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Chemical Constituents from *Swietenia macrophylla* Bark and Their Antioxidant Activity

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Abstract: Chemical constituents of the bark of *Swietenia macrophylla* King (Meliaceae) was investigated not only to develop further bark utilization but also to understand the biochemical function of the bark in the forest environment. A new phenylpropanoid-substituted catechin, namely, swietemacrophyllanin [(2*R**,3*S**,7"*R**)-catechin-8,7"-7,2"-epoxy-(methyl 4",5"-dihydroxyphenylpropanoate)] (**1**) was isolated from the bark of *S. macrophylla* together with two known compounds, catechin (**2**) and epicatechin (**3**). The structure of **1** was elucidated by spectroscopic data and by comparison of the NMR data with those of catiguanins A and B, phenylpropanoid-substituted epicatechins. The 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging activity of the isolated compounds indicated that all of the three compounds have strong activity compared with trolox as a reference. Swietemacrophyllanin (**1**) had the strongest activity with a 50% inhibitory concentration (IC_{50}) value of 56 μg mL^{-1}.

Key words: *Swietenia macrophylla*, bark extractives, phenylpropanoid-substituted catechin, catechin, antioxidant activity

INTRODUCTION

Swietenia macrophylla King (Meliaceae) called Big-Leaf mahogany or Honduras mahogany distributed in Central America and tropical South America (Brown *et al*., 2003; Lamb, 1966). Mahogany wood has been used for many purposes, such as fine furniture and cabinet making, interior trim, paneling, fancy veneers, musical instruments, boat building, pattern making, turnery and carving. The leaves can be used for dyeing agent (Mahale *et al*., 2006). The seeds have been used for leishmaniasis and abortion medicine by an Amazonian Bolivian ethnic group (Bourdy *et al*., 2000) and for treatment of hypertension, diabetes and malaria as a folk medicine in Indonesia (Kadota *et al*., 1990a). The antimalarial activity of a water extract of *S. macrophylla* seeds was found against *Plasmodium falciparum* (Murnigsih *et al*., 2005). The seeds also have antibabesial (Murnigsih *et al*., 2005) and antidiarrhoeal activities (Maiti *et al*., 2007). The bark extract has been used as an astringent for wounds and used occasionally for tanning because of the rich red colour. Because *S. macrophylla* was well-known for its fast growth and adaptability, it has been afforested for production of the timber as well as regeneration of forests in tropical regions including Indonesia. Although originally Mahogany wood was provided by *Swietenia mahagoni* (L.) Jacq. which is called Mahogany Tree or West Indian mahogany and is native to the West Indies and Florida, the species have now become very rare because of over-harvesting.

From *S. macrophylla* seeds many kinds of tetranortriterpenoids or limonoids, namely, swietenine (Solomon *et al*., 2003), swietenolide (Connolly *et al*., 1965), 8,30-epoxy-swietenine acetate (Taylor and Taylor, 1983), swietenolide diacetate (Chan *et al*., 1976), augustineolide and 3β,6-dihydroxydihydrocarapin (Mootoo *et al*., 1999), as well as five derivatives of the former three compounds (Kojima *et al*., 1998) were isolated and identified. The presence of known fatty acids and terpenoids were reported from the seeds (Chan *et al*., 1976). γ-Himachalene, germacrene D, germacrene A, cadina-1,4-diene, hexadecanoic acid and ethyl hexadecanoate were analyzed as the essential oil components from the fresh terminal shoots and mature leaves (Soares *et al*., 2003). However, no chemical constituents from the bark have been reported, although, from *S. mahagony* bark and wood, five limonoid-type triterpene possessing di- or mono-orthoesters (swietenialides A-E) together with 2-hydroxyswietenin (Saad *et al*., 2003) and cycloeucalenol (a known triterpene) (Amorós-Marín *et al*., 1959), respectively, were isolated. From the seeds of *S. mahagony*, eighteen tetranortriterpenoids [five swietenins (B-F), three acylswietenolides, seven swietemahonins (A-G),

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swietemahonolide, mahonin and secomahoganin] related to swietenine and swietenolide were isolated and identified (Kadota *et al*., 1990a-c). We have investigated chemical constituents of *S. macrophylla* bark not only to develop further bark utilization but also to understand the biochemical function of the bark in the forest environment. Bark is a waste material of wood processing industry, whereas it is a potential source of bioactive compounds such as an antioxidant, antifungal, or antitermite. In this paper, we would like to report isolation and identification of a new phenylpropanoid-substituted catechin together with catechin and epicatechin from the bark and their potent antioxidant activity. These compounds are polyphenols or flavan-3-ols that are different class of compounds from those isolated so far.

MATERIALS AND METHODS

General experimental procedures: Low to medium pressure column chromatography was conducted on a FMI pump system with a column of Merck silica gel 60 (230-400 mesh, ASTM). Analytical thin-layer chromatography (TLC) and preparative TLC were performed by using plates precoated with Merck silica gel 60 F_{254} (0.25 and 0.50 mm thickness, respectively). Analytical high-performance liquid chromatography (HPLC) was carried out on a JASCO MD-2010 plus equipped with a JASCO UV-970 intelligent UV/Vis detector (280 nm) and a Shimadzu Chromatopac C-R6A, using a reversed phase column (TOSOH, TSK-GEL ODS-80TS, 250×4.6 mm i.d., stainless steel). Preparative HPLC was done using the same system as above except for the column size (300×7.8 mm i.d.). A melting point was measured on a Yanaco MP 52641 micro melting point apparatus and was uncorrected. ^{1}H and ^{13}C nuclear magnetic resonance (NMR) spectra and two dimensional NMR spectra [^{1}H-^{1}H correlation spectroscopy (COSY), nuclear Overhauser effect (NOE) spectroscopy (NOESY), ^{1}H detected multiple quantum coherence (HMQC) spectroscopy and ^{1}H detected multiple bond connectivity (HMBC) spectroscopy] were determined on a JEOL JNM Alpha 400 FT-NMR spectrometer (400 MHz) using tetramethylsilane as an internal standard. Chemical shifts and coupling constants (*J*) were expressed as δ (in ppm) and Hz, respectively. Fast atom bombardment (FAB) mass spectra (MS) were acquired on a JEOL JMS-SX102A mass spectrometer. Fourier-transform infrared (FT-IR) spectra were measured on a Jasco FT/IR-670 Plus spectrophotometer. UV-visible spectra were carried out on a Shimadzu UV 1600 spectrophotometer.

Plant materials: The bark was stripped from *S. macrophylla* trunk, collected from Sumedang, West Java, Indonesia in July 2006. The chipped bark was ground in a Wiley mill and the resulting meal was screened to give 40-80 mesh bark meal in size. The voucher specimen was deposited in the Department of Forest Product Technology, Winaya Mukti University, Bandung, Indonesia.

Extraction and fractionation: The bark meal (40-80 mesh, 1500 g air dried) was extracted three times with acetone (each 3 L) for 48 h at room temperature to give an acetone extract (276.1 g) and a methanol extract (96.7 g), respectively. The acetone extract was reconstituted with 250 mL of acetone and the solution was suspended by the addition of 50 mL of water. The suspension was successively fractionated with *n*-hexane, diethyl ether and ethyl acetate, to give *n*-hexane soluble fraction (3.9 g), diethyl ether soluble fraction (16.1 g) and ethyl acetate soluble fraction (42.9 g), respectively.

Isolation of compounds: The ethyl acetate soluble fraction (20 g) was chromatographed on a silica-gel column (*n*-hexane/EtOAc = 100:0 to 0:100 and then 100% MeOH) by a stepwise elution to afford nine fractions (fr. 1' to 9'). Fr. 5' (2.5 g) was rechromatographed on a silica-gel column [CH_2Cl_2/MeOH = 80:20, (v/v)] to give eight fractions (fr. 5'-1 to 5'-8). Fr. 5'-3 (450 mg) was separated by preparative TLC [CH_2Cl_2/MeOH = 75:25, (v/v) as a developing solvent] to yield eight fractions (fr. 5'-3-1 to 5'-3-8) and then fr. 5'-3-5 (143.3 mg) was purified by preparative HPLC [flow rate 2.0 mL min^{-1}, detection: UV 255 nm, eluent: MeOH/H_2O (30:70, v/v)] to give compounds **1** (3.5 mg) and **3** (3.9 mg). The diethyl ether soluble fraction (15 g) was chromatographed on a silica-gel column (*n*-hexane/EtOAc = 100:0 to 0:100) to give nine fractions (fr. 1 to 9). Fr.7 (0.7 g) was separated by a Sep-pak column C18 (EtOAc/*n*-hexane = 20:80 to 0:100, as an eluent) to afford six fractions (fr.7-1 to 7-6). Fr.7-1 (489 mg) was purified by preparative TLC [CH_2Cl_2/MeOH = 85:15 (v/v)] to yield eight fractions (fr. 7-1 to 7-8). Fr. 7-1-6 (65 mg) was repurified by preparative HPLC [flow rate 2.0 mL min^{-1}, detection: UV 280 nm, eluent: MeOH/H_2O (30:70, v/v)] to give compound **2** (5.6 mg).

Spectroscopic data

Compound 1: Pale red amorphous solid. Mp. 202-204°C. IR (KBr): $\nu_{max}cm^{-1}$ 3366 (OH), 1743 (C=O), 1619 (aromatic C=C), 1524 (aromatic C=C), 1449 (aromatic C=C), 1282 (CO-OCH_3), 1112 (COO–CH_3). FAB-MS *m/z*: 505 $[M+Na]^+$, 483 $[M+H]^+$, 482 $[M]^+$. ^{1}H and ^{13}C NMR (CD_3OD): (Table 1).

Compound 2: Pale brown amorphous solid. IR (KBr): $\nu_{max}cm^{-1}$ 3367, 1608, 1521, 1467, 1285, 1145, 818. FAB-MS *m/z* : 291 $[M+H]^+$. ^{1}H NMR (CD_3OD): δ 2.50 (1H, dd, *J* = 16.1, 8.1 Hz, Hb-4), 2.84 (1H, dd, *J* = 16.1, 5.4 Hz, Ha-4),

Table 1: ^{1}H and ^{13}C NMR data of swietemacrophyllanin (**1**)

Position	^{1}H (δ)	^{13}C (δ)
2	4.73 (d, *J* = 7.1 Hz)	82.8
3	4.01 (m)	68.6
4	2.83 (dd, *J* = 16.3, 5.1 Hz)	28.3
	2.60 (dd, *J* = 16.4, 7.4 Hz)	
5		156.2
6	6.10 (s)	95.9
7		153.1
8		104.3
4a		103.9
8a		153.1
1'		132.2
2'	6.85 (d, *J* = 2.0 Hz)	115.3
3'		146.1
4'		146.3
5'	6.77 (d, *J* = 8.1 Hz)	116.1
6'	6.73 (dd, *J* = 8.3, 2.0 Hz)	119.7
1"		116.2
2"		146.6
3"	6.45 (s)	104.2
4"		146.3
5"		142.3
6"	6.63 (s)	114.9
7"	4.43 (dd, *J* = 7.4, 4.8 Hz)	31.4
8"	2.46 (dd, *J* = 14.2, 7.5 Hz)	45.0
	2.64 (dd, *J* = 14.3, 4.8 Hz)	
9"-C=O		174.4
-OCH_3	3.44 (s)	51.9

3.97 (1H, m, H-3), 4.56 (1H, d, *J* = 7.6 Hz, H-2), 5.85 (1H, s, H-8), 5.92 (1H, br. *s*, H-6), 6.71 (1H, dd, *J* = 8.3, 2.0 Hz, H-6'), 6.76 (1H, d, *J* = 8.1 Hz, H-5'), 6.83 (1H, d, *J* = 2.0 Hz, H-2'). ^{13}C NMR (CD_3OD): δ 28.6 (C-4), 68.9 (C-3), 82.9 (C-2), 95.5 (C-6), 96.3 (C-8), 100.9 (C-4a), 115.3 (C-2'), 116.1 (C-5'), 120.1 (C-6'), 132.3 (C-1'), 146.2 (C-3'), 146.3 (C-4'), 156.9 (C-8a), 157.6 (C-5), 157.9 (C-7).

Compound 3: Pale brown amorphous solid. IR (KBr): ν_{max}cm^{-1}3366, 1606, 1520, 1464, 1283, 1146, 1094, 825. FAB-MS *m/z*: 329 $[M+K]^+$, 313 $[M+Na]^+$, 291 $[M+H]^+$. ^{1}H NMR (CD_3OD): δ 2.73 (1H, dd, *J* = 16.8, 2.7 Hz, H-4a), 2.86 (1H, dd, *J* = 16.7, 4.0 Hz, H-4b), 4.17 (1H, m, *J* = 1.5 Hz, H-3), 4.81 (1H, br. *s*, H-2), 5.91 (1H, d, *J* = 2.4 Hz, H-8), 5.93 (1H, d, *J* = 2.4 Hz, H-6), 6.75 (1H, dd, *J* = 8.1, 2.2 Hz, H-6'), 6.77 (1H, d, *J* = 8.1 Hz, H-5'), 6.97 (1H, d, *J* = 2.0 Hz, H-2'). ^{13}C NMR (CD_3OD): δ 29.3 (C-4), 67.5 (C-3), 79.9 (C-2), 95.9 (C-6), 96.4 (C-8), 100.1 (C-4a), 115.3 (C-2'), 115.9 (C-5'), 119.4 (C-6'), 132.3 (C-1'), 145.8 (C-4'), 146.0 (C-3'), 157.4 (C-8a), 157.7 (C-5), 158.0 (C-7).

DPPH radical scavenging activity assay: The antioxidant activity of the isolated compounds was assayed on the effect of scavenging the stable DPPH free radicals by the literature method (Blois, 1958) with a slight modification. As a reference compound was used 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (trolox), an aqueous tocopherol analogue. The compounds and trolox were dissolved in MeOH to achieve concentrations of 25, 50, 75 and 100 μg mL^{-1} and each of the test sample solutions (90 μL) was added into mixtures of 0.4 mM DPPH solution, 20% MeOH aqueous solution and 0.2 M 2-(*N*-morpholino)ethanesulfonic acid (MES) buffer solution (1:1:1). The resulting mixtures were shaken on a vortex mixer and stood for 20 min and then the absorbance of the remaining DPPH in the mixtures was determined with a visible spectrophotometer at 520 nm. The percentage inhibition of the DPPH free radicals by the samples was calculated from the following equation:

$$\text{DPPH radical scavenging activity (\%)} = (1 - A/A_0) \times 100$$

where, A_0 is the absorbance of the mixture without a sample and A is the absorbance of the mixture with a sample after 20 min. The inhibitory concentration (IC_{50}) value was obtained by interpolation of concentration-DPPH radical scavenging activity curve.

RESULTS AND DISCUSSION

The bark meal of *S. macrophylla* was successively extracted with acetone and methanol. Fractionation of the acetone extract with *n*-hexane, diethyl ether and ethyl acetate and subsequent chromatographic separation of the fractions led to the isolation of three compounds **1**, **2** and **3**. Compounds **1** and **3** were isolated from the ethyl acetate soluble fraction. Compound **2** was isolated from the diethyl ether soluble fraction (Fig. 1).

Compound **1** was isolated as pale red amorphous solid. Its ^{1}H NMR spectrum (Table 1) showed one remarkable singlet at δ 3.44 (3H, -OCH_3) with seven aliphatic and six aromatic proton signals. The ^{13}C NMR spectrum (Table 1) showed eighteen aromatic carbon peaks indicating the presence of three aromatic rings as well as one ester carbonyl (>C=O) and six aliphatic carbons, one of which is -OCH_3, indicating the presence of -$COOCH_3$ and five methylenes and/or methines. The presence of the ester was also supported by the IR spectrum of **1** that showed strong bands at 1743 cm^{-1} (>C=O), 1282 cm^{-1} (CO-OR) and 1112 cm^{-1} (COO-R). The three aromatic signals in the ^{1}H NMR spectrum, namely, two doublets at δ 6.77 (1H, *J* = 8.1 Hz, H-5') and 6.85 (1H, *J* = 2.0 Hz, H-2') and a doublet of doublets at δ 6.73 (1H, *J* = 8.3, 2.0 Hz, H-6') as well as the ^{13}C NMR peaks at δ 146.1 (C-4'-O-) and 146.3 (C-3'-O-) indicated the presence of a 3',4'-dihydroxyphenyl group (B-ring). The four aliphatic proton signals, a doublet at δ 4.73 (1H, *J* = 7.1 Hz, H-2), a multiplet at δ 4.01 (1H, H-3) and two doublets of doublets at δ 2.60 (1H, *J* = 16.4, 7.4 Hz, Hb-4) and 2.83 (1H, *J* = 16.3, 5.1 Hz, Ha-4) for nonequivalent methylene protons adjacent to an asymmetric carbon (C-3)

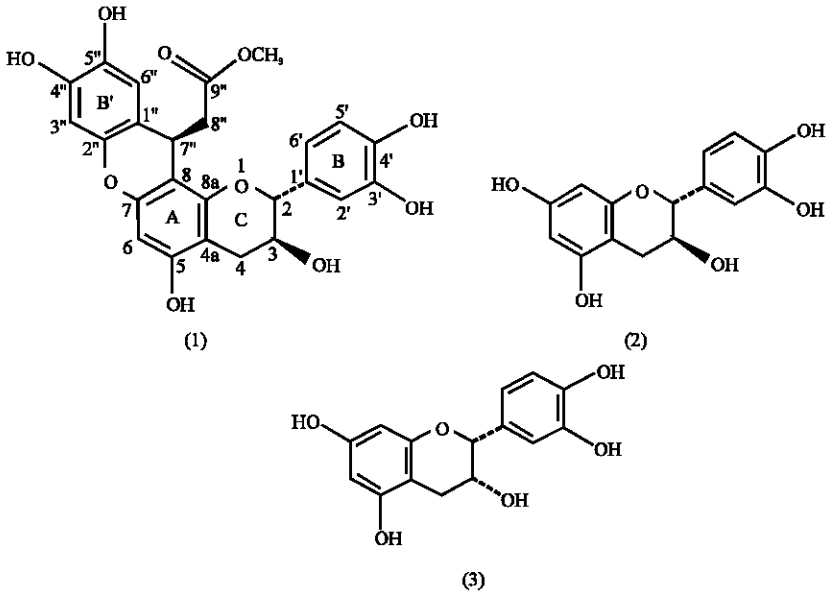

Fig. 1: Chemical constituents isolated from *Swietenia macrophylla* bark

showed the presence of a flavan-3-ol skeleton (C-ring), which was also supported by the ^{13}C NMR peaks of three aliphatic carbons at δ 82.8 (C-2), 68.6 (C-3) and 28.3 (C-4). The larger proton coupling constant between H-2 and H-3 ($J_{2,3}$= 7.1 Hz) indicated that the flavan-3-ol has a 2,3-*trans*-configuration, not a *cis*-configuration which gives the smaller proton coupling constant ($J_{2,3}$ = ~2 Hz). Therefore, it was determined that this compound is a derivative of catechin by comparison with the spectroscopic data of **2** and (+)-catechin (Davis *et al*., 1996) as well as **3** and (-)-epicatechin (Sun *et al*., 2006; Fan *et al*., 2004).

On the other hand, the aromatic A-ring is suggested to be a penta-substituted ring with only one unsubstituted carbon (C-6-H), because the ^{1}H and ^{13}C NMR showed peaks at δ 6.10 (1H, *s*, H-6) and δ 95.9 (C-6-H) and 104.3 (C-8-C) together with δ 156.2 (C-5-O), 153.1 (C-7-O), 153.1 (C-8a-O) and 103.9 (C-4a-C), but neither H-8 signal nor C-8-H peak (whose presence could be predicted around δ 96.3 for a catechin or 96.4 for an epicatechin). Beside the catechin skeleton, the presence of six aromatic carbons, two aliphatic carbons and a methyl ester was also shown by the ^{13}C NMR, which indicated that **1** consists of a methyl disubstituted-phenylpropanoate moiety (the aromatic B'-ring and the C-7", 8" and 9" side chain). The ^{1}H NMR spectrum also showed two singlets of aromatic protons at δ 6.45 (1H) and 6.63 (1H) which should be *para*-orientated and correspond to two ^{13}C NMR peaks of aromatic C-H at δ 104.2 and 114.9. The peak at δ 116.2 was assigned to aromatic C-1"-C and three peaks of the five peaks at δ 142.3-146.6 were assigned to three C-O of the B'-ring and the remaining two peaks were to two C-O of the B-ring as above. Thus, the B'-ring was determined as tetra-substituted one with C-1"-C, C-2"-O, C-4"-O, C-5"-O, C-3"-H and C-6"-H. Furthermore, the presence of C-7"-H (asymmetric methine) and C-8"-H_2 (nonequivalent methylene) was shown by the ^{1}H NMR spectrum: a doublet of doublets at δ 4.43 (J = 7.4, 4.8 Hz) and two doublets of doublets at δ 2.46 (J = 14.2, 7.5 Hz) and 2.64 (J = 14.3, 4.8 Hz), respectively and by the ^{13}C NMR peaks at δ 31.4 (C-7") and 45.0 (C-8"). The ^{13}C NMR peak of the C-8 (δ 104.3) is remarkably shifted to downfield due to deshielding, compared with that of C-8 (δ 95.5) in **2** (catechin). Therefore, the 1,2,4,5-tetra-substituted-phenylpropane moiety (B'-ring) is considered to be fused to the 4a,5,7,8,8a-penta-substituted A-ring of the catechin moiety at the C-8 and C-1" position via C-7" and at the C-7 and C-2" position via the C-7 oxygen atom. The FAB-MS of **1** showed its molecular ion peak and the related ion peaks: $[M+Na]^+$ at *m/z* 505, $[M+H]^+$ at *m/z* 483 and $[M]^+$ at *m/z* 482. This molecular weight supported the planar structure formula of **1**.

Thus, those data were carefully compared with those of catiguanins A and B, diastereomers of the phenylpropanoid-substituted epicatechins isolated very recently from the bark of *Trichilia catigua* (Meliaceae) (Tang *et al*., 2007). These are structurally analogous to compound **1**. However, the NMR data showed that there are two differences between them. One is the downfield shift of the C-2 peak (δ 82.8) of **1**, a catechin-type flavan, compared with those of the catiguanins (δ 79.8 for the A and 80.1 for the B), epicatechin-type flavans. The other is the larger proton coupling constant $J_{2,3}$ (= 7.1 Hz) of **1**

than those of the catiguanins (epicatechin-type), whose H-2 signals were appeared at δ 4.92 as broad singlets. The difference between catiguanins A and B is attributed to a difference of configuration at C-7" (C-9 in the literature). The ^{13}C NMR peaks of **1** at δ 95.9 (C-6), 103.9 (C-4a) and 104.3 (C-8) were consistent with those found in catiguanin A. The NOESY correlations of **1** (Fig. 2) showed that H-6" in the B' ring has correlation with both H-7" and methyl ester protons. This suggested that the methoxycarbonylmethyl group (C8"-C9") at C-7" in **1** is *trans*-oriented relative to the B-ring or is the β-configuration similar to catiguanin A and cinchonain 1a (Foo, 1987). All of the NMR data were assigned as in Table 1. The relative configuration of **1** is 2*R**, 3*S**, 7"*R**. Therefore, compound **1** was identified as a new phenylpropanoid-substituted catechin, (2*R**,3*S**,7"*R**)-catechin-8,7"-7,2"-epoxy-(methyl 4",5"-dihydroxyphenyl-propanoate), named as swietemacrophyllanin.

Compound **2** was isolated as pale brown amorphous solid. All of the ^{1}H and ^{13}C NMR signals of **2** were assigned as in the section spectroscopic data with the aid of two dimentional NMR spectra. FAB-MS showed $[M+H]^+$ peak at *m/z* 291. Those data suggested that **2** was a 5,7,3',4'-tetrahydroxyflavan-3-ol. The larger coupling constant between H-2 and H-3 ($J_{2,3}$ = 7.6 Hz) indicated the C-ring has a 2,3-*trans*-configuration. Therefore, compound **2** was identified as catechin, 2,3-*trans*-5,7,3',4'-tetrahydroxyflavan-3-ol, by comparison of those data with those of (+)-catechin isolated from green tea (Davis *et al*., 1996).

Compound **3** was isolated as pale brown amorphous solid. All of the ^{1}H and ^{13}C NMR signals of **3** were assigned as in the section spectroscopic data with the aid of two dimentional NMR spectra. FAB-MS showed $[M+K]^+$ peak at *m/z* 329, $[M+Na]^+$ peak at 313 and $[M+H]^+$ peak at 291. Those data suggested that **3** was a 5,7,3',4'-tetrahydroxyflavan-3-ol. The 2,3-*cis*-configuration of the C-ring was determined by the smaller coupling constant between H-2 and H-3. The signal of H-2 appeared as a broad singlet at δ 4.81 (Sun *et al*., 2006; Fan *et al*., 2004). Therefore, compound **3** was identified as epicatechin, 2,3-*cis*-5,7,3',4'-tetrahydroxyflavan-3-ol, by comparison of those data with those of (-)-epicatechin (Sun *et al*., 2006; Fan *et al*., 2004; Davis *et al*., 1996). Recently, this laboratory isolated **3** from Tanjung wood (*Mimusops elengi*) (Katayama *et al*., 2005).

The antioxidant activity of the isolated compounds was assessed by the DPPH free radical scavenging assay as shown in Table 2. All of the three compounds exhibited stronger activity than the trolox. Swietemacrophyllanin (**1**) scavenged 50% DPPH free radical at the lowest inhibitory concentration (IC_{50}: 56 μg mL^{-1}), which indicates that this new compound has the strongest activity of the three and trolox. Potent antioxidant activity of catechin and epicatechin is well-known.

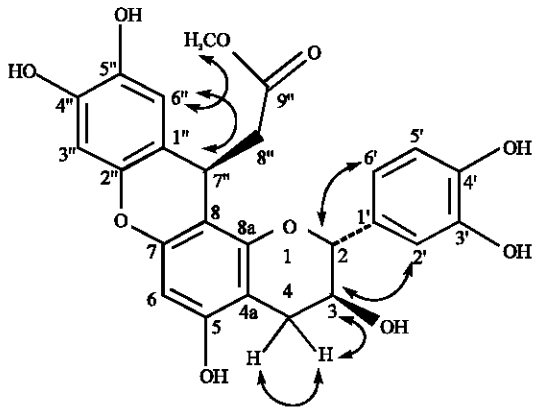

Fig. 2: NOESY correlations of swietemacrophyllanin (**1**)

Table 2: DPPH scavenging activity of the compounds isolated from *Swietenia macrophylla* bark with 50% inhibitory concentration [IC_{50} (μg mL^{-1})] value

Compounds	IC_{50} (μg mL^{-1})[A]
Swietemacrophyllanin (**1**)	56
Epicatechin (**3**)	59
Catechin (**2**)	70
Trolox	81

[A]: The values were obtained by interpolation of concentration-DPPH radical scavenging activity curve

REFERENCES

Amorós-Marín, L., W.I. Torres and C.F. Asenjo, 1959. Isolation of cycloeucalenol from West Indian mahogany wood. J. Org. Chem., 24: 411-413.

Blois, M.S., 1958. Antioxidant determinations by the use of a stable free radical. Nature, 181: 1199-1200.

Bourdy, G., S.J. De Walt, L.R. Chávez De Michel, A. Roca and E. Deharo *et al*., 2000. Medicinal plants uses of the Tacana, an Amazonian Bolivian ethnic group. J. Ethnopharmacol., 70: 87-109.

Brown, N., S. Jennings and T. Clements, 2003. The ecology, silviculture and biogeography of mahogany (*Swietenia macrophylla*): A critical review of the evidence. Persp. Plant Ecol. Evol. Syst., 6: 37-49.

Chan, K.C., T.S. Tang and H.T. Toh, 1976. Isolation of swietenolide diacetate from *Swietenia macrophylla*. Phytochemistry, 15: 429-430.

Connolly, J.D., R. McCrindle, K.H. Overton and W.D.C. Warnock, 1965. Swietenolide. Tetrahedron Lett., 6: 2937-2940.

Davis, A.L., Y. Cai, A.P. Davies and J.R. Lewis, 1996. ^{1}H and ^{13}C NMR assignments of some green tea polyphenols. Magn. Reson. Chem., 34: 887-890.

Fan, P.H., H.X. Lou, W.T. Yu, D.M. Ren, B. Ma and M. Ji, 2004. Novel flavanol derivatives from grape seeds. Tetrahedron Lett., 45: 3163-3166.

Foo, L.Y., 1987. Phenylpropanoid derivatives of catechin, epicatechin and phylloflavan from *Phyllocladus trichomanoides*. Phytochemistry, 26: 2825-2830.

Kadota, S., L. Marpaung, T. Kikuchi and H. Ekimoto, 1990a. Constituents of the seed of *Swietenia mahagoni* Jacq. I. isolations, structures and ^{1}H and ^{13}C nuclear magnetic resonance signal assignment of new tetranortriterpenoids related to swietenine and swietenolide. Chem. Pharm. Bull., 38: 639-651.

Kadota, S., L. Marpaung, T. Kikuchi and H. Ekimoto, 1990b. Constituents of the seeds of *Swietenia mahagoni* Jacq. II. structures of swietemahonin A, B, C, D, E, F and G and swietemahonolide. Chem. Pharm. Bull., 38: 894-901.

Kadota, S., L. Marpaung, T. Kikuchi and H. Ekimoto, 1990c. Constituents of the seed of *Swietenia mahagoni* Jacq. III. structure of mahonin and secomahoganin. Chem. Pharm. Bull., 38: 1495-1500.

Katayama, T., M. Maeda, T. Suzuki, W. Syafii and S. Muladi, 2005. Extractives from tanjung wood, akar kuning and gimbul wood and their antioxidant and antifungal activities. Proceedings of the 6th International Wood Science Symposium. August 29-31, Bali, Indonesia. LIPI-JSPS Core University Program in the Field of Wood Science, pp: 329-333.

Kojima, K., K. Isaka and Y. Ogihara, 1998. Tetranortriterpenoids from *Swietenia macrophylla*. Chem. Pharm. Bull., 46: 523-525.

Lamb, F.B., 1966. Mahogany of Tropical America: Its Ecology and Management. 1st Edn., University of Michigan Press, Ann. Arbor, Michigan .

Mahale, G., H. Medha and I. Goudar, 2006. Dyeing silk with mahogany leave extract. ATA J., 17: 72-75.

Maiti, A., S. Dewanjee and S.C. Mandal, 2007. *In vivo* evaluation of antidiarrhoeal activity of the seed of *Swietenia macrophylla* King (Meliaceae). Trop. J. Pharm. Res., 6: 711-716.

Mootoo, B.S., A. Ali, R. Motilal, R. Pingal and A. Ramlal *et al*., 1999. Limonoids from *Swietenia macrophylla* and *S. aubrevilleana*. J. Nat. Prod., 62: 1514-1517.

Murnigsih, T., Subekti, H. Matsuura, K. Takahashi and M. Yamasaki *et al*., 2005. Evaluation of the inhibitory activities of the extracts of Indonesian traditional medicinal plants against *Plasmodium falciparum* and *Babesia gibsoni*. J. Vet. Med. Sci., 67: 829-831.

Saad, M.M.G., T. Iwagawa, M. Doe and M. Nakatani, 2003. Swietenialides, novel ring D opened phragmalin limonoid orthoesters from *Swietenia mahogany* JACQ. Tetrahedron, 59: 8027-8033.

Soares, M.G., L.G. Batista-Pereira, J.B. Fernandes, A.G. Correa and M.F.G.F. Da Silva *et al*., 2003. Electrophysiological responses of female and male of *Hypsiphyla grandella* (Zeller) to *Swietenia macrophylla* essential oils. J. Chem. Ecol., 29: 2143-2151.

Solomon, K.A., R. Malathi, S.S. Rajan, S. Narasimhan and M. Nethaji, 2003. Swietenine. Acta Cryst. E, 59: 1519-1521.

Sun, J., Y. Jiang, X. Wei, J. Shi, Y. You, H. Liu, Y. Kakuda and M. Zhao, 2006. Identification of (-)-epicatechin as the direct substrate for polyphenol oxidase isolated from lichi pericarp. Food Res. Int., 39: 864-870.

Tang, W., H. Hioki, K. Harada, M. Kubo and Y. Fukuyama, 2007. Antioxidant phenylpropanoid-substituted epicatechin from *Trichilia catigua*. J. Nat. Prod., 70: 2010-2013.

Taylor, A.R.H. and D.A.H. Taylor, 1983. Limonoid extractives from *Swietenia macrophylla*. Phytochemistry, 22: 2870-2871.