.2	1503.0
Pt 10	14.0	0.0	81.3	42.4	0.0	17.3	0.0	1261.6	18.7	56.2	22.3	14.2	12.2	1540.3
Pt 11	13.8	0.0	73.8	37.9	0.0	15.0	0.0	1336.9	11.9	65.3	19.8	0.0	0.0	1574.4
Pt 12	21.9	0.0	71.7	44.1	8.0	19.0	0.0	1283.3	19.4	57.8	25.6	16.5	11.6	1578.9
Pt 13	20.3	0.0	76.9	47.3	8.7	16.7	0.0	1237.1	15.1	66.2	23.0	14.3	11.5	1537.2
Pt 14	21.4	0.0	72.3	41.0	0.0	19.3	0.0	1275.0	17.5	54.2	37.9	16.7	10.4	1565.6
mean value	**14.8**	**3.2**	**83.2**	**44.0**	**3.2**	**18.0**	**0.3**	**1268.5**	**17.3**	**56.7**	**24.5**	**13.5**	**9.4**	**1556.7**
std dev	**4.5**	**7.1**	**16.1**	**5.9**	**3.8**	**1.7**	**1.0**	**90.4**	**2.4**	**11.0**	**4.7**	**4.8**	**3.1**	**119.8**

[a] Abbreviations: Pt = Pistacia terebinthus; chol = cholesterol; brass = brassicasterol; camp = campesterol; stig = stigmasterol; 7-camp = 7-campesterol; 5.23-stigma* = 5.23-stigmastadienol*; chlero* = chlerosteriol*; β-sitost = β-sitosterol; sito* = sitostanol*; 5-aven* = 5-avenasterol*; 5.24-stigma* = 5.24-stigmastadienol*; 7-stig = 7-stigmasterol; 7-aven = 7-avenasterol; std dev = standard deviation.

a main value of 465.7 mg/kg. In comparison, the content of total tocopherols in rapeseed oil ranges between 430 and 2680 mg/kg and in soybean oil between 600 and 3370 mg/kg (*26*).

The predominant tocopherols in *P. terebinthus* seed oil were α- and γ-tocopherol, which were found in nearly the same amount. The content of α-tocopherol ranged from 116.4 mg/kg (*P. terebinthus*-1) to 150.7 mg/kg (*P. terebinthus*-6), with a mean value of 134.9 mg/kg, and γ-tocopherol was found in amounts between 113.3 mg/kg (*P. terebinthus*-5) and 155.1 mg/kg (*P. terebinthus*-3), with a mean value of 135.6 mg/kg. In addition to these tocopherols, the oil of the *P. terebinthus* seeds also contains noteworthy amounts of tocotrienols, especially γ-tocotrienol in a range between 78.5 mg/kg (*P. terebinthus*-6 and -10) and 114.1 mg/kg (*P. terebinthus*-9), with a mean value of 100.0 mg/kg. α- and δ-Tocotrienol were found to the same extent, with amounts of about 30 mg/kg.

In contrast to the fatty acid composition, a greater variation of the total tocopherol content and the content of individual tocopherols was found. But from the results it is not noticeable if this greater variation is the result of the different locations with different environmental conditions or if it is the result of plant specific characteristics.

Sterols. Table 4 presents the content and the composition of sterols in the turpentine fruit oils. The concentration of total sterol amounts ranged from 1341.3 (*P. terebinthus*-2) to 1802.5 (*P. terebinthus*-7). This is low in comparison to other vegetable oils, such as rapeseed oil, sunflower oil, or Sea buckthorn oil, which contain amounts equal to 9000, 3500, and 12 000 mg/kg. The composition of sterols in *P. terebinthus* seed oil is dominated by β-sitosterol, which accounted for about 80% of the total sterols in the oil. This is typical for many vegetable oils, in which β-sitosterol is predominant. Other sterols with some importance are campesterol (about 5% of the total sterols), 5-avenasterol (about 4%), and stigmasterol (about 3%). The variation of the total amount and the individual sterols are small, but it is conspicuous that some samples (*P. terebinthus*-3, *P. terebinthus*-7, and *P. terebinthus*-8) contained brassicasterol in amounts from 8.6 to 23.9 mg/kg. This sterol is characteristic for rapeseed oil and oils from other members of the family Brassicaceae. An explaination of the finding is not possible from this data.

As a result of the high oil content, seeds of *P. terebinthus* seem to be an interesting source for the production of vegetable oil. Looking at the characteristics of the oil shows that the fatty acid composition is neither particularly interesting for industrial applications, because no fatty acid is available in an extraordinary high amount, nor is the oil a highlight for nutritional purposes, because of the high amount of saturated fatty acids. Nevertheless, the composition of the oil is comparable to other commonly used oils or fats, such as palm olein, and therefore, the use of the oil in nutrition or technical applications is possible. Additionally, minor compounds like vitamin E active compounds and sterols are also only available in relatively small amounts in comparison to other commonly used vegetable oils.

LITERATURE CITED

(1) Davis, P. H. *Flora of Turkey and the East Aegean Islands.* Edinburgh at the University Press: Edinburgh, 1967; Vol. 2, pp 546−547.

(2) Walheim, L. *Western Fruit and Nuts.* HP Books, Inc.:, 1981; p 166.

(3) Baytop, T. *Treatment with Plants in Turkey*, İstanbul Univ. Publ. No. 3255; İnstanbul University: Istanbul, Turkey, 1984 (in Turkish).

(4) Duke, J. A. *CRC Handbook of Nuts*; CRC Press: Boca Raton, FL, 1989; pp 240−243.

(5) Dum, M. E.; Çakır, A.; Kordali, S.; Zengin, H.; Harmandar, M.; Izumi, S.; Hirata, T. Chemical composition and antifungal properties of essential oils of three Pistacia species. *Fitoterapia* **2003**, *74*, 170−176.

(6) Aydın, C.; Özcan, M. Some physico-mechanic properties of terebinth (*Pistacia terebinthus* Chia) fruits. *J. Food Eng.* **2002**, *53*, 97−101.

(7) Couladis, M.; Özcan, M.; Tzakou, O.; Akgül, A. Comparative essential oil composition of various parts of the turpentine tree (*Pistacia terebinthus*) growing wild in Turkey. *J. Sci. Food Agric.* **2003**, *83*, 136−138.

(8) Tümen, G.; Başer, K. H. C.; Kırımer, N. Essential oil composition of Turkish gum resinous. *11th Symposium on Plant Drugs* (BHAT), Ankara, Turkey, May 22−24, 1996.

(9) Papageorgiou, V.; Assimopoulou, A. N.; Yannovits-Argiriadis, N. Chemical composition of the essential oil of Chios Turpentine. *J. Essent. Oil Res.* **1999**, *11*, 367−368.

(10) Robeva, P.; Genav, K.; Stoyanova, M. Study on the turpentine tree (*Pistachia terebinthus*) as one essential oil plant. *Naukaza-Gorata* **1990**, *27*, 38−46.
(11) Küsmenoğlu, S.; Başer, K. H. C.; Özek, T. Constituents of the essential oil from the hulls of *Pistacia vera* L. *J. Essent. Oil Res.* **1995**, *7*, 441−442.
(12) Dung, N. X.; Nai, L. T.; Phuong, N. X.; Cu, L. D.; Thai, T. H.; Hoi, T. M. Volatile constituents of leaf oil of *Pistacia weinmenifolia* J Poiss ex Franch (Anacardiaceae family) from Vietnam. *J. Essent. Oil-Bear. Plants* **2000**, *3*, 131−134.
(13) Wyllie, G. S.; Brophy, J. J.; Sarafis, V.; Hobbs, M. Volatile components of the fruit of Pistacia lentiscus. *J. Food Sci.* **1990**, *55*, 1325−1326.
(14) Tanker, M.; Tanker, N. *Pharmacognosy*; Ankara University Press: Ankara, Turkey, 1990.
(15) Duru, M. E.; Çakır, A.; Kordali, S.; Zengin, H.; Harmandar, M.; Izumi, S.; Hirata, T. Chemical composition and antifungal properties of essential oils of three Pistacia species. *Fitoterapia* **2003**, *74*, 170−176.
(16) Nickavar, B.; Dolat-Abadi, R.; Majob, F.; Motanmed, S. M. Volatile constituents of the fruit Husk of *Pistacia vera* L. from Iran. *J. Essent. Oil-Bear. Plants* **2004**, *7*, 171−174.
(17) Satil, F.; Azcan, N.; Baser, K. H. C. Fatty acid Composition of Pistachio nuts in Turkey. *Chem. Nat. Compd.* **2003**, *39*, 322−324.
(18) *Oilseeds − Determination of hexane extract (or light petroleum extract), called "oil content"*. International Standard ISO 659: 1998, ISO: Geneva, 1998.
(19) *Animal and vegetable fats and oils − Preparation of methyl esters of fatty acids*. International Standard ISO 5509:2000, ISO: Geneva, 2000.
(20) Balz, M.; Schulte, E.; Thier, H-P. Trennung von Tocopherolen und Tocotrienolen durch HPLC. *Fat Sci. Technol.* **1992**, *94*, 209−213.
(21) *Animal and vegetable fats and oils - Determination of individual and total sterols contents − Gas chromatographic method*. International Standard ISO 12228:1999, ISO: Geneva, 1999.
(22) Özcan, M. Characteristics of fruit and oil of terebinth (*Pistacia terebinthus* L.) growing wild in Turkey. *J. Sci. Food Agric.* **2004**, *84*, 517−520.
(23) Johansson, A.; Laakso, P.; Kallio, H. Characterization of seed oils of wild, edible Finnish berries. *Z. Lebensm. Unters. Forsch.* **1997**, *204*, 300−307.
(24) Database, "Seed Oil Fatty Acids", www.bagkf.de/sofa/.
(25) Food and Agriculture Organization of the United Nations/World Health Organization, Joint FAO/WHO Food Standards Programme, Codex Alimentarius Commission, Codex Alimentarius Volume 8, *Fats, Oils and Related Products*, 2nd edition, Rome, 1993.
(26) *Official Methods and Recommended Practices of the American Oil Chemists' Society: Physical and Chemical Characteristics of Oils, Fats and Waxes; Section I*; AOCS Press: Champaign, Illinois, 1996.

Received for review April 9, 2006. Revised manuscript received July 28, 2006. Accepted July 30, 2006.

JF060990T