

NATURAL PRODUCT COMMUNICATIONS

An International Journal for Communications and Reviews Covering all
Aspects of Natural Products Research



Volume 8. Issue 9. Pages 1195-1352. 2013
ISSN 1934-578X (printed); ISSN 1555-9475 (online)
www.naturalproduct.us

EDITOR-IN-CHIEF**DR. PAWAN K AGRAWAL**

Natural Product Inc.
7963, Anderson Park Lane,
Westerville, Ohio 43081, USA
agrawal@naturalproduct.us

EDITORS**PROFESSOR ALEJANDRO F. BARRERO**

Department of Organic Chemistry,
University of Granada,
Campus de Fuente Nueva, s/n, 18071, Granada, Spain
afbarre@ugr.es

PROFESSOR ALESSANDRA BRACA

Dipartimento di Chimica Bioorganica e Biofarmacia,
Università di Pisa,
via Bonanno 33, 56126 Pisa, Italy
braca@farm.unipi.it

PROFESSOR DEAN GUO

State Key Laboratory of Natural and Biomimetic Drugs,
School of Pharmaceutical Sciences,
Peking University,
Beijing 100083, China
gda5958@163.com

PROFESSOR YOSHIHIRO MIMAKI

School of Pharmacy,
Tokyo University of Pharmacy and Life Sciences,
Horinouchi 1432-1, Hachioji, Tokyo 192-0392, Japan
mimakiy@ps.toyaku.ac.jp

PROFESSOR STEPHEN G. PYNE

Department of Chemistry
University of Wollongong
Wollongong, New South Wales, 2522, Australia
spyne@uow.edu.au

PROFESSOR MANFRED G. REINECKE

Department of Chemistry,
Texas Christian University,
Forts Worth, TX 76129, USA
m.reinecke@tcu.edu

PROFESSOR WILLIAM N. SETZER

Department of Chemistry
The University of Alabama in Huntsville
Huntsville, AL 35809, USA
wsetzer@chemistry.uah.edu

PROFESSOR YASUHIRO TEZUKA

Institute of Natural Medicine
Institute of Natural Medicine, University of Toyama,
2630-Sugitani, Toyama 930-0194, Japan
tezuka@inm.u-toyama.ac.jp

PROFESSOR DAVID E. THURSTON

Department of Pharmaceutical and Biological Chemistry,
The School of Pharmacy,
University of London, 29-39 Brunswick Square,
London WC1N 1AX, UK
david.thurston@pharmacy.ac.uk

HONORARY EDITOR**PROFESSOR GERALD BLUNDEN**

The School of Pharmacy & Biomedical Sciences,
University of Portsmouth,
Portsmouth, PO1 2DT U.K.
axuf64@dsl.pipex.com

ADVISORY BOARD

Prof. Berhanu M. Abegaz
Gaborone, Botswana

Prof. Viqar Uddin Ahmad
Karachi, Pakistan

Prof. Øyvind M. Andersen
Bergen, Norway

Prof. Giovanni Appendino
Novara, Italy

Prof. Yoshinori Asakawa
Tokushima, Japan

Prof. Lee Banting
Portsmouth, U.K.

Prof. Julie Banerji
Kolkata, India

Prof. Anna R. Bilia
Florence, Italy

Prof. Maurizio Bruno
Palermo, Italy

Prof. César A. N. Catalán
Tucumán, Argentina

Prof. Josep Coll
Barcelona, Spain

Prof. Geoffrey Cordell
Chicago, IL, USA

Prof. Ana Cristina Figueiredo
Lisbon, Portugal

Prof. Cristina Gracia-Viguera
Murcia, Spain

Prof. Duvvuru Gunasekar
Tirupati, India

Prof. Kurt Hostettmann
Lausanne, Switzerland

Prof. Martin A. Iglesias Arteaga
Mexico, D. F., Mexico

Prof. Leopold Jirovetz
Vienna, Austria

Prof. Vladimir I Kalinin
Vladivostok, Russia

Prof. Niel A. Koorbanally
Durban, South Africa

Prof. Karsten Krohn
Paderborn, Germany

Prof. Chiaki Kuroda
Tokyo, Japan

Prof. Hartmut Laatsch
Gottingen, Germany

Prof. Marie Lacaille-Dubois
Dijon, France

Prof. Shoei-Sheng Lee
Taipei, Taiwan

Prof. Francisco Macias
Cadiz, Spain

Prof. Imre Mathe
Szeged, Hungary

Prof. Ermino Murano
Trieste, Italy

Prof. M. Soledade C. Pedras
Saskatoon, Canada

Prof. Luc Pieters
Antwerp, Belgium

Prof. Peter Proksch
Düsseldorf, Germany

Prof. Phila Raharivelomanana
Tahiti, French Polynesia

Prof. Luca Rastrelli
Fisciano, Italy

Prof. Monique Simmonds
Richmond, UK

Dr. Bikram Singh
Palampur, India

Prof. John L. Sorensen
Manitoba, Canada

Prof. Valentin Stonik
Vladivostok, Russia

Prof. Winston F. Tinto
Barbados, West Indies

Prof. Sylvia Urban
Melbourne, Australia

Prof. Karen Valant-Vetschera
Vienna, Austria

INFORMATION FOR AUTHORS

Full details of how to submit a manuscript for publication in Natural Product Communications are given in Information for Authors on our Web site <http://www.naturalproduct.us>.

Authors may reproduce/republish portions of their published contribution without seeking permission from NPC, provided that any such republication is accompanied by an acknowledgment (original citation)-Reproduced by permission of Natural Product Communications. Any unauthorized reproduction, transmission or storage may result in either civil or criminal liability.

The publication of each of the articles contained herein is protected by copyright. Except as allowed under national "fair use" laws, copying is not permitted by any means or for any purpose, such as for distribution to any third party (whether by sale, loan, gift, or otherwise); as agent (express or implied) of any third party; for purposes of advertising or promotion; or to create collective or derivative works. Such permission requests, or other inquiries, should be addressed to the Natural Product Inc. (NPI). A photocopy license is available from the NPI for institutional subscribers that need to make multiple copies of single articles for internal study or research purposes.

To Subscribe: Natural Product Communications is a journal published monthly. 2013 subscription price: US\$2,395 (Print, ISSN# 1934-578X); US\$2,395 (Web edition, ISSN# 1555-9475); US\$2,795 (Print + single site online); US\$595 (Personal online). Orders should be addressed to Subscription Department, Natural Product Communications, Natural Product Inc., 7963 Anderson Park Lane, Westerville, Ohio 43081, USA. Subscriptions are renewed on an annual basis. Claims for nonreceipt of issues will be honored if made within three months of publication of the issue. All issues are dispatched by airmail throughout the world, excluding the USA and Canada.

The Composition, Anti-mildew and Anti-wood-decay Fungal Activities of the Leaf and Fruit Oils of *Juniperus formosana* from Taiwan

Yu-Chang Su^a, Kuan-Ping Hsu^b, Eugene I-Chen Wang^b and Chen-Lung Ho^{b*}

^aDepartment of Forestry, National Chung Hsing University, 250 Kuo Kuang Rd., Taichung, Taiwan 402

^bDivision of Wood Cellulose, Taiwan Forestry Research Institute, 53, Nanhai Rd., Taipei, Taiwan 100

chenlung@tfri.gov.tw

Received: April 5th, 2013; Accepted: May 28th, 2013

In this study, anti-mildew and anti-wood-decay fungal activities of the leaf and fruits essential oil and its constituents from *Juniperus formosana* were evaluated *in vitro* against seven mildew fungi and four wood decay fungi, respectively. The main compounds responsible for the anti-mildew and anti-wood-decay fungal activities were also identified. The essential oil from the fresh leaves and fruits of *J. formosana* were isolated using hydrodistillation in a Clevenger-type apparatus, and characterized by GC-FID and GC-MS, respectively. The leaf oil mainly consisted of α -pinene (41.0%), limonene (11.5%), α -cadinol (11.0%), elemol (6.3%), and β -myrcene (5.8%); the fruit oil was mostly α -pinene (40.9%), β -myrcene (32.4%), α -thujene (5.9%) and limonene (5.9%). Comparing the anti-mildew and anti-wood-decay fungal activities of the oils suggested that the leaf oil was the most effective. For the anti-mildew and anti-wood-decay fungal activities of the leaf oil, the active source compounds were determined to be α -cadinol and elemol.

Keywords: *Juniperus formosana*, Essential oil, Antimildew activity, Anti-wood-decay fungal activity, α -Cadinol, Elemol.

Juniperus formosana Hayata (Cupressaceae) is a large tree mainly distributed in Taiwan, and China [1]. However, only three references were found regarding the chemical compositions of this species from China [2-4]. In Taiwan, there is no report of the essential oil composition and bioactivities for *J. formosana*. Therefore, in this study, the essential oil from the leaves and fruits was first isolated using hydrodistillation, and then analyzed. In addition, the climate of Taiwan is warm and humid, and thus conducive to the growth of mildew and wood decay fungi. Mildew growth causes problems in the preservation of cultivated crops as well as inducing allergies, asthma, bronchitis, onychomycosis, cerebral infections, pneumonia, peritonitis, and immune-deficiency syndrome [5]. The wood decay fungi can easily cause damage to wooden products. Therefore, we also applied the essential oils to seven strains of mold fungi and four of wood decay fungi to examine their interdiction efficacies, respectively. The second part of the study examined the anti-mildew and anti-wood-decay fungal activities of the leaf and fruit oils. The purpose of this study was to establish a chemical basis for the effective multipurpose utilization of the species.

Hydrodistillation of *J. formosana* leaves and fruits produced yellow-colored oils with yields (v/w), on a moisture free basis, of 1.51 ± 0.06 and 1.86 ± 0.05 , v/w, respectively. All compounds are listed in order of their elution from the DB-5 column (Table 1). A total of 49 compounds were identified from the hydrodistilled leaf oil of *J. formosana*. Monoterpene hydrocarbons were predominant (69.2%), followed by oxygenated sesquiterpenes (20.5%), sesquiterpene hydrocarbons (5.4%), oxygenated monoterpenes (3.6%), and non-terpenoids (1.2%). Of the monoterpene hydrocarbons, α -pinene (41.0%), limonene (11.5%) and β -myrcene (5.8%) were the major compounds. α -Cadinol (11.0%) and elemol (6.3%) were the chief sesquiterpene hydrocarbons. In *J. formosana* leaf oil, Yu *et al.* [2] found 55 compounds, mainly α -pinene (9.6%), bornyl acetate (5.2%), limonene (4.3%), and myrcene (4.1%). Adams *et al.* [3] found 70 compounds, mainly α -pinene (47.7%),

myrcene (7.2%), limonene (4.0%), β -pinene (2.9%), γ -cadinene (2.4%), and germacrene D (2.3%). Our results differed from the above papers with α -pinene, limonene, α -cadinol, elemol, and β -myrcene as the major compounds. This is the first presentation of these compounds in *J. formosana* leaf oil.

Twenty-five components were identified from the fruit oil. Among them, monoterpene hydrocarbons were the most dominant (93.4%), followed by sesquiterpene hydrocarbons (2.5%), oxygenated sesquiterpenes (2.2%), and oxygenated monoterpenes (1.9%). α -Pinene (40.9%), β -myrcene (32.4%), α -thujene (5.9%) and limonene (5.9%) were the major monoterpene hydrocarbons. In *J. formosana* fruit oil, Yu and Xie [4] found 47 compounds mainly myrcene (27.1%), α -pinene (26.1%), γ -terpinene (10.7%), and limonene (6.0%). Our results differed from the above paper with α -pinene, β -myrcene, α -thujene and limonene as the main compounds. This is the first presentation of these compounds for *J. formosana* fruit oil.

The leaf and fruit oils of *J. formosana* were tested against seven mildew fungi (*Aspergillus clavatus* (A. c.), *A. niger* (A. n.), *Chaetomium globosum* (Ch. g.), *Cladosporium cladosporioides* (Cl. c.), *Myrothecium verrucaria* (M. v.), *Penicillium citrinum* (P. c.), and *Trichoderma viride* (T. v.)). The antifungal indexes demonstrated clearly that the leaf oil had antifungal activities superior to those of the fruit oil (Fig. 1). Among the fungi tested, the leaf oil was totally inhibitory of mycelial growth of *A. clavatus*, *Cl. cladosporioides*, *Ch. globosum*, and *M. verrucaria* at a 1 mg/mL concentration. The leaf oil was superior to the anti-mildew fungal activities of the essential oils from *Eucalyptus urophylla*, *E. grandis*, *E. camaldulensis*, *E. citriodora* [5], *Litsea cubeba* [6], *L. coreana* [7], and *Neolitsea parvigemma* [8]. The results verified that *J. formosana* leaf oil has notable antifungal activities.

However, to ascertain the source compounds responsible for *J. formosana* antifungal activities, the main components were

Table 1: Chemical composition of the leaf and fruit oils of *J. formosana*.

Constituents	K.I. ^{a)}	Concentration (%)		Identification ^{b)}
		Leaf	Fruit	
Tricyclene	927	0.1	- ^{c)}	MS, KI, ST
α -Thujene	930	0.1	5.9	MS, KI, ST
α -Pinene	939	41.0	40.9	MS, KI, ST
Camphene	954	0.6	0.5	MS, KI, ST
Verbene	968	0.5	0.4	MS, KI
β -Pinene	979	4.1	3.7	MS, KI, ST
β -Myrcene	991	5.8	32.4	MS, KI, ST
δ -2-Carene	1002	3.8	0.7	MS, KI
α -Phellandrene	1003	0.5	0.7	MS, KI, ST
<i>p</i> -Cymene	1025	0.8	0.3	MS, KI, ST
Limonene	1029	11.5	5.9	MS, KI, ST
Terpinolene	1089	0.4	1.9	MS, KI, ST
<i>p</i> -Cymenene	1091	0.2	-	MS, KI, ST
Linalool	1097	-	0.2	MS, KI, ST
<i>allo</i> -Ocimene	1132	-	0.2	MS, KI
<i>trans</i> -Pinoarveol	1139	0.2	-	MS, KI
<i>cis</i> -Verbenol	1141	0.2	-	MS, KI
Borneol	1169	0.3	-	MS, KI, ST
<i>cis</i> -Pinoampphone	1175	0.3	-	MS, KI
4-Terpineol	1177	0.4	0.8	MS, KI, ST
α -Terpineol	1189	-	0.6	MS, KI, ST
Citronellol	1226	0.5	-	MS, KI, ST
<i>trans</i> -Chrysanthenyl acetate	1238	0.1	-	MS, KI
Piperitone	1253	0.5	-	MS, KI
Bornyl acetate	1289	1.1	0.4	MS, KI, ST
Thymol	1290	0.1	-	MS, KI, ST
2-Undecanone	1294	0.4	-	MS, KI
Citronellic acid	1313	0.5	-	MS, KI, ST
α -Terpinyl acetate	1349	0.2	-	MS, KI, ST
α -Cubebene	1351	0.2	-	MS, KI, ST
α -Copaene	1377	0.4	-	MS, KI, ST
β -Bourbonene	1388	0.1	-	MS, KI
β -Caryophyllene	1419	0.4	0.9	MS, KI, ST
(<i>Z</i>)- β -Farnesene	1443	0.1	-	MS, KI, ST
α -Caryophyllene	1455	0.2	0.8	MS, KI, ST
(<i>E</i>)- β -Farnesene	1457	0.2	-	MS, KI
γ -Muuroleone	1480	0.2	-	MS, KI, ST
β -Selinene	1490	0.3	-	MS, KI
α -Muuroleone	1500	0.4	0.2	MS, KI, ST
β -Bisabolene	1506	-	0.3	MS, KI
γ -Cadinene	1514	-	0.2	MS, KI
Cubebol	1515	0.4	0.7	MS, KI
δ -Cadinene	1523	2.0	-	MS, KI, ST
<i>trans</i> -Calamenene	1529	0.5	-	MS, KI
Elemol	1550	6.3	-	MS, KI, ST
Germacrene B	1561	0.5	-	MS, KI, ST
Dodecanoic acid	1567	0.2	-	MS, KI, ST
Caryophyllene oxide	1583	0.1	-	MS, KI, ST
Cedrol	1601	0.5	-	MS, KI, ST
γ -Eudesmol	1632	0.2	-	MS, KI
α -Muurolo	1646	0.9	0.9	MS, KI, ST
α -Eudesmol	1654	0.7	-	MS, KI, ST
α -Cadinol	1654	11.0	0.3	MS, KI, ST
α -Bisabolol	1686	0.3	0.4	MS, KI
Monoterpene hydrocarbons (%)		69.2	93.4	
Oxygenated monoterpenes (%)		3.6	1.9	
Sesquiterpene hydrocarbons (%)		5.4	2.5	
Oxygenated sesquiterpenes (%)		20.5	2.2	
Others (%)		1.2	-	
Oil Yield (mL/100 g)		1.51 \pm 0.06	1.86 \pm 0.05	

^a Kovats index on a DB-5 column with reference to *n*-alkanes [9]. ^b MS, NIST and Wiley library spectra and the literature; KI, Kovats index; ST, authentic standard compounds. ^c Not detected.

individually tested for their antifungal activities (Fig. 2). As for α -pinene, β -myrcene and limonene, very low levels of activity were found against the seven mold fungi; none of the antifungal indices exceeded 30%. However, the sesquiterpenoids, elemol and α -cadinol exhibited better activities. Elemol and α -cadinol exhibited activity against *A. clavatus*, *Cl. cladosporioides*, *Ch. globosum*, *M. verrucaria* and *T. viride*, with the highest antifungal indexes ranging from 80% to 100% at 100 μ g/mL. The IC₅₀ values for α -cadinol against these five fungi were 20.8, 12.8, 33.8, 20.2, and

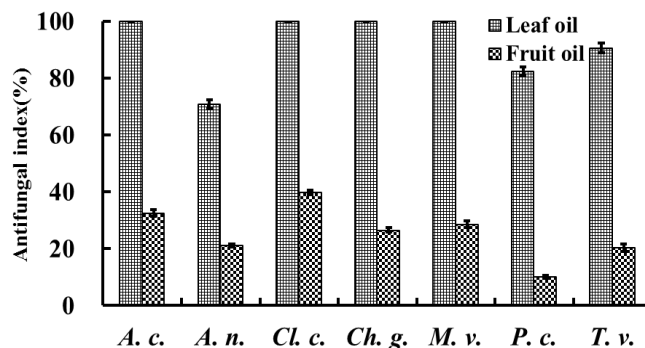


Figure 1: Antifungal activities of the leaf and fruit oils (1 mg/mL) from *J. formosana* against: *A. c.*: *Aspergillus clavatus*; *A. n.*: *A. niger*; *Cl. c.*: *Cladosporium cladosporioides*; *Ch. g.*: *Chaetomium globosum*; *M. v.*: *Myrothecium verrucaria*; *P. c.*: *Penicillium citrinum*; *T. v.*: *Trichoderma viride*

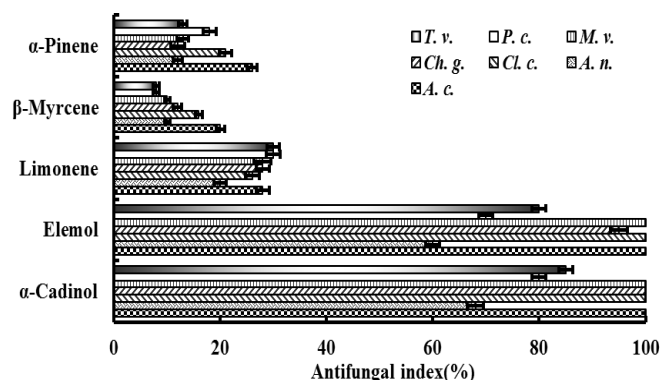


Figure 2: Anti-mildew fungal indices of the five main compounds (50 μ g/mL) of the leaf essential oil of *J. formosana*.

1. α -Pinene (98.5%), 2. β -Myrcene (98.5%), 3. Limonene (98.5%), 4. Elemol (98.5%), 5. α -Cadinol (100%). Compounds 1 to 3 were purchased from the Fluka Co., compound 4 from the Wako Co. (Tokyo, Japan) and compound 5 was from an isolate of Ho *et al*'s study on *Machilus philippinensis* essential oil [13].

Note: DDAC (didecyl dimethyl ammonium chloride) (50 μ g/mL) is a wood preservative for wood decay fungi and is used as a positive control.

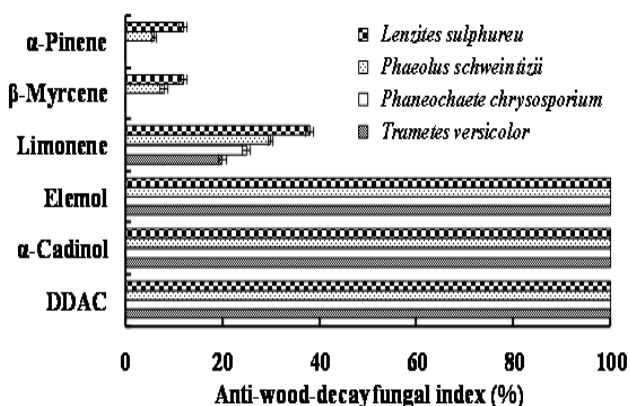
39.8 μ g/mL, respectively. The IC₅₀ values for elemol were 29.8, 20.8, 50.9, 36.8, and 48.9 μ g/mL, respectively. The results indicated that the active source compounds were α -cadinol and elemol. Previous studies support the contention that these compounds have significant activity for suppressing microbial growth [8,10].

The leaf and fruit oils of *J. formosana* were tested against two white rot fungi (*Trametes versicolor*, *Phanerochaete chrysosporium*) and two brown rot fungi (*Phaeolus schweinitzii*, *Lenzites sulphureu*). The anti-wood-decay fungal indices presented in Table 2 clearly demonstrate the excellent anti-wood-decay fungal activities of the leaf oil. Growth of *T. versicolor*, *Phane. chrysosporium*, *Phaeo. schweintzii* and *L. sulphureu* was completely inhibited at concentrations of 25, 50, 12.5, and 12.5 μ g/mL, respectively. The anti-wood-decay fungal activities of the leaf oil were superior to those of the essential oils from *L. coreana* [7], *Neolitsea parvigemma* [8], *Chamaecyparis formosensis* [11], *Machilus pseudolongifolia* [12], *M. philippinensis* [13], *Cinnamomum camphora* [14], *C. osmophloeum* [15], *L. mashaensis*, *L. linii* [16], and *L. acuminata* [17].

This study also tested the anti-wood-decay fungal activities of the major components of *J. formosana* leaf oil to ascertain its source compounds. Results indicated that the anti-wood-decay fungal activities were due to α -cadinol and elemol. At a concentration of 50 μ g/mL, α -cadinol and elemol showed total growth inhibition

Table 2: Anti-wood-decay fungal indices of leaf and fruit essential oils of *J. formosana*.

Essential oil	Dosage (µg/mL)	Antifungal index (%)			
		<i>Trametes versicolor</i>	<i>Phaeochaete chrysosporium</i>	<i>Phaeolus schweinitzii</i>	<i>Lenzites sulphureus</i>
Leaf	12.5	89 ± 3.3	68 ± 6.6	100 ± 0	100 ± 0
	25	100 ± 0	86 ± 3.3	100 ± 0	100 ± 0
	50	100 ± 0	100 ± 0	100 ± 0	100 ± 0
	75	100 ± 0	100 ± 0	100 ± 0	100 ± 0
	100	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Fruit	12.5	0 ± 0	0 ± 0	0 ± 0	0 ± 0
	25	0 ± 0	0 ± 0	0 ± 0	0 ± 0
	50	0 ± 0	0 ± 0	0 ± 0	0 ± 0
	75	0 ± 0	0 ± 0	0 ± 0	38 ± 3.3
	100	25 ± 3.3	18 ± 3.3	39 ± 3.3	56 ± 3.3

**Figure 3:** Anti-wood-decay fungal indices of the eight main compounds (50 µg/mL) of the leaf essential oil of *J. formosana*.

Note. DDAC (didecyl dimethyl ammonium chloride) (50 µg/mL) is a wood preservative for wood decay fungi and is used as a positive control.

against all the white-rot and brown-rot fungi tested. The presence of α -cadinol and elemol significantly contributed to the wood-decay fungi suppression activities of *J. formosana* leaf oil.

Experimental

Plant materials: Fresh leaves and fruits of *J. formosana* were collected in March 2012 from Yuanfeng (Nantou County, central Taiwan, elevation 2680 m, N 24° 07' 58", E 121° 14' 68"). The samples were compared with specimen no. ou8958 from the Herbarium of the National Chung-Hsing University and positively identified by Prof. Yen-Hsueh Tseng of NCHU. The voucher specimen (CLH-029) was deposited in the NCHU herbarium. Leaves and twigs of the species were collected for subsequent extraction and analysis.

Isolation of leaf and fruit essential oils: The essential oils of the air-dried leaves and fruits (1 kg) were hydrodistilled for 3 h using a

Clevenger-type apparatus. After distillation, the volume of oils obtained was measured, and the essential oils were stored in glass containers, hermetically sealed with rubber lids, covered with aluminum foil to protect the contents from light, and kept refrigerated at < 4°C until used. The oil yields and all test data are the average of triplicate analyses.

Essential oil analysis: A Hewlett-Packard HP 6890 gas chromatograph equipped with a DB-5 fused silica capillary column (30 m x 0.25 mm x 0.25 µm film thickness, J&W Scientific) and a FID detector was used for the quantitative determination of oil components. Oven temperature was programmed as follows: 50°C for 2 min, rising to 250°C at 5°C/min. Injector temperature: 270°C. Carrier gas: He with a flow rate of 1 mL/min. Detector temperature: 250°C, split ratio: 1:10. Diluted samples (1.0 µL, 1/100, v/v, in ethyl acetate) were injected manually in the split mode. Identification of the oil components was based on their retention indices and mass spectra, obtained from GC/MS analysis on a Hewlett-Packard HP 6890/HP5973 equipped with a DB-5 fused silica capillary column (30 m x 0.25 mm x 0.25 µm film thickness, J&W Scientific). The GC analysis parameters listed above and the MS were obtained (full scan mode: scan time: 0.3 s, mass range was m/z 30-500) in the EI mode at 70 eV. All data were the average of triplicate analyses.

Component identification: Identification of the leaf essential oil constituents was based on comparisons of retention index (RI) [6], retention times (RT), and mass spectra with those obtained from authentic standards and/or the NIST and Wiley libraries spectra, and literature [9,18].

Antifungal assays: The method of Su *et al.* [5] was adopted. Mold and wood decay fungi were obtained from the Culture Collection and Research Center of the Food Industry Research and Development Institute, Hsinchu City, Taiwan. References of ASTM G21, JIS Z 2911 and AATCC test method 30 were consulted for the mold fungal strains; 7 strains {*A. clavatus* (ATCC 1007), *A. niger* (ATCC 6275), *Ch. globosum* (ATCC 6205), *Cl. cladosporioides* (ATCC 13276), *M. verrucaria* (ATCC 9095), *P. citrinum* (ATCC 9849) and *T. viride* (ATCC8678)} were tested. The wood decay fungi used were *T. versicolor* (BCRC 35253), *Phaeo. chrysosporium* (BCRC 36200), *Phaeo. schweinitzii* (BCRC 35365) and *L. sulphureus* (BCRC 35305). Antifungal assays were carried out in triplicate and data were averaged. Different concentrations of the essential oils (12.5-1000 µg/mL) were added to sterilized potato dextrose agar (PDA). The test plates were incubated at 27°C. When the mycelium of fungi reached the edge of the control plate, the antifungal index was calculated as follows:

Anti-fungal index (%) = $(1 - Da/Db) \times 100$, where Da is the diameter of the growth zone in the experimental dish (cm) and Db is the diameter of the growth zone in the control dish (cm).

References

- [1] Yang YP, Liu HY. (1999) *Manual of Taiwan vascular plants*. Council of Agriculture, Executive Yuan, Taipei.
- [2] Yu D, Dai Z, Li L, Yu X, Xie J. (1994) The chemical constituents of essential oil from leaves of *Juniperus formosana* Hayata. *Journal of Yunnan University*, **16**, 145-148.
- [3] Adams RP, Zhang SZ, Chu GL. (1995) Essential oil of *Juniperus formosana* Hayata leaves from China. *Journal of Essential Oil Research*, **7**, 687-689.
- [4] Yu D, Xie J. (1995) The study of chemical constituents of essential oil from the fruits of *Juniperus formosana* Hayata. *Journal of Yunnan University*, **17**, 387-389.
- [5] Su YC, Ho CL, Wang EIC, Chang ST. (2006) Antifungal activities and chemical compositions of essential oils from leaves of four *Eucalyptus*. *Taiwan Journal of Forest Science*, **21**, 49-61.
- [6] Ho CL, Hsu KP, Chien TC, Wang EIC, Su YC. (2009) Essential oil compositions and antimicrobial paper activities of the various parts of *Litsea cubeba* (Lour.) from Taiwan. *Cross Strait Forest Products Technology Symposium Proceedings of 2009*, 80-82.

- [6] Ho CL, Hsu KP, Chien TC, Wang EIC, Su YC. (2009) Essential oil compositions and antimicrobial paper activities of the various parts of *Litsea cubeba* (Lour.) from Taiwan. *Cross Strait Forest Products Technology Symposium Proceedings of 2009*, 80-82.
- [7] Ho CL, Hsu KP, Tseng YH, Liao PC, Wang EIC, Narumon J, Chien TC, Dong WC, Su YC. (2010) Composition and antifungal activities of the leaf essential oil of *Litsea coreana* from Taiwan. *Natural Product Communications*, 5, 1677-1680.
- [8] Ho, CL, Liao PC, Wang, EIC, Su, YC. (2011) Composition and antifungal activities of the leaf essential oil of *Neolitsea parvigemma* from Taiwan. *Natural Product Communications*, 6, 1357-1360.
- [9] Adams RP. (2001) *Identification of essential oil components by gas chromatography/quadruple mass spectroscopy*. Allured, Carol Stream, IL.
- [10] Nabeta K, Katayama M, Matsubara C, Hatakeyama T, Shimada H, Tazaki H. (1992) Oxygenated sesquiterpenes from needles of Korean pine (*Pinus koraiensis* Sieb.). *Mokuzai Gakkaishi*, 38, 963-971.
- [11] Wang SY, Wu CL, Chu FH, Chien SC, Kuo YH, Shyur LF, Chang ST. (2005) Chemical composition and antifungal activity of essential oil isolated from *Chamaecyparis formosensis* Matsum. wood. *Holzforschung*, 59, 295-299.
- [12] Ho CL, Liao PC, Wang EIC, Dong WZ, Su YC. (2010) Composition and antimicrobial and anti-wood-decay fungal activities of the leaf essential oils of *Machilus pseudolongifolia* from Taiwan. *Natural Product Communications*, 5, 1143-1146.
- [13] Ho CL, Hsu KP, Wang EIC, Lin CY, Su YC. (2010) Composition and anti-wood-decay fungal activities of the leaf essential oil of *Machilus philippinensis* from Taiwan. *Natural Product Communications*, 5, 337-340.
- [14] Ho CL, Wang EIC, Su YC. (2009) Essential oil compositions and bioactivities of the various parts of *Cinnamomum camphora* Sieb. var. *linaloolifera* Fujuta. *Quarterly Journal of Forest Research*, 31, 77-95.
- [15] Wang SY, Chen PF, Chang ST. (2005) Antifungal activities of essential oils and their constituents from indigenous cinnamon (*Cinnamomum osmophloeum*) leaves against wood decay fungi. *Bioresource Technology*, 96, 813-818.
- [16] Ho CL, Liao PC, Tseng YH, Wang EIC, Su YC. (2009) Composition and antimicrobial activity of the leaf and twig oils of *Litsea mushaensis* and *L. linnii* from Taiwan. *Natural Product Communications*, 5, 1783-1788.
- [17] Su YC, Ho CL. (2013) Composition and two activities of the leaf essential oil of *Litsea acuminata* (Blume) Kurata from Taiwan. *Records of Natural Products*, 7, 27-34.
- [18] Massada Y. (1976) *Analysis of Essential Oil by Gas Chromatography and Spectrometry*, Wiley, New York.

<i>In vitro</i> Anti-diabetic Activity of <i>Sclerocarya birrea</i> and <i>Ziziphus mucronata</i> Nuno M.H. Da Costa Mousinho, Jacob J. van Tonder and Vanessa Steenkamp	1279
Secondary Metabolites from the Fungus <i>Emericella nidulans</i> Amer H. Tarawneh, Francisco León, Mohamed M. Radwan, Luiz H. Rosa and Stephen J. Cutler	1285
A New Glucuronolactone Glycoside Phoenixoside B from the Seeds of <i>Phoenix dactylifera</i> Sumbul Azmat, Rehana Ifzal, Faryal Vali Mohammad, Viqar Uddin Ahmad and Aqib Zahoor	1289
Cancer-Suppressive Potential of Extracts of Endemic Plant <i>Helichrysum zivojinii</i>: Effects on Cell Migration, Invasion and Angiogenesis Ivana Z. Matić, Ivana Aljančić, Vlatka Vajs, Milka Jadrnin, Nevenka Gligorijević, Slobodan Milosavljević and Zorica D. Juranić	1291
Analysis of Volatile Components, Fatty Acids, and Phytosterols of <i>Abies koreana</i> growing in Poland Anna Wajs-Bonikowska, Karol Olejnik, Radosław Bonikowski and Piotr Banaszczak	1297
Cytotoxic Effects of Air Freshener Biocides in Lung Epithelial Cells Jung-Taek Kwon, Mimi Lee, Gun-Baek Seo, Hyun-Mi Kim, Ilseob Shim, Doo-Hee Lee, Taksoo Kim, Jung Kwan Seo, Pilje Kim and Kyunghee Choi	1301
GC/GC-MS Analysis, Isolation and Identification of Bioactive Essential Oil Components from the Bhutanese Medicinal Plant, <i>Pleurospermum amabile</i> Phurpa Wangchuk, Paul A. Keller, Stephen G. Pyne, Malai Taweechotipatr and Sumalee Kamchonwongpaisan	1305
Antibacterial Activity of the Essential Oil of <i>Heracleum sibiricum</i> Dragoljub L. Miladinović, Budimir S. Ilić, Tatjana M. Mihajilov-Krstev, Dejan M. Nikolić, Olga G. Cvetković, Marija S. Marković and Ljiljana C. Miladinović	1309
Assessment of the Chemical Composition and <i>in vitro</i> Antimicrobial Potential of Extracts of the Liverwort <i>Scapania aspera</i> Danka R. Bukvicki, Amit K. Tyagi, Davide G. Gottardi, Milan M. Veljic, Snezana M. Jankovic, Maria E. Guerzoni and Petar D. Marin	1313
Essential Oils of <i>Alpinia rafflesiana</i> and Their Antimicrobial Activities Shariha Jusoh, Hasnah Mohd. Sirat and Farediah Ahmad	1317
Chemical Composition and Synergistic Antioxidant Activities of Essential Oils from <i>Atractylodes macrocephala</i> and <i>Astragalus membranaceus</i> Jinkui Li, Feng Li, Yan Xu, Wenjian Yang, Lili Qu, Qian Xiang, Cong Liu and Dapeng Li	1321
Chemical Analysis and Antioxidant Activity of the Essential Oils of Three Piperaceae Species Growing in the Central Region of Cuba Elisa Jorge Rodríguez, Yanelis Saucedo-Hernández, Yvan Vander Heyden, Ernesto F. Simó-Alfonso, Guillermo Ramis-Ramos, María Jesús Lerma-García, Urbano Monteagudo, Luis Bravo, Mildred Medinilla, Yuriam de Armas and José Manuel Herrero-Martínez	1325
The Composition, Anti-mildew and Anti-wood-decay Fungal Activities of the Leaf and Fruit Oils of <i>Juniperus formosana</i> from Taiwan Yu-Chang Su, Kuan-Ping Hsu, Eugene I-Chen Wang and Chen-Lung Ho	1329

Meeting/Report

Meeting Report: <i>First National Meeting on Aloe, April 20-21, 2013, Isernia, Italy</i> New Perspectives in Aloe Research: from Basic Science to Clinical Application Raffaele Capasso, Massimiliano Laudato and Francesca Borrelli	1333
----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	------

Review/Account

Alkaloids of the South African Amaryllidaceae: a Review Jerald J. Nair, Jaime Bastida, Carles Codina, Francesc Viladomat and Johannes van Staden	1335
------------------------------------------------------------------------------------------------------------------------------------------------------------	------

Natural Product Communications

2013

Volume 8, Number 9

Contents

<u>Original Paper</u>	<u>Page</u>
Alternate Biosynthesis of Valerenadiene and Related Sesquiterpenes Shashikumar K. Paknikar, Shahuraj H. Kadam, April L. Ehrlich and Robert B. Bates	1195
A Facile Synthesis of (±)-Heliannuol-D Tao Zhang, Liang-Zhu Huang, You-Qiang Li, Yimg-Meng Xu and Zhen-Ting Du	1197
A New Bioactive Diterpene Glycoside from <i>Molinaea retusa</i> from the Madagascar Dry Forest Alexander L. Eaton, Liva Harinantenaina, Peggy J. Brodie, Maria B. Cassera, Jessica D. Bowman, Martin W. Callmänder, Richard Randrianaivo, Roland Rakotondrajoana, Etienne Rakotobe, Vincent E. Rasamison and David G. I. Kingston	1201
Nitric Oxide and Tumor Necrosis factor-α Inhibitory Substances from the Rhizomes of <i>Kaempferia marginata</i> Kanidta Kaewkroek, Chatchai Wattanapiromsakul, Palangpon Kongsaree and Supinya Tewtrakul	1205
Bisembranoids from the Marine Sponge <i>Petrosia nigricans</i> Nguyen Xuan Nhiem, Ngo Van Quang, Chau Van Minh, Dan Thi Thuy Hang, Hoang Le Tuan Anh, Bui Huu Tai, Pham Hai Yen, Nguyen Thi Hoai, Do Cong Thung and Phan Van Kiem	1209
Isolation of Cycloeculanol from <i>Boophone disticha</i> and Evaluation of its Cytotoxicity Emmanuel Adekanmi Adewusi, Paul Steenkamp, Gerda Fouche and Vanessa Steenkamp	1213
Chemical Constituents from an Endophytic Fungus <i>Chaetomium globosum</i> Z1 Chun-Yan Zhang, Xiao Ji, Xuan Gui and Bao-Kang Huang	1217
Determination of C-23 Configuration in (20R)-23-Hydroxycholestane Side Chain of Steroid Compounds by ^1H and ^{13}C NMR Spectroscopy Alla A. Kicha, Anatoly I. Kalinovsky, Alexander S. Antonov, Oleg S. Radchenko, Natalia V. Ivanchina, Timofey V. Malyarenko, Alexander M. Savchenko and Valentin A. Stonik	1219
Oxasetin from <i>Lophiostoma</i> sp. of the Baltic Sea: Identification, <i>in silico</i> Binding Mode Prediction and Antibacterial Evaluation against Fish Pathogenic Bacteria Muftah Ali M. Shushni, Faizul Azam and Ulrike Lindequist	1223
Chemical Constituents from the Fruit Body of <i>Chlorophyllum molybdites</i> Zushang Su, Ping Wang, Wei Yuan, and Shiyu Li	1227
Pulchranins B and C, New Acyclic Guanidine Alkaloids from the Far-Eastern Marine Sponge <i>Monanchora pulchra</i> Tatyana N. Makarieva, Ekaterina K. Ogurtsova, Yuliya V. Korolkova, Yaroslav A. Andreev, Irina V. Mosharova, Ksenya M. Tabakmakher, Alla G. Guzii, Vladimir A. Denisenko, Pavel S. Dmitrenok, Hyi-Seung Lee, Eugene V. Grishin and Valentin A. Stonik	1229
Cloning and Characterization of a cDNA Encoding Calcium/Calmodulin-dependent Glutamate Decarboxylase from <i>Scutellaria baicalensis</i> Yeon Bok Kim, Md Romij Uddin, Do Yeon Kwon, Min-Ki Lee, Sun-Ju Kim, Chanhui Lee and Sang Un Park	1233
Biflavonoids, Main Constituents from <i>Garcinia bakeriana</i> Leaves Ahmed Al-Shagdari, Adonis Bello Alarcón, Osmany Cuesta-Rubio, Anna Lisa Piccinelli and Luca Rastrelli	1237
Analysis of Flavonoids and Iridoids in <i>Vitex negundo</i> by HPLC-PDA and Method Validation Somendu K. Roy, Khemraj Bairwa, Jagdeep Grover, Amit Srivastava and Sanjay M. Jachak	1241
Chemical Constituents of the Leaves of <i>Triumfetta semitriloba</i> Alejandra Barraza-Morales, Deisy Medrano-Nahuat, Sergio R. Peraza-Sánchez	1245
Phytochemical Evaluation of <i>Lythrum salicaria</i> Extracts and Their Effects on Guinea-pig Ileum Tímea Bencsik, Loránd Barthó, Viktor Sándor, Nóra Papp, Rita Benkó, Attila Felinger, Ferenc Kilár and Györgyi Horváth	1247
New Flavonol Glycosides from the Leaves of <i>Triantha japonica</i> and <i>Tofieldia nuda</i> Tsukasa Iwashina, Minoru N. Tamura, Yoshinori Murai and Junichi Kitajima	1251
Cytotoxic Activity of Dihydrochalcones Isolated from <i>Corema album</i> Leaves against HT-29 Colon Cancer Cells Antonio J. León-González, Miguel López-Lázaro, José L. Espartero and Carmen Martín-Cordero	1255
Immunomodulatory Activities of α-Mangostin on Peripheral Blood Mononuclear Cells Pimolkan Kasemwattanaoj, Primchanien Moongkarndi, Kovit Pattanapanyasat, Supachoke Mangmool, Ekkarat Rodpai, Jutima Samer, Julaporn Konlata and Kasama Sukapirom	1257
Antiplasmodial Quinones from the Rhizomes of <i>Kniphofia foliosa</i> Martha Induli, Meron Gebru, Negera Abdissa, Hosea Akala, Ingrid Wekesa, Robert Byamukama, Matthias Heydenreich, Sylvia Murunga, Ermias Dagne and Abiy Yenesew	1261
Biphenyl Derivatives from <i>Garcinia schomburgkiana</i> and the Cytotoxicity of the Isolated Compounds Chihiro Ito, Takuya Matsui, Eri Noda, Nijisiri Ruangrunsi and Masataka Itoigawa	1265
Anticarcinogenic Effect and Carcinogenic Potential of the Dietary Phenolic Acid: <i>o</i>-Coumaric Acid Alaattin Sen, Pelin Atmaca, Gulsum Terzioğlu and Sevki Arslan	1269
Bioproduction and Optimization of Rosmarinic Acid Production in <i>Solenostemon scutellarioides</i> through Media Manipulation and Conservation of High Yielding Clone via Encapsulation Ranabir Sahu, Saikat Dewanjee and Moumita Gangopadhyay	1275

Continued inside backcover