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The sesquiterpene-rich essential oils of *Erythrina variegata* growing wild in Vietnam

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Abstract
Erythrina variegata L. is a tree up to 20 meters tall that has been used for timber as well as medicine. Traditional Vietnamese medicine has used the bark of this plant to disinfect, treat itchy skin, treat rheumatism and numb. Elucidation of essential oil components in the bark may contribute to the explanation of biological activities. In this work, the essential oils from young branches and stem bark of *E. variegata* were obtained by hydrodistillation and analyzed by gas chromatography – mass spectrometry (GC-MS). The essential oils were dominated by sesquiterpenoids, including α-copaene (6.3% and 4.6%), β-copaene (9.4% and 7.0%), γ-muurolene (7.5% and 6.7%), α-muurolene (6.2% and 4.4%), γ-cadinene (6.3% and 5.9%), and δ-cadinene (6.7% and 5.6%). Although the essential oils were rich in sesquiterpenoids, the yields were low (0.045 and 0.052%).

Keywords: α-copaene, β-copaene, γ-muurolene, α-muurolene, γ-cadinene, δ-cadinene

1. Introduction
Erythrina L. (Fabaceae) is a genus of more than 160 taxa with a pantropical distribution [1, 2]. *Erythrina variegata* L. (Syn. *Erythrina indica* Lam., Vietnamese name: Vông nem, English name: India coral tree) is found throughout the Old-World tropics (China, Bangladesh, Cambodia, India, Indonesia, Japan (Ryukyu Islands), Laos, Malaysia, Myanmar, Philippines, Sri Lanka, Thailand, Vietnam; Australia, and the Pacific islands, and has been introduced to Africa and Central and South America [3]. The tree has been used for timber as well as medicine [4]. The ethnopharmacology and phytochemistry of *E. variegata* have been reviewed [5, 6].

The chemical constituents that have been reported in *E. variegata* include alkaloids, flavonoids, pterocarpans, triterpenes, steroids, alkyl *trans*-ferulates [5], oil and fatty acids [7]. This plant has shown many biological activities such as antibacterial, antioxidant, analgesic, anti-inflammatory, and cytotoxicity [5]. *E. variegata* has been used for a long time in Vietnam with many benefits in the treatment of a number of diseases [8]. The leaves are used as a sedative, treating insomnia or anxiety. The fresh young leaves are used by boiling them before eating. The dried leaves are used as a decoction. The fresh leaves are used to treat hemorrhoids and metroptosis, and are used by crushing them and applying them. The leaves are ground into a powder, sprinkled on open wounds or sores to help quickly heal. The bark on the trunk (the base of the tree) is used as a decoction or in alcohol to treat rheumatism.

Aqueous bark extracts of *E. variegata* have shown anxiolytic and anticonvulsant activities in mouse models [9]. An aqueous leaf extract of *E. variegata* has shown antinociceptive activity in a frog model [10]. Leaf extracts of *E. variegata* (as *E. indica*) leaf extracts have shown marginal mosquito larvicidal activity against *Culex quinquefasciatus*, *Aedes aegypti*, and *Anopheles stephensi* [11, 12]. A floral essential oil of *E. variegata* (as *E. indica*) has been obtained, but the composition was not reported [13]. As part of our general investigation into the essential oils of Vietnamese higher plants, we have obtained and characterized the essential oils from young branches and stem bark of *E. variegata* growing in Da Nang, Vietnam. As far as we are aware, there have been no previous investigations on these essential oils.

2. Materials and Methods

2.1. Plant Material

Plant parts (young branches, stem bark, 5 kg each) were collected in Da Nang (16º05′00″N, 108º13′45″E). The shredded fresh materials were hydrodistilled for 6 h using a Clevenger type apparatus (Witeg Labortechnik, Wertheim, Germany); the yields of three replicates were used to determine the mean yield of essential oil. The essential oils were dried by Na_2SO_4 and stored in sealed glass vials at 4 °C until used for analysis.

2.2. Gas Chromatography - Mass Spectrometry

The essential oils obtained from the young branches and the stem bark of *E. variegata* have been analyzed by gas chromatographic - mass spectral (GC-MS) methods as previously reported [14].

3. Results and Discussion

The essential oils from the small branches and the stem bark of *E. variegata* were obtained by hydrodistillation in 0.045 and 0.052% yield, respectively. The essential oils were subjected to gas chromatographic – mass spectral analysis (Table 1). A total of 71 and 76 compounds were identified in the two essential oils accounting for 97.4% and 97.5% of the total compositions. Both essential oils were rich in sesquiterpene hydrocarbons (70.3% and 64.0%) and oxygenated sesquiterpenoids (24.4% and 32.5%). The major sesquiterpene hydrocarbons in the shoots and bark essential oils were α-copaene (6.3% and 4.6%), β-copaene (9.4% and 7.0%), γ-muurolene (7.5% and 6.7%), α-muurolene (6.2% and 4.4%), γ-cadinene (6.3% and 5.9%), and δ-cadinene (6.7% and 5.6%).

Table 1: Essential oil compositions of *Erythrina variegata*.

RI_{calc}	RI_{db}	Components	% Composition	
			Branches	Bark
1288	1287	Dihydroedulan IA	---	tr
1347	1348	α-Cubebene	2.2	2.0
1369	1371	α-Ylangene	2.3	1.6
1375	1375	α-Copaene	6.3	4.6
1383	1382	β-Bourbonene	2.5	1.4
1387	1387	β-Cubebene	0.8	0.6
1389	1390	*trans*-β-Elemene	---	0.1
1394	---	Unidentified sesquiterpene hydrocarbon[a]	0.7	0.5
1418	1419	β-Ylangene	2.2	1.8
1419	1418	(*E*)-β-Caryophyllene	0.5	2.1
1430	1430	β-Copaene	9.4	7.0
1434	1437	β-Gurjunene	0.2	0.1
1438	1438	Aromadendrene	0.4	0.5
1444	1447	*iso*-Germacrene D	0.2	0.1
1449	1448	*cis*-Muurola-3,5-diene	---	0.1
1450	1452	α-Himachalene	0.1	0.1
1452	1452	(*E*)-β-Farnesene	---	0.4
1455	1454	α-Humulene	0.2	0.6
1460	1458	*allo*-Aromadendrene	2.5	1.8
1462	1463	*cis*-Muurola-4(14),5-diene	1.1	0.9
1468	1463	*cis*-Cadina-1(6),4-diene	0.2	---
1472	1473	*trans*-Cadina-1(6),4-diene	0.2	0.2
1474	1478	γ-Muurolene	7.5	6.7
1479	1479	α-Amorphene	1.0	0.8
1481	1480	Germacrene D	2.7	2.0
1483	1476	4,11-Selinadiene[b]	---	0.4
1487	1491	Eremophilene	---	0.4
1489	1489	β-Selinene	0.3	0.6
1492	1492	*trans*-Muurola-4(14),5-diene	1.9	1.8
1495	1497	*epi*-Cubebol	1.4	1.8
1496	1492	*cis*-β-Guaine	---	1.8
1498	1500	α-Muurolene	6.2	4.4
1504	1507	Eremophila-1(10),8,11-triene	---	0.3
1507	1508	β-Bisabolene	---	0.3
1513	1514	γ-Cadinene	6.3	5.9
1515	1515	Cubebol	0.5	1.0
1518	1518	δ-Cadinene	6.7	5.6
1520	1519	*trans*-Calamenene	1.7	2.2
1521	1528	*cis*-Calamenene	2.1	1.6
1530	1531	10-*epi*-Cubenol	---	0.3
1532	1533	*trans*-Cadina-1,4-diene	0.2	0.2
1536	1538	α-Cadinene	1.0	0.9
1541	1541	α-Calacorene	0.7	0.9
1547	1549	*cis*-Muurol-5-en-4β-ol	---	0.3
1559	1560	Germacrene B	---	0.2
1562	1564	β-Calcorene	0.4	0.4
1569	1572	1α,10α-Epoxyamorph-4-ene	0.2	0.2

1576	1576	Spathulenol	2.6	2.9
1582	1587	Caryophyllene oxide	0.4	0.5
1588	1591	β-Copaen-4α-ol	0.4	0.3
1592	1593	Salvial-4(14)-en-1-one	2.4	1.4
1597	1596	*trans*-β-Elemenone	---	0.4
1604	1605	Ledol	0.3	0.4
1606	1603	Guaiol	0.4	0.4
1609	1611	Humulene epoxide-II	---	0.3
1615	1616	1,10-di-*epi*-Cubenol	1.3	1.3
1622	1625	Junenol	0.1	0.1
1626	1624	Muurola-4,10(14)-dien-1α-ol	0.1	0.2
1627	1628	1-*epi*-Cubenol	0.7	0.7
1631	1632	Muurola-4,10(14)-dien-1β-ol	0.1	---
1634	1634	*cis*-Cadin-4-en-7-ol	0.4	0.5
1642	1643	τ-Cadinol	1.9	2.2
1643	1644	τ-Muurolol	1.0	1.3
1646	1651	δ-Cadinol (= α-Muurolol)	2.8	2.7
1653	1650	15-Copaenol	0.9	0.8
1655	1655	α-Cadinol	2.9	3.5
1659	1660	Atractylone	1.3	---
1659	---	Eudesma-4(15),7-dien-1α-ol[c]	---	0.5
1664	1663	*cis*-Calamenen-10-ol	0.1	---
1664	1665	Intermedeol	---	1.5
1672	1677	Cadalene	0.4	0.7
1678	1676	Tetradecanol	---	0.2
1684	1679	*cis*-14-*nor*-Muurol-5-en-4-one	0.1	---
1684	1686	*epi*-α-Bisabolol	---	0.5
1690	1687	Eudesma-4(15),7-dien-1β-ol	1.4	1.2
1692	1694	Germacrone	---	1.6
1700	1701	10-*nor*-Calamenen-10-one	0.1	---
1723	1715	Valeranal	---	0.2
1736	1733	Eremophilone	---	3.1
1739	1737	*iso*-Bicyclogermacrenal	---	0.2
1800	1800	Octadecane	0.2	---
1835	1836	Neophytadiene	0.3	---
1840	1841	Phytone	0.1	tr
1878	1879	4-Phytadiene	0.3	---
1900	1900	Nonadecane	0.2	---
1944	1946	Isophytol	0.5	---
1997	1997	Kaur-15-ene	---	0.4
2000	2000	Eicosane	0.1	---
2006	---	3,8a-Dimethyl-5-methylene-4a,6,7,8-tetrahydro-4*H*-benzo[f]benzofuran-2-one[c]	0.6	0.2
2021	2022	(*E*,*E*)-Geranyl linalool	0.3	---
2045	2046	Kaur-16-ene	---	0.4
2052	2049	Abietatriene	---	0.1
2100	2100	Heneicosane	0.1	---
2106	2106	Phytol	0.3	---
2200	2200	Docosane	0.1	---
2300	2300	Tricosane	0.1	---
2500	2500	Pentacosane	0.1	---
		Sesquiterpene hydrocarbons	70.3	64.0
		Oxygenated sesquiterpenoids	24.4	32.5
		Diterpenoids	1.6	0.8
		Others	1.1	0.2
		Total identified	97.4	97.5

RI_{calc} = Retention index determined with respect to a homologous series of *n*-alkanes on a ZB-5ms column [15]. RI_{db} = Reference retention index from the databases [16–19]. [a] MS: 204(17%), 161(100%), 133(13%), 119(84%), 105(100%), 93(21%), 91(31%), 81(36%), 55(18%), 41(20%)[b]. Correct stereoisomer not determined. [c] MS is a match (> 90%), but RI not available.

4. Conclusions

The essential oils of *E. variegata* have been shown to be rich sources of sesquiterpene hydrocarbons and oxygenated sesquiterpenoids. Unfortunately, the essential oil yields are low, so practical uses of these oils are likely to be limited.

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