Asadi, ***Journal of Medicinal Herbs***, Vol. 12, No. 4: 33-43, 2021
doi: 10.30495/MEDHERB.2021.687756

Journal of Medicinal Herbs
journal homepage:**www.jhd.iaushk.ac.ir**

Chemical structure of *Glycyrrhiza glabra* L. and *Salvia officinalis* L. essential oils collected from Kermanshah Province in west of Iran

Mohammad Asadi*

Department of Plant Protection, Faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Ardabil, Iran;
Email:** ***assadi20@gmail.com

ARTICLE INFO

Type: *Original Research*
Topic: *Medicinal Plants*
Received *September 10th 2021*
Accepted *December 23th 2021*

Key words:
- ✓ *Chemical analysis*
- ✓ *Dominant constituent*
- ✓ *Liquorice*
- ✓ *Sage*
- ✓ *Volatile compound*

ABSTRACT

Background & Aim: *Glycyrrhiza glabra* L. and *Salvia officinalis* L. due to their medicinal properties are valuable medicinal plants in Kermanshah province and the other western regions of Iran.
Experimental: In this research, chemical analysis of the essential oils isolated from these valuable medicinal plants were performed. For this, aerial parts of the plants were gradually dried (shadow conditions at 25 °C), pulverized, their essential oils isolated by hydro-distillation method, and analyzed by GC-MS.
Results: The results showed that there were important compounds in the essential oils of both plants. Total identification times of the compounds were estimated to be 38.469 and 38.230 min, respectively. Among constituents of *G. glabra*; Naphthalene, Decahydro-4a-Methyl (25.578 min-15.62%); 2, 6-Octadiene-1-ol, 3, 7-Dimethyl (24.702 min-6.96%); Butanoic Acid, 3, 7-Dimethyl-2 (23.587 min-5.79%), Lavandulyl Acetate (18.294 min-4.93%), 3-Hexene-1-ol, Benzoate (23.890 min-3.45%), and among *S. officinalis* constituents, Alpha-Thujone Bicyclo (8.904 min-24.22%); Bicyclo [2.2.1] Heptan-2-One (9.865 min-15.51%); 1, 8-Cineole 2-Oxabicyclo (7.250 min-10 %); Thujone Bicyclo [3.1.0] Hexan-3 (9.110 min-6.20%), and Veridiflorol (24.330 min-4.47%) were dominant, respectively.
Recommended applications/industries: These medicinal plants due to high diverse constituents could seriously be considered in medical, pharmacology, and toxicology researches.

1. Introduction

Glycyrrhiza glabra L. (Liquorice or licorice) is an important medicinal plant with many secondary compounds which many properties of them is remained unknown (Ghahreman and Attar, 1999; Duan *et al*., 2016; Esmaeili *et al*., 2019). This species is a perennial plant that has adapted well to mesophyte and xerophyte habitats during its evolutionary period. *G. glabra* is native for southern Europe, northern Africa, and temperate regions of Asia; but, is found in abundance in many parts of Iran, especially in the western half. Botanically, its leaves consist of 4 to 6 pairs of combs plus a terminal leaflet. This plant has sticky secretions, bluish flowers, and fruit pods with five to six brown seeds. Its flowering commonly occurs during June to August (Li and Cui, 1998) and seed propagation is done by attaching prickly and hairy pods to animal wool and skin (Zhou and Jin, 2016). Underground stem (rhizome) of this medicinal plant is widely used in medical. Its rhizome has brown skin and yellow kernel (Dini, 2005). This species is morphologically known for its diverse fruits (oval, rectangular, and rarely linear). According to Bao and Larsen (2010), *G. glabra* is considered as the most important species in genus *Glycyrrhiza* and also family Fabaceae which have been widely used as an important medicinal plant. The most important active ingredient (A.I.) of this plant is

glycyrrhizin ($C_{42}H_{22}O_{16}$), which is used as a natural sweetener and also as a valuable medicinal agent. Moreover, this compound has anti-inflammatory and protective effects for human liver (Hayashi and Sudo, 2009).

Salvia officinalis L. (Sage, also called as Garden Sage, Common Sage, or Culinary Sage) is a medicinal plant from family Lamiaceae (Labiatae). This species is a perennial and shrubby plant with evergreen stems with large, elongated, and entire leaves. The leaves are grayish green, about 8.5 × 2.5 cm, petiolate, with an acute apex, finely crenate margins, densely pubescent, and glandular-punctate having glands obscured by hairs. Height of the plant is about 50 to 80 cm and its young stem is dark green that covered with dense gray hairs (Asadi *et al*., 2018). This plant is native to the Mediterranean regions; but, it grows in most parts of the world and is also cultivated as an ornamental plant. *S. officinalis* needs heat and dry weather during its growing season and for this is also cultivated in some provinces of Iran which have mentioned conditions. Sage is aromatic in odor and somewhat bitter in taste. The leaves are gathered for use while the plant is in bloom and is dried in the shadow or indoors by circulating warm air (Dini, 2005).

Kermanshah province with an area including 24,640 m^2 is 17th province of Iran in term of area. Complete geographical coordinates of this province consist of longitude from 45°20' 39" to 48°1' 58" east and latitude from 33°37' 8" to 35°17' 8" north (Asadi, 2010). This province, which covers 1.5% of the area of Iran, is one of the western provinces, due to suitable climatic conditions, is a natural habitat for valuable medicinal plants from different genera and families, including *G. glabra* and *S. officinalis*, which are less considered. The huge genetic reserve of this region can be considered by researchers in various aspects including medicinal plants, medical, pharmacology, and toxicology (Asadi *et al*., 2018). This study has been designed and implemented in the same direction.

Essential oils are volatile materials in plants contain terpenes, terpenoids, aromatic, and non-aromatic compounds. Identifying of these compounds and understanding their roles are very important issues in plant science (Isman, 2000; Isman *et al*., 2008). Essential oils, also known as plant secondary metabolites, are mainly abundant in Myrtaceae, Lauraceae, Lamiaceae, and Asteraceae families due to their contact, fumigation, repellent, and anti-nutritional effects. These compounds are one of the main components in defense mechanisms of various plants that have been used them during many years against the herbivores (Bakkali *et al*., 2008; Rafiee-Dastjerdi *et al*., 2013; Asadi *et al*., 2018, 2019). In terms of isolation method, the aromatic products from distillation process that are separated by volatile mechanisms are called as the essential oil (Asadi *et al*., 2019). These compounds are different in each plant species and geographical area; therefore, it is not possible to expect same compounds from one plant species in different regions; although, there may be similarities between their compounds. The main aim of this study was to identify secondary compounds in *G. glabra* and *S. officinalis* from Kermanshah province in Iran as a basic research for using in later applications.

2. Materials and Methods

2.1. Project process

The present research was performed during 2017-2018 in the Department of Plant Protection, Faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Ardabil, Iran. The field part was conducted with the collection of two medicinal plants in Kermanshah province. The laboratory part was also continued with isolation of essential oils and their chemical analyses in the laboratory of mentioned university.

2.2. Identification of plant species

Identification of medicinal plants collected from their natural habitats of Kermanshah province was done by sending complete samples of them to a botany expert in Razi University Herbarium (RUHK), Herbarium codes: 1442 and 1846, Kermanshah, Iran.

2.3. Isolation of essential oil

G. glabra and *S. officinalis* specimens were collected from their natural habitats in twenty different locations in Kermanshah province which were listed in Table 1. After drying the specimens in the shadow (temperature about 25°C), they were transferred to the laboratory and their essential oils were gradually isolated.

Accordingly, aerial parts of the plants were gradually pulverized (Fig 1A). Then, 50 g of each plant powder was mixed with 500 ml of the distilled water in 1 liter balloon of the Clevenger apparatus (Babaee Ghaghelestany *et al*., 2020). As balloon heats up, the

volatile compounds are transferred to top of the tube and cooled by the condenser (Fig 1B). After three hours, the essential oil was separated as a pale green layer. In order to remove the water and purify the essential oils, sodium sulfate (Na_2So_4) was used (Asadi *et al*., 2019). Finally, the purified essential oils were stored in special containers (5 ml) covered with aluminum layer (Fig 1C) in refrigerator (about 4 °C) (Fig 1D) until GC-MS analyses (Negahban *et al*., 2007; Samsam Shariat, 2007; Parsia Aref and Valizadegan, 2015; Asadi *et al*., 2018; Babaee Ghaghelestany *et al*., 2020).

Table 1. Name and geographical locations which the plant specimens were collected.

Locality	Latitude	Longitude	Height from see level (m)
Tang-e Shouhan	34°, 06′, 50″	46°, 32′, 07″	1402
Darkhor	34°, 12′, 34″	46°, 38′, 50″	1373
Vahdat	34°, 11′, 36″	46°, 37′, 53″	1446
Hasan Abad	34°, 06′, 52″	34°, 39′, 29″	1363
Bagher Abad	34°, 05′, 22″	46°, 37′, 30″	1388
Anjirak	34°, 05′, 05″	46°, 50′, 26″	1383
Karim Haseleh	34°, 08′, 09″	46°, 37′, 39″	1474
Sorkhak	34°, 17′, 39″	46°, 32′, 28″	1397
Siakhor	34°, 07′, 35″	46°, 35′, 51″	1396
Tajar	34°, 06′, 54″	46°, 37′, 03″	1352
Ghaleh Shian	34°, 03′, 46″	46°, 42′, 04″	1382
Ali Abad	34°, 07′, 58″	46°, 26′, 03″	1337
Chalavbakr	34°, 07′, 39″	46°, 20′, 23″	1409
Torab	34°, 04′, 01″	46°, 27′, 31″	1342
Momei	34°, 02′, 44″	46°, 31′, 55″	1348
Koleh Joub	34°, 08′, 09″	46°, 38′, 02″	1446
Homeil	34°, 56′, 12″	46°, 46′, 01″	1354
Geravand	33°, 35′, 90″	46°, 46′, 19″	1360
Ghaleh Harasam	33°, 05′, 24″	46°, 49′, 57″	1345
Zaferan	33°, 35′, 39″	46°, 45′, 48″	1388

2.4. Gas Chromatography-Mass Spectroscopy (GC-MS)

Chemical compounds in the purified essential oils of *G. glabra* and *S. officinalis* were identified by using of a chromatographic device connected to mass spectroscopy (GC-MS: model Agilent 7980, made in the USA). This device was available in the central laboratory, University of Mohaghegh Ardabili, Ardabil, Iran. The device was able to inject different liquid samples with ability to their dilute split splitless inlet (SSI) as well as a mass spectroscopy detector (MSD) to quantitatively and qualitatively identify of samples. This detector was also equipped with EI ionization system and four-coupled single analyzer (SQA). To achieve the highest sensitivity in the detector, there was a triple detector (EMP) type that had very little noise and drift (Babaee Ghaghelestany *et al*., 2020). After injecting the essential oils by using of Hamilton syringe into the device, different compounds were gradually detected based on their molar mass at different times and finally the corresponding chromatograms were drawn by GC-MS (Figs 2 and 3).

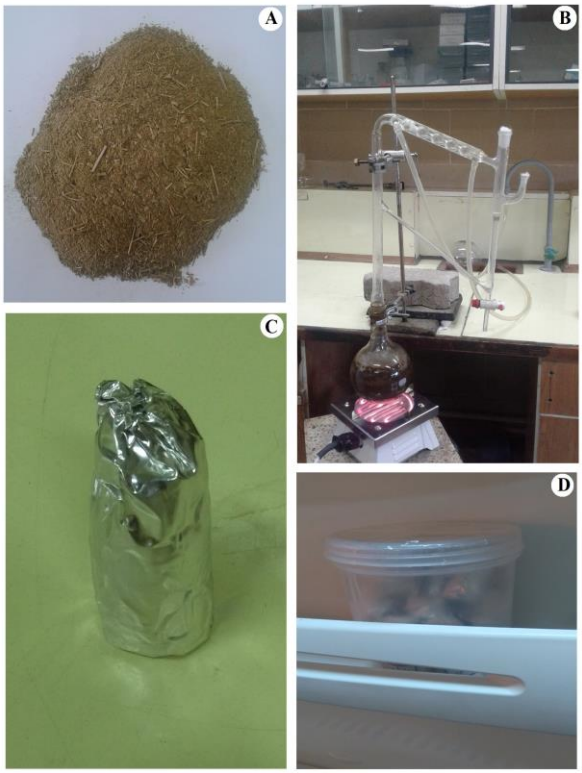

Fig 1. Steps of the essential oils isolation, A: powdered plant, B: Clevenger apparatus on heater, C: keeping purified essential oil in the special glass covered with aluminum foil, and D: maintenance of essential oil in the refrigerator.

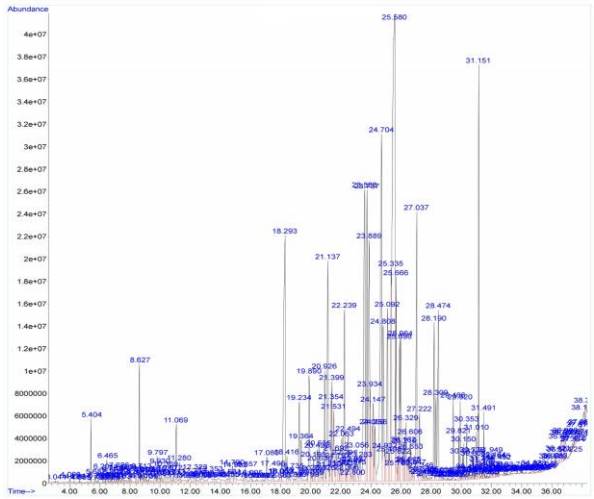

Fig 2. Chromatogram of total compounds available in *G. glabra* essential oil.

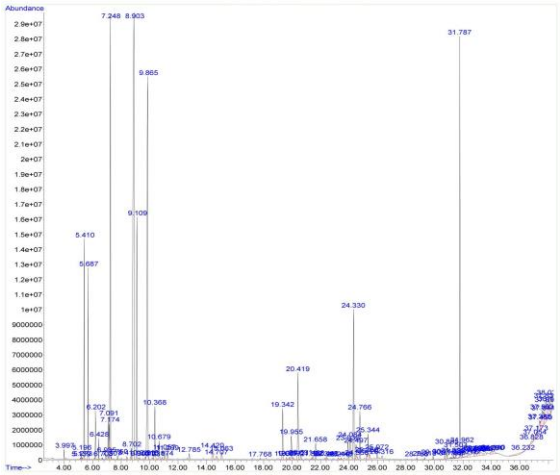

Fig 3. The chromatogram of available compounds in *S. officinalis* essential oil.

3. Results and discussion

The chromatograms of total chemical compounds in structure of *G. glabra* and *S. officinalis* essential oils by GC-MS are shown in Figs 1 and 2. In the chromatograms, longitudinal (X) and latitudinal (Y) axes are retention time and amount of each compound, respectively. According to the diagram, compounds with higher and lower peaks indicated high and low values in the essential oil, respectively.

The results showed that *G. glabra* essential oil contain 239 different chemical compounds which due to the great importance, one-hundred of them are given in (Table 2).

Table 2. Major compounds in *G. glabra* essential oil with their retention time and percentage.

Peak	Compound	Retention Time (min)	% of Total	Peak	Compound	Retention Time (min)	% of Total
6	1S-Alpha-Pinene	5.402	0.29	**118**	7, 8-Dihydrolinalool 1-Octen-3	23.936	0.59
12	Beta-Myrcene 1, 6-Octadiene	6.466	0.24	**119**	Dodecanoic Acid	24.09	0.74
24	1, 3, 6-Octatriene, 3, 7-Dimethyl	7.525	0.12	**120**	(-)-Caryophyllene Oxide	24.147	0.94
30	Linalool L	8.629	0.81	**121**	3-Cyclohexene-1-Ethanol	24.256	0.62
38	Isopinocarveol	9.642	0.12	**122**	2, 6-Octadiene-1-ol, 3, 7-Dimethyl	24.702	6.96
39	Cyclohexanol, 5-Methyl-2-(1-Methyl)	9.797	0.2	**123**	(E)-2-Formyl-6-Methyl-3-(1-Propylen)	24.805	2.24
40	Etracyclo [5.3.0.0<2, 6>.0<3, 10>]	9.928	0.18	**124**	1, 6, 10, 14-Hexadecatetraen-3-ol	24.931	0.33
43	Pinocarvone 6, 6-Dimethyl	10.277	0.12	**125**	1, 6, 10-Dodecatrien-3-ol	25.091	2.12
44	Borneol L	10.369	0.19	**126**	Bicyclo [2.2.1] Heptane-2-Carboxale	25.2	0.28
46	3-Cyclohexene-1-ol, 4-Methyl-1	10.672	0.12	**127**	Naphthalene, 1, 2, 3, 4, 4a, 5, 6, 8a	25.337	2.09
48	Alpha Terpineol	11.067	0.49	**128**	Naphthalene, Decahydro-4a-Methyl	25.578	15.62
49	Estragole	11.279	0.18	**129**	Hinesol	25.664	1.57
58	Geraniol	13.356	0.27	**131**	Bicyclo [5.3.0] Decane, 2-Methylene	25.824	0.22
61	6, 11-Dimethyl-2, 6, 10-Dodecatrien	13.882	0.15	**132**	Beta-Eudesmol 2-Naphthalene	25.898	1.28
64	2H-1-Benzopyran, 3, 4, 4a, 5, 6, 8a-H	14.792	0.24	**133**	2-Naphthalenemethanol	25.967	1.98
65	Theaspirane A	14.981	0.2	**134**	Citronellyl 2-Methylpropanoate	26.161	0.46
67	6, 10, 10-Tetramethyl-1-Oxa	15.656	0.19	**135**	(2e, 6s)-2, 6-Dimethyl-2, 7-Octadiene	26.219	0.32
73	2, 6-Octadiene, 2, 6-Dimethyl	17.081	0.27	**136**	(+)-(4S, 8S)-Beta-Bisabolol	26.327	0.67
74	Neryl Acetate	17.498	0.17	**137**	Azulene, 1, 4-Dimethyl-7-(1-Methylene)	26.419	0.23
78	Lavandulyl Acetate	18.294	4.93	**138**	Geranyl Tiglate 2-Butenoic Acid	26.516	0.15
79	2-Oxa-1, 3-Disilacyclohexane	18.414	0.19	**139**	Alpha-Bisabolol	26.608	0.38
80	Cis-Jasmone 2-Cyclopenten	18.734	0.2	**140**	(-)-Anymol 4-[1'-Hydroxy']	26.653	0.22
83	Bicyclo [3.1.1] Hept-2-Ene	19.232	0.77	**141**	1, 3, 6, 10-Dodecatetraene	26.848	0.17
84	Caryophyllene	19.364	0.42	**142**	Geranyl Tiglate	27.037	3.04
86	(-)-Endo-2, 6-Dimethyl-6-(4-Methyl)	19.89	1.46	**143**	Acetic Acid, 1-Methylcyclopentyl	27.22	0.64
89	3-Buten-1-ol, 3-Methyl, Benzoate	20.193	0.24	**144**	Geranyl Isovalerate Butanoic Acid	27.346	0.12
91	Alpha-Caryophyllene	20.422	0.36	**151**	Neryl Propionate 2, 6-Octadiene	28.193	1.34
92	1, 6, 10-Dodecatriene, 7, 11-Dimethyl	20.537	0.31	**152**	Geranyl Acetate 2, 6-Octadiene	28.307	0.68
93	Beta-Santalene Bicyclo	20.634	0.23	**153**	Benzyl Benzoate Benzoic Acid	28.473	2.14
95	1H-Cycloprop [E] Azulene,	20.926	1.02	**162**	Neryl 2-Methylpropanoate	29.463	0.54

	Decahydro						
96	Geranyl Propionate 2, 6-Octadiene	21.137	2.59	**164**	2-Hexadecen-1-ol	29.823	0.26
97	(-)-Isoledene	21.223	0.15	**165**	2-Pentadecanone, 6, 10, 14-Trimethyl	29.921	0.46
98	Benzene, 1-(1, 5-Dimethyl-4-Hexene)	21.355	0.63	**167**	Oxalic Acid, Di (2-Phenylethyl)	30.081	0.12
99	Trans-Beta-Farnesene (E)	21.401	0.93	**168**	3, 7, 11, 15-Tetramethyl-2-Hexadecen	30.15	0.21
100	3-Buten-2-ol, Benzoate	21.532	0.85	**170**	Neophytadiene 2, 6, 10-Trimethy	30.35	0.3
101	Di-Epi-Alpha-Cedrene-(I)	21.693	0.36	**175**	Citronellyl Propionate	30.808	0.13
102	Benzyl E-2-Methyl-2-Butenoate	21.796	0.32	**178**	Geranyl Propionate 2, 6-Octadiene	31.008	0.42
103	Benzene, Tert-Buty	21.961	0.16	**179**	Geranyl Benzoate	31.151	2.55
104	Cyclohexene, 1-Methyl-4-(5-Methyl)	22.064	0.42	**184**	Geranyl Propionate 2, 6-Octadiene	31.489	0.25
105	Propanoic Acid, 2-Methyl	22.242	1.82	**192**	Benzenepropanoic Acid, 3, 7-Dimethyl	32.164	0.17
106	Methyl 2-(3', 3'-Dimethyl)	22.293	0.18	**220**	Heptasiloxane, Hexadecamethyl	35.992	0.25
108	Beta-Sesquiphellandrene	22.494	0.57	**223**	Cyclononasiloxane, Octadecamethyl	36.421	0.29
109	Butanoic Acid, 3, 7-Dimethyl-6	22.602	0.19	**224**	Octasiloxane, 1, 1, 3, 3, 5, 5, 7, 7, 9	36.507	0.14
111	Camphene Bicyclo [2.2.1] Heptan	22.877	0.15	**225**	Cyclononasiloxane, Octadecamethyl	36.638	0.31
112	Benzene, 1-Ethyl-2, 3-Dimethyl	22.94	0.17	**226**	Iron, Monocarbonyl-(1, 3-Butadien)	36.713	0.44
113	Geraniol Formate 2, 6-Octadiene	23.054	0.47	**227**	3, 6-Dioxa-2, 4, 5, 7-Tetrasilaoctan	36.844	0.3
114	Trans-Z-Alpha-Bisabolene Epoxide	23.283	0.31	**228**	5-(Diethylamino)-1, 2, 3, 4, 5-Pentan	36.907	0.38
115	Butanoic Acid, 3, 7-Dimethyl-2	23.587	5.79	**235**	Hexasiloxane, Tetradecamethyl	37.811	0.16
116	Nerolidol 1, 6, 10-Dodecatrien	23.735	3.22	**238**	1, 1, 1, 5, 7, 7, 7-Heptamethyl-3	38.137	0.29
117	3-Hexene-1-ol, Benzoate	23.89	3.45	**239**	2, 2, 2-Trichloroethyl 8-Iodo-1	38.303	0.19

Total retention time was about 38.469 min. The retention time in first and last compounds (2-Butenal, 3-Methyl and 2, 2, 2-Trichloroethyl 8-Iodo-1) were determined to be 3.045 and 38.303 min, respectively. By comparing the percentage of each compound on total volume of the essential oil, it was found that Naphthalene, Decahydro-4a-Methyl at peak 128 (25.578 min-15.62 %) and 18 different compounds each with 0.01% of total volume at peaks 1, 3, 4, 5, 8, 11, 14, 163, 188, 201, 206, 207, 208, 211, 215, 217, 218, and 229 (Table 3) were the highest and lowest constituents in this essential oil, respectively. These 18 compounds have been identified by the detector in initial and final peaks. In contrast, the dominant compounds of the essential oil have been detected in the middle peaks. Looking closely at the composition of the essential oil, there were 219 different compounds with percentage of less than 1% in the total volume which totally contained 32.74% of the essential oil.

Moreover, *S. officinalis* essential oil contained 93 chemical compounds (Table 4) with total retention time of 38.230 min that in Cis-Salvene Cis-2-Methyl-3 and 5, 6, 8, 9-Tetramethoxy-2-Methylpep as first and last compounds was 3.994 and 38.132 min, respectively.

Among the compounds, Alpha-Thujone Bicyclo (8.904 min-24.22%) at peak of 18 and Cyclopentadiene, 2, 5, 5-Trimethyl (5.139 min-0.02%) at peak 2 were major and minor compounds in the essential oil, respectively.

Table 3. Eighteen compounds in *G. glabra* essential oil that had the lowest percentage in total.

Peak	Compound	Retention Time (min)	% of Total
1	2-Butenal, 3-Methyl	3.045	0.01
3	O-Xylene	4.292	0.01
4	Styrene Benzene, Ethenyl	4.647	0.01
5	Benzene, 1, 3-Dimethyl	4.687	0.01
8	Bicyclo [3.1.0] Hex-3-En-2-ol	5.785	0.01
11	6-Methyl-5-Hepten-2-One	6.352	0.01
14	Cis-2-(2-Pentenyl)Furan	6.627	0.01
163	11, 13-Dimethyl-12-Tetradecen-1	29.623	0.01
188	Alpha-Cis-1-Hydroxymethyl-2	31.826	0.01
201	Tetracosamethyl Cyclododecasiloxan	32.948	0.01
206	1, 4-Cyclohexadiene, 1, 3, 6-Tris	33.915	0.01
207	N-Methyl-1-Adamantaneacetamide	33.989	0.01
208	Semicarbazide, 1-(4-Tert-Butyl)	34.041	0.01
211	5-(4, 5, 6, 7-Tetrahydrobenzofuran)	34.596	0.01
215	1, 4-Cyclohexadiene, 1, 3, 6-Tris	35.128	0.01
217	5-(Diethylamino)-1, 2, 3, 4, 5-Penta	35.465	0.01
218	Adamantane-1-Carboxamide	35.545	0.01
229	1, 4-Cyclohexadiene, 1, 3, 6-Tris	37.228	0.01

Table 4. Total compounds in *S. officinalis* essential oil with their retention time and percentage.

Peak	Compound	Retention Time (min)	% of Total	Peak	Compound	Retention Time (min)	% of Total
1	Cis-Salvene Cis-2-Methyl-3	3.994	0.14	**48**	Naphthalene, 1, 2, 3, 5, 6, 7, 8, 8a	23.443	0.04
2	Cyclopentadiene, 2, 5, 5-Trimethyl	5.139	0.02	**49**	1H-Cycloprop [E] Azulen-7-Ol	23.935	0.50
3	Tricyclo [2.2.1.0(2, 6)] Heptane	5.196	0.13	**50**	(-)-Caryophyllene Oxide	24.084	0.83
4	Bicyclo [3.1.0] Hex-2-Ene, 2-Methyl	5.276	0.03	**51**	Veridiflorol	24.330	4.47
5	1S-Alpha-Pinene	5.408	3.52	**52**	1,2-Dihydropyridine	24.496	0.42
6	Camphene Bicyclo [2.2.1] Heptan	5.688	3.17	**53**	Eudesma-4(14), 11-Diene	24.571	0.09
7	Bicyclo [3.1.1] Heptane, 6, 6-Dimet	6.203	0.81	**54**	12-Oxabicyclo [9.1.0] Dodeca-3, 7-D	24.765	1.30
8	Beta-Myrcene 1, 6-Octadiene	6.426	0.34	**55**	2, 6-Dimethylbicyclo [3.2.1] Octane	25.257	0.17
9	Alpha-Phellandrene	6.701	0.04	**56**	Trans-Z-Alpha-Bisabolene Epoxide	25.343	0.84
10	Alpha-Terpinene 1, 3-Cyclohexen	6.935	0.10	**57**	Caryophyllenol-Ii Bicyclo	25.440	0.20
11	Benzene, 1-Methyl-4-(1-Methylethyl)	7.090	0.78	**58**	(1RS,2SR, 3SR, 4SR, 6SR)-1	25.972	0.25
12	Dl-Limonene Cyclohexen	7.176	0.76	**59**	Caryophyllene Oxide 5-Oxatric	26.316	0.14
13	1, 8-Cineole 2-Oxabicyclo	7.250	10.00	**60**	Humulen-(V1)	28.765	0.05
14	Cis-Ocimene 1, 3, 7-Octatriene	7.307	0.05	**61**	3,5-Methanocyclopentapyrazole	29.314	0.06
15	Gamma-Terpinene 1,4-Cyclohexen	7.748	0.08	**62**	2-Pentadecanone, 6, 10, 14-Trimethyl	29.903	0.06
16	Benzene, Methyl (1-Methylethenyl)	8.412	0.10	**63**	Phenanthrene, 7-Ethenyl-1	30.722	0.07
17	1, 6-Octadien-3-Ol, 3, 7-Dimethyl	8.704	0.26	**64**	Bicyclo [6.1.0] Nonane, 9-(1-Methyl)	30.882	0.21
18	Alpha-Thujone Bicyclo	8.904	24.22	**65**	1=(1'-Methylallenyl)-2-Ethenyl	31.162	0.03
19	Thujone Bicyclo [3.1.0] Hexan-3	9.110	6.20	**66**	Cembrene	31.328	0.06
20	2, 3, 3-Trimethyl-3-Cyclopentene	9.304	0.05	**67**	Kaur-15-Ene	31.391	0.03
21	Bicyclo [3.1.0] Hexan-3-Ol, 4-Methyl	9.705	0.09	**68**	Androst-16-En-3-One	31.506	0.13
22	Bicyclo [2.2.1] Heptan-2-One	9.865	15.51	**69**	1-Naphthalenepropanol	31.786	4.10
23	Exo-Methyl-Camphenilol	9.917	0.07	**70**	5,7-Dimethoxy-1-Naphthol	31.963	0.19
24	Bicyclo [3.1.1] Heptan-3-One	10.231	0.05	**71**	Silane, Trimethyl	32.278	0.15
25	Borneol L	10.369	1.65	**72**	Octasiloxane, 1, 1, 3, 3, 5, 5, 7, 7, 9	32.450	0.18
26	3-Cyclohexen-1-Ol, 4-Methyl-1	10.678	0.52	**73**	1, 4-Cyclohexadiene, 1, 3, 6-Tri	32.753	0.52
27	Thymol	10.872	0.08	**74**	Cyclodecasiloxane, Eicosamethyl	32.822	0.08
28	P-Menth-1-En-8-Ol	11.055	0.23	**75**	2-(2-Amino-Benzoimidazol-1-Yl)-1	32.879	0.21
29	2(3H)-Furanone, Dihydro-5	11.267	0.22	**76**	Propanoic Acid, 2-[4-(1,1-Dimethyl)]	33.096	0.24
30	2-Cyclohexen-1-One, 2-Methyl-5	12.783	0.20	**77**	Etracosamethylcyclododecasiloxa	33.279	0.34
31	Benzene, 1-Methoxy-4-(1-Propenyl)	14.420	0.50	**78**	Formic Acid, 1-(4, 7-Dihydro-2)	33.565	0.23
32	Bicyclo [3.1.0] Hex-2-Ene, 4-Methyl	14.706	0.18	**79**	4-Methoxy-3-(3-Methoxyphenyl)-4	33.989	0.13
33	Phenol, 2-Methyl-5-(1-Methylethyl	15.061	0.26	**80**	1,3-Xylyl-15-Crown-4, 2, 3-.Pinan	34.092	0.12
34	(-)-Isoledene	17.767	0.05	**81**	1,4-Cyclohexadiene, 1, 3, 6-Tris	34.138	0.23
35	Caryophyllene	19.341	1.60	**82**	Phenylacetic Acid, 2-(1-Adamanty)	36.232	0.43
36	1H-Cyclopropa [A] Naphthalene	19.610	0.07	**83**	1,4-Cyclohexadiene, 1, 3, 6-Tris	36.827	0.12
37	Selina-3, 7(11)-Diene Naphthalen	19.816	0.08	**84**	2,4-Cyclohexadien-1-One	37.056	0.14
38	1H-Cycloprop[E]Azulene	19.953	0.76	**85**	1,4-Cyclohexadiene, 1, 3, 6-Tris	37.176	0.24
39	Beta-Selinene Naphthalene	20.090	0.09	**86**	Bis [(1, 1, 3, 3-Tetramethylbutyl)]	37.388	0.76
40	Alpha-Humulene	20.416	2.65	**87**	Silicone Grease, Siliconfett	37.451	0.22
41	Aromadendrene	20.628	0.13	**88**	1-Naphthaleneethanol	37.565	1.09
42	3-Buten-2-One, 4-(2, 6, 6-Trimethyl)	21.395	0.05	**89**	Bis[(1, 1, 3, 3-Tetramethylbutyl)]	37.645	0.59
43	Gamma-Himachalene	21.458	0.09	**90**	Iron, Monocarbonyl-(1,3-Butadien)	37.828	1.67
44	Ledene 1H-Cycloprop [E] Azulene	21.658	0.45	**91**	2, 2, 2-Trichloroethyl 8-Iodo-1	37.891	0.69
45	Aromadendrene, Dehydro	22.345	0.05	**92**	3, 6-Dioxa-2, 4, 5, 7-Tetrasilaoctan	38.034	1.13
46	1s,Cis-Calamenene	22.448	0.08	**93**	5, 6, 8, 9-Tetramethoxy-2-Methylpep	38.132	0.52
47	2(1H)-Naphthalenone	23.249	0.07				

The lowest compounds in this medicinal plant were shown in Table 5. Dominant compounds in this essential oil that identified by the detector were random and had not clear arrangement, apposite to *G. glabra***.**

Table 5. Twenty compounds in *S. officilias* essential oil that had the lowest percentage in total.

Peak	Compound	Retention Time (min)	% of Total
2	Cyclopentadiene, 2, 5, 5-Trimethyl	5.139	0.02
4	Bicyclo [3.1.0] Hex-2-Ene, 2-Methyl	5.276	0.03
65	1=(1'-Methylallenyl)-2-Ethenyl	31.162	0.03
67	Kaur-15-Ene	31.391	0.03
9	Alpha-Phellandrene	6.701	0.04
48	Naphthalene, 1, 2, 3, 5, 6, 7, 8, 8a	23.443	0.04
14	Cis-Ocimene 1, 3, 7-Octatriene	7.307	0.05
20	2, 3, 3-Trimethyl-3-Cyclopentene	9.304	0.05
24	Bicyclo [3.1.1] Heptan-3-One	10.231	0.05
34	(-)-Isoledene	17.767	0.05
42	3-Buten-2-One, 4-(2, 6, 6-Trimethyl)	21.395	0.05
45	Aromadendrene, Dehydro	22.345	0.05
60	Humulen-(V1)	28.765	0.05
61	3,5-Methanocyclopentapyrazole	29.314	0.06
62	2-Pentadecanone, 6, 10, 14-Trimethyl	29.903	0.06
66	Cembrene	31.328	0.06
23	Exo-Methyl-Camphenilol	9.917	0.07
36	1H-Cyclopropa[A]Naphthalene	19.610	0.07
47	2(1H)-Naphthalenone	23.249	0.07
63	Phenanthrene, 7-Ethenyl-1	30.722	0.07

Due to high importance of *G. glabra* and *S. officinalis*, various researches have been done on these valuable plants in different regions of the world. According to the literature, there were good studies on the extract of these medicinal plants, which is beyond my scope of work and we abandon them. In addition, there were some studies on their essential oils that we will briefly review them and explain the reasons for differences or similarities with our results. Miyazawa and Kameoka (1990) investigated volatile components in *Glycyrrhiza radix* L. from China and reported that there were 81volatile compounds in the essential oil while 35.0% of them were from terpenoid group. They detected main constituents as Octanoic acid, Paeonol, Octadecane, Benzaldehyde, Alpha-Terpineol, and 4-Terpineol. In comparison, higher diversity of aromatic compounds was observed in my study, which indicates suitability of Kermanshah province in Iran compared to China for this medicinal plant. However, the species studied by them were different to each other and this is a main reason for differences in the secondary compounds between two plant species. In general, plants produce more volatile compounds under suitable conditions in terms of climate and nutrition. This case is also observed in plants under stress or attack by various plant pests and diseases that must seriously be considered. Farag *et al*., (2012) investigated volatile compounds of *G. glabra* rhizome in Egypt by distillation method and found that Phenols, Thymol, and Carvacrol were exclusively in the essential oil. Their results indicated that type and plant part as well as climatic conditions affected volatile compounds in different plant species. Ali (2013) studied different aspects of *G. glabra* essential oil in Egypt and reported that Alpha-Pinene, Beta-Pinene, Octanol, Gamma-Terpinene, Estragole, Isofenchon, Beta-Caryophyllene, Citronellyl Acetate, Caryophyllene Oxide, and Geranyl Hexanolate were available in the essential oil; among them, Geranyl Hexanolate had the highest percentage in total volume. As mentioned earlier, plants produce more volatile compounds under suitable conditions, especially in hot climates compared to cool, which confirm the results of mentioned study. Type of plant organ also influences the results; therefore, in order to make a correct comparison, the essential oil isolated from each part should be compared together.

Chouitah *et al*., (2013) investigated chemical constituents of *G. glabra* leaves in Algeria and concluded that the main constituents of the essential oil were Isoniazid, Diethyl Toluamide, Benzoic Acid, Benzene, Linalool, Presterone, Warfarin, Idoquinol, and Phenol, 4-(2) Amino Propyl that was very different with my analysis. The reasons for this difference can be related to plant collection, method of isolation, and even the analyzer device, which are very effective in changing the results. Plants in different regions have fundamental differences in structure of their essential oils, and this subject makes the science of plant essential oils very attractive and amazing. Wagner *et al*., (2016) studied the aromatic compounds in *G. glabra* by using molecular sensory science and concluded that 16 compounds were identified for first time in this important medicinal plant while Gamma-Nonalactone, 4-Hydroxy-2, 5-Dimethylfuran-3(2H)-One, and 4-Hydroxy-3-Methoxy Benzaldehyde had the highest flavor dilution factor and 43 compounds showed low stability. Essential oils generally contain volatile and unstable compounds; but, some compounds are more volatile and therefore have a variety of roles in plants. Although, stability of 239 compounds was not studied in our study, addressing such cases could open up new aspects of the science of

plant essential oils, especially about the important medicinal plant, *G. glabra*.

Different compounds from *G. glabra* have memory enhancement, antidepressant, antimicrobial, anticancer, antioxidant, protective, anti-inflammatory, antiulcer, antidiabetic, hypolipidemic, and the other medicinal applications (Kameoka and Nakai, 1978). Al-Snafi (2018) examined medicinal properties from the rhizome and leaf of *G. glabra* and concluded that there were Alkaloids, Glycosides, Carbohydrates, Starches, Phenolic compounds, Flavonoids, Proteins, Pectin, Mucilage, Saponin, Lipids, Tannins, Sterols, and Steroids in both of them. He identified different compounds in the leaf and rhizome separately and found that the main constituents from the leaves were Isoniazids, Diethyl Toluamide, Benzoic Acid, Benzene, Linalool, Progesterone, Warfarin, Idoquinol, and Phenol,4-(2-Aminopropyl). Moreover, among 82 compounds in the rhizome; Hexanoic Acid, Hexadecanoic Acid, Hexanol, and Octanoic Acid were dominant. In the end, he concluded that aromatic properties of the essential oil in this plant were related to Estragel (Methyl Chavicol), Anethole, Eugenol, Indole along with Gamma-Nonalactone, and Comic Alcohol. As you see, the compounds in the rhizome and aerial parts of this plant in Egypt were very different compared to Iran, which confirm previous stated items. Asadi *et al*., (2018) studied essential oil components in the aerial parts of *G. glabra* and *S. officinalis* samples collected from Ardabil province in north of Iran and found that there were 43 and 44 dominant compounds in the essential oils of both medicinal plants while Aristolene and Beta-Thujone were identified as dominant constituents. According to this study, effect of climatic conditions on changes of number and percentage of secondary compounds was clear so that in more temperate regions (Kermanshah province) these medicinal plant has more number and variety of compounds compared to cold climate (Ardabil province).

Quirós Sauceda *et al*., (2016) confirmed that *G. glabra* samples collected from Egypt, Afghanistan, Syria, and China were different in types and quantities of volatile materials; however, volatile compounds in the rhizome were (E)-2-Heptenal, 5-Methyl-Furfural, (2E, 1E) Heptadienol, (E)-2-Octen-1-Al, O-Guaiacol, 2-Phenylethanol, (Z)-Pinene Hydrate, Lavandulol, Terpinen-4-ol, (E)-Linalool Oxide, P-Cymen-8-ol, A-Terpineol, Methyl Chavicol, (4E)-Decenal, Decanal, (2E, 4E)-Nonadienal, Cumin Aldehyde, Carvone, Piperitone, (E)-Cinnamaldehyde, (E)-Anethole, (2E, 4Z)-Decadienal, Thymol, Indole, Carvacrol, (2E, 4Z)-Decadienal, P-Vinyl-Guaiacol, Eugenol, Nonalactone, Methyl Eugenol, Beta-Caryophyllene, Beta-Dihydro-Ionone, Himachalene Epoxide, Spathulenol, (1α, 10α)-Epoxy-Amorph-4-Ene, B-Caryophyllene Oxide, and Humulene Epoxide II. Unfortunately, available compounds about the rhizome of *G. glabra* were not studied in my research and I can't do any comparison with the similar researches in this regard; but, it could certainly be said that the compounds in each part of plants are different from another and this is one of the exciting aspects of plant essential oils which can be of interest to researchers.

Various species of *Salvia* are used as flavorings, food condiments, cosmetics, perfume additives, and as herbal medicine such as antibacterial, antiviral, antitumor, spasmolytic, antioxidant, and anti-inflammatory. Badiee *et al*., (2012) analyzed available compounds in *S. officinalis* essential oil and concluded that 40 components occupied about 99.58% of the total volume while Cineole, Borneol, Alpha-Thujone, Ledene, Beta-Pinene, Alpha-Humulene, and Trans-Caryophyllene were major constituents. They also indicated that the essential oil isolated from this plant showed suitable antifungal effects that could be applied as a natural alternative for synthetic as a fungicide in control of fungal diseases in variable agricultural crops. Their specimens collected from Shiraz in southwest of Iran and this subject indicates suitability of Iran for this valuable medicinal plant. Also, Abu-Darwish *et al*., (2013) studied the essential oil of common sage (*S. officinalis*) from Jordan and concluded that its main compounds were 1, 8-Cineole (between 39.5% to 50.3%), and Camphor (between 8.8% to 25%). Additionally, Lakhal *et al*., (2013) investigated chemical composition and biological activity of the essential oil isolated from this important medicinal plant in Batna from Algeria and reported that 35 components contained 98.39% of its total volume. They mentioned that Alpha-Thujone (24.52%), 1, 8-Cineole (15.92%), Camphor (16.86%), Beta-Thujone (6.50%), and Veridiflorol (6.35%) were major components. About Alpha-Thujone there was near similarity with my results that is very amazing, the reason for this similarity can be related to geographical location, type of essential oil isolation or even type of analyzer device. Porte *et al*., (2013) investigated

chemical composition of *S. officinalis* essential oil in Rio-de-Janeiro from Brazil and stated that 47 constituents were identified containing 94.90% of compounds and major of them were distinguished as Alpha-Thujone (40.90%), Camphor (26.12%), Alpha-Pinene (5.85%), and Beta-Thujone (5.62%). They concluded that their essential oil was similar to those found in several European countries and can be a valuable product for small farmers from the Petrópolis region in Rio-de-Janeiro State. Dominant compounds and analyzed device in their study was similar to our results and this subject has made extremely similar results.

Russo *et al*., (2013) studied chemical composition of the essential oil from *S. officinalis* grown in different environmental conditions and concluded that the main compounds were Alpha-Thujone, Camphor, Borneol, Gamma-Murolene, and Sclareol; but, percentage of these compounds varied to environmental factors such as altitude, water availability, and pedo-climatic conditions. About main compounds, there was similrtiy with results of the present study about Alpha-Thujone; although, the effect of different climatic conditions was not studied in my research that can be considered in future research. Also, Ben Khedher *et al*., (2017) investigated chemical composition of *S. officinalis* essential oil from Tunisia by GC-MS and reported that there were 49 compounds in the essential oil while Camphor (25.14%), Alpha-Thujone (18.83%), 1, 8-Cineole (14.14%), Viridiflorol (7.98%), Beta-Thujone (4.46 %), and Beta-Caryophyllene (3.30%) were major components. The results were extremely different with mine. Although, the analyzer device was similar; but, climatic parameters related to geographical conditions could be effective in the changes of results. Finally, El Eucha *et al*., (2019) investigated chemical analysis in *S. officinalis* essential oil and stated that 18 compounds were available while contained 96.94% of the present compounds. They reported the main components were Camphor (33.61%), 1, 8-Cineole (22.22%), and Alpha-Thujone (21.43 %). About the main compounds there were low differences with my results; but, variation of compounds is very limited than my study (18 vs. 93). Environmental and maintenance conditions are very effective factors in changes the secondary metabolites that indicated that our condition was more suitable.

4. Conclusion

Medicinal plants are valuable biological resources in every country and are considered as God-given natural resources. Therefore, identification, classification, and study of chemical properties, including the study of compounds in their essential oils and extracts are very important topics in plant science. *G. glabra* and *S.officinalis* are valuable medicinal plants in Kermanshah province in west of Iran. These plants have a significant number and variety of secondary compounds, especially about their essential oils, which can be used in various ways, including antioxidants, antimicrobials, as well as their applications in medical, pharmacology, and toxicology.

5. References

Abu-Darwish, M. S., Cabral, C., Ferreira, I. V., Gonçalves, M. J., Cavaleiro, C., Cruz, M. T., Al-Bdour, T. H. and Salgueiro, L. 2013. Essential oil of common sage (*Salvia officinalis* l.) from Jordan: assessment of safety in mammalian cells and its antifungal and anti-inflammatory potential. *BioMed Research Internatonal*, 1–9.

Ali, E. M. 2010. Phytochemical composition, antifungal, antiaflatoxigenic, antioxidant and anticancer activities of *Glycyrrhiza glabra* L. and *Matricaria chamomilla* L. essential oils. *Journal of Medicinal Plant Research*, 7(29): 2197–2207.

Al-Snafi, A. E. 2018. *Glycyrrhiza glabra*: A phytochemical and pharmacological review. *Journal of Pharmacognosy*, 8(6): 2250–3013.

Asadi, M. 2010. Identification of Neuroptera fauna from Eslamabad-e Gharb and Sarpol-e Zahab cities in Kermanshah province. M. Sc. Thesis, Razi University, Kermanshah, Iran. pp 110.

Asadi, M., Rafiee-Dastjerdi, H., Nouri-Ganbalani, G., Naseri, B. and Hassanpour, M. 2018. The effects of plant essential oils on the functional response of *Habrobracon hebetor* Say (Hymenoptera: Braconidae) to its host. *Invertebrate Survival Journal*, 15: 169–182.

Asadi, M., Rafiee-Dastjerdi, H., Nouri-Ganbalani, G., Naseri, B. and Hassanpour, M. 2019. Insecticidal activity of the isolated essential oils from three medicinal plants on the biological control agent, *Habrobracon hebetor* Say (Hymenoptera: Braconidae). *Acta Biologica Szegediensis*, 63(1): 63–68.

Babaee Ghaghelestany, A., Alebrahim, M. T. and Asadi, M. 2020. Chemical analysis and identifying dominant essential oil compositions from sage (*Salvia officinalis* L.). *Food Science and Technology*, 17(101): 155–165.

Badiee, P., Nasirzadeh, A. R. and Motaffaf, M. 2012. Comparison of *Salvia officinalis* L. essential oil and antifungal agents against candida species. *Journal of Pharmaceutical and Technical Drug Research*, 1: 1–5.

Bakkali, F., Averbeck, S., Averbeck, D. and Idomar, M. 2008. Biological effects of essential oils. *Food and Chemical Toxicology*, 46: 446 –475.

Bao, B. J. and Larsen, K. 2010. *Glycyrrhiza*, in Flora of China. Science Press, Beijing. pp 511.

Ben *Khedher*, M. R., Ben Khedher, S., Chaiebm I., Tounsim, S. and Hammami, M. 2017. Chemical composition and biological activities of *Salvia officinalis* essential oil from Tunisia. *Exclinical Journal*, 16: 160–173.

Chouitah, O., *Meddah*, B., Aoues, A. and Sonnet, P. 2013. Chemical composition and antimicrobial activities of the essential oil from *Glycyrrhiza glabra* leaves. *Journal of Essential Oil Bearing Plants*, 14(3): 284–288.

Dini, M. 2005. Medicinal plants used in traditional medicine. Publications of Research Institute of Forests and Rangelands Organization of the country, Tehran, Iran. pp 420.

Duan, L., Yang, X., Liu, P. L., Johnson, G., Wen, J. and Chang, Z. Y. 2016. A molecular phylogeny of Caraganeae (Leguminosae, Papilionoideae) reveals insights into new generic and infrageneric delimitations. *Phytokey*, 70: 111–137.

El Eucha, S. K., Hassinecde, D. B., Cazauxc, S., Bouzouita, N.and Bouajila, J. 2019. *Salvia officinalis* essential oil: chemical analysis and evaluation of anti-enzymatic and antioxidant bioactivities. *South African Journal of Botany*, 120: 253–260.

Esmaeili, H., Karami, A., Hadian, J., Saharkhiz, M. J. and Ebrahimi, S. N. 2019. Variation in the phytochemical contents and antioxidant activity of *Glycyrrhiza glabra* populations collected in Iran. *Industrial Crop and Products*, 137: 248–259.

Farag, M. A. and Wessjohann, L. A. 2012. Volatiles profiling in medicinal Licorice roots using steam distillation and solid-phase microextraction (SPME) coupled to chemometrics. *Journal of Food Science*, 77(11): 1179–1184.

Ghahreman, A. and Attar, F. 1999. Biodiversity of plant species in Iran: the vegetation of Iran, plant species, red data of Iran, endemic species, rare species, species threatened by extinction. Central Herbarium of Tehran University, Faculty of Science, Tehran, Iran. pp 1218

Hayashi, H. and Sudo, H. 2009. Economic importance of liquorice. *Plant Biotechnology*, 26: 101–104.

Isman, M. B. 2000. Plant essential oils for pest and disease management. *Crop Protection*, 19: 603–608.

Isman, M. B., Wilson, J. A. and Bradbury, F. 2008. Insecticidal activities of commercial rosemary oil (*Rosmarinus officinalis*) against larvae of *Pseudaletia unipunctata* and *Trichoplusia ni* in relation to their chemical compositions. *Pharmaceutical Biology*, 46(1–2): 82 –87.

Kameoka, H. and Nakai, K. 1978. Components of essential oil from the root of *Glycyrrhiza glabra*. *Nippon Nage Kaish*, 61(9): 1119–1121.

Lakhal, H., Ghorab, H., Chibani, S., Kabouche, A., Semra, Z., Smati, F., Abuhamdah, S. and Kabouche, Z. 2013. Chemical composition and biological activities of the essential oil of *Salvia officinalis* from Batna (Algeria). *Der Pharmacia Lettre*, 5(3): 310–314.

Li, P. C. and Cui, H. B. 1998. *Glycyrrhiza*, in Flora Reipublicae Popularis Sinicae. Science Press, Beijing. pp 176.

Miyazawa, M. and Kameoka, K. 1990. Volatile flavor components of *Glycyrrhizae radix* (*Glycyrrhiza glabra* L. var. *glandulifera* Regel et Herder) from China. *Flavor and Fragrance Journal*, 5(3): 157–160.

Negahban, M., Moharramipour, S.and Sefidkon, F. 2007. Fumigant toxicity of essential oil from *Artemisia sieberi* Besser against three insects. *Journal of Stored Product Research*, 43: 123–128.

Parsia Aref, S. and Valizadegan, O. 2015. Fumigant toxicity and repellent effect of three Iranian eucalyptus species against the lesser grain beetle, *Rhyzopertha dominica* (F.) (Col.: Bostrychidae). *Journal of Entomlogy and Zoology Studies*, 3(2): 198–202.

Porte, A. I., Godoy, R. L. O. and Maia-Porte, L. H. 2013. Chemical composition of sage (*Salvia officinalis* L.) essential oil from the Rio de Janeiro State (Brazil). *Revista Brasiliero Plantas Medica*, 15(3): 438–441.

Quirós Sauceda, A. E., Ovando-Martínez, M., Velderrain-Rodríguez, G. R., González-Aguilar, G. A. and Ayala-Zavala, J. F. 2016. Licorice (*Glycyrrhiza glabra* Linn.) Universidad de Sonora Press, New Zealand.

Rafiee-Dastjerdi, H., Khorrami, F., Razmjou, J., Esmaielpour, B., Golizadeh, A. and Hassanpour, M. 2013. The efficacy of some medicinal plant extracts and essential oils against potato tuber moth, *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae). *Journal of Crop Protection*, 2(1): 93–99.

Russoa, A., Formisanob, C., Riganob, D., Senatoreb, F., Delfinec, S., Cardiled, V., Rossellie, S. and Brunoe, M. 2013. Chemical composition and anticancer activity of essential oil of Mediterranean sage (*Salvia officinalis* L.) grown in different environmental conditions. *Food and Chemical Toxicology*, 55: 42–47

Samsam Shariat, S. H. 2007. Extraction and extraction of active plant substances. Tehran: Mani Publications. pp 266 .

Wagner, J., Granvogl, M. and Schieberle, P. 2016. Characterization of the key aroma compounds in raw Licorice (*Glycyrrhiza glabra* L.) by means of molecular sensory science. *Journal of Agriculture and Food Chemistry*, 64: 8388–8396.

Zhou, C. M. and Jin, G. Q. 2016. Liquorice. China Agriculture Press, Beijing.