Xanthones and Benzophenones from the Stems of *Garcinia multiflora*

Yi-Ming Chiang,[†] Yueh-Hsiung Kuo,*[,†] Shyuzo Oota,[‡] and Yoshiyasu Fukuyama*[,‡]

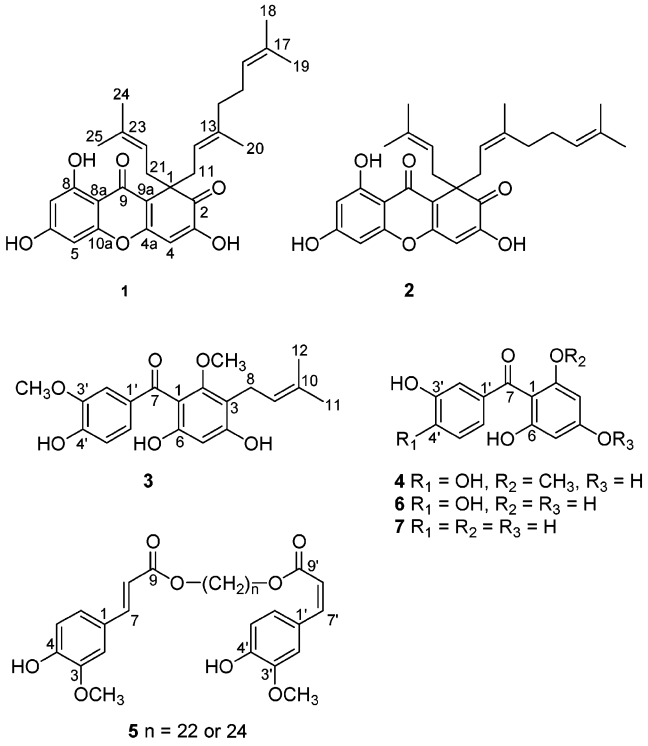
Department of Chemistry, National Taiwan University, Taipei, Taiwan, Republic of China, and Institute of Pharmacognosy, Faculty of Pharmaceutical Sciences, Tokushima Bunri University, Tokushima 770-8514, Japan

Received February 17, 2003

Two new xanthone derivatives, garcinianones A (**1**) and B (**2**), two new benzophenone derivatives, 4,6,4′-trihydroxy-2,3′-dimethoxy-3-prenylbenzophenone (**3**) and 4,6,3′,4′-tetrahydroxy-2-methoxybenzophenone (**4**), and a new inseparable mixture of (1*E*,22*Z*)-1,22-diferuloyloxydocosane and (1*E*,24*Z*)-1,24-diferuloyloxyteracosane (**5**), together with the previously known 3,8-dihydroxy-2,4,6-trimethoxyxanthone, 6,3′-dihydroxy-2,4-dimethoxybenzophenone, maclurin (**6**), 2,4,6,3′-tetrahydroxybenzophenone (**7**), and naringenin, were isolated from the stems of *Garcinia multiflora*. The structures of **1**−**5** were elucidated by extensive analysis of their spectral data. Compounds were evaluated in the brine shrimp lethality test and in the DPPH antioxidant assay.

Prenylated xanthones and their structurally related benzophenones often exhibit a wide range of biological and pharmacological activities,[1] e.g., antioxidant, cytotoxic, antiinflammatory, antimicrobial, antifungal, and inhibitory effects on xanthine oxidase and monoamine oxidase. Garciniaxanthone B, a prenylated xanthone, enhances choline acetyltransferase activity in a cultured neuronal cell system derived from fetal rat hemisphere.[2] Since xanthones have been found in genera of the Guttiferae,[3] we are interested in the chemical constituents of this family. The genus *Garcinia* numbers over 200 species, and there are only three species in Taiwan, namely, *G. subelliptica*, *G. multiflora*, and *G. linii*.[4] *G. multiflora*, a dioecious tree, is about 3−10 m tall and is distributed in southern mainland China, Hong Kong, and the southern part of Taiwan.[4] It can be used in making furniture and as a dye.[5]

Previous phytochemical studies by Konoshima et al.[6] on the bark of *G. multiflora* led to the identification of seven biflavonoids, and Chen et al.[5,7] on the heartwood of this plant identified 11 flavonoids and xanthones. In the present work, two new xanthone derivatives named garcinianones A (**1**) and B (**2**), two new benzophenone derivatives, 4,6,4′-trihydroxy-2,3′-dimethoxy-3-prenylbenzophenone (**3**) and 4,6,3′,4′-tetrahydroxy-2-methoxybenzophenone (**4**), and a new inseparable mixture of (1*E*,22*Z*)-1,22-diferuloyloxydocosane and (1*E*,24*Z*)-1,24-diferuloyloxyteracosane (**5**), together with the previously known 3,8-dihydroxy-2,4,6-trimethoxyxanthone,[10] 6,3′-dihydroxy-2,4-dimethoxybenzophenone,[11] maclurin (**6**),[9] 2,4,6,3′-tetrahydroxybenzophenone (**7**),[11] and naringenin,[12] were isolated. The brine shrimp lethality test and the DPPH assays are convenient initial screening methods for cytotoxic and antioxidative natural products, respectively. In this paper, we report the structures of **1**−**5** and the biological activities of all the isolated compounds.



Results and Discussion

The molecular formula of garcinianone A (**1**) was established as $C_{28}H_{32}O_6$ by HREIMS. The IR spectrum showed absorption bands at 3343 cm^{-1} (hydroxyl group) and 1667 and 1649 cm^{-1} (conjugated carbonyl group). The ^1H NMR data (Table 1) of **1** showed characteristic signals for one prenyl group [δ_H 1.48 (6H, s, H_3-24 and H_3-25), 2.80 (1H, m, H-21a), 3.45 (1H, m, H-21b), and 4.64 (1H, m, H-22)], one 3,7-dimethyl-2,6-octadienyl group [δ_H 1.47 (3H, s, H_3-20), 1.48 (3H, s, H_3-18), 1.60 (3H, s, H_3-19), 1.78, 1.82 (both 2H, m, H_2-15 and H_2-14, respectively), 2.80 (1H, m, H-11a), 3.45 (1H, m, H-11b), 4.64 (1H, m, H-12), and 4.87 (1H, t, J = 6.8 Hz, H-16)], two aromatic and one olefinic proton [δ_H 6.29 and 6.35 (each 1H, d, J = 2.0 Hz, H-7 and H-5, respectively) and 6.48 (1H, s, H-4)], and three D_2O-exchangeable protons, including one phenol proton [δ_H 6.25 (1H, br s, 6-OH)], one five-membered ring chelated enol proton [δ_H 7.01 (1H, s, 3-OH)], and one six-membered ring chelated phenol proton [δ_H 13.29 (1H, s, 8-OH)]. The ^{13}C NMR and DEPT spectra of **1** indicated five CH_3, four CH_2, six CH, and 13 C signals, including those for a prenyl group, a 3,7-dimethyl-2,6-octadienyl group, one quaternary carbon (δ_C 56.0, C-1), two tertiary aromatic and one enol

* To whom correspondence should be addressed. (Y.-H.K.) Tel: 886-2-23638146. Fax: 886-2-23636359. E-mail: yhkuo@ccms.ntu.edu.tw. (Y.F.) Tel: 81-88-622-9611. Fax: 81-88-655-3051. E-mail: fukuyama@ph.bunri-u.ac.jp.
[†] National Taiwan University.
[‡] Tokushima Bunri University.

10.1021/np030065q CCC: $25.00
Published on Web 07/30/2003

Table 1. ^{1}H and ^{13}C NMR Spectral Data for Compounds **1** and **2**[a]

	1		**2**	
position	δ_H	δ_C	δ_H	δ_C
1		56.0		55.9
2		201.3		201.2
3		159.3		159.2
4	6.48 (s)	108.6	6.50 (s)	108.7
4a		151.9		151.8
5	6.35 (d, 2.0)	93.6	6.35 (br s)	93.6
6		161.7		161.7
7	6.29 (d, 2.0)	99.4	6.29 (br s)	99.4
8		162.9		163.0
8a		105.1		105.6
9		179.2		179.2
9a		116.8		116.7
10a		156.8		156.8
11a	2.80[b] (1H, m)	37.8	2.82[b] (1H, m)	37.5
11b	3.45[b] (1H, m)		3.44[b] (1H, m)	
12	4.64[b] (m)	117.7	4.62[b] (m)	118.1
13		139.1		139.1
14	1.82 (2H, m)	39.6	1.92 (2H, m)	31.9
15	1.78 (2H, m)	26.5	1.88 (2H, m)	26.5
16	4.87 (t, 6.8)	123.8	5.04 (t, 6.8)	124.0
17		131.4		131.7
18	1.48 (3H, s)	25.7	1.67 (3H, s)	25.7
19	1.60 (3H, s)	17.9	1.59 (3H, s)	17.6
20	1.47 (3H, s)	16.2	1.49 (3H, s)	23.3
21a	2.80[b] (1H, m)	38.0	2.82[b] (1H, m)	38.0
21b	3.45[b] (1H, m)		3.44[b] (1H, m)	
22	4.64[b] (m)	117.6	4.62[b] (m)	117.6
23		135.3		135.4
24	1.48 (3H, s)	25.5	1.49 (3H, s)	25.7
25	1.48 (3H, s)	17.6	1.48 (3H, s)	17.9
OH-3	7.01 (s)		7.00 (s)	
OH-6	6.25 (br s)		5.98 (br s)	
OH-8	13.29 (s)		13.24 (s)	

[a] 400 MHz (^{1}H) and 100 MHz (^{13}C) in $CDCl_3$. Figures in parentheses are coupling constants (J) in Hz. [b] Data obtained from HMQC spectrum.

tertiary olefinic carbon [δ_C 93.6 (C-5), 99.4 (C-7), and 108.6 (C-4)], two non-oxygenated quaternary aromatic carbons [δ_C 105.1 (C-8a) and 116.8 (C-9a)], four oxygenated aromatic and one oxygenated olefinic carbon [δ_C 151.9 (C-4a), 156.8 (C-10a), 159.3 (C-3), 161.7 (C-6), and 162.9 (C-8)], and two carbonyl carbons [δ_C 179.2 (C-9) and 201.3 (C-2)]. The oxygenated aromatic carbon signals appeared at δ_C 156.8−162.9 and, together with three tertiary aromatic and olefinic carbon signals appearing at δ_C 93.6−108.6, indicated the presence of a *meta*-dioxygenated benzene ring[8] and an enol moiety. On the basis of this evidence and analysis of its 2D NMR spectra (HMQC and HMBC), **1** was deduced to consist of a xanthone skeleton bearing a prenyl and a geranyl group, the presence of which was supported by prominent α-cleavage fragments (Figure S1, Supporting Information) observed in the EIMS. In the HMBC spectrum, the long-range ^{1}H−^{13}C correlations between H-4/C-2, C-3, C-4a, C-9a; H_2-11/C-1, C-2, C-9a, C-21; and H_2-21/C-1, C-2, C-9a, C-11 established that the prenyl and 3,7-dimethyl-2,6-octadienyl groups are attached to the C-1 position of the xanthone skeleton (Figure 1a). H-11a and H-11b are diastereotopic protons as in the case of H-21a and H-21b. Together with the similar environment of H_2-11 and H_2-21, this led to the overlapping ^{1}H NMR signals of H-11a and H-21a as well as of H-11b and H-21b. Additionally, NOESY correlations of H_2-11/H_3-20 and H-12/H_2-14 suggested the 12*E* configuration for the 3,7-dimethyl-2,6-octadienyl group (Figure 1b). Although there is a single chiral center (C-1), **1** was found to be a racemic mixture because of having no observed specific rotation. Thus, the structure of garcinianone A was deduced as shown in formula **1**.

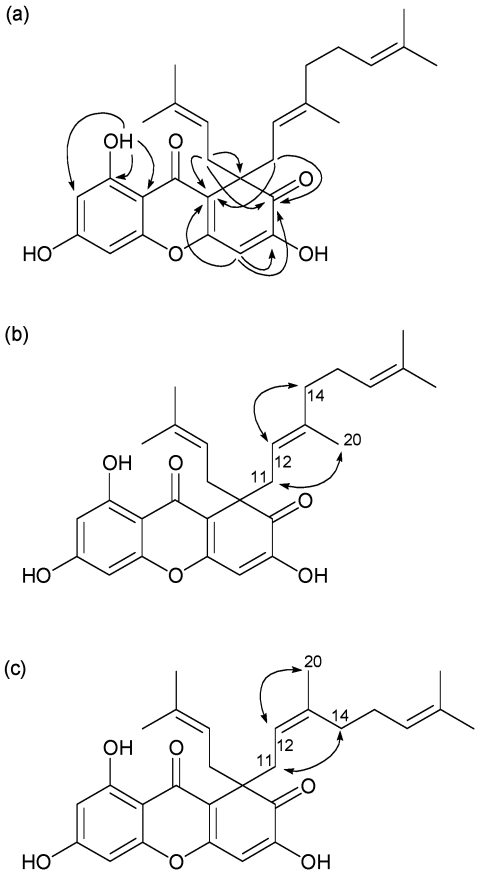


Figure 1. (a) Selected HMBC correlations and (b) selected NOESY correlations for compound **1**, and (c) selected NOESY correlations for compound **2**.

Garcinianone B (**2**), a stereoisomer of **1**, was obtained from the same chromatographic fraction and exhibited very similar spectral properties (Table 1). The only difference found between **1** and **2** was the geometry of the C-12 and C-13 double bond in the 3,7-dimethyl-2,6-octadienyl substituent. The 12*Z* geometry in **2** was established by NOESY correlations for H_2-11/H_2-14 and H-12/H_3-20 (Figure 1c) and the diagnostic high-field shift (δ_C 31.9) for C-14 in the ^{13}C NMR spectrum of **2**. Thus, the structure of garcinianone B (**2**) was determined as shown. Garcinianones A and B were isolated from a Si gel column with R_f values of 0.38 and 0.32 ($CHCl_3$−MeOH = 49:1), respectively.

Compound **3** had HREIMS and ^{13}C NMR data consistent with the molecular formula $C_{20}H_{22}O_6$, indicating 10 indices of hydrogen deficiency (IHD). Its IR spectrum showed hydroxy (3338 cm^{-1}) and conjugated ketone (1620 cm^{-1}) functionalities. The ^{1}H NMR spectrum (Table 2) in DMSO-d_6 exhibited a prenyl group [δ_H 1.61, 1.66 (both 3H, s, H_3-12 and H_3-11, respectively), 3.10 (2H, d, J = 6.8 Hz, H_2-8), and 5.13 (1H, t, J = 6.8 Hz, H-9)], one shielded aromatic proton on a pentasubstituted benzene ring [δ_H 6.22 (1H, s, H-5)], three aromatic protons on a 1,2,4-trisubstituted benzene ring [δ_H 6.78 (1H, d, J = 8.2 Hz, H-5′), 7.08 (1H, dd, J = 8.2, 2.1 Hz, H-6′), and 7.35 (1H, d, J = 2.1 Hz, H-2′)], two methoxy groups [δ_H 3.42 (3H, s, OMe-2) and 3.78 (3H, s, OMe-3′)], and three D_2O-exchangeable phenolic protons [δ_H 9.33, 9.57, and 9.93 (each 1H, s, OH-6, OH-4, and OH-4′, respectively)]. The ^{13}C NMR (Table 2) and DEPT spectra of **3** indicated four CH_3, one CH_2, five CH, and 10 C signals, including one prenyl group, two methoxy groups, four tertiary aromatic carbons, eight aromatic

Table 2. ^{1}H and ^{13}C NMR Spectral Data for Compounds **3**[a] and **4**[b]

	3		**4**	
position	δ_H	δ_C	δ_H	δ_C
1		113.0		107.8
2		156.8	5.95 (d, 1.8)	157.9
3		111.8		90.2
4		157.2	5.98 (d, 1.8)	158.9
5	6.22 (s)	98.4		94.8
6		153.6		155.7
7		193.3		192.7
8	3.10 (d, 6.8)	22.0		
9	5.13 (t, 6.8)	123.9		
10		129.5		
11	1.66 (3H, s)	25.5		
12	1.61 (3H, s)	17.7		
1′		130.2		129.9
2′	7.35 (d, 2.1)	111.2	7.14 (d, 1.8)	115.6
3′		147.4		144.3
4′		151.6		149.8
5′	6.78 (d, 8.2)	114.7	6.74 (d, 8.2)	114.4
6′	7.08 (dd, 8.2, 2.1)	125.2	7.04 (dd, 8.2, 1.8)	121.6
OMe-2	3.42 (3H, s)	61.8	3.54 (3H, s)	54.7
OH-4	9.57 (s)			
OH-6	9.33 (s)			
OMe-3′	3.78 (3H, s)	55.5		
OH-4′	9.93 (s)			

[a] 400 MHz (^{1}H) and 100 MHz (^{13}C) in DMSO-d_6. [b] 400 (^{1}H) and 100 (^{13}C) MHz in CD_3OD. Figures in parentheses are coupling constants (J) in Hz.

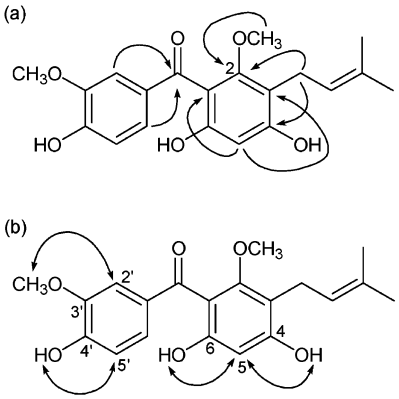


Figure 2. (a) Selected HMBC correlations and (b) selected NOESY correlations for compound **3**.

quaternary carbons, and one conjugated carbonyl carbon. The above spectral data disclosed that compound **3** is a prenylated benzophenone, having one pentasubstituted ring and one 1,2,4-trisubstituted benzene ring. This assignment was supported additionally by the observation of the α-cleavage fragments (Figure S2, Supporting Information) in the EIMS of **3**. The positioning of the substituents on the two benzene rings was elucidated on the basis of chemical shift considerations, mainly coupled with the results of HMBC and NOESY experiments: the HMBC correlations for H-5/C-1, C-3, C-4, C-6; H-8/C-2, C-3, C-4; H-2′/C-3′, C-4′, C-6′, C-7; H-6′/C-2′, C-4′, C-7; OMe-2/C-2; OH-4/C-3, C-4, C-5 (Figure 2a) and the NOESY correlations for H-5/4-OH, OH-6; H-2′/OMe-3′; H-5′/OH-4′ (Figure 2b). Thus, compound **3** was assigned as 4,6,4′-trihydroxy-2,3′-dimethoxy-3-prenylbenzophenone.

Compound **4** exhibited HREIMS and ^{13}C NMR data consistent with the molecular formula $C_{14}H_{12}O_6$. The IR spectrum showed the presence of hydroxyl (3307 cm^{-1}) and conjugated carbonyl (1628 cm^{-1}) groups that were confirmed by ^{13}C NMR and DEPT experiments. The ^{1}H and ^{13}C NMR spectra (Table 2) were similar to those of maclurin (**6**),[9] which was also isolated in the present investigation. The only difference between their structures was that **4** had a methoxyl group attached to C-2, instead of a hydroxyl group existing in **6**. Thus, the structure of compound **4** was elucidated as 4,6,3′,4′-tetrahydroxy-2-methoxybenzophenone.

Table 3. Brine Shrimp Lethality (LD_{50}) and DPPH Scavenging Activity (IC_{50}) Data of Compounds from *G. multiflora*

	1	**2**	**4**	**6**	**7**	berberine	catechin
BSL test (μM)	7.7	25.8	>100	43.1	>100	67.0	*a*
DPPH assay (μM)	107.4	144.8	7.8	5.3	66.3	*a*	2.53

[a] Not evaluated.

Compound **5**, which was isolated as an inseparable mixture of two phenylalkanoids, exhibited typical (*Z*)- and (*E*)-ferulic acid and long-chain alcohol signals in its ^{1}H and ^{13}C NMR spectra. The carbon numbers of the long-chain alcohols were determined by the HRFABMS, which exhibited the molecular formulas $C_{42}H_{62}O_8Na$ and $C_{44}H_{66}O_8Na$. Thus, **5** was assigned as a mixture of (1*E*,22*Z*)-1,22-diferuloyloxydocoane and (1*E*,24*Z*)-1,24-diferuloyloxyteracosane. The relative ratio in the FABMS of $C_{42}H_{62}O_8Na$ and $C_{44}H_{66}O_8Na$ is 1.38. Thus, the relative amount of these two new compounds was determined as 58:42.

Five known compounds, 3,8-dihydroxy-2,4,6-trimethoxyxanthone,[10] 6,3′-dihydroxy-2,4-dimethoxybenzophenone,[11] maclurin (**6**),[9] 2,4,6,3′-tetrahydroxybenzophenone (**7**),[11] and naringenin,[12] were also isolated and were identified by comparison of their spectral data with those published in the literature.

The brine shrimp lethality test[13,14] (BSL) and an assay for DPPH radical-scavenging activity were carried out on the EtOAc fraction of *G. multiflora* and isolated compounds (Table 3). The EtOAc fraction was found to have a LD_{50} value of 120 ppm in the BSL test but no significant DPPH radical-scavenging activity at 100 ppm. Compounds **1**, **2**, and **6** were found to be toxic to brine shrimp, with LD_{50} values of 7.7, 25.8, and 43.1 μM, respectively. Compounds **4** and **6** exhibited antioxidant activity (IC_{50} = 7.8 and 5.3 μM, respectively) in the DPPH scavenging assay.[15]

Experimental Section

General Experimental Procedures. Optical rotations were measured on a JASCO DIP-1000 digital polarimeter. IR spectra were recorded on a JASCO FT-IR 5300 spectrophotometer. UV spectra were taken on a Hitachi S-3200 spectrometer. ^{1}H and ^{13}C NMR spectra were run on a JEOL ECP-400 spectrometer. EIMS were obtained on a JEOL AX-500 mass spectrometer. Si gel (Merck 70−230 mesh, 230−400 mesh, ASTM) was used for column chromatography. Chemicals and reagents including 1,1-diphenyl-2-picrylhydrazyl (DPPH) and catechin were purchased from Sigma Chemical Co. (St. Louis, MO). Sephadex LH-20 was purchased from Amersham Pharmacia Biotech. TLC analysis was performed on Si gel 60 F_{254} and RP-18 F_{254S} (Merck), with compounds visualized by spraying with 10% (v/v) H_2SO_4. All other chemicals and solvents used in this study were of reagent grade or HPLC grade.

Plant Materials. *Garcinia multiflora* was collected in Pinton, south of Taiwan, in February 2001. The plant was identified by Muh-Tsuen Gun, formerly a technician of the Department of Botany, National Taiwan University, and a voucher specimen (voucher no. 183837) has been deposited at the Herbarium of the Department of Botany of the National Taiwan University, Taipei, Taiwan.

Extraction and Isolation. The dried and crushed stems of *G. multiflora* (12 kg) were extracted with MeOH (120 L) at

room temperature (7 days, twice). This combined extract was evaporated in vacuo to yield a residue, which was suspended in H_2O and then partitioned with EtOAc. The combined EtOAc layers afforded a black syrup (260 g), which was subsequently chromatographed over Si gel with a hexane−EtOAc gradient solvent system to give fractions A−S. Fraction E (1.1 g) was first subjected to Sephadex LH-20 chromatography eluting with MeOH−$CHCl_3$ (1:1) to give fractions 1−3. Fraction 3 (78 mg) was further chromatographed on a Si gel column eluting with $CHCl_3$−MeOH (29:1) to give garcinianones A (**1**) (5 mg) and B (**2**) (4.3 mg). Fraction G (1.5 g) was chromatographed on a Sephadex LH-20 column eluting with MeOH−$CHCl_3$ (1:1) to give fractions 4−8. Fraction 6 (394 mg) was subjected to Si gel chromatography eluting with $CHCl_3$−EtOAc (4:1) to afford 4,6,4′-trihydroxy-2,3′-dimethoxy-3-prenylbenzophenone (**3**) (62 mg) and 6,3′-dihydroxy-2,4-dimethoxybenzophenone (261 mg). Fraction I (2.0 g) was chromatographed on Sephadex LH-20 with MeOH as solvent to give fractions 9−15. Fraction 13 (114 mg) was further chromatographed over Si gel eluting with $CHCl_3$−EtOAc (3:2) to give fractions 16−21. Finally, fraction 18 (65 mg) was purified by preparative TLC with MeOH−H_2O (1:1) to give 4,6,3′,4′-tetrahydroxy-2-methoxybenzophenone (**4**) (24 mg), maclurin (**6**) (10 mg), and 2,4,6,3′-tetrahydroxybenzophenone (**7**) (13 mg). Fraction F (587 mg) was chromatographed on Sephadex LH-20 with MeOH−$CHCl_3$ (1:1) and then was purified by Si gel chromatography with $CHCl_3$−MeOH (9:1) to give a mixture of (1*E*,22*Z*)-diferuloyloxydocosane and (1*E*,24*Z*)-diferuloyloxytetracosane (**5**) (14 mg). Repeated Si gel chromatography of fraction H (860 mg) yielded 3,8-dihydroxy-2,4,6-trimethoxyxanthone (2.5 mg) and naringenin (8.4 mg).

Garcinianone A (1): yellow oil; $[\alpha]^{25}_D$ 0° (*c* 0.48, $CHCl_3$); UV (EtOH) λ_{max} (log ϵ) 293 (4.20), 236 (4.25), 222 (4.32) nm; IR (film) ν_{max} 3343, 1667, 1649 cm^{-1}; ^1H and ^{13}C NMR data, see Table 1; EIMS *m*/*z* 464 $[M]^+$ (8), 395 $[M - C_5H_9]^+$ (31), 327 $[M - C_{10}H_{17}]^+$ (59), 137 (13), 69 (100); HREIMS *m*/*z* 464.2195 (calcd for $C_{28}H_{32}O_6$, 464.2199).

Garcinianone B (2): yellow oil; $[\alpha]^{25}_D$ 0° (*c* 0.21, $CHCl_3$); UV (EtOH) λ_{max} (log ϵ) 314 (3.92), 239 (4.06), 221 (4.19) nm; IR (film) ν_{max} 3339, 1647 cm^{-1}; ^1H and ^{13}C NMR data, see Table 1; EIMS *m*/*z* 464 $[M]^+$ (22), 395 $[M - C_5H_9]^+$ (61), 327 $[M - C_{10}H_{17}]^+$ (100), 137 (18), 69 (90); HREIMS *m*/*z* 464.2189 (calcd for $C_{28}H_{32}O_6$, 464.2199).

4,6,4′-Trihydroxy-2,3′-dimethoxy-3-prenylbenzophenone (3): yellow oil; UV (EtOH) λ_{max} (log ϵ) 315 (3.76), 289 (3.71), 229 (4.01) nm; IR (film) ν_{max} 3338, 1620 cm^{-1}; ^1H and ^{13}C NMR data, see Table 2; EIMS *m*/*z* 358 $[M]^+$ (100), 343 $[M - CH_3]^+$ (24), 235 $[M - C_7H_7O_2]^+$ (15), 151 (35), 69 (11); HREIMS *m*/*z* 358.1434 (calcd for $C_{20}H_{22}O_6$, 358.1416).

4,6,3′,4′-Tetrahydroxy-2-methoxybenzophenone (4): yellow oil; UV (EtOH) λ_{max} (log ϵ) 320 (3.99), 288 (3.86), 228 (4.07) nm; IR (film) ν_{max} 3307, 1628 cm^{-1}; ^1H and ^{13}C NMR data, see Table 2; EIMS *m*/*z* 276 $[M]^+$ (100), 167 $[M - C_6H_5O_2]^+$ (88), 137 $[M - C_7H_7O_3]^+$ (31); HREIMS *m*/*z* 276.0613 (calcd for $C_{14}H_{12}O_6$, 276.0634).

(1*E*,22*Z*)-1,22-Diferuloyloxydocosane and (1*E*,24*Z*)-1,24-diferuloyloxytetracosane (5): yellow oil; UV (EtOH) λ_{max} (log ϵ) 235 (4.28), 326 (4.44) nm; IR (film) ν_{max} 3404, 1709 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ 1.25 (about 38H, br s), 4.12 and 4.19 (2H each, t, J = 6.6 Hz), 3.93 (6H, s, OMe-3 and OMe-3′), 5.89 (2H, s, OH-4 and OH-4′), 5.82 and 6.79 (1H each, d, J = 13.0 Hz, H-8′ and H-7′, respectively), 6.29 and 7.61 (1H each, d, J = 15.7 Hz, H-8 and H-7, respectively), 6.88 and 6.91 (1H each, d, J = 8.3 Hz, H-5′ and H-5, respectively), 7.03 and 7.77 (1H each, d, J = 1.8 Hz, H-2 and H-2′, respectively), 7.07 and 7.10 (1H each, dd, J = 8.3, 1.8 Hz, H-6 and H-6′, respectively); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 29.7 and 29.3 (CH_2), 64.6 and 64.7 (OCH_2), 55.9 and 55.9 (OMe-3 and OMe-3′), 109.3 (C-2), 112.8 (C-2′), 113.8 (C-5′), 114.7 (C-5), 115.7 (C-8), 116.9 (C-8′), 123.0 (C-6), 125.5 (C-6′), 127.0 (C-1′), 127.2 (C-1), 143.6 (C-7′), 144.6 (C-7), 145.9 (C-3′), 146.7 (C-3), 147.0 (C-4′), 147.9 (C-4), 166.6 (C-9′), 167.4 (C-9); FABMS *m*/*z* 717 $[M + Na]^+$ and 745 $[M + Na]^+$; HRFABMS *m*/*z* 717.4343 (calcd for $C_{42}H_{62}O_8Na$, 717.4366) and 745.4697 (calcd for $C_{44}H_{66}O_8Na$, 745.4655).

Brine Shrimp Lethality Test. The BSL test was carried out using a previously reported method.[14]

Radical-Scavenging Activity. DPPH assays were carried out according to the method reported in the literature.[15] A solution of 180 μL of 1,1-diphenyl-2-picrylhydrazyl (DPPH) (0.1 mM) in EtOH was added to 20 μL of a solution of the test sample in EtOH. After 20 min, the absorbance at 517 nm was measured. The scavenging activity of the tested compound was measured as the decrease in absorbance of the DPPH and expressed as a percentage of the absorbance of a control DPPH solution without test sample. Catechin was used as a positive control.

Acknowledgment. This research was partially supported by the National Science Council of the Republic of China and by a Grant-in Aid for Scientific Research (No. 12480175) from the Ministry of Education, Culture, Sports, Science, and Technology of Japan.

Supporting Information Available: EIMS fragments from α-cleavage of compounds **1** and **2** (Figures S1 and S2). This material is available free of charge via the Internet at http://pubs.acs.org.

References and Notes

(1) Minami, H.; Kinoshita, M.; Fukuyama, Y.; Kodama, M.; Yoshizawa, T.; Sugiura, M.; Nakagawa, K.; Tago, H. *Phytochemistry* **1994**, *36*, 501−506, and references therein.
(2) Fukuyama, Y.; Kamiyama, A.; Mima, Y.; Kodama, M. *Phytochemistry* **1991**, *30*, 3433−3346.
(3) Bennett, G. J.; Lee, H. H. *Phytochemistry* **1989**, *28*, 967−998.
(4) Huang, T. C. In *Flora of Taiwan*, 2nd ed.; Editorial Committee of the Flora of Taiwan: Taipei, 1996; Vol. 2, pp 695−698.
(5) Chen, F. C.; Lin, Y. M.; Hung, J. C. *Phytochemistry* **1975**, *14*, 300−303.
(6) Konoshima, M.; Ikeshiro, Y.; Miyahara, S.; Yen, K. Y. *Tetrahedron Lett.* **1970**, 4203−4206.
(7) Chen, F. C.; Lin, Y. M.; Hung, J. C. *Phytochemistry* **1975**, *14*, 818−820.
(8) Markham, K. R.; Chari, V. M. In *The Flavonoids: Advances in Research*; Harborne, J. B., Mabry, T. J., Eds.; Chapman and Hall: London, 1982; Chapter 2, pp 20−24.
(9) Holloway, D. M.; Scheinmann, F. *Phytochemistry* **1975**, *14*, 2517−2518.
(10) Ikeya, Y.; Sugama, K.; Okada, M.; Mitsuhashi, H. *Phytochemistry* **1991**, *30*, 2061−2065.
(11) Atkinson, J. G.; Gupta, P.; Lewis, J. R. *Tetrahedron* **1969**, *25*, 1507−1511.
(12) Agrawal, P. K. *Carbon-13 NMR of Flavonoids*; Elsevier: Amsterdam, 1989; p 103.
(13) Anderson, J. E.; Goetz, C. M.; McLaughlin, J. L.; Suffness, M. *Phytochem. Anal.* **1991**, *2*, 107−111.
(14) Fukuyama, Y.; Ogawa, M.; Takahashi, H.; Minami, H. *Chem. Pharm. Bull.* **2000**, *48*, 301−303.
(15) Blois, M. S. *Nature* **1958**, *181*, 1199−1120.

NP030065Q