

NATURAL PRODUCT COMMUNICATIONS

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



Volume 1, No. 1, 1978
ISSN 0368-0769
New York, N.Y.

0-09

Bukti online

<http://members.naturalproduct.us/secure/issue.aspx?volumeissueid=99>




catatan: arsip jurnal hanya dapat dibuka bagi member. Registrasi untuk member adalah free

Natural Product Communications

Welcome, suciatiryani@yahoo.com | [Log Out](#)[Home](#)
[Journal Archive](#)
[Change Security](#)

Volume No. 9 2014

No. 2

-  [Authors \(88KB\)](#)
-  [Manuscripts in Press \(147KB\)](#)
-  [Table of Contents \(167KB\)](#)

Volatile Glycosides from the Leaves of *Morus alba* with a Potential Contribution to the Complex Anti-diabetic Activity

Attila Hunyadi, Ibolya Herke, Katalin Veres, Anna Erdei, András Simon and Gábor Tóth

Keywords: *Morus alba*, Mulberry leaves, Megastigmane glycoside, Phenyl-propane, GC-MS, Type 2 diabetes, NIDDM, Anti-diabetic.

Web Published Date: 31 Jan 2014

 [Abstract \(104KB\)](#)

A New Eudesmane Sesquiterpene from *Dichrocephala integrifolia*

Fang Qin, Yi-Bing Wu, Rui-xia Guo, Mei Dong, Françoise Sauriol, Qing-Wen Shi, Yu-Cheng Gu and Hiromasa Kiyota

Keywords: Asteraceae, *Dichrocephala integrifolia*, Eudesmane, Sesquiterpene, Spectral analysis.

Web Published Date: 31 Jan 2014

 [Abstract \(100KB\)](#)

Evaluation of the Anti-melanoma Activities of Sarcophine, (+)-7 α ,8 β -Dihydroxydeepoxysarcophine and Sarcophytolide from the Red Sea Soft Coral *Sarcophyton glaucum*

Pawel T. Szymanski, Safwat A. Ahmed, Mohamed M. Radwan, Sherief I. Khalifa and Hesham Fahmy

Keywords: Cembranoids, Sarcophine, *Sarcophyton glaucum*, Skin cancer, Melanoma.

Web Published Date: 31 Jan 2014

 [Abstract \(125KB\)](#)

Steroidal Aglycones from Stems of *Marsdenia tenacissima* that Inhibited the Hedgehog Signaling Pathway

Lin Zhang, Feng-yang Chen, Shi-fang Xu, Yi-ping Ye and Xiao-yu Li

Keywords: *Marsdenia tenacissima*, Asclepiadaceae, Steroidal aglycone, Hedgehog signaling pathway.

Web Published Date: 31 Jan 2014

 [Abstract \(91KB\)](#)

Chemical Constituents, and their Cytotoxicity, of the Rare Wood Decaying Fungus *Xylaria humosa*

Sirirath Sodngam, Sasiphimol Sawadstitang, Nuttika Suwannasai and Wiyada Mongkolthanaruk

Keywords: *Xylaria humosa*, Xylariaceae, Natural products, Cytotoxicity, Tryptoquivaline, Triterpenoid, Quinazolinone.

Web Published Date: 31 Jan 2014

 [Abstract \(98KB\)](#)

Synthesis of 2-Acetyl-1,4-Dimethoxynaphthalene, A Potential Intermediate for Disubstituted Naphtho[2,3,c]pyran-5,10-dione*Kimberly Chinae, William Vera and Ajoy K. Banerjee*

Keywords: Bromination, Substitution, Methylation, Acetylation.

Web Published Date: 31 Jan 2014



Abstract (59KB)

Anthraquinone and Naphthoquinone Derivatives from the Roots of *Coptosapelta flavescens**Wipapan Kongyen, Vatcharin Rukachaisirikul, Souwalak Phongpaichit, Nongyao Sawangjaroen, Phruksa Songsing and Hattaya Madardam*Keywords: *Coptosapelta flavescens*, Rubiaceae, Antibacterial, Antiprotozoal, Anthraquinone, Naphthoquinone.

Web Published Date: 31 Jan 2014



Abstract (90KB)

Methicillin-resistant *Staphylococcus aureus*, Vancomycin-resistant *Enterococcus faecalis* and *Enterococcus faecium* active Dimeric Isobutyrylphloroglucinol from *Ivesia gordonii**Marwa H. Ahmed, Mohamed Ali Ibrahim, Jin Zhang, Farouk R. Melek, Seham S. El-Hawary, Melissa R. Jacob and Ilias Muhammad*Keywords: *Ivesia gordonii*, 1,5-Dihydroxy-2-(2'-methylpropionyl)-3-methoxy-6-methylbenzene, Diacetylphloroglucinol, Antimicrobial, Methicillin-resistant *Staphylococcus aureus*, Vancomycin-resistant *Enterococcus faecium*, *Enterococcus faecalis*.

Web Published Date: 31 Jan 2014



Abstract (127KB)

Biological Studies of Turmeric Oil, Part 3: Anti-Inflammatory and Analgesic Properties of Turmeric Oil and Fish Oil in Comparison with Aspirin*James N. Jacob and Dinesh K. Badyal*

Keywords: Turmeric oil, Fish oil, Aspirin, Inflammation, Analgesic properties, Eicosapentaenoic acid (EPA), Docosahexaenoic acid (DHA).

Web Published Date: 31 Jan 2014



Abstract (64KB)

Cyclic Dipeptides Produced by Marine Sponge-Associated Bacteria as Quorum Sensing Signals*Gennaro Roberto Abbamondi, Salvatore De Rosa, Carmine Iodice and Giuseppina Tommonaro*

Keywords: Quorum sensing, Diketopiperazines, Plate "T" streak bioassay, Inter-kingdom cross talking.

Web Published Date: 31 Jan 2014



Abstract (81KB)

Isolation of the Tetrapeptide Apicidins G, H and I from the Fungus *Fusarium semitectum**Suciati and Mary J. Garson*Keywords: Tetrapeptides, Apicidins, Fungus, *Fusarium*.

Web Published Date: 31 Jan 2014



Abstract (78KB)

The Co-identity of Lipiamycin A3 and Tiacumicin B*Angelo Bedeschi, Piera Fonte, Giovanni Fronza, Claudio Fuganti and Stefano Serra*Keywords: Lipiamycin A3, Clostomicin B1, Tiacumicin B, *Actinoplanes deccanensis*, *Micromonospora echinospora*, *Dactylosporangium aurantiacum*, Macrolactone antibiotics, Chemical structure revision.

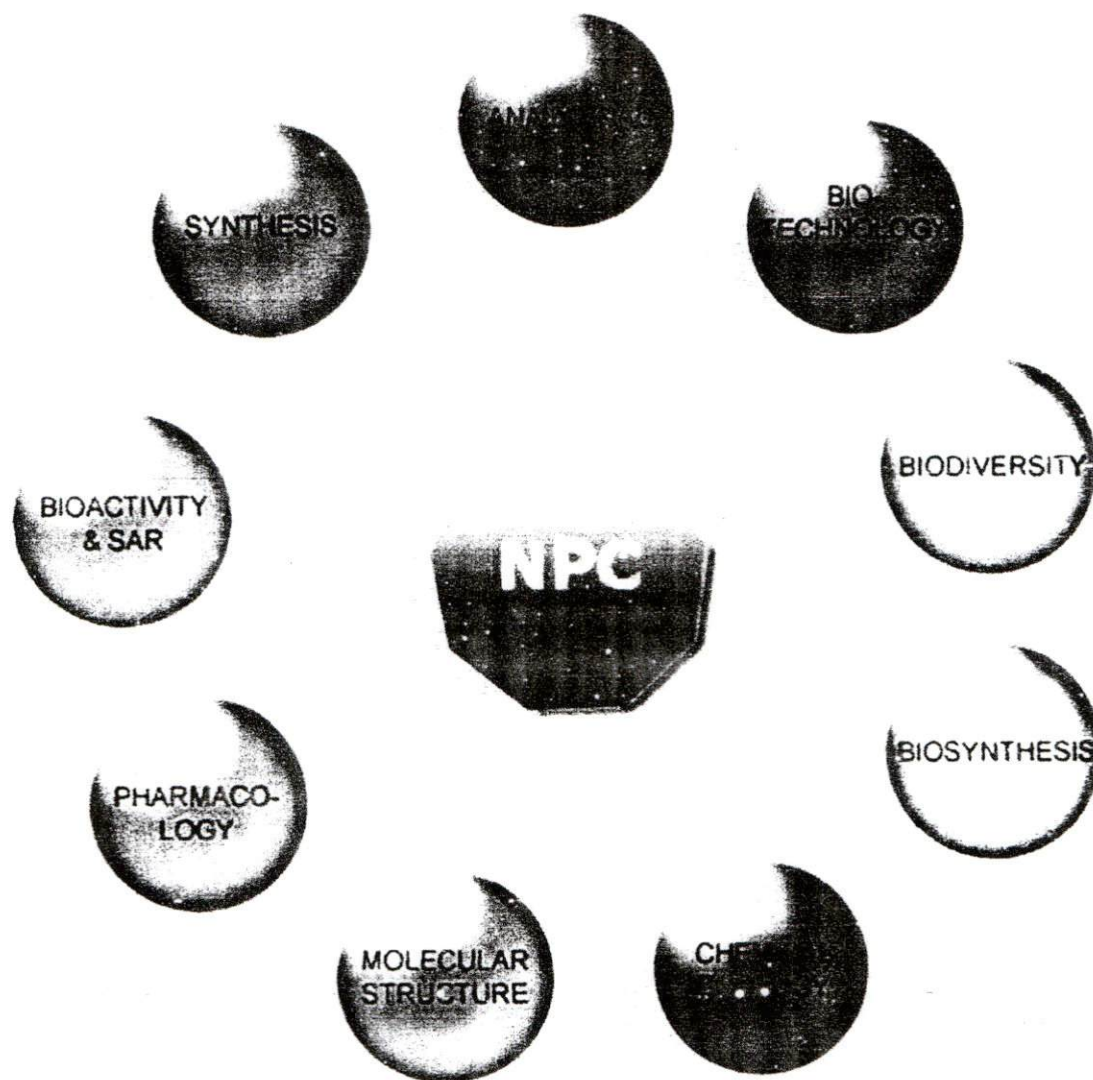
Web Published Date: 31 Jan 2014



Abstract (79KB)

NATURAL PRODUCT COMMUNICATIONS

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



Volume 9, Issue 2, Pages 145-292, 2014
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,
Universita 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 H. 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@iunm.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@dsi.pipes.com

ADVISORY BOARD

Prof. Viqar Uddin Ahmad
Karachi, Pakistan

Prof. Giovanni Appendino
Novara, Italy

Prof. Yoshinori Asakawa
Tokushima, Japan

Prof. Roberto G. S. Berlinck
São Carlos, Brazil

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. Fatih Demirci
Eskişehir, Turkey

Prof. Dominique Guillaume
Reims, France

Prof. Ana Cristina Figueiredo
Lisbon, Portugal

Prof. Cristina Gracia-Viguera
Murcia, Spain

Prof. Duvvuru Gunasekar
Thirupati, India

Prof. Hisahiro Hagiwara
Niigata, Japan

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. Chiaki Kuroda
Tokyo, Japan

Prof. Hartmut Laatsch
Göttingen, Germany

Prof. Marie Lacaille-Dubois
Dijon, France

Prof. Shoen-Sheng Lee
Taipei, Taiwan

Prof. Imre Mathe
Szeged, Hungary

Prof. Ermino Murano
Trieste, Italy

Prof. M. Soledad C. Pedras
Saskatoon, Canada

Prof. Luc Pieters
Antwerp, Belgium

Prof. Peter Proksch
Düsseldorf, Germany

Prof. Phila Raharivelomanana
Tahiti, French Polynesia

Prof. Luca Pastrelli
Fisciano, Italy

Prof. Stefano Serra
Milano, Italy

Prof. Monique Simmonds
Richmond, UK

Dr. Bikram Singh
Palampur, India

Prof. John L. Sorensen
Manitoba, Canada

Prof. Johannes van Stadec
Scottsville, South Africa

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. 2014 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.

Natural Product Communications

2014

Volume 9, Number 2

Contents

<i>Original Paper</i>	<i>Page</i>
Volatile Glycosides from the Leaves of <i>Morus alba</i> with a Potential Contribution to the Complex Anti-diabetic Activity Attila Hunyadi, Ibolya Herke, Katalin Veres, Anna Erdei, András Simon and Gábor Tóth	145
A New Eudesmane Sesquiterpene from <i>Dichrocephala integrifolia</i> Fang Qin, Yi-Bing Wu, Rui-xia Guo, Mei Dong, Françoise Sauriol, Qing-Wen Shi, Yu-Cheng Gu and Hiromasa Kiyota	149
Evaluation of the Anti-melanoma Activities of Sarcophine, (+)-7α,8β-Dihydroxydeepsarcophine and Sarcophytolide from the Red Sea Soft Coral <i>Sarcophyton glaucum</i> Pawel T. Szymanski, Safwat A. Ahmed, Mohamed M. Radwan, Sherief I. Khalifa and Hesham Fahmy	151
Steroidal Aglycones from Stems of <i>Marsdenia tenacissima</i> that Inhibited the Hedgehog Signaling Pathway Lin Zhang, Feng-yang Chen, Shi-fang Xu, Yi-ping Ye and Xiao-yu Li	155
Chemical Constituents, and their Cytotoxicity, of the Rare Wood Decaying Fungus <i>Xylaria humosa</i> Sirirath Sodngam, Sasiphimol Sawadstitang, Nuttika Suwannasai and Wiyada Mongkolthanaruk	157
Alkaloids from <i>Habranthus tubispathus</i> and <i>H. jamesonii</i>, two Amaryllidaceae with Acetyl- and Butyrylcholinesterase Inhibition Activity Valeria Cavallaro, Natalia P. Alza, Maria G. Murray and Ana P. Murray	159
Further Characterization of Foliar Flavonoids in <i>Crossostephium chinense</i> and their Geographic Variation Ayumi Uehara, Junichi Kitajima, Goro Kokubugata and Tsukasa Iwashina	163
Hawaiian Propolis: Comparative Analysis and Botanical Origin Saori Inui, Takahiro Hosoya and Shigenori Kumazawa	165
Nutritional and Functional Properties of Aqueous and Hydroalcoholic Extracts from Argentinean Propolis Fátima C. Danert, Catiana Zampini, Roxana Ordoñez, Luis Maldonado, Enrique Bedascarrasbure and María Inés Isla	167
Anti-trypanosomal Phenolic Derivatives from <i>Baccharis uncinella</i> Simone dos S. Grecco, Maria Júlia P. Félix, João Henrique G. Lago, Érika G. Pinto, André G. Tempone, Paulete Romoff, Marcelo José P. Ferreira and Patricia Sartorelli	171
Polyphenols in Representative <i>Teucrium</i> Species in the Flora of R. Macedonia: LC/DAD/ESI-MSⁿ Profile and Content Ilija Mitreski, Jasmina Petreska Stanoeva, Marina Stefova, Gjosh Stefkov and Svetlana Kulevanova	175
<i>In vitro</i> Inhibitory Effects of <i>Limonium contortirameum</i> and <i>L. virgatum</i> Extracts from Sardinia on α-Amylase, α-Glucosidase and Pancreatic Lipase Marzia Foddai, Violet Kasabri, Giacomo L. Petretto, Emanuela Azara, Angela Sias, Fatma U. Afifi, Giovanna Delogu, Mario Chessa and Giorgio Pintore	181
Search for Skin-whitening Agent from <i>Prunus</i> Plants and the Molecular Targets in Melanogenesis Pathway of Active Compounds Kazuya Murata, Keisuke Takahashi, Haruka Nakamura, Kimihisa Itoh and Hideaki Matsuda	185
<i>In Silico</i> Prediction of Tyrosinase and Adenylyl Cyclase Inhibitors from Natural Compounds Pedro Fong, Henry H. Y. Tong and Chi M. Chao	189
Molecular Docking and Reaction Kinetic Studies of Chrysin Binding to Serum Albumin Bingli Jiang, Anran Zhao, Jianhua Miao, Pengfei Chang, Hailin Chen, Weigao Pan and Cuiwu Lin	195
Anthocyanins from the Flowers of Nagai Line of Japanese Garden Iris (<i>Iris ensata</i>) Kaori Kitahara, Yoshinori Murai, Sang Woo Bang, Junichi Kitajima, Tsukasa Iwashina and Yukio Kaneko	201
New Chromone and Triglyceride from <i>Cucumis melo</i> Seeds Sabrin R. M. Ibrahim	205
Five New Acylphloroglucinol Glycosides from the Leaves of <i>Eucalyptus robusta</i> Qian-Yi Guo, Xiao-Jun Huang, Bing-Xin Zhao, Yu-Qing Jian, Shi-Lin Luo, Ying Wang and Wen-Cai Ye	209
Umsic acid and Triacylglycerides Production by the Cultured Lichen Mycobiont of <i>Ramalina celastri</i> Alejandra T. Fazio, Mónica T. Adler and Marta S. Maier	213
A New Lignan Glycoside from <i>Chamaecyparis obtusa</i> var. <i>breviramea</i> f. <i>crippsii</i> Jian Xu, Guang-Zhi Zeng, Ke-Li Chen, Yi-Mei Liu, Zhang-Hua Sun, Ning-Hua Tan and Yu-Mei Zhang	215
Synthesis of 2-Acetyl-1,4-Dimethoxynaphthalene, A Potential Intermediate for Disubstituted Naphtho[2,3-c]pyran-5,10-dione Kimberly Chinae, William Vera and Ajoy K. Banerjee	217
Anthraquinone and Naphthoquinone Derivatives from the Roots of <i>Coptosapelta flavescens</i> Wipapan Kongyen, Vatcharin Rukachaisirikul, Souwalak Phongpaichit, Nongyao Sawangjaroen, Phruksa Songsing and Hattaya Madardam	219
Methicillin-resistant <i>Staphylococcus aureus</i>, Vancomycin-resistant <i>Enterococcus faecalis</i> and <i>Enterococcus faecium</i> active Dimeric Isobutyrylphloroglucinol from <i>Ivesia gordonii</i>	221
Biological Studies of Turmeric Oil, Part 3: Anti-Inflammatory and Analgesic Properties of Turmeric Oil and Fish Oil in Comparison with Aspirin James N. Jacob and Dinesh K. Badyal	225

Continued inside backcover

Cyclic Dipeptides Produced by Marine Sponge-Associated Bacteria as Quorum Sensing Signals Gennaro Roberto Abbamondi, Salvatore De Rosa, Carmine Iodice and Giuseppina Tommonaro	229
Isolation of the Tetrapeptide Apicidin G, H and I from the Fungus <i>Fusarium semitectum</i> Suciati and Mary J. Garson	233
The Co-identity of Lipiarmycin A3 and Tiacumicin B Angelo Bedeschi, Piera Fonte, Giovanni Fronza, Claudio Fuganti and Stefano Serra	237
PSY-1, a <i>Taxus chinensis</i> var. <i>mairei</i> Extract, Inhibits Cancer Cell Metastasis by Interfering with MMPs Zao-qian Zheng, Ying-Ying Fu, Bo-Heng Li, Mei-Ling Zhang, Xiu-Li Yang, Chuan-wei Xin, Jia-na Shi, Yin Ying and Ping Huang	241
Antimicrobial Activity of Endophytic Fungi Isolated from <i>Swietenia macrophylla</i> Leaves Darah Ibrahim, Chong Chai Lee and Lim Sheh-Hong	247
Aroma Profile of Star Anise and the Structure-odor Relationship of Anethole Toshio Hasegawa, Haruna Seimiya, Takashi Fujihara, Noriko Fujiwara and Hideo Yamada	251
The Essential Oil of <i>Populus balsamifera</i> Buds: Its Chemical Composition and Cytotoxic Activity Marianne Piochon-Gauthier, Jean Legault, Muriel Sylvestre and André Pichette	257
Comparative Chemical Study and Cytotoxic Activity of <i>Uvariadendron angustifolium</i> Essential Oils from Benin Jean-Pierre Noudogbessi, Magali Gary-Bobo, Aristide Adomou, Elvis Adjalian, Guy Alain Alitonou, Félicien Avlessi, Marcel Garcia, Dominique C. K. Sohounlhoue and Chantal Menut	261
Composition of Essential Oil from <i>Tagetes minuta</i> and its Cytotoxic, Antioxidant and Antimicrobial Activities Nasser A. Awadh Ali, Farukh S. Sharopov, Ali G. Al-kaf, Gabrielle M. Hill, Norbert Arnold, Saeed S. Al-Sokari, William N. Setzer and Ludger Wessjohann	265
Chemical Composition of the Essential Oil of <i>Croton bonplandianus</i> from India Rajesh K. Joshi	269
Chemical Composition of <i>Angelica paniculata</i> Essential Oil Determined by Liquid and Headspace GC-MS Techniques Strahinja R. Simonović, Vesna P. Stankov-Jovanović, Violeta D. Mitić, Marija D. Ilić, Goran M. Petrović and Gordana S. Stojanović	271
Chemical Description and Essential Oil Yield Variability of Different Accessions of <i>Salvia lavandulifolia</i> Jaime Usano-Alemay, Jesús Pala-Paúl, Manuel Santa-Cruz Rodríguez and David Herraiz-Peñalver	273
Antimicrobial Constituents and Synergism Effect of the Essential Oils from <i>Cymbopogon citratus</i> and <i>Alpinia galanga</i> Sarin Tadtong, Rith Watthanachaiyingcharoen and Narisa Kamkaen	277
<i>In vitro</i> Antibacterial Activity of <i>Lidanosol</i> Essential Oil in Combination with Conventional Antibiotics Dragoljub L. Miladinović, Budimir S. Ilić, Tatjana M. Mihajilov-Krstev, Jovana L. Jović and Marija S. Marković	281
<u>Review/Account</u>	
Modernization of Ayurveda: A Brief Overview of Indian Initiatives Ambarish Mukherjee, Mousumi Banerjee, Vivekananda Mandal, Amrithesh C. Shukla and Subhash C. Mandal	287

Isolation of the Tetrapeptide Apicidins G, H and I from the Fungus *Fusarium semitectum*Suciati^{a,b} and Mary J. Garson^{a,*}^aSchool of Chemistry and Molecular Biosciences, The University of Queensland, Brisbane QLD 4072, Australia^bFaculty of Pharmacy, Airlangga University, Surabaya, East Java 60286, Indonesia

m.garson@uq.edu.au

Received: November 7th, 2013; Accepted: December 12th, 2013

This study reports the isolation and characterization of three new tetrapeptides, apicidins G (1), H (2) and I (3), along with the known apicidin (4), apicidin A (5), apicidin C (6), diketopiperazine 7, equisetin (8) and 7-hydroxy-2-(2-hydroxypropyl)-5-methylchromone (9). The structures of the new compounds were deduced by 2D NMR spectroscopic and MS data.

Keywords: Tetrapeptides, Apicidins, Fungus, *Fusarium*.

Fusarium semitectum (Syn. *Fusarium pallidoroseum*) is a fast growing fungus which was first described in 1875 from the petioles of banana leaves [1]. In common with other *Fusarium* species, *F. semitectum* has the ability to produce mycotoxins, such as nivalenol and (-)-zearalenone [2,3]. Other metabolites isolated include the antibiotic equisetin and α -pyrones, for example fusapyrone and deoxyfusapyrone [4,5]. In 1996, Singh *et al.* reported the isolation of the cyclic tetrapeptides apicidin and apicidin A from *Fusarium pallidoroseum* [6a]. Subsequent investigation of the same *F. pallidoroseum* sample by Singh *et al.* yielded apicidins B, C, D₁, D₂ and D₃ [6b-6c]. The unusual structural motif in apicidins is the presence of the amino acid 2-amino-8-oxo-decanoic acid (Aoda). Substitution of the Aoda residues has been reported for apicidins D₁-D₃ [6c]. All apicidins contain a (*D*)-pipecolic acid (Pip) unit, except for apicidin B, which has a (*D*)-proline (Pro) residue. Apicidin C has a (*L*)-valine residue instead of (*L*)-isoleucine (Ile). An *N*-methoxy-(*L*)-tryptophan is present in both apicidin and its congeners, except for apicidin A. This series of compounds has shown antiprotozoal activity by reversible blocking of histone deacetylase (HDAC) inhibitors [6d]. Apicidins are structurally related to trapoxin A, HC-toxin, WF-3161, Cyl-2 and chlamydocin [7-11]. The long chain amino acid with a terminal epoxy group in each of these cyclic tetrapeptides has been suggested to be responsible for their antiproliferative activity [12]. Jin *et al.* have identified the gene cluster responsible for apicidin biosynthesis in *F. semitectum*, and isolated apicidin E containing a 2-aminodecanoic acid unit [13]. Apicidin F, with *L*-phenylalanine (Phe) instead of Ile and *L*-2-aminooctanedioic acid instead of Aoda, has recently been identified from *F. fujikuroi* [14]. In this report, we describe the isolation and structure elucidation of three new tetrapeptides, apicidins G, H and I (1-3), together with six known compounds from *F. semitectum* (Figure 1). The stereochemistry of the new apicidins was proposed by comparison with the known apicidins and from biosynthetic considerations.

F. semitectum was isolated from a dead cicada skin collected from the Tawangmangu Botanic Garden in Central Java, Indonesia. The fungus was cultured in rice media, extracted with MeOH, then with EtOAc, to obtain a dark purple extract. This was chromatographed on silica gel and RP-HPLC to yield three new apicidins (1-3), together with the known (-)-apicidin (4), apicidins A (5) and C (6),

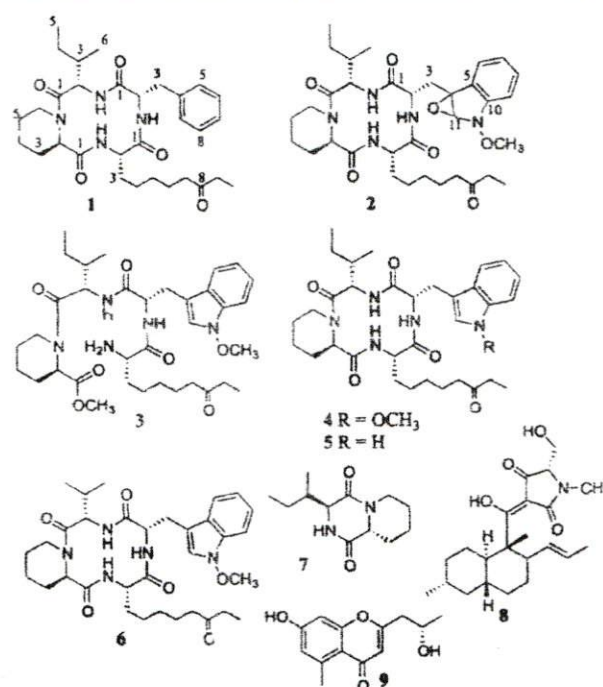


Figure 1: Structures of metabolites isolated from *F. semitectum*

(-)-cyclo-(*D*-pipecolinyl-*L*-isoleucine) (7) [15], (-)-equisetin (8) [6], and (+)-7-hydroxy-2-(2-hydroxypropyl)-5-methylchromone (9) [16].

Apicidin G (1) was isolated together with apicidin C (6) as a 1:1 mixture using RP-HPLC (MeOH/H₂O). The HRESIMS data of the fraction containing 1 suggested a nitrogenous compound from an adduct ion at m/z 577.3360 [M+Na]⁺, corresponding to the molecular formula C₃₁H₄₆N₄O₅. The ¹H NMR spectrum of 1 (Table 1) showed signals for four α -protons (δ_H 5.06, 4.72, 4.16 and 3.80), three NH signals (δ_H 7.25, 6.46 and 6.43), five aromatic protons [δ_H 7.27 (2H), 7.19 (2H) and 7.22 (1H)] and three methyl groups

Table 1 NMR spectroscopic data for apicidins G, H and I.

1				2				3					
Residue	Position	δ_c^a	δ_H mult (J in Hz) ^b	Residue	Position	δ_c^a	δ_H mult (J in Hz) ^b	Residue	Position	δ_c^a	δ_H mult (J in Hz) ^b		
Pipelic acid	1	171.6	-	Pipelic acid	1	170.3 ^c	-	Pipelic acid	1	172.8	-		
	2	50.8	5.06 br d (6.0)		2	51.0	3.49 br s		2	51.0	3.49 br s	58.3	4.12 br d (10.0)
	3	24.1	a 2.01 m b 1.57 m		3	24.3	a 2.04 m b 1.59 m		3	24.3	a 2.04 m b 1.59 m	26.7	a 2.13 br d (13.5) b 1.84 m
	4	19.2	a 2.14 m b 1.58 m		4	19.3	a 2.20 m b 1.62 m		4	19.3	a 2.20 m b 1.62 m	21.8	a 1.89 m b 1.57 m
	5	25.4	a 1.80 m b 1.40 m		5	25.1	a 1.87 m b 1.41 m		5	25.1	a 1.87 m b 1.41 m	22.1	1.80 m
	6	44.1	a 4.04 m b 3.04 br t (12.9)		6	44.0	a 3.83 br d (12.8) b 3.53 td (12.8, 2.0)		6	44.0	a 3.83 br d (12.8) b 3.53 td (12.8, 2.0)	44.4	a 3.47 br d (12.0) b 2.92 td (12.0, 3.5)
Isoleucine	1	174.4	-	Isoleucine	OMe	-	-	Isoleucine	OMe	52.2	3.56 s		
	2	54.4	4.72 t (10.5)		1	171.2	-		1	171.2	-	172.7	-
	3	34.5	2.08 m		2	54.5	4.65 br t (9.3)		2	54.5	4.65 br t (9.3)	56.8	4.37 dd (8.0, 5.5)
	4	24.7	a 1.59 m b 1.19 m		3	34.4	1.97 m		3	34.4	1.97 m	37.6	1.84 m
	5	10.7	0.94 t (7.4)		4	24.7	a 1.71 m b 1.20 m		4	24.7	a 1.71 m b 1.20 m	25.3	1.36 ddd (13.5, 7.2, 4.6)
	6	15.7	0.87 d (6.6)		5	10.6	0.91 t (7.5)		5	10.6	0.91 t (7.5)	11.4	0.86 t (7.5)
Phenylalanine	NH	-	7.25 d (10.0)	6	15.6	0.90 d (6.5)	6	15.6	0.90 d (6.5)	15.5	0.83 d (7.0)		
	1	174.7	-	Tryptophan-N-OMe (epoxy)	NH	-	7.12 m ^d	Tryptophan-N-OMe (epoxy)	NH	-	7.14 br d (7.5)		
	2	62.7	3.80 m		1	171.3	-		1	171.3	-	172.2	-
	3	35.3	a 3.72 dd (13.5, 11.2) b 3.25 dd (13.5, 5.8)		2	65.6	4.73 br d (9.9)		2	65.6	4.73 br d (9.9)	54.6	4.71 td (8.5, 6.5)
	4	137.1	-		3	42.5	a 2.57 d (14.6) b 2.41 br d (14.6)		3	42.5	a 2.57 d (14.6) b 2.41 br d (14.6)	27.6	a 3.30 dd (15.0, 9.0) b 3.22 dd (15.0, 6.5)
	5/9	129.1	7.19 m		4	84.2	-		4	84.2	-	106.8	-
	6/8	128.8	7.27 m		5	129.6	-		5	129.6	-	123.9	-
	7	127.3	7.22 m		6	121.8	7.31 d (8.5)		6	121.8	7.31 d (8.5)	119.3	7.67 d (8.0)
	NH	-	6.43 d (6.8)		7	124.3	7.09 td (7.8, 0.5)		7	124.3	7.09 td (7.8, 0.5)	122.5	7.19 td (8.0, 1.0)
					8	130.6	7.34 td (7.6, 0.5)		8	130.6	7.34 td (7.6, 0.5)	119.8	7.08 td (8.0, 1.0)
			9		114.9	7.04 d (7.9)	9		114.9	7.04 d (7.9)	108.1	7.34 d (8.0)	
Aoda	1	175.8	-	Aoda	10	148.9	-	Aoda	10	148.9	-		
	2	53.5	4.16 m		11	97.0	5.99 s		11	97.0	5.99 s	122.4	7.31 s
	3	29.0	a 1.75 m b 1.52 m		12	64.1	3.85 s		12	64.1	3.85 s	65.8	4.02 s
	4	25.2	1.19 m		NH	-	7.12 m ^d		NH	-	7.12 m ^d	-	8.29 br d (7.5)
	5	28.6	1.24 m		1	173.1 ^e	-		1	173.1 ^e	-	172.4	-
	6	23.4	1.52 m		2	53.7	4.32 dd (9.5, 4.2)		2	53.7	4.32 dd (9.5, 4.2)	55.3	4.18 br q (7.5)
	7	42.1	2.34 t (7.4)		3	32.9	a 2.03 m b 1.96 m		3	32.9	a 2.03 m b 1.96 m	31.4	a 1.62 m b 1.55 m
	8	211.8	-		4	25.6	1.32 m		4	25.6	1.32 m	25.3	1.07 m
	9	35.9	2.40 q (7.4)		5	29.2	1.31 m		5	29.2	1.31 m	28.4	1.10 m
	10	7.7	1.04 t (7.4)		6	23.8	1.53 m		6	23.8	1.53 m	23.4	1.40 m
NH	-	6.46 d (10.4)	7	42.3	2.36 t (7.5)	7	42.3	2.36 t (7.5)	42.1	2.29 t (7.0)			
			8	211.8	-	8	211.8	-	212.1	-			
			9	36.0	2.38 q (7.4)	9	36.0	2.38 q (7.4)	36.0	2.32 q (7.5)			
			10	7.9	1.01 t (7.3)	10	7.9	1.01 t (7.3)	7.8	1.03 t (7.0)			
			NH/NH ₂ ^f	-	6.19 br d (7.6)	NH/NH ₂ ^f	-	6.19 br d (7.6)	-	8.35 br d (6.5)			

^aChemical shifts (ppm) taken from 2D NMR spectra referenced to CDCl₃ (δ_c 77.16), data recorded at 500 MHz; ^bChemical shifts (ppm) referenced to CHCl₃ (δ_H 7.26), data recorded at 500 MHz; ^cAssignments may be interchangeable; ^dOverlapping signals, assigned by 2D-TOCSY; ^eNH for 2, NH₂ for 3.

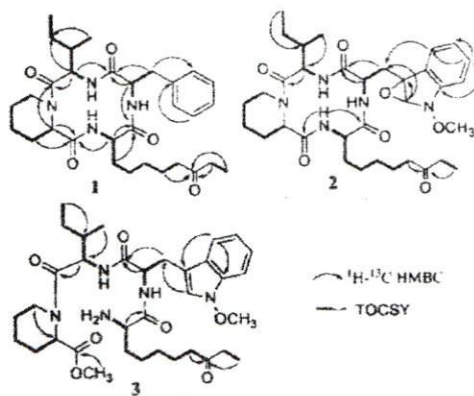


Figure 2: TOCSY and selected HMBC correlations for apicidins G (1), H (2) and I (3).

(δ_H 1.04, 0.94, 0.87). The ¹³C NMR spectrum contained amide signals at δ_c 175.8, 174.7, 174.4 and 171.6 and a ketone signal at δ_c 211.8. The side chain signals of individual amino acids were determined by DQF-COSY and 2D-TOCSY data, and were consistent with the presence of Ile, Phe, Pip and Aoda residues. The signal at δ_H 5.06 (br d, 6.0 Hz) was assigned as the α -proton of Pip since it was linked to four methylene groups (including two downfield methylene protons at δ_H 4.04 and 3.04) by 2D-TOCSY (Figure 2). For Ile, the α -proton signal at δ_H 4.72 was a triplet with 10.0 Hz couplings to both NH (δ_H 7.25) and methine (δ_H 2.08)

signals. The TOCSY data revealed cross peaks from this α -proton to the methyl groups at δ_H 0.94 (t, 7.4 Hz) and 0.87 (d, 6.6 Hz). The presence of Phe was established from an α -proton signal at δ_H 3.80, which showed couplings to methylene signals at δ_H 3.72 and 3.25 by TOCSY, and by HMBC correlations from the methylene protons to an aromatic carbon at δ_c 129.1. The amino acid 2-amino-8-oxodecanoic acid (Aoda) was apparent from signals for five methylene groups [δ_H 2.34 (2H, t, 7.4), 1.75 (1H, m), 1.52 (3H, m), 1.24 (2H, m), 1.19 (2H, m)], an ethyl group [δ_H 1.04 (3H, t, 7.4 Hz), 2.40 (2H, q, 7.4 Hz)], and by HMBC correlations from the methyl group at δ_H 1.04 and the methylene protons at δ_H 1.52 and at δ_H 2.40 to the ketone signal at δ_c 211.8.

The amide carbons of Aoda, Phe, and Pip were assigned to the signals at δ_c 175.8, 174.7, and 171.6, respectively, by the ³J_{CH} correlations from their β protons; the remaining amide signal at δ_c 174.4 therefore belonged to Ile. ²J_{CH} correlations from the respective α -protons fully supported these assignments. The sequence of the amino acid residues in apicidin G was determined from HMBC correlations, in particular from the α -proton of Pip to the carbonyl group (δ_c 174.4) of Ile, from the α -proton of Ile to the carbonyl group (δ_c 174.7) of Phe, and from the α -proton of the Aoda residue to the carbonyl group (δ_c 171.6) of Pip. The sequence was identical to that in apicidin (4) [6a] except for the Trp-N-OMe moiety, which was replaced by Phe in apicidin G (1).

The configuration of 1 was determined by analysis of proton NMR coupling constants compared with those in other apicidins [6]. The

α -proton of Phe was coupled to the adjacent NH proton with a J value of 6.8 Hz, and indicated a *syn*-relationship. In contrast, the 10.4 and 10.0 Hz coupling between the α -protons of the Aoda and Ile residues and the corresponding NH protons suggested an *anti*-relationship, as reported for apicidin (4). In the pipelicolic acid unit the 6.0 Hz coupling of the α -proton matched the 5.5 Hz coupling for the corresponding signal in apicidin [6a]. In view of the co-isolation of (-)-apicidin (4), the absolute configurations of the shared amino acid constituents were inferred to be (*R*)-Pip, (*S*)-Ile, and (*S*)-Aoda. An (*S*)-Phe residue was inferred from the $J_{\text{NH-H}2}$ value [6a,6b], and by analogy with trapoxin-A [7]. Specific rotation measurements and verification of the amino acid configurations were not undertaken owing to the inseparable mixture of 1 and 6.

Apicidin H (2) was obtained as a colorless oil by RP-HPLC using MeOH/H₂O. The HRESIMS data of 2 indicated a molecular formula of C₃₄H₄₉N₅O₇ from a sodiated adduct ion at m/z 662.3545, and established the presence of one additional oxygen in 2 with respect to apicidin (4). The ¹H NMR data suggested that 2 was structurally related to 4 from the characteristic signals corresponding to Pip [δ_{H} 3.49, 3.83 and 3.53], Ile [δ_{H} 4.65, 0.91 (3H), 0.90 (3H)] and Aoda residues [δ_{H} 4.32, 2.38 (2H), 2.36 (2H) and 1.01 (3H)]. The signal at δ_{H} 4.73 (d, 9.9) linked to a signal at δ_{C} 65.6 by HSQC was assigned as the α -proton of the remaining amino acid unit, and showed 2D-TOCSY correlations to a methylene group at δ_{H} 2.57 and 2.41, and to an NH proton (δ_{H} 7.12). A methine signal at δ_{H} 5.99 (H-11) was linked to a signal at δ_{C} 97.0 by HSQC. These chemical shifts, together with HMBC correlations from this methine proton to a methylene carbon (δ_{C} 42.5, C-3) and to a quaternary carbon (δ_{C} 84.2, C-4), were all consistent with an epoxy-derivatized Trp-*N*-OMe moiety. An amide signal at δ_{C} 171.3 was assigned to the epoxy-Trp-*N*-OMe moiety by ³ J_{CH} correlations from the β protons; HMBC correlations were seen from the NH proton (δ_{H} 6.19) of the Aoda residue to signals at δ_{C} 173.1 and 170.3, therefore the remaining amide signal at δ_{C} 171.2 could be assigned to Ile. This assignment is valid providing the sequence of amino acid constituents is unchanged from those in other apicidins. The signals at δ_{C} 173.1 and 170.3 were provisionally assigned to Aoda and Pip, respectively, with the δ_{H} 6.19/ δ_{C} 170.3 correlation representing an inter-unit correlation. Intra-unit correlations from the α -proton of epoxy-Trp-*N*-OMe to the carbonyl at δ_{C} 171.3 and from the α -proton of Ile to the carbonyl at δ_{C} 171.2 were observed.

The relative configuration of the epoxy ring was not determined. The specific rotation of 2 was -42, and when compared to literature values reported for apicidin ($[\alpha]_{\text{D}}$ -80.4) [6a], apicidin D₁ ($[\alpha]_{\text{D}}$ -72.6), apicidin D₂ ($[\alpha]_{\text{D}}$ -68.5), and apicidin D₃ ($[\alpha]_{\text{D}}$ -60.4) [6c], the three amino acid constituents shared between these various metabolites were suggested to be (*R*)-Pip, (*S*)-Ile, and (*S*)-Aoda. The structural similarity of apicidin H with other apicidin metabolites implies that the configuration of the epoxy-Trp-*N*-OMe residue should be *S*.

Apicidin I (3) was the final apicidin metabolite isolated from *F. semitectum*. The HRESIMS data of 3 exhibited an adduct ion at m/z 656.4037 $[\text{M}+\text{H}]^+$, corresponding to a molecular formula C₃₃H₅₃N₅O₇, which was 32 mass units larger than that of 4. The ¹H and ¹³C NMR spectra of 3 (Table 1) closely resembled those of 4, revealing the presence of four α -protons (δ_{H} 4.71, 4.37, 4.18, and 4.12), five aromatic signals (δ_{H} 7.67, 7.34, 7.31, 7.19 and 7.08), two methyl triplets (δ_{H} 1.03, 0.86) and one methyl doublet (δ_{H} 0.83). The NMR spectra of 3 also indicated the presence of two amide protons (2 x NH, δ_{H} 8.29, 7.14), one amino group (NH₂, δ_{H} 8.35) and one additional methoxy group (δ_{H} 3.56, δ_{C} 52.2). Assignments of the amino acid residues were undertaken by HMBC, DQF-COSY,

and 2D-TOCSY experiments, and by comparison with the data reported for apicidins [6a-6c]. TOCSY data revealed correlations from the NH₂ protons to the α -proton (δ_{H} 4.18) and to the five methylene groups of the Aoda residue. The methoxy group at δ_{H} 3.56 showed a HMBC correlation to the carbonyl group (δ_{C} 172.8) of the Pip unit. This information, together with the MS data, suggested a linear tetrapeptide as opposed to the cyclic tetrapeptide core of apicidin and its congeners. HMBC correlations were observed from the three α -protons at δ_{H} 4.37 (Ile), 4.71 (Trp-*N*-OMe) and 4.18 (Aoda) to the carbonyl groups at δ_{C} 172.7, 172.2 and 172.4, respectively. No inter-amino acid correlations were apparent in the HMBC spectrum, but the presence of Pip-OMe and Aoda-NH₂ implies that apicidin I is an artefact from methanolysis of apicidin at the Pip residue. The same absolute configuration is therefore proposed. Apicidin I gave the same negative sign of specific rotation $[\alpha]_{\text{D}}$ -17.3 (c 0.16, MeOH) as previous apicidins.

Apicidin was screened against a panel of bacterial (Gram-positive and -negative) and fungal strains, but was without activity. There was insufficient quantity of the new apicidins for biological screening. In conclusion, three new tetrapeptides, apicidins G (1), H (2) and I (3) were isolated together with six known compounds from *Fusarium semitectum*. The results from our study have shown modification at the Trp-*N*-OMe unit with an epoxy group in apicidin H. The absolute configurations of the apicidin metabolites were proposed by comparison of J values, specific rotation values, and from the biosynthetic similarities between the various metabolites. Tetrapeptides such as apicidin and its congeners may be chemotaxonomic markers for this fungal species.

Experimental

General: NMR data of 1-3 were measured on a Bruker Avance 500 MHz spectrometer (5 mm inverse probe, gradient selection) in CDCl₃ at 298K. For HSQC and HMBC spectra, data were acquired using a ¹ $J_{\text{C-H}}$ of 135 Hz, while HMBC spectra were acquired using ² $J_{\text{C-H}}$ of 8 Hz. TOCSY data (mixing time 60 msec) were determined in phase sensitive mode. Positive ion electrospray mass spectra were determined using either a Bruker Esquire HCT instrument (LRESIMS) or a MicroTof Q instrument (HRESIMS) with MeOH as solvent. Reverse phase HPLC was carried out on an Agilent 1100 series instrument fitted with either a Phenomenex Gemini C₁₈ (250 x 10 mm i.d., 5 μ) column or a C₁₈ analytical column with UV detection at 254 nm. Silica gel 60 G and silica TLC plates F₂₅₄ were purchased from Merck. All solvents were either distilled or were of HPLC grade.

Fungal material: A white fungus isolated from a dead cicada skin was collected at the Tawangmangu Botanic Garden, Indonesia, and identified as *Fusarium semitectum* based on morphological comparison with *F. semitectum*. [2,4]. A voucher specimen (SC-131208-1, AQIS IP09011654) is held in the School of Biology, UQ.

Culture conditions: The fungus was grown on Petri dishes containing PDA media at room temperature for 7 days. Rice media for fermentation was prepared by soaking 50 g of long grain rice in 50 mL of distilled water in 250 mL Erlenmeyer flasks. After 6 h, the rice media was autoclaved for 15 min. Thirty Erlenmeyer flasks containing rice media were inoculated with a small plug of agar containing the mycelia of *F. semitectum*, and the cultures were kept in the dark at room temperature for 21 days.

Extraction and isolation of metabolites: Mycelia and media were homogenized by stirring, then extracted with MeOH (3 x 700 mL) using ultrasonic vibration for 30 min. The extract was filtered, then concentrated *in vacuo* to an aqueous residue, which was partitioned

with EtOAc (3 x 300 mL) to give a dark purple oil (3.6 g). The extract was subjected to vacuum liquid chromatography using stepwise gradient elution (100% hexanes to 100% EtOAc) to obtain 11 fractions. Fraction 5 (225 mg) was subjected to NP-flash column chromatography using a stepwise elution of DCM/MeOH to give equisetin (**8**) (59.3 mg). Combined fractions 6 and 7 (570 mg) were chromatographed on silica using a stepwise elution of DCM/EtOAc/MeOH to give 11 fractions coded 6n7-1 to 6n7-11. Combined fractions 6n7-1 to 7-3 (17.4 mg) were purified by RP-HPLC (65-100% MeOH/H₂O) to yield (-)-apicidin (**4**) (3.7 mg) then (-)-equisetin (**8**) (1.8 mg). Fraction 6n7-5 (150 mg) was subjected to RP flash column chromatography with MeOH/H₂O to give apicidin (**4**) (16.2 mg), a mixture of apicidin (**4**) and equisetin (**8**) (41.1 mg) and fraction 6n7-5-1 (9.5 mg), which was further purified by RP-HPLC (70-100% MeOH/H₂O) to yield apicidin I (**3**) (2.4 mg). Fraction 6n7-6 (99 mg) was purified by RP-HPLC (80-100% MeOH/H₂O) and gave 7 fractions. (-)-Cyclo-(*D*-pipecolinyl-*L*-isoleucine) [**15**] (**7**) (0.9 mg) was in fraction 6n7-6-2. Fraction 6n7-6-5 contained a 1:1 mixture of apicidins G (**1**) and C (**6**) (5.4 mg). Apicidin (**4**) (36.4 mg) was in fraction 6n7-6-6. Fraction 6n7-6-4 (3.2 mg) was purified by RP-HPLC (75% MeOH/H₂O) affording apicidin H (**2**) (0.5 mg) and apicidin A (**5**) (1.3 mg). Combined fractions 6n7-7 and 7-8 (43.5 mg) were chromatographed using a RP Sep-pak™ (20-100% MeOH/H₂O) to give (+)-7-hydroxy-2-(2-hydroxypropyl)-5-methylchromone (**9**) [**16**] (2.2 mg), apicidin (**4**) (16.2 mg), and a mixture of apicidin (**4**) and equisetin (**8**) (5.5 mg).

Apicidin G 1

Colorless film

¹H NMR and ¹³C NMR (CDCl₃): Table 1.HRESIMS: *m/z* [M+Na]⁺ calcd for C₃₁H₄₆N₄NaO₅; 577.3360; found: 577.3360.**Apicidin H 2**

Colorless film

[α]_D²⁴: -42 (c 0.03, MeOH)¹H NMR and ¹³C NMR (CDCl₃): Table 1.HRESIMS: *m/z* [M+Na]⁺ calcd for C₃₄H₄₉N₅NaO₇; 662.3524; found: 662.3545.**Apicidin I 3**

Colorless film

[α]_D²⁴: -17 (c 0.16, MeOH)¹H NMR and ¹³C NMR (CDCl₃): Table 1.HRESIMS: *m/z* [M+H]⁺ calcd for C₃₅H₅₄N₅O₇; 656.4018; found: 656.4037.

Acknowledgments - We thank the Australian Research Council and the University of Queensland for financial support, Prof. Baharuddin Saleh (Universiti Sains Malaysia) for fungal identification, Assoc. Prof. Elizabeth Aitken and Dr James Fraser for advice and access to laboratory facilities. Sample collection was made with assistance of staff of Faculty of Pharmacy, Airlangga University and Tawangmangu Botanic Garden, Indonesia.

References

- (a) Desjardins AE. (2006) *Fusarium Mycotoxins: Chemistry, Genetics, and Biology*. The American Phytopathology Society: Minnesota; (b) Gerlach W, Nirenberg H. (1982) *The Genus Fusarium: A Pictorial Atlas*. Biologische Bundesanstalt für Land- und Forstwirtschaft, Berlin.
- Zaccardelli M, Balmas V, Altomare C, Corazza L, Scotti C. (2006) Characterization of Italian isolates of *Fusarium semitectum* from alfalfa (*Medicago sativa* L.) by AFLP analysis, morphology, pathogenicity and toxin production. *Journal of Phytopathology*, 154, 454-460.
- Marasas WFO, Nelson PE, Toussoun TA. (1984) *Toxicogenic Fusarium Species: Identity and Mycotoxicology*. The Pennsylvania State University Press, London.
- Wheeler MH, Stipanovic RD, Puckhaber LS. (1999) Phytotoxicity of equisetin and epi-equisetin isolated from *Fusarium equiseti* and *F. pallidoroseum*. *Mycological Research*, 103, 967-973.
- Evidente A, Conti L, Altomare C, Bottalico A, Sindona G, Segre AL, Logrieco A. (1994) Fusapyrone and deoxyfusapyrone, two antifungal apyrone from *Fusarium semitectum*. *Natural Toxins*, 2, 4-13.
- (a) Singh SB, Zink DL, Polishook JD, Dombrowski AW, Darkin-Rattray SJ, Schmatz DM, Goetz MA. (1996) Apicidins: novel cyclic tetrapeptides as coccidiostats and antimalarial agents from *Fusarium pallidoroseum*. *Tetrahedron Letters*, 37, 8077-8080; (b) Singh SB, Zink DL, Liesch JM, Dombrowski AW, Darkin-Rattray SJ, Schmatz DM, Goetz MA. (2001) Structure, histone deacetylase, and antiprotozoal activities of apicidins B and C, congeners of apicidin with proline and valine substitutions. *Organic Letters*, 3, 2815-2818; (c) Singh SB, Zink DL, Liesch JM, Mosley RT, Dombrowski AW, Bills GF, Darkin-Rattray SJ, Schmatz DM, Goetz MA. (2002) Structure and chemistry of apicidins, a class of novel cyclic tetrapeptides without a terminal α-keto epoxide as inhibitors of histone deacetylase with potent antiprotozoal activities. *Journal of Organic Chemistry*, 67, 815-825; (d) Darkin-Rattray SJ, Gurnett AM, Myers RW, Dulski PM, Crumley TM, Allocco JJ, Cannova C, Meinke PT, Colletti SL, Bednarek MA, Singh SB, Goetz MA, Dombrowski AW, Polishook JD, Schmatz DM. (1996) Apicidin: a novel antiprotozoal agent that inhibits parasite histone deacetylase. *Proceedings of the National Academy of Sciences*, 93, 13143-13147.
- Itazaki H, Nagashima K, Sugita K, Yoshida H, Kawamura Y, Yasuda Y, Matsumoto K, Ishii K, Uotani N, Nakai H, Terui A, Yoshimatsu S, Ikenishi Y, Nakagawa Y. (1990) Isolation and structural elucidation of new cyclotetrapeptides, trapoxins A and B, having detransformation activities as antitumor agents. *Journal of Antibiotics*, 43, 1524-1532.
- Liesch JM, Sweeley CC, Staffeld GD, Anderson MS, Weber DJ, Scheffer RP. (1982) Structure of HC-toxin, a cyclic tetrapeptide from *Helminthosporium carbonum*. *Tetrahedron*, 38, 45-48.
- Umehara K, Nakahara K, Kiyoto S, Iwami M, Okamoto M, Tanaka H, Kohsaka M, Aoki H, Imanaka H. (1983) Studies on WF-3161, a new antitumor antibiotic. *Journal of Antibiotics*, 36, 478-483.
- Hirota A, Suzuki A, Aizawa K, Tamura S. (1973) Structure of cyl-2, a novel cyclotetrapeptide from *Cylindrocodium scoparium*. *Agricultural and Biological Chemistry*, 37, 955-956.
- Closse A, Huguenin R. (1974) Isolation and structure elucidation of chladomycin. *Helvetica Chimica Acta*, 57, 533-545.
- Shute RE, Dunlap B, Rich DH. (1987) Analogues of the cytostatic and antimetastatic agents chlamydocin and HC-toxin: synthesis and biological activity of chloromethyl ketone and diazomethyl ketone functionalized cyclic tetrapeptides. *Journal of Medicinal Chemistry*, 30, 71-78.
- Jin JM, Lee S, Lee J, Baek SR, Kim JC, Yun SH, Park SY, Kang S, Lee YW. (2010) Functional characterization and manipulation of the apicidin biosynthetic pathway in *Fusarium semitectum*. *Molecular Microbiology*, 76, 456-466.
- von Bargen KW, Niehaus EM, Bergander K, Brun R, Tudzynski B, Humpf HU. (2013) Structure elucidation and antimalarial activity of apicidin F: an apicidin-like compound produced by *Fusarium fujikuroi*. *Journal of Natural Products*, 76, 2136-2140.
- Mitova M, Tutino ML, Infusini G, Marino G, De Rosa S. (2005) Exocellular peptides from Antarctic psychrophile *Pseudoalteromonas haloplanktis*. *Marine Biotechnology*, 7, 523-531.
- Kashiwada Y, Nonaka GI, Nishioka I. (1984) Studies on rhubarb (*Rhei rhizome*). V. Isolation and characterization of chromone and chromanone derivatives. *Chemical and Pharmaceutical Bulletin*, 32, 3493-3500.