

Chemical Composition and Antimicrobial Activity of Essential Oils of *Ocimum basilicum* var. *album* (L.) Benth, *Lavandula angustifolia* subsp. *Angustifolia*, *Melissa officinalis* Belonging to Lamiaceae Family

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Abstract: The present study was conducted to evaluate the chemical composition and antimicrobial activities of essential oils of *Ocimum basilicum* var. *album* (L.) Benth, *Lavandula angustifolia* subsp. *angustifolia*, *Melissa officinalis*. The chemical composition of a hydrodistilled essential oils of *Ocimum basilicum* var. *album* (L.) Benth., *Lavandula angustifolia* subsp. *angustifolia*, *Melissa officinalis* was analyzed by a GC/MS system. *Ocimum basilicum* var. *album* (L.) Benth essential oil contains 1,6-octadien-3-ol,3,7-dimethyl (53.79%), *Lavandula angustifolia* subsp. *angustifolia* essential oil 1,6-octadien-3-ol,3,7-dimethyl (42.07%), *Melissa officinalis* essential oil d-limonene (26%). Antimicrobial screening of the essential oils was made by disc diffusion. The antimicrobial test results showed that the *Ocimum basilicum* var. *album* (L.) Benth, *Melissa officinalis*, *Lavandula angustifolia* subsp. *angustifolia* essential oils have great potential of antimicrobial activity against all three (*Staphylococcus aureus* (ATCC 6338) Gram positive, *Escherichia coli* (ATCC 10536), *Pseudomonas aeruginosa* (ATCC 15442) Gram negative bacteria), one fungi (*Aspergillus niger*), one yeast (*Candida albicans*) species tested.

Key words: Essential oil, GC/MS composition, antimicrobial activity.

1. Introduction

Essential oils are composed by secondary metabolites produced in various parts of aromatic plants [1]. Currently, approximately 3,000 essential oils are known, about 300 of which are commercially available [2]. They are colorless compounds that get a dark color over time owing to oxidation. They are a mixture of saturated and unsaturated hydrocarbons, alcohol, aldehydes, esters, ethers, ketones, oxides phenols and terpenes, producing characteristic odors [3, 4]. In pharmaceutical industry, the essential oils have been used because of its anticancer, antinociceptive, antiphlogistic, antiviral, antibacterial and antioxidant properties [5]. And they also have

other uses in food and cosmetic industry [6-8]. Lipophilic characteristic of the essential oils is very important in inhibiting the growth of pathogens [1].

Of the 9,000 plant species found in the natural flora of Turkey, 500 are used for medical purposes, and the vast majority of them grow naturally and only a few are cultivated. Basil (*Ocimum basilicum* L.), lavender (*Lavandula angustifolia* Mill.) and, melissa (*Melissa officinalis* L.) belong to Lamiaceae family and grow in Turkey [9]. The *O. basilicum* essential oils exhibit a wide and varying array of chemical compounds, depending on variations in chemotypes, leaf and flower colours, aroma and origin of the plants. The chief constituents include chavicol methyl ether or estragole, linalool and eugenol [10]. There is a long tradition of using basil as a medicinal plant in treating coughs, diarrhoea, worm infestations and kidney

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malfunctions [11]. Recent studies even suggest that basil oil displays great potential as a stress repressor [12], and it is also used as a component in drugs for leukaemia treatment [13]. Several *Lavandula* species are essential oil rich-plants showing high yield values. In food manufacturing, the essential oil of lavandin has been employed in flavoring beverages, ice cream, baked goods, and chewing gum [14]. Lavender oil contains linalool, linalyl acetate, levender, geraniol, tannin, flavonoids, and cineol, and has antimicrobial, antifungal, antibiotic, and antidepressant effects [15]. Medical authorities of ancient Greece and Rome mentioned topical *Melissa* as a treatment for wounds. The herb was later used orally as a treatment for influenza, insomnia, anxiety, depression, and nervous stomach [16]. *Melissa officinalis* is a well-known medicinal plant species used in perfumes, cosmetics, tea and food products in many countries, and has been reported to possess sedative, spasmolytic and antibacterial properties. Herbal essential oils generally contain a variety of volatile compounds, which may have medicinal properties. It has been reported that *M. officinalis* essential oil has antimicrobial, antioxidative and antitumor properties [17]. A study on *M. officinalis* showed that long-term oral administration of *M. officinalis* essential oil (at an effective dose of 0.04 mg/day) can suppress chemical hyperalgesia in diabetic rats [18].

This study aimed to extract basil (*Ocimum basilicum* var. *album* (L.) Benth), lavender (*Lavandula angustifolia* subsp. *angustifolia*), and melissa (*Melissa officinalis*) essential oils to identify its constituents the compounds from the oil using gas chromatography mass spectrometry (GC-MS) analysis and evaluate its the antimicrobial activity of the oils.

2. Materials and Methods

2.1 Plant Material

Ocimum basilicum var. *album* (L.) Benth plants were collected at the flowering stage from the Oltu valley in eastern Anatolia, Turkey, *Lavandula*

angustifolia subsp. *angustifolia*, *Melissa officinalis* plants were collected in southeast of Marmara sea, Bursa, Turkey. The taxonomic identification of plant materials was confirmed by a plant taxonomist, retired Prof. Dr. Hikmet Ozbek, in the Department of Plant Protect, Ataturk University, Erzurum, Turkey. Collected plant materials were dried in the shade, then separated from the stem of the plant.

2.2 Essential Oil Extraction Preparation

The aerial parts of the air-dried plants of basil (*Ocimum basilicum* var. *album* (L.) Benth), lavender (*Lavandula angustifolia* subsp. *angustifolia*), and Melissa (*Melissa officinalis*) were submitted for 4 h modified Clevenger collector apparatus. Obtained essential oil was dried over anhydrous sodium sulfate (Na_2SO_4) and stored at -4°C until tested and analyzed [9]. Qualitative and quantitative analyses of the oils were performed using GC/MS.

2.3 Test Organisms

A total of five organisms were tested on the antimicrobial activity. Namely *Staphylococcus aureus* (ATCC 6338) Gram positive, *Escherichia coli* (ATCC 10536) and *Pseudomonas aeruginosa* (ATCC 15442) are Gram negative, *Aspergillus nigeris* fungus, *Candida albicans* is a yeast.

2.4 Determination of Antimicrobial Activity of Essential Oil

The antimicrobial activity was tested out by disc diffusion method. Discs with 6 mm in diameter of Whatman No. 1 filter paper were used. Briefly, 100 μL suspension of individual test microorganism was spread homogenously on each plate of mannitol salt agar media. Each disc was soaked with 100 μL of pure essential oil and placed on the microbial lawn. Positive control experiments were carried out under similar condition by using ofloxacin for antibacterial activity and nystatin for antifungal activity. Negative control experiments were carried out by using sterile

water. The tests were repeated three times to ensure reliability. The plates were incubated at 37 °C for 24 h and the inhibition zones were checked [19].

2.5 GC-MS Analysis

The analysis of the essential oil was performed using a Thermo Finnigan Trace GC/TraceDSQ/A1300 equipped with an SGE-BPX5 MS capillary column (30 m × 0.25 mm id, 0.25 µm). For GC/MS detection an electron ionisation system with an ionisation energy of 70 eV was used. Helium was the carrier gas at a flow rate of 1 mL·min⁻¹. Injector and MS transfer line temperatures were set at 220 and 290 °C respectively. The column temperature was raised from 50 to 150 °C at a rate of 3 °C·min⁻¹, held isothermal for 10 min and finally raised to 250 °C at 10 °C·min⁻¹. Diluted samples (1:100 v/v in methylene chloride) of 1.0 µL were injected manually in splitless mode. The components were identified by comparison of their relative retention times and mass spectra with those of standards, Wiley 7N library data of the GC/MS system and literature data [19]. The results were also confirmed by comparison of the elution order of the compounds with their relative retention indices on non-polar phases reported in the literature [19].

3. Results

3.1 Antimicrobial Activity of Essential Oil

The essential oil exhibited antimicrobial activity against Gram negative, Gram positive, fungus and yeast. Discs (6 mm) containing 100 µL essential oil were subjected to five microbial strains individually. Among the tested microbial strains, strong inhibition effect was found against all of them.

3.2 Chemical Composition of Essential oil of *Ocimum basilicum* var. *album* (L.) Benth

The GC-MS analysis of the *Ocimum basilicum* var. *album* (L.) Benth essential oil led to identification of 48 different compounds. The total compounds percentage was 100%. 1,6-octadien-3-ol,3,7-dimethyl

(53.79%), 3-Allyl-6-methoxyphenol (12.57%), eucalyptol(1,8-cineole) (4.33%), α-murolol (3.87%) were major compounds (Table 1).

3.3 Chemical Composition of Essential Oil of *Melissa officinalis*

The GC-MS analysis of the *Melissa officinalis* essential oil leads to identification of 48 different compounds. The total compounds percentage was 100%: D-limonene (26.00%), citral (14.93%), neral (13.60%), caryophyllene oxide (11.45%), benzene,1-(1,5-dimethyl-4-hexenyl)-4-methyl (6.97%) were major compounds (Table 2).

3.4 Chemical Composition of Essential Oil of *Lavandula angustifolia* subsp. *angustifolia*

The GC-MS analysis of the *Lavandula angustifolia* L. essential oil led to identification of 48 different compounds. The total compounds percentage was 100%. 1,6-octadien-3-ol,3,7-dimethyl (42.07%), linalyl acetate (18.26%), camphor (5.89%), alpha-terpineol (4.83%), geranyl acetate (2.56%) were major compounds (Table 3).

4. Discussion

Table 1 lists the chemical composition of the essential oils of *Ocimum basilicum* var. *album* (L.) Benth. The major compound of *Ocimum basilicum* var. *album* (L.) Benth oil is 1,6-octadien-3-ol,3,7-dimethyl (53.79%). In addition to 3-Allyl-6-methoxyphenol (12.57%), eucalyptol (1,8-cineole) (4.33%), and α-murolol (3.87%) as major constituents. However, we found very low levels of bicyclo[3.1.1]hept-2-ene,2,6-dimethyl-6-(4-methyl-3-pentenyl)-, alfa-humulene, bicyclogermacrene: 1.72%, 1.02% and 0.85%, respectively. Ref. [10] reported that the content of essential oil in Egypt basil varieties was from 0.3 to 0.7%. Nineteen compounds, representing 96.7% of the total oil were identified. The main components were as follows: linalool (48.4%), 1,8-cineol (12.2%), eugenol (6.6%), methyl cinnamate

Table 1 Chemical composition of essential oil of *Ocimum basilicum* var. *album* (L.) Benth.

N	R. time	Compound	%
1	8.398	hex-2(E)-enal	0.08
2	11.744	alpha-pinene	0.33
3	12.345	camphene	0.15
4	13.458	sabinene	0.17
5	13.543	β-pinene	0.44
6	14.270	Myrcene	0.50
7	15.768	d-limonene	0.50
8	15.863	1,8-cineole (eucalyptol)	4.33
9	16.205	cis-ocimene	0.06
10	16.613	(E)-beta-ocimene	0.66
11	16.996	gamma-terpinene	0.06
12	17.707	linalool oxide	0.47
13	18.151	1,3,3-Trimethylbicyclo[2.2.1]heptan-2-ol	1.11
14	18.328	trans-linalool oxide	0.46
15	19.109	3,7-Dimethyl-1,6-octadien-3-ol	53.79
16	20.431	(+)-2-bornanone	2.28
17	22.436	1-methoxy-4-(2-propenyl)benzene	1.49
18	27.743	alfa-cubebene	0.09
19	28.185	3-Allyl-6-methoxyphenol	12.57
20	28.648	copaene	0.18
21	28.940	beta-bourbonene	0.26
22	29.172	beta-elemene	1.47
23	29.547	1,2-Dimethoxy-4-(2-methoxyethenyl)benzene	2.14
24	30.063	trans(beta)-caryophyllene	0.31
25	30.557	bicyclo[3.1.1]hept-2-ene,2,6-dimethyl-6-(4-methyl-3-pentenyl)-	1.72
26	30.658	alpha-guaiene	0.64
27	30.909	(+)-epi-bicyclosesquiphellandrene	0.11
28	31.155	alpha-humulene	1.02
29	31.434	(+)-epi-bicyclosesquiphellandrene	0.45
30	31.547	italicene	0.06
31	32.009	d-dermacrene	1.15
32	32.088	farneseneE-beta	0.18
33	32.166	beta-selinene (CAS)	0.16
34	32.483	bicyclogermacrene	0.85
35	32.759	azulene, 1,2,3,4,5,6,7,8-octahydro-1,4-dimethyl-7-(1-methylethenyl)-, (1S,4S,7R)-	1.08
36	33.018	naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)	2.09
37	33.258	naphthalene, 1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)-	0.48
38	33.693	naphthalene, 1,2,4a,5,8,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-	0.05
39	35.071	caryophyllene oxide	0.08
40	35.195	alloaromadendrene oxide	0.08
41	35.383	salvial-4(14)-en-1-one	0.06
42	35.839	12-oxabicyclo[9.1.0]dodeca-3,7-diene,1,5,5,8-tetramethyl	0.18
43	37.517	alfa-murolol	3.87
44	38.035	3-methyl-5-propyl-4-butylidene-cyclohex-2-ene-1-one	0.89
45	38.605	tetradecanal	0.07
46	42.028	phytone	0.08
47	44.982	n-hexadecanoic acid	0.16
48	49.122	9-octadecenoic acid	0.25

Table 2 Chemical composition of essential oil of *Melissa officinalis*.

N	R. time	Compound	%
1	11.740	α -pinene	0.58
2	13.453	Sabinene	1.10
3	14.126	6-methyl-5-hepten-2-one	2.22
4	14.275	Myrcene	0.41
5	15.911	d-limonene	26.00
6	18.563	3-methyl-2-(2-methyl-2-butenyl)-furan	0.27
7	18.758	z-citral	0.46
8	18.844	3,4,4-trimethyl-2-cyclopenten-1-one	0.24
9	19.944	7-Oxabicyclo[4.1.0]heptane,1-methyl-4-(1-methylethenyl)	0.21
10	20.127	(+)-E-limonene oxide	0.69
11	20.572	trans-chrysanthemal	0.37
12	20.724	Citronella	0.16
13	21.577	2-(2',3'-Epoxy-3'-methylbutyl)-3-methylfuran	0.75
14	21.847	Verbenol	0.81
15	22.325	(S)-(-)-(4-isopropenyl-1-cyclohexenyl)methanol	0.75
b16	22.452	santolina triene	0.33
17	24.115	Neral	13.60
18	24.480	Piperitone	0.21
19	25.197	Citral	14.93
20	28.197	neryl acetate	0.31
21	28.639	Copaene	0.86
22	28.848	geranyl acetate	2.37
23	28.941	β -bourbonene	0.67
24	29.838	1H-3a,7-methanoazulene,2,3,4,7,8,8a-hexahydro-3,6,8,8-tetramethyl	0.82
25	30.084	trans(β)-caryophyllene	0.92
26	31.150	α -humulene	0.33
27	31.377	Nealloocimene	0.92
28	31.707	geranyl propanoate	0.57
29	31.845	γ -cadinene	0.21
30	32.052	benzene,1-(1,5-dimethyl-4-hexenyl)-4-methyl	6.97
31	32.453	Bicyclogermacrene	0.17
32	32.793	β -bisabolene	0.15
33	32.886	α -cedrene	0.19
34	33.005	naphthalene,1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-	0.72
35	33.267	Deltacadinene	0.33
36	33.697	naphthalene,1,2,4a,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)	0.25
37	34.167	caryophyllene oxide	0.39
38	35.187	caryophyllene oxide	11.45
39	35.289	benzenebutanoic acid,2,5-dimethyl-,methyl ester	0.37
40	35.428	benzenebutanoic acid,2,5-dimethyl-,methyl ester	0.28
41	35.575	1H-Cycloprop[e]azulen-7-ol,decahydro-1,1,7-trimethyl-4-methylene	1.94
42	35.864	12-oxabicyclo[9.1.0]dodeca-3,7-diene,1,5,5,8-tetramethyl-	1.24
43	36.684	2,6-octadienoic acid,3,7-dimethyl-,methyl ester	0.27
44	37.110	1H-benzocyclohepten-7-ol,2,3,4,4a,5,6,7,8-octahydro-1,1,4a,7-tetramethyl-	0.15
45	42.029	Phytone	0.28
46	44.963	n-hexadecanoic acid	0.21
47	48.458	4-methyl-5-(3methyl-2-butenyl)-6-methyl-1-formyl-6-(4methyl-3-penten)	0.16
48	49.105	cis-vaccenic acid	0.44

Table 3 Chemical composition of essential oil of *Lavandula angustifolia* subsp. *angustifolia*.

N	R. time	Compound	%
1	7.412	hexane,1-methoxy-(CAS)	0.10
2	11.742	alpha-pinene	0.17
3	12.342	Camphene	0.24
4	13.456	Sabinene	0.05
5	14.086	beta-pinene	0.16
6	14.086	3-octanone (CAS)	0.64
7	14.280	Myrcene	1.30
8	14.923	herboxide second isomer	0.07
9	15.250	hexyl-ethanoate	0.86
10	15.590	para-cymene	0.06
11	15.770	cyclohexene,1-methyl-5-(1-methylethenyl)-	0.97
12	15.870	eucalyptol(1,8-cineole)	3.73
13	16.214	alfa-pinene	1.08
14	16.627	(E)-beta-ocimene	1.57
15	17.677	linalool oxide	2.11
16	18.178	alpha-terpinolene	0.33
17	18.325	trans-linalool oxide	1.64
18	19.113	1,6-octadien-3-ol,3,7-dimethyl	42.07
19	19.726	cyclobutanecarboxylic acid, octyl ester	0.13
20	19.847	Alloocimene (CAS)	0.06
21	20.478	Camphor	5.89
22	20.604	propanoic acid,2-methyl-,hexyl ester (CAS)	0.29
23	20.680	Lilac aldehyde B	0.06
24	20.814	2H-pyran,3,6-dihydro-4-methyl-2-(2-methyl-1-propenyl)	0.12
25	21.966	2-cyclohexen-1-one,4-(1-methylethyl)	0.17
26	22.254	hexyl-butyrate	2.01
27	22.535	alpha-terpineol	4.83
28	22.933	acetic acid,2-ethylhexyl ester (CAS)	1.33
29	23.270	gamma-terpinene	0.32
30	23.505	isobornyl formate	0.29
31	23.840	hexyl 2-methyl butyrate	0.24
32	23.920	benzaldehyde, 4-(1-methylethyl)	0.10
33	24.013	butanoate hexyl-,3-methyl-	0.29
34	24.678	linalyl acetate	18.26
35	25.046	Citral	0.07
36	25.597	endobornyl acetate	0.08
37	25.759	lavandulyl acetate	0.08
38	27.081	hexyl tglate	0.60
39	27.793	linalool	0.08
40	28.215	neryl acetate	1.42
41	28.810	geranyl acetate	2.56
42	30.070	trans-beta-caryophyllene	0.42
43	31.160	(E)-beta-farnesene	0.28
44	31.994	D-germacrene	0.13
45	32.784	neryl(S)-2-methylbutanoate	0.18
46	35.077	caryophyllene oxide	0.47
47	44.962	n-hexadecanoic acid	0.07
48	49.121	9-octadecenoic acid, E	0.27
			100

(6.2%), α -cubebene (5.7%), caryophyllene (2.5%), β -ocimene (2.1%) and α -farnesene (2.0%). The tested oil showed significant antifungal activity that was dependent on the used oil concentration. Differences in basil essential oil content between this study and another report from research conducted in Egypt could be due to differential environmental conditions Egypt and Turkey. It has been demonstrated that basil essential oil can vary depending on growth conditions [20]. In a study conducted in Australia, the morphological characteristics, yield and essential oil components of 5 different varieties of basil were investigated. Researchers have reported that plant length varies from 39 to 61 cm, single plant weights vary from 80 to 499 g, and total plant weights vary from 448 to 1,624 kg/d, and the components of the varieties are different according to the results of the gas chromatography analysis and that the main components of the essential oils are methyl chavicol, linalol, 1,8-sineol [21].

In another study, the chemical compositions of essential oils of the two types of basil grown in Turkey were examined. Essential oils of over-ground parts of plants were obtained and their components were determined by GC-MS.

Korucu [22] found that the highest amounts of essential oil components in fresh basil samples were linalol (16.67%-25.58%) and eugenol (7.31%-12.64%) while [23] found that lidenin was between 11.79%-30.07%, pilosin was between 1.99%-7.24%, genkwan was between 2.38%-5.16%, salvigen was between 2.29%-4.32%, cirsiliol was between 1.42%-26.01%, and apigenin was between 4.5%-5.35%. In one study, they found that the essential oil ratio of the basil flower varies between 0.13% and 1.23%, while essential oil content of its leaf varies between 0.18% and 1.70%. The main components of essential oil were methyl chavicol and eugenol [24].

In our study, we found that *S. aureus*, *E. coli*, *P. aeruginosa*, *A. niger* and *C. Albicans* are inhibited by

the essential oils of *O. basilicum* L. This can be explained by the fact that the oil acts on the bacterial membrane. Monoterpenes or sesquiterpene hydrocarbons and their oxygenated derivatives exhibit a potential antimicrobial activity [25]. Ref. [10] showed that compounds of *O. basilicum* essential oil such as linalool, 1,8-cineol, eugenol, methyl cinnamate and α -cubebene were among the main components present. The antimicrobial activity of an essential oil is attributed mainly to its major compounds. However, the synergistic and antagonistic effect of one compound in minor percentage in the mixture has to be considered. Some researchers reported that there is a relationship between the chemical structures of the most abundant compounds in the essential oils and the antimicrobial or antifungal activities [26].

Table 2 lists the chemical composition of the essential oils of *Melissa officinalis*. The major compound of *Melissa officinalis* oil is d-limonene (26.00%), following by citral (14.93%), neral (13.60%), caryophyllene oxide (11.45%), and benzene,1-(1,5-dimethyl-4-hexenyl)-4-methyl (6.97%). However, we found very low levels of 6-methyl-5-hepten-2-one, geranyl acetate, 1H-Cycloprop[e]azulen-7-ol, decahydro-1,1,7-trimethyl-4-methylene: 2.22%, 2.37% and 1.94%, respectively.

In the research of Ref. [27], (E)-citral (37.2%), neral (23.9%) and citronella (20.3%) have the highest percentages (81.4%) among the 14 components identified. *M. officinalis* L. has a strong lemon odour, which may be due in large part to (E)-citral. (E)-citral is not optically active and is a principal component of lemon grass oil. This compound has been utilized in perfumes, as a flavouring agent, and as an intermediate for other fragrances and vitamin A synthesis. The pure form of neral is a colourless liquid and has a rose-neroli odour.

This compound is utilized for perfumery and flavouring. Citronellal has both d- and l-isomers [27]. Biological and aromatic effects of the main and minor

compounds of the essential oil of *M. officinalis* L. have high importance in term of their possible use in medicine, cosmetics and foods [28].

The obtained essential oil is rich in monoterpenes and sesquiterpenes. The main compounds of volatile oil are citral (geranial, neral) and citronellal, giving the characteristic lemon odor to the oil. Other ingredients are benzoic acids (gallic acid, protocatechuic acid), flavonoids (apigenin, luteolin), triterpenes (ursolic acid, oleanolic acid) and phenylpropanoyl glycosides [29, 30]. Ref. [21] reported that thirty three components were identified representing 89.30% of the total oil in leaves composition. Six predominant components followed in the essential oils from *Melissa officinalis* were citronellal (14.40%), isogeraniol (6.40%), geraniol acetate (10.20%), nerolecetate (5.10%), caryophyllene (8.10%) and caryophyllene oxide (11.00%), representing 55.20% of the total oil [24]. However, the age of *Melissa officinalis* plant effected the concentration of other constituents and the proportions of the following compounds were subject to especially high fluctuations: citronellal (8.7% and 0.4%), geraniol (trace amounts and 0.6%), and geranyl acetate (0.5% and 3.0%), as well as, among others, isogeranial, E-caryophyllene oxide, germacrene D, and carvacrol [31].

In the essential oil of *Melissa officinalis* ssp *inodora*, sesquiterpenes such as alpha-kubeben, beta-cariophyllene and alpha-kadinol were found as main components [32].

Melissa officinalis plant has sedative, carminative, antimicrobial and topical antiviral effects. It is used internally for nervous sleep problems, anxiety, unrest, irritability and functional gastrointestinal disorders [33, 34]. Other study showed that *M. officinalis* essential oil has anti-bacterial, anti-fungal, anti-parasitic and anti-histaminic activities [35]. Thanks to its anti-microbial effect, it has a preventive effect on the growth of yeasts which cause the food degradation in the food industry [36].

In a study in German, N. Catariave *M. officinalis* essential oils have been researched for antibacterial activities against bacteria that affect the respiratory system and cause skin infections. The highest antibacterial activity in all the bacteria used belonged to *M. officinalis* essential oil. In particular, *M. officinalis* essential oil was found to be the most effective one against *Streptococcus pneumoniae* strain with the lowest MIC value [37].

In a study using disk diffusion method on essential oil obtained by hydrodistillation from the aerial parts of the plant, it was found that essential oil was effective against all gram positive and gram negative bacterial strains tested at different ratios and showed high antimicrobial activity especially on *Sigella sonnei* which is a very resistant bacterium and *E. coli* [38].

As seen in Table 3, the major compound of *Lavandula angustifolia* Mill. oil is 1,6-octadien-3-ol,3,7-dimethyl (42.07%). In addition to linalyl acetate (18.26%), camphor (5.89%), alpha-terpineol (4.83%), and eucalyptol (1,8-cineole) (3.73%) as major constituents. However, we found very low levels of geranyl acetate, linalool oxide, acetic acid, and 2-ethylhexyl ester (CAS): 2.56%, 2.11%, and 1.33%, respectively.

Results of other studies indicated that the essential oil of *lavandula* from Iranian contains 1,8-cineole (47.94%), borneol (26.14%), camphor (14.4%), while the essential oil *lavandula* from Romania contains camphor (32.7%) and eucalyptol (26.9%) [39]. In the other reports, linalool and linalyl acetate were the major components of the essential oil of Hungarian *lavandula* [40].

Essential oils of the *Lavandula* species (lavender) exhibit various biological activities, namely anti-microbial, antimutagenic, anti-inflammatory and analgesic properties [41]. Chemical components of plants are determined by a series of factors, including plant genetic, climate, edaphic, elevation, topography, and also by interaction of various factors [14].

The principal compound of the essential oil from *L.*

angustifolia (Croatia) is linalool (66.83%), while for the same species grown in France, this compound only represents 37.31% of the chemical composition of the oil, being curcuminol (41.32%) the major component. Moreover, the oil of the same *Lavandula* species (*L. angustifolia*) grown at high altitude in France also presents a great amount of linalool (23.49%), but with linalylformate (41.72%) being the most abundant compound. The main compounds of the other *Lavandula* species from Croatia (*L. officinalis*) are linalool (47.86%), linalyl formate (22.09%), and limonene (14.78%) [26]. Linalool and linalyl acetate have maximum and great absorbing properties from skin during massage with a depression of central nervous system. Linalool shows sedative effects and linalyl acetate shows marked narcotic actions. These two actions may be responsible for its use in lavender pillow anxiety patients with sleep disturbance pattern, improving the feeling of well being, supporting mental alertness and suppressing aggression and anxiety [42].

5. Conclusion

Most of the essential oils obtained from plants form terpene type compounds. Terpenoid type compounds are used in many fields such as medicines, cosmetics, perfumery, food because of their pleasant smells and their high biological activity. Similar studies have to be done and increased to find plants containing these compounds in high proportion.

Antimicrobial resistance in bacteria is increasing rapidly. In contrast, bacteria do not gain resistance to plant and plant products that show antimicrobial properties. The reason for this is that synthetically produced medicines are made by isolating any active substance in plants. Bacteria can neutralize medicines by creating resistant breeds against synthetic drugs containing a single structure in time.

On the other hand, since the active substances in plants are in a complex structure with other substances, it is difficult for bacteria to develop resistance against this structure. Therefore, as an alternative to

antibiotics, it may be appropriate to increase the number of researches for the use of plants and herbal products as traditional antibiotics. At the same time, the use of plants and herbal products is advantageous in this respect because of the higher number of side effects of synthetically derived materials. However, especially the more detailed results obtained by purely obtaining essential oil components or their main groups and testing them on microorganisms may be even more enlightening.

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