10. M.R. Akhgar, A. Rustaiyan, S. Masoudi and M. Bigdeli, *Essential oils of* Ferula microcolea *(Boiss.) Boiss. and Ferula hirtella Boiss. from Iran.* J. Essent. Oil Res., **17**, 237–238 (2005).
11. A. Rustaiyan, M. Nadimi, H. Mazloomifar and S. Masoudi, *Composition of the essential oil of* Ferula macrocolea *(Boiss.) Bioss. from Iran.* J. Essent. Oil Res., 17, 55–56 (2005).
12. A. Rustaiyan, A. Monfared, S. Masoudi and N. Ameri, *Essential oils of the stem and root of* Ferula galbaniflua *Boiss. et Buhse. from Iran.* J. Essent. Oil Res., **14**, 286–287 (2002).
13. F. Assadian, S. Masoudi, F. Nematollahi, A. Rustaiyan, K. Larijani and H. Mazloomifar, *Volatile constituents of* Xanthogalum purpurascens *Ave- Lall.,* Eryngium caeruleum *M.B. and* Pimpinella aurea *DC. three Umbelliferae herbs growing in Iran.* J. Essent. Oil Res., 17, 243–245 (2005).
14. F. Askari, F. Sefidkon and V. Mozafarian, *Essential oil composition of* Pimpinella aurea *D. C. from Iran.* Flav. Fragr. J., **20**, 115–117 (2005).
15. R. Ivanc, K. Savin and F.V. Robinson, *Essential oil from* Pimpinella serbica *fruits.* Planta Med., **48**, 60–61 (1983).
16. A. Velasco – Negueruela, M.J. Perez- Alonso, P.L.P. de Paz, C. G. Vallejo, J. Pala- Paul and A. Inigo, *Chemical composition of the essential oils from the roots, fruits, leaves and stems of* Pimpinella cumbrae *Link. growing in the Canary Islands (Spain).* Flav. Fragr. J., **17**, 468–471 (2002).
17. K.H.C. Baser, T. Özek, H. Duman and A. Guner, *Essential oil of* Pimpinella aromatica *Bieb. from Turkey.* J. Essent. Oil Res., **8**, 463–464 (1996).
18. R.P. Adams, *Identification of Essential Oil Components by Gas Chromatography/ Quadrupole Mass Spectroscopy.* Allured Publ. Corp., Carol Stream, IL (2001).

The Botanical Source of Chinese Cedarwood Oil: *Cupressus funebris* or Cupressaceae Species?

Robert P. Adams*,
Biology Department , Baylor University, Box 97366, Waco, TX 76798, USA, email: Robert_Adams@baylor.edu
Shufen Li,
School of chemical Engineering and Technology Tianjin University, China

Abstract

Cupressus funebris is generally regarded as the botanical source of Chinese cedarwood oil. However, due the limited amount of mature forest trees of *C. funebris* in China, other species in the Cupressaceae that have wood oils high in α-cedrene, β-cedrene, thujopsene and cedrol might be utilized for cedarwood oil production. Wood samples of putative *C. funebris* were extracted and the extracts were analyzed and compared with several lots of Chinese cedarwood oil. Wood oils were also extracted from *Juniperus chinensis* and *J. c.* cv. *torrulosa* and analyzed. Considerable variation was found among the wood oils of putative *C. funebris*. The various lots of commercial Chinese cedarwood oils were very variable: α-cedrene (3.6–44.2%), β-cedrene (3.5–11.5%), *cis*-thujopsene (1.9–37.4%), cedrol (1.7–23.4%). The presence of β-biotol and β-biotone in several Chinese cedarwood oils seems to indicate that wood of *Platycladus orientalis* (*Biota orientalis*) was utilized in their production. It appears that Chinese cedarwood oil is derived from a mixture of woods from several Cupressaceae species.

Key Word Index

Cupressus funebris, Juniperus chinensis, Cupressaceae, Chinese cedarwood oils, essential oil composition, α-cedrene, β-cedrene, cedrol, *cis*-thujopsene, cuparene, origin, variation.

*Address for correspondence

Received: December 2006
Revised: February 2007
Accepted: April 2007

1041-2905/08/0003-0235$14.00/0

Introduction

Commercial cedarwood oils have been obtained from three genera of Cupressaceae: *Juniperus* (Texas, Virginia and African oils); *Cupressus* (China) and *Cedrus* (Morocco, India) according to Bauer and Garbe (1). However, Texas (*Juniperus ashei* Buch.), Virginia (*J. virginiana* L.) and Chinese (putatively, *Cupressus funebris* Endl.) cedarwood oils account for almost all the cedarwood oil commercially produced today (2,3). The heartwood oils of the Cupressaceae are well known for having the same components across the family (i.e., evolutionally conserved), so the occurrence of similar oils in different genera is not surprising.

Cupressus funebris is generally regarded as the botanical source of Chinese cedarwood oil (1,2,3). Farjon (4) records the ecology of *Cupressus funebris* as occurring on "calcareous soil or sandy loam over sandstone; also widely planted". He examined 133 specimens at the Academia Sinica Herbarium, Beijing (PE) and found that only 16 (12%) came from natural areas (4). These 16 specimens were from N Guizhou, W. Hunan and former E Sichuan (Chongqing) and these areas may be only regions where *C. funebris* grows naturally. The general source of Chinese cedarwood oil is from stumps after logging. Workers dig the stumps, cut off the cortex (or sapwood, that contains little or no oil), and distill the heartwood. A factory buys the rough oil and refines it to an exportable Chinese cedarwood oil. Obviously, this general method is based on having considerable trees available, and that the trees are large enough for lumber, and plentiful enough for commercial harvesting. Given the limited natural stands of mature *C. funebris*, it would seem likely that some other genera such as *Calocedrus, Chamaecyparis, Fokienia, Juniperus, Platycladus* (=*Biota*), and *Xanthocyparis* might also be utilized. Preliminary analysis of commercial samples of Chinese cedarwood oils led the senior author to attempt to gather additional samples of oil as well as un-extracted wood used for distillation in China (i.e., putative *C. funebris*). One might note that *C. funebris* has also been called *Chamaecyparis funebris* (Endl.) Franco. However, Little, using DNA sequencing data (5,6), has clearly shown that all the *Cupressus* of the eastern hemisphere form a clade that is distinct from the clades *Chamaecyparis, Juniperus*, and *Cupressus* (now *Callitropsis*) of the western hemisphere Therefore, *Cupressus funebris* is the correct name.

There are some reports on the wood oil of *C. funebris*, but these analyzed commercial samples of Chinese cedarwood oil and report it as *C. funebris* oil (2,7). However, Hoi et al. (8) distilled wood from native, putative *C. funebris* trees from northern Vietnam and reported the major components. Recently, Duquesnoy et al. (9) analyzed the composition of a commercial pyrolytic oil of putative *C. funebris* from northern Vietnam. A comparison of the major components of Vietnamese putative *C. funebris* cedarwood and pyrolytic oils, (Table I) shows that both are high in α-cedrene, β-cedrene and cedrol. Presumably, any thujopsene present was degraded during the pyrolytic distillation.

Thus, it would appear that the cedarwood oil of *C. funebris* from Vietnam has had some chemical analysis. The problem arises with the taxonomy of *C. funebris* from Vietnam. Farjon (1) restricts the range of *C. funebris* to China, not Vietnam.

Table I. Comparison of the major components of cedarwood oil and pyrolytic oil of putative *C. funebris* from northern Vietnam.

	essential oil[8]	pyrolytic oil[9]
α-funebrene	2.4	0.7
α-cedrene	39.1	26.7
β-funebrene	3.0	0.2
β-cedrene	10.5	6.6
thujopsene	7.8	-
cuparene	3.7	0.7
cedrol	18.6	12.3

On field trips to northern Vietnam, Keith Rushforth (pers. comm.) found only two cypress species in northern Vietnam: *Xanthocyparis vietnamensis* Farjon & Hiep (= *Callitropsis vietnamensis* (Farjon & Hiep) D. P. Little) and *Cupressus tonkinensis* Silba (treated as *C. torrulosa* D. Don by Farjon (1)). However, Rushforth also noted (pers. comm.) that *C. tonkinensis* that he collected in northern Vietnam might be a form of *C. funebris*. So the report on the wood oil of *C. funebris* in northern Vietnam by Hoi et al. (8) might be of *C. torrulosa*. Clearly additional field collections are needed to resolve these taxonomic problems.

In order to investigate the botanical origin of Chinese cedarwood oil(s), we have assembled wood samples of putative *C. funebris* from materials used for distillation in China, commercial Chinese cedarwood oils, and oils distilled from authentic *J. chinensis*, collections. As a reference, commercial Texas and Virginia cedarwood oils, each from known species sources (*J. ashei* and *J. virginiana*) are included in the study.

Experimental

Samples of putative *C. funebris* wood: Cf1, white wood, Jens-Achim Protzen, Paul Kaders, GmbH, = Adams 10988; Cf2, reddish wood, Jens-Achim Protzen, Paul Kaders, GmbH, Adams10989; Cf3, Li #1, white wood, Adams 10552; Cf4, Li #2, white wood, Adams 10553. Commercial Chinese cedarwood oils: HAC, Hangzhou Aroma Chem. Co., ex Jerry King, Adams 10487; PG30, Paul Gaders GmbH 610730, Adams 11007; G34, Paul Gaders GmbH 610734, Adams 11010; Jens-Achim Protzen, Paul Kaders, GmbH, 610740, = Adams 11012; G41, Jens-Achim Protzen, Paul Kaders, GmbH, 610741, = Adams 11013; G42, Jens-Achim Protzen, Paul Kaders, GmbH, 610742, = Adams 11014; G35, Jens-Achim Protzen, Paul Kaders, GmbH, 610735, = Adams 11011; G33, Jens-Achim Protzen, Paul Kaders, GmbH, 610733, = Adams 11009; G32, Jens-Achim Protzen, Paul Kaders, GmbH, 610732, = Adams 11008. *Juniperus chinensis* wood oils: JcTr, *J. chinensis* cv. *torrulosa* wood, Adams 11024, cultivated, Waco, Texas, Jchin, *J. chinensis* wood, Adams 9736, Japan. Other commercial cedarwood oils from single source species: Tex, Texas Cedarwood oil, ex. Texarome, perfume grade, ex *J. ashei*, Adams = 6474; Virg, Virginia Cedarwood oil, ex Texarome, ex *J. virginiana*, = Adams 11239.

Wood samples were radially cut in 1 cm segments using a band saw. The radial sections were then cut linearly into 2 x 5

Table II. Composition of oils from putative *Cupressus funebris*, commercial Chinese cedarwood oils, *J. chinensis* wood oils, Texas Cedarwood oil and Virg, Virginia Cedarwood oil.

RI	Compound	putative C. funebris				Chinese cedarwood oils									J. chinensis		comm. oils	
		[1]Cf1	Cf2	Cf3	Cf4	HAC	G30	G40	G41	G34	G42	G35	G33	G32	JcTr	Jchin	Tex	Virg
932	α-pinene	0.7	0.5	t	t	-	-	t	-	-	t	-	-	-	t	-	-	0.2
974	β-pinene	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
988	myrcene	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1008	δ-3-carene	-	t	-	-	-	-	t	-	-	-	-	-	-	t	-	-	-
1020	p-cymene	-	-	-	-	-	t	t	-	-	-	-	-	-	-	-	-	-
1024	limonene	-	-	-	-	-	0.5	0.1	-	-	t	-	-	-	-	-	-	-
1025	β-phellandrene	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1086	terpinolene	-	-	-	-	-	0.5	0.1	-	-	-	-	-	-	t	-	-	-
1141	camphor	-	t	t	-	-	t	-	-	-	-	-	-	-	-	-	-	-
1165	borneol	-	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1174	terpinen-4-ol	-	-	t	-	-	0.1	0.1	-	-	t	-	-	t	-	-	t	-
1178	naphthalene	-	-	-	-	-	t	-	-	-	-	-	-	-	-	t	-	-
1186	α-terpineol	t	t	-	-	-	0.1	t	-	t	-	-	0.1	0.1	-	-	-	-
1283	isobornyl acetate	t	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1241	**methyl carvacrol**	-	t	t	-	0.1	0.8	2.3	0.2	t	0.2	-	-	-	-	-	-	-
1289	thymol	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-
1293	methyl myrtenate	t	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1298	carvacrol	-	-	t	-	-	t	-	-	-	-	-	-	-	-	-	t	-
1350	α-longipinene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-
1346	α-terpinyl acetate	0.2	-	-	-	-	t	-	-	-	-	-	-	t	-	-	-	-
1374	α-copaene	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-
1374	isoledene	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-
1380	2-epi-α-funebrene	0.1	t	-	-	0.5	1.2	0.9	0.8	1.3	0.6	0.1	1.8	1.1	0.4	0.1	t	0.5
1387	α-duprezianene	0.1	0.1	t	-	0.3	0.5	0.4	0.4	1.1	0.3	0.1	1.5	1.0	0.5	0.6	0.3	0.6
1389	isolongifolene	-	-	-	t	0.3	0.3	0.3	0.3	-	0.3	-	-	t	0.2	-	-	0.1
1389	β-elemene	-	0.1	-	0.6	0.4	0.5	0.6	0.4	1.1	0.4	-	1.6	1.0	0.1	-	-	-
1390	7-epi-sesquithujene	0.1	-	-	-	-	-	-		-	-	-	-	-	0.2	-	t	0.3
1396	**α-chamipinene**	-	-	t	0.4	0.9	0.8	0.9	0.9	0.3	0.9	-	t	0.3	0.2	-	-	0.1
1401	isoitalicene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-
1402	**α-funebrene**	-	-	-	t	-	0.2	0.3	-	-	-	-	-	-	-	-	-	0.3
1405	sesquithujene	-	-	-	-	-	-	-	0.1	-	-	-	-	-	0.1	-	-	-
1407	longifolene	-	-	-	-	0.2	-	-	-	0.6	0.8	-	0.7	-	-	-	-	-
1407	α-barbatene	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-
1410	**α-cedrene**	3.4	1.3	0.7	2.2	19.0	20.8	19.0	20.8	26.6	17.9	3.7	44.2	27.9	1.6	3.1	21.8	27.7
1413	**β-funebrene**	3.4	1.3	-	2.2	-	-	-	-	-	-	-	-	-	7.1		-	t
1413	β-duprezianene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5
1417	β-caryophyllene	1.0	-	-	1.2	t	-	t	t	-	t	-	t	t	3.5	1.2	-	-
1419	**β-cedrene**	1.9	2.1	0.3	0.8	5.9	6.2	5.3	6.7	7.3	5.7	3.1	11.5	30	3.5	0.6	5.9	6.3
1429	***cis*-thujopsene**	2.3	0.8	1.4	18.7	35.3	33.2	33.6	28.9	26.6	28.4	1.9	21.6	37.4	28.4	8.1	24.6	17.9
1436	isobazzanene	-	-	t	0.3	0.1	0.4	t	t	-	t	0.1	t	-	0.4	0.1	-	0.3
1440	(Z)-β-farnesene	t	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
1440	**β-barbatene**	-	-	-	t	0.2	0.4	0.2	0.1	t	0.4	-	-	-	0.2	t	-	-
1444	**prezizaene**	t	-	-	t	0.1	0.3	0.2	0.2	0.3	0.5	-	0.7	-	0.2	t	-	0.2
1445	myltayl-4(12)-ene	-	-	-	-	-	-	0.2	0.2	-	-	-	-	-	-	-	-	-
1449	α-himachalene	-	-	-	t	-	-	-	-	0.4	-	-	-	-	-	-	0.6	0.1
1452	α-humulene	t	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
1454	(E)-β-farnesene	0.9	0.1	-	0.3	0.4	0.2	0.2	0.3	-	0.5	-	0.5	-	0.2	-	-	0.1
1464	**α-acoradiene**	-	-	t	t	0.5	0.3	0.5	0.4	0.2	0.4	0.7	-	-	0.3	0.1	-	t
1465	**thujopsadiene**	-	-	t	-	0.5	0.4	0.4	0.4	0.2	0.5	-	0.7	1.2	-	0.2	1.0	0.4
1469	β-acoradiene	0.6	0.2	t	-	0.3	0.3	0.3	-	0.5	0.9	0.8	0.9	-	0.4	0.2	0.7	0.4
1470	10-epi-β-acoradiene, isomer	0.4	-	-	-	-	-	-	0.2	0.4	-	-	-	-	-	-	-	0.3
1471	sesquiterpene 119, 105, FW204[1]	-	-	-	-	-	-	-	-	-	-	0.8	-	-	-	-	-	-
1474	α-neocallitropsene	-	-	-	-	0.3	-	-	-	-	0.6	-	-	-	-	-	-	-
1475	γ-gurjunene	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-
1475	β-chamigrene, isomer	-	-	-	-	-	-	-	-	-	-	0.6	-	0.2	-	-	-	-
1476	β-chamigrene	-	-	t	1.2	2.0	1.3	1.7	1.9	1.3	2.5	1.2	0.6	1.3	1.1	0.3	1.2	1.3
1478	γ-muurolene	-	0.3	-	-	-	-	-	-	-	-	-	0.6	-	-	-	-	-

Table II. Continued

RI	Compound	putative *C. funebris*				Chinese cedarwood oils									*J. chinensis*		comm. oils	
		[1]Cf1	Cf2	Cf3	Cf4	HAC	G30	G40	G41	G34	G42	G35	G33	G32	JcTr	Jchin	Tex	Virg
1479	ar-curcumenene	-	0.3	-	0.2	0.4	0.4	0.5	0.5	0.5	1.8	1.8	1.8	0.8	0.1	-	0.4	0.2
1481	widdra-2,4(14)-diene	-	-	-	0.5	-	-		-	-	-	-	-	-	0.1	-	-	-
1484	germacrene D	1.4	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
1485	11-αH-himachala-1,4-diene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.8	-	-
1489	β-selinene	-	0.3	-	0.1	0.2	0.3	0.3	0.2	0.3	1.1	1.0	0.8	0.3	0.4	-	-	t
1498	β-alaskene	0.2	0.3	-	0.3	0.5	0.4	0.4	0.1	0.3	1.7	1.6	0.5	0.4	0.4	-	0.2	0.2
1499	pseudowiddrene	-	-	-	-	1.1	1.7	-	1.6	-	-	-	-	-	t	-	0.6	0.3
1500	bicyclogermacrene	-	-	-	-	-	-	-	-	-	1.5	-	-	-	-	-	-	-
1500	**β-himachalene**	-	-	-	**1.5**	**2.2**	**1.7**	**2.5**	**1.6**	**1.6**	**1.6**	**6.4**	**1.2**	**1.2**	**3.1**	**3.1**	**1.8**	**0.6**
1500	α-muurolene	-	0.3	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-
1503	α-chamigrene	-	-	-	0.2	t	0.3	0.2	0.3	0.2	0.2	1.4	0.4	0.4	0.5	-	1.2	1.0
1504	cuparene	-	0.3	0.5	2.4	3.9	3.7	4.1	3.6	1.8	4.8	10.2	2.2	3.8	1.0	1.9	3.6	1.7
1505	β-bisabolene	0.2	0.3	-	0.2	0.2	-	t	-	-	0.3	t	-	-	-	-	-	-
1508	germacrene A	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1512	α-alaskene	0.7	0.2	0.3	1.8	2.5	2.1	2.2	2.2	0.4	2.9	4.8	0.6	0.7	-	0.2	0.6	0.7
1513	γ-cadinene	-	0.2	-	-	-	-	-	-	-	t	t	-	-	-	-	-	-
1514	β-curcumene	t	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-
1516	γ-dehydro-ar-himachalene	-	-	-	-	-	-		-	-	-	-	-	-	0.7	-	0.1	-
1517	sesquiterpene 173, 188,FW204[2]	-	-	-	-	-	-	-	-	-	1.1	2.8	-	0.3	-	-	-	-
1521	β-sesquiphellandrene	0.4	-	-	0.3	0.1	-	-	0.1	-	-	-	-	-	0.2	-	-	-
1521	*trans*-calamenene	-	0.2	-	-	0.2	0.1	-	0.2	0.1	1.4	3.9	0.2	0.3	-	0.3	-	-
1522	δ-cadinene	-	0.2	-	-	0.2	0.2	-	-	0.1	1.5	2.6	0.3	0.3	-	0.3	-	-
1528	zonarene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-
1529	(E)-γ-bisabolene	0.1	-	-	-	0.5	0.4	0.4	0.8	-	0.4	0.6	-	-	-	-	-	-
1532	γ-cuprenene	0.1	-	0.2	1.4	1.3	0.9	1.1	0.7	0.9	0.3	2.8	0.4	0.4	2.7	-	-	1.2
1537	α-cadinene	-	t	-	-	-	-	-	-	-	0.4	1.2	-	t	-	-	-	-
1542	δ-cuprenene	-	-	0.1	0.4	0.5	0.4	0.4	0.4	0.5	-	-	0.3	0.4	0.9	0.4	-	0.4
1544	α-calacorene	-	t	-	-	-	-	-	-	-	0.6	3.1	-	-	-	0.2	-	-
1548	elemol	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1558	eremophilla ketone	-	-	-	-	-	t	-	-	-	0.1	0.5	-	0.1	-	-	-	-
1561	(E)-nerolidol	0.2	t	-	t	-	-	0.1	t	-	-	-	-	t	-	-	-	-
1562	longicamphenylone	-	t	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-
1570	caryophyllenyl alcohol	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-
1571	caryolan-8-ol	-	-	-	-	-	-	-	-	-	-	1.0	-	-	-	-	-	-
1582	caryophyllene oxide	-	-	-	-	-	-	-	-	-	-	-	0.1	t	-	-	-	-
1582	1,4,6-trimethyl naphthalene*	-	-	-	-	-	-	-	-	-	-	0.8	-	-	-	-	-	-
1586	thujopsan-2α-ol	0.5	t	-	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-
1589	allo-cedrol	2.0	1.1	0.5	1.3	0.2	0.4	0.3	0.3	2.1	0.3	1.4	0.2	0.4	0.4	3.1	0.3	0.2
1595	*cis*-dihydro-mayurone	-	-	-	-	-	-	-	-	-	0.1		-	-	-	-	-	-
1599	**widdrol**	-	-	-	**t**	-	**t**	**0.8**	**t**	**t**	-	-	**0.8**	**t**	**9.2**	**2.0**	-	**t**
1600	**cedrol**	**43.9**	**54.6**	**72.1**	**45.0**	**14.4**	**19.0**	**15.3**	**17.4**	**13.7**	**14.1**	**23.4**	**1.7**	**5.5**	**13.7**	**39.4**	**30.5**	**26.5**
1607	**β-biotone**	-	-	-	-	-	-	-	-	**0.4**	**0.6**	**t**	**t**	**0.1**	-	-	-	-
1612	**β-biotol**	-	-	-	-	-	-	-	-	**2.0**	**0.6**	**1.6**	**0.2**	**0.4**	-	-	-	-
1618	junenol	-	-	-	-	-	-	-	-	-	-	1.0	-	-	-	-	-	-
1618	epi-cedrol	0.2	0.5	0.2	0.3	0.2	0.3	0.2	.03	0.2	0.5	-	t	t	0.2	0.5	0.3	0.3
1626	2-epi-α-cedren-3-one	-	-	-	-	-	-	-	-	-	0.3	0.9	-	-	-	-	-	-
1625	α-longipinen-12-ol*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	-
1626	α-acorenol isomer	0.5	0.3	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
1630	γ-eudesmol	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1633	sesquiterpen-ol 179, 161, FW220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-
1634	α-acorenol	0.4	0.3	0.5	0.9	0.1	0.1	0.1	0.3	0.5	0.4	0.6	-	0.1	0.1	1.0	1.2	0.8
1636	β-acorenol	-	-	0.3	0.4	-	0.1	-	0.3	1.0	0.3	0.5	-	-	0.2	0.7	0.6	0.4
1638	epi-α-cadinol	-	-	-	-	-	-	-	0.1	-	0.2	t	-	-	-	-	-	-
1639	1,7-di-epi-α-cedrenal	-	-	-	-	-	-	-	-	-	-	0.2	-	0.1	-	-	-	-
1640	epi-α-muurolol	t	0.9	-	-	-	-	-	0.2	-	0.2	0.3	-	-	-	-	-	-

Table II. Continued

RI	Compound	putative C. funebris				Chinese cedarwood oils									J. chinensis		comm. oils	
		[1]Cf1	Cf2	Cf3	Cf4	HAC	G30	G40	G41	G34	G42	G35	G33	G32	JcTr	Jchin	Tex	Virg
1641	3-iso-thujopsanone	-	-	-	-	-	-	-	-	-	0.1	-	-	0.1	-	-	-	-
1644	α-muurolol	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1645	sesquiterpen-ol 119, 109, FW222	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.9	-	-
1648	sesquiterpen-ol, 123, 91, FW218	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7
1649	β-eudesmol	1.6	t	-	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-
1650	cedr-8(15)-en-9-α-ol	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-
1652	α-eudesmol	0.8	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-
1652	α-cadinol	-	1.6	-	-	-	-	-	0.3	-	0.2	-	-	0.1	-	-	-	-
1653	3-thujopsanone	-	-	-	0.1	-	-	-	-	0.5	0.3	-	0.1	-	-	-	-	-
1658	selin-11-en-4α-ol	0.7	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-
1660	**sesquiterpen-ol 135, 79, FW220**	-	-	-	-	-	-	-	-	-	-	-	-	-	**0.3**	**1.4**	-	-
1664	junicedranone	-	-	0.3	-	-	0.1	0.1	0.3	-	0.1	-	-	-	-	-	-	0.3
1665	intermedeol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
1666	14-hydroxy-iso-caryophyllene	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1670	sesquiterpen-ol 147, 148, FW220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	-
1670	epi-β-bisabolol	-	-	0.2	-	-	0.1	-	0.1	0.3	0.1	0.1	0.1	-	-	-	-	0.3
1675	cadalene	-	-	-	-	-	-	-	0.1	-	0.2	0.2	-	-	-	-	-	-
1683	epi-α-bisabolol	0.7	0.4	2.6	2.0	0.9	0.4	-	0.5	0.3	0.3	0.4		0.1	1.6	1.5	0.2	-
1688	**8-cedren-13-ol**	-	-	-	-	-	-	-	-	-	-	-	-	-	**0.5**	**2.2**	-	-
1692	junicedranol	-	-	0.5	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-
1692	4-cuprenen-1-ol	-	-	-	0.3	-	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-
1695	cedr-3-en-15-ol*	-	-	-	-	-	-	-	-	-	-	-	-	-	t	3.2	-	-
1701	***cis*-thujopsenol**	-	-	-	-	-	-	-	-	-	-	-	-	-	**3.4**	**3.4**	-	-
1703	mayurone	-	-	0.4	1.5	0.1	0.1	0.1	-	t	0.2	-	0.1	0.1	-	-	1.1	0.7
1708	*cis*-thujopsenal	-	-	-	0.2	0.1	0.1	0.2	t	-	-	-	t	-	0.9	-	-	0.7
1710	sesquiterpen-al 123, 41, FW218	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.9	0.8	t
1751	cuparenal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	t
1762	β-acoradienol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-
1767	cedryl acetate	0.9	1.9	-	-	0.1	0.1	-	0.2	-	-	-	-	-	-	-	-	-
1773	sesquiterpene 105, 135, FW220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	-
1786	sesquiterpen-ol 135, 91, FW220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.1	-	-
1792	β-eudesmol acetate	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1794	α-eudesmol acetate	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1813	cryptomeridiol	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1863	*cis*-thujopsenic acid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	0.1	-
1889	cedrane-8S,14-diol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-
1938	11-acetoxyeudesman-4α-ol	0.8	t	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1959	nootkatin	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-
2022	**abieta-8,12-diene**	-	-	-	**0.1**	-	-	-	-	-	-	-	-	-	-	-	-	-
2055	abietatriene	-	-	0.6	0.5	-	0.1	-	-	-	-	-	-	-	-	-	-	-
2056	manool	2.7	7.6	6.0	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
2087	abietadiene	-	-	4.4	5.3	-	0.2	t	0.1	-	-	-	-	-	-	-	-	-
2107	diterpenol, 191, 41, 177, FW 290	7.6	13.7	-	-	-	-	0.1	0.4	-	-	-	-	-	-	-	-	-
2149	abienol	4.5	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2153	abieta-8(14),13(15)-diene	-	-	0.1	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-
2184	sandaracopimarinal	-	-	0.2	0.1	-	-	-	-	-	-	-	-	-	-	0.1	-	-
2222	sclareol	0.7	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2264	diterpenal, 43, 81, 147, FW 286	0.3	0.8	0.8	t	-	-	-	-	-	-	-	-	-	-	-	-	-

Table II. Continued

RI	Compound	putative C. funebris				Chinese cedarwood oils									J. chinensis		comm. oils	
		[1]Cf1	Cf2	Cf3	Cf4	HAC	G30	G40	G41	G34	G42	G35	G33	G32	JcTr	Jchin	Tex	Virg
2269	sandaracopimarinol	-	-	1.1	0.6	-	-	-	-	-	-	-	-	-	-	0.1	-	-
2310	diterpenol, <u>43</u>, 257, 275, FW 290	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2315	6,7-dehydro-ferruginol	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2331	***trans*-ferruginol**	**-**	**-**	**0.3**	**0.2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.1**	**-**	**-**
2360	**torulosol**	**0.1**	**t**	**0.5**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
2557	**hinokienone**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.1**	**-**	**-**

[1]Cf1-Cf4 = oils from wood samples from China; HAC, G30, G40, G41, G34, G42, G35, G33, G32 = commercial Chinese cedarwood oils; JcTr, Jchin = oils from wood of *J. chinensis*; Tex = Texas cedarwood oil; Virg = Virginia cedarwood oil. [2]for unknown cpds., base ion (100%) is underlined, next ions are major ions; FW = formula weight, *= tentatively identified, RI = Arithmetic Index on DB-5(= SE54). column. Compositional values less than 0.1% are denoted as traces (t); Unidentified components less than 0.5% are not reported.

Table III. Summary of some key components in various cedarwood oils.

RI	Compound	Cf1	Cf2	Cf3	Cf4	HAC	G30	G40	G41	G34	G42	G35	G33	G32	JcTr	Jchin	Tex	Virg
1402	α-funebrene	-	-	-	t	-	0.2	0.3	-	-	-	-	-	-	-	-	-	0.3
1410	α-cedrene	3.4	1.8	0.7	2.2	19.0	20.8	19.0	20.8	26.6	17.9	3.7	44.2	27.9	3.6	3.1	21.8	27.7
1413	β-funebrene	3.4	1.8	-	2.2	-	-	-	-	-	-	-	-	-	7.1		-	t
1419	β-cedrene	1.9	2.1	0.3	0.8	5.9	6.2	5.8	6.7	7.3	5.7	3.1	11.5	8.0	3.5	0.6	5.9	6.3
1429	cis-thujopsene	2.3	0.8	1.4	18.7	35.3	33.2	33.6	28.9	26.6	28.4	1.9	21.6	37.4	28.4	8.4	24.6	17.9
1599	widdrol	-	-	-	t	-	t	0.8	t	t	-	-	0.8	t	9.2	2.0	-	t
1600	cedrol	43.9	54.6	72.8	45.0	14.4	19.0	15.3	17.4	13.7	14.1	23.4	1.7	5.5	13.7	39.4	30.5	26.5
Sum of key components (% of total)		54.9	61.1	75.2	68.9	74.6	79.4	74.8	73.8	74.2	66.1	32.1	79.8	78.8	65.8	53.5	82.8	79.1
Number of components		59	52	40	54	44	56	51	54	42	62	47	41	45	48	50	32	44

mm (x 1 cm) pieces. The wood (25 g) was placed in a 125 mL screw cap bottle to which 50 mL of pentane was added. The bottles were shaken for 24 h on a rotary shaker. The pentane extract was filtered and the pentane evaporated by use of nitrogen. The extracted wood was oven dried 48 h, 110°C for use in the oven dry weight calculations. Percent yields were determined on an oven dry weight basis as: 100 x oil wt./(oil wt. + oven dry wood wt.). All oil samples (including commercial cedarwood oils) were dissolved in diethyl ether (10% oil solution) and stored at -20°C until analyzed.

The extracts were analyzed on a HP5971 MSD mass spectrometer operated in the EI mode, scan time 1sec., acquisition mass range: 41-500, directly coupled to a HP 5890 gas chromatograph, using a J & W DB-5, 0.26 mm x 30 m, 0.25 micron coating thickness, fused silica capillary column, 0.2 µL injected of a 10% solution in diethyl ether, and split 1/10, injector: 220°C, transfer and MSD: 240°C, column temperature linearly programmed: 60–246°C/ 3°C min. Identifications were made by library searches of our volatile oil library (10), using the HP Chemstation library search routines, coupled with retention time data of authentic reference compounds. All samples were also run on an HP 5890 gas chromatograph equipped with FID, using a J & W DB-5, 0.26 mm x 30 m, 0.25 micron coating thickness, fused silica capillary column, 0.2 µl injected of a 10 % solution in diethyl ether, and split 1/10, injector: 220°C, transfer and FID: 240°C, column temperature linearly programmed: 60–246°C/ 3°C min. Quantitation was by use of the HP Chemstation software.

Results and Discussion

The oil compositions are shown in Table II. Unidentified compounds (less than 0.5% oil) were: RI 1471, sesquiterpene, FW 204(25%), 41(50), 55(30), 77(20), 91(40), 105(45), 119(100), 133(35), 189(20); RI1517, sesquiterpene, FW 204(2), 77(6), 91(6), 115(7), 128(9), 158(8), 173(100), 188(15); RI 1633, sesquiterpene alcohol, FW 220(3), 41(30), 55(25), 95(20), 109(25), 119(30), 161(62), 179(100), 189(10), 204(25); RI 1645, sesquiterpene alcohol, FW 222(26), 41(90), 55(75), 69(42), 82(48), 93(53), 109(78), 119(100), 137(30), 151(21), 161(18), 204(22); RI 1648, sesquiterpene aldehyde, FW 218(18), 41(82), 55(50), 79(43), 91(50), 107(31), 123(100), 135(18), 147(16), 206(10); RI 1660, sesquiterpene alcohol, FW 220(12), 41(30, 79(48), 91(28), 105(28), 135(100), 147(15), 177(12), 189(10); RI 1670, sesquiterpene alcohol, FW 220(10), 41(81), 69(40), 79(42), 91(45), 105(32), 123(44), 147(100), 148(91), 161(75), 189(15), 204(80); RI 1710, sesquiterpene aldehyde, FW 218(5), 41(88), 55(61), 67(28), 79(78), 91(81), 107(43), 123(100), 135(20), 150(10), 163(9), 178(15), 191(16), 206(12); RI 1773, sesquiterpene, FW220(25), 41(30), 55(22), 69(20), 79(25), 91(38), 105(96), 119(15), 135(100), 189(12); RI 1786, sesquiterpene alcohol, FW 220(80), 41(70), 55(40), 67(28), 79(53), 91(80), 105(75), 121(50), 135(100), 150(28), 177(15), 189(20); RI 2107, diterpene alcohol, FW 290(1), 41(100), 55(60), 69(60), 81(50), 95(40), 109(30), 123(22), 137(18), 149(10), 163(8), 177(18), 191(100), 257(4), 272(2); RI 2264, diterpene aldehyde, FW 286(1), 43(100), 55(65), 71(43), 81(58), 95(31), 107(28), 123(22), 133(18), 147(16), 161(10), 175(8), 189(8), 218(7), 257(7), 271(4); and RI 2310, diterpene alcohol, FW 290(1), 43(100), 55(40), 67(30), 81(38), 93(32), 109(28), 123(26), 135(16), 149(20), 163(14), 177(20), 187(12), 205(14), 257(22), 275(16).

The first wood sample of putative *C. funebris* (Cf1, Table II) was received, labeled 'fir wood', was white-pale yellow and of low density wood that appeared to be sapwood (cortical). Cf1 yielded 0.20 % (oven dry wt. basis) of clear oil. The second putative *C. funebris* sample (Cf2, Table II), labeled 'cedarwood', was light red as one might expect for heartwood and low density, with a yield of 0.55% of light yellow oil. The wood samples of Li (Cf3, Cf4, Table II), were white-pale yellow and of low density woods and yielded 1.64 and 0.32%, respectively, of light- and very pale - yellow oils.

The pairs of wood samples (Cf1, Cf2; Cf3, Cf4) have oils that reflect their origins. Several compounds (Table II) are characteristic of (Cf1, Cf2) or (Cf3, Cf4): α-pinene, β-acoradiene, β-acorenol, epi-α-muurolol, cedryl acetate, 1-acetoxyeudesman-4α-ol, abietatriene, abietadiene, abienol, abieta-8(14),13(15)-diene, sandaracopimarinal, sclareol, sandaracopimarinol, *trans*-ferruginol, and several unidentified diterpenes. The diterpenes found in the putative *C. funebris* wood samples were generally missing or very small in the commercial cedarwood oil samples (Table II). The diterpenes may have been removed by fractional distillation if the crude oils were refined.

Samples G30 and G40 have noticeable amounts of monoterpenes (Table II). Although one might suspect that some leaves were inadvertently included in the distillation, that seems unlikely if stumps are utilized for the raw material. Six of the commercial Chinese cedarwood oils (HAC, G30, G40, G41, G34, G42) share (Table II) several compounds that seem to indicate they may be from a single botanical source: methyl carvacrol, α-chamipinene, β-barbatene and prezizaene.

Five of the essential oils (G34, G42, G35, G33, G32) contain β-biotone and β-biotol. None of the other samples, nor putative *C. funebris*, or *Juniperus* oils have these compounds. β-biotone and β-biotol were discovered in *Biota orientalis* (now *Platycladus orientalis*) by Tomita et al. (11). Because *P. orientalis* wood oil is (12) rich in α-cedrene (8.0%), β-cedrene (7.6%), cedrol (11.8%), widdrol (10.1%), it is likely to have been utilized and provide the source of β-biotol and β-biotone in these five Chinese cedarwood oils.

Partial analyses of authentic *J. chinensis* wood oil have been reported by several authors (13–15). Analyses of *J. chinensis* var. *chinensis* and *J. chinesis* cv. *torrulosa* in this study revealed that their oils (Table II) contained four compounds that are unique to all the samples in this study: caryophyllenyl alcohol, 8-cedren-13-ol, cedr-3-en-15-ol and *cis*-thujopsenol. The fact that none of the commercial Chinese cedarwood oils contained any of these three compounds suggests that *J. chinensis* wood may not be utilized to produce Chinese cedarwood oil. Of course, our sampling is limited and these compounds may be found in oil samples from other regions.

The Chinese cedarwood oils analyzed were extremely complex mixtures. Many peaks contained 2, 3 or 4 components. Numerous unidentified trace components were present. The putative *C. funebris* wood samples (Cf1 - Cf4, Table III) had 40–59 components. Texas cedarwood oil (Tex, Table II) is the simplest oil (32 cpds.). One of the Chinensis cedarwood oils (G42) had 62 components.

Key components of Chinese cedarwood oils were very variable (Table III): α-cedrene (3.6–44.2), β-cedrene (3.5–11.5), cis-thujopsene (1.9–37.4), cedrol (1.7–23.4). The sum of key components varied from 32.1% (G35, Table III) to 79.8 (G33, Table III). It was noticeable that both Texas and Virginia cedarwood oils were very high in the key components (82.8, 79.1).

In summary, the presence of β-biotol and β-biotone in several Chinese cedarwood oils, coupled with their absence in the putative *C. funebris* wood samples, is strong evidence that the wood of *Platycladus orientalis* was utilized in their production. Whether other Cupressaceae species, in addition to *C. funebris*, are utilized could not be conclusively demonstrated, but the oils do appear to be produced from a mixture of Cupressaceae species.

Acknowledgments

Thanks to Jens-Achim Protzen, Paul Kaders, Gmbh for useful discussion, wood samples and samples of Chinese cedarwood oil. Thanks to Jerry King (U. Arkansas) for useful discussion and the sample of Chinese cedarwood oil from the Hangzhou Aroma Chem. Co. This research was supported in part by Baylor University.

References

1. K. Bauer, D. Garbe, *Common fragrance and flavor materials.* CVH Verlagsgesellschaft, Weinheim, Germany (1985).
2. B.M. Lawrence, *Essential Oils 1995–2000.* Allured Publ., Carol Stream, IL (2003).
3. R.P. Adams, *Investigation of* Juniperus *species of the United States for new sources of cedarwood oil.* Econ. Bot., **41**, 48–54 (1987).
4. A. Farjon, *A monograph of* Cupressaceae *and* Sciadopitys. Royal Botanic Gardens Press, Kew, London (2005).
5. D.P. Little, *Evolution and circumscription of the true cypresses (Cupressaceae:* Cupressus*).* Syst. Bot., **31**, 461–480 (2006).
6. D.P. Little, A.E. Schwarzbach, R.P. Adams and C-F. Hsieh, *The circumscription and phylogenetic relationships of* Callitropsis *and the newly described genus* Xanthocyparis (Cupressaceae*).* Am. J. Bot., **91**, 1872–1881 (2004).
7. R.P. Adams, *Cedarwood oil - analysis and properties. In: Modern methods of plant analysis, new series. Vol. 12. Essential oils and waxes.* Edits., H.F. Linskens and J.F. Jackson, pp. 159–173., Springer Verlag, New York, NY (1991).

8. T.M. Hoi, L.D. Moi, A. Muselli, A. Bighelli and J. Casanova, *Analyse de L'huile essentielle de Cupressus funebris du Vietnam par RMN du carbone-13.* Rivista Ital. EPPOS (special issue), 633–637 (1996).
9. E. Duquesnoy, H.D. Nguyen, V. Castola and J. Casanova, *Composition of a pyrolytic oil from* Cupressus funebris *Endl. of Vietnamese origin.* Flav. Fragr. J., **21**, 453–457 (2006).
10. R.P. Adams, *Identification of Essential Oils Components by Gas Chromatography/Mass Spectrometry, 4th Ed.* Allured Publ., Carol Stream, IL, (2006).
11. B. Tomita, Y. Hirose and T. Nakatsuka, *Terpenoids. XVI. New constituents of* Biota orientalis. Tetrahedron Letters, **7**, 843–848 (1968).
12. H. Wang, *Extraction and identification of essential oil from* Platycladus orientalis. Zhongcaoyao, **35**, 863–865 (2005).
13. J-M. Fang, Y-C. Chen, B-W. Wang and Y-S. Cheng, *Terpenes from heartwood of* Juniperus chinensis. Phytochemistry, **41**, 1361–1365 (1996).
14. T. Nakatsuka and Y. Hirose, *Occurrence of nootkatin and hinokitiol in* Juniperus chinensis *wood.* J. Japan Forest Soc., **37**, 196–197 (1955).
15. L-L. Shiu, W-C. Chen and Y-H. Kuo, *Five new cis-himachalane-type sesquiterpenes from the heartwood of* Juniperus chinensis *var.* tsukusiensis. Chem. Pharm. Bull., **47**, 557–560 (1999).

Volatile Compounds of *Pourouma cecropiifolia* Mart. Fruits from Colombia

Jorge A. Pino,

Instituto de Investigaciones para la Industria Alimenticia, Carretera al Guatao km 3½, La Habana 19200, Cuba.

Clara E. Quijano*

Universidad de los Andes, Facultad de Ciencias, Dpto. de Química, Cra. 1ª Este N° 18-A-10 Edif. (Q-826), Bogotá, Colombia. E-mail: cquijano@uniandes.edu.co

Abstract

The chemical composition of volatile compounds from fruits of *Pourouma cecropiifolia* Mart. grown in Colombia was studied by GC and GC/MS. Sixty-four compounds were identified, of which linalool (20.1%) and hexadecanol (18.9%) were the major components.

Key Word Index

Pourouma cecropiifolia, Moraceae, fruit volatiles, linalool, hexadecanol.

Plant Name

Pourouma cecropiifolia Mart. (Moraceae). Common name: Uva caimarona, uva de monte.

Source

Fresh mature fruits of *Pourouma cecropiifolia*. Herbarium specimen No: PC 458 were picked from bushes grown in Caquetá, Colombia, and transported by airplane to the laboratory within 24 h after harvest. The fruits were allowed to ripen at room temperature.

Plant Part

Fruits were peeled, cut in short pieces and the volatile compounds were isolated from 200 g of material by simultaneous distillation-solvent extraction with 60 mL of previous distilled diethyl ether-pentane (1:1 v/v) for 1 h in a Likens-Nickerson apparatus (1). Internal standard (0.2 g of decanol) was added to the supernatant before isolation. The extract was dried over anhydrous sodium sulfate and concentrated with a Kuderna-Danish apparatus with a Vigreux column to 1 mL and then, to 0.2 mL with a gentle Nitrogen stream.

*Address for correspondence

Received: January 2007
Revised: March 2007
Accepted: January 2007

1041-2905/08/0003-0242$14.00/0—