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The wood essential oil of *Sassafras albidum*

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Abstract

The essential oil from the heartwood of *Sassafras albidum* was obtained by hydrodistillation and analyzed by GC-MS, GC-FID, and chiral GC-MS. The major components in the wood essential oil were α -pinene (25.6%), 1,8-cineole (10.7%), α -terpineol (10.1%), β -pinene (8.8%), linalool (8.0%), and limonene (5.4%). The (+)-enantiomers predominated for α -pinene, β -pinene, limonene, and α -terpineol, while linalool was nearly racemic.

Keywords: Essential oil, sassafras, chemical composition, enantiomeric distribution, chiral, gas chromatography

1. Introduction

There are currently 69 genera making up the Lauraceae ^[1] and as many as 3000-3500 species ^[2]. Many members of the Lauraceae are used as spices and flavoring ^[3] and the wood essential oils of some species have shown importance ^[4]. These include *Aniba rosaeodora* Ducke (Brazilian rosewood, pau-rosa) as well as *Aniba parviflora* (Meisn.) Mez (macacaporanga or louro-rosa) ^[5], *Cinnamomum camphora* L. (camphorwood) ^[6], and *Ocotea cymbarum* Kunth (cascarillo) ^[7, 8].

Sassafras albidum (Nutt.) Nees (Lauraceae) is a small to medium-sized tree, 12-15 m tall and 20-30 cm in diameter ^[9]. The tree is readily identified by variably lobed leaves and distinctive aromatic odor. It is an early successional tree, often found in old fields, fence rows, and forest margins. The native range of *S. albidum* is the eastern United States, from central Florida and the Gulf Coast, north into Michigan, New York, New Hampshire ^[10]. The purpose of this work was to investigate *Sassafras albidum* wood essential oil for fragrance potential. This work complements our previous investigations on the leaf ^[11] and bark ^[12] essential oils of *S. albidum*.

2. Materials and Methods

2.1 Plant Material

A stand of *S. albidum* was located on private property in Newville, Alabama (31.4412218 N, 85.3593392 W). The tree was identified by S.K.L. by comparison with samples in the New York Botanical Garden, C. V. Starr Virtual Herbarium (<http://sweetgum.nybg.org/science/vh/>, specimen 02511805) and the Missouri Botanical Garden Herbarium (<http://legacy.tropicos.org/Image/100398663>, bar code MO-2824052). A large branch (ca. 10 cm diameter) from a large tree was obtained on 15 November 2020 and allowed to dry in the dark for 80 days. The dried heartwood was chopped and a sample (119.42 g) was hydrodistilled using a Likens-Nickerson apparatus with continuous extraction with dichloromethane for four hours to give a colorless essential oil (180.6 g).

2.2 Gas Chromatography – Mass Spectrometry

The wood essential oil of *S. albidum* was subjected to gas chromatographic–mass spectral (GC–MS) analysis as previously reported ^[13]: Shimadzu GCMS-QP2010 Ultra, electron impact (EI) mode with electron energy = 70 eV, scan range = 40–400 atomic mass units, scan rate = 3.0 scans/s; ZB-5ms fused silica capillary GC column (60 m length, 0.25 mm inside diameter, 0.25 μ m film thickness); He carrier gas, column head pressure = 208.3 kPa, flow rate = 2.00 mL/min; injector temperature = 260 °C, ion source temperature = 260 °C; GC oven temperature program: initial temperature = 50 °C, temperature increased 2 °C/min to 260 °C. For each sample, a 5% w/v solution in CH₂Cl₂ was prepared, and 0.1 μ L was injected using a split ratio of 24.5:1.

Identification of the individual components of the essential oils was determined by comparison of their retention indices, determined using a series of *n*-alkanes, in addition to comparison of the mass spectral fragmentation patterns with those found in the MS databases [14–17], using the Lab Solutions GCMS solution software version 4.45, and with matching factors > 90%.

2.3 Gas Chromatography – Flame Ionization Detection

The GC-FID analyses were carried out using a Shimadzu GC 2010 equipped with flame ionization detector, a split/splitless injector, and Shimadzu autosampler AOC-20i, with a ZB-5 capillary column (60 m × 0.25 mm i.d.; film thickness 0.25 μm). The oven temperature was programmed as above for GC-MS. Injector and detector temperatures were maintained at 260 °C, respectively. The carrier gas was He and the flow rate was 1.0 mL/min. For each sample, a 5% w/v solution in CH₂Cl₂ was prepared, and 0.1 μL was injected using a split ratio of 31:1. The percent compositions of the essential oils were calculated from peak areas without standardization.

2.4 Chiral Gas Chromatography – Mass Spectrometry

Chiral GC-MS of the three leaf essential oils was carried out, as reported previously [13]: Shimadzu GCMS-QP2010S (Shimadzu Scientific Instruments, Columbia, MD, USA), electron impact (EI) mode, electron energy = 70 eV; scan range = 40–400 amu, scan rate = 3.0 scans/s; Restek B-Dex 325 chiral capillary GC column (30 m length × 0.25 mm

inside diameter × 0.25 μm film thickness). Oven temperature program: starting temperature = 50 °C, temperature increased 1.5 °C/min to 120 °C, then 2 °C/min to 200 °C, and kept at 200 °C for an additional 5 min; carrier gas was helium, flow rate = 1.8 mL/min. For each essential oil sample, a 3% w/v solution in CH₂Cl₂ was prepared, and 0.1 μL was injected using a split ratio of 45:1. The enantiomers of the monoterpenoids were identified by comparison of retention times with authentic samples obtained from Sigma-Aldrich (Milwaukee, WI, USA). The enantiomer percentages were determined from peak areas.

3. Results and Discussion

3.1 Essential Oil Composition

Dried wood of *S. albidum* was hydrodistilled to give a colorless essential oil in 0.151% yield. Analysis of the essential oil was carried out using GC-MS and GC-FID and led to identification of 58 components accounting for 100% of the essential oil composition (Table 1). Monoterpenoids dominated *S. albidum* wood essential oil (87.8%) with α-pinene (25.6%), β-pinene (8.8%), limonene (5.4%), 1,8-cineole (10.7%), linalool (8.0%), and α-terpineol (10.1%) as the major components. Interestingly, safrole was not detected in the wood essential oil. The root bark of *S. albidum* is notorious for the high concentration of the carcinogenic phenylpropanoid safrole [18–20]. Additionally, neither the leaf essential oil [11] nor the bark essential oil [12] contain safrole.

Table 1: Chemical composition of the wood essential oil of *Sassafras albidum*.

RT (min)	RI _{calc}	RI _{lab}	Compound	%
12.0	924	923	Tricyclene	0.1
12.2	927	925	α-Thujene	0.2
12.6	935	932	α-Pinene	25.6
13.4	948	948	α-Fenchene	0.1
13.5	950	950	Camphene	3.0
13.7	954	953	Thuja-2,4(10)-diene	tr
14.7	973	972	Sabinene	0.2
15.1	979	978	β-Pinene	8.8
15.4	985	984	6-Methylhept-5-en-2-one	0.1
15.7	989	989	Myrcene	1.7
16.7	1008	1006	α-Phellandrene	0.3
16.9	1010	1008	δ-3-Carene	0.1
17.4	1018	1017	α-Terpinene	0.2
17.9	1025	1024	p-Cymene	1.1
18.2	1030	1030	Limonene	5.4
18.3	1032	1031	β-Phellandrene	0.7
18.4	1033	1032	1,8-Cineole	10.7
20.0	1058	1057	γ-Terpinene	0.4
20.9	1071	1069	cis-Linalool oxide (furanoid)	0.2
21.8	1085	1087	Terpinolene	0.4
22.0	1087	1086	trans-Linalool oxide (furanoid)	0.1
22.9	1101	1101	Linalool	8.0
26.1	1147	1145	Camphor	3.7
27.8	1173	1170	δ-Terpineol	0.3
28.4	1181	1180	Terpinen-4-ol	2.8
29.5	1196	1195	α-Terpineol	10.1
30.2	1207	1205	Verbenone	0.2
32.3	1238	1238	Neral	1.2
34.3	1267	1266	Geranial	2.2
35.4	1283	1282	Bornyl acetate	0.1
38.8	1334	1335	δ-Elementene	0.1
39.6	1346	1348	α-Cubebene	0.4
41.5	1374	1375	α-Copaene	0.1
42.4	1388	1390	trans-β-Elementene	0.9
44.3	1418	1417	(E)-β-Caryophyllene	0.2
44.9	1427	1427	γ-Elementene	0.2
46.3	1451	1452	(E)-β-Farnesene	0.1

46.5	1453	1454	α -Humulene	0.6
48.1	1479	1480	Germacrene D	0.5
48.6	1487	1489	β -Selinene	0.1
48.8	1490	1490	γ -Amorphene	0.1
48.9	1493	1494	α -Zingiberene	1.0
49.2	1496	1497	α -Muurolene	0.1
49.5	1502	1503	(<i>E,E</i>)- α -Farnesene	0.2
49.7	1505	1508	β -Bisabolene	0.2
50.0	1511	1512	γ -Cadinene	0.1
50.4	1516	1518	δ -Cadinene	0.8
50.7	1521	1523	β -Sesquiphellandrene	0.9
52.8	1556	1557	Germacrene B	0.3
54.1	1579	1577	Caryophyllene oxide	0.2
54.8	1590	1592	Viridiflorol	0.2
55.1	1595	1596	<i>trans</i> - β -Elemenone	1.2
56.0	1611	1613	Tetradecanal	0.1
56.9	1627	1628	1- <i>epi</i> -Cubenol	0.4
57.8	1643	1643	τ -Cadinol	0.2
58.0	1647	1645	τ -Muurolol	0.4
58.7	1659	1656	β -Eudesmol	1.3
58.8	1662	1659	α -Cadinol	1.2
			Monoterpene hydrocarbons	48.2
			Oxygenated monoterpenoids	39.6
			Sesquiterpene hydrocarbons	6.9
			Oxygenated sesquiterpenoids	5.0
			Others	0.2
			Total identified	100.0

RT = Retention time. RI_{calc} = Retention index determined with respect to a homologous series of *n*-alkanes on a ZB-5ms column. RI_{db} = Reference retention index from the databases [14-17]. tr = trace (< 0.05%)

Of the commercially-important wood essential oils from the Lauraceae, *Aniba rosaedora* wood essential oil is generally dominated by linalool [5], *Cinnamomum camphora* is generally dominated by camphor [21, 22], *Aniba parviflora* is rich in sesquiterpenoids, 33.3% sesquiterpene hydrocarbons and 45.4% oxygenated sesquiterpenoids [23]. Several other wood essential oils from the Lauraceae have been shown to be rich in sesquiterpenoids. For example, *Ocotea brenesii* Standl. wood oil is composed of 32.3% sesquiterpene hydrocarbons and 34.6% oxygenated sesquiterpenoids [24]. The resin essential oil of *Ocotea caparrapi* Dugand, on the other hand had a high percentage of monoterpene hydrocarbons (35.1-71.1%) and oxygenated monoterpenoids (22.4-61.6%) [8, 25]. The wood essential oil of *S. albidum* is most similar to the resin essential oil from *O. caparrapi*, which has α -pinene (18.5-47.2%), β -pinene (2.4-14.7%), limonene (1.2-5.1%), 1,8-cineole (1.5-3.9%), linalool (0.0-0.2%), and α -terpineol (7.3-34.9%) [8, 25]. There is also qualitative similarity to the wood essential oil of *Ocotea austinii* with α -pinene (14.9%), β -pinene (8.2%), limonene (2.4%), 1,8-cineole (0.4%), and α -

terpineol (1.0%) [26].

3.2 Enantiomeric Distribution

The enantiomeric distribution of terpenoid constituents in *S. albidum* wood essential oil was carried out using chiral GC-MS (Table 2). For the major components, the dextrorotatory enantiomer was the dominant stereoisomer for α -pinene (90.4:9.6), β -pinene (76.3:23.7), limonene (74.9:25.1), and α -terpineol (63.6:36.4). Linalool was nearly racemic (42.7:57.3). There is a paucity of information on the enantiomeric distributions in wood essential oils of the Lauraceae, so general trends are not possible. Nevertheless, the enantiomeric distribution of monoterpenoids in *C. camphora* wood essential oil has been investigated [22] and is included in Table 2 for comparison. A noteworthy point is the enantiomeric distribution in camphor. *Cinnamomum camphora* wood contains almost pure (+)-camphor while (-)-camphor is dominant in *S. albidum* wood essential oil (9.5:90.5).

Table 2: Enantiomeric distribution of terpenoid constituents in *Sassafras albidum* and *Cinnamomum camphora* wood essential oils, and *Ocotea quixos* and *Nectandra angustifolia* leaf essential oils

Compound	<i>Sassafras albidum</i> wood essential oil ^a		<i>Cinnamomum camphora</i> wood essential oil ^b		<i>Ocotea quixos</i> leaf essential oil ^c		<i>Nectandra angustifolia</i> leaf essential oil ^d	
	% (+)	% (-)	% (+)	% (-)	% (+)	% (-)	% (+)	% (-)
α -Thujene	26.1	73.9	30.9	69.1	-	-	-	-
α -Pinene	90.4	9.6	60.5	39.5	94.2	5.8	83.0	17.0
Camphene	14.7	85.3	70.0	30.0	0.0	100.0	-	-
β -Pinene	76.3	23.7	24.3	75.7	14.1	85.9	80.0	20.0
α -Phellandrene	64.6	35.4	93.5	6.5	-	-	-	-
Limonene	74.9	25.1	78.1	21.9	46.1	53.9	44.0	56.0
β -Phellandrene	8.8	91.2	-	-	-	-	-	-
Linalool	42.7	57.3	-	-	0.0	100.0	-	-
Camphor	9.5	90.5	99.6	0.4	-	-	-	-
Terpinen-4-ol	42.4	57.6	33.0	67.0	100.0	0.0	-	-
α -Terpineol	63.6	36.4	23.4	76.6	-	-	-	-

<i>trans</i> - β -Elemene	0.0	100.0	-	-	-	-	-	-
(<i>E</i>)- β -Caryophyllene	0.0	100.0	-	-	-	-	-	-
Germacrene D	93.7	6.3	-	-	-	-	-	-
δ -Cadinene	0.0	100.0	-	-	-	-	-	-

^aThis work. ^bPoudel *et al.* (2021) ^[22]. ^cGilardoni *et al.* (2021) ^[27]. ^dTorres *et al.* (2011) ^[28].

Enantioselective GC analysis has been carried out on *Ocotea quixos* (Lam.) Kosterm ^[27] and *Nectandra angustifolia* (Schrad.) Nees & Mart ^[28], leaf essential oils (see Table 2). (+)- α -Pinene is the dominant enantiomer in these leaf essential oils, but there is no trend for β -pinene. Limonene seems to be nearly racemic in the *O. quixos* and *N. angustifolia* leaf essential oils. The enantiomers of linalool have been examined for a population of *Aniba rosaeodora* leaf [66.3-89.6% (+), 10.4-33.7% (-)] and branch [55.8-81.1% (+), 18.9-55.8% (-)] essential oils ^[29], *Lindera umbellata* Thunb. Commercial essential oil [32.2% (+), 67.8% (-)] ^[30], *Cinnamomum tamala* (Buch.-Ham.) T. Nees & Eberm. Essential oil from Pakistan [9.0% (+), 91.0% (-)] ^[31], but *C. tamala* leaf oil from India showed exclusively 100% (+)-linalool ^[32]. Thus, linalool enantiomeric distributions seem to vary extensively.

4. Conclusions

Sassafras trees are relatively abundant, fast-growing, readily reproducing by lateral root sprouts, and are therefore a renewable resource. The wood essential oil of *S. albidum*, if free from safrole, should be considered as a potential fragrance essential oil, comparable to *O. caparrapi* resin essential oil.

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Conflicts of Interest

The authors declare no conflicts of interest.

6. References

- WFO World Flora Online. Lauraceae Juss. <http://www.worldfloraonline.org/taxon/wfo-7000000321>. 6 February, 2022
- Mandriñán S. Lauraceae Columbianae. <https://botanica.uniandes.edu.co/investigacion/lauraceae.htm>. 6 February, 2022
- Mabberley DJ. Mabberley's Plant-Book, 3rd ed, Cambridge University Press, Cambridge, UK, 2008, 900-901.
- Rhind JP. Essential Oils: A Comprehensive Handbook for Aromatic Therapy, Singing Dragon, London, UK, 2020, 912.
- Da Trindade RCS, Xavier JKAM, Setzer WN, Maia JGS, da Silva JKR. Chemical diversity and therapeutic effects of essential oils of *Aniba* species from the Amazon: A review. *Plants*. 2021;10(9):1854.
- Flora of China, *Cinnamomum camphora*, Flora of China, Lauraceae, 2022, 7. http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200008697. 6 February
- WFO World Flora Online. *Ocotea cymbarum* Kunth, 2022. <http://www.worldfloraonline.org/taxon/wfo-0000383024>.
- Delgado Ávila WA, Cuca Suárez LE, Caroprese JF. Chemical composition of essential oil of *Ocotea cymbarum* Kunth (cascarilla and/or sassafras) from the Orinoquía region. *Rev Cuba Plantas Med*, 2016;21(3):248-260.
- Brown CL, Kirkman LK. *Trees of Georgia and Adjacent States*, Timber Press, Inc., Portland, Oregon, USA, 1990, 292.
- Kartesz JT. The biota of North America program (BONAP). *North American Plant Atlas*, 2015. <http://bonap.net/napa>. February 6, 2022.
- Kaler KM, Setzer WN. Seasonal variation in the leaf essential oil composition of *Sassafras albidum*. *Nat Prod Commun*. 2008;3(5):829-832.
- Kennedy JE, Davé PC, Harbin LN, Setzer WN. Allelopathic potential of *Sassafras albidum* and *Pinus taeda* essential oils. *Allelopath J*. 2011;27(1):111-122.
- DeCarlo A, Johnson S, Okeke-Agulu KI, Dosoky NS, Wax SJ, Owolabi MS, *et al.* Compositional analysis of the essential oil of *Boswellia dalzielii* frankincense from West Africa reveals two major chemotypes. *Phytochemistry*. 2019;164:24-32.
- Adams RP. Identification of Essential Oil Components by Gas Chromatography/Mass Spectrometry, 4th ed, Allured Publishing, Carol Stream, Illinois, USA, 2007.
- Mondello L. FFNSC 3. Shimadzu Scientific Instruments, Columbia, Maryland, USA, 2016.
- NIST, NIST17. National Institute of Standards and Technology, Gaithersburg, Maryland, USA, 2017.
- Satyral P. Development of GC-MS Database of Essential Oil Components by the Analysis of Natural Essential Oils and Synthetic Compounds and Discovery of Biologically Active Novel Chemotypes in Essential Oils, Ph.D. dissertation. University of Alabama in Huntsville, Huntsville, Alabama, USA, 2015.
- Tucker AO, Maciarello MJ. Filé and the essential oils of the leaves, twigs, and commercial root teas of *Sassafras albidum* (Nutt.) Nees (Lauraceae). In: Charalambous G (Ed). *Spices, Herbs, and Edible Fungi*. Elsevier, Amsterdam, Netherlands, 1994.
- Kamdem DP, Gage DA. Chemical composition of essential oil from the root bark of *Sassafras albidum*. *Planta Med*. 1995;61(6):574-575.
- Simić A, Soković MD, Ristić M, Grujić-Jovanović S, Vukojević J, Marin PD. The chemical composition of some Lauraceae essential oils and their antifungal activities. *Phyther Res*. 2004;18(9):713-717.
- Stubbs BJ, Specht A, Brushett D. The essential oil of *Cinnamomum camphora* (L.) Nees and Eberm. Variation in oil composition throughout the tree in two chemotypes from eastern Australia. *J Essent Oil Res*. 2004;16(3):200-205.
- Poudel DK, Rokaya A, Ojha PK, Timsina S, Satyal R, Dosoky NS, *et al.* The chemical profiling of essential oils from different tissues of *Cinnamomum camphora* L. and their antimicrobial activities. *Molecules*. 2021;26(17):5132.
- Da Silva JKR, Maia JGS, Dosoky NS, Setzer WN. Antioxidant, antimicrobial, and cytotoxic properties of *Aniba parviflora* essential oils from the Amazon. *Nat Prod Commun*. 2016;11(7):1025-1028.

24. Chaverri C, Ciccio JF. Essential oil of trees of the genus *Ocotea* (Lauraceae) in Costa Rica. I. *Ocotea brenesii*. *Rev Biol Trop*. 2022;53(3-4):431-436.
25. Tafurt García G, Muñoz Acevedo A. Volatile secondary metabolites in cascarillo (*Ocotea caparrapi* (Sandino-Groot ex Nates) Dugand - Lauraceae). *J Essent Oil-Bear Plants*. 2018;21(2):374-387.
26. Chaverri C, Ciccio JF. Essential oils from *Ocotea austinii* C. K. Allen (Lauraceae) from Costa Rica. *J Essent Oil Res*. 2007;19(5):439-443.
27. Gilardoni G, Montalván M, Vélez M, Malagón O. Chemical and enantioselective analysis of the essential oils from different morphological structures of *Ocotea quixos* (Lam.) Kosterm. *Plants*. 2021;10(10):2171.
28. Torres AM, Camargo FJ, Ricciardi GAL, Ricciardi AIA, Dellacassa E. Neutralizing effects of *Nectandra angustifolia* extracts against *Bothrops neuwiedi* snake venom. *Nat Prod Commun*. 2011;6(9):1393-1396.
29. Lara CS, Barata LES, Sampaio P de TB, Eberlin MN, Fidelis CH de V. Linalool enantiomeric distribution in rosewood-reminiscent populations in Central Amazon. *J Essent Oil Res*, 2018;30(6):464-469.
30. Sakurai K, Tamai E, Masuda Y, Urakami K, Kusuhara M. Volatile components of the kuromoji essential oil (*Lindera umbellata* Thunb.) and the utilization for touch care treatment. *J Oleo Sci*. 2021;70(11):1661-1668.
31. Özek T, Tabanca N, Demirci F, Wedge DE, Hüsni Can Başer K. Enantiomeric distribution of some linalool containing essential oils and their biological activities. *Rec Nat Prod*. 2010;4(4):180-192.
32. Chanotiya CS, Yadav A. Enantioenriched (3S)-(+)-linalool in the leaf oil of *Cinnamomum tamala* Nees et Eberm. From Kumaon. *J Essent Oil Res*. 2010;22(6):593-596.