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Chemical Composition of Gum Mastic Quality of Natural *Pistacia* Species Plants of Turkey

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In this study, the mastic, leaf and fruit samples from cultivated *Pistacia lentiscus* L. varieties, pruned naturally grown bush forms of *Pistacia lentiscus* and *Pistacia atlantica* were examined. The samples were collected from different locations between August and September and distilled with a Clevenger device. By GC/MS analysis, the essential oil components were determined. The essential oil components of the mastics from the Aegean coast belt of Turkey and the mastics from Chios Island of Greece, the unique producer of mastic, have similar characteristics.

Key Words: Essential oil, *Pistacia atlantica* L., Mastic gum, *Pistacia lentiscus* L.

INTRODUCTION

The mastic gum and leaves of *Pistacia lentiscus* L. and *P. atlantica* Desf. varieties of Anacardiaceae family belong to the Mediterranean natural cover plants.

The unique producer in the world is the Chios Island in Greece. The mastic gum can only be obtained from branches and trunks pruned appropriately. Browicz[1] also indicates that mastic flow is accelerated when the trunk and thick branches warm up under sunlight.

Turkey is full of millions of *Pistacia* and their hybrids in various forms as bush or single trees. Some of the other species of *Pistacia* genus present in Turkish flora are: *P. terebinthus, P. atlantica, P. vera* and *P. lentiscus* and *P. x saportae,* a hybrid of *P. terebinthus.* Most of these plants are grown as wild and not used for agricultural purposes[2]. According to Davis[3], its distribution is mainly in the Aegean-Mediterranean coast belt of Turkey and may go up to 200 m above sea level.

It is resistant to drought and salt stress and therefore an excellent plant that can be used against water and wind erosion with its deep roots and dense leaf structure[4, 5]. Mastic is not soluble in water but soluble in ether, alcohol, naphtha

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oil and chloroform. Its specific gravity[6] is 1074. Mastic's chemical structure is composed of 97% of acids as masticinic, masticolic, masticonic and masticore-cenine and 1–3% essential oils[7, 8]. It is determined that mastic in little amounts destroys *Helicobacter pylori* which causes peptic ulcer[9]. Tassou[10] determined that the addition of mastic to a culture medium containing *Staphylococcus aureus, Lactobacillus plantarum, Pseudomanas fragi* and *Salmonella enteridis* stopped microbial activities. Hussain[11] determined that ethanol extract of *Pistacia lentiscus* has antibacterial effect on Gram +ve bacteria. It is used against high blood pressure in Spain[12]. Now-a-days, there are a lot of areas where mastic is used; medicine, paint, cosmetics, food and drink industries are the leaders in this list. It is used as a preserver covering varnish in painting and statues[9, 13]. The research done by the Faculty of Pharmacy in University of Athens proved that mastic and mastic oil have valuable antibacterial and fungicidal effects[14].

The study aims to forward alternative sources for mastic production. The gum mastic, fruit and leaf samples were taken from cultivated form and pruned bushes of naturally grown types of *P. lentiscus* and *P. atlantica* to determine their essential oil composition in order to assess their potential as an alternative to commercially available mastic for food and medicine industries.

EXPERIMENTAL

This study was performed between May and December of 2003 on *Pistacia lentiscus* L. (Sample numbers 1, 2, 3, 4, 5) and *P . atlantica Desf.* (Sample number 7) plants which are frequently found in Cesme (Izmir) and Fethiye-Kayaköy and Ölüdeniz sites (Mugla) in western Turkey. Sample number 6 was collected from Chios Island, Greece.

Between August and September, mastic, leaf and fruit samples were taken from 10 plants for each variety and mixed homogeneously. 100 g from leaf mixtures, 10 g from mastic mixtures and 100 g from the fruits of females with 5 leaves of *Pistacia lentiscus* L. and *P. atlantica* Desf. were taken and distilled with Clevenger device. Each distillate was analyzed by using a GC/MS device and their essential oil components were determined.

RESULTS AND DISCUSSION

The essential oil content was found 10, 12, 10, 15, 6, 10, 45 mL kg^{-1} in sample numbers 1 to 7, respectively. *P. lentiscus* samples collected from the Aegean Region in Turkey ranged betwen 6–15 mL kg^{-1}. The value obtained with the sample originating from Chios Island of Greece was 10 mL kg^{-1} and was within the range of the Turkish mastic samples. The analysis of *P. atlantica* revealed much higher essential oil content of 45 mL kg^{-1}.

The retention time and area (%) of major components in essential oil samples extracted from mastic of *P. lentiscus* of Turkish and Chios Island (Greece) origin and of *P. atlantica* are given in Table-1.

TABLE-1
RETENTION TIME AND AREAS (%) OF SOME IMPORTANT ESSENTIAL OIL COMPONENTS OF MASTIC BELONGING TO *PISTACIA ATLANTICA* AND CULTIVATED FORMS OF *PISTACIA LENTISCUS*

Component		% Areas						
		P. lentiscus 5 leaflets Ovacik	*P. lentiscus* 3 leaflets Alacati	*P. lentiscus* 5 leaflets Ovacik	*P. lentiscus* 5 leaflets Cakabev	*P. lentiscus* 5 leaflets Avavorgi	*P. lentiscus* Chios Island	*P. atlantica* Fethiye
Sample No.		1	2	3	4	5	6	7
α-Thujoene	Rt/min	–	–	–	–	–	–	3.70
	% Area	–	–	–	–	–	–	0.52
Sabinene	Rt/min	3.69	3.97	–	–	3.69	–	3.97
	% Area	0.28	0.28	–	–	0.46	–	14.70
α-Pinene	Rt/min	3.77	3.77	3.77	3.76	3.77	3.76	3.77
	% Area	52.40	57.70	43.50	57.34	60.64	43.47	17.40
(+)-Alpha	Rt/min	–	–	–	3.86	–	–	–
	% Area	–	–	–	0.83	–	–	–
Pinene	Rt/min	–	–	–	–	–	–	–
	% Area	–	–	–	–	–	–	–
Camphene	Rt/min	–	3.87	–	–	–	–	–
	% Area	–	0.47	–	–	–	–	–
Myrcene	Rt/min	4.00	4.00	4.00	3.99	4.00	3.99	4.00
	% Area	21.42	21.59	38.16	27.55	26.93	33.38	2.20
β-Pinene	Rt/min	–	4.03	3.87	3.68	–	3.68	4.03
	% Area	–	2.32	0.36	0.74	–	0.46	7.19
Para-	Rt/min	–	–	–	–	–	–	4.29
cymene	% Area	–	–	–	–	–	–	0.79
Limonene	Rt/min	4.35	4.35	4.35	4.34	–	4.34	4.35
	% Area	3.47	3.88	1.99	2.50	–	7.96	32.46
Anethol	Rt/min	6.74	6.74	6.74	6.72	–	6.37	–
	% Area	1.85	2.04	0.56	0.60	–	0.90	–
Terpinolen	Rt/min	–	–	–	–	–	–	4.82
	% Area	–	–	–	–	–	–	0.86
Sabinene	Rt/min	–	–	–	–	–	–	4.91
hydrate	% Area	–	–	–	–	–	–	0.84
Terpineol	Rt/min	–	–	–	5.78	5.79	5.78	5.80
	% Area	–	–	–	0.50	0.22	1.00	2.64
(+)-	Rt/min	–	–	–	–	–	–	6.24
Carvone	% Area	–	–	–	–	–	–	0.68
Bornylesler	Rt/min	–	–	–	–	–	–	6.75
	% Area	–	–	–	–	–	–	0.42
‘β-Caryo-	Rt/min	8.56	8.56	8.56	8.55	8.56	8.54	8.56
phyllene	% Area	6.01	6.28	8.66	3.32	4.58	4.06	0.79
α-	Rt/min	8.95	8.95	8.95	8.94	8.95	8.94	–
Humulene	% Area	0.63	0.71	0.95	0.31	0.44	0.36	–
δ-3-Carene	Rt/min	10.38	–	–	–	–	–	–
	% Area	1.29	–	–	–	–	–	–
D-Germa-	Rt/min	–	–	–	9.24	–	–	–
crene	% Area	–	–	–	0.43	–	–	–

The monoterpenes represented by myrcene, α-pinene, sabinene, anethole, terpinole and limonene composed the major part in essential oils of the mastic samples. The two major monoterpenes were α-pinene and myrcene in mastics of *P. lentiscus* samples of Turkish and Greek origin. The previous findings related to the monoterpene composition of mastics show variations. Castola *et al.*[15] reports myrcene as the major monoterpene component of mastics from Spain, Sicily and Greece and α-pinene for mastic of French origin. Castola *et al.*[15] state the major components as: myrcene of mastics from Spain and Sicily, α-pinene from France, terpinene-4-ol in Sardinia and δ-3-carene in Egypt. On the other hand, Papageorgiou *et al.*[7] indicates α-pinene as the major component followed by myrcene confirming the results obtained in the study for Turkish and Greek mastics. The general composition of monoterpenes varied slightly among *P. lentiscus* samples of different origin. Mastic of the Turkish *P. lentiscus* samples showed a marked difference from the sample of Chios in respect to limonene content.

The sesquiterpenes of the mastic extracted from *P. atlantica* were also very limited compared to *P. lentiscus* (Table-1). P. *lentiscus* samples had higher β-caryophyllen contents (3–9%) than *P. atlantica* (0.8%). Germacrene-d was detected only in the sample taken from Cakabey (No. 4). Boelens and Jimenez[16] indicate little importance of D-germacrene among mastic sesquiterpenes.

Essential oil components obtained by distillation of leaf samples are given in Table-2. All leaves of *P. lentiscus* have myrcene as the major component. Terpinene-4-ol, ocymene, α-pinene, terpineole and α-amorphene are present at lower concentrations. Aromadendrene, α-copaene and β-cubenene are minor components having less than 1%. In *P. atlantica,* the absence of myrcene among major components and higher (40.87%) share of germacrene-B are the two major differences with *P. lentiscus.* Besides these, components like ocymen and α-copaen are not determined in *P. atlantica.*

The study was initiated upon Bailey's[17] determination that *Pistacia lentiscus, P. terebinthus* and *P. atlantica* have similar mastic quality and the trees in the experimental site were pruned upon Browicz's[1] determination that mastic flow in thick body and branches is accelerated under sunlight. According to the results of this study, there are high similarities between mastics of cultivated trees and natural bushes of *P. lentiscus* taken from different localities in the Aegean coast belt. On the other hand, no great differences were determined between the Turkish samples and the mastic coming from Chios Island. In all of the examined *P. lentiscus* samples, monoterpenes are the major components, α-pinene and myrcene being the first two. Likewise, in *P. atlantica* monoterpene components are still the major and limonene, α-pinene and sabinene have the first ranks. Components determined by the distillation of the leaves from pruned natural bushes of mastic plants have similar quality.

In all leaf samples of *P. lentiscus,* myrcene, germacrene-D, β-caryophyllene and δ-cadinene, germacrene-B, limonene, α-humulene were the major components while in the leaves of *P. atlantica,* myrcene was not determined among the major monoterpenes but germacrene-B exists at high concentration (40.87%). Besides this, *P. lentiscus and P. atlantica* are similar in composition (Table-2).

TABLE-2
ESSENTIAL OIL COMPONENTS IN LEAVES

S. No.	Component	% Areas					
		P. lentiscus 3 leaflets	*P. lentiscus* spear leaflets	*P. lentiscus* 5 leaflets	*P. lentiscus* 5 leaflets	*P. lentiscus* 5 leaflets	*P. atlantica*
		Alacati	Alacati	Ayayorgi	Cakabey	Ovacik	Fethiye
	Sample No.	1	2	3	4	5	6
1.	Myrcene	31.03	52.99	29.96	30.59	39.34	–
2.	Germacrene D	26.41	18.72	33.95	30.77	26.45	23.21
3.	β-Caryophyllene	11.50	7.84	6.75	3.76	2.24	2.79
4.	λ-Cadinene	4.23	3.79	8.64	5.89	4.85	1.41
5.	Germacrene B	4.03	3.95	3.95	4.51	3.22	40.87
6.	Limonene	3.18	1.47	–	–	5.02	1.71
7.	α-Humulene	3.00	2.44	3.77	2.78	2.25	1.54
8.	Ocymene	1.80	–	0.48	–	–	–
9.	Terpinene-4-ol	1.77	0.44	–	0.60	0.63	2.96
10.	α-Amorphene	1.71	1.95	4.10	2.51	2.11	1.16
11.	α-Pinene	1.46	0.56	0.32	–	0.92	1.61
12.	Terpineol	1.02	–	0.55	1.04	1.32	1.08
13.	Aromadendrene	0,90	0.30	1.40	1.09	0.93	1.19
14.	α-Copaene	0.65	0.73	1.04	0.84	0.76	–
15.	β-Cubenene	0.64	0.60	0.72	5.43	0.68	0.45
16.	Gamma terpinene	0.49	–	–	–	–	1.85
17.	(+)-2-Carene	0.41	–	–	–	4.67	–
18.	Muurolol	–	–	–	3.72	–	–
19.	β-Phellandrene	–	–	–	1.28	–	–
20.	Borneol	–	–	–	0.58	2.62	0.96
21.	δ-3-Carene	–	–	–	0.48	–	–
22.	α-terpinene	–	–	–	0.29	–	1.21
23.	DL-camphor	–	–	–	–	0.59	–
24.	Sabinene	–	–	–	–	–	9.21
25.	Isobornyl acetate	–	–	–	–	–	0.71
26.	Terpinolene	–	–	–	–	–	0.65
27.	Camphene	–	–	–	–	–	0.31
28.	α-Thujene	–	–	–	–	–	0.22
29.	Not identified	5.77	3.79	4.37	3.84	1.40	4.90

In fruit samples of *P. lentiscus* var. chia, myrcene was the major component, but it does not exist in *P. atlantica*. Sabinene, on the other hand, was the major component for *P. atlantica* but this component was not determined in *P. lentiscus* fruit (Table-3).

TABLE-3
ESSENTIAL OIL COMPONENTS IN FRUITS

S. No.	Component	% Areas	
		P. lentiscus 5 leaflets	*P. atlantica*
		Ovacik	Fethiye
		Sample 1	Sample 2
1.	Myrcene	65.71	–
2.	Germacrene D	13.81	14.45
3.	β-Caryophyllene	1.24	0.34
4.	λ-Cadinene	3.03	–
5.	Germacrene B	1.82	16.27
6.	Limonene	5.42	3.82
7.	α-Humulene	1.41	–
8.	Ocymene	–	14.60
9.	Terpinene-4-ol	–	4.81
10.	α-Amorphene	1.19	–
11.	α-Pinene	0.78	4.05
12.	Terpineol	1.29	2.00
13.	Aromadendrene	0.63	–
14.	α-Copaene	0.59	–
15	β-Cubenene	–	–
16.	Gamma terpinene	–	2.06
17.	(+)-2-Carene	0.49	–
18.	Muurolol	–	–
19.	β-Phellandrene	–	–
20.	Borneol	1.52	1.70
21.	δ-3-Carene	–	–
22.	α-Terpinene	–	1.26
23.	DL-camphor	1.01	–
24.	Sabinene	–	24.09
25.	Isobornyl acetate	–	0.92
26.	Terpinolene	–	–
27.	Camphene	–	0.49
28.	α-Thujene	–	0.62
29.	(+)-Camphene	–	1.24
30.	Not identified	0.02	7.25

In order to have very useful species from this valuable species, some short or long term practices may be recommended. The recommendation for the short term is to prune *P. lentiscus* plants which develop naturally in bush forms in the Aegean-Mediterranean coast belts and to transform them into the form of a tree. Through this practice, secretion of mastic will start producing within 3–4 years. *P.*

atlantica which is common in the region can be utilized as a rootstock and a cultivated form of *P. lentiscus* can be grafted and it will be able to secrete mastic within 3–4 years.

In the long term, a new orchard may be established with saplings of the cultivated form of *P. lentiscus*. Under these conditions the start of mastic production may take 8–10 years. The orchard may be a closed area or in the form of boundary trees. It is possible to use mastic plants in landscaping since it is well adapted to the Mediterranean climate and soil conditions and demonstrates a good development. The mastic trees may create an attractive arrangement in the coastal areas affected by the sea and on slopes, with its decorative form. In addition to these properties, being evergreen and having the covering property, *P. lentiscus* may be used to prevent rain and wind erosion. Due to its long life span and a wide crown structure, *P. atlantica* may be used in landscaping as well. Because of all these reasons, they may contribute to the ecological balance. Besides, varieties of *P. lentiscus,* naturally found as bushes, need to be kept under protection in order to save the existing genetic resources.

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