

REVIEW

# A review on the essential oil chemical profile of *Salvia* genus from Iran

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## Abstract

Iran is one of the major centres of diversity for *Salvia*, with 58 species of which 25% are endemic. A literature-based survey of the chemical profile of *Salvia* species essential oil found in Iran was carried out. As a result, 46 species belonging to *Salvia* genus were identified for their essential oil composition. A concise review of the scientific literature pertaining to components of *Salvia* essential oils and volatile fractions is presented. The present review showed that the Iranian *Salvia* species have been classified into four main categories based on the GC/MS and GC-FID analyses of their essential oils. monoterpene chemotype, mono and sesquiterpene chemotype, sesquiterpene chemotype and GLV chemotype which stands for green leaf volatiles. It was indicated that the most of the studied *Salvia* species were considered as sesquiterpene chemotype. Among the sesquiterpenes,  $\beta$ -caryophyllene followed by germacrene D, spathulenol and caryophyllene oxide were the most common and abundant in Persian *Salvia* species. The  $\beta$ -caryophyllene and germacrene D were reported from 27 and 22 *Salvia* species in Iran, respectively.

**Keywords:** *Salvia*, Lamiaceae, 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. Essential oils are used to give flavour 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 (de Almeida et al., 2011).

The largest genus of the Lamiaceae family, the genus *Salvia* L. represents an enormous and cosmopolitan assemblage of nearly 1000 species displaying remarkable variation. It has undergone marked species radiations in three regions of the world: Central and South America (500 spp.), Central Asia/ Mediterranean (250 spp.) and Eastern Asia (90 spp.) (Walker et al., 2004, Claßen-Bockhoff, 2017). Iran, particularly, is one of the centers of origin of the genus with 58 species, here called with the common Persian name of "Maryam-Goli" and about 25% of endemics (Mozaffarian, 1996.)

Several species of *Salvia* are cultivated for their aromatic characteristics and are used as flavourings, food condiments, cosmetics, and perfume additives (Firdous et al., 1999). Additionally, *Salvia* species have commonly been widely used as folk medicines as antibacterial, antiviral, antitumor, spasmolytic, antioxidant and anti-inflammatory treatments and have further been used in the treatment of nervous and gastrointestinal conditions (Lu & Foo, 2002; Tepe et al., 2004)

The diversity, species richness, and variation, as well as chemical properties have led to much research on the genus *Salvia*. Diterpenoids of the abietane, icetexane, labdane, neoclerodane and phenalenone types (Kusumi et al., 1985; Nieto et al., 2000), triterpenes and sterols (Rauter et al., 2007), anthocyanins, coumarins, polysaccharides, flavonoids and phenolic acids and their derivatives (Lu & Foo, 2002) were reported as major

constituents of *Salvia* species. Most *Salvia* species are rich in essential oils, and various biologically active monoterpene/sesquiterpene have been reported in them possessing diverse biological activities such as antioxidant (Tepe et al., 2004; Kabouche et al., 2007; Guy et al., 2010), anti-inflammatory [11,12], analgesic and antipyretic [13], antiepileptic, anti-ulcerogenic, tranquillizing activities [14] and (Guy et al., 2010; El-Sayed et al., 2006) antimicrobial activities (Tepe et al., 2004; Tepe et al., 2005; Usama & Mohamed, 2006). Furthermore, the *Salvia* species, often pleasantly aromatic plants of potential economic interest, comprise most of the essential oil rich genera of the Lamiaceae, and particularly tend to accumulate monoterpenoid-rich essential oils.

There are several reports on the chemical composition of the essential oils from the members of the genus *Salvia* 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 *Salvia*, here we review systematically the articles reported over the past decades, concerning the isolation and structural elucidation of Persian *Salvia* sp. essential oil components. Particularly, we report on the essential oil composition referring to 46 native and endemic species of *Salvia* grow wild in Iran.

## Materials and Methods

The present study was carried out based on the literature review of the essential oil chemical composition of native or endemic *Salvia* species found in Iran. The data presented in this work was collected using scientific data retrieved from encyclopaedia books, journals, articles, and websites including Pubmed, Scopus and Google Scholar.

## Results and Discussion

In this review the essential oil chemical profile of 46 species including the native and endemic *Salvia* species found in Iran have been reported. All the native and endemic species which grow wild in Iran are given in Table 1.

Table 1. The native and endemic *Salvia* species found in Iran (Mozaffarian, 1996).

No.	Scientific Name	Persian Name	Synonyms	N/E	[Ref.]
1	<i>S. aegyptiaca</i> L.	Mesri Maryam-goli	<i>S. multicaulis</i> Vahl.	Native	(Jassbi et al., 2012)
2	<i>S. aethiopsis</i> L.	Pashmalu Maryam-goli	<i>S. sclarea</i> L.	Native	(Rajabi et al., 2014; Salimpour et al., 2011)
3	<i>S. aristata</i> Aucher ex Benth.	Sikhak-dar Maryam-goli	-	Native	(Emadipoor et al., 2016)
4	<i>S. artopatana</i> Bunge	Azerbaijani Maryam-goli	-	Native	(Jassbi et al., 2012; Salimpour et al., 2011; Mirza & Ahmadi, 2000)
5	<i>S. bazmanica</i> Rech. f. & Esfand	Bazmani Maryam-goli	<i>S. multicaulis</i> Vahl.	Endemic	(Akhgar et al., 2011)
6	<i>S. brachyantha</i> (Bordz.) Pobed	Forutan Maryam-goli	<i>S. indica</i> L.	Native	(Jamzad et al., 2012)
7	<i>S. bracteata</i> Banks & Soland.	Barge-dar Maryam-goli	-	Native	(Amiri, 2077; Sefidkon et al., 2007)
8	<i>S. ceratophylla</i> L.	Shakh-gavazni Maryam-goli	-	Native	-
9	<i>S. choloroleuca</i> Rech. f. & Aell.	Sefid Maryam-goli	-	Native	(Jassbi et al., 2012; Khalilzadeh et al., 2011)
10	<i>S. chorassanica</i> Bunge.	Khorassani Maryam-goli	<i>S. limbata</i> C. A. Mey., <i>S. splendens</i> Ker. Gawl.	Endemic	(Ebrahimi et al., 2014)
11	<i>S. compressa</i> Vent.	Marmarashk	<i>S. macrosiphon</i> Boiss., <i>S. spinosa</i> L., <i>S. hydrangea</i> DC. ex Benth.	Native	(Mirza & Bahernik, 2007)

12	<i>S. eremophila</i> Boiss.	Biabani Maryam-goli	-	Endemic	(Jassbi et al., 2012; Rajabi et al., 2014; Salehi et al., 2014)
13	<i>S. frigida</i> Boiss.	Yakhchali Maryam-goli	-	Native	-
14	<i>S. glutinosa</i> L.	Jangali Maryam-goli	-	Native	(Tavassoli et al., 2009)
15	<i>S. grossheimii</i> Sosn.	Nakhjavani Maryam-goli	<i>S. viridis</i> L.	Native	(Mirza & Bahernik, 2010)
16	<i>S. hydrangea</i> DC.	Aghraban	-	Native	(Sonbili et al., 2006; Ebrahimi & Ranjbar, 2016)
17	<i>S. hypochionaea</i> Boiss.	Khoee Maryam-goli	-	Endemic	-
18	<i>S. hypoleuca</i> Benth.	Boland Maryam-goli	-	Endemic	(Jassbi et al., 2012; Sonbili et al., 2016; Nichavar et al., 2005)
19	<i>S. indica</i> L.	Hendi Maryam-goli	-	Native	(Jamzad et al., 2011; Bahernik & Mirza, 2010)
20	<i>S. jamzadii</i> Mozaff.	Bakhtiari Maryam-goli	-	Endemic	-
21	<i>S. kermanshahensis</i> Rech. f.	Kermanshahi Maryam-goli	<i>S. atropatana</i> Bunge., <i>S. staminea</i> Montbr. & Auch. ex Benth.	Endemic	-
22	<i>S. lanchocalyx</i> Hedge.	Eghlidi Maryam-goli	-	Endemic	-
23	<i>S. lanigera</i> Poir.	Ilami Maryam-goli	-	Native	-
24	<i>S. leriifolia</i> Benth.	Kaboli Maryam-goli	-	Native	(Attaran et al., 2016; Monfared & Ghorbanli, 2010; Yousefi et al., 2015)
25	<i>S. limbata</i> C. A. Mey.	Labeh-dar Maryam-goli	-	Native	(Sajjadi & Shahpiri, 2004; Rajabi et al., 2014; Rustaiyan et al., 2005; Morteza-Semnani et al., 2014; Mirza et al., 2005)
26	<i>S. macilenta</i> Boiss.	Masghati Maryam-goli	-	Native	(Sonbili et al., 2005)
27	<i>S. macrochlamys</i> Boiss. & Kotschy	Gol-dorosht Maryam-goli	-	Native	(Kazemizadeh et al., 2010)
28	<i>S. macrosiphon</i> Boiss.	Lule-e Maryam-goli	-	Native	(Jassbi et al., 2012; Rajabi et al., 2014; Mirza et al., 2005; Sefidkon et al., 2013; Kariminik et al., 2019; Salimpour et al., 2011)
29	<i>S. mirzayanii</i> Rech. f. & Esfand.	Morpojo	<i>S. brachyantha</i> (Bordz.) Pobed.	Endemic	(Sonboli et al., 2006; Yamini et al., 2008; Mirza et al., 2003; Asadipour et al., 2013; Haghghat et al., 2012; Javidnia et al., 2002)
30	<i>S. multicaulis</i> Vahl.	Arghavani Maryam-goli	-	Native	(Ahmadi & Mirza, 1999)
31	<i>S. nemorosa</i> L.	Mazrae-rui Maryam-goli	-	Native	(Rajabi et al., 2014; Mirza & Sefidkon, 1999)
32	<i>S. officinalis</i> L.	Daruee Maryam-goli	-	Native	(Kazemi et al., 2015; Alizadeh & Shaabani, 2012)
33	<i>S. oligophylla</i> Auch. ex Benth.	Rudbari Maryam-goli	-	Endemic	(Salimpour et al., 2011)
34	<i>S. pachstachys</i> Trautv.	Kutah-sonbol Maryam-goli	-	Native	(Amiri, 2007; Shakeri et al., 2018)
35	<i>S. palaestina</i> Benth.	Felestini Maryam-goli	-	Native	(Rustaiyan et al., 2005; Salehi et al., 2005)
36	<i>S. persepolitana</i> Boiss.	Persopolisi Maryam-goli	<i>S. aristata</i> Aucher. ex Benth.	Endemic	-
37	<i>S. plebeia</i> R. Br.	Baluchestani Maryam-goli	-	Native	-
38	<i>S. poculata</i> Nab.	Fenjani Maryam-goli	-	Native	-
39	<i>S. reuterana</i> Boiss.	Isfahani Maryam-goli	-	Native	(Jassbi et al., 2012; Rajabi et al., 2014; Mirza & Sefidkon, 1999; Batooli et al., 2013; Salimpour et al., 2011; Lari Yazdi et al., 2005)
40	<i>S. rhytidea</i> Benth.	Taftani Maryam-goli	-	Native	(Rustaiyan et al., 2005; Sajjadi & Ghanndi, 2005; Habibi et al., 2008)
41	<i>S. russellii</i> Benth.	Halabi Maryam-goli	-	Native	-

42	<i>S. sahendica</i> Boiss. & Buhse.	Sahandi Maryam-goli	-	Endemic	(Salehi et al., 2004)
43	<i>S. santolinifolia</i> Boiss.	Khaliji Maryam-goli	-	Native	(Jassbi et al., 2012; Sonboli et al., 2006; Rustayian et al., 2005; Bahadori et al., 2016; Salehi et al., 2014)
44	<i>S. sclarea</i> L.	Maryam-goli	-	Native	(Rajabi et al., 2014; Batooli et al., 2013; Salimpour et al., 2011)
45	<i>S. sclareopsis</i> Bornm. ex Hedge.	Karandi Maryam-goli	<i>S. ceratophylla</i> L.	Endemic	(Hemmati et al., 2018)
46	<i>S. sharifii</i> Rech. f. & Esfand.	Jonubi Maryam-goli	<i>S. hydrangea</i> DC. ex Benth.	Endemic	(Zare & Jassbi, 2014; Asgarpanah et al., 2017)
47	<i>S. spinosa</i> L.	Khar-dar Maryam-goli	-	Native	(Salehi et al., 2014; Bahernik & Mirza, 2005)
48	<i>S. staminea</i> Montbr. & Auch. ex Benth.	Parcham-boland Maryam-goli	-	Native	(Salehi et al., 2013)
49	<i>S. suffruticosa</i> Montbr. & Auch. ex Benth.	Bute-e Maryam-goli	<i>S. aristata</i> Aucher. ex Benth.	Native	(Jamzad et al., 2011; Norouzi-Arasi et al., 2005)
50	<i>S. syriaca</i> L.	Suri Maryam-goli	-	Native	(Lari Yazdi et al., 2005; Sefidkon & Mirza, 1999)
51	<i>S. tebesana</i> Bunge.	Tabasi Maryam-goli	-	Native	(Goldansaz et al., 2017)
52	<i>S. trichoclada</i> Benth.	Shakhe-korki Maryam-goli	-	Native	-
53	<i>S. urumiensis</i> Bunge.	Urumie-e Maryam-goli	-	Endemic	(Khalilzadeh et al., 2011)
54	<i>S. verticillata</i> L.	Banafsh Maryam-goli	-	Native	(Rajabi et al., 2014)
55	<i>S. virgata</i> Jacq.	Harz Maryam-goli	-	Native	(Rajabi et al., 2014; Sefidkon & Mirza, 1999)
56	<i>S. viridis</i> L.	Sabz Maryam-goli	-	Native	-
57	<i>S. wendelboi</i> Hedge.	Sanandaji Maryam-goli	-	Endemic	-
58	<i>S. xanthocheila</i> Boiss. ex Benth.	Alborzi Maryam-goli	-	Native	(Khalilzadeh et al., 2011; Salehi et al., 2005)

The essential oils of the Iranian *Salvia* species are the best-studied *Salvia* products. To the best of our knowledge, the essential oils from 46 species of sage, have been analysed by gas chromatography (GC) and gas chromatography/Mass (GC/MS) spectroscopy. Publications on *Salvia* essential oils clearly demonstrate that chemical polymorphism is characteristic of this genus, and the oil composition depends on variety, growing site, climatic conditions, and analysis method. However, the composition of volatile compounds is known for most of the species, few data are found in chemotaxonomic studies of this genus.

The Iranian *Salvia* species have been classified into four main categories based on the GC/MS and GC-FID (flame ionization detector) analyses of their essential oils (Jassbi et al., 2012).

The first category (monoterpene chemotype) includes the *Salvia* species which contain monoterpene-rich essential oils with pinane, *p*-menthane, isocamphane, and bornane C-skeletons. The bornane-type monoterpenes are mostly in the form of borneol or its acetate ester.  $\alpha$ -pinene,  $\beta$ -pinene, linalool and the related ester linalyl acetate, 1,8-cineole and borneol are characterized as the main chemical markers of the first category. Camphene and sabinene are the other major monoterpenes in some species in this chemotype. Most of the oils in this category contain  $\alpha$ - and  $\beta$ -pinene as the monoterpene hydrocarbons, but the single-isomer is usually in higher concentration.

The second category (mono and sesquiterpene chemotype) consists of the *Salvia* species which contain almost equal quantities of monoterpenes with 2,6-dimethyl octane, pinane, *p*-menthane, and bornane C-skeleton, and sesquiterpenes with caryophyllane, aromadendrane, germacrene, or cadinane C-skeleton.  $\beta$ -caryophyllene, germacrene D, bicyclogermacrene, spathulenol, and caryophyllene oxide are identified as the major chemical markers of this category.

The third category of the *Salvia* species (sesquiterpene chemotype) contains sesquiterpenes with caryophyllane-type C-skeleton as the predominant compounds, germacrane, aromadendrane, cadinane, and other sesquiterpenes as the other major constituents. The monoterpene fractions of these oils are in lower levels compared to the sesquiterpene.

The last category of the *Salvia* species (GLV chemotype) is rich in green leaf volatiles (GLVs; C6 alcohols, aldehydes, and their ester derivatives), aldehydes, esters and other fatty acids or low-molecular-weight acid derivatives, aromatic phenylpropanoids, and finally non-phenylpropanoid volatiles, which are synthesized from amino acid pathways (Baldwin, 2010). This group is called GLV producers.

Among the terpenes, the most abundant components determined are the sesquiterpenes that frequently appear as the main constituents and most of the studied *Salvia* species are considered as sesquiterpene chemotype. Sesquiterpenes are a class of terpenes that consist of three isoprene units and often have the molecular formula  $C_{15}H_{24}$ . They may be acyclic or contain rings.

The biosynthesis of the sesquiterpenes is described as production of sesquiterpene precursor farnesyl diphosphate (FDP) from coupling dimethylallyl diphosphate (DMAPP) and isopentenyl diphosphate (IPP) (Degenhardt et al., 2009). Then, these precursors are taken as substrates by different sesquiterpene synthases, many of which are multi-product enzymes. Biochemical modifications such as oxidation or rearrangement produce the related sesquiterpenoids.

Among the sesquiterpenes,  $\beta$ -caryophyllene followed by germacrene-D, spathulenol and caryophyllene oxide are the most common and abundant in Persian *Salvia* species studied. The  $\beta$ -caryophyllene and germacrene D have been reported from 27 and 22 *Salvia* species in Iran, respectively.  $\beta$ -Caryophyllene and germacrene D are representative of the sesquiterpenes derived from an initial macrocyclic intermediate formed by a  $C_1$ – $C_{11}$  ring closure. These sesquiterpenes are distinguished by being directly derived from the trans FPP substrate and not requiring isomerization to the Cis conformation or nerolidyl diphosphate intermediate and in this regard these components might be considered the simplest of sesquiterpenes.

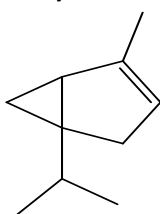
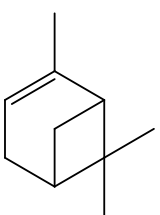
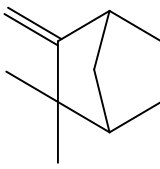
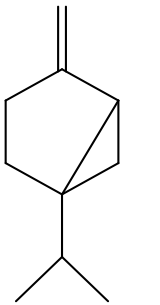
According to the Table 2, *S. aethiopsis*, *S. atropatana*, *S. bracteata*, *S. compressa*, *S. grossheimii*, *S. hypoleuca*, *S. indica*, *S. nemorosa*, *S. palaestina*, *S. reuteriana*, *S. syriaca*, *S. verticillata*, *S. verbascifolia*, *S. virgata*, and *S. xanthocheilacan* are include the third category of the *Salvia* classification while *S. brachysiphon*, *S. chloroleuca*, *S. hydrangea*, *S. hypoleuca*, *S. lachnocalyx*, *S. limbata*, *S. mirzayanii*, and *S. virgata* can be classified in the second category of mono and sesquiterpene chemotype in which the *Salvia* species produce essential oils with almost equal quantities of mono and sesquiterpenes.

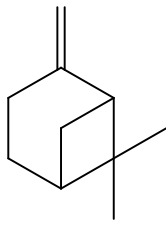
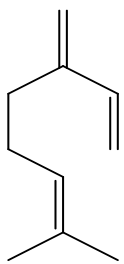
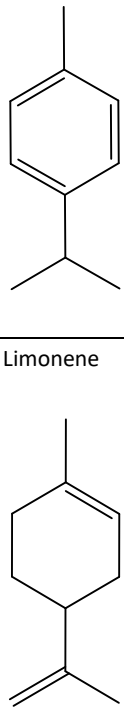
$\alpha$ -Pinene constituted the most abundant compound in the oils of the *Salvia* species in the first category of monoterpene chemotype.

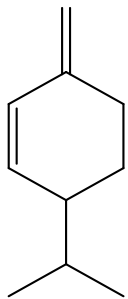
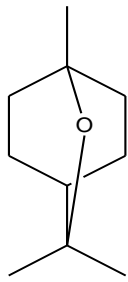
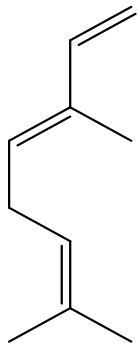
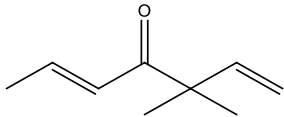
*Salvia* species, which the essential oils contain monoterpenes include *S. aegyptiaca*, *S. brachycalyx*, *S. bracteata*, *S. eremophila*, *S. limbata*, *S. leriifolia*, *S. macilenta*, *S. mirzayanii*, *S. multicaulis*, *S. rhytidea*, *S. sahendica*, *S. santolinifolia*, and *S. suffruticosa*.

*S. atropatana*, *S. macrosiphon*, *S. persepolitana*, *S. reuteriana*, *S. sclareopsis*, and *S. spinosa* are the species which the essential oils are rich in GLVs and other low-molecular-weight acid derivatives. Greenleaf volatiles are biosynthesized via different pathway. They are synthesized from fatty acid hydroperoxides (Dewick, 1997).

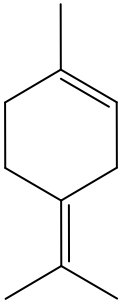
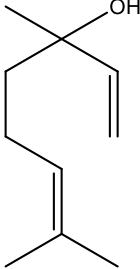
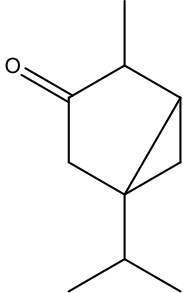
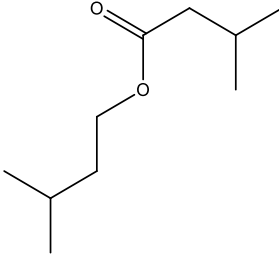
Table 2. Components of the essential oil of *Salvia* species found in Iran (5% <).

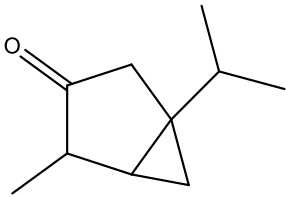
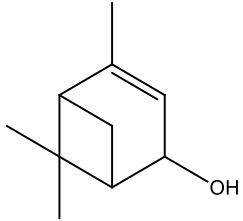
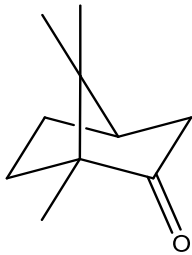
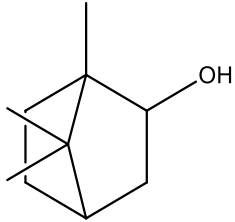
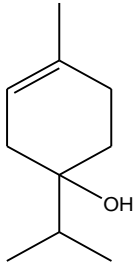
N o.	Compound	Species	Percentage (%)	References
1	$\alpha$ -Thujene 	<i>S. bazmanica</i>	9.5	(Akhgar et al., 2011)
2	$\alpha$ -Pinene 	<i>S. aegyptiaca</i> <i>S. aristata</i> <i>S. bazmanica</i> <i>S. bracteata</i> <i>S. chloroleuca</i> <i>S. eremophila</i> <i>S. hydrangea</i> <i>S. hypoleuca</i>  <i>S. indica</i> <i>S. lerifolia</i> <i>S. limbata</i>  <i>S. macilenta</i>  <i>S. multicaulis</i> <i>S. pachystachys</i> <i>S. sahendica</i> <i>S. santolinifolia</i> <i>S. tebesana</i>  <i>S. urumiensis</i> <i>S. tebesana</i>	8.3 6.7 8.9 28.9 11.4 31.5 5.5 5.8, 29.3, 5.9  17.0 15.1, 16.5  15.5, 17.1, 23.7  60.0 15.6 8.0 14.2 52.5, 49.3, 72.4  7.5 14.0	(Jassbi et al., 2012) (Emadipour et al., 2016) (Akhgar et al., 2011) (Amiri, 2007) (Khalilzadeh et al., 2011) (Jassbi et al., 2012) (Sonboli et al., 2006) (Jassbi et al., 2012; Sonboli et al., 2016; Nickavar et al., 2005) (Jamzad et al., 2011) (Attaran et al., 2016; Monfared & Ghorbanli, 2010) (Sajjadi & Shahpiri, 2004; Rajabi et al., 2014; Rustaiyan et al., 2005) (Sonboli et al., 2005) (Ahmadi & Mirza, 1999) (Shakeri et al., 2018) (Salehi et al., 2004) (Jassbi et al., 2012; Sonbili et al., 2006; Bahadori et al., 2016) (Khalilzadeh et al., 2011) (Goldansaz et al., 2017)
3	Camphene 	<i>S. eremophila</i> <i>S. lerifolia</i> <i>S. pachystachys</i> <i>S. santolinifolia</i>  <i>S. suffruticosa</i>	13.7 10.9 11.7 8.1, 7.8  7.9	(Salehi et al., 2014) (Yousefi et al., 2015) (Amiri, 2007) (Rustaiyan et al., 2005; Salehi et al., 2014) (Jamzad et al., 2011)
4	Sabinene 	<i>S. chloroleuca</i> <i>S. limbata</i>  <i>S. rhytidea</i>  <i>S. sahendica</i>	9.6 8.3, 10.6, 14.5  5.8, 13.5, 17.5  8.5	(Khalilzadeh et al., 2011) (Sajjadi & Shahpiri, 2004; Rustaiyan et al., 2005; Morteza-Semnani et al., 2014) (Rustaiyan et al., 2005; Sajjadi & Ghannadi, 2005; Habibi et al., 2008) (Salehi et al., 2004)

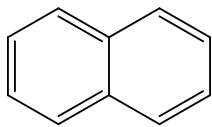
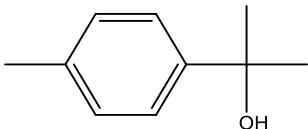
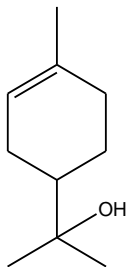
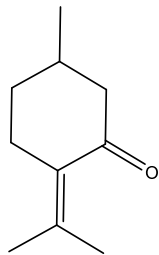
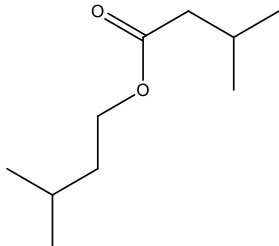
5		<i>S. bazmanica</i>	37.5	(Akhgar et al., 2011)
		<i>S. bracteata</i>	7.9	(Amiri, 2007)
		<i>S. chloroleuca</i>	9.7	(Khalilzadeh et al., 2011)
		<i>S. hydrangea</i>	11.6	(Ebrahimi & Ranjbar, 2016)
				(Sonboli et al., 2016; Nickavar et al., 2005)
		<i>S. hypoleuca</i>	29.8, 7.2	(Jamzad et al., 2011)
				(Attaran et al., 2016)
		<i>S. indica</i>	11.3	(Sajjadi & Shahpiri, 2004; Rajabi et al., 2014;
		<i>S. lerifolia</i>	24.3, 26.0	Rustaiyan et al., 2005)
		<i>S. limbata</i>	9.2, 19.6, 18.7	(Kazemi, 2015)
		(Salehi et al., 2004)		
		(Jassbi et al., 2012; Sonboli et al., 2006)		
		<i>S. officinalis</i>	9.1	
		<i>S. sahendica</i>	12.6	
		<i>S. santolinifolia</i>	7.0, 6.6	
6		<i>S. bracteata</i>	7.7	(Amiri, 2007)
		<i>S. hypoleuca</i>	8.3	(Jassbi et al., 2012)
7	Hexyl acetate $C_8H_{16}O_2$	<i>S. reuteriana</i>	6.7, 7.6	(Jassbi et al., 2012; Mirza & Sefidkon, 1999)
8	p-Cymene	<i>S. santolinifolia</i>	5.1	(Jassbi et al., 2012)
9		<i>S. aegyptiaca</i>	46.4	(Jassbi et al., 2012)
		<i>S. bracteata</i>	7.2	(Amiri, 2007)
		<i>S. eremophila</i>	6.2	(Jassbi et al., 2017)
		<i>S. multicaulis</i>	8.3	(Ahmadi & Mirza, 1999)
		<i>S. reuterana</i>	5.2	(Batooli et al., 2013)
		<i>S. rhytidea</i>	14.9	(Habibi et al., 2008)
		<i>S. santolinifolia</i>	6.0, 7.7, 5.3	(Jassbi et al., 2012; Sonboli et al., 2006;
				Bahadori et al., 2016)
				(Zare & Jassbi, 2014)
		<i>S. sharifii</i>	7.0	

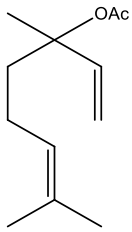
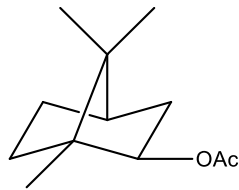
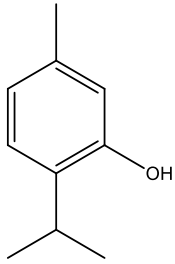
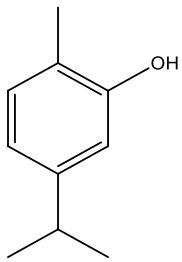
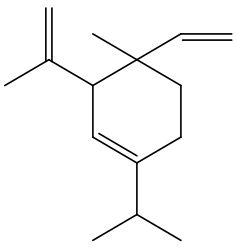
10	$\beta$ -Phellandrene	<i>S. bazmanica</i> <i>S. rhytidea</i>	15.3 22.7	(Akhgar et al., 2011) (Rustaiyan et al., 2005)
				
11	1,8-Cineol	<i>S. aristata</i> <i>S. brachyantha</i> <i>S. hydrangea</i>  <i>S. indica</i> <i>S. leriifolia</i>  <i>S. limbata</i>  <i>S. macrochlamys</i> <i>S. macrosiphon</i> <i>S. mirzayanii</i>   <i>S. multicaulis</i> <i>S. officinalis</i>  <i>S. pachystachys</i> <i>S. suffruticosa</i>	8.3 10.2 12.7, 15.2  13.4 20.2, 20.0  11.0, 9.3  18.9 5.3 21.2, 8.0, 12.1, 8.7, 9.4  8.3 15.0, 7.9  13.5 18.6	(Emadipoor et al., 2016) (Jamzad et al., 2012) (Sonboli et al., 2006; Ebrahimi & Ranjbar, 2016) (Jamzad et al., 2011) (Attaran et al., 2016; Monfared & Ghorbanli, 2010) (Sajjadi & Shahpiri, 2004; Rajabi et al., 2014) (Kazemizadeh et al., 2010) (Rajabi et al., 2014) (Sonboli et al., 2006; Yamini et al., 2008; Mirza, 2003; Asadipour et al., 2013) (Ahmadi & Mirza, 1999) (Kazemi, 2015; Alizadeh & Shaabani, 2012) (Shakeri et al., 2018) (Norouzi-Arasi et al., 2005)
				
12	(E)- $\beta$ -Ocimene	<i>S. reuterana</i> <i>S. sclareoides</i> <i>S. spinosa</i>	32.3 11.8 30.9, 12.3	(Mirza & Sefidkon, 1999) (Sepahvand et al., 2014) (Salehi et al., 2014; Bahernik & Mirza, 2005)
				
13	Artemisia ketone	<i>S. leriifolia</i>	62.9	(Monfared & Ghorbanli, 2010)
				

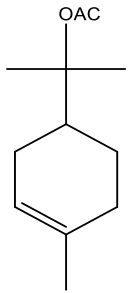
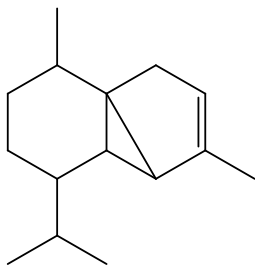
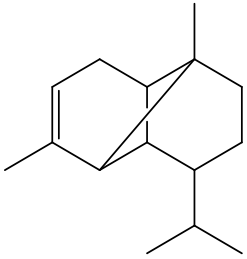
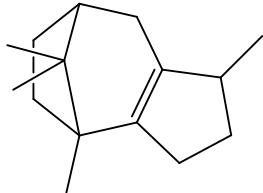
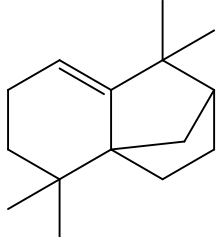


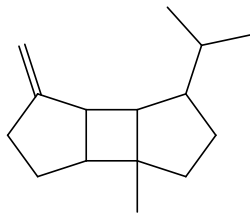
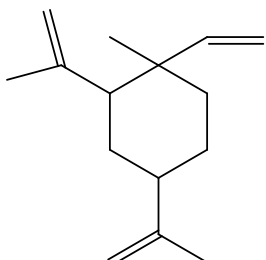
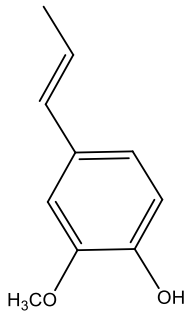
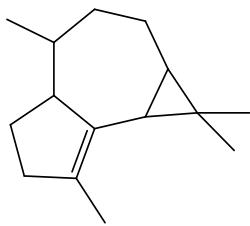
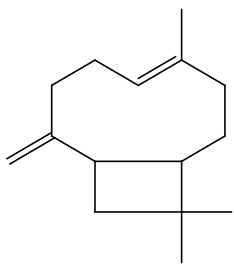
14	$\alpha$ -Terpinolene	<i>S. spinosa</i>	32.7	(Salehi et al., 2014)
				
15	Linalool	<i>S. aethiopsis</i> <i>S. eremophilla</i> <i>S. limbata</i> <i>S. macrosiphon</i>	51.6 12.7-46.2 17.5 21.8, 34.0, 54.8, 16.1-27.8,	(Rajabi et al., 2014) (Rajabi et al., 2014) (Mirza et al., 2005) (Jassbi et al., 2012; Rajabi et al., 2014; Sefidkon et al., 2013; Kariminik et al., 2019) (Sonboli et al., 2006; Yamini et al., 2008; Mirza et al., 2003; Asadipour et al., 2013; Javidnia et al., 2002)
		<i>S. mirzayanii</i>	8.9, 9.0, 19.0, 11.8, 5.2	Rajabi et al., 2014) (Rajabi et al., 2014; Salimpour et al., 2011) (Sepahvand et al., 2014)
		<i>S. nemorosa</i> <i>S. sclarea</i>	5.0-8.1 7.4, 12.2-21.4	
		<i>S. sclareoides</i>	27.6	
16	$\alpha$ -Thujone	<i>S. officinalis</i>	5.7, 41.5	(Kazemi , 2015; Alizadeh & Shaabani, 2012)
				
17	Isopentyl isovalerate	<i>S. spinose</i>	9.5	(Bahernik & Mirza, 2005)
				

18	$\beta$ -Thujone	<i>S. officinalis</i>	6.8	(Alizadeh & Shaabani, 2012)
				
19	Verbenol	<i>S. macrosiphon</i>	7.3	(Rajabi et al., 2014)
				
20	Camphor	<i>S. hydrangea</i>	12.1	(Ebrahimi & Ranjbar, 2016)
		<i>S. lerifolia</i>	18.5	(Monfared & Ghorbanli, 2010)
		<i>S. officinalis</i>	6.0	(Kazemi, 2015)
		<i>S. pachystachys</i>	31.0	(Shakeri et al., 2018)
		<i>S. suffruticosa</i>	48.5	(Norouzi-Asadi et al., 2005)
21	Borneol	<i>S. compressa</i>	9.3	(Mirza & Bahernik et al., 2007)
		<i>S. eremophila</i>	22.9	(Jassbi et al., 2012)
		<i>S. hydrangea</i>	5.2	(Sonboli et al., 2006)
		<i>S. officinalis</i>	12.7, 8.3	(Kazemi, 2015; Alizadeh & Shaabani, 2012)
		<i>S. santolinifolia</i>	5.2	(Jassbi et al., 2012)
22	4-Terpineol	<i>S. limbata</i>	8.9	(Morteza-Semnani et al., 2014)
		<i>S. rhytidea</i>	5.5	(Sajjadi & Ghannadi, 2005)

23	Naphthalene	<i>S. hydrangea</i>	10.8	(Ebrahimi & Ranjbar, 2016)
				
24	p-Cymene-8-ol	<i>S. rhytidea</i>	11.9	(Sajjadi & Ghannadi, 2005)
				
25	α-Terpineol	<i>S. mirzayanii</i> <i>S. sclarea</i>	6.3 5.6	(Asadipour et al., 2013) (Rajabi et al., 2014)
				
26	Decanal C <sub>10</sub> H <sub>20</sub> O	<i>S. palaestina</i>	7.0	(Salehi et al., 2005)
27	Pulegone	<i>S. rhytidea</i>	6.4	(Sajjadi & Ghannadi, 2005)
				
28	Hexyl isovalerate C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>	<i>S. macrosiphon</i> <i>S. reuteriana</i>	5.8, 9.4 12.1	(Jassbi et al., 2012; Mirza et al., 2005) (Jassbi et al., 2012)
29	Geraniol	<i>S. compressa</i>	10.5	(Mirza & Bahernik, 2007)
				

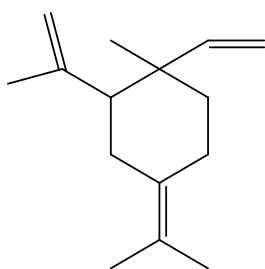
30	Linalyl acetate	<i>S. limbata</i> <i>S. mirzayanii</i>  <i>S. reuterana</i> <i>S. sclarea</i>  <i>S. virgata</i>	16.1 5.4, 7.6, 12.9, 11.8  5.0 6.8, 13.1-52.6  5.2	(Mirza et al., 2005) (Sonboli et al., 2006; Yamini et al., 2008; Asadipour et al., 2013) (Rajabi et al., 2014) (Rajabi et al., 2014; Salimpour et al., 2011) (Rajabi et al., 2014)
				
31	Hexyl valerate	<i>S. macrosiphon</i>	5.0	(Salimpour et al., 2011)
	$C_{11}H_{22}O_2$			
32	Bornyl acetate	<i>S. chloroleuca</i> <i>S. eremophila</i> <i>S. limbata</i> <i>S. macrosiphon</i> <i>S. multicaulis</i> <i>S. officinalis</i> <i>S. syriaca</i> <i>S. urumiensis</i>	5.9 5.4 12.5 7.8 18.1 5.0 10.5 7.7	(Jassbi et al., 2012) (Jassbi et al., 2012) (Rajabi et al., 2014) (Rajabi et al., 2014) (Ahmadi & Mirza, 1999) (Kazemi, 2015) (Lari Yazdi et al., 2005) (Khalilzadeh et al., 2011)
				
33	Thymol	<i>S. macilenta</i>	5.2	(Sonboli et al., 2005)
				
34	Carvacrol	<i>S. aristata</i>	22.7	(Emadipour et al., 2016)
				
35	$\delta$ -elemene	<i>S. limbata</i> <i>S. syriaca</i>	5.1 7.9	(Sajjadi & Shahpiri, 2004) (Lari Yazdi et al., 2005)
				

36	$\alpha$ -Terpinyl acetate	<i>S. mirzayanii</i>	22.6, 11.5, 11.0, 9.5, 5.2	(Sonboli et al., 2005; Mirza et al., 2003; Haghighat et al., 2012; Javidnia et al., 2002)
				
37	$\alpha$ -Cubebene	<i>S. atropatana</i>	13.0	(Salimpour et al., 2011)
				
38	$\alpha$ -Copaene	<i>S. aethiopsis</i>	16.6, 24.3	(Rajabi et al., 2014; Salimpour et al., 2011)
				
		<i>S. macrosiphon</i>	9.1	(Rajabi et al., 2014)
		<i>S. rhytidea</i>	5.3	(Sajjadi & Ghannadi, 2005)
		<i>S. sclarea</i>	6.8	(Batooli et al., 2013)
		<i>S. staminea</i>	7.0	(Salehi et al., 2013)
		<i>S. xanthocheila</i>	11.9, 14.1	(Khalilzadeh et al., 2011; Salehi et al., 2005)
39	$\beta$ -Patchoulene	<i>S. spinosa</i>	12.8	(Salehi et al., 2014)
				
40	Hexyl hexanoate $C_{12}H_{24}O_2$	<i>S. macrosiphon</i>	6.0	(Jassbi et al., 2012)
41	Isolongifolene	<i>S. oligophylla</i>	9.9	(Salimpour et al., 2011)
		<i>S. reuterana</i>	6.5	(Salimpour et al., 2011)
				

42	$\beta$ -Bourbonene	<i>S. macrosiphon</i>	6.0	(Rajabi et al., 2014)
				
43	$\beta$ -Elemene	<i>S. aethiopsis</i> <i>S. macrosiphon</i> <i>S. reuteriana</i>	9.4 5.4 11.7, 6.3	(Rajabi et al., 2014) (Salimpour et al., 2011) (Jassbi et al., 2012; Salimpour et al., 2011)
				
44	<i>cis</i> -Isoeugenol	<i>S. aethiopsis</i>	9.2	(Salimpour et al., 2011)
				
45	$\alpha$ -Gurjunene	<i>S. nemorosa</i> <i>S. verticillata</i>	14.1 5.7	(Mirza & Sefidkon, 1999) (Rajabi et al., 2014)
				
46	$\beta$ -Caryophyllene	<i>S. aegyptiaca</i> <i>S. aethiopsis</i> <i>S. aristata</i> <i>S. atropatana</i> <i>S. bracteata</i> <i>S. chloroleuca</i> <i>S. chorassanica</i>	8.3 12.0, 9.0-18.9 6.1 14.5, 6.1, 16.3 41.6 5.2, 6.7 37.0	(Jassbi et al., 2012) (Rajabi et al., 2014; Salimpour et al., 2011) (Emadipoor et al., 2016) (Jassbi et al., 2012; Salimpour et al., 2011, Mirza & Ahmadi, 2000) (Sefidkon et al., 2007) (Jassbi et al., 2012; Khalilzadeh et al., 2011) (Ebrahimi et al., 2014) (Rajabi et al., 2014) (Tavassoli et al., 2009) (Mirza & Bahernik, 2010)
				

	<i>S. eremophilla</i>	5.6-14.7	(Sonboli et al., 2006)
	<i>S. glutinosa</i>	20.9	(Jassbi et al., 2012; Sonboli et al., 2016; Nickavar et al., 2005)
	<i>S. grossheimii</i>	22.4	(Sajjadi & Shahpiri, 2004)
	<i>S. hydrangea</i>	25.1	(Kazemizadeh et al., 2010)
	<i>S. hypoleuca</i>	13.8, 21.7, 14.6	(Rajabi et al., 2014)
	<i>S. limbata</i>	5.3	(Ahmadi & Mirza, 1999)
	<i>S. macrochlamys</i>	32.7	(Rajabi et al., 2014; Mirza & Sefidkon, 1999)
	<i>S. macrosiphon</i>	6.3-16.3	(Rustaiyan et al., 2005; Salehi et al., 2005)
	<i>S. multicaulis</i>	16.5	(Jassbi et al., 2012; Rajabi et al., 2014; Lari Yazdi et al., 2005)
	<i>S. nemorosa</i>	14.6, 18.8-60.6	(Rajabi et al., 2014; Batooli et al., 2013; Salimpour et al., 2011)
	<i>S. palaestina</i>	6.1, 36.4	(Sepahvand et al., 2014)
	<i>S. reuteriana</i>	6.9, 13.1, 9.7	(Zare & Jassbi, 2014; Asgarpanah et al., 2017)
	<i>S. sclarea</i>	7.6, 17.3, 8.5	(Bahernik & Mirza, 2005)
	<i>S. sclareoides</i>	16.6	(Goldansaz et al., 2017)
	<i>S. sharifii</i>	12.8, 12.3	(Rajabi et al., 2014)
	<i>S. spinosa</i>	10.2	(Rajabi et al., 2014; Sefidkon & Mirza, 1999)
	<i>S. tebesana</i>	7.7	(Khalilzadeh et al., 2011; Salehi et al., 2005)
	<i>S. verticillata</i>	17.0-41.0	
	<i>S. virgata</i>	46.6, 30.0	
	<i>S. xanthocheila</i>	6.7, 14.8	

47  $\gamma$ -Elemene



*S. hypoleuca*

7.7

(Nickavar et al., 2005)

*S. macilentata*

6.1

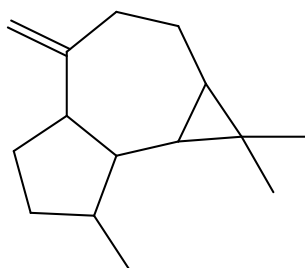
(Sonboli et al., 2005)

*S. officinalis*

6.2

(Kazemi, 2015)

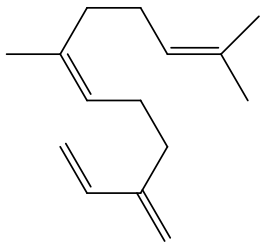
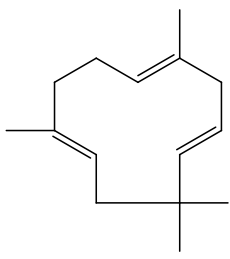
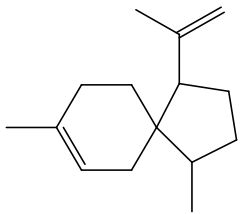
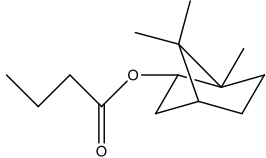
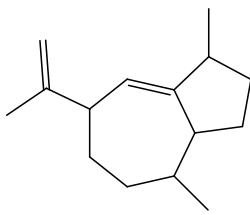
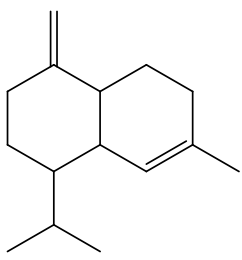
48 Aromadendrene



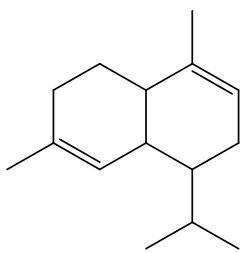
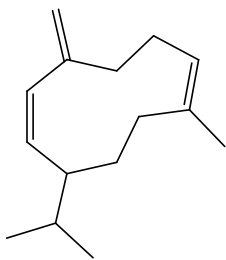
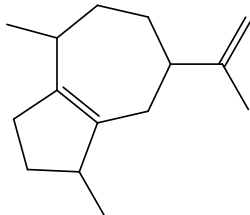
*S. indica*

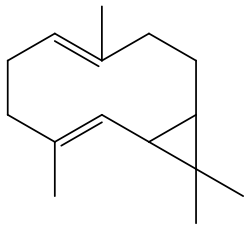
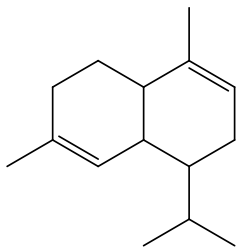
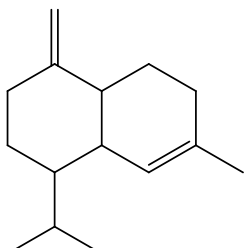
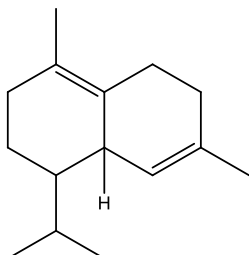
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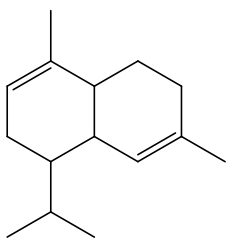
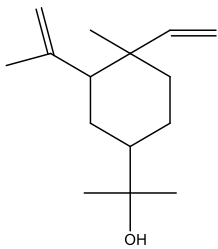
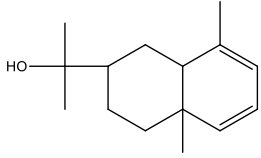
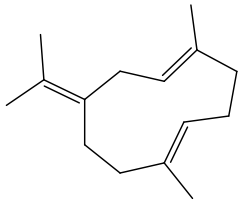
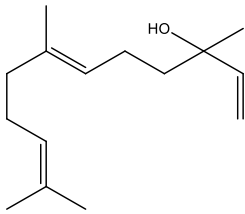
(Bahernik & Mirza, 2010)

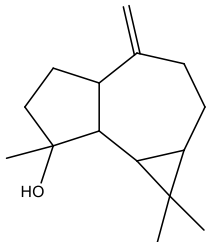
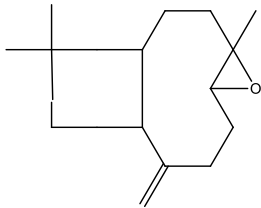
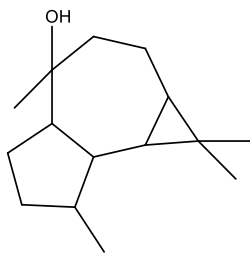
49	Z-β-Farnesene	<i>S. aethiopsis</i> <i>S. nemorosa</i>	8.6 6.0	(Rajabi et al., 2014) (Mirza & Sefidkon, 1999)
				
50	α-Humulene	<i>S. glutinosa</i> <i>S. sclareopsis</i> <i>S. verticillata</i>	9.4 18.4 5.4-14.0	(Tavassoli et al., 2009) (Hemmati et al., 2018) (Rajabi et al., 2014)
				
51	Acoradiene	<i>S. oligophylla</i>	5.6	(Salimpour et al., 2011)
				
52	Isobornyl butanoate	<i>S. palaestina</i>	5.8	(Salehi et al., 2005)
				
53	γ-Gurjunene	<i>S. virgata</i>	6.5	(Rajabi et al., 2014)
				
54	γ-Muurolene	<i>S. brachyantha</i> <i>S. bracteata</i>	7.5 36.3	(Jamzad et al., 2012) (Sefidkon et al., 2007)
				

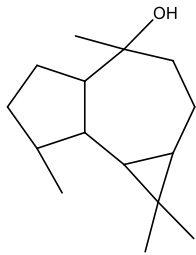
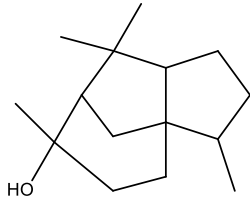
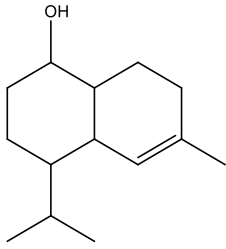
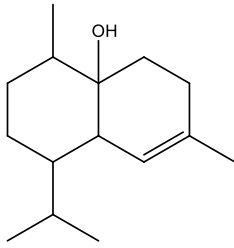
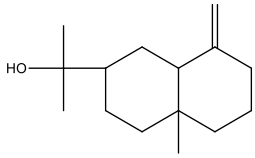
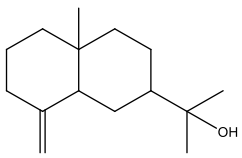


55	$\alpha$ -Amorphene	<i>S. hydrangea</i>	9.3	(Ebrahimi & Ranjbar, 2016)
				
56	Germacrene D	<i>S. aethiopis</i>	61.5, 25.2	(Rajabi et al., 2014; Salimpour et al., 2011)
		<i>S. atropatana</i>	19.7, 5.1	(Jassbi et al., 2012; Salimpour et al., 2011)
		<i>S. chloroleuca</i>	15.7, 15.7	(Jassbi et al., 2012; Khalilzadeh et al., 2011)
		<i>S. glutinosa</i>	18.0	(Tavassoli et al., 2009)
		<i>S. grossheimii</i>	45.4	(Mirza & Bahernik, 2010)
		<i>S. hypoleuca</i>	8.8	(Jassbi et al., 2012)
		<i>S. indica</i>	10.4	(Bahrnik & Mirza, 2010)
		<i>S. limbata</i>	25.7	(Mirza et al., 2005)
		<i>S. macrosiphon</i>	10.5-8.1	(Rajabi et al., 2014)
		<i>S. nemorosa</i>	5.6, 5.5-6.3	(Rajabi et al., 2014; Mirza & Sefidkon, 1999)
		<i>S. palaestina</i>	14.0	(Salehi et al., 2005)
		<i>S. reuteriana</i>	14.1, 11.2, 11.2, 21.2	(Jassbi et al., 2012; Mirza & Sefidkon, 1999; Batooli et al., 2013; Salimpour et al., 2011)
		<i>S. sahendica</i>		(Salehi et al., 2004)
		<i>S. sclarea</i>	8.3	(Rajabi et al., 2012; Batooli et al., 2013; Salimpour et al., 2011)
		<i>S. sclareoides</i>	12.7, 20.8, 9.5-17.7	(Sepahvand et al., 2014)
		<i>S. sharifii</i>		(Zare & Jassbi, 2014; Asgarpanah et al., 2017)
	<i>S. staminea</i>	10.0	(Salehi et al., 2013)	
	<i>S. syriaca</i>	9.5, 30.3	(Sefidkon & Mirza, 1999)	
	<i>S. urumiensis</i>	36.3	(Khalilzadeh et al., 2011)	
	<i>S. verticillate</i>	29.2	(Rajabi et al., 2014)	
	<i>S. virgata</i>	5.2	(Sefidkon & Mirza, 1999)	
	<i>S. xanthocheila</i>	6.4-13.0	(Khalilzadeh et al., 2011; Salehi et al., 2005)	
		5.7		
		44.0, 17.6		
57	<i>cis</i> - $\beta$ -Guaiene	<i>S. macrosiphon</i>	8.6	(Rajabi et al., 2014)
				

58		Bicyclgermacrene			
		<i>S. aethiopis</i>	5.8	(Rajabi et al., 2014)	
		<i>S. bracteata</i>	9.9	(Sefidkon et al., 2007)	
		<i>S. chloroleuca</i>	18.5, 17.0	(Jassbi et al., 2012; Khalilzadeh et al., 2011) (Mirza & Baher, 2010)	
		<i>S. grossheimii</i>	7.1	(Jassbi et al., 2012; Sonboli et al., 2016;	
		<i>S. hypoleuca</i>	19.8, 37.3, 15.3	Nickavar et al., 2005) (Sajjadi & Shahpiri, 2004) (Haghighat et al., 2012)	
		<i>S. limbata</i>	21.1	(Rajabi et al., 2014)	
		<i>S. mirzayanii</i>	8.0	(Batooli et al., 2013)	
		<i>S. nemorosa</i>	7.7	(Salehi et al., 2004)	
		<i>S. reuterana</i>	8.2	(Batooli et al., 2013)	
		<i>S. sahendica</i>	15.8	(Zare & Jassbi, 2014; Asgarpanah et al., 2017)	
		<i>S. sclarea</i>	8.8	(Rajabi et al., 2014)	
<i>S. sharifii</i>	5.6, 15.7				
	<i>S. verticillata</i>	13.0-21.0			
59		$\alpha$ -Muurolene	<i>S. sclareopsis</i>	8.4	(Hemmati et al., 2018)
60		$\gamma$ -cadinene	<i>S. mirzayanii</i>	5.2, 5.8	(Sonboli et al., 2006; Javidnia et al., 2002) (Rajabi et al., 2014)
			<i>S. virgata</i>	6.2	
61		$\delta$ -Cadinene	<i>S. aethiopis</i>	8.2	(Salimpour et al., 2011)
			<i>S. hydrangea</i>	8.3	(Ebrahimi & Ranjbar, 2016) (Asadipour et al., 2013; Haghighat et al., 2012)
			<i>S. mirzayanii</i>	5.7, 7.5	(Rajabi et al., 2014)
			<i>S. virgata</i>	16.0	

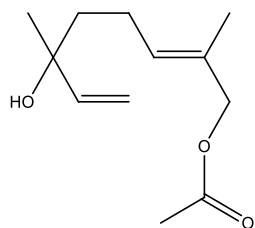
62	$\alpha$ -Cadinene	<i>S. syriaca</i> <i>S. virgata</i>	10.3 32.0	(Lari Yazdi, 2005) (Rajabi et al., 2014)
				
63	Elemol	<i>S. brachyantha</i>	5.9	(Jamzad et al., 2012)
				
64	Occidentalol	<i>S. oligophylla</i>	24.0	(Salimpour et al., 2011)
				
65	Germacrene B	<i>S. atropatana</i> <i>S. nemorosa</i> <i>S. syriaca</i> <i>S. virgata</i>	10.0 21.3 34.8 13.9	(Mirza & Ahmadi, 2000) (Mirza & Sefidkon, 1999) (Sefidkon & Mirza, 1999) (Sefidkon & Mirza, 1999)
				
66	Nerolidol	<i>S. tebesana</i>	12.1	(Goldansaz et al., 2017)
				
67	Hexyl octanoate $C_{14}H_{28}O_2$	<i>S. atropatana</i> <i>S. macrosiphon</i>	12.2 8.9	(Mirza & Ahmadi, 2000) (Sefidkon et al., 2013)
68	Spathulenol	<i>S. brachyantha</i> <i>S. chloroleuca</i> <i>S. chorassanica</i> <i>S. eremophilla</i>	6.2 5.1 39.5 22.0-35.4	(Jamzad et al., 2012) (Khalilzadeh et al., 2011) (Ebrahimi et al., 2014) (Rajabi et al., 2014)

		<i>S. hypoleuca</i>	12.4, 12.5	(Jassbi et al., 2012; Nickavar et al., 2005)
		<i>S. limbata</i>	8.1, 8.2, 13.2	(Sajjadi & Shahpiri, 2004; Rajabi et al., 2012; Morteza-Semnani et al., 2014)
		<i>S. macrosiphon</i>	5.8, 17.1	(Rajabi et al., 2012; Salimpour et al., 2011)
		<i>S. mirzayanii</i>	10.4	(Javidnia et al., 2002)
		<i>S. nemorosa</i>	6.8-26.0	(Rajabi et al., 2012; Lari Yazdi et al., 2005)
		<i>S. reuterana</i>	12.4, 17.0	(Sajjadi & Ghannadi, 2005)
		<i>S. rhytidea</i>	7.3	(Rajabi et al., 2012; Batooli et al., 2013; Salimpour et al., 2011)
		<i>S. sclarea</i>	6.9, 10.0, 5.0	(Zare & Jassbi, 2014)
		<i>S. sharifii</i>	6.9	(Lari Yazdi et al., 2005)
		<i>S. syriaca</i>	18.6	(Khalilzadeh et al., 2011)
		<i>S. urumiensis</i>	14.6	(Rajabi et al., 2014)
	<i>S. verticillata</i>	11.0-17.0	(Sefidkon & Mirza, 1999)	
	<i>S. virgata</i>	6.4	(Khalilzadeh et al., 2011)	
	<i>S. xanthocheila</i>	7.0		
69	Caryophyllene oxide	<i>S. aethiopsis</i>	10.3	(Rajabi et al., 2014)
		<i>S. atropatana</i>	17.6, 19.3	(Jassbi et al., 2012; Salimpour et al., 2011)
		<i>S. brachyantha</i>	6.7	(Jamzad et al., 2012)
		<i>S. chorassanica</i>	22.7	(Ebrahimi et al., 2014)
		<i>S. compressa</i>	15.7	(Mirza & Bahernik, 2007)
		<i>S. eremophilla</i>	9.5-17.8	(Rajabi et al., 2014)
		<i>S. hydrangea</i>	11.5	(Sonboli et al., 2006)
		<i>S. macrosiphon</i>	11.3-26.9,	(Rajabi et al., 2014)
		<i>S. nemorosa</i>	6.8, 19-27	(Rajabi et al., 2014; Mirza & sefidkon, 1999)
		<i>S. reuterana</i>	38.0	(Rajabi et al., 2014; Batooli et al., 2013)]
		<i>S. sclarea</i>	10.4, 6.3-8.5	(Hemmati et al., 2018)
		<i>S. sclareopsis</i>	7.7	(Zare & Jassbi, 2014)
		<i>S. sharifii</i>	5.5	(Goldansaz et al., 2017)]
		<i>S. tebesana</i>	6.8	(Rajabi et al., 2014)
		<i>S. verticillata</i>	7.0-10.0	(Rajabi et al., 2014; Sefidkon & Mirza, 1999)
		<i>S. virgata</i>	13.2, 10.0	(Khalilzadeh et al., 2011)
	<i>S. xanthocheila</i>	15.5		
70	Globulol	<i>S. indica</i>	24.1	(Bahernik & Mirza, 2010)
		<i>S. mirzayanii</i>	5.4	(Haghighat et al., 2012)

71	Viridiflorol	<i>S. hypoleuca</i>	17.5	(Nickavar et al., 2005)
		<i>S. officinalis</i>	5.9	(Alizadeh & Shaabani, 2012)
		<i>S. sclareopsis</i>	23.5	(Hemmati et al., 2018)
				
72	Cedrol	<i>S. mirzayanii</i>	16.3	(Haghighat et al., 2012)
				
73	tau-Cadinol	<i>S. compressa</i>	36.0	(Mirza & Bahernik, 2007)
				
74	Cubenol	<i>S. leriifolia</i>	9.4	(Monfared & Ghorbanli, 2010)
		<i>S. palaestina</i>	9.8	(Salehi et al., 2005)
				
75	β-Eudesmol	<i>S. eremophilla</i>	7.2	(Rajabi et al., 2014)
		<i>S. macrosiphon</i>	9.7-16.1	(Rajabi et al., 2014)
		<i>S. reuterana</i>	7.6	(Rajabi et al., 2014)
		<i>S. santolinifolia</i>	20.0	(Bahadori et al., 2016)
				
76	α-Eudesmol	<i>S. macrosiphon</i>	5.3	(Rajabi et al., 2014)
				

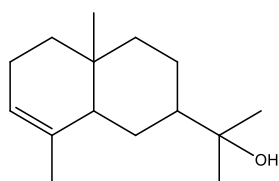
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77	8-Acetoxy linalool	<i>S. mirzayanii</i>	11.0	(Yamini et al., 2008)
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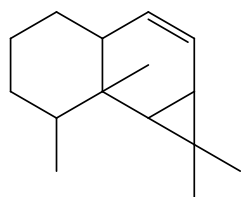
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78	7-epi- $\alpha$ -eudesmol	<i>S. tebesana</i>	17.5	(Goldansaz et al., 2017)
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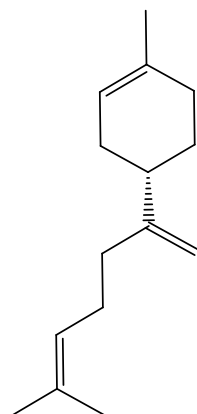
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79	Aristolene	<i>S. macrosiphon</i>	5.7	(Salimpour et al., 2011)
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80	$\beta$ -Bisabolene	<i>S. palaestina</i>	11.9	(Salehi et al., 2005)
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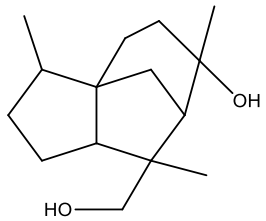
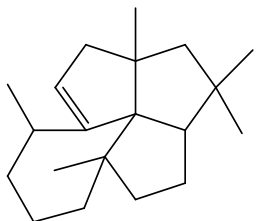
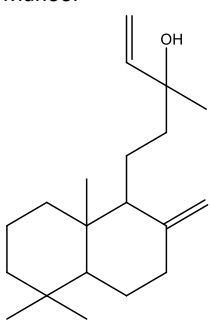
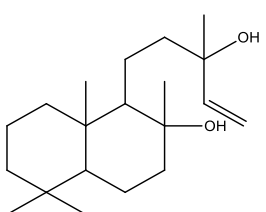
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81	Octadecane C <sub>18</sub> H <sub>38</sub>	<i>S. sclareopsis</i>	20.6	(Hemmati et al., 2018)
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82	Hexahydrofarnesyl acetone C <sub>18</sub> H <sub>36</sub> O	<i>S. staminata</i>	11.2	(Salehi et al., 2013)
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83	8,13-Cedranediol	<i>S. reuterana</i>	9.9	(Batooli et al., 2013)
				
84	<i>epi</i> -Laurene	<i>S. reuterana</i>	9.5	(Batooli et al., 2013)
				
85	Manool	<i>S. macrosiphon</i> <i>S. persepolitana</i>	27.3 37.3	(Kariminik et al., 2019) (Habibi et al., 2008)
				
86	Sclareol	<i>S. atropatana</i> <i>S. macrosiphon</i> <i>S. sclarea</i>	13.3 15.8, 8.6 5.3	(Mirza & Ahmadi, 2000) (Sefidkon et al., 2013; Salimpour et al., 2011) (Salimpour et al., 2011)
				

As shown in Table 2, 86 compounds were identified in the essential oil of Persian *Salvia* species in sizeable amounts (>5%). The essential oil composition of these species is dominated by mostly the presence of monoterpene hydrocarbons, sesquiterpene hydrocarbons, oxygenated monoterpenes and oxygenated sesquiterpenes.

$\beta$ -Caryophyllene as the most abundant component in many *Salvia* species essential oil, has been reported in *S. aegyptiaca*, *S. aethiopis*, *S. aristata*, *S. atropatana*, *S. bracteata*, *S. chloroleuca*, *S. chorassanica*, *S. eremophilla*, *S. glutinosa*, *S. grossheimii*, *S. hydrangea*, *S. hypoleuca*, *S. limbata*, *S. macrochlamys*, *S. macrosiphon*, *S. multicaulis*, *S. nemorosa*, *S. palaestina*, *S. reuteriana*, *S. sclarea*, *S. sclareoides*, *S. sharifii*, *S. spinosa*, *S. tebesana*, *S. verticillata*, *S. virgata*, *S. xanthocheila* of which the oils of *S. bracteata*, *S. nemorosa* and *S. virgata* contain more than 40 %  $\beta$ -caryophyllene. Germacrene D is the other abundant component reported in the most *Salvia* species such as *S. aethiopis*, *S. atropatana*, *S. chloroleuca*, *S. glutinosa*, *S. grossheimii*, *S. hypoleuca*, *S. indica*, *S. limbata*, *S. macrosiphon*, *S. nemorosa*, *S. palaestina*, *S. reuteriana*, *S. sahendica*, *S. sclarea*, *S. sclareoides*, *S. sharifii*, *S. staminea*, *S. syriaca*, *S. urumiensis*, *S. verticillata*, *S. virgata*,

*S. xanthocheila* of which the *S. aethiopsis*, *S. grossheimii* and *S. xanthocheila* produce essential oils contained more than 40 % of germacrene D.

$\alpha$ -Pinene as the dominant component of the first category of the Iranian sage presents in 18 *Salvia* species including *S. aegyptiaca*, *S. aristata*, *S. bazmanica*, *S. bracteata*, *S. chloroleuca*, *S. eremophila*, *S. hydrangea*, *S. hypoleuca*, *S. indica*, *S. leriifolia*, *S. limbata*, *S. macilenta*, *S. multicaulis*, *S. pachystachys*, *S. sahendica*, *S. santolinifolia*, *S. tebesana* and *S. urumiensis* among which the *S. macilenta* and *S. santolinifolia* possess the essential oil with more than 60 % of  $\alpha$ -pinene.

## Conclusion

Data in the Table 2 represents 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. 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. It was also concluded that the most of the studied Iranian *Salvia* species were considered as sesquiterpene chemotype and  $\beta$ -caryophyllene followed by germacrene D, spathulenol and caryophyllene oxide were the most common and abundant in Persian *Salvia* species.

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## CONFLICTS OF INTEREST

The author does not have conflicts of interest to declare.

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