

Essential oil Composition of *Ficus benjamina* (Moraceae) and *Irvingia barteri* (Irvingiaceae)

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Essential oils obtained by hydrodistillation of leaves of two Nigerian species were analyzed for their constituents by gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS). The leaf oil of *Ficus benjamina* L. (Moraceae), collected during the day, contained high contents of α -pinene (13.9%), abietadiene (9.7%), *cis*- α -bisabolene (8.2%) and germacrene-D-4-ol (8.4%), while the night sample was dominated by germacrene-D-4-ol (31.5%), 1,10-*di-epi*-cubanol (8.8%) and hexahydrofarnesylacetone (8.3%). This could be a possible indication of differences in emissions of volatiles by *F. benjamina* during the day and night. The main compounds of *Irvingia barteri* Hook. f. (Irvingiaceae) were β -caryophyllene (17.0%), (*E*)- α -ionone (10.0%), geranyl (7.6%), (*E*)- β -ionone (6.6%) and β -gurjunene (5.1%).

Keywords: *Ficus benjamina*, *Irvingia barteri*, Essential oil, α -Pinene, Germacrene-D-4-ol, β -Caryophyllene.

In continuation of extensive research on the different volatile emissions from *Ficus* species [1-3] and other plant from Nigeria, we report herein the volatile compounds of *F. benjamina* and *Irvingia barteri*. *F. benjamina* L. is one of hundreds of species of figs, dozens of which are very common in cultivation. Figs are members of the family Moraceae, a huge family of plants with over 1000 species. Most Moraceae are tropical plants, and *F. benjamina* is no exception, being native to the tropics of south Asia and northern Australia. However, this is probably the most common of all the *Ficus* species. The plant is credited with many biologically active compounds and uses [4,5]. α -Copaene, cyclosativene and β -ocimene were the major compounds of its volatile oil [6]. The chemical composition of essential oils of some *Ficus* species growing in Nigeria have been reported [1-3,7-10]. Phytol and 6,10,14-trimethyl-2-pentadecanone have been described as chemical markers of Nigerian grown *Ficus* oils [2,3,8-10].

Wild mango, *Irvingia barteri* O'Rorke Bail (syn *Irvingia gabonensis*), family Irvingiaceae, is native to some Central and West African countries. The fruit is succulent and available between July and October. Due to the pleasant aroma, the roasted seeds are commonly used in Africa as flavoring in traditional dishes. *I. barteri* is known in the Nigerian languages by various names such as 'biri' or 'goron' (Hausa), 'oro' (Yoruba) and 'obono' (Igbo). The fruits have been reported to be rich in vitamin C and are widely consumed as a desert fruit or snack throughout Western and Central Africa with various nutritional and dietary aspects [11,12]. Extracts of the plant have been reported to possess antimicrobial activities and to be used as a painkiller for toothache. Some antimicrobial agents such as 3-friedelanone, betulinic acid, oleanolic acid, 3,3',4'-tri-*O*-methylellagic acid, 3,4-*di-O*-methyl-ellagic acid and hardwickiic acid have been isolated from the plant [13]. Literature information is scanty about the volatile constituents except for the key odorant compounds of the seeds and fruits [14-16].

The plant samples yielded low contents of essential oils: 0.1% (v/w; *F. benjamina*; colorless) and 0.23% (v/w; *I. barteri*; light yellow), calculated on a dry weight basis. Forty-seven and thirty-eight components respectively were identified from the day and night samples of *F. benjamina*. The main compounds of the day sample were α -pinene (13.9%), abietadiene (9.7%), germacrene-D-4-ol (8.4%) and *cis*- α -bisabolene (8.2%). Isobornyl acetate (5.0%) and abietatriene (4.9%) were also present in sizeable quantity. However, germacrene-D-4-ol (31.5%) was the most singly abundant compound of the night sample. Other significant constituents were 1,10-*di-epi*-cubanol (8.8%), hexahydrofarnesyl-acetone (8.3%), *E*-geranyl acetone (6.2%), cubanol (5.5%) and 1, 8-cineole (4.2%). Significant differences were observed in the major classes of compounds of the day and night samples of *F. benjamina* (Table 1). Oxygenated sesquiterpenoids were the dominant class of compounds in the night sample. On the other hand, the day sample contained equal proportions of monoterpene hydrocarbons and oxygenated monoterpenes. However, diterpenoids and sulfur compounds, which were present in the day sample, could not be identified in the night sample. The volatiles emitted by plants depend on factors such as climatic conditions, morphology of the plant, and time of collection. The present result is an indication of the possible difference in emissions of volatiles by *F. benjamina* during the day and night. This is the first report of different volatile emissions of *F. benjamina*. Previous investigation into the volatiles of this plant [6] identified significant amounts of α -copaene, cyclosativene and β -ocimene. These compounds are conspicuously absent in the present study. Moreover, compounds such as phytol, 6, 10, 14-trimethyl-2-pentadecanone, and acorenone B, which are characteristics of other *Ficus* species from Nigeria [1-3, 8], were not detected in the present investigation (Table 2).

The thirty-six essential oil components of *I. barteri* were dominated by oxygenated monoterpene (34.0%) and sesquiterpene hydrocarbons (41.5%) (Table 3). The main compounds identified in

Table 1: Components of *F. benjamina* essential oil.

Constituents	LRI ^a	Percent % (day)	Percent % (night)
(E)-2-Hexenal	856	-	0.9
α -Pinene	939	13.9	1.2
Camphene	953	1.1	0.4
Thuja-2,4(10)-diene	957	0.8	-
Benzaldehyde	961	0.1	0.4
Sabinene	976	3.7	-
β -Pinene	980	-	0.6
6-Methyl-5-hepten-2-one	985	-	0.5
Myrcene	991	0.8	0.6
α -Phellandrene	1005	0.7	-
δ -3-Carene	1011	tr	-
α -Terpinene	1018	0.1	-
<i>p</i> -Cymene	1027	1.2	tr
Limonene	1031	2.0	0.4
1,8-Cineole	1034	2.1	4.2
Phenylacetaldehyde	1045	-	0.5
γ -terpinene	1062	0.1	-
<i>cis</i> -Linalool oxide (furanoid)	1076	0.3	-
Dehydro- <i>p</i> -cymene	1088	2.0	-
Linalool	1099	0.8	1.6
Nonanal	1103	tr	1.3
Dipropyl disulfide	1107	1.2	-
α -Campholenal	1127	1.4	-
<i>trans</i> -Pinocarveol	1140	2.5	-
Camphor	1145	1.2	1.2
Isoborneol	1156	-	1.4
Pinocarvone	1164	1.2	-
<i>p</i> -Mentha-1,5-dien-8-ol	1166	2.1	-
4-Terpineol	1179	2.5	-
<i>p</i> -Cymen-8-ol	1185	0.2	-
α -Terpineol	1190	-	0.4
Myrtenal	1194	2.4	-
Safranal	1200	tr	0.9
Verbenone	1207	2.2	-
<i>trans</i> -Carveol	1218	0.2	-
β -Cyclocitral	1219	0.5	0.8
Methyl carvacrol	1244	0.2	-
Carvone	1245	tr	-
3,7-Dimethyl-2,6-octadienal	1268	tr	-
Isobornyl acetate	1286	5.0	1.0
Carvacrol	1299	-	0.6
Undecanal	1306	-	0.5
Dipropyl trisulfide	1328	1.5	-
α -Copaene	1376	-	tr
(E)- β -Damascone	1409	-	0.5
β -Caryophyllene	1418	0.9	2.3
(E)- α -Ionone	1428	0.2	1.3
(E)-Geranyl acetone	1454	1.2	6.3
(E)- β -Farnesene	1458	0.8	-
9- <i>epi</i> -(E)-Caryophyllene	1467	-	0.2
(E)- β -Ionone	1485	-	1.5
β -Bisabolene	1509	-	1.6
δ -Cadinene	1524	0.2	tr
<i>cis</i> - α -Bisabolene	1555	8.2	-
<i>trans</i> -Nerolidol	1565	-	0.5
Germacrene D-4-ol	1575	8.4	31.5
Caryophyllene oxide	1581	-	2.6
<i>n</i> -Hexadecane	1600	-	0.3
1,10-di- <i>epi</i> -Cubanol	1614	0.3	8.8
Cubanol	1638	-	5.5
Pentadecanal	1717	-	1.2
Hexahydrofarnesylacetone	1845	1.2	8.3
Abietatriene	2054	4.9	-
Abietadiene	2080	9.7	-
Total		90.0	91.0
Monoterpene hydrocarbons		26.4	3.2
Oxygenated monoterpenes		26.2	21.2
Sesquiterpene hydrocarbons		10.1	4.6
Oxygenated sesquiterpenes		9.9	57.2
Diterpenes		14.6	-
Sulfur compounds		2.7	-
Others		0.1	5.6

^a Retention indices on HP-5MS capillary column

tr, trace amount < 0.1%

-, not identified

Table 2: Major compounds of *Ficus* species from Nigeria.

Species	Major compounds	Ref
<i>F. exasperata</i>	1, 8-cineole (13.8%), (E)-phytol (13.7%), <i>p</i> -cymene (11.4%)	7
<i>F. exasperata</i>	α -terpineol (33.7%), α -pinene (10.8%), sabinene (5.6%)	9
<i>F. mucosa</i>	β -caryophyllene (37.0%), ethyl octanate (13.9%), methyl octanate (8.6%), caryophyllene oxide (6.0%)	1
<i>F. thonningii</i>	6, 10, 14-trimethyl-2-pentadecanone (18.8%), phytol (14.7%), acorenone B (7.6%), β -gurjunene (6.3%)	2
<i>F. lutea</i>	acorenone (20.7%), phytol (16.2%), demethoxyageratochromene (6.0%), 6, 10, 14-trimethyl-2-pentadecanone (5.1%), zingiberene (5.2%)	2
<i>F. polita</i>	phytol (23.3%), 6, 10, 14-trimethyl-2-pentadecanone (15.0%), (E)-6, 10-dimethyl-5,9-undecadien-2-one (7.3%), drimenol (5.8%)	2
<i>F. ovata</i>	(E)-phytol (24.5%), hexadecanoic acid (10.0%), caryophyllene oxide (7.6%), 6, 10, 14-trimethyl-2-pentadecanone (6.1%)	8
<i>F. elasticoides</i>	(E)-phytol (20.9%), 6, 10, 14-trimethyl-2-pentadecanone (8.7%), $\alpha\beta$ -caryophyllene (6.8%)	8
<i>F. natalensis</i> subsp. <i>leprieurii</i>	(E)-phytol (37.6%), 6, 10, 14-trimethyl-2-pentadecanone (24.9%)	8
<i>F. elastica</i>	6, 10, 14-trimethyl-2-pentadecanone (25.9%), geranyl acetone (9.9%), heneicosene (8.4%), 1, 8-cineole (8.2%)	3
<i>F. capensis</i>	α -pinene (9.3-36.7%), β -pinene (4.5-14.9%), α -cadinol (10.6%), <i>n</i> -hexadecanoic acid (15.5-33.3%)	10

Table 3: Essential oil composition of *I. barteri*.

Constituents	LRI ^a	Percent %
Sabinene	976	0.7
6-Methyl-5-hepten-2-one	985	tr
2-Pentyl furan	991	0.7
<i>o</i> -Cymene	1022	tr
Limonene	1031	2.6
1,8-Cineole	1034	tr
Dehydro- <i>p</i> -cymene	1088	tr
Nonanal	1103	1.4
2,4-Dimethyl benzaldehyde	1180	tr
Naphthalene	1182	tr
Safranal	1197	tr
β -Cyclocitral	1219	2.1
Neral	1240	2.9
<i>p</i> -Menth-4-en-3-one	1251	1.0
β -Homocyclocitral	1254	1.3
Geranial	1272	7.6
1,2,3,4-Tetrahydro-1,5,7-trimethyl naphthalene	1310	tr
1,2-Dihydro-1,1,6-trimethyl naphthalene	1354	2.1
β -Caryophyllene	1418	17.0
(E)- α -Ionone	1428	10.0
β -Gurjunene	1432	5.1
<i>trans</i> - α -Bergamotene	1439	1.4
(E)-Geranyl acetone	1453	2.5
α -Humulene	1455	1.6
γ -Muurolene	1477	2.9
(E)- β -Ionone	1488	6.6
Valencene	1492	1.9
α -Muurolene	1499	3.7
Pentadecane	1500	1.5
<i>trans</i> - γ -Cadinene	1513	2.8
δ -Cadinene	1524	3.6
<i>trans</i> -Nerolidol	1565	1.5
Caryophyllene oxide	1581	2.9
Selin-11-en-4- α -ol	1652	tr
Hexahydrofarnesylacetone	1845	1.7
Abietatriene	2054	0.9
Total		90.0%
Monoterpene hydrocarbons		3.3
Oxygenated monoterpenes		34.0
Sesquiterpene hydrocarbons		41.5
Oxygenated sesquiterpenes		6.1
Diterpenes		0.9
Others		4.2

^a Retention indices on HP-5MS capillary column; tr, trace amount < 0.1%

the oil were β -caryophyllene (17.0%), (*E*)- α -ionone (10.0%), geranial (7.6%), (*E*)- β -ionone (6.6%) and β -gurjunene (5.1%). Previous studies of the volatile contents have been concentrated on fruit samples. There were remarkable differences between this oil composition and previous studies [14-16]. The key aroma compounds in the Nigerian grown species were methional, 2-acetyl-1-pyrroline, butan-2,3-dione, pentan-2,3-dione, 2-ethyl-3,5-dimethylpyrazine and 2,3-diethyl-5-methylpyrazine [14]. Samples from Cameroon [15,16] were found to comprise mainly of ethyl-2-methylbutyrate (11.9-14.2%), methyl-2-methylbutyrate (28.6-31.6%), zingiberene (12.4-15.7%), nerolidol (5.1-8.5%), terpinen-4-ol (8.4-7.9%) and α -terpineol (7.9-8.7%). Except for *trans*-nerolidol, the present oil lacked several of the compounds mentioned above.

Experimental

Plant materials: Fresh leaves of *Ficus benjamina* were collected from Lagos State University, Ojo, Nigeria, in June 2010. The day samples were collected at about noon on sunny days; the night samples were harvested at about 11.30 pm during darkness. The leaves of *Irvingia barteri* were harvested from Ijede Area, Ikorodu, Lagos, Nigeria, in January 2011. The plants were authenticated by Curators at the Herbarium of the Botany Department, University of Lagos, Nigeria. Voucher specimens LUH 3223 (*F. benjamina*) and LUH 3323 (*I. barteri*) were deposited at the Herbarium for future reference. All samples were air-dried under laboratory shade prior to extraction of the oils.

Extraction of essential oils: Air-dried leaves (300 g) were subjected to separate hydrodistillation in an all-glass Clevenger type apparatus for 4 h in accordance with British Pharmacopoeia [17].

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