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RESEARCH ARTICLE

Composition of the Essential Oils of *Scutellaria galericulata* and *S. tortumensis* from Turkey

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Abstract

The genus *Scutellaria* L. (Lamiaceae) is represented by 39 taxa in Turkey. The ratio of endemism in Turkey is 43.6%. The chemical compositions of the essential oils obtained by hydrodistillation of *Scutellaria galericulata* and *S. tortumensis* from Turkey were analyzed by gas chromatography and gas chromatography-mass spectrometry, simultaneously. The main components were determined as caryophyllene oxide (27.5%), β-caryophyllene (13.4%) and caryophylla-2(12),6-dien-5β-ol (4.8%) in the oil of *S. galericulata*. Germacrene D (29.8%), β-caryophyllene (17.1%) phytol (8.3%) and nonacosane (7.1%) were found as major components in the oil of *S. tortumensis*. Overall, *S. galericulata* and *S. tortumensis* essential oils representing 88.6% and 94.3% of the total, respectively.

Keywords: *Scutellaria galericulata*, *S. tortumensis*, Lamiaceae, essential oil composition

Introduction

Scutellaria L., a member of mint family, is a subcosmopolitan genus with 471 species (Paton, 1990a; WCSP, 2019) and widely spread in the tropical and southern hemisphere in the world (Paton, 1990b). The genus comprises 39 taxa, 17 of which are endemic (43.6%) in Turkey (Edmondson, 1982; Davis et al., 1988; Duman, 2000; Çiçek et al., 2011; Çiçek, 2012; Çiçek and Yaprak, 2011; Çiçek and Yaprak, 2013; Celep and Dirmenci 2016).

Scutellaria, known as "Kaside" in Turkish, is not widely used in Turkey, but uses for various purposes in traditional medicines for example as a soothing, hemostatic, tonic and wound healing agent, and for constipation in Anatolian folk medicine have been reported (Baytop, 1999; Özçelik, 1990). In recent years, according to ethnobotanical studies made in Turkey, *S. orientalis* subsp. *pichleri* (Stapf) J.R. Edm. and *S. orientalis* subsp. *virens* (Boiss. & Kotschy) J.R.Edm. have been used against cancer and hemorrhoids. *S. orientalis* subsp. *bicolor* (Hochst.) J.R.Edm. and *S. orientalis* subsp. *pichleri* (Stapf) J.R.Edm. have been used as astringent in folk remedies (Çakıcıoğlu et al., 2010).

It has been reported that some *Scutellaria* species (*S. baicalensis* Georgi, *S. viscidula* Bunge, *S. amoena* C.H.Wright, *S. rehderiana* Diels, *S. ikonnikovii* Juz. and *S. hypericifolia* H.Lév.) are used in Traditional Chinese Medicine (TCM) to treat diseases such as hepatitis, jaundice, tumor, leukemia, arteriosclerosis, diarrhea and inflammation (Huang et al., 2005; The Grand Dictionary of Chinese Herbs, 1977). The leaves of *S. indica* L. and *S. baicalensis* species in Asia are used as vegetables and also, as herbal tea (Tanaka, 1976). *S. laterifolia* L. (American skullcap) has been used against neurological diseases such as epilepsy, contraction, hysteria and

insomnia (Millspaugh, 1974). The roots of *S. baicalensis* (Baikal skullcap) are known to be used to increase memory in TCM (Adams, 2007).

Many *Scutellaria* species have been tested for biological activities such as spasmolytic, antidiarrheal, antifungal, antipyretic, antioxidant, anticancer, anti-HIV, antibacterial, antiviral, anti-inflammatory and anticonvulsant (Ersöz et al., 2002; Lin et al, 2009; Shang et al., 2010). The flavones isolated from the roots of *Scutellaria* show antioxidant, anti-viral, anti-thrombotic, anti-inflammatory, antitumor and anti-cardiovascular properties against some diseases (Kimura et al., 1997; Wang et al., 1998; Gao et al., 1999; Huang et al., 2000; Wu et al., 2001; Ma et al., 2002; Chi et al., 2003; Hwang et al., 2005; Gua et al., 2007; Wang et al., 2007).

In this present study, we aimed to investigate chemical composition of essential oils of *Scutellaria galericulata* L. and *S. tortumensis* (Kit Tan & Sorger) A.P.Khokhr. from Turkey. This study is a continuation of our previous studies. Up to now, we have reported compositions of the essential oils of all subspecies of *Scutellaria albida* L. (Çiçek et al., 2010), *S. diffusa, S. heterophylla, S. salviifolia*, (Çiçek et al., 2011) and all subspecies of *S. brevibracteata* Stapf from Turkey (Yılmaz et al., 2019). We, also, carried out acetylcholinesterase, butyrylcholinesterase, and tyrosinase inhibitory activities and antioxidant activities in 33 *Scutellaria* taxa from Turkey (Şenol et al., 2010). Here, we report on the isolation and characterization of various components present in the essential oils of *S. galericulata* and *S. tortumensis*.

Materials and Methods

Plant material

Aerial parts of *Scutellaria galericulata* (voucher number: AEF 23936) and *S. tortumensis* (voucher number: AEF 23967) were collected from their natural habitat in Bolu and Erzurum provinces, respectively. Voucher specimens were identified by M. Çiçek and deposited at Ankara University, Herbarium of Faculty of Pharmacy (AEF).

Isolation of the essential oils

Air-dried aerial parts of the plants were hydrodistilled for 3 h using a Clevenger-type apparatus to produce a small amount of essential oil which was trapped in *n*-hexane. The analysis processes of gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) were performed with reference to Demirci et al. (2017).

Results and Discussion

Analyses of the hydrodistilled oils were performed on GC and GC-MS systems, simultaneously. The composition of the *Scutellaria galericulata* and *S. tortumensis* are given in Table 1, according to their relative retention indices (RRI) and with their relative percentages (%).

A total of 42 compounds were characterized in the essential oil of *Scutellaria galericulata*, representing 88.6% of the total oil. The main components were determined as caryophyllene oxide (27.5%), β-caryophyllene (13.4%) and caryophylla-2(12),6-dien-5β-ol (4.8%). The results of analyses showed that the essential oil of *S. galericulata* comprised mainly oxygenated sesquiterpenes (43.2%), sesquiterpene hydrocarbons (36.8%), fatty acids (2.9%) and diterpenes (2.2%).

In the oil of *Scutellaria tortumensis*, 35 components were characterized representing 94.3% of the total oil. Germacrene D (29.8%), β-caryophyllene (17.1%) phytol (8.3%) and nonacosane (7.1%) were found as major

components. The essential oil composition of *S. tortumensis* consisted dominantly of sesquiterpenes hydrocarbons (57.6%), diterpenes (8.3%), oxygenated sesquiterpenes (7.2%) and others (19.2%).

Lawrence et al. (1972) reported caryophyllene (29.4%), trans-β-farnesene (17.0%), menthone (10.4%) and 1-octen-3-ol (8.0%) as main constituents in the oil of *Scutellaria galericulata* in Canada. In this study, the main components in the essential oil of *S. galericulata* were determined as caryophyllene oxide (27.5%), β-caryophyllene (13.4%) and caryophylla-2(12),6-dien-5β-ol (4.8%).

Table 1. The essential compositions of the *Scutellaria galericulata* and *S. tortumensis*

RRI	Compound	***S. galericulata* (%)**	***S. tortumensis* (%)**
1400	Nonanal	0.2	-
1452	1-Octen-3-ol	1.7	-
1466	α-Cubebene	1.1	0.5
1482	Longipinene	0.6	1.3
1497	α-Copaene	1.1	-
1500	Pentadecane	-	2.0
1535	β-Bourbonene	0.2	0.5
1549	β-Cubebene	2.4	-
1553	Linalool	-	0.3
1589	β-Ylangene	-	0.2
1600	β-Elemene	0.2	-
1612	β-Caryophyllene	13.4	17.1
1668	(*Z*)-β-Farnesene	1.1	1.0
1671	Acetophenone	0.5	-
1687	α-Humulene	3.6	1.7
1700	Heptadecane	-	2.0
1704	γ-Muurolene	-	0.2
1711	γ-Himachalene	2.1	-
1726	Germacrene D	2.2	29.8
1729	β-Himachalene	0.6	-
1743	Eremophilene	2.1	1.6
1755	Bicyclogermacrene	-	3.0
1773	δ-Cadinene	1.7	0.5
1776	γ-Cadinene	tr	0.2
1800	Octadecane	-	0.4
1801	β-Cuprenene	0.5	-
1849	Cuparene	2.7	-
1849	Calamenene	tr	-
1882	α-Dehydro-*ar*-himachalene	0.3	-
1888	*ar*-Himachalene	0.6	-
1900	Nonadecane	-	0.7
1900	*epi*-Cubebol	0.8	-
1924	γ-Dehydro-*ar*-himachalene	0.3	-
1957	Cubebol	1.1	-
1958	(*E*)-β-Ionone	-	0.7
2000	Eicosane	-	0.6

2001	Isocaryophyllene oxide	0.8	0.6
2008	Caryophyllene oxide	27.5	5.3
2050	(*E*)-Nerolidol	1.0	-
2071	Humulene epoxide-II	3.8	-
2080	Cubenol	0.4	-
2088	1-*epi*-Cubenol	0.5	-
2100	Heneicosane	-	0.7
2131	Hexahydrofarnesyl acetone	1.1	1.8
2144	Spathulenol	-	0.4
2174	Fokienol	0.7	-
2200	Docosane	-	0.5
2204	Eremoligenol	-	-
2209	T-Muurolol	-	0.4
2255	α-Cadinol	-	0.5
2289	Oxo-α-Ylangene	1.1	-
2300	Tricosane	-	0.8
2324	Caryophylla-2(12),6(13)-dien-5α-ol (=*Caryophylladienol II*)	0.7	-
2392	Caryophylla-2(12),6-dien-5β-ol (=*Caryophyllenol II*)	4.8	-
2400	Tetracosane	-	0.3
2500	Pentacosane	tr	1.4
2503	Dodecanoic acid	tr	-
2622	Phytol	2.2	8.3
2670	Tetradecanoic acid	tr	-
2700	Heptacosane	-	0.2
2900	Nonacosane	-	7.1
2931	Hexadecanoic acid	2.9	1.7
	Oxygenated Monoterpenes	-	0.3
	Sesquiterpene Hydrocarbons	36.8	57.6
	Oxygenated Sesquiterpenes	43.2	7.2
	Fatty acids	2.9	1.7
	Diterpenes	2.2	8.3
	Others	3.5	19.2
	Total	**88.6**	**94.3**
	Oil yield	tr	tr

RRI: Relative retention indices calculated against *n*-alkanes. % calculated from FID data. tr: Trace (< 0.1 %)

In this study, it was shown that high percentage of caryophyllene oxide (27.5%) and germacrene D (29.8%) were the major components of the essential oils obtained from *Scutellaria galericulata* and *S. tortumensis*, respectively. β caryophyllene content was similar in both *Scutellaria* species.

Table 2: The major components in the essential oil of various *Scutellaria* species growing naturally in Turkey

Species	**Major Components**	**Referances**
S. albida subsp. *albida*	linalool (20.4%), hexadecanoic acid (15.6%), β-caryophyllene (14.2%),α-terpineol (8.2%)	(Çiçek et al., 2010)
S. albida subsp. *colchica*	hexadecanoic acid (12.9%), (E)-nerolidol (9.1%), hexahydrofarnesyl acetone (7.3%)	(Çiçek et al., 2010)
S. albida subsp. *condensata*	linalool (28.5%), (E)-nerolidol (16.8%), geraniol (8.1%), hexadecanoic acid (6.0%)	(Çiçek et al., 2010)
S. albida subsp. *velenovskyi*	β-caryophyllene (20.0%), hexadecanoic acid (17.3%) and tetradecanoic acid (10.2%)	(Çiçek et al., 2010)
S. diffusa	hexadecanoic acid (30%)- caryophyllene oxide (9%)	(Çiçek et al., 2010)
S. heterophylla	germacrene D (21%), hexadecanoic acid (16%) caryophyllene (11%)	(Çiçek et al., 2010)
S. salviifolia	germacrene D (40%), bicyclogermacrene (14%), -caryophyllene (11%)	(Çiçek et al., 2010)
S. brevibracteata subsp. *brevibracteata*	β-caryophyllene (22.8%),- caryophyllene oxide (16.0%)	(Yılmaz et al., 2019)
S. brevibracteata subsp. *subvelutina*	β-caryophyllene(28.3%), linalool(12.4,) hexadecanoic acid (10.8%)	(Yılmaz et al., 2019)
S. brevibracteata subsp. *pannosula*	β-caryophyllene (36.4%), α-cadinol (9.8%), δ-cadinene (7.0%)	(Yılmaz et al., 2019)

Main components of the essential oils of various *Scutellaria* species in growing naturally in Turkey are given in Table 2. As shown in the table, while hexadecanoic acid (30%) was found to be at the highest ratio in S. diffusa, its content in *S. albida* and *S. heterophylla* essential oils was found to be similar. High contents of β-caryophyllene and hexadecanoic acid present in the essential oil of *S. brevibracteata* subsp. *subvelutina* showed similarity to those of *S. albida* subsp. *albida*, *S. albida* subsp. *velenovskyi* and *S. heterophylla*.

Germacrene D and β-Caryophyllene are among the main components of the essential oils of all *Scutellaria* species (Çiçek et al., 2010; Raju Sripathi et al.2017; Yılmaz et al. 2019). Other main components are caryophyllene oxide and linalool.

Despite many traditional uses of *Scutellaria*, biological activity studies are limited. According to our literature search, we could see that biological activity studies were mostly conducted on *S. baicalensis*. Anti-RSV, Anti-HIV, anti-inflammatory, hepatoprotective, neuroprotective, anti-oxidative, antimutagenic, anti-HBV, anti-convulsant activities has been reported from the compounds isolated from *S. baicalensis*. Anti-tumor activity has also been demonstrated in *S.barbata* and *S. baicalensis*. Anti-feedent activity was found to be present in *S. rubicunda* and *S. galericulata*; anti-oxidant activity in *S. baicalensis*, *S. barbata*, *S. immaculata* & S. ramosissina; anxiolytic activity was showed in *S. baicalensis* and *S. laterfollia* (Raju Sripathi et al., 2017).

Anti-microbial studies carried out on the essential oils are very scarce. Anti-microbial activity has been shown in the essential oils of *S. immaculata, S. ramosiss, S. barbata, S. albida* ssp. *albida*, *S. sieberi* and *S. rupestris* ssp. *adenotrich* species. Antibacterial activity studies were performed on *S. grossa*; antioxidant and larvicidal activity studies were performed on *S. wightiana* essential oils (Raju Sripathi et al., 2017).

Although there have been studies of compounds isolated from many *Scutellaria* species and their biological activity studies, their pharmacological activities have not been fully studied. More phytochemical studies are needed due to the fact that the plants, which have a high traditional usage, are promising in the search for new drugs. There are few studies on *Scutellaria* species in our country. In this study we have examined the essential oils of *S. galericulata* and *S. tortumensis*. Here, we report on the isolation and characterization of various components present in essential oils. Furthermore, we plan to carry out the biological activities of the essential oil.

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