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Chemical Composition and Antibacterial Activity of Bornean Medicinal Ginger *Alpinia aquatica*

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One new phenylbutenoid, (3*Z*)-2',4',5'-trimethoxyphenylbutadiene (**1**) along with five known metabolites were isolated from aquatic galangal (*Alpinia aquatica* Rosc.) and their chemotaxonomy importance in five populations of *A. aquatica* collected from Kota Kinabalu, Ranau and Kota Belut in Sabah, Malaysia. The antibacterial potential as well as the chemosystematics importance of this discovery is discussed.

Keywords: *Alpinia aquatica*, Zingiberaceae, Chemotaxonomy, Phenylbutenoid, Sesquiterpene, Borneo Island.

Alpinia, belongs to the family Zingiberaceae and is the largest, most ubiquitous genus in the ginger family. It consists of about 230 species in Asia, Australia and Pacific Islands [1]. Members in the genus *Alpinia* such as *Alpinia galanga* (L) Willd, *Alpinia officinarum* Hance and *Alpinia speciosa* K. Schum are used as spices and ingredient in traditional medicines [2]. *Alpinia aquatica* Rosc. is widely distributed in West Malaysia, Borneo and Sumatra, and grows in low altitudes coastal habitats. Only one report on the essential oil constituent is available, where a population contained eighteen compounds and its major metabolite was identified as β-sesquiphellandrene [2]. Non-essential oil chemical constituents of *A. aquatica* has not been studied. It is important that a full chemical description is known due to its use as herb. Present lack of information, initiated our interest to investigate the secondary metabolites in *A. aquatica* of Borneo. Data reported here is the first documented evidence of this species collected from South East Asia, and its ability to produce secondary metabolites.

Compounds **1**-**6** were isolated from the three populations of *A. aquatica* (Figure 1). All structures of compounds were elucidated independently and confirmed by comparisons of physical and ^{1}H and ^{13}C NMR data with previous reported values. Compound **1** is a new phenylbutenoid resulting from an isomerization for C_1-C_2 of 2',4',5'-trimethoxyphenylbutadiene (**2**). Its structure was proposed based on spectroscopic data. In this study, we present for the first time the NMR spectroscopic data (Table 1) of the compound **1**.

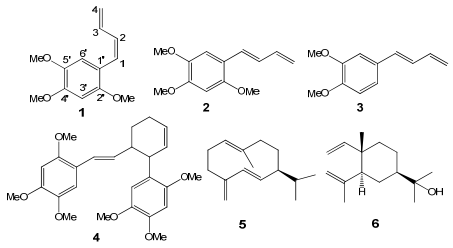

Figure 1: Structures of compounds **1**-**6**.

Compound **2** was previously isolated and reported from various gingers such as *Alpinia flabellata* Ridl. [3] and *Zingiber* Roxb. [4]. Relative stereochemistry of **1** was differed to those of **2** by the present of *cis* geometry for an olefin at C-1/C-2, which can be deduced from vicinal coupling constants $^{3}J_{1\text{-}2}$ = 11.0 Hz (Table 1). On the contrary, the *trans* geometry at C-1/C-2 in **2** with $^{3}J_{1\text{-}2}$ = 16.0 Hz has significantly larger coupling constants compared to those of **1**, further supported this finding [3].

Table 1: ^{1}H and ^{13}C NMR data (600 and 150 MHz, $CDCl_3$) for **1** and **2** (δ in ppm, *J* in Hz).

	1		**2**	
Position	**δ_C**	**δ_H (mult., *J* in Hz)**	**δ_C**	**δ_H (mult., *J* in Hz)**
1	126.5	6.54 d (11.0)	127.8	6.86 d (16.5)
2	130.3	6.25 t (11.0)	128.7	6.68 dd (16.5, 10.3)
3	134.3	6.81 dt (16.5, 11.0)	138.6	6.53 dt (16.5, 10.3)
4	119.4	5.35 d (16.5)	116.6	5.28 d (16.5)
		5.19 d (11.0)		5.10 d (10.3)
1'	119.4		118.7	
2'	152.5		152.3	
3'	98.2	6.54 s	98.4	6.50 s
4'	150.0		150.3	
5'	143.3		144.1	
6'	115.2	6.89 s	110.1	7.01 s
OMe	57.4	3.82 s	57.3	3.84 s
OMe	57.2	3.85 s	57.1	3.88 s
OMe	56.8	3.92 s	56.7	3.90 s

Antibacterial activity had been tested against four human pathogenic bacteria such as *Escherichia coli*, *Proteus mirabilis*, *Salmonella typhii* and *Staphylococcus aureus* [5]. Compounds **1**-**4** demonstrated variable antibacterial activity (Table 2). Compound **1** displayed bactericidal activity against both the tested microbes. Compounds **2** and **3** that resembled structure **1** also displayed bactericidal activity against *E. coli* and *S. typhii*, and bacteriostatic activity against *P. mirabilis* and *S. aureus*. Compound **4** showed bacteriostatic activity against all the four strains of bacteria tested. The *A. aquatica* has medicinal importance as it is being practiced by the local communities in Borneo.

Table 2: Antibacterial activities of compounds **1**-**6** from Bornean *A. aquatica*.

Stains	**MIC; MBC in µg/mL (ratio MBC:MIC)**					
	1	**2**	**3**	**4**	**5**	**6**
E. coli	80;100 (1.25)	200;400 (2.00)	200;500 (2.50)	600;2500 (4.2)	ND	ND
P. mirabilis	250;1250 (5.00)	250;1500 (6.0)	200;1200 (6.00)	500;2500 (5.00)	ND	ND
S. typhii	100;125 (1.25)	250;500 (2.0)	200;600 (3.0)	400;2400 (6.00)	ND	ND
S. aureus	250;1250 (5.00)	250;1500 (6.00)	200;1200 (6.00)	500;3000 (6.00)	ND	ND

Standard deviations were <5 % of the values obtained and are not shown; ND-Not Detected.

The diversity of chemical structures in genus *Alpinia* includes diarylheptanoids, flavonoids, phenolics, phenylbutenoid and terpenoids. Among the isolated compounds, diarylheptanoids type skeleton was reported as the major secondary metabolites in the

genus [2, 6-8]. The isolated compounds consist of four chemical skeleton types; phenylbutenoid type (**1**, **2** and **3**), phenylbutenoid dimer type (**4**), germacrene type (**5**) and elemane-type (**6**). Compounds **2** and **4** have been previously isolated from the rhizomes of *A. flabellata* [3]. The chemical constituents of this Bornean *A. aquatica* are quite different from those of the studied *Alpinia* species [3, 9-15]. The occurrence of chemical similarity (compounds **2** and **4**) between *A. aquatica* and *A. flabellata* indicates that these two species are chemically related. Besides, the first report of compounds **5** and **6** from *A. aquatica* could be regarded as an important chemotaxonomic character for East Malaysian variety.

Experimental

General: IR, Nexus, Thermo, USA; Optical Rotation Rudolf, Auto Pol V; HRESIMS, Shimadzu Japan; HPLC, Prominent, Shimadzu, Japan; NMR, Jeol ECA 600 MHz.

Plant material: *Alpinia aquatic* Rosc. were collected from the Kota Kinabalu (UMS Hill), Ranau and Kota Belut in Sabah, Malaysia. The voucher specimen (BORH37976) was deposited in the BORNEENSIS Herbarium of Institute for Tropical Biology and Conservation (BORH), Universiti Malaysia Sabah.

Extraction, isolation and structure elucidation: Air dried rhizomes of *A. aquatica* (400 g) were extracted in ethanol (4 L), yielded 8.2 g of crude extract. Extract (1.5 g) was fractionated in SiO_2 gel in gradient of hexane and ethyl acetate (9:1–0:1) and six fractions were obtained. Fraction 1 eluted with hexane (hex):ethyl acetate (EtOAc) (9:1) was subjected to PTLC with toluene (tol) (100%) to isolate germacrene D (**5**, 5.6 mg, 0.37%) [16,17]. Fraction 2 eluted with hex:EtOAc (8:2) was purified by PTLC with tol:EtOAc (90:10, v/v) to acquire 4-(3',4'-dimethoxyphenyl)but-1,3-diene (**3**, 8.8 mg, 0.59%) [18] and elemol (**6**, 3.2 mg, 0.21%) [19]. Fraction 3 eluted with hex:EtOAc (7:3) was subjected to PTLC with chloroform (100%) to give (3*Z*)-2',4',5'-trimethoxyphenylbutadiene (**1,** 10.8 mg, 0.72%) and 2',4',5'-trimethoxyphenylbutadiene (**2**, 68.0 mg, 4.53%) [4]. Alflabene (**4**, 82.8 mg, 5.52%) [20] isolated from Fraction 4 eluted with hex:EtOAc (6:4). The compounds were subjected to ^{1}H and ^{13}C NMR, and 2D NMR measurements.

Antibacterial activity: The bacteria were obtained from American Type Cell Culture (ATCC) and tested against the isolated compounds based on the method described by [5,21].

Compound 1

Colorless oil, $[\alpha]_D^{25}$: +4.8 (*c* 0.40, $CHCl_3$)
IR (KBr) : 2829, 1620, 1536 and 1035 cm^{-1}
^{1}H and ^{13}C NMR (150 MHz $CDCl_3$): Table 1
HR-TOFMS *m/z* 185.1184 $[M + H]^+$ (calcd for $C_{20}H_{31}O$, 185.1178).

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References

[1] Kress WJ, Liu AL, Newman M, Li QJ. (**2005**) The phylogeny, evolution and classification of the genus *Globba* and tribe Globbeae(Zingiberaceae): appendages do matter. *American Journal of Botany*, ***91***, 167-178.
[2] Sirat HM, Basar N, Jani NA. (**2011**) Chemical compositions of the rhizome oils of two *Alpinia* species of Malaysia. *Natural Product Research*, ***25***, 982-986.
[3] Masuda T, Andoh T, Yonemori S, Takeda Y. (**1999**) Phenylbutenoids from the rhizomes of *Alpinia flabellata*. *Phytochemistry*, ***50***, 163-166.
[4] Nugroho BW, Schwarz B, Wray V, Proksh P. (**1996**) Insecticidal constituents from rhizomes of *Zingiber cassumunar* and *Kaempferia rotunda*. *Phytochemistry*, ***41***, 129-132.
[5] Vairappan CS, Ang MY, Ong CY, Phang SM. (**2004**) Biologically active polybrominated indoles in the red alga *Laurencia similis* from the coastal waters of Sabah (Rhodomelaceae, Ceramiales). *Malaysian Journal of Science*, ***23***, 119-126.
[6] Pancharoen O, Prawat U, Tuntiwachwuttikul P. (**2000**) Phytochemistry of the Zingiberaceae. *Studies in Natural Products Chemistry*, ***23***, 797-865.
[7] Sirat HM, Jani NA. (**2013**) Chemical constituents of the leaf of *Alpinia mutica* Roxb. *Natural Product Research*, ***27***, 1468-1470.
[8] Ma X N, Xie CL, Miao L, Yang Q, Yang XW. (**2017**) An overview of chemical constituents from *Alpinia* species in the last six decades. *Royal Society of Chemistry Advances*, ***7***, 14114-14144.
[9] Kadota S, Tezuka Y, Prasain J, Shawkat Ali M, Banskota AH. (**2003**) Novel diarylheptanoids of *Alpinia blepharocalyx*. *Current Topics in Medicinal Chemistry*, ***3***, 203-225.
[10] Liu L, Luo JG, Kang LY. (**2012**) Chemistry and antioxidant activity of phenolic compounds isolated from *Alpinia bracteata*. *Chemistry of Natural Compounds*, ***48***, 785-788.
[11] Xu JJ, Zheng GZ, Yang SC, Shen Y, Tan NH. (**2013**) 8-9' linked neolignans with cytotoxicity from *Alpinia conchigera*. *Fitoterapia*, ***91***, 82-86.
[12] Kong LY, Qin MJ, Niwa M. (**2000**) Diterpenoids from the rhizomes of *Alpinia calcarata*. *Journal of Natural Products*, ***63***, 939-942.
[13] Juwitaningsih T, Juliawaty LD, Syah YM. (**2016**) Two pyrones with antibacterial activities from *Alpinia malaccensis*. *Natural Product Communications*, ***11***, 1297-1298.
[14] Konno K, Sawamura R, Sun Y, Yasukawa K, Shimizu T, Watanabe W, Kato M, Yamamoto R, Kurokawa M. (**2011**) Antiviral activities of diarylheptanoids isolated from *Alpinia officinarum* against respiratory syncytial virus, poliovirus, measles virus, and herpes simplex virus type 1 *in vitro*. *Natural Product Communications*, ***6***, 1881-1884.
[15] Nam JW, Seo EK. (**2012**) Structural characterization and biological effects of constituents of the seeds of *Alpinia katsumadai* (Alpina Katsumadai Seed). *Natural Product Communications*, ***7***, 795-798.
[16] Yoshihara K, Ohta Y, Sakai T, Hirose Y. (**1969**) Germacrene D, a key intermediate of cadinene group compounds and bourbonenes. *Tetrahedron Letters*, ***27***, 2263-2264.
[17] Bülow N, König WA. (**2000**) The role of germacrene D as a precursor in sesquiterpene biosynthesis: investigations of acid catalyzed, photochemically and thermally induced rearrangements. *Phytochemistry*, ***55***, 141-168.
[18] Amatayakul T, Cannon J, Dampawn P, Dechatiwongse T, Giles RF, Hantrakul C, Kusamran K, Mokkhasamit M, Raston C, Reutrakul V, White A. (**1979**) Chemistry and crystal structures of some constituents of *Zingiber cassumunar*. *Australian Journal of Chemistry*, ***32***, 71-88.
[19] Southwell IA. (**1970**) A new occurrence of hedycaryol, the precursor of elemol, in *Phebalium ozothamnoides* (Rutaceae). *Phytochemistry*, ***9***, 2243-2245.
[20] Mori I, Nakachi Y, Ueda K, Uemura D, Hirata Y. (**1978**) Isolation and structure of alflabene from *Alpinia flabellata* Ridl. *Tetrahedron Letters*, ***19***, 2297-2298.
[21] Nagappan T, Ramasamy P, Wahid MEA, Segaran TC, Vairappan CS. (**2011**) Biological activity of carbozole alkaloids and essential oils of *Murraya koenigii* against antibiotic resistant microbes and cancer cell lines. *Molecules*, ***16***, 9651-9664.