
Journal of
Natural
Medicines

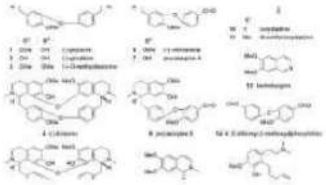
Journal of Natural Medicines

Editors

Volume 66, issue 3, July 2012

22 articles in this issue

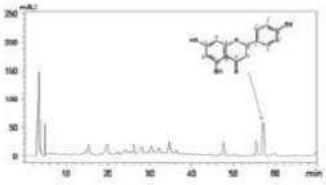
Vasorelaxant effect of isoquinoline derivatives from two species of *Popowia perakensis* and *Phaeanthus crassipetalus* on rat aortic artery



Kazumasa Zaima, Yuka Takeyama ... Hiroshi Morita

Original Paper | Published: 28 October 2011 | Pages: 421 - 427

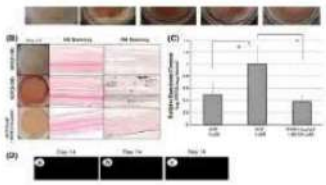
Phytochemical characterization and antinociceptive effect of *Lippia gracilis* Schauer



Adriana G. Guimarães, Silvana V. F. Gomes ... Lucindo J. Quintans Júnior

Original Paper | Published: 22 October 2011 | Pages: 428 - 434

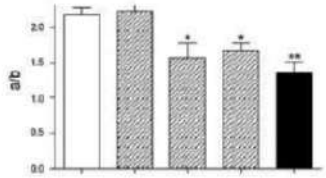
Withania somnifera extract attenuates stem cell factor-stimulated pigmentation in human epidermal equivalents through interruption of ERK phosphorylation within melanocytes



Hiroaki Nakajima, Katsunori Fukazawa ... Genji Imokawa

Original Paper | Published: 16 November 2011 | Pages: 435 - 446

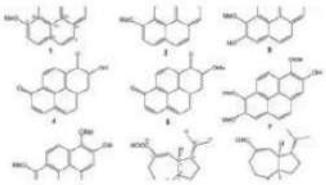
Anti-inflammatory and anti-nociceptive effects of the ethanolic extracts of *Alkanna frigida* and *Alkanna orientalis*



H. Monsef Esfahani, Z. Navvab Esfahani ... Seyed Nasser Ostad

Original Paper | Published: 16 November 2011 | Pages: 447 - 452

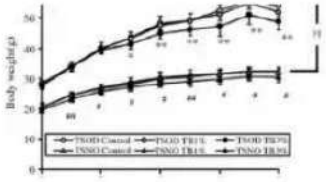
Pyrenes and pyrendiones from *Uvaria lucida*



Masataka Moriyasu, Sousuke Takeuchi ... Patrick B. ChaloMutiso

Original Paper | Published: 30 November 2011 | Pages: 453 - 458

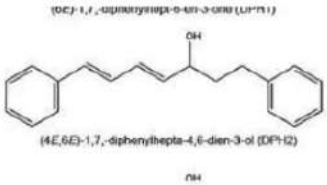
Preventive effect of *Terminalia bellirica* on obesity and metabolic disorders in spontaneously obese type 2 diabetic model mice



Hiroko Makihara, Tsutomu Shimada ... Masaki Aburada

Original Paper | Published: 22 November 2011 | Pages: 459 - 467

Pharmacokinetics and organ distribution of diarylheptanoid phytoestrogens from *Curcuma comosa* in rats



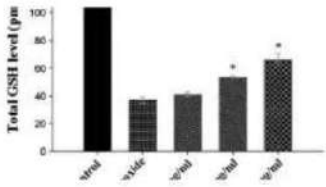
Jian Su, Kittisak Sripanidkulchai ... Bungorn Sripanidkulchai

Original Paper | Published: 20 November 2011 | Pages: 468 - 475

Neuroprotective properties of *Loranthus parasiticus* aqueous fraction against oxidative stress-induced damage in NG108-15 cells

Daniel Zin Hua Wong, Habsah Abdul Kadir ... Bey Hing Goh

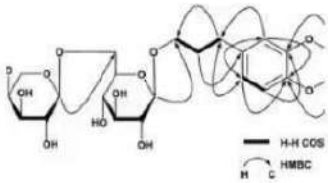
Original Paper | Published: 09 February 2012 | Pages: 544 - 551



Medicinal plants of Thailand. II: chemical studies on the seed kernels of *Entada rheedei* Sprengel

Sachiko Sugimoto, Katsuyoshi Matsunami & Hideaki Otsuka

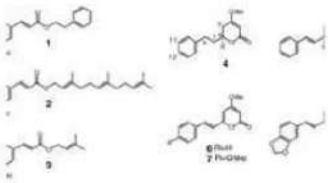
Note | Published: 07 December 2011 | Pages: 552 - 557



In vitro antitrypanosomal activity of some phenolic compounds from propolis and lactones from Fijian Kawa (*Piper methysticum*)

Kazuhiko Otoguro, Masato Iwatsuki ... Haruki Yamada

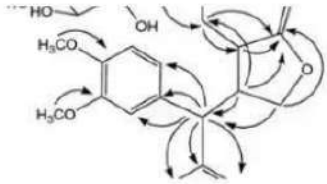
Note | Published: 25 November 2011 | Pages: 558 - 561



Three new secolignan glycosides from *Urtica fissa* E. Pritz

Bao-min Feng, Hai-hong Qin ... Yong-qi Wang

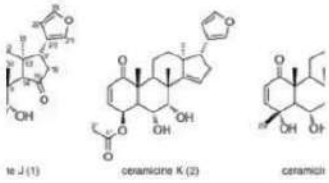
Note | Published: 29 November 2011 | Pages: 562 - 565



Ceramicines J–L, new limonoids from *Chisocheton ceramicus*

Chin Piow Wong, Misae Shimada ... Hiroshi Morita

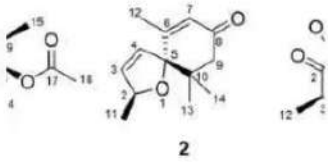
Note | Published: 13 December 2011 | Pages: 566 - 570



Antiplasmodial decarboxyportentol acetate and 3,4-dehydrotheaspirone from *Laumoniera bruceadelpha*

Hiroshi Morita, Reika Mori ... A. Hamid A. Hadi

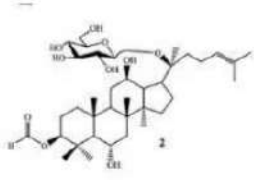
Note | Published: 03 January 2012 | Pages: 571 - 575



Three new triterpenoids from *Panax ginseng* exhibit cytotoxicity against human A549 and Hep-3B cell lines

Hai-Ying Ma, Hui-Yuan Gao ... Bo Yang

Note | Published: 12 April 2012 | Pages: 576 - 582



For authors

Submission guidelines

Explore

Online first articles

J Nat Med (2012) 66:571–575
DOI 10.1007/s11418-011-0618-7

NOTE

Antiplasmodial decarboxyportentol acetate and 3,4-dehydrotheaspirone from *Laumoniera bruceadelpha*

Hiroshi Morita · Reika Mori · Jun Deguchi · Shiori Oshimi · Yusuke Hirasawa · Wiwied Ekasari · Aty Widyawaruyanti · A. Hamid A. Hadi

Received: 12 October 2011 / Accepted: 7 December 2011 / Published online: 3 January 2012

Abstract A new spiro heterocycle, decarboxyportentol acetate (**1**) was isolated from the barks of *Laumoniera bruceadelpha* Nooteboom (Simaroubaceae), together with 3,4-dehydrotheaspirone (**2**), and their structures were elucidated by 2D NMR analysis. 3,4-Dehydrotheaspirone (**2**) showed potent antiplasmodial activity against *Plasmodium falciparum* 3D7.

Keywords Decarboxyportentol acetate · 3,4-Dehydrotheaspirone · *Laumoniera bruceadelpha* · Simaroubaceae · Antiplasmodial activity · *Plasmodium falciparum* 3D7

Introduction

Malaria is one of the crucial infectious diseases in the world and continues to cause morbidity and mortality on a large scale in tropical countries [1]. The antimalarial potential of compounds derived from plants has been proven by examples such as quinine from *Cinchona* species and artemisinin from *Artemisia annua* [2]. The plants belonging to Simaroubaceae are known to contain various terpenoids with biological activities such as antimalarial, antifeedant, anti-inflammatory, antiulcer, antipyretic, and cytotoxic activities [3–6]. We have previously reported that two new quassinoids, delaumonones A and B, isolated from *Laumoniera bruceadelpha* Nooteboom (Simaroubaceae) showed potent antiplasmodial activity [7].

In our search for bioactive constituents targeting malaria from medicinal plants, two spiro heterocycles, decarboxyportentol acetate (**1**) and 3,4-dehydrotheaspirone (**2**), were isolated from the barks of *L. bruceadelpha*, both of which showed potent antiplasmodial activity. This paper describes the isolation and structural elucidation of **1** and **2** with antiplasmodial activity against *Plasmodium falciparum* 3D7 (chloroquine-sensitive clone).

The barks of *L. bruceadelpha*, which were collected in Malaysia, were extracted with MeOH, and the extract was suspended in H_2O and then partitioned between $CHCl_3$ and *n*-BuOH, successively. The $CHCl_3$-soluble materials were subjected to a silica gel column, and then an ODS column followed by an ODS HPLC to afford decarboxyportentol acetate (**1**) and 3,4-dehydrotheaspirone (**2**).

Decarboxyportentol acetate (**1**), colorless amorphous solid, $[\alpha]_D^{20}$ +58 (*c* 0.5, $CHCl_3$), showed molecular formula, $C_{18}H_{28}O_4$, which was determined by HRESIMS [*m/z* 331.1861 $(M + Na)^+$, Δ −2.4 mmu]. IR absorptions implied the presence of carbonyl (1739 and 1653 cm^{-1}) and ether (1242 cm^{-1}) functionalities. ^1H and ^{13}C NMR data are presented in Table 1. The ^{13}C NMR spectrum revealed 18 carbon signals due to one sp^3 quaternary carbon, two carbonyl carbons, one olefinic carbon, one sp^2 methine, six sp^3 methines, and seven methyls. Among them, four carbons (δ_C 76.9, 80.7, 170.6, and 200.5) were ascribed to those bearing an oxygen atom.

The structure of **1** was deduced from extensive analyses of the two-dimensional NMR data, including the

H. Morita (✉) · R. Mori · J. Deguchi · S. Oshimi · Y. Hirasawa
Faculty of Pharmaceutical Sciences, Hoshi University, Ebara 2-4-41 Shinagawa-ku, Tokyo 142-8501, Japan
e-mail: moritah@hoshi.ac.jp

W. Ekasari · A. Widyawaruyanti
Faculty of Pharmacy, Airlangga University, Jalan Dharmawangsa Dalam, Surabaya 60286, Indonesia

A. H. A. Hadi
Department of Chemistry, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia

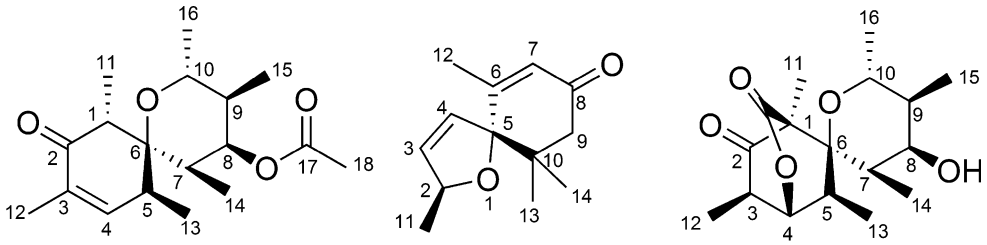
Table 1 ^{1}H and ^{13}C NMR data for decarboxyportentol acetate (**1**) and 3,4-dehydrotheaspirone (**2**) at 300 K

Position	δ_H [int., mult., *J* (Hz)]		δ_C	
	1[a]	**2**[b]	**1**[a]	**2**[b]
1	2.79 (1H, q, 6.8)		46.6	
2		4.32 (1H, dq, 4.2, 6.2)	200.5	68.7
3		5.75 (1H, m)	133.5	136.9
4	6.62 (1H, d, 6.6)	5.77 (1H, m)	147.4	130.1
5	3.37 (1H, dq, 6.6, 7.0)		33.9	79.9
6			80.7	168.0
7	2.09 (1H, dq, 2.9, 7.3)	5.87 (1H, m)	37.1	127.1
8	5.13 (1H, dd, 3.0, 2.9)		76.9	201.3
9a	1.56 (1H, m)	2.15 (1H, d, 17.4)	40.5	50.7
9b		2.52 (1H, d, 17.4)		
10	3.56 (1H, dq, 12.2, 6.3)		66.3	49.0
11	1.16 (3H, d, 6.8)	1.24 (3H, d, 6.2)	7.3	23.8
12	1.72 (3H, s)	1.91 (3H, s)	15.6	19.5
13	1.13 (3H, d, 7.0)	1.00 (3H, s)	14.7	24.4
14	0.62 (3H, d, 7.3)	2.52 (3H, s)	17.0	23.4
15	0.79 (3H, d, 6.9)		12.9	
16	1.14 (1H, d, 6.3)		19.0	
17			170.6	
18	2.10 (3H, s)		20.9	

δ in ppm

[a] 600 MHz, $CDCl_3$

[b] 400 MHz, CD_3OD



1 **2** **3**

^{1}H–^{1}H COSY, HSQC, and HMBC spectra in $CDCl_3$ (Fig. 1). The ^{1}H–^{1}H COSY spectrum revealed connectivity of three partial structures **a** (C-1 and C-11), **b** (C-4 to C-5 and C-13), and **c** (C-7 to C-10, C-14, C-15, and C-16) as shown in Fig. 1. Connectivity of units **a** and **b** was implied by HMBC correlations for H_3-11 to C-2 (δ_C 200.5) and H_3-12 to C-2, C-3 (δ_C 133.5), and C-4 (δ_C 147.4). HMBC correlations were observed for H_3-11, H-4, H-10 and H_3-14 to C-6 (δ_C 80.7) suggesting that units **a**, **b**, and **c** connected through C-6. Judging from the ^{13}C chemical shift of C-6, **1** was deduced to have a spiro cyclic structure at C-6 incorporated in a tetrahydropyran ring. The presence of an acetylate at C-8 (δ_C 76.9) was implied by the HMBC correlations for H-8 and H_3-18 to C-17 (δ_C 170.6).

The relative configuration of **1** was elucidated by NOESY correlations and $^{3}J_{1_H-1_H}$ couplings as depicted in the computer-generated three-dimensional drawing (Fig. 2). The NOESY correlation for H-7/H-9 and $^{3}J_{(H\text{-}9/H\text{-}10)}$, $^{3}J_{(H\text{-}7/H\text{-}8)}$, and $^{3}J_{(H\text{-}8/H\text{-}9)}$ coupling values (12.2, 2.9, and 3.0 Hz, respectively) suggested that the tetrahydropyran ring took a chair form with axial orientations for H-7, H-9, and H-10, and equatorial orientation for H-8. The orientations of C-11 and C-13 and the relative configuration of C-6 were elucidated by NOESY correlations for H-1/H_3-13, H-7/H_3-11, and H-5/H-10, and the high field ^{1}H chemical shift (δ_H 0.62) of H_3-14 by the anisotropic effect of C-3 to C-4 double bond. Thus, the relative configuration of **1** was assigned as in Fig. 2.

Portentol (**3**) was first isolated as the lichen constituent from *Roccella portentosa* [8]. Decarboxyportentol acetate (**1**) has been derived from portentol though decarboxyportentol followed by acetylation [8]. The absolute structure of **1** was also assigned to be the same as that derived from portentol [8]. Therefore, it is a first isolation from plants as a natural product.

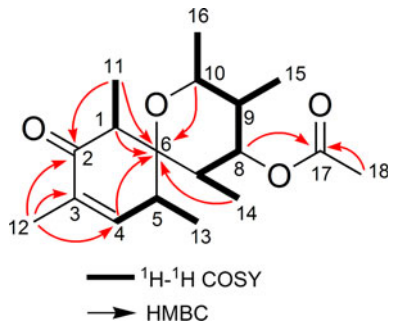


Fig. 1 Selected 2D NMR correlations for decarboxyportentol acetate (**1**)

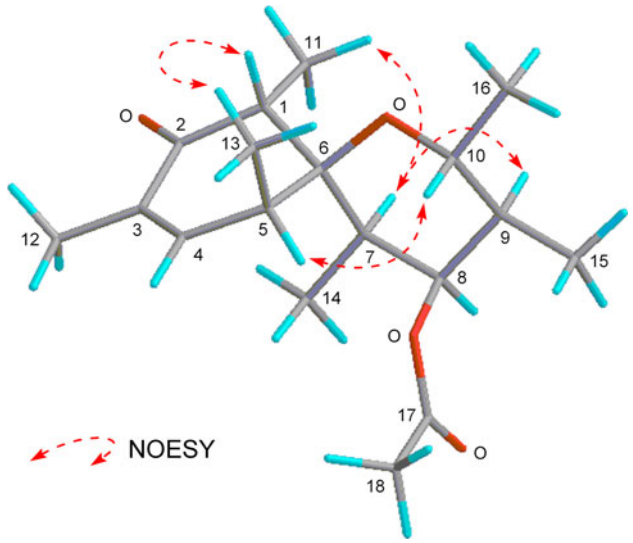


Fig. 2 Selected NOESY correlations and relative configuration for decarboxyportentol acetate (**1**)

3,4-Dehydrotheaspirone (**2**), colorless amorphous solid, $[\alpha]_D^{20}$ +155 (*c* 1.0, MeOH), showed molecular formula, $C_{13}H_{18}O_2$, which was determined by HRESITOFMS [*m/z* 207.1376 $(M + H)^+$, Δ −0.9 mmu]. IR absorptions implied the presence of carbonyl (1671 cm^{-1}) and ether (1249 cm^{-1}) functionalities. ^{1}H and ^{13}C NMR data are presented in Table 1. The ^{1}H NMR spectrum of **2** was similar to that of excoecariol B [9] except for an oxymethylene signal at the low field region (δ_H 4.08 and 4.23) in place of a methyl signal. By using spectroscopic analysis, **2** was assigned as 3,4-dehydrotheaspirone [10], which was recently isolated from the leaves of *Juniperus brevifolia* [11].

Decarboxyportentol acetate (**1**) and 3,4-dehydrothespirone (**2**) showed potent in vitro antiplasmodial activity against *Plasmodium falciparum* 3D7 (IC_{50} **1**: 16 μM, IC_{50} **2**: 0.027 μM). In particular, 3,4-dehydrothespirone (**2**) did not show potent cytotoxicity against HL-60 cells (IC_{50} **1**: >100 μM, IC_{50} **2**: 2.7 μM). 3,4-Dehydrotheaspirone (**2**) had a high selectivity index (>100) and may have potential as an antiplasmodial agent. Further studies on **2** including the mode of action of its antiplasmodial activity are under investigation.

Experimental

General experimental procedures

Optical rotations were measured on a JASCO P-1030 polarimeter. Mass spectra were obtained with a Micromass LCT spectrometer. IR spectra were recorded on a JASCO FTIR-230 spectrometer and UV spectra on a Shimadzu UV-250 spectrophotometer. CD spectra were measured on a JASCO J-820 polarimeter. ^{1}H and 2D NMR spectra were recorded on a 600 and 400 spectrometer at 300 K, while ^{13}C NMR spectra were measured on a 150 MHz spectrometer. Each NMR sample was prepared by dissolving in 100 μL of $CDCl_3$ and CD_3OD in 2.5 mm micro cells (Shigemi Co. Ltd.) and chemical shifts were reported using residual $CHCl_3$ (δ_H 7.26 and δ_C 77.0) and CH_3OH (δ_H 3.31 and δ_C 49.0) as internal standard. Standard pulse sequences were employed for the 2D NMR experiments. COSY and NOESY spectra were measured with spectral widths of both dimensions of 4800 Hz, and 32 scans with two dummy scans were accumulated into 1 K data points for each of 256 t_1 increments. NOESY spectra in the phase-sensitive mode were measured with a mixing time of 800 and 30 ms, respectively. For HSQC spectra in the phase-sensitive mode and HMBC spectra, a total of 256 increments of 1 K data points were collected. For HMBC spectra with *Z* axis PFG, a 50-ms delay time was used for long-range C–H coupling. Zero-filling to 1 K for F_1 and multiplication with squared cosine-bell windows shifted in both dimensions were performed prior to 2D Fourier transformation. Merck silica gel 60 (40–60 μm) and Cosmosil 140C_{18}-OPN were used for the column chromatography. Waters Sunfire ODS Pro C18 (5 μm, 10 × 250 mm) column was used for HPLC analysis.

Plant material

The barks of *Laumoniera bruceadelpha* were collected at Mersing, Malaysia in 2001. The botanical identification was made by Mr. Teo Leong Eng, Faculty of Science, University of Malaya. Voucher specimens (KL4099) are deposited in the Herbarium of Chemistry Department, University of Malaya.

Extraction and isolation

The barks of *L. bruceadelpha* (1.4 kg), were extracted with MeOH, and a part (40 g) of the extract (126 g) was

suspended in H_2O and then partitioned between $CHCl_3$ and *n*-BuOH, successively. The $CHCl_3$-soluble materials were subjected to a silica gel column ($CHCl_3$/MeOH, 1:0 → 0:1), in which a fraction eluted by $CHCl_3$/MeOH (1:0) was further purified on an ODS HPLC with 40% MeOH to afford decarboxyportentolacetate (**1**, 2.2 mg). A fraction eluted by $CHCl_3$/MeOH (40:1) was further purified on an ODS column with MeOH/H_2O (3:7 → 1:0) followed by an ODS HPLC with MeOH/H_2O (2:3) to afford 3,4-dehydrotheaspirone (**2**, 2.3 mg).

Decarboxyportentol acetate (**1**): colorless amorphous solid, $[\alpha]_D^{20}$ +58 (*c* 0.5, $CHCl_3$); IR ($CHCl_3$) ν_{max} 1739, 1653, and 1242 cm^{-1}; UV (MeOH) λ_{max} 240 (ε 1298) nm; CD (MeOH) λ_{max} 238 ($\Delta\varepsilon$ 0.59) nm; ^1H and ^{13}C NMR (Table 1); ESIMS (pos.) *m/z* 331 $(M + Na)^+$; HRESI-TOFMS (pos.) *m/z* 331.1861 $(M + Na)^+$, calcd. for $C_{18}H_{28}O_4Na$, 331.1885.

3,4-Dehydrotheaspirone (**2**): colorless amorphous solid, $[\alpha]_D^{20}$ +155 (*c* 1.0, MeOH); IR ($CHCl_3$) ν_{max} 1671 and 1249 cm^{-1}; UV (MeOH) λ_{max} 235 (ε 8870) nm; CD (MeOH) λ_{max} 204 ($\Delta\varepsilon$ 2.29) nm; ^1H and ^{13}C NMR (Table 1); ESIMS (pos.) *m/z* 207 $(M + H)^+$; HRESI-TOFMS (pos.) *m/z* 207.1376 $(M + H)^+$, calcd. for $C_{13}H_{19}O_2$, 207.1385.

Antiplasmodial activity

Human malaria parasites were cultured according to the method of Trager and Jensen [12]. The antimalarial activity of the isolated compounds was determined by the procedure described by Budimulja et al. [13]. In brief, stock solutions of the samples were prepared in DMSO (final DMSO concentrations of <0.5%) and were diluted to the required concentration with complete medium (RPMI 1640 supplemented with 10% human plasma, 25 mM HEPES and 25 mM $NaHCO_3$) until the final concentrations of samples in culture plate wells were 10, 1, 0.1, 0.01, and 0.001 μg/ml. The malarial parasite *P. falciparum* 3D7 clone was propagated in 24-well culture plates. Growth of the parasite was monitored by making a blood smear fixed with MeOH and stained with Geimsa stain. The antimalarial activity of each compound was expressed as an IC_{50} value, defined as the concentration of the compound causing 50% inhibition of parasite growth relative to an untreated control ($n = 2$).

The percentage of growth inhibition was expressed according to following equation:

$$\text{Growth inhibition } \% = 100 - [(\text{test parasitaemia}/\text{control parasitemia}) \times 100].$$ Chloroqine : $IC_{50}0.011\ \mu M$.

Cytotoxic activity

HL-60 human promyelocytic leukemia cells were maintained in RPMI-1640 medium. The growth medium was supplemented with 10% fetal calf serum and 1% penicillin–streptomycin. The cells (5×10^3 cells/well) were cultured in Nunc disposable 96-well plates containing 90 μl of growth medium per well and were incubated at 37°C in a humidified incubator of 5% CO_2. 10 μl of samples were added to the cultures at 24 h of incubation. After 48 h of incubation with the samples, 15 μl of 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) (5 mg/ml) were added to each of the wells. The cultures were incubated for another 3 h before the cell supernatants were removed. After the removal of the cell supernatants, 50 μl of dimethyl sulfoxide (DMSO) was added to each well. The formazan crystal formed was dissolved by re-suspension by pipette. The optical density was measured using a microplate reader (Bio-Rad, USA) at 550 nm with reference wavelength at 700 nm. In all experiments, three replicates were used. Cisplatin was used as positive control (IC_{50}: 0.87 μM for HL-60).

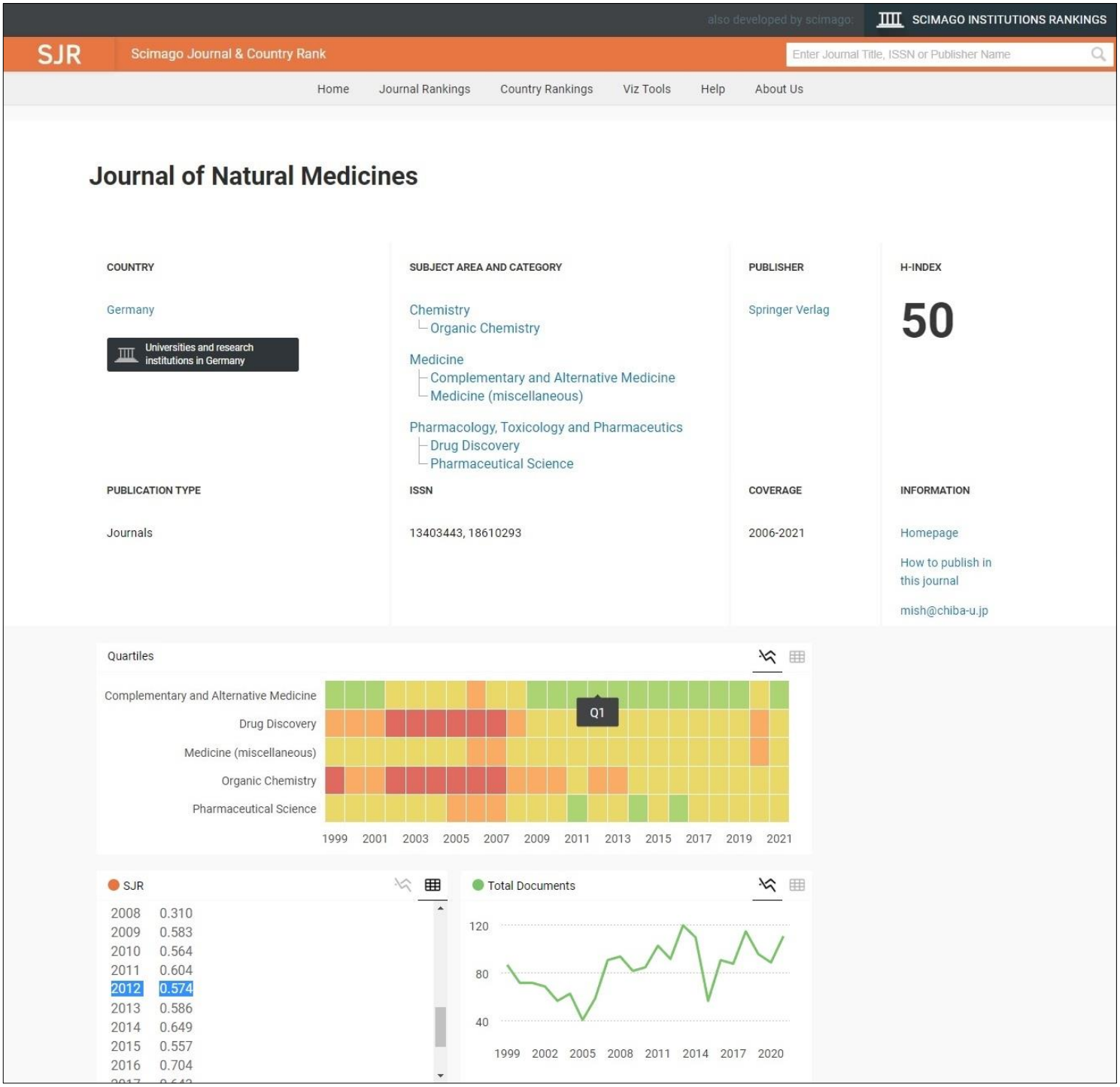
Acknowledgments This work was partly supported by a Grant-in-Aid for Scientific Research from the Ministry of Education, Culture, Sports, Science, and Technology of Japan, and a grant from the Open Research Center Project.

References

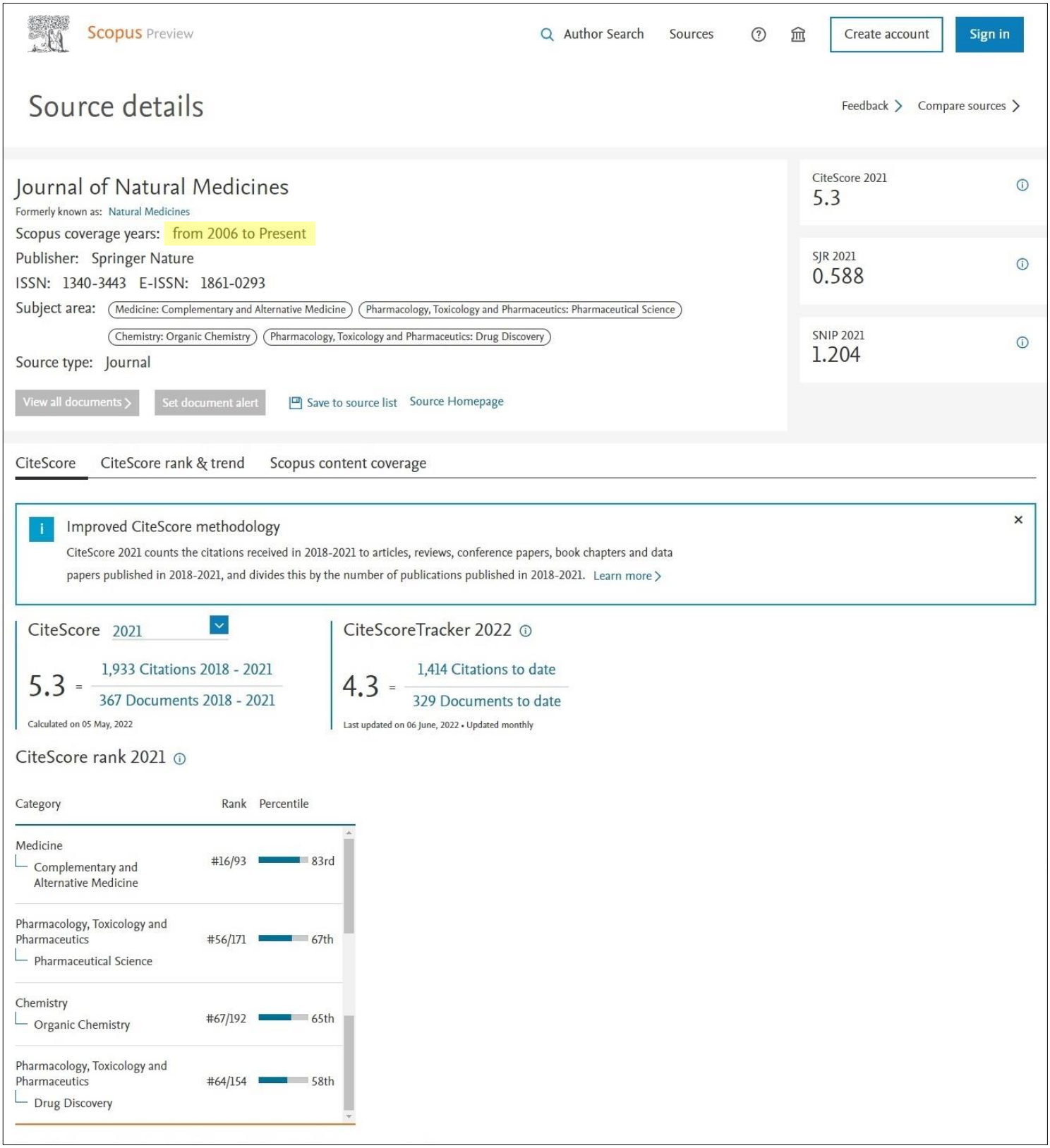
1. Wyler DJ (1993) Malaria: overview and update. Clin Infect Dis 16:449–456
2. Peters W (1982) Antimalarial drug resistance: an increasing problem. Br Med Bull 32:187–192
3. Bawm S, Matsuura H, Elkhateeb A, Nabeta K, Nonaka N, Oku Y, Katakura K (2008) In vitro antitrypanosomal activities of quassinoid compounds from the fruits of a medicinal plant, *Brucea javanica*. Vet Parasitol 158:288–294
4. Muhammad I, Samoylenko V (2007) Antimalarial quassinoids: past, present and future. Expert Opin Drug Discov 2:1065–1084
5. Guo Z, Vangapandu S, Sindelar RW, Walker LA, Sindelar RD (2005) Biologically active quassinoids and their chemistry: potential leads for drug design. Curr Med Chem 12:173–190
6. Klocke JA, Arisawa M, Honda S, Kinghorn AD, Cordell GA, Farnsworth NR (1985) Growth inhibitory, insecticidal and antifeedant effects of some antileukemic and cytotoxic quassinoids on two species of agricultural pests. Experientia 41:379–382
7. Oshimi S, Takasaki A, Hirasawa Y, Awang K, Hadi AHA, Ekasari W, Widyawaruyanti A, Morita H (2009) Delaumonones A and B, new antiplasmodial quassinoids from *Laumoniera bruceadelpha*. Chem Pharm Bull 57:867–869
8. Aberhart DJ, Overton KH, Huneck S (1970) Lichen substances. 75. Portentol: an unusual polypropionate from the lichen *Roccella portentosa*. J Chem Soc C 1612–1623
9. Giang PM, Son PT, Matsunami K, Otsuka H et al (2005) New megastigmane glucosides from *Excoecaria cochinchinensis* LOUR var. *cochinchinensis*. Chem Pharm Bull 53:1600–1603

10. Weyerstahl P, Meisel T (1994) Synthesis and olfactory properties of various racemic theaspirones, ketoedulans and edulans. Liebigs Ann Chem 415–427
11. Moujir LM, Seca AML, Araujo L, Silva AMS, Barreto MC (2011) A new natural spiro heterocyclic compound and the cytotoxic activity of the secondary metabolites from *Juniperus brevifolia* leaves. Fitoterapia 82:225–229
12. Trager W, Jensen JB (1976) Human malaria parasites in continuous culture. Science 193:673–675
13. Budimulja AS, Syafruddin TP, Wilairat P, Marzuki S (1997) The sensitivity of Plasmodium protein synthesis to prokaryotic ribosomal inhibitors. Mol Biochem Parasitol 84:137–141

Bukti – Subject Area and Category, Quartile dan SJR Tahun Terbit (2012)



Bukti – Scopus Coverage, Publisher dan ISSN



Scopus Preview

Author Search Sources Create account Sign in

Source details

Feedback > Compare sources >

Journal of Natural Medicines

Formerly known as: Natural Medicines

Scopus coverage years: from 2006 to Present

Publisher: Springer Nature

ISSN: 1340-3443 E-ISSN: 1861-0293

Subject area: Medicine: Complementary and Alternative Medicine | Pharmacology, Toxicology and Pharmaceutics: Pharmaceutical Science | Chemistry: Organic Chemistry | Pharmacology, Toxicology and Pharmaceutics: Drug Discovery

Source type: Journal

View all documents > | Set document alert | Save to source list | Source Homepage

CiteScore 2021
5.3

SJR 2021
0.588

SNIP 2021
1.204

CiteScore | CiteScore rank & trend | Scopus content coverage

Improved CiteScore methodology

CiteScore 2021 counts the citations received in 2018-2021 to articles, reviews, conference papers, book chapters and data papers published in 2018-2021, and divides this by the number of publications published in 2018-2021. Learn more >

CiteScore 2021

5.3 = 1,933 Citations 2018 - 2021 / 367 Documents 2018 - 2021

Calculated on 05 May, 2022

CiteScoreTracker 2022

4.3 = 1,414 Citations to date / 329 Documents to date

Last updated on 06 June, 2022 • Updated monthly

CiteScore rank 2021

Category	Rank	Percentile
Medicine — Complementary and Alternative Medicine	#16/93	83rd
Pharmacology, Toxicology and Pharmaceutics — Pharmaceutical Science	#56/171	67th
Chemistry — Organic Chemistry	#67/192	65th
Pharmacology, Toxicology and Pharmaceutics — Drug Discovery	#64/154	58th