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CONSTITUENT COMPOSITION AND ANTIMICROBIAL ACTIVITY OF ESSENTIAL OIL FROM *Scutellaria oxystegia*

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The plant genus *Scutellaria* L. (Lamiaceae) is represented globally by about 360–469 species that are broadly distributed in temperate, subtropical, and tropical zones, including Europe, North America, and East Asia [1, 2]. Uzbekistan contains 38 *Scutellaria* species, several of which are used in folk medicine to treat epilepsy, allergy, neurosis, hypertonia, and other diseases [3]. Essential oils isolated from *S. immaculata*, *S. ramosissima*, *S. albida*, and other species of this genus were reported to have antioxidant and antimicrobial activity [4–6]. However, the composition of essential oil from *S. oxystegia* Juz. has not been studied.

The aerial part and roots of this plant afforded the flavonoids chrysin, oroxylin A, and (–)-5,2′-dihydroxy-6,7,8,6′-tetramethoxyflavanone [7]. The composition of essential oil from the aerial part of *S. oxystegia* collected during flowering (May 2021) in Kamchik Pass, Tashkent Region, was studied by us for rational use of the plant raw material and in a search for biologically active compounds. The species was identified by Cand. O. M. Nigmatullaev, Laboratory of Medicinal and Technical Plants, S. Yu. Yunusov Institute of the Chemistry of Plant Substances, AS, RUz (herbarium No. 2169).

Essential oil was isolated from ground air-dried aerial parts by steam distillation at atmospheric pressure for 2.5 h. The obtained distillate was extracted with CH_2Cl_2. The extract of essential oil was dried over anhydrous Na_2SO_4 and stored in a refrigerator at –4°C until use. The qualitative and quantitative compositions of the essential oil were determined on an Agilent 5975C Inert MSD/7890A GC-MS under the previously reported analysis conditions [8]. Constituents were identified by comparing mass spectral characteristics with data in electronic libraries and retention indices (RI) of compounds determined relative to retention times of a mixture of *n*-alkanes (C_9–C_{24}) and their mass spectral fragmentation with those in the literature [9].

A total of 43 compounds were characterized in the essential oil. This was 91.4% of the total amount of oil (Table 1). The essential oil was dominated by aldehydes and ketones (41.6%), saturated and unsaturated hydrocarbons (13.2%), oxygenated sesquiterpenes (9.3%), alcohols (7.3%), carboxylic acids (6.6%), and phenols (4.4%). The main constituents of the essential oil were acetophenone (23.9%), cyclohexanone (10.1%), phytol (4.4%), palmitic acid (3.6%), benzylideneacetone (2.9%), cetene (2.7%), ledene oxide-(II) (2.4%), and phenylethyl alcohol (2.1%). The essential oil contained an insignificant amount of sesquiterpene hydrocarbons (2.5%) and oxygenated monoterpenes (1.3%). Acetophenone was also the main component of essential oils from *S. immaculata* and *S. schachristanica* [4].

Antimicrobial activity has been reported for essential oils from plants of the genus *Scutellaria* [10–12]. Considering that, we studied the antimicrobial activity of essential oil and extracts from the aerial part of *S. oxystegia*. Antibacterial and antifungal activities of samples were assessed using a modified agar-diffusion method and concentrations of tested substances of 0.2 mg/disk [13, 14]. Ampicillin, ceftriaxone, and fluconazole (Himedia Laboratories Pvt., Ltd.) were used as positive controls; the solvent for extraction, as a negative control. Test cultures contained microorganism strains of *Bacillus subtilis* (RKMUz-5), *Staphylococcus aureus* (ATCC 25923), *Pseudomonas aeruginosa* (ATCC 27879), *Escherichia coli* (RKMUz-221), and fungal strain *Candida albicans* (RKMUz-247). The RKMUz strains were obtained from the collection of the Institute of Microbiology, AS, RUz.

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TABLE 1. Constituent Composition of Essential Oil from *Scutellaria oxystegia*

Constituent	RI	Content, %	Constituent	RI	Content, %
(*E*)-2-Hexenal	1197	0.4	Dodecylcyclohexane	1904	0.2
(*E*)-4-Dodecene	1231	0.7	Caprylic acid	2002	0.8
2,3-Dicyclohexylbutane	1239	0.9	Benzylideneacetone	2041	2.9
Acetoin	1243	0.3	Spathulenol	2063	1.2
Cyclohexanone	1249	10.1	Eugenol	2090	1.8
1-Cyclohexylhexane	1265	1.6	Pelargonic acid	2108	0.6
(*Z*)-3-Hexen-1-ol	1343	0.8	9-Heptadecanone	2113	1.5
Tetradecane	1400	0.8	4-Vinylguaiacol	2176	1.9
Furfural	1416	1.0	Ledene oxide-(II)	2261	2.4
(*E*)-4-Tetradecene	1435	2.1	7-Hydroxyfarnesene	2272	1.3
Benzaldehyde	1470	0.9	8-Cedren-13-ol	2359	1.3
n-Octylcyclohexane	1480	1.2	2,3-Dihydrobenzofuran	2389	0.8
Linalyl acetate	1515	1.3	Vanillin	2555	0.6
(*E*)-β-Caryophyllene	1556	0.7	Apocynin	2621	0.7
Acetophenone	1590	23.9	β-Costol	2558	2.3
Hexadecane	1600	0.7	Phytol	2570	4.4
α-Humulene	1623	1.3	Palmitic acid	2931	3.6
Cetene	1637	2.7	Aldehydes and ketones		41.6
3-Cyclohexene-1-carbinol	1690	3.0	Hydrocarbons		13.2
δ-Cadinene	1712	0.5	Oxygenated sesquiterpenes		9.3
Isoaromadendrene epoxide	1766	0.8	Alcohols		7.3
Caproic acid	1792	1.6	Carboxylic acids		6.6
Octadecane	1800	0.9	Phenols		4.4
Benzyl alcohol	1809	1.4	Sesquiterpene hydrocarbons		2.5
1-Octadecene	1840	1.4	Others		6.5
Phenylethyl alcohol	1843	2.1	Total		91.4

TABLE 2. Antimicrobial Activity of Essential Oil from *S. oxystegia*, mm

Sample	Gram-positive bacteria		Gram-negative bacteria		Conditionally pathogenic fungi
	B. subtilis	*S. aureus*	*P. aeruginosa*	*E. coli*	*C. albicans*
Essential oil	6.04 ± 0.10	7.08 ± 0.12	I.a.	6.16 ± 0.20	I.a.
Ampicillin (10 µg/disk)	26.04 ± 0.10	27.08 ±0.12	N.t.	N.t.	N.t.
Ceftriaxone (30 µg/disk)	N.t.	N.t.	26.12 ± 0.13	28.16 ± 0.20	N.t.
Fluconazole (25 µg/disk)	N.t.	N.t.	N.t.	N.t.	29.04 ± 0.10

I.a., inactive; N.t., not tested.

The results of *in vitro* screening (Table 2) showed that essential oil exhibited weak (6.04 ± 0.10–7.08 ± 0.12) antibacterial activity against *B. subtilis*, *S. aureus*, and *E. coli* while the hydrocarbon, $CHCl_3$, *n*-BuOH, EtOAc, and EtOH (70%) extracts turned out to be inactive against the studied microorganism strains.

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