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COMPOSITION OF THE ESSENTIAL OILS OF *Artemisia radicans* AND *A. frigida*

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The results are given of the GLC analysis on a capillary column of the essential oils of two species of wormwood close in morphological characteristics growing in Kazakhstan: Artemisia radicans *A. Kuprijanov and* A. frigida *Willd., fam. Asteraceae.*

Artemisia radicans A. Kuprijanov is a recently described endemic species [1]. Perennial plant 20—30 cm high. Rhizome thin, creeping, woody. Vegetative shoots procumbent, shortened at nodes, form a loose turf spread over the surface of the soil. Almost white from a copious down of silvery hairs. Grows on the slopes and at the foot of low hills and on sandy river banks.

Artemisia frigida Willd. is a petrophytic form widely distributed in Kazakhstan [2, 3]. Perennial plant about 40 cm high. Root woody, many-headed. Numerous stems, sometimes lignifying, form a loose or dense turf. Down white, silky. Color of plant gray-green, grows predominantly on the tops and detrital slopes of hills, more rarely on sandy soil.

From *A. radicans* we obtained an essential oil with a yield of 1.14% calculated on the air-dry raw material; it consisted of a colorless liquid with a pleasant odor containing not less than 67 components, the main ones being camphor (26.7%), 1,8-cineole (21.0%), borneol (8.9%), and camphene (7.6%).

The essential oil of *A. frigida*, obtained with a yield of 0.7%, calculated on the air-dry raw material, consisted of a light yellow liquid with an attractive wormwood smell containing not less than 63 components. A comparison of the components of the two wormwood species (Table 1) showed that the main compounds of *A. frigida* again included 1,8-cineole (24.7%), camphor (22.6%) and borneol (8.9%). Also distinguished quantitatively were β-thujone (5.2%) and thujanols (1.3—2.5%).

Thus, the results of a chemical investigation of the compositions of the essential oils of *A. radicans* and of *A. frigida* have confirmed the closeness of these species of wormwood established on the basis of the morphological characteristics of the plants [1].

Since the main components of the essential oils of *A. radicans* and of *A. frigida* are camphor and 1,8-cineole — the end-products of synthesis according to the Poltavchenko-Rudakov "ladder" hypothesis [4] — the wormwood species that we have studied may be considered evolutionarily ancient; i.e., these species exist at a relatively high degree of development. A confirmation of this is the comparatively low content of thujones (α-thujone 1.2—1.5%; β-thujone 0.4—5.2%).

The practically identical levels of borneol (8.9%) in the two species of wormwood permits a discussion of the biosynthesis of both camphor and camphene, which were detected in the essential oils of *A. radicans* (7.6%) and *A. frigida* (4.2%). α-Terpineol is a precursor of 1,8-cineole and of terpinolene.

In the systematic respect, the species that we studied — *A. radicans* and *A. frigida* — are located in the one series Argyrophyllae Poljak, which also includes *Artemisia austriaca* Jacq., *A. sericea* Web. ex Stechn., *A. aschurbajevii* Winkl., and *A. lagocephala* (Bess.) DC. Characteristic for representatives of this series is a considerable content of terpene ketones: α- and β-thujones — up to 30% [5] — and fenchone — up to 10%: and of bicyclic terpene alcohols: borneol — up to 48% [6]. Also characteristic is the presence of azulene-forming sesquiterpenoids [3, 6].

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TABLE 1. Component Compositions of the Essential Oils of *A. radicans* and of *A. frigida*

Number of the peak on a chromatogram	Component	Content, wt-%	
		A. radicans	A. frigida
1	Achillene	0.6	0.2
2	α-Thujene	0.7	0.4
3	α-Pinene	3.1	1.2
4	Camphene	7.6	4.2
5	α-Fenchene	0.2	0.2
6	Sabinene	0.4	Tr.
7	β-Pinene	1.1	0.3
8	Not identified	0.3	Tr.
9	β-Myrcene	0.2	0.3
10	α-Phellandrene	0.2	0.3
11	*p*-Cymene	0.5	0.3
12	Limonene	2.7	1.1
13	β-Phellandrene	Tr.	0.4
14	1,8-Cineole	21.0	24.7
15	Not identified	Tr.	0.2
16	γ-Terpinene	0.8	0.8
17	*trans*-Ocimene	1.8	0.7
18	Achillenol	0.2	Tr.
19	Terpinolene	0.3	1.1
20	Linalool	0.2	0.5
21	α-Thujone	1.5	1.2
22	β-Thujone	0.4	5.2
23	Alloocimene	Tr.	0.3
24	Isothujanol	0.8	2.5
25	Menth-3-enol	1.1	0.4
26	Thujanol	0.5	1.3
27	Camphane	26.7	22.6
28	Pinan-2-ol	0.3	1.1
29	Isoborneol	0.5	Tr.
30	Borneol	8.9	8.9
31	Terpinen-4-ol	3.3	2.3
32	Not identified	0.2	0.3
33	α-Terpineol	2.3	2.2
34	Myrtenol	0.2	0.4
38	Phellandral	0.4	1.0
39	*p*-Menth-3-en-7-ol	0.2	2.3
40	Nerol	0.2	0.5
41	Not identified	0.3	0.3
42	Geraniol	0.5	0.5
45	Thymol	0.2	1.5
46	Bornyl acetate	2.3	0.7
50	Neryl acetate	0.2	1.0
51	Eugenol	0.1	0.2
52	γ-Elemene	0.1	0.2
53	β-Cubebene	0.2	0.2
54	β-Elemene	0.3	0.3
55	β-Caryophyllene	0.1	Tr.
58	Germacrene-D	0.8	0.4
61	*trans*-Nerolidol	0.4	0.2
62	Spathulenol	0.4	0.2
63	Caryophyllene oxide	0.1	0.2
64	β-Bisabolene	0.1	-
65	Cadinene	0.1	-
66	β-Eudesmol	0.1	-
67	Eudesmyl acetate	0.5	-

EXPERIMENTAL

A. radicans and *A. frigida* were collected during the flowering phase in the environs of Botakar in the Bukhar-Zhyrauskii region of the Karagandinskaya oblast.

The essential oils were obtained from the wormwood species studied by steam distillation of the dried and comminuted epigeal part of the plants. The yields, calculated on the air-dry raw material were 1.14% from *A. radicans* and 0.73% from *A. frigida*.

Physicochemical indices of the essential oils: for *A. radicans*, d_{20} 0.9315, n_D 1.4788, acid No. 2.76, ester No. 80.4; for *A. frigida*, d_{20} 0.9302, n_D 1.4678, acid No. 3.35, ester No. 93.7.

GLC analysis was conducted on a 0.2 mm × 50 m capillary column containing a feebly polar methylphenylsilicone phase on a Chrom-5 chromatograph in the regime of linear temperature programming from 80 to 250°C at the rate of 3 degrees per minute. Injector temperature 230°C, detector temperature 250°C, flow split 1:80. Rate of flow of carrier gas, helium, 0.8 ml/min.

The components of the essential oils were identified by comparing their indices in a sliding system of the C_9—C_{22} normal hydrocarbons [7] with the retention indices of authentically known substances determined by us under the conditions of GLC analysis. The quantitative levels of the substances were determined by the normalization method with the aid of a computer program linked with the chromatograph.

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