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Essential oil of *Nepeta* genus (Lamiaceae) from Iran: a review

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A literature-based survey of *Nepeta* species essential oil composition found in Iran was carried out. As a result, forty-one species belonging to the *Nepeta* genus were identified for their essential oil composition. A concise review of the scientific literature pertaining to constituents of *Nepeta* essential oils and volatile fractions is presented.

Keywords: Lamiaceae; *Nepeta*; essential oil

Introduction

Aromatic plants are at present widely studied for their large therapeutic potential and benefits. These benefits depend largely on essential oils, which, in general terms, occur in many herbs. The essential oils that are the essence of the plant's fragrance are also called ethereal oils or volatile oils because they evaporate quickly when exposed to the air at ordinary temperatures (1). In general, the essential oils consist of chemical mixtures involving several tens to hundreds of different types of molecules. Only a few have a high percentage of a single component. Essential oils are used to give flavor to foods and drinks and as fragrances in the food and cosmetics industries, where numerous herbal plant and spice ingredients are components in the manufacture of skin creams, lip balms, shampoos, soaps and perfumes (1).

One of the largest genera of the Lamiaceae family, genus *Nepeta*, belongs to the subfamily Nepetoideae and tribe Mentheae, which comprises about 300 herbaceous perennial, rarely annual species (2). This genus has beautiful flowers with a pleasant odor (3). The greatest diversity and richness of species is found in two areas: Southwestern Asia, especially Turkey and Iran, and the Western Himalayas including Hindu Kush. Iran, particularly, is one of the centers of origin of the genus with sixty-seven species, here described by the common Persian name of 'Pune-sa' and about 53% of endemics (4). Several *Nepeta* spp. are used in folk medicine as diuretic, diaphoretic, antitussive, antispasmodic, anti-asthmatic, febrifuge, emmenagogue and sedative agents, and for antiseptic and astringent properties as a topical remedy in children with cutaneous eruptions, and for snake and scorpion bites (2). Some species are used as medicinal herbs in Iran, for example, *N. ispahanica, N. binaloudensis, N. bracteata, N. pogonosperma* and *N. pungens*, while *N. crispa* is used as a culinary herb (5). *Nepeta cataria*, the most intensively studied species, is found in the Eastern Mediterranean, Southern Asia, Iran and China, and is commonly known as 'Catnip' or "Catmint" because of its irresistible action on cats (2). The diversity, species richness and variation, as well as chemical properties have led to much research on the genus *Nepeta*. Nepetalactones, iridoids and their glucosides, diterpenes, triterpenes and flavonoids were reported as major constituents of *Nepeta* species. Most *Nepeta* species are rich in essential oils, and various biologically active iridoids/monoterpene nepetalactones have been reported in its several species possessing diverse biological activities, namely feline attractant, canine attractant, insect repellant, arthropod defense (6, 7), antibacterial, antifungal and antiviral activities (6). Furthermore, the Nepetoideae, often pleasantly aromatic plants of potential economic interest, comprise the majority of the essential oil rich genera of the Lamiaceae, and particularly tend to accumulate monoterpenoid-rich essential oils (2).

There are several reports on the chemical composition of the essential oils from the members of the genus *Nepeta* found in Iran. With the purpose of giving an overview of the structural complexity and interesting chemical diversity of the essential oil composition of the genus *Nepeta*, here we review systematically the articles reported over the past decades, concerning the isolation and structural elucidation of Persian *Nepeta* species essential oil components. Particularly, we report the essential oil composition referring to forty-one native or endemic species of *Nepeta* growing wild in Iran.

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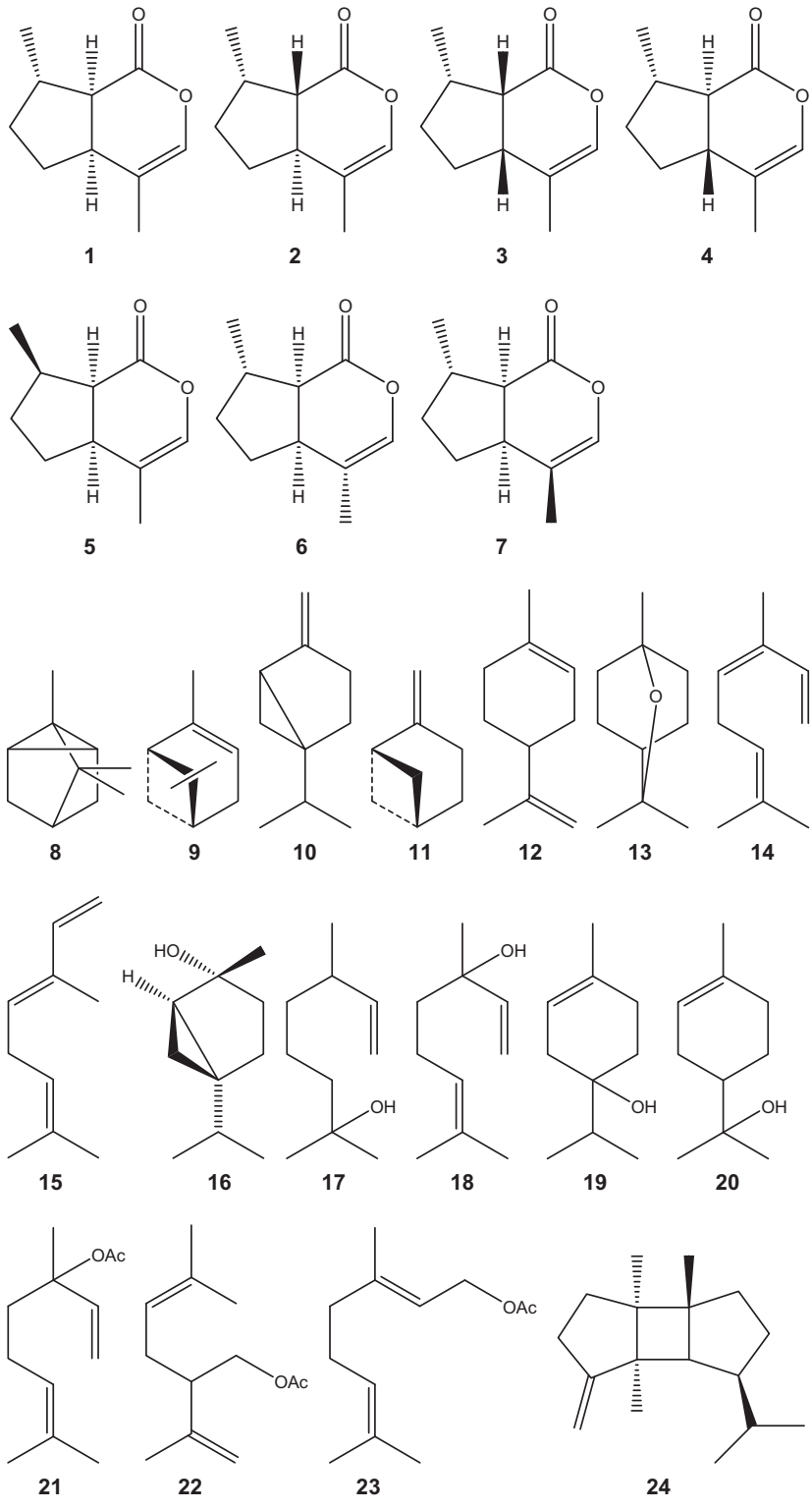

Figure 1. Structures of the nepetolactones identified in species of genus *Nepeta* found in Iran.

Methodology

The present study was carried out based on the literature review of the essential oil composition of native or endemic *Nepeta* species found in Iran. The data presented in this paper were collected using all scientific data come from encyclopedias, books, journals, articles and websites including Pubmed, Scopus and Google Scholar.

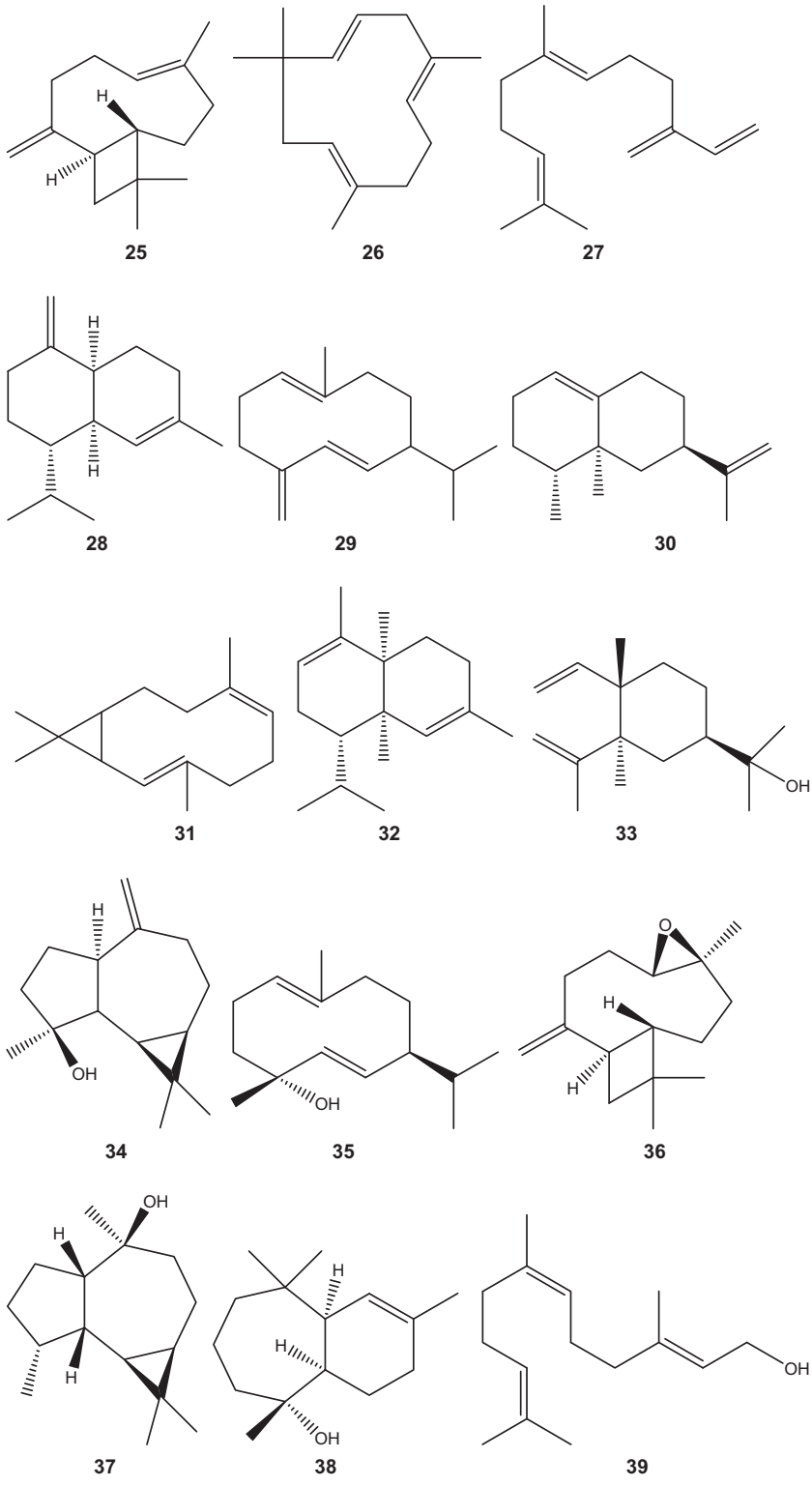

Figure 2. Structures of the terpenoids identified in species of genus *Nepeta* found in Iran.

Results and discussion

In this review, the essential oil composition of thirty-eight species including the native and endemic *Nepeta* species found in Iran have been reported. All the native and endemic species that grow wild in Iran are given in Table 1.

Table 1. The native and endemic *Nepeta* species found in Iran (15).

No.	Scientific name	Persian name	Synonyms	Native/endemic	Essential oil composition (Ref.)
1	*N. adenoclada* Bornm.	Persepolis Pune-sa	–	Endemic	
2	*N. allotria*	–	–	Endemic	
3	*N. amoena* Stapf.	Ziba Pune-sa	–	Native	
4	*N. archibaldii* Rech. f.	Zard-kuhi Pune-sa	–	Endemic	
5	*N. assadii* Jamzad	Krandi Pune-sa	–	Endemic	
6	*N. assurgens* Hausskn. & Bornm.	Barafrashteh Pune-sa	–	Endemic	(16)
7	*N. asterotricha* Rech. f.	Kork-setareii Pune-sa	–	Endemic	(17–19)
8	*N. bakhtiarica* Rech. f.	Bakhtiari Pune-sa	–	Endemic	
9	*N. betonicifolia* C. A. Mey.	Taleshi Pune-sa	*N. grandiflora* M. B.	Native	(20)
10	*N. binaludensis* Jamzad	Binaludi Pune-sa	*N. bodeana* Bunge.	Endemic	(19)
11	*N. bornmulleri* Hausskn. Ex Bornm.	Hezari Pune-sa	–	Native	(21)
12	*N. bracteata* Benth.	Bargeh-dar Pune-sa	*N. globiflora* Bunge.; *N. cabulica* Rech. f.	Native	(21, 22)
13	*N. cataria* L.	Gorbeii Pune-sa	–	Native	(23, 24)
14	*N. cephalotes* Boiss.	Koppeii Pune-sa	*N. longipetiolata* Rech. f.	Endemic	(21, 25)
15	*N. chionophila* Boiss. & Hausskn.	Moattar Pune-sa	*N. cilicica* Boiss; *N. concolor* Boiss & Heldr	Endemic	
16	*N. crassifolia* Boiss. & Buhse	Alborzi Pune-sa	–	Endemic	(12, 23, 26)
17	*N. crispa* Willd.	Mofarrah	*N. cryptantha* Boiss. & Hausskn. Ex Boiss.; *N. involucrate* (Bunge)Bornm.	Endemic	(27–30)
18	*N. curvidens* Boiss. & Bal. ex Boiss.	Dandan-kamani Pune-sa	–	Native	
19	*N. denaensis* Boiss.	Denaee Pune-sa	–	Native	(22, 31)
20	*N. denudate* Benth.	Oryan Pune-sa	–	Endemic	(25)
21	*N. depauperata* Benth.	Kam-gol Pune-sa	–	Endemic	(22, 32)
22	*N. dschuparensis* Bornm.	Jupari Pune-sa	*N. elborsensis* Rech. f.	Endemic	
23	*N. elymaitica* Bornm.	Ilami Pune-sa	–	Native	(33)
24	*N. eremokosmos* Rech. f.	Taj-korki Pune-sa	*N. eremophila* Hausskn. & Bornm.; *N. ispahanica* Boiss.	Endemic	(27)
25	*N. eriosphaera* Rech. f. & Koeie	Sar-korki Pune-sa	*N. erivanensis* Grossh.; *N. involucrate* (Bunge)Bornm	Native	
26	*N. fissa* C. A. Mey.	Shekafteh Pune-sa	*N. microphylla* Stapf.; *N. trautvetteri* Bois. & Buhse; *N. carmanica* Bornm.; *N. fissicalyx* Rech. f.; *N. juncea* Benth. subsp. desertorum	Native	(30)
27	*N. gedrosiaca* Bornm.	–	–	Endemic	
28	*N. gloeocephala* Rech. f.	Yazdi Pune-sa	–	Endemic	(34)
29	*N. glomerulosa* Boiss.	–	–	Endemic	(35)
30	*N. glomerulosa* Boiss. subsp. *carmanica* (Bornm.) Rech. f.	Anbuh-kermani Pune-sa	–	Endemic	(36)
31	*N. glomerulosa* Boiss. subsp. *glomerulosa*	Anbuh Pune-sa	–	Endemic	
32	*N. glomerulosa* Boiss. subsp. *stapfiana* (Bornm. Ex arech. f.) Rech. f.	Bamuee Pune-sa	*N. stapfiana* Bornm. ex Rech. f.	Endemic	

33	*N. haussknechtii* Bornm.	Araqi Pune-sa	–	Native	(37)
34	*N. heliotropifolia* Lam.	Aftab-parasti Pune-sa	*N. callichroa* Hausskn. & Briq.	Endemic	(10, 38)
35	*N. humilis* Benth.	Pa-kutah Pune-sa	–	Native	
36	*N. hymenodonta* Boiss.	Dandaneh-shaffaf Pune-sa	*N. inconspicua* Bornm.	Endemic	
37	*N. involucrate* (Bunge.)Bornm.	Gariban-dar Pune-sa	*N. cryptantha* Boiss. & Hausskn. Ex Boiss.; *N. erivanensis* Grossh.	Endemic	(30, 39)
38	*N. iranshahrii* Rech. f.	Ardali Pune-sa	–	Endemic	
39	*N. ispahanica* Boiss.	Isfahani Pune-sa	*N. eremophila* Hausskn. & Bornm.	Endemic	(11, 19, 27, 40)
40	*N. juncea* Benth. subsp. desertorum Bornm.	Baluchistani Pune-sa	*N. gedrosiaca* Bornm.	Native	
41	*N. koeieana* Rech. f.	Dezfuli Pune-sa	*N. kopetdaghensis* Pojark.; *N. ucrainica* L. subsp. *kopetdaghensis*	Endemic	
42	*N. kotschyi* Boiss.	Kuh-delu Pune-sa	*N. kurdica* Hausskn. & Bornm; *N. wettsteinii* H. Braun.; *N. lagopsioides* Parsa	Endemic	(41)
43	*N. lasiocephala* Benth.	Kuh-sari Pune-sa	–	Endemic	
44	*N. laxiflora* Benth.	Tonok Pune-sa	*N. scabridifolia* Stapf.; *N. leucostegia* Boiss. & Heldr.; *N. longiflora* Vent.	Endemic	(22, 42)
45	*N. macrosiphon* Boiss.	Lule-boland Pune-sa	*N. marifolia* Boiss. & Huet.; *N. racemosa* Lam.	Native	(43)
46	*N. mahanensis* Jamzad & Simmonds	Mahani Pune-sa	–	Native	(27)
47	*N. makuensis* Jamzad et Mozaff.	Makuee Pune-sa	–	Endemic	(44)
48	*N. menthoides* Boiss. & Buhse.	Sabalani Pune-sa	–	Endemic	(29, 42, 45)
49	*N. Meyeri* Benth.	Azari Pune-sa	*N. michauxii* Briq.; *N. micrantha* Bge.; *N. microphylla* Stapf.; *N. fissa* C. A. Mey.	Native	(46, 47)
50	*N. mirzayanii* Rech. f. & Esfand	Karvandari Pune-sa	–	Endemic	(21)
51	*N. monocephala* Rech. f.	Tak-kapeh Pune-sa	*N. mussinii* Spreng.; *N. racemosa* Lam.	Native	
52	*N. nuda* L.	Bi-kork Pune-sa	*N. meda* Stapf.	Native	
53	*N. oxyodonta* Boiss.	Tiz-dandan Pune-sa	*N. oligophylla* Rech. f.	Endemic	(22, 48)
54	*N. persica* Boiss.	Irani Pune-sa	–	Native	(13, 49)
55	*N. petraea* Benth.	Sanglakhi Pune-sa	–	Native	
56	*N. pogonosperma* Jamzad et Assadi	–	–	Endemic	(50)
57	*N. prostrate* Benth.	Gostardeh Pune-sa	–	Endemic	
58	*N. pungens* (Bunge)Benth.	Nish-dar Pune-sa	–		(22)
59	*N. racemosa* Lam.	Alborzi Pune-sa	*N. elbursensis* Rech. f.; *N. mussinii* Spreng.; *N. grandiflora* M. B.; *N. marifolia* Boiss. & Huet.	Native	(51, 52)
60	*N. rivularis* Bornm.	Juybari Pune-sa	–	Endemic	(27)
61	*N. saccharata* Bunge.	Shirin Pune-sa	–	Native	(20)
62	*N. satureioides* Boiss	Marzeii Pune-sa	–	Native	(53)
63	*N. schiraziana* Boiss.	Shirazi Pune-sa	*N. schischkinii* Pojark	Endemic	
64	*N. scrophularioides* Rech. f.	Gol-meymuni Pune-sa	–	Endemic	
65	*N. sessilifolia* Bunge.	Ghahroudi Pune-sa	*N. sewerzowii* Regel.	Endemic	(37)
66	*N. sintenisii* Bornm.	Torkamani Pune-sa	–	Endemic	(54)
67	*N. speciosa* Boiss. & Nöe	Tamashaee Pune-sa	*N. stapfiana* Bornm. & Rech. f.	Native	
68	*N. stenantha* Kotschy & Boiss. ex Boiss.	Gol-barik Pune-sa	–	Native	

(*Continued*)

Table 1. (*Continued*).

No.	Scientific name	Persian name	Synonyms	Native/endemic	Essential oil composition (Ref.)
69	*N. straussii* Hausskn. & Bornm.	Araki Pune-sa	*N. subincisa* Benth.; *N. teucriifolia* sensu Boiss.	Endemic	
70	*N. ucrainica* L. subsp. *kopetdaghensis* (Pojark.) Rech. f.	Kopetdaghi Pune-sa	*N. kopetdaghensis* Pojark	Endemic	
71	*N. ucrainica* L. subsp. *schischkinii* Pojark.	Ukraini Pune-sa	*N. schischkinii* Pojark.	Native	
72	*N. wettsteinii* H. Braun.	Zanjani Pune-sa	*N. kurdica* Hausskn. & Bornm	Endemic	
73	*N. zangezurea* Grossh.	Armanestani Pune-sa	–	Native	

There are several reports on the chemical composition of the essential oils from the members of the genus *Nepeta* from Iran. Publications on *Nepeta* volatile oils clearly demonstrate that chemical polymorphism is characteristic of this species, and the oil composition depends on variety, growing site, climatic conditions and analysis method (2). Generally, it appears that there are two main chemotypes for the essential oils of these plants: the first is the nepetolactone chemotype that comprises species containing the diastereoisomeric nepetalactones 1–5 (Table 2).

The various nepetalactone isomers such as 4aα, 7α,7aα-nepetalactone, 4aα,7α,7aβ-nepetalactone, 4aβ, 7α,7aβ-nepetalactone, 4aβ,7α,7aα-nepetalactone and 4aα,7β,7aα-nepetalactone, have been labeled as the biochemical markers of the *Nepeta* essential oils and are very useful in chemotaxonomic studies (8). The occurrence of these compounds in *Nepeta* species growing wild in Iran is compiled in the Table 2.

Among the monoterpenoids, the most abundant components determined are the iridoid monoterpenes, nepetalactones 1–5, that frequently appear as the main constituents (2). The nepetalactone is a cyclopentanoid monoterpene with two fused rings, a cyclopentane and a lactone. There exist eight stereoisomers of nepetalactone, four diastereoisomers and their corresponding enantiomers. With some exceptions, the (7*S*)-diastereomers are the ones found in natural sources (9).

The 4aα,7α,7aα-nepetalactone (**1**) was isolated from fourteen *Nepeta* species in Iran. It was the first methylcyclopentane monoterpenoid fully characterized (2). Subsequently, numerous such monoterpenoids were identified, many by correlation with **1** and its degradation products. The epimer, 4aα,7α,7aβ-nepetalactone (**2**), was isolated from eight *Nepeta* species, and its structure and absolute configuration were determined by degradation and partial synthesis (10, 11). The third nepetalactone diastereoisomer, 4aβ,7α,7aβ-nepetalactone (**3**), was isolated from the essential oil of ten *Nepeta* species. Its structure and configuration were deduced by degradation, and by comparison of its 1H- and 13C-NMR spectra with those of **1** and **2** (2). The nepetalactones **4** and **5** were detected in eight and two *Nepeta* species, respectively. The spectral data of 4aα,7β,7aα-nepetalactone (**5**) were described for the first time in an article that reported the conversions of (−)-limonene to nepetalactones in a stereochemically controlled manner (2).

Different compounds related to nepetalactone have been isolated from *Nepeta* species. Hydrogenated derivatives of nepetalactone, α-dihydronepetalactone (**6**) and δ-dihydronepetalactone (**7**), were found to occur naturally in the essential oils of *N. crassifolia* (12) and *N. persica* (13).

The second group is the 1,8-cineole and/or linalool chemotype that produces an essential oil of herbaceous, mildly menthole-like odor, which may be attributed to its high content of 1,8-cineole (Table 3).

As shown in Table 3, thirty-three compounds were identified in the essential oil of Persian *Nepeta* species in sizeable amounts. The essential oil composition of these species is dominated by the presence of monoter-

Table 2. Chemical constituents of the essential oil of nepetolactone chemotype species of genus *Nepeta* found in Iran.

No.	Compound	Species	Percentage	Ref.
1.	4aα,7α,7aα-Nepetalactone	*N. asterotricha*	<5	(17)
		N. binaloudensis	25	(19)
		N. bornmuelleri	<5	(21)
		N. cephalotes	90.1	(21)
			35.1	(25)
		N. crassifolia	72.8	(12)
			5.9	(23)
			92.6	(26)
		N. crispa	10.3	(27)
		N. eremophila	<5	(27)
		N. heliotropifolia	<5	(10)
		N. ispahanica	6.2	(11)
		N. menthoides	23.2	(42)
		N. meyeri	<5	(46)
		N. mirzayanii	61.0	(21)
		N. racemosa	64.9	(52)
			24.4	(51)
		N. rivularis	<5	(27)
		N. mahanensis	37.6	(27)
2.	4aα,7α,7aβ-Nepetalactone	*N. cataria*	28.8	(23)
		N. crassifolia	<5	(12)
		N. crispa	20.3	(28)
		N. heliotropifolia	16.3	(10)
		N. meyeri	68.1	(46)
			53.2	(47)
		N. persica	26.5	(13)
			28.3	(49)
		N. racemosa	7.4	(52)
			25.6	(51)
		N. pogonosperma	57.6	(50)
3.	4aβ,7α,7aβ-Nepetalactone	*N. asterotricha*	14.8	(17)
			18.2	(18)
		N. bornmuelleri	64.0	(21)
		N. sintenisii	23.4	(54)
		N. crassifolia	<5	(12)
			<5	(26)
		N. crispa	9.2	(27)
		N. eremophila	73.3	(27)
		N. mirzayanii	<5	(21)
		N. persica	62.3	(49)
		N. racemosa	33.6	(51)
		N. saccharata	6	(20)
4.	4aβ,7α,7aα-Nepetalactone	*N. binaloudensis*	<5	(19)
		N. crassifolia	<5	(26)
		N. crispa	<5	(27)
		N. elymatica	35.6	(33)
		N. ispahanica	<5	(27)
		N. kotschyi	92.0	(41)
		N. persica	26.5	(13)
5.	4aα,7β,7aα-Nepetalactone	*N. cataria*	11.9	(23)
		N. crassifolia	81.1	(23)
		N. betonicifolia	42.0	(20)
6.	4α-Dihydronepetalactone	*N. crassifolia*	<5	(12)
		N. persica	26.5	(13)
7.	4β-Dihydronepetalactone	*N. crassifolia*	<5	(12)

Table 3. Components of the essential oil of 1,8-cineole and/or linalool chemotype species of genus *Nepeta* found in Iran (>5%).

No.	Compound	Species	Percentage	Ref.
8	Tricyclene	*N. depauperata*	8.2	(22)
9	α-Pinene	*N. fissa*	5.8	(30)
		N. gloeocephala	7.1	(34)
		N. depauperata	41.0	(22)
		N. denaensis	14.5	(31)
		N. involucrate	5.0	(30)
		N. laxiflora	19.7	(42)
		N. glomerulosa	9.4	(35)
		N. cataria	10.3	(24)
		N. glomerulosa subsp. *carmanica*	18.3	(36)
10	Sabinene	*N. gloeocephala*	7.8	(34)
		N. involucrate	6.7	(39)
		N. rivularis	14.8	(27)
		N. saccharata	6.5	(20)
11	β-Pinene	*N. fissa*	6.0	(30)
		N. crispa	5.0	(29)
			6.9	(28)
		N. menthoides	5.6	(29)
			8.8	(45)
		N. assurgens	5.3	(16)
		N. gloeocephala	21.8	(34)
		N. involucrate	12.2	(39)
		N. cephalotes	18.2	(25)
			7.5	(21)
		N. rivularis	10.7	(27)
		N. ispahanica	8.9	(11)
12	Limonene	*N. glomerulosa*	8.2	(35)
		N. glomerulosa subsp. *carmanica*	9.7	(36)
13	1,8-Cineole	*N. racemosa*	9.0	(51)
		N. sintenisii	8.2	(54)
		N. ispahanica	45.8	(11)
			71.7	(27)
			66.0	(19)
			78.2	(40)
		N. binaludensis	42.0	(19)
		N. haussknechtii	36.7	(37)
		N. cataria	21.0	(24)
			13.5	(23)
		N. denudata	48.0	(25)
		N. cephalotes	11.4	(25)
		N. pogonosperma	26.4	(50)
		N. elymatica	29.7	(33)
		N. heliotropifolia	16.8	(10)
			19.0	(38)
		N. crassifolia	9.0	(12)
		N. crispa	71.0	(29)
			47.9	(30)
			62.8	(27)
		N. mahanensis	27.2	(27)
		N. eremophylla	13.1	(27)
		N. rivularis	38.5	(27)
		N. asterotricha	17.4	(19)
			11.6	(18)
		N. meyeri	29.3	(47)
		N. burnmuelleri	7.1	(21)
		N. menthoides	41.1	(29)
			33.8	(42)
			57.3	(45)

(*Continued*)

Table 3. (*Continued*).

No.	Compound	Species	Percentage	Ref.
		N. assurgens	21.3	(16)
		N. oxyodonta	9.4	(22)
		N. depauperata	7.3	(22)
		N. denaensis	9.9	(22)
		N. gloeocephala	35.2	(34)
		N. involucrate	23.1	(39)
		N. laxiflora	11.8	(42)
		N. meyeri	29.3	(47)
		N. glomerulosa subsp. *carmanica*	13.9	(36)
14	(*Z*)-β-Ocimene	*N. gloeocephala*	6.9	(34)
		N. racemosa	9.5	(52)
15	(*E*)-β-Ocimene	*N. gloeocephala*	7.1	(34)
16	*cis*-Sabinene hydrate	*N. sintenisii*	6.5	(54)
		N. heliotropifolia	16.1	(10)
17	Linalool	*N. satureioides*	23.8	(53)
		N. heliotropifolia	11.9	(10)
		N. asterotricha	17.4	(19)
		N. sessilifolia	14.2	(37)
18	Nonanal	*N. oxyodonta*	6.1	(22)
19	4-Terpineol	*N. menthoides*	7.1	(29)
		N. denaensis	7.4	(22)
		N. asterotricha	22.8	(19)
			24.8	(18)
20	α-Terpineol	*N. menthoides*	5.7	(29)
		N. denaensis	5.7	(22)
21	Linalyl acetate	*N. satureioides*	11.1	(53)
		N. sessilifolia	14.7	(37)
22	Lavandulyl acetate	*N. satureioides*	6.6	(53)
23	Geranyl acetate	*N. menthoides*	6.1	(29)
			8.1	(45)
		N. glomerulosa	9.3	(35)
		N. cataria	8.2	(24)
24	β-Bourbonene	*N. oxyodonta*	8.1	(48)
		N. ucrainica ssp. *kopetdaghensis*	5.8	(55)
25	β-Caryophyllene	*N. fissa*	17.4	(30)
		N. depauperata	12.9	(32)
			23.4	(22)
			7.8	(22)
		N. oxyodonta	12.6	(48)
			17.8	(22)
		N. satureioides	6.6	(53)
		*N. bracteat*a	5.0	(22)
		N. laxiflora	7.2	(22)
		N. denaensis	5.4	(22)
			7.8	(22)
			27.1	(31)
		N. pungens	20.0	(22)
		N. bracteata	11.2	(21)
		N. cataria	5.7	(23)
		N. heliotropifolia	11.3	(38)
26	α-Humulene	*N. cataria*	14.4	(24)
27	E-β-Farnesene	*N. sintenisii*	9.5	(54)
28	γ-Muurolene	*N. fissa*	7.9	(30)
20	Germacrene D	*N. oxyodonta*	7.4	(48)
		N. macrosiphon	9.2	(43)
		N. involucrate	15.1	(39)
		N. mahanensis	6.5	(27)
		N. betonicifolia	6.0	(20)
		N. saccharata	12.9	(20)
		N. daenensis	11.4	(31)
		N. ucrainica ssp.	39.7	(55)

(*Continued*)

Table 3. (*Continued*).

No.	Compound	Species	Percentage	Ref.
30	Valencene	*N. fissa*	6.6	(30)
31	Bicyclogermacrene	*N. macrosiphon*	5.7	(43)
		N. bracteata	11.4	(21)
		N. daenensis	9.6	(31)
32	α-Muurolene	*N. macrosiphon*	6.0	(43)
33	Elemol	*N. sintenisii*	16.1	(54)
		N. haussknechtii	11.4	(37)
34	Spathulenol	*N. depauperata*	31.8	(32)
		N. oxyodonta	8.5	(48)
		N. macrosiphon	14.1	(43)
		N. makuensis	9.0	(44)
		N. bracteata	14.0	(21)
		N. heliotropifolia	8.3	(38)
35	Germacrene D-4-ol	*N. oxyodonta*	6.8	(48)
36	Caryophyllene oxide	*N. fissa*	12.3	(30)
		N. depauperata	10.3	(32)
		N. oxyodonta	5.3	(48)
		N. satureioides	6.4	(53)
		N. macrosiphon	8.1	(43)
		N. glomerulosa	8.0	(35)
		N. mirzayanii	7.8	(21)
		N. bracteata	12.3	(21)
		N. heliotropifolia	14.2	(38)
37	Viridiflorol	*N. makuensis*	17.5	(44)
38	α-Cadinol	*N. depauperata*	5.4	(32)
		N. macrosiphon	5.0	(43)
39	(*Z*,*E*)-Farnesol	*N. satureioides*	14.7	(53)

pene hydrocarbons, sesquiterpene hydrocarbons, oxygenated monoterpenes and oxygenated sesquiterpenes. 1,8-Cineole, as the most abundant component in many *Nepeta* species essential oil, has been reported in *N. racemosa*, *N. sintenisii*, *N. cataria*, *N. crispa*, *N. menthoides*, *N. assurgens*, *N. oxyodonta*, *N. depauperata*, *N. daenensis*, *N. gloeocephala*, *N. involucrate*, *N. laxiflora*, *N. meyeri*, *N. ispahanica*, *N. binaludensis*, *N. denudate*, *N. cephalotes*, *N. pogonosperma*, *N. elymatica*, *N. heliotropifolia*, *N. crassifolia*, *N. mahanensis*, *N. eremophylla*, *N. rivularis*, *N. asterotricha* and *N. burnmuelleri*. However, linalool, which was the other abundant component in most *Nepeta* species (8), was present accompanying its ester, linalyl acetate, in just two species – *N. satureioides* and *N. sessilifolia*. *Nepeta heliotropifolia* and *N. asterotricha* also contained linalool but lacked linalyl acetate. β-Caryophyllene, the other major constituent of the oil samples, has also been reported in various *Nepeta* species such as *N. fissa*, *N. depauperata*, *N. oxyodonta*, *N. satureioides*, *N. bracteata*, *N. laxiflora*, *N. daenensis*, *N. pungens*, *N. cataria* and *N. heliotropifolia*. Likewise, the other major components such as the monoterpene hydrocarbons, α-pinene and β-pinene, have been both reported in *N. fissa*, *N. gloeocephala* and *N. involucrate*.

(*E*)-β-ocimene was found just in *N. gloeocephala* while its isomer (*Z*)-β-ocimene identified in both *N. gloeocephala* and *N. racemosa*. Nonanal, β-bourbonene and germacrene D-4-ol was identified just in *N. oxyodonta*. *Nepeta sintenisii* was the only species contained *cis*-sabinene hydrate, *E*-β-farnesene and elemol. Bicyclogermacrene and α-muurolene were just found in the essential oil of *N. macrosiphon* while γ-muurolene and valencene were found just in that of *N. fissa*. Compounds such as tricyclene, α-humulene, (*Z*,*E*)-farnesol and viridiflorol were found in sizable amounts in just *N. depauperata*, *N. menthoides*, *N. cataria*, *N. satureioides* and *N. makuensis* respectively.

Data from Tables 2 and 3 show a complex composition of the essential oils, especially for the same species. Indeed the composition of essential oils depends on climatic and ecological conditions, plant organ and vegetative cycle stage. Thus, it is of utmost importance to characterize the essential oils composition as well as the influence of the referred parameters on its quality, in order to obtain essential oils of constant composition. According to Guedes et al. (14), this could only be possible if essential oils are extracted under the same conditions from the same organ of the plant, which has been growing on the same soil, under the same climate and has been picked in the same season.

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