

Comparison of the Volatile Leaf Oils of *Juniperus davurica* Pall. from Mongolia, with Plants Cultivated in Kazakhstan, Russia and Scotland

Robert P. Adams*

Plant Biotechnology Center, Baylor University
BU Box 97372, Waco, TX 76798

S. Shatar

Chemistry Institute, Academy of Sciences of the Mongolian People's Republic
Ulan-Bator, Mongolia

A. D. Dembitsky

Institute of Chemical Sciences, Academy of Sciences of Kazakhstan
106 Krasin St., Alma Ata, Kazakhstan

Received: September 1993

ABSTRACT: The composition of the volatile leaf oils of *Juniperus davurica*, putative *J. davurica* plants cultivated in Alma Ata and Moscow, and cv. *expansa variegata* are reported. The major compounds of *J. davurica* (Mongolia) are sabinene (28.6%), cedrol (11.5%), methyl citronellate (7.4%), citronellol (6.5%), terpinen-4-ol (5.8%) and α -pinene (4.1%). In contrast, the major compounds of *J. davurica* cv. *expansa variegata* are bornyl acetate (23.5%), sabinene (13.1%), terpinen-4-ol (7.7%), manool (6.3%) and myrcene (6.0%).

KEY WORD INDEX: *Juniperus davurica*, cv. *expansa variegata*, Cupressaceae, essential oil composition, monoterpenes, taxonomy, sabinene, bornyl acetate, cedrol.

INTRODUCTION: *Juniperus davurica* Pall. (often spelled *dahurica*), section *Sabina*, is a trailing shrub that grows in the far southeastern Siberian region of Russia and northern Mongolia (1). Pallas (2) actually described two varieties (not in a strict taxonomic sense): one with scale leaves and the other with acicular leaves. Actually, the leaves on the second variety are not acicular but decurrent, as the junipers with acicular leaves are in section *Juniperus* (3). Three cultivars are commonly listed under *J. davurica* (4): cv. *expansa*, probably imported from Japan in 1862; cv. *expansa aureospicata*, similar to the preceding; and cv. *expansa variegata*, imported to the United States under the name *J. squamata albovariegata*. These cultivars have also been treated as varieties of *J. chinensis* (4).

*Senior author

Table I. Comparisons (percentage) of leaf oils of *Juniperus davurica* from various sites

Compound	RT	<i>J. davurica</i>			<i>cv. expansa</i>	<i>J. chinensis</i> Ganus
		MONG	AABG	MBG	<i>variegata</i> RBGE	
tricyclene	301	t	t	t	0.6	t
α -thujene	307	1.2	0.5	0.3	0.9	0.7
α -pinene	319	4.1	15.5	12.8	4.2	16.7
α -fenchene	337	t	-	-	-	-
camphene	340	t	0.2	0.2	0.7	0.2
verbenene (= pinadiene)	364	-	0.3	0.2	-	-
sabinene	379	28.6	11.4	9.2	13.1	17.8
β -pinene	386	-	2.1	2.1	0.8	0.4
myrcene	408	3.0	3.3	3.1	6.0	3.2
1,3,5-trimethyl benzene	414	-	-	-	-	0.1
(methyl 5-methylhexanoate)	417	1.9	-	-	-	-
δ -2-carene	427	0.1	1.1	1.9	-	t
α -phellandrene	435	-	t	0.1	t	-
δ -3-carene	445	1.0	t	t	t	-
α -terpinene	457	1.1	0.4	0.3	1.1	0.4
p-cymene	471	0.2	t	t	0.2	0.3
limonene	481	1.0	18.4	15.0	2.8	15.1
β -phellandrene	482	-	t	-	t	t
(E)- β -ocimene	519	0.3	0.2	0.3	0.1	0.2
γ -terpinene	545	1.8	0.1	0.4	1.9	0.7
trans-sabinene hydrate	560	0.6	0.5	0.6	1.8	0.6
terpinolene	608	1.1	0.7	0.7	0.9	0.6
2-nonanone	614	-	-	0.3	-	-
cis-sabinene hydrate	629	0.3	0.2	0.3	1.1	0.4
linalool	632	2.6	-	t	-	1.0
2-nonanol	634	-	-	0.3	-	-
isopentyl isovalerate	645	0.7	-	-	-	-
1-octen-3-yl, acetate	658	-	0.2	0.2	-	-
terpene	673	0.7	-	-	t	-
cis-pinene hydrate	683	0.4	0.2	0.5	0.6	0.2
trans-pinene hydrate	725	0.2	t	0.3	0.3	t
camphor	734	-	-	-	1.1	-
trans-verbenol	735	-	-	0.2	-	0.1
camphene hydrate	746	-	-	-	0.3	-
borneol	789	-	-	-	1.1	-
terpinen-4-ol	820	5.8	1.0	1.1	7.7	2.1
α -terpineol	852	0.3	0.3	0.4	0.3	0.1
methyl chavicol	869	-	-	-	-	0.3
trans-piperitol	896	0.1	-	0.1	0.1	-
citronellol	950	6.5	-	0.1	-	-
myrtenyl acetate	967	-	0.2	0.1	-	-
piperitone	1011	t	0.2	0.8	-	-
linalyl acetate	1023	0.6	-	-	-	-
trans-myrtanol	1026	0.6	0.1	-	-	-
methyl citronellate	1035	7.4	-	-	-	t
terpene alcohol	1063	-	0.7	0.6	-	-
(E)-anethole	1094	-	-	-	-	t
bornyl acetate	1099	-	0.3	0.4	23.5	0.1
safrole	1101	-	-	-	-	5.1
trans-sabinyl acetate	1117	t	-	-	-	-
2-undecanone	1119	1.6	0.3	0.4	-	-
methyl geranate	1192	0.6	-	-	-	-
α -terpinyl acetate	1264	-	2.5	2.8	-	-

Table I. (cont.)

Compound	RT	<i>J. davurica</i>			<i>cv. expansa</i>	<i>J. chinensis</i> Gansu
		MONG	AABG	MBG	<i>variegata</i> RBGE	
citronellyl acetate	1275	-	0.1	0.2	-	-
methyl eugenol	1401	-	-	-	-	3.4
α -cedrene	1421	-	-	-	-	t
1,7-di-epi- β -cedrene	1422	1.0	-	-	-	0.1
β -cedrene	1441	0.3	-	-	-	0.2
thujopsene	1467	-	-	-	-	0.3
(Z)- β -farnesene	1532	0.2	-	-	-	-
γ -muurolene	1586	-	-	-	-	t
germacrene D	1594	0.5	0.2	0.5	t	0.1
epi-cubebol	1629	-	t	-	0.2	-
α -muurolene	1643	0.3	0.1	-	0.3	t
β -bisabolene	1667	0.3	0.1	-	-	-
α -alaskene	1675	0.4	-	-	-	t
γ -cadinene	1676	0.4	0.4	0.3	0.6	0.2
δ -cadinene	1700	1.6	0.4	0.3	1.5	0.5
α -cadinene	1733	-	t	-	-	t
elemol	1759	-	6.9	5.2	4.0	-
elemicin	1772	-	-	-	-	0.5
(E)-nerolidol	1796	-	0.2	0.2	-	-
(Z)-3-hexenyl benzoate	1809	-	-	-	-	0.6
germacrene D-4-ol	1821	1.3	1.3	3.4	3.6	0.6
sesquiterpene alcohol	1852	-	-	-	-	1.1
cedrol	1876	11.5	-	-	-	20.1
β -oplophenone	1898	0.3	0.2	0.1	0.2	0.9
α -acorenil	1951	-	-	-	-	t
γ -eudesmol	1951	-	0.4	0.3	0.5	-
epi- α -cadinol (= T-cadinol)	1973	0.2	0.5	0.4	1.1	0.3
epi- α -muurolol (= T-muurolol)	1976	0.2	0.6	0.3	1.1	0.4
torreyol	1984	t	-	0.1	0.4	0.1
β -eudesmol	1993	-	0.8	0.5	0.6	-
α -eudesmol	2000	-	1.2	0.5	0.6	-
α -cadinol	2003	0.8	1.8	1.3	3.8	1.3
bulnesol	2034	-	1.3	1.9	1.1	-
oplopanone	2183	-	-	-	-	0.6
cedryl acetate	2246	0.3	-	-	-	-
8- α -acetoxyelemol	2306	-	3.7	2.8	0.2	-
13-epi-manool	2660	-	-	-	-	t
abietatriene	2841	t	-	-	-	t
manool	2845	-	0.4	1.3	6.3	-
abietadiene	2891	0.4	1.2	0.4	-	-
(cis-totarol)	3253	-	-	-	0.1	t
4-epi-abietal	3272	0.1	-	-	-	0.2
cis-abietal	3275	-	2.8	4.6	1.1	-
trans-totarol	3297	-	-	-	0.4	t
abieta-7,13-diene-3-one	3298	0.3	9.0	9.3	-	-
cis-abietol	3435	-	0.4	0.2	t	-

Compounds are listed in order of their elution from a DB5 column
 Sites: MONG = a natural site in Mongolia; putative: AABG = cultivated at the Alma Ata Botanical Garden, and MBG = Moscow Botanic Garden; *cv. expansa variegata*: RBGE = cultivated at the Royal Botanic Gardens, and Edinburgh, Gansu = *J. chinensis* from Gansu, China
 Compounds in parenthesis are tentatively identified.
 t = trace (<0.1%), unidentified components less than 0.5% are not reported

Using Random Amplified Polymorphic DNAs (RAPDs), *J. davurica* (cultivated in Kazakhstan) has recently been shown to be the most similar to *J. chinensis* from Gansu, China, not *J. squamata* (3).

A preliminary report has been made on the leaf oil of *J. davurica* (5). In this paper we give a complete analysis of the leaf oil and compare it with oils from putative *J. davurica* cultivated at Alma Ata, Kazakhstan and Moscow, Russia. In addition, we compare these oils with that of cv. *expansa variegata* cultivated in Scotland and *J. chinensis* from Gansu, China (6).

EXPERIMENTAL: Fresh foliage (10-12 terminal branches, 15-20 cm long) was collected (*J. davurica*, S. Shatar, Mongolia (=Adams, 6167), *J. davurica*, Alma Ata Bot. Gard., Adams 6724, *J. davurica*, Moscow Bot. Gard. (origin: Okeanskaja), Adams 6123-6124; cv. *expansa variegata*, Royal Botanic Garden, Edinburgh, Adams 5628). Specimens are deposited at the Chemical Institute, Ulan Bator and BAYLU.

The volatile leaf oils were isolated by steam distillation (200 g foliage, FW) using a circulatory Clevenger apparatus (7) for 2 h. The oil samples were concentrated (diethyl ether trap removed when collected in a Clevenger unit) with nitrogen and stored at -20°C until analyzed. Mass spectral analyses were performed on a Finnigan Ion Trap (ITD) mass spectrometer, model 700, directly coupled to a Varian 6500 gas chromatograph, using a J&W DB5, 30 m x 0.26 mm (0.25 μm film thickness), fused silica capillary column (see reference 8 for operating details). Identifications were made by library searches of our volatile oil library, LIBR(TP) (8) using the Finnigan library search routines based on fit and retention times for authentic standards. Additional searches were made of the EPA/NIH mass spectral data base (9). Mass spectra for unidentified constituents [ITMS, m/z (rel. int.)]: RT 673: FW170⁺, 41(100), 53(12), 57(47), 68(72), 77(2), 85(26), 95(2), 103(3); RT 1852, 222 [M⁺], 43(100), 55(27), 67(28), 79(27), 95(37), 105(21), 119(19), 137(7), 149(39), 161(14), 189(3), 207(6), sesquiterpene alcohol.

RESULTS AND DISCUSSION: The oils were light yellow and yields (2 h) ranged from 0.8 to 1.5% (oil wt/extracted, oven dried foliage wt). The volatile leaf oil of *J. davurica*, Mongolia (MONG, Table I) is dominated by sabinene (28.6%), cedrol (11.5%), methyl citronellate (7.4%), citronellol (6.5%), terpinen-4-ol (5.8%) and α -pinene (4.1%). The plants cultivated under the name *J. davurica* at the Alma Ata Botanic Garden (AABG) and the Moscow Botanic Garden (MBG) had almost identical oils (Table I). The oils (AABG, MBG) were dominated by limonene (18.4%, 15.0%), α -pinene (15.5%, 12.8%), sabinene (11.4%, 9.2%), abieta-7,13-diene-3-one (9.0%, 9.3%) and elemol (6.9%, 5.2%). In addition, they share numerous small components not found in *J. davurica* from Mongolia. The oil of *J. davurica* cv. *expansa variegata* (RBGE, Table I) is dominated by bornyl acetate (23.5%), sabinene (13.1%), terpinen-4-ol (7.7%), manool (6.3%) and myrcene (6.0%). The oil of cv. *expansa variegata* is not very similar to either *J. davurica* from Mongolia or the putative *J. davurica* cultivated at AABG and MBG.

The putative *J. davurica* plants cultivated at AABG and MBG are more similar to *J. chinensis* than to *J. davurica* from Mongolia, this concurs with the RAPDs data (3). However, the large number and high concentrations of diterpenes in the putative *J. davurica* plants cultivated at AABG and MBG seems to indicate that these plants may represent a quite divergent variety of *J. chinensis* or indeed, some other taxon.

ACKNOWLEDGMENTS: This research was supported by funds from US NSF grant INT8901632.

REFERENCES

1. V. L. Komarov, *Flora of the USSR*. **1**, pp 148-149, Leningrad (1934).
2. P. S. Pallas, *Flora Rossia*. I. Part 2. p 13, Petropoli, Russia (1789).
3. R. P. Adams and T. Demeke, *Systematic relationships in Juniperus based on random amplified polymorphic DNAs (RAPDs)*. *Taxon*, **42**, 553-572 (1993).
4. P. den Ouden and B. K. Boom, *Manual of Cultivated Conifers*. Martinus Nijhoff, The Hague (1965).
5. S. Shatar, *Mono- und sesquiterpene in atherischen ol mongolischer Juniperus-Arten*. *Pharmazie*, **39**, 66-67 (1984).
6. R. P. Adams, Chu Ge-lin and Zhang Shao-Zhen, *Comparison of the volatile leaf oils of Juniperus chinensis L., J. chinensis var. kaizuca Hort. and cv. pyramidalis from China*. *J. Essent. Oil Res.*, **6**(2), 149-154 (1994).
7. R. P. Adams, *Cedar Wood Oil - Analysis and Properties*. In: *Modern Methods of Plant Analysis: Oils and Waxes*. Edits. H. F. Linskens and J. F. Jackson, Springer-Verlag, Berlin (1991).
8. R. P. Adams, *Identification of Essential Oils by Ion Trap Mass Spectroscopy*. Academic Press, New York (1989).
9. S. R. Heller and G.W.A. Milne, *EPA/NIH Mass Spectral Data Base*. US Government Printing Office, Washington, DC (1978, 1980, 1983).