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CHEMICAL COMPOSITION AND ANTIBACTERIAL ACTIVITY OF THE ESSENTIAL OILS OF *Semenovia frigida* AND *Chaerophyllum bulbosum* FROM IRAN

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11 Species of genus *Semenovia* are found in Iran, and five of them are endemic: *S. tragioides*, *S. frigida*, *S. suffruticosa , S. subscaposa*, and *S. dichotoma* [1, 2].

Water-distilled oils obtained from the aerial parts of *S. suffruticosa* (Freyn et Bornm.) Manden. and *S. tragioides* Boiss. Manden. have been the subject of our previous studies [3, 4].

Also we reported the antibacterial activity and composition of the essential oil of *S. dichotoma* (Boiss.) Manden. The results of the antibacterial screening showed that *S. dichotoma* oil was active against the Gram-positive bacteria *Staphylococcus aureus*, *S. epidermidis*, and *S. saprophyticus* (50 mm, 40 mm and 31 mm diameter, respectively) but had only moderate inhibitory activity against Gram-negative bacteria [5].

The genus *Chaerophyllum* is comprised of about 110 species, 8 of which are described in the flora of Iran, among which two are endemic*: C. nivale* and *C. khorassancum* [1, 2].

Previous phytochemical investigation of *Chaerophyllum* species have revealed the presence of secondary plant metabolites like lignans [6], phenyl propanoids and polyacetylenes [7], phenolic acids [8], and flavonoid glycosides [9, 10].

Previous investigation on oils of the *Chaerophyllum* genus showed varying compositions [11–17].

Of the oil isolated from the epigeal part of *C. bulbosum* growing in Azerbaijan, 18 components were identified, amounting to only (32.0%) of the total oil. Oxygen-containing monoterpenes constituted the main fraction (20.0%), with linalool as the major component (18.0%). α-Pinene (8.0%) was the other main component of the oil [18].

The biological activity of some *Chaerophyllum* species, such as antimicrobial, antioxidant, glutathione *S. transferase* inhibitory activity, and cytotoxic properties have been investigated [8, 19–22].

The trend to use essential oils or essential-oil-containing plants in foods, which may act as natural antimicrobial or antioxidant preservatives, may also influence the health of consumers as well as prolong the shelf-life of relevant food products [23, 24].

The composition of the essential oils obtained by hydrodistillation from the aerial parts of *Semenovia frigida* (Boiss.& Hausskn.) Manden. which is endemic to Iran (Voucher number 6931), and *Chaerophyllum bulbosum* L., (Voucher number 1724), which was deposited at the Herbarium of the Research Institute of Forests and Rangelands (TARI), Tehran, Iran were analyzed by GC and GC/MS. GC/MS analysis was performed using a Hewlett–Packard 5973 with a HP-5MS column (30 m × 0.25 mm, film thickness 0.25 μm). The column temperature was kept at 60°C for 3 min and programmed to 220°C with a 5°C/min rate and kept constant at 220°C for 5 min. The flow rate of helium as carrier gas was 1 mL/min. MS were taken at 70 eV.

The composition of the essential oil from *Semenovia frigida* and *Chaerophyllum bulbosum* is listed in Tables 1 and 2, respectively. The percentage and retention indices of the components are given. Identification of the constituents of each oil was achieved by comparison of their mass spectra and retention indices with those reported in the literature and those of authentic samples [25].

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TABLE 1. Chemical Composition of Essential Oil from *Semenovia frigida*

Compound	RI	Percentage	Compound	RI	Percentage
Octane	800	1.2	β-Caryophyllene	1418	3.2
Decane	999	0.4	α-Humulene	1454	0.2
Octanol	1070	0.4	*ar*-Curcumene	1483	0.2
Linalool	1098	2.8	Bicyclogermacrene	1494	0.3
Neryl oxide	1153	0.2	Pentadecane	1500	0.2
Lavandulol	1166	0.2	Cuparene	1502	0.2
α-Terpineol	1184	1.6	Geranyl isobutyrate	1514	3.8
Dodecane	1199	0.2	(*Z*)-Nerolidol	1534	2.8
Citronellol	1228	13.8	Spathulenol	1576	14.5
Neral	1240	0.2	Caryophyllene oxide	1581	4.8
Piperitone	1252	1.7	Viridiflorol	1590	1.6
Geraniol	1255	1.8	Hexadecane	1600	0.6
Geranial	1270	0.3	10-epi-γ-Eudesmol	1619	1.8
Bornyl acetate	1285	0.1	β-Eudesmol	1649	5.3
Lavandulyl acetate	1289	0.6	Tetradecanoic acid	1771	2.3
Neryl acetate	1365	16.2	6,10,14-trimethyl-2-pentadecanone	1849	0.4
Geranyl acetate	1383	0.6	Pentadecanoic acid	1872	0.2
(*E*)-Jasmone	1388	0.2	Hexadecanoic acid	1973	5.5
Tetradecane	1399	0.2			

TABLE 2. Chemical Composition of the Essential Oil of *Chaerophyllum bulbosum*

Compound	RI	Percentage	Compound	RI	Percentage
α-Pinene	939	0.2	2-Methylnaphthalene	1308	0.5
β-Pinene	980	0.3	Neryl acetate	1365	0.5
Myrcene	991	0.4	α-Copaene	1376	0.4
Octanal	1001	1.9	2,7-Dimethylnaphthalene	1392	1.0
p-Cymene	1026	2.7	1,7-Dimethylnaphthalene	1409	1.1
Limonene	1031	0.2	2,6-Dimethylnaphthalene	1415	0.7
(*Z*)-β-Ocimene	1040	18.8	β-Caryophyllene	1418	1.3
(*E*)-β-Ocimene	1050	4.0	(*E*)-β-Farnesene	1458	22.3
γ-Terpinene	1062	0.4	Germacrene D	1480	0.7
Nonanal	1096	0.5	Cuparene	1502	0.6
Linalool	1098	0.3	Myristicin	1520	17.1
allo-Ocimene	1129	5.1	Spathulenol	1576	0.6
Geraniol	1255	1.7	Caryophyllene oxide	1581	6.6
1-Methylnaphthalene	1286	0.8	Hexadecanoic acid	1973	0.6
Thymol	1290	0.9			

As shown in Table 1, in *S. frigida* oil, 37 components, which represent about 90.6% of the total composition, were identified. The oil of *S. frigida* consisted of 14 oxygenated monoterpenes (43.9%), five sesquiterpene hydrocarbons (4.1%), six oxygenated sesquiterpenes (30.8%), and 12 aliphatic compounds (11.8%). Neryl acetate (16.2%), spathulenol (14.5%), and citronellol (13.8%) were the major components in this oil, followed by hexadecanoic acid (5.5%) and β-eudesmol (5.3%).

As shown in Table 2, 29 components in the oil of *C. bulbusum*, which represent about 92.2% of the total oil, were identified. The oil of *C. bulbusum* consisted of nine monoterpene hydrocarbons (32.1%), four oxygenated monoterpenes (3.4%), five sesquiterpene hydrocarbons (25.3%), two oxygenated sesquiterpenes (7.2%), and nine aliphatic and aromatic compounds (24.2%). (*E*)-β-Farnesene (22.3%), (*Z*)-β-ocimene (18.8%), and myristicin (17.1%) were the major components in this oil. The other notable compounds in the oil of the plant were caryophyllene oxide (6.6%), allo-ocimene (5.1%), and (*E*)-β-ocimene (4.0%).

As mentioned above in the oil from the epigeal part of *C. bulbusum* grown in Azerbaijan [18], linalool and α-pinene were predominant, while in our study of the aerial parts oil of the plant these two compounds were found in relatively small amounts (0.3% and 0.2%, respectively).

TABLE 3. Antibacterial Activity of Essential Oils of *S. frigida* and *C. bulbosum*

Microorganisms	Gram +/–	*S. frigida*		*C. bulbosum*		Gentamicin
		IZ	MIC	IZ	MIC	
Staphylococcus aureus PTCC 1885	+	60	1.56	20	25	13
Streptococcus pyogenes PTCC 1949	+	20	25	60	1.56	13
Bacillus anthracis PTCC 1036	+	30	12.5	60	1.56	32
Escherichia coli PTCC 1330	–	15	25	20	25	13
Klebsiella pneumoniae PTCC 1249	–	–	–	20	25	20
Pseudomonas aeruginosa PTCC 1547	–	–	–	–	–	16

IZ – inhibition zone (mm); MIC – minimum inhibitory concentration (mg/mL).

Antibacterial Activity. The antibacterial activities of *S. frigida* and *C. bulbosum* oils were assayed against six Gram-positive and Gram-negetive bacteria, and the results presented in Table 3 were compared with standard antibiotics such as gentamicin. The antibacterial activities of the essential oils were evaluated by the disc diffusion method using Muller-Hinton Agar for bacteria with determination of inhibition zones and minimal inhibitory concentrations.

The present study reveal that the essential oil of *S. frigida* showed significant activity against all Gram-positive bacteria, especially *Streptococcus pyogenes* and *Bacillus anthracis*, and moderate inhibitory activity against the Gram-negative bacteria *Escherichia coli* and *Klebsiella pneumonia. Pseudomnas aeruginosa* was insensitive to the oil.

The essential oil of *C. bulbosum* also showed significant activity against all Gram-positive bacteria, especially *Staphylococcus aureus* and *Bacillus anthracis*, moderate inhibitory activity against *Escherichia coli*, and inactivity against *Klebsiella pneumonia* and *Pseudomonas aeruginosa*.

These results are interesting and confirm the importance of the correlation between the chemical content of the oils and the antibacterial activities.

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