Original scientific paper
UDC 665.52:615.272

ANTIOXIDANT ACTIVITY AND COMPOSITION OF ESSENTIAL OILS OF FIVE AROMATIC AND MEDICINAL PLANTS FROM ALBANIA

Entela Hodaj[1,2], Olga Tsiftsoglou[2], Diamanto Lazari[2*], Erjon Mamoci[3], Dimitra Hadjipavlou-Litina[4]

[1]Department of Industrial Chemistry, Faculty of Natural Sciences, University of Tirana, Bld. ZOG I, 1001 Tirana, Albania
[2]Laboratory of Pharmacognosy, School of Pharmacy, Faculty of Health Sciences, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, Greece
[3]Faculty of Biotechnology and Food, Agricultural University of Tirana, Koder-Kamz, 1001 Tirana, Albania
[4]Department of Pharmaceutical Chemistry, School of Pharmacy, Faculty of Health Sciences, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, Greece

[*]e-mail: dlazari@pharm.auth.gr

Abstract

Antioxidant activity and composition of the volatile oils of five species from Albania, namely *Juniperus communis, Laurus nobilis, Origanum vulgare, Salvia officinalis* and *Satureja montana*, have been investigated.

The essential oils were purchased from Xherdo Co. Ltd, Albania, and their analyses were performed by gas chromatography-mass spectroscopy (GC-MS). Identification of the compounds was made by comparison of mass spectra and retention indices with literature records.

Analyses of the oils resulted in the identification of 105 compounds. The major resulted compounds were: in *J. communis*: α-pinene (35.8%), β-myrcene (19.9%), sabinene (10.0%); in *L. nobilis*: eucalyptol (48.2%) and sabinene (10.4%); in *O. vulgare*: carvacrol (72.2%) and p-cymene (12.0%); in *S. officinalis*: cis-thujone (27.8%), camphor (22.2%) and eucalyptol (11.3%) and in *S. montana*: thymol (47%) and p-cymene (8.4%). The essential oil of *O. vulgare* and *S. officinalis*, showed high anti-lipid peroxidation activity ranged from (92.64%) to (95.50%), whereas, the essential oil of *J. communis* did not present any effect. The essential oil of *L. nobilis* and *S. montana* presented lower activity. The tested samples *S. officinalis*, *L. nobilis*, *O. vulgare*, and *S. montana* significantly inhibit soybean lipoxygenase (69.76 - 94.23%), whereas the *J. communis* did not presented any inhibition.

Due to their excellent protective features exhibited in antioxidant activity tests, as well as interesting anti-inflammatory properties, the essential oils of *O. vulgare*, *S. officinalis* could be used as a natural source and find applications as "nutraceutical" and culinary herbs. Our results of the antioxidant activities are totally in agreement with the previously reported data of antioxidant activities of Albanian *S. officinalis* and the chemotypes with camphor predominating are highly recommended.

***Key words**: Essential oils, Antioxidant, Juniperus communis, Laurus nobilis, Origanum vulgare, Salvia officinalis, Satureja montana.*

1. Introduction

Medicinal plants present a rich source of new biologically active compounds. Especially popular today is the concept of food that combines nutritional and medicinal benefits. Essential oils (EOs) from aromatic and medicinal plants receive particular attention as potential natural agents with a wide spectrum of biological activities. EOs are proven to have various pharmacological effects, such as: spasmolytic, carminative, hepatoprotective, antiviral, and anticarcinogenic effects (Bowles [1], Lahlou [2]).

Antioxidants minimize oxidation of the lipid components in foods. There is an increasing interest in the use of natural and/or synthetic antioxidants in food preservation, but it is important to evaluate such compounds fully for both antioxidant and pro-oxidant properties. In our screening project for the search of antioxidative

agents from natural sources we evaluated the antioxidant activity of: *Juniperus communis*, *Laurus nobilis*, *Origanum vulgare, Salvia officinalis,* and *Satureja montana* essential oils.

J. communis L. (*Cupressaceae*) is a natural evergreen shrub or tree growing in dry uncultivated regions of Asia, Europe, North Africa and North America. For its diuretic, antiseptic and gastrointestinal properties (Stanić *et al.,* [3]) *J. communis* L. has been known as medicinal plant for centuries. Juniper oil is a natural product which is used in the pharmaceutical and food industries and perfumery, as well as in cosmetics. Certain spirits (gin) are made by distillation from fermented juniper berries (Morton *et al.,* [4], and Marsee *et al.,* [5]).

L. nobilis L. (bay) is an evergreen tree or shrub that belongs to the *Lauraceae* family and is cultivated in many temperate and warm parts of the world, particularly the Mediterranean countries of: Turkey, Greece, Spain, Portugal, Morocco, and in Mexico. *L. nobilis* L. is used as an aroma in the food and cosmetics industries. Dry fruits and dry leaves are used for adding fragrance to food and consumed as tea, respectively (Baytop [6]). The antimicrobial, analgesic, anti-inflammatory, anti-tumoral, acetylcholine esterase inhibiting properties of the *L. nobilis* L. essential oil have been reported (Sayyah *et al.,* [7], Ferreira *et al.,* [8], Soylu *et al.,* [9], and Loizzo *et al.,* [10]).

O. vulgare belongs to the *Lamiaceae* family, and is an important aromatic plant widely used in many countries for foods flavouring. Mexico, Greece, Israel, Albania, Morocco and Turkey are the main countries involved in production and export of oregano (Koksal *et al.,* [11]). Species of the genus *Origanum* are the most commonly used in the oregano commercial production. The oregano leaves and essential oil were used for centuries because of its medicinal properties, in particular for its positive effect on human health that has been attributed to the: antioxidant, antibacterial, antifungal, diaphoretic, antimicrobial carminative, antispasmodic and analgesic activities (Sahin *et al.,* [12], Faleira *et al.,* [13], Souza *et al.,* [14], Saraç *et al.,* [15], Coelo da Costa *et al.,* [16], and Tommasi *et al.,* [17]).

S. officinalis L. is the largest genus of the *Lamiaceae* family. It is native to Southern Europe, currently being successfully cultivated as a medicinal plant in Europe. Sage finds in Albania best culture conditions, especially on land, rocky and limestone, exposed to the sun, which maintains very well the colors and the fragrance in leaves. Since ancient times *S. officinalis* leaves have been widely applied in traditional medicine as herbal remedy for a wide range of disorders and illnesses by applying it either internally or externally. It is employed as diuretic, tonic, menstruation's promoter, local styptic, antiseptic, anti-inflammatory, antifungal and spasmodic pain relief (Ioannides [18]).

S. montana L., commonly known as winter savory or mountain savory, belongs to the *Lamiaceae* family. It inhabits arid, sunny, and rocky regions. *S. montana* L. is native to the Mediterranean and is found throughout Europe, Russia, and Turkey (Oliviera *et al.,* [19]). It is frequently used as traditional medicinal herb (Skocibusic and Bezic [20]), spice for food, teas, and has biological properties that are related to the presence of its major EO chemical compounds carvacrol and p-cymene (Radonic and Milos, [21]) and thymol and carvacrol (Skocibusic and Bezic [20]).

2. Materials and Methods

2.1 Chemicals

Five EOs from Albania were used in this study, and all of them were purchased as commercial samples from Xherdo Co. Ltd, Albania. 1,1-Diphenyl 2-picryl hydrazyl (DPPH), lipoxygenase (1.13.11.12) type I-B (Soybean) and linoleic acid (sodium salt), 99% purity, were purchased from Sigma (St Louis. MO, USA). Nordihydroguaiaretic acid (NDGA), butyl hydroxytoluene (BHT) and caffeic acid were purchased from Merck. All other chemicals were of analytical grade. A Perkin Elmer Lambda 20 UV-Vis spectrophotometer has been used for the radical scavenging activity experiments.

2.2 Gas chromatography-mass spectrometry

Essential oil analyses were performed on a Shimadzu GC-2010-GCMS-QP2010 system operating at 70eV. This was equipped with a split/splitless injector (230 ^{0}C) and a fused silica HP-5 MS capillary column (30 m x 0.25 mm i.d., film thickness 0.25 µm). The temperature program was from 50 ^{0}C to 290 ^{0}C, at a rate of 4 ^{0}C/min. Helium was used as a carrier gas at a flow rate of 1.0 mL/min. Injection volume of each sample was 1.0 µL. Arithmetic indices for all compounds were determined according to Van den Dool and Kratz (Van den Dool and Kratz [22]), using n-alkanes as standards. The identification of the components was based on comparison of their mass spectra with those of NIST21 and NIST107 (Massada [23]), and by comparison of their retention indices with literature data (Adams [24]). Essential oils were often subjected to co-chromatography with authentic compounds (Fluka, Sigma).

2.3 Inhibition of linoleic acid lipid peroxidation

Production of conjugated diene hydroperoxide by oxidation of linoleic acid in an aqueous dispersion is monitored at 234 nm in the presence of 2,2'-Azo-bis(2-amidinopropane) dihydrochloride (AAPH) of 50 µL of 40 mM AAPH solution as a free radical initiator in 0.05 M phosphate buffer, pH 7.4. Oxidation was carried out in the presence of the tested samples (10 µL/10 mg/mL stock solution). The rate of oxidation at room

temperature was monitored by recording the increase in absorption at 234 nm caused by conjugated diene hydroperoxides. Trolox was used as a reference drug.

2.4 Soybean lipoxygenase inhibition study *in vitro*

The tested samples dissolved in DMSO (10 mg/mL stock solution) were incubated 10 µL at room temperature with sodium linoleate (0.1 mM) and 0.2 mL of enzyme solution (1/9 x 10^{-4} w/v in saline) in tris buffer pH 9. The conversion of sodium linoleate to 13-hydroperoxylinoleic acid was recorded at 234 nm compared with the appropriate standard inhibitor (caffeic acid).

2.5 Interaction with DPPH

To a solution of DPPH (0.1 mM in methanol) the tested samples dissolved in DMSO (10 mg/mL stock solution) were added (10 µL). After 20/60 min. the antioxidant activity is recorded at 517 nm and the percentage of reducing activity (RA) was calculated and compared to the reference compound NDGA (nordihydroguaiaretic acid).

3. Results and Discussion

The results obtained by chemical analysis of *Salvia officinalis* L., *Juniperus communis* L., *Laurus nobilus* L., *Satureja montana* L., and *Origanum vulgare* EOs are presented in Table 1.

S. officinalis oil is composed mainly of oxygenated monoterpene (54.5%) and monoterpene hydrocarbons (29.1%). The main constituents of *Salvia officinalis* L. are: α-thujone (27.8%), camphor (22.2%), eucalyptol (11.3%) and α-caryophellene (6.5%). *Salvia* from different European countries has been analysed and: α-thujone, camphor, β-thujone and eucalyptol were found as major constituents in most of the essential oil analysed. Schmiderer and colleagues analysed many different samples of *S. officinalis* originated from south to northern of Albania. They reported the main constituents of sage EO from the north the following: α-thujone (14.8 - 26.3%), camphor (13.1 - 23.8%), eucalyptol (8.2 - 13.4%) and α-caryophyllene (4.3 - 12.2%); and from the south: camphor (13.9 - 38.8%), eucalyptol (2.3 - 38.7%), α-thujone (1.1 - 17.5%), α-caryophyllene (1.1 - 8.9%) (Schmiderer *et al.,* [25]). Our results are more compatible with the northern sage essential oil analysis, which makes us believe that *S. officinalis* used by the industry was originated from northern Albania.

S. montana L. is composed mainly of oxygenated monoterpenes (66.9%) and monoterpene hydrocarbons (16.5%). The principal constituents were: thymol (47.0%), p-cymene (8.4%), γ-terpinene (8.0%), and carvacrol methy ether (7.4%). Previously, Ibraliu (Ibraliu *et al.,* [26]) have reported only the main constituents of Albanian *S. montana* from different locations south and north Albania: carvacrol (21.5 - 56.8%, thymol (0.7 - 27.3%), γ-terpinene (5.3 - 13.1%) and p-cymene (0.7 - 16.2%).

L. nobilis is composed mainly of oxygenated monoterpenes (65.9%) and monoterpene hydrocarbons (18.6%). The major constituents of *L. nobilis* were: eucalyptol (48.2%), sabinene (10.4%), linalool (10.3%) and sabinene (10.4%). There are no data reported for the composition of essential oil from *L. nobils* from Albania. These results were partly similar to those reported before from *L. nobilis* composition of essential oil mainly in the absence of high amounts of β-ocimene (Kilic *et al.,* [27]).

O. vulgare is mainly composed of oxygenated monoterpenes (89.6%). The principal constituents were: carvacrol (72.2%) and p-cymene (12.0%). Previously, the major compounds of *O. vulgare* (carvacrol and thymol) and *O. vulgare* subps. *hirtum* (thymol 29.4 - 39.9%, carvacrol (2.4 - 77.8%, γ-terpinene 8.2 - 11.0%, p-cymene 8.1 - 10% have been reported by Papajani (Papajani *et al.,* [28]) and Ibraliu (Ibraliu *et al.*, [26]), respectively. We can assume that *O. vulgare* we analysed is carvacrol chemotype differing from the reported Albanian *O. vulgare*.

J. communis L. is composed mainly of monoterpene (71.8%) and sesquiterpene hydrocarbons (18.7%). The main constituents of *J. communis* were: α-pinene (35.8%), β-myrcene (19.9%), sabinene (10.0%) and germacene D (4.5%). There were no data reported for the composition of essential oil from *J. communis* from Albania. Our results are in agreement with samples from Greece (Chatzopoulou and Katsiotis [29]), Serbia (Matović *et al.,* [30]), Bulgaria (Höferl *et al.,* [31]) and Kosovo (Harizi *et al.,* [32]) with major components being α-pinene (27 - 51.4%), β-myrcene (8.3 - 14.1%) and sabinene (5.8 - 13.3%).

The antioxidant activities of *Juniperus communis*, *Laurus nobilis*, *Origanum vulgare, Salvia officinalis,* and *Satureja montana* essential oils have been evaluated (Table 2). The essential oil of *O. vulgare* is presenting the highest interaction with the stable radical DPPH, followed by essential oil of *L. nobilis*. For all these samples the reducing activity is increased by the time e.g. it enhances after 20 min. of interaction and it is higher after 60 min. It is time dependent with the exception of essential oil of *S. montana* which presents higher interaction at 20 min. and lower after 60 min. The other samples *O. vulgare* and *J. communis* showed lower reducing ability.

The essential oil of *O. vulgare* and *S. officinalis*, showed high anti-lipid peroxidation activity ranged from 92.64 to 95.50%, whereas, the essential oil of *J. communis* did not present any effect. The essential oil of *L. nobilis* and *S. montana* presented lower activity.

The tested samples *S. officinalis*, *L. nobilis*, *O. vulgare* and *S. montana* significant inhibit soybean lipoxygenase (69.76 - 94.23%), whereas the *J. communis* did not present any inhibition.

Table 1. Composition of the essential oils of *J. communis* (JC), *L. nobilis* (LN), *O. vulgare* (OV), *S. officinalis* (SO), *S. montana* (SM)

Compounds[a]	AI[b]	JC	LN	OV	SO	SM	ID[c]
Tricyclene	919	tr	nd	nd	0.1	nd	AI, MS
α-Thujene	926	0.1	0.4	0.1	0.1	0.7	AI, MS
α-Pinene	931	35.8	5.0	0.8	2.9	0.8	AI, MS, Co-GC
Camphene	945	0.3	0.4	0.2	**5.0**	0.6	AI, MS
Thuja-2,4(10)-diene	952	tr	nd	nd	nd	nd	AI, MS
Sabinene	972	10.0	10.4	nd	nd	nd	AI, MS
β-Pinene	973	nd	nd	0.1	1.4	0.2	AI, MS, Co-GC
Octen-3-ol	983	nd	nd	nd	nd	0.5	AI, MS
β-Myrcene	992	19.9	0.9	1.1	0.7	1.6	AI, MS, Co-GC
α-Phellandrene	1003	0.1	0.4	0.1	tr	0.3	AI, MS
δ-2-Carene	1008	nd	nd	nd	nd	tr	AI, MS
δ-3-Carene	1015	0.5	0.3	nd	nd	1.9	AI, MS, Co-GC
α-Terpinene	1016	nd	0.5	1.1	0.1	nd	AI, MS
p-Cymene	1024	0.7	0.7	12.0	1.1	8.4	AI, MS, Co-GC
Limonene	1027	3.5	nd	nd	2.1	0.9	AI, MS
Sylvestrene	1027	nd	nd	0.5	nd	nd	AI, MS
Eucalyptol	1029	nd	48.2	0.2	11.3	0.4	AI, MS
trans-Ocimene	1040	nd	nd	nd	nd	0.8	AI, MS
cis-Ocimene	1050	nd	0.3	0.1	nd	0.2	AI, MS
γ-Terpinene	1059	1.0	1.0	4.6	0.2	8.0	AI, MS, Co-GC
cis-Sabinenehydrate	1067	nd	nd	nd	nd	0.9	AI, MS
Terpinolene	1087	1.0	0.3	0.2	0.1	0.3	AI, MS
trans-Sabinenehydrate	1098	nd	nd	nd	nd	0.1	AI, MS
Linalool	1101	0.1	10.3	0.1	0.4	0.5	AI, MS, Co-GC
α-Thujone	1104	nd	nd	0.1	27.8	0.1	AI, MS
β-Thujone	1116	nd	nd	nd	4.7	tr	AI, MS
cis-p-Menth-2-en-1-ol	1122	nd	nd	nd	nd	tr	AI, MS
α-Campholenal	1126	tr	nd	nd	nd	nd	AI, MS
trans-Pinocarveol	1138	tr	nd	nd	nd	nd	AI, MS
Camphor	1143	nd	nd	0.2	22.2	0.3	AI, MS
neo-3-Thujanol	1151	nd	nd	nd	tr	nd	AI, MS
trans-Pinocamphone	1160	nd	nd	nd	0.1	nd	AI, MS
Borneol	1164	tr	tr	0.4	3.3	2.4	AI, MS, Co-GC
δ-Terpineol	1169	nd	0.2	nd	tr	tr	AI, MS
Terpinene-4-ol	1176	2.2	2.6	0.9	0.4	1.8	AI, MS, Co-GC
p-Cymen-8-ol	1187	0.1	nd	nd	nd	tr	AI, MS
α-Terpineol	1191	0.3	1.9	0.1	0.1	0.4	AI, MS
Myrtenol	1196	nd	nd	nd	tr	nd	AI, MS
trans-dihydro Carvanone	1197	nd	nd	0.1	nd	nd	AI, MS
Citronellol	1232	tr	nd	nd	nd	nd	AI, MS
Thymol methyl ether	1236	nd	nd	nd	nd	0.4	AI, MS
Carvacrol methyl ether	1244	nd	nd	0.3	nd	7.4	AI, MS
Linalool acetate	1258	nd	0.1	nd	nd	nd	AI, MS
Bornyl acetate	1286	0.3	0.4	nd	2.4	0.2	AI, MS, Co-GC
Thymol	1294	nd	nd	1.4	nd	47.0	AI, MS, Co-GC
(Z)-Sabinyl acetate	1296	nd	nd	nd	0.2	nd	AI, MS
Undecanone	1297	tr	nd	nd	nd	nd	AI, MS
Carvacrol	1304	nd	nd	72.2	tr	3.7	AI, MS
δ-Terpinyl acetate	1318	nd	0.5	nd	nd	nd	AI, MS
α-Cubebene	1349	0.7	nd	nd	nd	nd	AI, MS
α-Terpinyl acetate	1350	nd	9.8	nd	tr	nd	AI, MS
Thymyl acetate	1356	nd	nd	nd	nd	0.5	AI, MS

Citronellyl acetate	1357	tr	nd	nd	nd	nd	AI, MS
Eugenol	1362	nd	0.4	nd	nd	nd	AI, MS
Neryl acetate	1368	nd	0.1	nd	nd	nd	AI, MS
α-Ylangene	1371	tr	tr	tr	tr	nd	AI, MS
α-Copaene	1375	0.9	nd	nd	nd	0.1	AI, MS
β-Burbonene	1384	nd	nd	nd	nd	0.2	AI, MS
Geranyl acetate	1387	nd	nd	nd	nd	0.2	AI, MS
β-Elemene	1392	1.5	0.5	nd	nd	nd	AI, MS
Sibirene	1401	0.2	nd	nd	nd	nd	AI, MS
Methyl eugenol	1407	nd	2.5	nd	nd	nd	AI, MS
α-Gurjunene	1409	nd	nd	nd	nd	tr	AI, MS
β-Caryophyllene	1419	2.0	0.8	1.8	3.8	3.4	AI, MS, Co-GC
β-Copaene	1428	0.1	nd	nd	nd	0.1	AI, MS
γ-Elemene	1434	0.5	nd	nd	nd	tr	AI, MS
Aromadendrene	1438	tr	nd	nd	0.1	0.8	AI, MS
Myltayl-4(12)-ene	1443	nd	nd	nd	nd	tr	AI, MS
Cis-Muurola-3,5-diene	1450	tr	nd	nd	nd	nd	AI, MS
α-Carryophyllene	1453	1.7	nd	0.2	6.5	0.2	AI, MS, Co-GC
(E)-β-Farnesene	1458	0.8	nd	nd	nd	nd	AI, MS
Allo-Aromadendrene	1460	nd	nd	nd	tr	0.1	AI, MS
cis-Muurola-4(14),5-diene	1463	tr	nd	nd	nd	nd	AI, MS
trans-Cadina-1 (6), 4-diene	1473	0.1	nd	nd	nd	nd	AI, MS
Dauca-5,8-diene	1474	nd	nd	nd	nd	tr	AI, MS
γ-Muurolene	1477	1.0	nd	nd	0.1	0.3	AI, MS
Germacrene D	1481	4.5	nd	nd	nd	nd	AI, MS
β-Selinene	1486	0.4	tr	nd	nd	tr	AI, MS
δ-Selinene	1488	nd	nd	nd	nd	tr	AI, MS
trans-Muurola-4(14),5-diene	1492	0.1	nd	nd	nd	nd	AI, MS
Viridiflorene	1495	0.9	0.3	nd	0.2	0.7	AI, MS
α-Muurolene	1500	0.7	nd	nd	nd	0.1	AI, MS
β-Bisabolene	1508	nd	nd	0.5	nd	nd	AI, MS
δ-Amorphene	1510	0.1	nd	nd	nd	nd	AI, MS
γ-Cadinene	1514	1.0	tr	nd	nd	0.2	AI, MS
δ-Cadinene	1524	2.9	0.2	0.1	0.1	0.5	AI, MS
α-Cadinene	1538	0.2	nd	nd	nd	tr	AI, MS
Selina-3,7(11)-diene	1541	0.2	nd	nd	nd	nd	AI, MS
Germacrene B	1557	1.3	nd	nd	nd	nd	AI, MS
β-Calacorene	1564	tr	nd	nd	nd	nd	AI, MS
Spathulenol	1578	0.1	nd	nd	nd	0.2	AI, MS
Carryophyllene oxide	1583	tr	0.1	0.1	tr	0.3	AI, MS, Co-GC
Viridiflorol	1592	nd	nd	nd	1.3	nd	AI, MS
Humulene epoxide II	1610	tr	nd	nd	0.3	nd	AI, MS
1-*epi*-Cubenol	1629	tr	nd	nd	nd	nd	AI, MS
α-Muurolol (Torreyol)	1643	0.1	nd	nd	nd	nd	AI, MS
Cubenol	1648	t	nd	nd	nd	nd	AI, MS
α-Cadinol	1656	0.1	nd	nd	nd	nd	AI, MS
Total		**98.2**	**99.3**	**99.6**	**98.1**	**98.2**	
Monoterpene Hydrocarbons		71.8	18.6	5.8	29.1	16.5	
Oxygenated Monoterpenes		3.8	65.9	89.6	54.5	66.9	
Sesquiterpene Hydrocarbons		18.7	1.3	2.6	10.4	6.7	
Oxygenated Sesquiterpenes		0.3	0.1	0.1	-	0.5	

[a]Compounds listed in order of elution from an HP-5 MS capillary column; [b]AI: Arithmetic indices as determined on a HP-5 MS capillary column using a homologous series of n-alkanes (C9-C23); [c]Identification method: AI = Arithmetic Index, MS = Mass Spectrum, Co-GC = Coinjection with authentic compound. Concentrations below 0.05% are marked as tr (traces).

Table 2. Percentage (%) interaction of essential oils with DPPH, their% soybean LOX inhibitory activity and their% Inhibition of lipid peroxidation

Essential Oil	% Interaction with the stable free radical of DPPH		% Inhibition of LOX	% Inhibition of lipid peroxidation
Time	20 min.	60 min.		
Concentration	10 µL	10 µL	10 µL	10µL
J. communis	2.18	37.54	-	-
L. nobilis	24.73	57.19	69.76	23.11
O. vulgare	21.09	67.72	94.23	95.50
S. officinalis	28.73	28.77	90.05	92.64
S. montana	56.00	39.65	82.23	39.92
NDGA	81			
TROLOX			73	
CA				IC50 = 600 µM

4. Conclusions

- The present study showed that due to the diversity and complexity of the essential oils of the above herbs, it is rather difficult to compare their antioxidant activities. There are also some antioxidant activities in herbs that may be attributable to synergistic interactions.

- It is well known that free radicals play an important role in the inflammatory process. Consequently, herbs with antioxidant/scavenging properties could be expected to offer protection in rheumatoid arthritis and inflammation. Due to their excellent protective features exhibited in antioxidant activity tests, as well as interesting anti-inflammatory properties (LOX inhibition) the essential oils of *O. vulgare*, *S. officinalis* could be used as a natural source and find applications as "nutraceutical" and culinary herbs.

- Our results of the antioxidant activities are totally in agreement with the previously reported data of antioxidant activities of Albanian *S. officinalis* and the chemotypes with camphor predominating are highly recommended (Tosun *et al.,* [33]).

Acknowledgement

The authors are grateful to Xherdo Co. Ltd, Albania for providing the essential oils.

5. References

[1] Bowles E. J. (2004). *The Chemistry of Aromatherapeutic oils* (Third Ed.). Crows Nest, NSW, Allen & Unwin Academic, New South Wales, Australia.

[2] Lahlou M. (2004). *Essential oils and fragrance compounds: bioactivity and mechanisms of action*. Flavour and Fragrance Journal, 19, pp. 159-165.

[3] Stanić G., Samarzija I., and Blazevic N. (1998). *Time-dependent diuretic response in rats treated with juniper berry preparations*. Phytotherapy Research, 12, pp. 494-497.

[4] Morton D., and Mac Leod A. J. (Eds.). (1986). *Food Flavours. Part B. The Flavour of Beverages*. Elsevier, Amsterdam, Oxford, New-York, Tokyo, Netherlands, pp. 239.

[5] Maarse H. (1991). *Volatile compounds in Foods and Beverages*. Marcel Dekker, New York, USA, pp. 329-340.

[6] Baytop T. (2000) *Therapy with medicinal plants in turkey (past and present)*. Nobel Tıp Press, Istanbul, Turkey, pp. 13-31.

[7] Sayyah M., Saroukhani G., Peirovi A., and Kamalinejad M. (2003). *Analgesic and anti-inflammatory activity of the leaf essential oil of Laurus nobilis* Linn. Phytotheraphy Research, 17 pp. 733-736.

[8] Ferreira A., Proença C., Serralheiro M. L., and Araújo M. E. (2006). *The in-vitro screening for acetylcholinesterase inhibition and antioxidant activity of medicinal plants from Portugal*. Journal of Ethnopharmacology, 108, pp. 31-37.

[9] Soylu E. M., Soylu S., and Kurt S. (2006). *Antimicrobial activities of the essential oils of various plants against tomato late blight disease agent Phytophthora infestans*. Mycopathologia, 161, pp. 119-128.

[10] Loizzo M. R., Tundis R., Menichini F., Saab A. M., Statti G. A., and Menichini F. (2007). *Cytotoxic activity of essential oils from Labiatae and Lauraceae families against in-vitro human tumor models*. Anticancer Research, 27, pp. 3293-3299.

[11] Koksal O., Gunes, E., Ozer, O. O., and Ozden M. (2010). *Analysis of effective factors on information sources at Turkish oregano farm*. African Journal of Agricultural Research, 5, pp. 142-149.

[12] Sahin F., Gulluce M., Daferera, D., Sokmen A., Polissiou M., and Agar G. (2004). *Biological activities of the essential oils and methanol extract of Origanum vulgare subsp. vulgare in the Eastern Anatolia Region of Turkey.* Food Control, 15, pp. 549-557.

[13] Faleiro L., Miguel G., Gomes S., Costa L., Venâncio F., Teixeira A., Figueiredo C., Barroso J. G., and Pedro L. G. (2005). *Antibacterial and antioxidant activities of essential oils isolated from Thymbra capitata L. (Cav.) and Origanum vulgare* L. Journal of Agricultural and Food Chemistry, 53, pp. 8162-8168.

[14] Souza E. L., Stamford T. L. M., Lima, E. O., and Trajano V. N. (2007*). Effectiveness of Origanum vulgare L. essential oil to inhibit the growth of food spoiling yeasts.* Food Control, 18, pp. 409-413.

[15] Saraç N., Uğur, A., Duru, M. E., and Varol, Ö. (2009). *Antimicrobial activity, antioxidant activity and chemical composition of Origanum onites L. and Origanum vulgare L. subsp. hirtum (Link) letswaart from Mugla (Turkey).* Acta Horticica, 826, pp. 397-403.

[16] Coelho da Costa A., Cavalcanti dos Santos B. E., Santos F. L., and Lima E. O. (2009). *Antibacterial activity of the essential oil of Origanum vulgare L. (Lamiaceae) against bacterial multiresistant strains isolated from nosocomial patients*. Rev. Bras. Farmacogn., 19, pp. 236-241.

[17] Tommasi L., Negro C., Miceli A., and Mazzotta F. (2009). *Antimicrobial activity of essential oils from aromatic plants grown in the Mediterranean area*. Journal of Essential Oils Research, 21, pp. 185-189.

[18] [18] Ioannide C. (2002). *Pharmacokinetic interactions between herbal remedies and medicinal drugs*. Xenobiotica, 32, (6), pp. 451-478.

[19] Oliveira T. L., Soares R. A., Ramos E. M., Cardoso M. G., Alves E., and Piccoli R. H. (2011). *Antimicrobial activity of Satureja montana L. essential oil against Clostridium perfringens type A inoculated in mortadella-type sausages formulated with different levels of sodium nitrite*. International Journal of Food Microbiology, (144), 3, pp. 546-555.

[20] Skocibusic M., Bezic N. (2004*). Phytochemical analysis and in vitro antimicrobial activity of two Satureja species essential oils.* Phytotherapy Research 18, pp. 967–970.

[21] Radonic A., Milos M. (2003). *Chemical Composition and In Vitro Evaluation of Antioxidant Effect of Free Volatile Compounds From Satureja montana* L. Free Radical Research, (37), 6, pp. 673-679.

[22] Van den Dool H., Kratz P. D. (1963). *A generalization of the retention index system including linear temperature programmed gas—liquid partition chromatography*. Journal of Chromatography A, 11, pp. 463-471.

[23] Massada Y. (1976). *Analysis of Essential Oils by Gas Chromatography and Mass Spectrometry*. John Wiley & Sons, New York, USA.

[24] Adams R. P. (2007). *Identification of Essential Oil Components by Gas Chromatography/Mass Spectrometry* (Forth Ed.). Allured Publishing Corporation, Carol Stream, IL, USA.

[25] Schmiderer C., Torres-Londoño P., and Novak J. (2013). *Proof of geographical origin of Albanian sage by essential oil analysis*. Biochemical Systematics and Ecology, 51, pp.70-77.

[26] Ibraliu A., Mi X., Ristić M., Dajic-Stefanovic Z., Shehu J. (2011). *Analysis of essential oils of three wild medicinal plants in Albania.* Journal of Medicinal Plants Research, 5, (1), pp. 58-62.

[27] Kilic A., Hafizioglu H., Kollmannsberger H., and Nitz S. (2004). *Volatile constituents and key odorants in leaves, buds, flowers, and fruits of Laurus nobilis* L. Journal of Agricultural and Food Chemistry, 52, pp. 1601-1608.

[28] Papajani V., Haloci E., Goci E., Shkreli R., and Manfredini S. (2015). *Evaluation of antifungal activity of origanum vulgare and rosmarinus officinalis essential oil before and after inclusion in β-cyclodextrine*. International Journal of Pharmacy and Pharmaceutical Sciences, 7, (5), pp. 270-273.

[29] Chatzopoulou P., and Katsiotis. S. (2006). *Headspace analysis of the volatile constituents from Juniperus communis L. 'berries' (cones) grown wild in Greece.* Flavour and fragrance Journal, 21, pp. 492-496.

[30] Matović M., Bojović B., Jusković M. (2011). *Composition of essential oils from three classes of juniper fruit from Serbia*. Journal of Medicinal Plants Research, 5, (26), pp. 6160-6163.

[31] Höferl M., Stoilova I., Schmidt E., Wanner J., Jirovetz L. Trifonova D., Krastev L. and Krastanov A. (2014). *Chemical composition and antioxidant properties of juniper berry (Juniperus communis L.) essential oil. Action of the essential oil on the antioxidant protection of Saccharomyces cerevisiae model organism.* Antioxidants, 3, pp. 81-98.

[32] Haziri A., Faiku F., Mehmeti A., Govori S., Abazi S., Daci M., Haziri M., Bytyqi-Damoni A., Mele A. (2013). *Antimicrobial properties of the essential oil of Juniperus communis (L.) growing wild in Kosovo*. American Journal of Pharmacology and Toxicology, 8, (3), pp. 128-133.

[33] Tosun A., Khan S., Shik K. Y., Calín-Sánchez Á., Hysenaj Xh. and Carbonell-Barrachinan Á. A. (2014). *Essential Oil Composition and Anti-Inflammatory Activity of Salvia officinalis L (Lamiaceae) in Murin Macrophages.* Tropical Journal of Pharmaceutical Research, 13, (6), pp. 937-942.