Composition of Stem Bark Essential Oils of Three Vietnamese Species of *Kadsura* (Schisandraceae)

Do N. Dai 1, Bui V. Thanh 2, Luu D.N. Anh 2, Ninh K. Ban 3, Tran D. Thang 4, * and Isiaka A. Ogunwande 5, *

1 Faculty of Biology, Vinh University, 182-Le Duan, Vinh City, Nghean Province, Vietnam
2 Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, 18-Hoang Quoc Viet, Cau Giay, Hanoi, Vietnam
3 Institute of Marine Biochemistry, Vietnam Academy of Science and Technology, Hanoi, Vietnam
4 Faculty of Chemistry, Vinh University, 182-Le Duan, Vinh City, Nghean Province, Vietnam
5 Natural Products Research Unit, Department of Chemistry, Faculty of Science, Lagos State University, Badagry Expressway Ojo, P. M. B. 0001, Lasu Post Office, Ojo, Lagos, Nigeria

(Received June 11, 2013; Revised August 12, 2014; Accepted October 01, 2014)

**Abstract:** The chemical composition of volatiles from the stem barks of three different *Kadsura* species has been studied. The essential oils were obtained by hydrodistillation and analyzed by GC and GC-MS. The components were identified by MS libraries and their LRIs. The essential oils content varied between 0.15% and 0.20% (v/w), calculated on a dry weight basis. Sesquiterpene hydrocarbons (25.2% - 57.9%) and oxygenated sesquiterpenes (27.1% - 64.4%) are the main oil fractions. *Kadsura coccinea* (Lemaire) A. C. Smith., afforded oil whose major compounds were \( \beta \)-caryophylene (23.6%), \( \delta \)-cadinene (8.6%), caryophyllene oxide (7.8%), *epi-\( \alpha \)-bisabolol* (7.5%) and \( \alpha \)-copaene (6.6%). On the other hand, \( \alpha \)-muurolol (43.5%) was the most singly abundant constituent of *Kadsura longipedunculata* Finet & Gagnepain., with minor amounts of \( \alpha \)-cadinol (5.4%), \( \beta \)-caryophylene (5.4%) and \( \delta \)-cadinene (5.0%). However, we have identified \( \alpha \)-acorenol (10.1%), \( \delta \)-cadinene (9.6%), \( \gamma \)-cadinene (8.1%) and \( \delta \)-elemene (6.8%) as the major constituents of *Kadsura induta* A. C. Smith.

**Keywords:** Kadsura; essential oil composition; terpenes.

© 2015 ACG Publications. All rights reserved.

1. Introduction

The Schisandraceae family constitute a small “primitive” angiosperm family with only two species: Schisandra (25 species) and Kadsura (22 species). *Kadsura coccinea* (Lemaire) A. C. Smith, is a glabrous plants in which the leaf blade is elliptic to rarely ovate and papery to leathery. The flowers tepals are whitish red, purplish red or occasionally yellowish while the fruit peduncle have the apocarps as red to purplish red with 1 or 2 seeds. Flowering is from May through July while fruiting takes place between October and December [1]. *K. coccinea* fruit is a good source of nutrition [2] and is known to contain natural antioxidant polyphenols and anthocyanin [2, 3].

* Corresponding author: E-Mail: thangtd@vinhuni.edu.vn; isiaka.ogunwande@lasu.edu.ng; Phone:+234-8059929304
Phytochemical investigations revealed the characterisation of dibenzocyclooctadiene lignans kadsuralignan G and kadsuralignan L which moderate NO production inhibitory activities, arynaphthalene lignin [4-6], kadsuralignan H, kadsuralignans I, J and K [7], kadsulignans L-N, lanostane-type triterpenoids, coccinone A, coccinone B, coccinone C, coccinone D and coccinilactone B [8], secococinic acids A-F and coccinilactone A with exhibited antiproliferative effects [9], kadsuccilactones A-J, kadsuphilactone A and micrandilactone B [10], kadsuccilactones K-R, triterpenoids [11], kadsuccilactone O with cytotoxicity against K562, Bel-7402, and A549 cell lines [10], 3-hydroxy-12-acetoxycoccinic acid [12, 13], seco-cycloartanes triterpenes [14], kadsuracoccinic acids A-C, kadsuric acid and micranodic acid A [15], 3-hydroxy-12-hydroxyl coccinic acid and 3-hydroxy-neokadsuranic acid A with antiproliferative effects against four human tumor cell lines, A549, HCT116, HL-60 and HepG2. Lignans such as kadagustin L and kadcocilignan which has inhibitory activities on LPS-induced NO production [16, 17] as well as ascorbic acid [18] were also isolated from the plant. A known record of its root essential oil identified β-caryophyllene (52.17%) as the major compound while β-himachalene (5.95%), α-humulene (5.04%), β-pinene (4.38%), α-copaene (3.47%) and δ-cadinene (3.47%) were the minor compounds [19]. Another investigation identified the main compounds of the oil as iso-caryophyllene, δ-elemene, bornyl acetate, δ-cubebene, β-gurjunene and γ-muurolene [20].

*Kadsura indica* A. C. Smith., is a plant with young shoots. The petiole 1.7–2.6 cm long, are pubescent-tomentose while the leaf baldes are elliptic. Fruit peduncle, 4 cm wide, are apocarps red and bears about 3 or 4 seeds. Flowering is in July while fruiting occurs in November [1]. The non-volatile constituents of this species includes dibenzocyclooctane lignans, kadsurindutins A and B, and structurally related lignans schisantherin L, schisantherin P, kadsulignan P, kadsulignan L, and neokadsuranin. Both kadsurindutins A, kadsulignan L and neokadsuranin showed *in vitro* antiviral effects on hepatitis B virus [21]. In addition, lignans, kadsurindutins C and H as well 18(13→12)-abeo-lanostane triterpenoid acid and kadindutic acid, were isolated from the stems of *Kadsura indica* [22]. The authors are not aware of any report of its essential oil composition.

*Kadsura longipedunculata* Finet & Gagnepain, is an evergreen twining vine. The leaf baldes are elliptic to rarely ovate-elliptic or obovate-elliptic, 5.5–12(–15) × 2–4.5(–6.5) cm, papery to leathery. The flower tepals are pale yellow, yellow, or occasionally reddish, while the fruit peduncles are apocarps red, purple, or rarely black, which bears 1-3 seeds. The flowering stages occur between June and September, with fruiting taking place between September and December. This species is used medicinally. The fruit is edible [1]. The total triterpenic acid (containing kadsuric acid and nigranoic acid) from this plant prevented gastric mucosal lesions induced by indomethacin, absolute alcohol, as well stress [1]. The plant also possesses free radical scavenging activity [23]. Phytochemical studies revealed the characterisation of dibenzocyclooctadiene lignans [24], tetrahydrofuran lignans and cadinane-type sesquiterpenoid [25], anti HIV-1 protease lignans, longipedunins A, B and C and triterpene dilactones [26-28]. The chemical compositions of its root essential oil, which also possess antimicrobial, antioxidant activities and cytotoxicities activities [29] were cadinane type compounds and their derivatives (54.2%) and especially δ-cadinene (13.8%). Another author [30] identified δ-cadinene (21.79%), camphene (7.27%), borneol (6.05%), cubenol (5.12%) and δ-cadinol (5.11%) as the major components of the oil.

The essential oil profiles of these plant species have received very little attention and this arouses our interest on researches into the volatile compositions of these relatively unexploited floras of Vietnam. In this paper, we report herein the compounds identified in the essential oils from the stem bark of *K. coccinea*, *K. indica* and *K. longipedunculata*.

2. Materials and Methods

2.1. Plants collection

Stem bark of *K. indica* were obtained from Lào Cai Province, Vietnam, on September 2011, while those of *K. coccinea* were harvested from Tam Đō National Park, Vĩnh Phúc Province, Vietnam, on September 2011. However, sample of *K. longipedunculata* were collected from Kon Tum province, Vietnam, on July 2010. Voucher specimens BVT 16, BVT 21 and BVT 15, respectively
were deposited at the Botany Museum, Vinh University, Vietnam. Plant samples were air-dried prior to extraction.

2.2 Extraction of the oils

Aliquots of 0.5 kg of each of pulverised plant samples was used for the experiment and their oils were obtained by hydrodistillation for 3h at normal pressure, according to the Vietnamese Pharmacopoeia [31]. The plant samples yielded a low content of essential oils: 0.20% (v/w; K. induta; light yellow); 0.15% (v/w; K. coccinea; light yellow); and 0.20% (v/w; K. longipedunculata; light yellow), calculated on a dry weight basis.

2.3 Gas Chromatography (GC) analysis of the oils

Gas chromatography analysis was performed on an Agilent Technologies HP 6890 Plus Gas chromatograph equipped with a FID and fitted with HP-5MS column (both 30 m x 0.25 mm, film thickness 0.25 μm, Agilent Technology). The analytical conditions were: carrier gas H₂ (1 mL/min), injector temperature (PTV) 250°C, detector temperature 260°C, column temperature programmed from 40°C (2 min hold) to 220°C (10 min hold) at 4°C/min. Samples were injected by splitting and the split ratio was 10:1. The volume injected was 1.0 μL (diluted oil in hexane). Inlet pressure was 6.1 kPa. Each sample was analyzed thrice.

2.4 Gas Chromatography-Mass spectrometry (GC-MS) analysis

An Agilent Technologies HP 6890N Plus Chromatograph fitted with a fused silica capillary HP-5MS column (30 m x 0.25 mm, film thickness 0.25 μm) and interfaced with a mass spectrometer HP 5973 MSD was used for the GC/MS analysis, under the same conditions as those used for GC analysis. The conditions were the same as described above with He (1 mL/min) as carrier gas. The MS conditions were as follows: ionization voltage 70 eV; emission current 40 mA; acquisitions scan mass range of 35-350 amu at a sampling rate of 1.0 scan/s.

2.5 Identification of the constituents

The identification of constituents was performed on the basis of retention indices (RI) determined by co-injection with reference to a homologous series of n-alkanes, under identical experimental conditions. Further identification was performed by comparison of their mass spectra with those from NIST [32] and and the home-made MS library built up from pure substances and components of known essential oils, as well as by comparison of their retention indices with literature values [33, 34].

3.  Results and Discussion

Table 1 indicates the list of compounds identified from the studied oil samples. Sesquiterpene hydrocarbons (57.9%, 25.2% and 55.1% respectively) and oxygenated sesquiterpenes (33.8%, 64.4% and 27.1% respectively) are the main oil fractions of K. coccinea, K. longipedunculata and K. induta respectively. Monoterpenes are less common, 0.5%, 0.2% and 14.5% respectively.

The main sesquiterpene constituents of K. coccinea were β-caryophyllene (23.6%), δ-cadinene (8.6%), caryophyllene oxide (7.8%), epi-α-bisabolol (7.5%), α-copaene (6.6%) and τ-muurolol (6.1%). The quantitative amount of caryophyllene is in agreement with previous reports [19, 20], but differ in the fact that compounds such as β-pinene, bornyl acetate, δ-elemene, β-himachalene and β-gurjunene, found in the said reports, were conspicuously absent in the present investigation.

The major sesquiterpene of K. longipedunculata was α-muurolol (43.5%) along with minor ones such as α-cadinol (5.4%), β-caryophyllene (5.4%) and δ-cadinene (5.0%). Cadinane type compounds and their derivatives, especially δ-cadinene were characteristics of previous report [29, 30] as against α-muurolol identified in this oil sample. The sesquiterpenes of K. induta were represented by α-acorenoi (10.1%), δ-cadinene (9.6%), γ-cadinene (8.1%), δ-elemene (6.8%), γ-amorphene (5.4%) and τ-muurolol (5.2%), while terpinen-4-ol (6.5%) was the only monoterpene of quantitative significant.
No record of its essential oil composition could be found in literature as such this may represent the first of its kind.

**Table 1.** Volatile compounds of three *Kadsura* species from Vietnam.

<table>
<thead>
<tr>
<th>Compounds</th>
<th>RI&lt;sup&gt;a&lt;/sup&gt;</th>
<th>RI&lt;sup&gt;b&lt;/sup&gt;</th>
<th>K&lt;sub&gt;c&lt;/sub&gt;</th>
<th>K&lt;sub&gt;i&lt;/sub&gt;</th>
<th>MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>α-Thujene</td>
<td>924</td>
<td>924</td>
<td>-</td>
<td>-</td>
<td>2.5</td>
</tr>
<tr>
<td>α-Pinene</td>
<td>931</td>
<td>932</td>
<td>-</td>
<td>-</td>
<td>0.3</td>
</tr>
<tr>
<td>Sabineine</td>
<td>970</td>
<td>964</td>
<td>-</td>
<td>-</td>
<td>1.8</td>
</tr>
<tr>
<td>β-Pinene</td>
<td>974</td>
<td>974</td>
<td>-</td>
<td>-</td>
<td>0.3</td>
</tr>
<tr>
<td>β-Myrcene</td>
<td>988</td>
<td>988</td>
<td>-</td>
<td>-</td>
<td>0.5</td>
</tr>
<tr>
<td>α-Terpinene</td>
<td>1015</td>
<td>1014</td>
<td>-</td>
<td>-</td>
<td>0.3</td>
</tr>
<tr>
<td>β-Cymene</td>
<td>1024</td>
<td>1020</td>
<td>-</td>
<td>-</td>
<td>0.7</td>
</tr>
<tr>
<td>β-Pheollandrene</td>
<td>1027</td>
<td>1025</td>
<td>-</td>
<td>-</td>
<td>0.2</td>
</tr>
<tr>
<td>(E)-β-Ocimene</td>
<td>1045</td>
<td>1044</td>
<td>-</td>
<td>-</td>
<td>0.2</td>
</tr>
<tr>
<td>γ-Terpinene</td>
<td>1056</td>
<td>1054</td>
<td>-</td>
<td>-</td>
<td>0.5</td>
</tr>
<tr>
<td>Terpinolene</td>
<td>1086</td>
<td>1086</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td>Terpinen-4-ol</td>
<td>1177</td>
<td>1174</td>
<td>0.2</td>
<td>-</td>
<td>6.5</td>
</tr>
<tr>
<td>α-Terpineol</td>
<td>1191</td>
<td>1186</td>
<td>0.5</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Bornyl acetate</td>
<td>1284</td>
<td>1287</td>
<td>-</td>
<td>-</td>
<td>0.3</td>
</tr>
<tr>
<td>δ-Elemene</td>
<td>1337</td>
<td>1335</td>
<td>-</td>
<td>-</td>
<td>6.8</td>
</tr>
<tr>
<td>α-Cubebene</td>
<td>1351</td>
<td>1345</td>
<td>0.7</td>
<td>-</td>
<td>1.3</td>
</tr>
<tr>
<td>Neryl acetate</td>
<td>1363</td>
<td>1359</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td>α-Copaene</td>
<td>1377</td>
<td>1374</td>
<td>6.6</td>
<td>0.7</td>
<td>4.3</td>
</tr>
<tr>
<td>Daucone</td>
<td>1378</td>
<td>1380</td>
<td>-</td>
<td>-</td>
<td>0.2</td>
</tr>
<tr>
<td>β-Cubebene</td>
<td>1389</td>
<td>1387</td>
<td>0.3</td>
<td>-</td>
<td>2.7</td>
</tr>
<tr>
<td>β-Elemene</td>
<td>1391</td>
<td>1389</td>
<td>0.2</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Sesquithujene</td>
<td>1404</td>
<td>1405</td>
<td>0.2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>cis-α-Bergamotene</td>
<td>1414</td>
<td>1411</td>
<td>-</td>
<td>0.6</td>
<td>-</td>
</tr>
<tr>
<td>β-Caryophylenene</td>
<td>1419</td>
<td>1417</td>
<td>23.6</td>
<td>5.4</td>
<td>0.7</td>
</tr>
<tr>
<td><em>trans</em>-α-Bergamotene</td>
<td>1434</td>
<td>1432</td>
<td>2.0</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Aromadendrene</td>
<td>1441</td>
<td>1439</td>
<td>0.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>cis</em>-Murola-3,5-diene</td>
<td>1449</td>
<td>1448</td>
<td>0.2</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>α-Humulene</td>
<td>1454</td>
<td>1452</td>
<td>4.8</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td><em>9-epi-(E)</em>-Caryophyllene</td>
<td>1460</td>
<td>1464</td>
<td>0.4</td>
<td>-</td>
<td>0.8</td>
</tr>
<tr>
<td><em>cis</em>-Murola-4(14),5-diene</td>
<td>1462</td>
<td>1465</td>
<td>-</td>
<td>0.7</td>
<td>-</td>
</tr>
<tr>
<td>γ-Murolene</td>
<td>1476</td>
<td>1478</td>
<td>0.8</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Germacrine D</td>
<td>1480</td>
<td>1484</td>
<td>0.5</td>
<td>0.9</td>
<td>1.1</td>
</tr>
<tr>
<td>β-Sehine</td>
<td>1486</td>
<td>1489</td>
<td>1.0</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td><em>trans</em>-Murola-4(14),5-diene</td>
<td>1491</td>
<td>1493</td>
<td>0.5</td>
<td>-</td>
<td>2.0</td>
</tr>
<tr>
<td>Viridiflorene</td>
<td>1494</td>
<td>1496</td>
<td>1.6</td>
<td>0.8</td>
<td>-</td>
</tr>
<tr>
<td>γ-Amorphene</td>
<td>1495</td>
<td>1495</td>
<td>-</td>
<td>-</td>
<td>5.4</td>
</tr>
<tr>
<td><em>cis</em>-Cadinha-1,4-diene</td>
<td>1498</td>
<td>1496</td>
<td>0.6</td>
<td>0.1</td>
<td>0.6</td>
</tr>
<tr>
<td>α-Murolone</td>
<td>1499</td>
<td>1500</td>
<td>1.3</td>
<td>-</td>
<td>2.1</td>
</tr>
<tr>
<td>β-Bisabolene</td>
<td>1507</td>
<td>1505</td>
<td>1.3</td>
<td>0.3</td>
<td>-</td>
</tr>
<tr>
<td>γ-Cadinene</td>
<td>1510</td>
<td>1507</td>
<td>0.2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>δ-Amorphene</td>
<td>1513</td>
<td>1511</td>
<td>0.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Compound</td>
<td>δ-Cadinene</td>
<td>δ-Cadinene</td>
<td>trans-Cadin-1(6), 4-diene</td>
<td>α-Cadinene</td>
<td>Elemol</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------</td>
<td>------------</td>
<td>---------------------------</td>
<td>------------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>1521</td>
<td>1521</td>
<td>1.4</td>
<td>1.4</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Zonarene 1521 1521 1.4 - MS, RI

δ-Cadinene 1525 1522 8.6 5.0 9.6 MS, RI, Co

trans-Cadin-1(6), 4-diene 1535 1533 0.7 0.3 1.0 MS, RI, Co

α-Cadinene 1537 1537 1.6 - MS, RI, Co

Elemol 1550 1548 0.1 - - MS, RI, Co

Germacrene B 1556 1559 - - 0.4 MS, RI, Co

β-Calacorene 1563 1564 0.2 - 0.2 MS, RI, Co

Caryophyllenyl alcohol 1571 1570 0.1 0.3 - MS, RI, Co

Scapanol 1572 1580 - - 0.5 MS, RI, Co

Spathulenol 1579 1577 2.2 3.2 0.6 MS, RI, Co

Caryophyllene oxide 1584 1582 7.8 4.3 - MS, RI, Co

Gleenol 1585 1586 - - 0.8 MS,RI

Champacol 1593 1602 0.4 - 0.4 MS,RI

Humulene Epoxide II 1609 1608 1.2 0.6 0.4 MS,RI

10-diepi-Cubenol 1616 1618 - 2.3 - MS,RI

epi-Cubenol 1629 1627 2.2 0.9 4.6 MS,RI

α-Acorenol 1632 1632 - - 10.1 MS,RI, Co

γ-Eudesmol 1633 1630 0.6 - - MS,RI

Caryophylla-3(15), (7(14)-dien-6-ol 1637 - 0.6 0.6 - MS,RI

t-Muurolol 1643 1640 1.0 - 5.2 MS,RI

α-Muurolol 1647 1644 1.0 43.5 1.5 MS,RI, Co

1(10)-Sprouvetiene-7-ol 1648 - - 1.5 - MS,RI, Co

β-Eudesmol 1652 1649 0.7 - - MS,RI

α-Cadinol 1656 1652 2.6 5.4 1.5 MS,RI

Cadalone 1676 1675 0.5 0.5 - MS,RI

epi-α-Bisabolol 1685 1683 7.5 0.3 - MS,RI,Co

Eudesma-4(15), 7-dien-1-ol 1686 1687 - 1.0 0.2 MS,RI

(E,E)-Farnesol 1720 - - - 0.9 MS,RI

5-Hydroxycalamenene 1785 - - - 0.4 MS,RI

1,2-Benzenedicarboxylic acid 1917 1917 - 0.3 - MS,RI

(1Z)-9-Octadecenamide 2398 2398 0.2 - - MS,RI

<table>
<thead>
<tr>
<th>Total</th>
<th>92.6</th>
<th>90.1</th>
<th>96.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monoterpane hydrocarbons</td>
<td>-</td>
<td>-</td>
<td>7.4</td>
</tr>
<tr>
<td>Oxygenated monoterpenes</td>
<td>0.7</td>
<td>0.2</td>
<td>7.1</td>
</tr>
<tr>
<td>Sesquiterpane hydrocarbons</td>
<td>57.9</td>
<td>25.2</td>
<td>55.1</td>
</tr>
<tr>
<td>Oxygenated sesquiterpenes</td>
<td>33.8</td>
<td>64.4</td>
<td>27.1</td>
</tr>
</tbody>
</table>

Non-terpenes 0.2 0.3 -

a SD= Standard deviation were recorded, values were insignificant and omitted from the Table to avoid congestion; b Elution order on HP-5MS capillary column; c Retention indices on HP-5MS capillary column; d Literature Retention indices (see Experimental); e Tentative assignment; f Correct isomer not identified; - Not identified and not present in Literature; K,c = Kadsura coccinea; K,l = Kadsura longipenduculata; K. i = Kadsura interrupta; MI Mode of identification; MS, Mass spectrum; RI, Retention indices; Co, Co-injection with authentic samples.
Few literature reports are available on the oil contents of Kadsura plants. The main components of *K. heteroclita* stem oil were α-eudesmol (17.56%), 4-terpineol (9.74%) and δ-cadinene (9.27%) and essential oil showed potential to be developed as a possible natural insecticide/nematicide for control of stored product insects/nematodes [35]. However, δ-cadinene (22.59%), δ-cadinol (17.64%) and calarene (7.63%) were the main compounds identified in another investigation [36]. Li et al. [37] demonstrated that the supercritical carbon dioxide fluid extraction and steam distillated oils of *K. heteroclita* contained δ-cadinene (14.42% and 19.46%), δ-cadinol (9.94% and 11.14%) and calarene (6.50% and 8.00%) respectively, as major compounds.

The predominance of sesquiterpene compounds in the present investigation is in agreement with previous reports on the compositions of some Kadsura species [19, 20, 29, 30, 35-37]. Cadinane type compounds such as cis-cadina-1-4-diene, γ-cadinene, δ-adinene and α-cadinol are also prominent among the sesquiterpene volatiles of these Kadsura oils, as previously found in *K. longipedunculata* [29, 30], *K. coccinea* [19, 20], *K. heteroclita* [35-37] and *K. oblongifolia* [38]. However, it was noted that β-caryophyllene, the major compound of the stem oil of *K. coccinea* was also the significant compound of the leaf oil of *K. oblongifolia* [38] from Vietnam.

Acknowledgments

Authors are grateful to Mrs. Musilimat Ogunwande for the typesetting of the manuscript.

References


et al
and their effects on embryonic cell division of
Kadsura
F. 62
J. Mod. Food Pharm.
Kadsura coccinea
Nibret
and their inhibitory activities on LPS
W. Ma, X. Ma, Y. Lu and C. Chen (2009).
J.
X. 4
(2008). Three new compounds from
Q.
Mulyaningsih
Ashour
L. Fang, C. Xie, H. Wang, D.
Kadsura longepedunculata
(Tokyo)
L.
-
Chemistry web book. Data from NIST Standard
35
,
4
Spectrometry
D.
M.
Radix Kadsurae
Kadsura coccinea,
Z.
Org. Lett
The Chemical composition of essential oil
2
Lignans from the roots of
Wang, L.
J.X. Pu, R.T. Li, W.L. Xiao, R. Pu, W.
392
92
Xiao, R.
J. Pharm. Pharmacol.
2361
by GC
Gao, C.
9
M.
and
90,
triterpenes from
Dibenzocyclooctane lignans from the stems of
Kadsura induta,
Kadsura coccinea
J. Nat. Prodt
J.
L. Song, J.
Kadsura angustifolia
(2011)
56
Food Ind.
L.
134
57,
using hydrophobic organic
,
Zhao, L.
62
and
Chin. Chem. Lett
Lignans
Huang, Y.
Tetrahedron
(2010). A new triterpenoid from
H. Li
Li, S.
Li, H. Xue and X. Li (1991).
Yang, Y
Chem. Pharm.
Kadsura longipedunculata
Lei, W.
Sun
Y. Song,
Y. Ito
Schisandra sphenanthera, Amer. J. Chinese Med
-
16
158
Kadsura coccinea
-
162.

Essential oils of Kadsura from Vietnam


