



Analysis of the Essential Oils of *Nepeta straussii*, *N. amoena*, *N. haussknechtii* and *N. speciosa* from Iran

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Abstract

The aerial parts essential oils of nine populations of four *Nepeta* species (*N. straussii* Hausskn. & Bornm., *N. amoena* Stapf., *N. haussknechtii* Bornm. and *N. speciosa* Boiss. & Noë), from Iran, were analyzed by gas chromatography, flame ionization detector (GC-FID), and mass spectrometric detection (GC/MS). In the oil of one population of *N. straussii*, 1,8-cineole (40.1%) was the main constituent. In contrast, the oil of the second population consisted of germacrene D (11.6%), caryophyllene oxide (11.9%), and n-nonadecane (10.3%) as major compounds. Caryophyllene oxide (36.2%) in one population and hexadecanoic acid (33.4%) in another population of *N. amoena* were the major compounds. In the oils of two populations of *N. haussknechtii*, 1,8-cineole (45.1% and 48.6%) was the main constituent, while 4 α -7 α -7 α -nepetalacton (26.7%) and 1,8-cineole (24.5%) were major components in the oil of third population. In the essential oil of one population of *N. speciosa*, 4 α -7 β -7 α -nepetalacton (74.8%) and the other population, 1,8-cineole (32.3%), were the main constituents. Therefore, in addition to variations between essential oil compositions of different *Nepeta* species, there are variations in the oil composition of one *Nepeta* species from different localities that may be due to climatic conditions or having the potential to form chemotypes.

Keywords: *Nepeta*; Essential oil; 1, 8-cineole; Nepetalactone; Chemotype; Population.

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1. Introduction

Plants have been indispensable primary sources of life since human existence. Herbs and plant extracts have been used to prevent and treat human diseases in many countries for medical purposes [1].

The *Nepeta* genus is one of the largest genera of Lamiaceae, with 300 species. The most incredible diversity of this genus is in Southwest Asia and the Western Himalayas. Iran has 75 species of this genus, many of which are endemic [2]. Due to the medicinal importance and traditional uses of *Nepta* species in Iran, much research has been done to identify their secondary metabolites.

Neptalactones, flavonoids [3], and phenolic acids [4] have been reported as the main secondary metabolites of *Nepta* species. Flavonoids are potent bioactive compounds with anticarcinogenic effects [5, 6].

Neptalactones are cyclopentanoid monoterpenes that are found at different amounts in *Nepeta* spp. oils [7]. Variation has been reported in the essential oil composition of different *Nepeta* species. In previous research, twenty-one compounds have been reported in the flower oil of *N. straussii*, with 1,8-cineole (22.1%), germacrene-D (18.5%), and β -pinene (12.1%) as the main compounds [8]. 1,8-cineole (36.7%) and elemol (11.4%) were the main components of *N. haussknechtii* oil [9]. Nepetalactone isomers and 1,8-cineole were identified as the main components of the essential oils of many *Nepeta* species. For example, 1,8-cineole (62.8%), 4 α -7 α -7 α -nepetalactone (10.3%) and 4 α β -7 α -7 α β -nepetalactone (9.2%) in *N. crispa*, 1,8-cineole (71.7%) in *N. ispahanica*, nepetalactone (37.6%) and 1,8-cineole (27.2%) in *N. mahanensis*, 4 α β -7 α -7 α β -nepetalactone (73.3%) and 1,8-cineole (13.1%) in *N. eremophila*, 1,8-cineole (38.5%), sabinene (14.8%) and β -pinene (10.7%) in *N. rivularis* [10], and 4 α -7 α -7 α -nepetalactone

(90.1%) in *N. cephalotes* [11] were reported as major components of the essential oils.

Other monoterpenes and sesquiterpenes were reported in the oils of other *Nepeta* species, for example, α -pinene (9.4%), geranyl acetate (9.3%), limonene (8.2%) and caryophyllene oxide (8.0%) in *N. glomerulosa* [12] oil, 1,8-cineole (23.1%), germacrene-D (15.1%) and β -pinene (12.2%) in *N. involucrate* [13] oil, and germacrene-D (39.7%), palmitic acid (10.8%), β -bourbonene (5.8%) and spathulenol (5.6%) in *N. ucraïnica* oil [14].

Nepeta species from different origins (localities) showed variation in oil composition; for example, in the essential oil of *N. crassifolia* collected from northern Tehran province (capital city of Iran), 4 α ,7 α ,7 α -nepetalactone (92.6%) was the main compound [15]. In contrast, in a plant sample from Mazandaran province (North of Iran), 4 α -7 β -7 α -nepetalactone (81.1%) and 4 α -7 α -7 α -nepetalactone (5.9%) were the major components [16].

Some *Nepta* species treat liver, kidney, gum, heart diseases, and snake and scorpion bites [3, 17, 18]. The effectiveness of *Nepeta* species has also been determined as anti-asthmatic, anti-cough, anti-spasm, anti-febrile, expectorant, diuretic, sedative, as well as antiseptic, fungicidal, anti-microbial, anti-viral and insecticide [3, 17, 19, 20].

Nepeta straussii is an endemic annual aromatic plant that grows in mountainous areas, stony slopes at an altitude of 1500-2000m in the Irano-Turanian region of Iran [21]. *Nepeta amoena* is a native herbaceous annual plant that grows in mountainous areas, stony and gravel slopes at 300-1900m altitude in Irano-Turanian and Caspian regions of Iran [22]. *Nepeta*

haussknechtii is a native herbaceous perennial aromatic plant that grows in mountainous areas, rocky and stony slopes at an altitude of 1400-2800m in Irano-Turanian and Caspian regions of Iran [22]. *Nepeta speciosa* is a native herbaceous perennial aromatic plant that grows in mountainous areas at an altitude of 1300-3200m in the Irano-Turanian region of Iran [21].

Due to the importance of *Nepta* species in medicinal topics and the relation between secondary metabolites and pharmaceutical effects, in this study essential oil content and composition of nine populations from four *Nepta* species (*N. straussii*, *N. amoena*, *N. haussknechtii*, and *N. speciosa*) were investigated.

2. Materials and Methods

2.1. Plant material

The aerial parts of four *Nepeta* species were collected from their natural habitats (**Table 1**) at the complete flowering stage and dried at room temperature before distillation. The voucher specimens have been deposited in the National Herbarium of Iran (TARI), Gilan Agricultural and Natural Resources Research and Education Center (Gilan Herbarium).

2.2. Isolation procedure

Air-dried aerial parts of the plants (60-80g) were subjected to hydro-distillation for three hours using a Clevenger-type apparatus. The oils separated from water, dried over anhydrous sodium sulfate, and were stored in sealed vials at low temperatures before analysis. The essential oil yields were calculated based on dried plant materials weights.

2.3. Gas chromatography (GC) and GC-mass spectrometric (GC/MS) analysis

Gas chromatography analyses were performed using a Shimadzu GC-9A with a DB-5 fused silica column (30 m x 0.25 mm i.d., film thickness 0.25 μ m). The oven temperature was held at 50°C for 5 min. and then programmed to 250°C at a rate of 3°C/min. The flame ionization detector (FID) temperature was 265°C, and the injector temperature was 260°C. Helium was used as carrier gas with a linear velocity of 32 cm/s.

Gas chromatography-mass spectrometry analysis was conducted with a Varian 3400 GC connected to a mass spectrometer Saturn model, equipped with a DB- 5- fused silica capillary column (30 m length, 0.25 mm internal diameter, and 0.25 μ m film thickness); the injection chamber temperature and the transfer line were set at 260 and 270°C, respectively. The carrier gas was helium with a linear velocity of 31.5 cm/s, split ratio of 1 to 60, 1 s of scan time, and mass range of 40–300 a.m.u. The oven temperature adjustment program was the same as for GC.

The percentages of compounds were calculated by the area normalization method without considering response factors. The oil components were identified by comparing their mass spectra with those of a computer library or authentic compounds. They were confirmed by comparing their retention indices with authentic compounds or with data published in the literature [43-45]. The retention indices were calculated for all volatile constituents using a homologous series of n-alkanes.

Table 1: Location of collected plants and herbarium numbers.

No.	Plant Species	Population	Collecting data & herbaria
1	<i>Nepeta straussii</i> Hausskn. & Bornm. (endemic)	<i>stra1</i>	Hamedan, Asadabad, Rahdarkhaneh, 2397 m, Kalvandi, 1554 (TARI)
2		<i>stra2</i>	Hamedan, Malayer, Arak Road, Joorab Village, 1977m, Kalvandi, 5757 (TARI)
3	<i>Nepeta amoena</i> Stapf. (native)	<i>amoe1</i>	Gilan, Manjil to Gilvan, near Sepidrood , 360m, Moradi, 13072 (TARI)
4		<i>amoe2</i>	Gilan, Lushan, 801 m, Moradi, 103022 (TARI)
5	<i>Nepeta haussknechtii</i> Bornm. (native)	<i>hauss1</i>	Ardabil, Arasbaran, 1841 m, Assadi, 24768 (TARI)
6		<i>hauss2</i>	Gilan, Asalem to Khalkhal, 1905 m, Jamzad, 83138 (TARI)
7		<i>hauss3</i>	Between Gilan and Ardabil, Punel to Khalkhal, after Jahangirieh, 1700 m, Moradi, 6411 (TARI)
8	<i>Nepeta speciosa</i> Boiss. & Noe (native)	<i>speci1</i>	Ardabil, Khalkhal, Bildir, 1900 m, Azimi, 22 (TARI)
9		<i>speci2</i>	Ardabil, Sardul, 2800 m, Bidarlord, 10032 (Gilan Herbarium)

3. Results and Discussion

3.1. Plant materials and essential oil extraction and analysis

The aerial parts of nine populations from four Iranian *Nepeta* species named *Nepeta straussii* Hausskn. & Bornm., *N. amoena* Stapf., *N. haussknechtii* Bornm. and *N. speciosa* Boiss. & Noë were collected from their natural habitats (Table 1), and their essential oils were obtained by hydro-distillation. Essential oil yields were calculated based on the dry weights of plant materials. The oils were analyzed using GC-FID and GC/MS.

3.2. Essential oil yield

The oils isolated by hydro-distillation from the aerial parts of *N. straussii*, *N. amoena*, *N.*

haussknechtii, and *N. speciosa* were found to be pale yellow to yellow liquids.

The oil yields of all populations from these four studied *Nepeta* species were 0.11% to 0.51% (weight/weight). The oil yields of *N. straussii* populations (0.22% and 0.51%) and *N. haussknechtii* (0.23-0.48%) were higher than *N. speciosa* (0.12% and 0.38%) and *N. amoena* (0.11% and 0.19%) (Table 1). The oil yields for many *Nepeta* species were reported to be less than 1% [8, 11, 15, 23-26], while some other species, such as *N. binaludensis* [27] and *N. pogonosperma* [28], contain more oil percentage than species in the present study.

3.3. Essential oil composition

The essential oils were analyzed using flame ionization and mass spectrometric detection by capillary gas chromatography. All identified

components with their percentage and retention indices on the DB-5 column are presented in **Table 2**.

Forty-nine components were identified in the essential oils of two populations of *N. strausii* (representing 99.7 and 85.8% of the oils). The main components of one population (*stra1*) were 1,8-cineole (40.1%), myrcene (10%), germacrene D (8.9%), caryophyllene oxide (6.2%), and E-caryophyllene (5.8%), while 1,8-cineole (6.1%) was found in the oil of second population (*stra2*) at a much lower percentage. The other major oil constituents of *stra2* were caryophyllene oxide (11.9%), germacrene D (11.6%), n-nonadecane (10.3%), and E-caryophyllene (7.1%). There also were differences in minor oil components of both populations; for example, khusinol (4.9%), eudesma-4 (15), 7-dien-1,β-ol (3.9%), and some other minor compounds were just found in *stra2* oil. In comparison, myrtenol (2.4%), β-copaene (2.3%), and other compounds were identified in the oil of *stra1*. These differences may be due to the higher altitude of *stra1* (**Table 1**) and other related climatic conditions compared to *stra2*. Rustaiyan *et al.* (2013) have reported 1,8-cineole (22.1%), germacrene-D (18.5%), and β-pinene (12.1%) as the main components of the flower oil of *N. strausii* collected from Isfahan province [8]. The present study is the first report on the aerial parts essential oil of *N. strausii*.

Thirty-nine components were identified in the essential oils of two populations of *N. amoena* (representing 91.9 and 96.8% of the oils). The major components of *amoel* oil were caryophyllene oxide (36.2%), α-vetivone (8.4%), trans-calamenene (7.1%), hexadecanoic acid (6.8%), and n-heneicosane (5.1%). In the oil of *amoel2*, hexadecanoic acid (33.4%) was found in

a higher percentage. After that, n-heneicosane (12%), trans calamenene (7.8%), spathulenol (6.9%), and α-vetivone (6%) were the major constituents; this is the first study on the essential oil composition of *N. amoena* oil, and the results showed the potential of this species to make chemotypes.

Thirty-five compounds were identified in the oils of three populations of *N. haussknechtii*, representing 90.8-98.7% of the oils. 1,8-cineole was found at a high percentage in the oils of *hauss1* (48.6%) and *hauss3* (45.1%) and a lower amount in the oil of *hauss2* (24.5%). After 1,8-cineole, the major compounds were germacrene D (8.6%), 4α,7β,7α-nepetalacton (7.4%) and caryophyllene oxide (5.2%) in the essential oil of *hauss1* and 4α,7β,7α-nepetalacton (10.5%), trans calamenene (7.6%) and caryophyllene oxide (5.5%) in the oil of *hauss3*. The chemical composition of *hauss2* oil was more different and contained 4α,7α,7α-nepetalacton (26.7%), α-selinene (11.8%), Selina-3,11-dien-6-α-ol (6.2%) and caryophyllene oxide (6%) as the other main components. In a literature review, there was only one research about *N. haussknechtii* oil (plant material from Arasbaran (Northwest of Iran) forests) that has been reported 1,8-cineole (36.7%) and elemol (11.4%) as the main components [9] without any percentage of nepetalactone isomer.

Twenty-nine components were identified in the essential oils of two populations of *N. speciosa*, representing 99.3% of the oils. 4α,7β,7α-nepetalacton (74.8%) was found in high amounts in the oil of one population (*speci1*), while it was not found in the second one (*speci2*). The other significant constituents in the oil of *speci1* were limonene (7.8%) and 4α,7α,7α-

nepetalactone (5.4%). The essential oil of *speciosa* contained 1,8-cineole (32.3%), 4 α ,7 α ,7 α -nepetalactone (19.5%), trans calamenene (9.4%), and caryophyllene oxide (5%) as main components. So it can be said that these two populations are two chemotypes.

Essential oil diversity and chemical varieties have been reported for some *Nepeta* species previously. Hadi et al. (2016) have reported three chemotypes for *N. kotschy*, including a containing 4 α ,7 α ,7 α -nepetalactone, b containing 4 α ,7 α ,7 β -nepetalactone and cubenol, and c containing geranyl acetate and cubenol [23]. Chemodiversity of *N. menthoides* [29], *N. cataria* [30], *N. nuda* [31], and other *Nepeta* species [32] were also reported previously.

1,8-cineole, which was found in some *Nepeta* species oils in the present study, is a saturated monoterpene found in various plant species, including Eucalyptus, Rosmarinus, Psidium, Croton, and Salvia, the main sources of which are Eucalyptus leaves [33]. 1,8-cineole is a well-known compound reported in clinical studies to effectively control and improve asthma and prevent the exacerbation of chronic obstructive pulmonary disease (COPD) [34].

Nepetalactones that were found in high amounts in the oils of some populations of *N. speciosa* and *N. haussknechtii* are produced by *N. cataria* (catnip) and some other *Nepeta* species, which protect these plants from herbivorous insects by functioning as insect repellents. They are also produced by many aphids, which are sex pheromones [35]. Nepetalactones are iridoids, a class of atypical monoterpenes that act as defensive compounds in some flowering plants.

Repellent activity of the *N. cataria* oil and nepetalactone isomers against the malaria

mosquito, the brown ear tick, *Rhipicephalus appendiculatus*, and the red poultry mite, *Dermanyssus gallinae* showed the nepetalactone isomers have the potential to be used in human and livestock protection against major pathogen vectors [36].

There are many other references about the properties of nepetalactone isomers [30, 37-42]. Therefore, it could be suggested that the essential oils of *N. speciosa* and *N. haussknechtii*, as two Iranian *Nepeta* species, have the same properties and can be used for those purposes.

4. Conclusion

The essential oil content and composition of nine Iranian *Nepeta* species populations were investigated and compared. In the oils of *Nepeta straussii* Hausskn. & Bornm., *N. amoena* Stapf., *N. haussknechtii* Bornm. and *N. speciosa* Boiss. & Noë, 49, 39, 35, and 29 compounds were identified that approximately constitute 85.8-99.7%, 91.9-96.8%, 90.8-98.7%, and 99.3% of the oils, respectively.

As the main component of some *Nepeta* species oils, Nepetalactone is found in *N. speciosa* oil (more than 82% in one population and 19.5% in the other population) and *N. haussknechtii* oil (at different percentages), while *N. straussii* and *N. amoena* oils contained no nepetalactone isomer.

1,8-cineole was the main compound in the oil of one population of *N. straussii* (about 40%) and two populations of *N. haussknechtii* (more than 45%). A high percentage of caryophyllene oxide (36.2%) and hexadecanoic acid (33.4%) were found in the essential oils of two populations of *N. amoena* from two localities (with different altitudes) separately.

The results of this study that was the first study on the aerial parts essential oil of *N. straussi*, *N. amoena*, and *N. speciosa* (and a new study on the oil composition of three populations of *N. haussknechtii*), revealed specific compounds of each oil and also showed phytochemical variation between different species and also a different population of one species. Thus, it can be concluded that based on expected medicinal effects, one or some populations of each species can be selected for cultivation, oil extraction, and processing or breeding and producing superior plant varieties.

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Conflict of interest

The authors declare to have no conflict of interest.

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Table 2- Percentage composition of the essential oils of *Nepeta* species.

No	Compound	RI	<i>Nepeta straussii</i>		<i>Nepeta amoena</i>		<i>Nepeta haussknechtii</i>			<i>Nepeta speciosa</i>	
			<i>stra1</i>	<i>stra2</i>	<i>amoe1</i>	<i>amoe2</i>	<i>hauss1</i>	<i>hauss2</i>	<i>hauss3</i>	<i>speci1</i>	<i>speci2</i>
1	α -pinene	942	1.4	-	-	-	1.0	0.5	tr	-	0.4
2	Sabinene	977	1.1	-	-	-	1.5	0.4	tr	0.1	1.7
3	β -pinene	981	0.5	-	-	-	0.9	0.3	-	-	-
4	myrcene	992	10.0	tr	-	-	2.6	1.9	2.0	0.2	-
5	α -terpinene	1017	-	-	-	-	0.6	1.0	tr	-	-
6	p-cymene	1027	0.4	-	-	-	2.8	0.5	0.9	-	1.1
7	limonene	1030	0.7	-	-	-	0.9	0.3	0.5	7.8	0.4
8	β -phellandrene	1030	-	-	-	-	2.3	1.5	0.7	-	-
9	1,8-cineole	1032	40.1	6.1	-	-	48.6	24.5	45.1	0.2	32.3
10	Linalool	1100	-	-	-	-	0.5	-	-	-	4.8
11	n-nonanal	1101	-	-	0.9	-	-	-	-	-	-
12	α -campholenal	1129	0.4	1.4	-	-	-	-	-	-	-
13	Trans pinocarveol	1142	3.0	1.0	-	-	-	-	-	-	-
14	Cis sabinol	1146	0.6	0.7	-	-	-	-	-	-	-
15	β -pinene oxide	1154	-	-	-	-	-	-	-	-	1.7
16	pinocarvone	1168	2.1	0.6	-	-	-	-	0.5	-	1.4
17	borneol	1169	-	0.7	-	-	-	-	-	-	-
18	terpinen-4-ol	1180	0.8	0.7	1.0	-	2.0	tr	0.7	-	4.2
19	geranyl acetate	1381	-	0.9	-	-	-	-	-	-	-
20	p-cymene-8-ol	1185	-	-	-	-	-	-	-	-	0.6
21	hexyl butyrate	1191	-	-	tr	-	-	-	-	-	-
22	α -terpineol	1192	-	0.2	0.2	-	-	-	0.9	-	-
23	myrtenol	1198	2.4	-	-	-	-	-	-	-	-
24	myrtenal	1199	2.8	0.7	-	-	1.0	-	-	-	-
25	verbenone	1207	-	-	-	-	-	1.9	2.5	-	-

No	Compound	RI	<i>Nepeta strausii</i>		<i>Nepeta amoena</i>		<i>Nepeta haussknechtii</i>			<i>Nepeta speciosa</i>	
			<i>stra1</i>	<i>stra2</i>	<i>amoe1</i>	<i>amoe2</i>	<i>hauss1</i>	<i>hauss2</i>	<i>hauss3</i>	<i>speci1</i>	<i>speci2</i>
26	trans carveol	1219	-	-	-	-	-	-	-	1.3	0.5
27	cis myrtanol	1253	-	-	-	-	-	-	1.2	-	-
28	cis chrysanthenyl acetate	1265	-	-	1.0	tr	-	-	-	-	-
29	n-decanal	1273	-	-	1.1	-	-	-	-	-	-
30	bornyl acetate	1292	-	1.8	-	-	-	-	-	-	-
31	carvacrol	1302	-	0.6	-	-	-	-	-	-	-
32	4 α -7 α -7 α -nepetalactone	1363	-	-	-	-	1.4	26.7	2.4	5.4	19.5
33	isolekene	1374	-	-	tr	1.8	-	-	-	-	-
34	α -copaene	1380	0.5	0.9	1.3	1.2	1.9	-	0.4	0.8	-
35	β -cubebene	1388	-	0.4	-	-	-	-	-	-	-
36	4 α -7 α -7 α β -nepetalactone	1390	-	-	-	-	0.8	0.7	2.3	1.9	-
37	β -bourbonene	1391	0.9	0.7	1.6	0.9	-	-	-	-	-
38	β -elemene	1394	tr	0.9	-	-	-	-	-	-	-
39	4 α ,7 β ,7 α -nepetalacton	1396	-	-	-	-	7.4	2.3	10.5	74.8	-
40	methyl eugenol	1404	-	-	-	-	-	-	-	tr	-
41	E-caryophyllene	1422	5.8	7.1	4.5	3.0	-	-	0.6	-	1.8
42	β -copaene	1435	2.3	-	-	-	-	-	-	-	-
43	α -trans-bergamotene	1435	4.2	0.2	-	-	-	-	-	-	-
44	geranyl acetone	1455	-	0.3	0.9	-	-	-	-	-	-
45	α -humulene	1458	0.5	0.7	-	-	-	-	0.7	-	-
46	E- β -farnesene	1460	0.3	-	1.4	0.6	-	-	-	-	-
47	γ -muurolene	1483	-	-	1.3	1.4	-	-	1.6	-	-
48	germacrene D	1485	8.9	11.6	-	-	8.6	-	-	-	-
49	β -selinene	1490	-	-	2.4	-	-	-	-	-	4.0
50	E- β -ionone	1492	-	-	0.7	-	-	-	-	-	-

No	Compound	RI	<i>Nepeta straussii</i>		<i>Nepeta amoena</i>		<i>Nepeta haussknechtii</i>			<i>Nepeta speciosa</i>	
			<i>stra1</i>	<i>stra2</i>	<i>amoe1</i>	<i>amoe2</i>	<i>hauss1</i>	<i>hauss2</i>	<i>hauss3</i>	<i>speci1</i>	<i>speci2</i>
51	epi-cubenol	1494	-	-	-	-	-	-	0.7	-	-
52	valencene	1496	-	1.9	-	-	-	-	-	-	-
53	trans muurolo-4(14),5-diene	1497	-	-	-	-	-	-	-	0.8	3.3
54	α -selinene	1498	-	-	-	-	2.3	11.8	0.6	-	-
55	bicyclogermacrene	1500	0.1	-	-	-	1.7	-	-	-	-
56	E,E- α -farnesene	1506	-	1.0	-	-	0.5	-	-	-	-
57	germacrene A	1509	0.2	1.0	-	-	-	-	-	-	-
58	myristicin	1517	-	-	-	0.7	-	-	-	-	-
59	γ -cadinene	1517	-	-	1.1	-	-	-	-	1.4	-
60	δ -cadinene	1526	0.1	1.2	1.1	-	-	-	-	-	-
61	cis calamenene	1528	-	-	tr	4.6	-	-	-	-	-
62	trans calamenene	1532	-	-	7.1	7.8	1.6	2.2	7.6	0.6	9.4
63	α -cadinene	1539	-	-	0.3	-	-	-	-	-	-
64	α -calacorene	1546	-	-	0.4	-	-	-	-	-	-
65	elemicin	1557	-	-	-	-	-	-	-	tr	-
66	germacrene B	1561	0.5	-	-	-	-	-	-	-	-
67	epi-longipinanol	1564	-	1.3	0.6	-	-	-	-	-	-
68	1-nor-bourbonene	1566	0.5	1.6	-	-	-	-	-	-	-
69	longicamphenylone	1568	-	-	-	-	-	-	-	-	-
70	spathulenol	1581	0.5	3.7	2.9	6.9	2.6	0.8	2.8	0.2	1.5
71	caryophyllene oxide	1586	6.2	11.9	36.2	2.7	5.2	6.0	5.5	0.8	5
72	presilphiperfolan-8-ol	1586	-	-	3.1	-	-	-	-	-	-
73	globulol	1589	-	-	-	-	-	0.7	0.4	0.8	1.7
74	copaen-4 α -ol	1590	-	2.2	-	-	-	-	-	-	-
75	guaiol	1601	-	1.1	-	-	-	-	-	-	-

No	Compound	RI	<i>Nepeta strausii</i>		<i>Nepeta amoena</i>		<i>Nepeta haussknechtii</i>			<i>Nepeta speciosa</i>	
			<i>stra1</i>	<i>stra2</i>	<i>amoe1</i>	<i>amoe2</i>	<i>hauss1</i>	<i>hauss2</i>	<i>hauss3</i>	<i>speci1</i>	<i>speci2</i>
76	trans Isolongifolanone	1627	0.2	-	-	-	-	-	-	-	-
77	selina-3, 11-dien-6- α -ol	1644	-	-	-	-	tr	6.2	1.6	-	-
78	epi- α -cadinol	1645	-	-	-	0.9	-	-	-	-	-
79	α -muurolol	1646	-	-	-	0.7	-	-	-	-	-
80	trans- β -guaiene	1646	-	-	tr	1.7	-	-	-	-	-
81	α -cadinol	1654	-	2.3	-	-	-	-	-	-	-
82	β -eudesmol	1654	-	-	-	-	-	-	-	0.4	-
83	neo-intermedeol	1658	-	-	-	1.2	-	-	-	-	-
84	valerianol	1658	0.5	-	-	-	-	-	-	-	-
85	intermedol	1665	-	-	-	0.8	-	-	-	-	-
86	muurol-5-en-4-one (cis-14-nor)	1671	0.3	-	-	-	-	0.6	1.3	-	-
87	cadalene	1675	-	-	tr	3.4	-	-	-	-	-
88	khusinol	1683	-	4.2	-	1.2	-	-	-	-	-
89	epi- α -bisabolol	1683	-	-	tr	1.7	-	-	-	-	-
90	eudesma-4(15),7-dien-1, β -ol	1691	-	3.9	0.5	-	-	-	-	1.8	-
91	kusimol	1741	-	-	-	2.2	-	-	-	-	-
92	α -vetivone	1842	-	-	8.4	6.0	-	-	-	-	-
93	n-nonadecane	1904	0.9	10.3	-	-	-	-	1.0	-	-
94	hexadecanoic acid	1959	-	-	6.8	33.4	-	-	-	-	-
95	n-heneicosane	2104	-	-	5.1	12.0	-	-	-	-	4.0
Total percentage			99.7	85.8	91.9	96.8	98.7	90.8	95.0	99.3	99.3
Essential oil yield (%)			0.51	0.22	0.11	0.19	0.23	0.48	0.25	0.38	0.12