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## Essential Oil Composition of *Mentha longifolia* from Wild Populations Growing in Tajikistan

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**Keywords:** Carvone, *cis*-piperitone epoxide, horse mint, menthone, piperitenone oxide, pulegone, thymol, wild mint.

### ABSTRACT

*Mentha longifolia* selections, collected from three different sites in south-central Tajikistan, were analyzed to determine essential oil constituency. Essential oils were extracted by hydrodistillation of the plants and subsequently analyzed by gas chromatography – mass spectrometry. A total of 82 compounds were identified, representing 84.5-99.0% of total oil composition. Although qualitatively similar, the Tajikistan *M. longifolia* samples did show quantitative differences. The major components and their percentage of the oil were *cis*-piperitone epoxide (7.8-77.6%), piperitenone oxide (1.5-49.1%), carvone (0.0-21.5%), pulegone (0.3-5.4%), menthone (0.0-16.6%), thymol (1.5-4.2%),  $\beta$ -thujone (0.2-3.2%), carvacrol (0.0-2.7%), and (*E*)-caryophyllene (0.9-2.5%).

### INTRODUCTION

The mints, *Mentha* species belonging to the family Labiatae (Lamiaceae), are widely distributed in Eurasia, Australia, and South and North Africa (Gulluce *et al.*, 2007; Lange and Croteau, 1999). Various species of *Mentha* have been used as folk remedies for treatment of bronchitis, flatulence, anorexia, ulcerative colitis and liver complaints, due to their anti-inflammatory, carminative, antiemetic, diaphoretic, antispasmodic, analgesic, stimulant, emmenagogue, and anticatharral activities (Al-Bayati, 2009; Džamić *et al.*, 2010; Gulluce *et al.*, 2007; Hajlaoui *et al.*, 2010; Hussain, 2009; Mimica-Dukić

*et al.*, 1991; Mkaddem *et al.*, 2009; Oyedeji and Afolayan, 2006; Rasooli and Rezaei, 2002; Viljoen *et al.*, 2006). The active virtues of the mints depend on the abundant volatile oils that contain a wide variety of terpenes and terpenoids.

The mint species, *Mentha longifolia* (L.) Huds., has been commonly used as a kitchen and medicinal plant for centuries. Known as wild mint and horse mint, the plant can reach to 1.5 m high in favorable conditions. The plant has a strong aroma.

The objectives of this study were to analyze the composition of the oil of *Mentha longifolia* growing wild in different areas of Tajikistan. In this report, the essential oil compositions of five samples collected at three sites in south-central Tajikistan. To our knowledge, no previous reports on *M. longifolia* essential oil in this area have been made.

### MATERIALS AND METHODS

**Plant material.** Aerial parts of *M. longifolia* were collected from the three regions of Tajikistan. Samples numbered 1, 2, and 4 were gathered in the area of Korvon village, Dushanbe (38.506044N, 68.751535E, 800 m above sea level), on 25 April 2010. Sample number 3 was gathered in the area of Khonaobod village, Muminobod region (38.107547 N, 69.966431 E, 1200 m above sea level), on 7 May 2010, and sample number 5 was gathered in the Chormaghzak village area, Yovon region, (38.417502 N, 69.172175 E, 1300 m above sea level), on 25 July 2010. The plants were identified by F. S. Sharopov,

and a voucher specimens (TJ2010-031) have been deposited in the herbarium of the Chemistry Institute of the Tajikistan Academy of Sciences.

From the collected plant samples, 300 g of each were air dried, crushed into smaller pieces, and hydrodistilled for 3 h, producing yellow colored essential oils at a yield of 0.5-0.9%. The oils were dried over sulfuric acid and subsamples were taken for analysis of the oil constituents.

**Essential oil analysis.** The essential oils were analyzed using an Agilent 6890 gas chromatograph connected to an Agilent 5973 mass selective detector (EIMS, electron energy = 70 eV, scan range = 45-400 amu, and scan rate = 3.99 scans/s). A fused silica capillary column (HP-5 ms, 30 m × 0.25 mm) coated with 5% phenyl-polymethylsiloxane (0.25 μm phase thickness) was used in the gas chromatography, the carrier gas was helium with a flow rate of 1 mL/min, and the injection temperature was 200°C. The oven temperature was programmed to initially hold for 10 min at 40°C before ramping to 200°C at 3°C/min, and then to 220°C at 2°C/min. The interface temperature was 280°C.

A 1% w/v solution of each oil was prepared in CH<sub>2</sub>Cl<sub>2</sub> was prepared, and 1 μL of the samples was used in the analysis. The sample was injected into the gas chromatograph using a splitless injection. Identification of the oil components was based on their retention indices as determined by reference to a homologous series of *n*-alkanes (C<sub>9</sub>-C<sub>30</sub>), and by comparison of their mass spectral fragmentation patterns with those reported in the literature (Adams, 2007), and stored on the MS library [NIST database (G1036A revision D.01.00)/ChemStation data system (G1701CA, version C.00.01.080)]. The percentages of each essential oil component are reported as raw percentages based on total ion current without standardization.

**Numerical cluster analysis.** For comparison of the essential oil constituency, the 47 samples of *Mentha longifolia* were treated as operational taxonomic units (OTUs). The percentage of the 26 major essential oil components (carvone, piperitenone oxide, menthofuran, menthone, pulegone, *cis*-piperitone epoxide, 1,8-cineole, *trans*-piperitone epoxide, *cis*-carveol,

menthol, limonene, piperitone, (*E*)-caryophyllene, β-pinene, *trans*-dihydrocarvone, isomenthone, diosphenol, germacrene D, borneol, myrcene, α-pinene, piperitenone, rotundifolone, thymol, *cis*-dihydrocarvone, and menthyl acetate) were used to determine the chemical relationship between the different *M. longifolia* essential oil samples by cluster analysis using the NTSYSpC software, version 2.2 (Rohlf, 2005). Correlation was selected as a measure of similarity, and the unweighted pairgroup method with arithmetic average (UPGMA) was used for cluster definition.

## RESULTS

A total of 82 compounds were identified in the essential oils extracted from *M. longifolia* plants collected in Tajikistan (Table 1). The identified oil compounds represented 84.5-99.0% of the total oil compositions. The major components of Tajikistan *M. longifolia* oil were *cis*-piperitone epoxide (7.8-77.6%), piperitenone oxide (1.5-49.1%), carvone (0.0-21.5%), menthone (0.0-16.6%), thymol (1.5-4.2%), pulegone (0.3-5.4%), β-thujone (0.2-3.2%), (*E*)-caryophyllene (0.9-2.5%), myrcene (0.3-2.5%), carvacrol (0.0-2.7%), borneol (0.9-1.8%), and *p*-cymene (0.2-1.9%).

Although qualitatively similar, the Tajikistan *M. longifolia* oils showed notable quantitative differences. For example, *cis*-piperitone epoxide was relatively abundant in all samples, ranging from a low of 7.8% in sample #1 from Dushanbe to 77.6% in sample #5 from Yovon. Similarly, piperitenone oxide had the lowest concentration in the Yovon sample (1.5%), but highest in Dushanbe #1 (49.1%). Neither carvone nor menthone were detected in Yovon #5, but were both present in the other oil samples.

## DISCUSSION

*M. longifolia* essential oils from other geographical locations have been extensively studied. The species has demonstrated a great degree of morphological diversity (Gobert *et al.*, 2002), and the Missouri Botanical Garden lists some 276 subspecies, varieties, and forms (Missouri Botanical Garden, 2011).

Table 1. Chemical composition of *Mentha longifolia* essential oils from Tajikistan.

RI	Oil constituent <sup>1</sup>	Sample number					RI	Oil constituent	Sample number				
		1	2	3	4	5			1	2	3	4	5
		(% of total oil)							(% of total oil)				
854	(2E)-Hexenal	---	0.1	---	---	0.1	1243	Carvone	0.8	1.1	10.2	21.5	---
867	(2E)-Hexenol	---	0.1	---	---	---	1254	cis-Piperitone epoxide	7.8	27.1	25.0	23.1	77.6
907	Santolina triene	---	0.1	0.1	0.1	---	1262	cis-Chrysanthenyl acetate	---	---	---	0.5	---
935	$\alpha$ -Thujene	---	tr <sup>3</sup>	0.1	---	tr	1262	Unidentified	0.7	---	---	---	---
941	$\alpha$ -Pinene	0.1	0.2	0.1	0.2	0.4	1278	trans-Carvone oxide	---	---	0.1	---	---
953	Camphene	---	0.1	0.1	---	0.2	1286	Bornyl acetate	0.1	0.2	0.2	---	0.4
963	Benzaldehyde	---	tr	tr	---	---	1287	Dihydroedulan I	0.1	---	---	0.2	---
976	Sabinene	---	0.1	0.1	0.3	0.3	1292	Isothymol	0.4	---	0.3	---	---
978	$\beta$ -Pinene	---	0.1	0.1	0.2	0.6	1293	Thymol	4.2	1.5	3.1	3.5	3.0
981	1-Octen-3-ol	---	tr	0.1	---	---	1298	Diosphenol	---	---	---	0.1	0.7
992	Myrcene	0.8	2.2	1.9	2.5	0.3	1302	Unidentified	0.6	---	---	---	---
996	3-Octanol	0.2	0.6	0.5	0.7	0.9	1303	6-Hydroxy-6-isopropyl-3-methylcyclohex-2-enone	---	0.7	0.9	---	3.2
1004	$\alpha$ -Phellandrene	0.2	0.3	0.2	0.3	0.1	1305	Carvacrol	2.7	0.8	2.5	1.7	---
1016	$\alpha$ -Terpinene	0.1	0.1	0.1	0.1	0.1	1340	Piperitenone	0.6	0.3	0.3	0.4	---
1024	<i>p</i> -Cymene	0.6	1.6	1.8	1.9	0.2	1368	Piperitenone oxide	49.1	29.4	28.2	20.4	1.5
1028	Limonene	0.1	0.3	0.2	0.6	0.9	1386	$\beta$ -Bourbonene	---	0.1	0.2	0.2	---
1030	1,8-Cineole	0.2	0.4	0.4	0.5	0.2	1388	Unidentified	1.3	---	---	---	---
1036	Santolina alcohol	0.3	0.3	0.5	0.5	---	1392	4a- $\alpha$ ,7- $\beta$ ,7a- $\alpha$ -Nepetalactone	---	0.1	0.2	0.1	---
1038	(Z)- $\beta$ -Ocimene	---	---	---	---	0.1	1392	Unidentified	0.7	---	---	---	---
1043	Phenylacetaldehyde	---	tr	---	---	0.1	1394	$\beta$ -Elemene	---	0.1	---	---	---
1048	(E)- $\beta$ -Ocimene	---	tr	tr	---	---	1400	(Z)-Jasmone	---	0.1	0.1	---	---
1058	$\gamma$ -Terpinene	0.3	0.4	0.4	0.6	0.2	1419	(E)-Caryophyllene	1.4	2.1	1.7	2.5	0.9
1066	cis-Sabinene hydrate	---	---	0.1	---	---	1436	$\alpha$ -trans-Bergamotene	---	0.1	---	---	---
1088	Terpinolene	---	---	---	---	0.1	1441	Unidentified	6.4	0.3	---	---	---
1097	3-Nonanol	---	tr	---	---	0.1	1454	$\alpha$ -Humulene	0.2	0.2	0.2	0.2	---
1097	trans-Sabinene hydrate	---	---	0.1	---	---	1455	Unidentified	0.1	---	---	0.2	1.5
1100	Linalool	0.1	0.1	0.1	0.1	0.4	1458	(E)- $\beta$ -Farnesene	0.1	0.1	0.2	0.2	---
1105	$\alpha$ -Thujone	0.5	0.8	1.1	0.8	0.3	1462	Unidentified	0.5	---	---	---	---
1116	$\beta$ -Thujone	1.5	2.6	3.2	2.5	0.2	1475	Unidentified	0.8	0.2	0.1	0.2	---
1121	cis- <i>p</i> -Menth-2-en-1-ol	---	tr	0.1	---	---	1482	Germacrene D	0.3	0.6	0.3	0.7	0.1
1125	3-Octyl acetate	---	0.2	0.1	0.1	---	1487	(E)- $\beta$ -Ionone	---	---	0.1	---	---
1144	Camphor	---	0.1	0.1	---	0.2	1497	Bicyclogermacrene	---	0.1	---	---	---
1152	Menthone	2.8	16.6	4.1	2.1	---	1509	$\beta$ -Bisabolene	0.3	0.3	0.5	0.1	---
1161	Pinocarvone	---	---	---	---	0.1	1524	$\delta$ -Cadinene	---	---	0.1	---	---
1166	Borneol	1.6	1.8	1.0	0.9	1.4	1565	(E)-Nerolidol	0.1	0.1	---	---	---
1171	Menthol	0.2	0.1	0.1	---	---	1566	Unidentified	---	---	0.6	---	---
1175	cis/trans-Isopulegone	---	0.4	0.4	0.7	---	1578	Spathulenol	0.9	0.5	0.5	0.3	---
1176	Terpinen-4-ol	0.2	---	---	---	0.2	1584	Caryophyllene oxide	1.6	0.9	1.4	0.7	---
1184	<i>p</i> -Cymen-8-ol	0.3	0.1	0.4	0.5	---	1610	Unidentified	---	0.3	0.9	---	---
1189	$\alpha$ -Terpineol	0.3	0.2	0.2	0.2	0.2	1635	Isospathulenol	0.2	0.1	0.1	---	---
1195	Myrtenal	0.1	0.1	---	---	0.1	1642	(2S,5E)-Caryophyll-5-en-12-al	0.2	---	---	---	---
1195	cis-Dihydrocarvone	---	---	0.3	0.6	---	1654	$\alpha$ -Cadinol	0.1	---	---	---	---
1220	Coahuilensol methyl ether	0.3	0.1	0.2	0.2	0.1	1669	14-Hydroxy-9- <i>epi</i> -(E)-caryophyllene	0.2	---	---	---	---
1224	Citronellol	0.5	---	---	---	---	1685	Germacre-4(15),5,10(14)-trien-1- $\alpha$ -ol	0.1	---	---	---	---
1226	Unidentified	---	0.1	0.2	0.5	1.4	1758	14-Hydroxy- $\alpha$ -Muurolene	0.1	---	---	---	---
1229	Thymol methyl ether	0.1	---	---	---	---	1991	Manool oxide	0.1	---	---	---	---
1237	Pulegone	1.6	1.6	2.6	5.4	0.3		Total constituents identified	84.5	98.2	97.0	99.0	95.6

<sup>1</sup>Size of text in RI 1303 = 6-Hydroxy-6-isopropyl-3-methylcyclohex-2-enone, 1392 = 4a- $\alpha$ ,7- $\beta$ ,7a- $\alpha$ -Nepetalactone, 1642 = (2S,5E)-Caryophyll-5-en-12-al, 1669 = 14-Hydroxy-9-*epi*-(E)-caryophyllene, and 1685 = Germacre-4(15),5,10(14)-trien-1- $\alpha$ -ol was reduced to fit table. Constituent identification based on RI & MS matching using Adams (2007) and NIST database. tr = trace (<0.01%).

With the extent of morphological diversity in *M. longifolia*, a great degree of chemical variation in the species might be expected as well. Indeed, results from previous studies on several wild and cultivated *M. longifolia* have produced a number of chemotypes (Table 2). Identified chemotypes of *M. longifolia* include those dominated by piperitenone oxide (Baser *et al.*, 1999; Gulluce *et al.*, 2007; Hussain, 2009; Maffei, 1988; Mastelic and Jerkovic, 2002; Rezaei *et al.*, 2000; Sharipova *et al.*, 1983; Venskutonis, 1996; Viljoen *et al.*, 2006), piperitone epoxide (Baser *et al.*, 1999; Fleisher and Fleisher, 1998; Fraise *et al.*, 1985; Hussain, 2009; Karousou *et al.*, 1998; Kokkini and Papageorgiou, 1988; Vidal *et al.*, 1985; Viljoen *et al.*, 2006), carvone (Banthorpe *et al.*, 1980; Fraise *et al.*, 1985; Kokkini *et al.*, 1995; Lawrence, 1978; Lawrence, 2007; Mastelic and Jerkovic, 2002; Monfared *et al.*, 2002; Vidal *et al.*, 1985; Younis and Beshir, 2004), menthone (Fraise *et al.*, 1985; Hajlaoui *et al.*, 2010; Mimica-Dukić *et al.*, 2003; Oyedeji and Afolayan, 2006; Vidal *et al.*, 1985), pulegone (Fleisher and Fleisher, 1991; Gulluce *et al.*, 2007; Hajlaoui *et al.*, 2010; Mkaddem *et al.*, 2009; Oyedeji and Afolayan, 2006), piperitone (Džamić *et al.*, 2010; Ghoulemi *et al.*, 2000; Rasooli and Rezaei, 2002; Rezaei *et al.*, 2000), *trans*-dihydrocarvone (Džamić *et al.*, 2010; Matovic and Lavadinovic, 1999; Mimica-Dukić *et al.*, 1991), isomenthone (Mimica-Dukić *et al.*, 1991; Mimica-Dukić *et al.*, 2003; Mkaddem *et al.*, 2009), menthofuran (Mimica-Dukić *et al.*, 1991; Viljoen *et al.*, 2006), menthol (Al-Bayati, 2009; Hajlaoui *et al.*, 2010), 1,8-cineole (Fleisher and Fleisher, 1998; Oyedeji and Afolayan, 2006), isopiperitenone (Rezaei *et al.*, 2000), piperitenone (Ghoulemi *et al.*, 2000), and borneol (Hussain, 2009).

Comparing the results obtained for our *M. longifolia* plant samples with those reported for the same species from other locations of the world reveals profound differences in essential oil composition. A cluster analysis (Figure 1) illustrated the numerous different chemotypes of *M. longifolia* and

showed that the essential oil of Tajikistan samples labeled #1, #2, #4 (Dushanbe region), and #3 (Muminobod region) form a cluster (rich in piperitenone oxide and *cis*-piperitone epoxide) distinct from other *M. longifolia* samples. The essential oil of Tajikistan sample #5 (Yovon region), dominated by *cis*-piperitone epoxide, is separate from the cluster formed by the other samples from Tajikistan.

Kokkini and co-workers (Karousou *et al.*, 1998; Kokkini *et al.*, 1995) observed analogous chemical differences between samples from western Crete compared with those from the eastern end of the island. Other notable clusters in this analysis include a piperitenone oxide cluster (India and S. Africa #9), a *trans*-piperitone epoxide cluster (Crete #5 and #6), a menthone/menthol cluster (Tunisia samples #4, #5, #6, and #7), a *cis*-carveol cluster (Iran samples #3, #4, and #5), a menthofuran cluster (S. African samples #5, #6, #7, #10, #11, and #12), a carvone cluster (Iran #1, Sudan, Crete #1, Crete #2, and Greece #1), a menthone/pulegone/1,8-cineole cluster (S. Africa #1, #2, and #3) as well as a pulegone/menthone/1,8-cineole cluster (Tunisia #2 and #3).

Viljoen and co-workers (2006) had reported the clustering of their South African samples (#5, #6, #7, #10, #11, and #12), distinct from two other samples in their study (#8 and #9), and these are all chemically distinct from other samples from South Africa reported by Asekun and co-workers (2007). Seasonal variation in essential oil does occur (Hussain, *et al.*, 2010) and geographical location and environmental factors (climate/weather, soil/nutrition, herbivory/disease) undoubtedly play a large role in the morphological and chemical differentiation of *Mentha longifolia*.

Table 2. Main constituents in *Mentha longifolia* samples collected at various locations.

Country	Main essential oil constituents	Reference
Crete	Carvone (56-66%), 1,8-cineole (2-13%), limonene (3-11%), trans-dihydrocarvone (1-33%)	(Kokkini <i>et al.</i> , 1995)
Croatia	Carvone, piperitenone oxide, limonene and $\beta$ -caryophyllene	(Mastelic and Jerkovic, 2002)
France	Chemotype I: Menthone (60%), pulegone (10%) and 1,8-cineole (9%); Chemotype II: Piperitone oxide isomer (60%), piperitenone oxide (15%), $\alpha$ -muurolol (6%) and 1,8-cineole (3%); Chemotype III: Carvone (57%), 1,8-cineole (13%) and limonene (7%)	(Fraisse <i>et al.</i> , 1985; Vidal <i>et al.</i> , 1985)
Greece	Piperitone oxide	(Kokkini and Papageorgiou, 1988)
Greece	Chemotype 1: Carvone (55%), limonene (20%) Chemotype 2: cis-Piperitone epoxide (33%), 1,8-cineole (25%), trans-piperitone epoxide (17%)	(Koliopoulos <i>et al.</i> , 2010)
India	Piperitenone oxide (54%), trans-piperitone epoxide (20%)	(Singh <i>et al.</i> , 2008)
Israel	1,8-cineole (29%), cis-piperitone oxide (15%) and piperitone (14%)	(Fleisher and Fleisher, 1998)
Iran	Piperitone (68%), 1,8-cineole (12%)	(Jaimand and Rezaei, 2002)
Iran	Carvone (62%), limonene (19%)	(Monfared <i>et al.</i> , 2002)
Iran	Piperitone (44%), limonene (14%) and trans-piperitol (13%)	(Rasooli and Rezaei, 2002)
Iran	Isopiperitenone (12-58%), piperitenone oxide (20-34%), piperitone (8-44%)	(Rezaei <i>et al.</i> , 2000)
Iraq	(-) Menthol	(Al-Bayati, 2009)
Italy	Piperitenone oxide (77%)	(Maffei, 1988)
Jordan	Pulegone (70%)	(Fleisher and Fleisher, 1991)
Kazakhstan	Piperitenone oxide (52%)	(Sharipova <i>et al.</i> , 1983)
Lithuania	Piperitenone oxide (44-57%), 1,8-cineole (8-15%), myrcene (6-10%)	(Venskutonis, 1996)
Morocco	Piperitenone and piperitone	(Ghoulami <i>et al.</i> , 2000)
Netherlands	Carvone (66%)	(Lawrence, 1978)
Pakistan	Piperitenone oxide (40-65%), piperitone (2-16%), and borneol (2-13%)	(Hussain, 2009)
Serbia	trans-Dihydrocarvone (24%), piperitone (17%), cis-dihydrocarvone (16%)	(Džamić <i>et al.</i> , 2010)
Serbia	trans-Dihydrocarvone (16-31%)	(Matovic and Lavadinovic, 1999)
Serbia	Chemotype A: trans-Dihydrocarvone (18%), isomenthone (12%), piperitone (8%) Chemotype B: Isomenthone (42%), methone (12%) Chemotype C: Menthofuran (38%), 1,8-cineole (10%), (E)-caryophyllene (11%)	(Mimica-Dukić <i>et al.</i> , 1991)
Serbia	Menthone and isomenthone	(Mimica-Dukić <i>et al.</i> , 2003)
South Africa	Menthone (31-48%), pulegone (18-35%), 1,8-cineole (13-17%)	(Asekun <i>et al.</i> , 2007)
South Africa	Menthone (51%), pulegone (19%), 1,8-cineole (12%)	(Oyedeki and Afaloayan, 2006)
South Africa	Menthofuran (51-62%), cis-piperitone oxide (15-36%), piperitenone oxide (15-66%)	(Viljoen <i>et al.</i> , 2006)
Sudan	Carvone (77%)	(Banthorpe <i>et al.</i> , 1980)
Sudan	Carvone (67%), limonene (14%)	(Younis and Beshir, 2004)
Tunisia	Pulegone (54%), isomenthone (12%)	(Mkaddem <i>et al.</i> , 2009)
Tunisia	Menthol (33%), menthone (21%), pulegone (18%)	(Hajlaoui <i>et al.</i> , 2010)
Turkey	Piperitone oxide (65%), piperitenone oxide (12%),	(Baser <i>et al.</i> , 1999)
Turkey	cis-Piperitone epoxide (18%), pulegone (16%), piperitenone oxide (15%)	(Gulluce <i>et al.</i> , 2007)

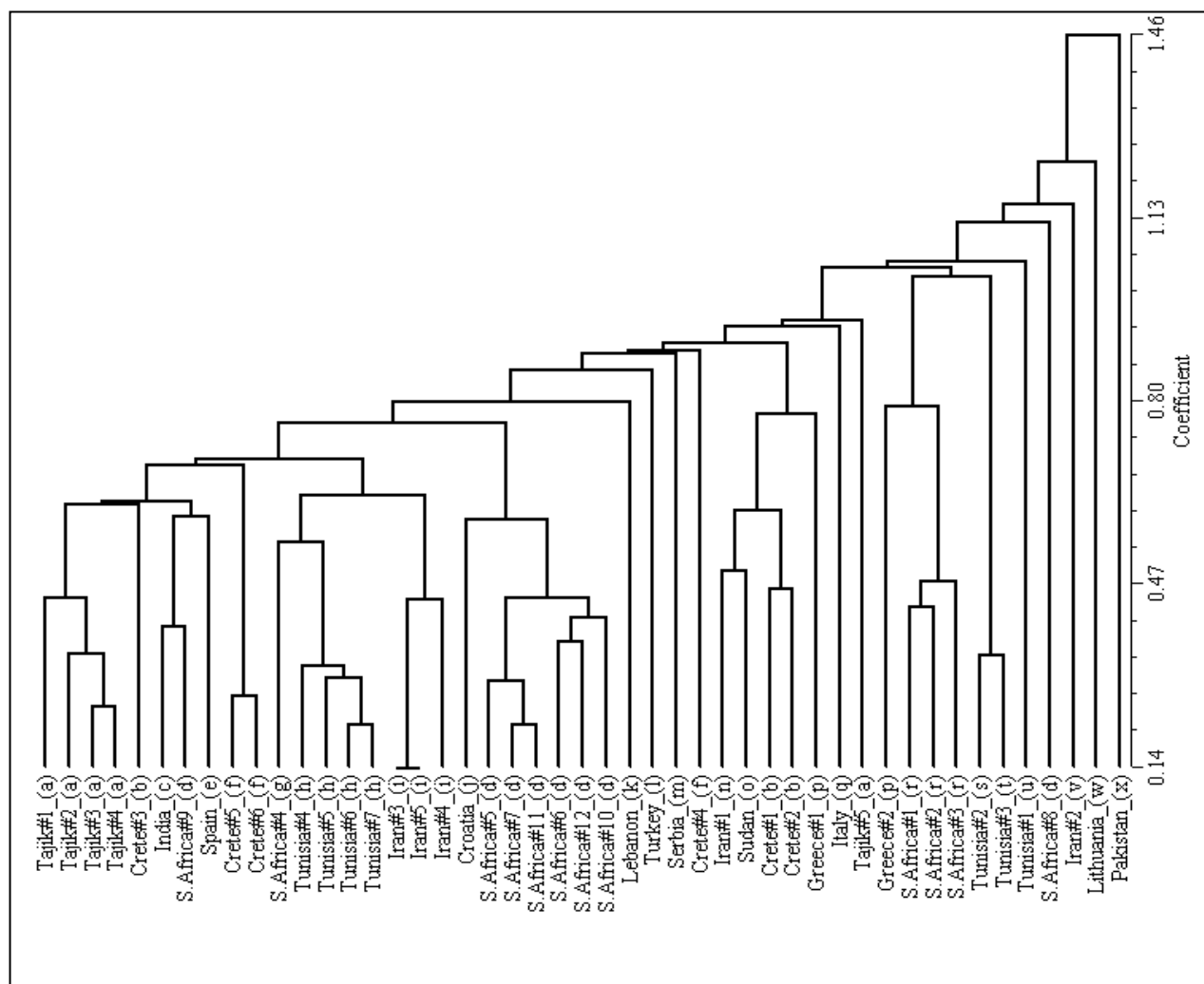


Figure 1. Dendrogram obtained by cluster analysis of the percentage composition of essential oils from *Mentha longifolia* samples. Results are based on correlation and use of the unweighted pair-group method with arithmetic average (UPGMA). Data from: (a) current study; (b) Kokkini *et al.*, 1995; (c) Singh *et al.*, 2008; (d) Petkar, 2006; (e) Pérez Raya *et al.*, 1990; (f) Karousou *et al.*, 1998; (g) Oyediji and Afolayan, 2006; (h) Hajlaoui *et al.*, 2008; (i) Zeinali *et al.*, 2005; (j) Mastelic and Jerkovic, 2002; (k) Hilan *et al.*, 2006; (l) Gulluce *et al.*, 2007; (m) Džamić *et al.*, 2010; (n) Monfared *et al.*, 2002; (o) Younis and Beshir, 2004; (p) Koliopoulos *et al.*, 2010; (q) Maffei, 1988; (r) Asekun *et al.*, 2007; (s) Snoussi *et al.*, 2008; (t) Hajlaoui *et al.*, 2009; (u) Mkaddem *et al.*, 2009; (v) Jaimand and Rezaei, 2002; (w) Venskutonis, 1996; (x) Hussain, 2009.



## REFERENCES

- Adams, R.P. 2007. *Identification of Essential Oil Components by Gas Chromatography / Mass Spectrometry*, 4th Ed. Allured Publishing, Carol Stream, Illinois.
- Al-Bayati, F.A. 2009. Isolation and identification of antimicrobial compound from *Mentha longifolia* L. leaves grown wild in Iraq. *Ann. Clin. Microbiol. Antimicrob.* 8:20 (doi:10.1186/1476-0711-8-20).
- Asekun, O.T., D.S. Grierson, and A.J. Afolayan. 2007. Effects of drying methods on the quality and quantity of the essential oil of *Mentha longifolia* L. subsp. *capensis*. *Food Chem.* 101:995-998.
- Banthorpe, D.V., R.J.H. Duprey, M. Hassan, J.F. Janes, and B.M. Modawi. 1980. Chemistry of the Sudanese flora. Part II. Essential oil of *Mentha longifolia*. *Egypt. J. Chem.* 23:63-65.
- Baser, K.H.C., M. Kurkcuglu, G. Tarimcila, and G. Kaynak. 1999. . Essential oils of *Mentha* species from northern Turkey. *J. Essent. Oil Res.* 11:579-588.
- Džamić, A.M., M.D. Soković, M.S. Ristić, M. Novaković, S. Grujić-Jovanović, V. Tešević, and P.D. Marin. 2010. Antifungal and antioxidant activity of *Mentha longifolia* (L.) Hudson (Lamiaceae) essential oil. *Bot. Serb.* 34:57-61
- Fleisher, A. and Z. Fleisher. 1991. The essential oils from *Mentha longifolia* growing in Sinai and Isreal. *Aromatic plants of the Holy Land and the Sinai part IV.* *J. Essent. Oil Res.* 3:57-58.
- Fleisher, Z. and A. Fleisher. 1998. Volatile extracts of *Mentha longifolia* growing in Israel. *Aromatic plants of the Holy Land and Sinai. Part XIII.* *J. Essent. Oil Res.* 10:647-648.
- Fraisse, K.N., C. Suon, M.G. Scharff, G. Vernin, R.M. Zamkotsian, and J. Metzger. 1985. Huiles essentielles de menthe crépue. *Parf. Cosm. Aromes* 65: 71-75.
- Ghoulami, S., A. Idrissi, and S. Fkih-Tetouani. 2000. Phytochemical study of *Mentha longifolia* of Morocco. *Fitoterapia* 72:596-598.
- Gobert, V., S. Moja, M. Colson, and P. Taberlet. 2002. Hybridization in the section *Mentha* (Lamiaceae) inferred from AFLP markers. *Am. J. Bot.* 89:2017-2023.
- Gulluce, M., F. Sahin, M. Sokmen, H. Ozer, D. Daferera, A. Sokmen, M. Polissiou, A. Adiguzel, and H. Ozkan. 2007. Antimicrobial and antioxidant properties of the essential oils and methanol extract from *Mentha longifolia* L. ssp. *longifolia*. *Food Chem.* 103:1449-1456.
- Hajlaoui, H., M. Snoussi, H. Ben Jannet, Z. Mighri, and A. Bakhrouf. 2008. Comparison of chemical composition and antimicrobial activities of *Mentha longifolia* L. ssp. *longifolia* essential oil from two Tunisian localities (Gabes and Sidi Bouzid). *Ann. Microbiol.* 58:513-520.
- Hajlaoui, H., N. Trabelsi, E. Noumi, M. Snoussi, H. Fallah, R. Ksouri, and A. Bakhrouf. 2009. Biological activities of the essential oils and methanol extract of two cultivated mint species (*Mentha longifolia* and *Mentha pulegium*) used in the Tunisian folkloric medicine. *World J. Microbiol. Biotechnol.* 25:2227-2238.
- Hajlaoui, H., A.F. Ben, M. Mejdj, E. Noumi, and A. Bakhrouf. 2010. Effect of *Mentha longifolia* L. ssp *longifolia* essential oil on the morphology of four pathogenic bacteria visualized by atomic force microscopy. *Afr. J. Microbiol. Res.* 4:1122-1127.
- Hilan, C., R. Sfeir, D. Jawish, and S. Aitour. 2006. Huiles essentielles de certaines plantes medicinales Libanaises de la famille des Lamiaceae. *Leb. Sci. J.* 7:13-22.
- Hussain, A.I. 2009. Characterization and biological activities of essential oils of some species of Lamiaceae. Ph.D. thesis, University of Agriculture, Faisalabad, Pakistan. pp. 68-78.
- Hussain, A.I., F. Anwar, P. S.Nigam, M. Ashraf, and A.H. Gilani. 2010. Seasonal variation in content, chemical composition and antimicrobial and cytotoxic activities of essential oils from four *Mentha* species. *J. Sci. Food Agric.* 90:1827-1836.
- Jaimand, K. and M.B. Rezaei. 2002. Chemical constituents of essential oils from *Mentha*

- longifolia* (L.) Hudson var. *asiatica* (Boriss.)  
Rech. f. from Iran. J. Essent. Oil Res. 14:107-108.
- Karousou R., T. Lanaras, and S. Kokkini. 1998. Piperitone oxide-rich essential oils from *Mentha longifolia* subsp. *petiolata* and *M. villosa-nervata* grown wild on the island of Crete (S. Greece). J. Essent. Oil Res. 10:375-379.
- Kokkini, S. and V.P. Papageorgiou. 1988. Constituents of essential oils from *Mentha longifolia* growing wild in Greece. *Planta Med.* 54:59-60.
- Kokkini S., R. Karousou, and T. Lanaras. 1995. Essential oils of spearmint (carvone-rich) plants from the island of Crete (Greece). *Biochem. Syst. Ecol.* 23:425-430.
- Koliopoulos G., D. Pitarokili, E. Kioulos, A. Michaelakis, and O. Tzakou. 2010. Chemical composition and larvicidal evaluation of *Mentha*, *Salvia*, and *Melissa* essential oils against the West Nile virus mosquito *Culex pipiens*. *Parasitol. Res.* 107:327-335.
- Lange, B.M. and R. Croteau. 1999. Genetic engineering of essential oil production in mint. *Curr. Opin. Plant Biotechnol.* 2:139-144.
- Lawrence, B.M. 1978. A study of the monoterpene interrelationships in the genus *Mentha* with special reference to the origin of pulegone and menthofuran. Ph.D. thesis, State University, Groningen, Netherlands.
- Lawrence, B.M. 2007. *Mint: The Genus Mentha*. CRC Press, Boca Raton, Florida. p. 333.
- Maffei, M. 1988. A chemotype of *Mentha longifolia* (L.) Hudson particularly rich in piperitenone oxide. *Flavour Fragr. J.* 3:23-26.
- Mastelic, J. and I. Jerkovic. 2002. Free and glycosidically bound volatiles of *Mentha longifolia* growing in Croatia. *Chem. Nat. Comp.* 38:561-564.
- Matovic M. and V. Lavadinovic. 1999. Essential oil composition of *Mentha longifolia* (L.) Hudson from the Mountain Zlatar in Yugoslavia. J. Essent. Oil-Bear. Plants 2:78-81.
- Mimica-Dukić, N., O. Gasić, G. Kite, L. Fellow, and R. Jancić. 1991. A study of the essential oil of *Mentha longifolia* growing in Yugoslavia. *Planta Med.* 57:83-84.
- Mimica-Dukić, N., B. Bozin, M. Soković, B. Mihajlović, and M. Matavulj. 2003. Antimicrobial and antioxidant activities of three *Mentha* species essential oils. *Planta Med.* 69:413-419.
- Missouri Botanical Garden. 2011. Accessed on the web at <http://www.tropicos.org/>
- Mkaddem, M., J. Bouajila, M. Ennajar, A. Lebrhi, F. Mathieu, and M. Romdhane. 2009. Chemical composition and antimicrobial and antioxidant activities of *Mentha (longifolia* L. and *viridis*) essential oils. *J. Food Sci.* 74:358-363.
- Monfared, A., M.R. Nabid, and A.A.H. Roustaeian. 2002. Composition of a carvone chemotype of *Mentha longifolia* (L.) Hudson from Iran. J. Essent. Oil Res. 14:51-52.
- Oyedeji, A.O. and A.J. Afolayan. 2006. Chemical composition and antibacterial activity of the essential oil isolated from South African *Mentha longifolia* (L.) L. subsp. *capensis* (Thunb.) Briq. J. Essent. Oil Res. 18:57-59.
- Pérez Raya, M.D., M.P. Utrilla, M.C. Navarro, and J. Jiménez. 1990. CNS activity of *Mentha rotundifolia* and *Mentha longifolia* essential oil in mice and rats. *Phytother. Res.* 4:232-234.
- Petkar, S. 2006. The composition, geographical variation and antimicrobial activity of *Mentha longifolia* subspecies *polyadena* (Lamiaceae) leaf essential oils. M.S. thesis, University of Witwaterstrand, Johannesburg, South Africa.
- Rasooli, I. and M.B. Rezaei. 2002. Bioactivity and chemical properties of essential oils from *Zataria multiflora* Boiss and *Mentha longifolia* (L.) Hudson. J. Essent. Oil Res. 14:141-146.
- Rezaei, M.B., K. Jaymand, and Z. Jamzad. 2000. Chemical constituents of *Mentha longifolia* (L.) Hudson var. *chlorodictya* Rech. f. from three different localities. *Pajouhesh-va Sazandegi* 13:60-63.
- Rohlf, J.F. 2005. *NTSYSpc, Numerical Taxonomy and Multivariate Analysis System*. Applied Biostatistics Inc., New York.

- Sharipova, F.S., L.A. Elchibekova, E.S. Nedeko, and L.E. Gusak. 1983. Wild mints of Kazakhstan. II. Study of the chemical composition of *Mentha arvensis* L, *Mentha longifolia* (L) Hudson, *Mentha crispa* L, and *Mentha interrupta* essential oils. SSR J. Ser. Khimiya 4:67-71 [Chem. Abstr. 1983. CA 99(24), 200387j].
- Singh, H.P., D.R. Batish, S. Mittal, K.S. Dogra, S. Yadav, and R.K. Kohli. 2008. Constituents of leaf essential oil of *Mentha longifolia* from India. Chem. Nat. Comp. 44:528-529.
- Snoussi, M., H. Hajlaoui, E. Noumi, D. Usai, L.A. Sechi, S. Zanetti, and A. Bakhrouf. 2008. In-vitro anti-*Vibrio* spp. activity and chemical composition of some Tunisian aromatic plants. World J. Microbiol. Biotechnol. 24:3071-3076.
- Venskutonis, R. 1996. A chemotype of *Mentha longifolia* L from Lithuania rich in piperitenone oxide. J. Essent. Oil Res. 8:91-95.
- Vidal, J.P., I. Noleau, G. Bertholon, J. Lamy, and H. Richard. 1985. Constituents volatils des huiles essentielles de Menthes sylvestres de la Drôme. Parf. Cosm. Aromes 64:83-87.
- Viljoen, A.M., S. Petkar, S.F. van Vuuren, and A.C. Figueiredo. 2006. The chemo-geographical variation in essential oil composition and the antimicrobial properties of “wild mint” – *Mentha longifolia* subsp. *polyadena* (Lamiaceae) in southern Africa. J. Essent. Oil Res. 18:60-65.
- Younis, Y.M.H. and S.M. Beshir. 2004. Carvone-rich essential oils from *Mentha longifolia* (L.) Huds. ssp. *schimper* Briq. and *Mentha spicata* L. grown in Sudan. J. Essent. Oil Res. 16:539-554.
- Zeinali, H., A. Arzani, K. Razmjoo, and M.B. Rezaee. 2005. Evaluation of oil compositions of Iranian mints (*Mentha* spp.). J. Essent. Oil Res. 17:156-159.