Iridoid Constituents of *Tarenna attenuata*

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Members of a rare type of iridoid with two α,β-unsaturated acid units were isolated from the whole plant of *Tarenna attenuata*, including a new compound, tarennin (**1**), an extraction artifact, and seven new glucosides, tarenninosides A−G (**2**−**8**), together with two known iridoid glucosides, ixoside and 10-methylixoside. The structures of **1**−**8** were elucidated by analysis of spectroscopic data including HMQC, HMBC, ^{1}H−^{1}H COSY, and ROESY NMR spectra and by comparison with known analogues. Antioxidant and cytotoxic activities were evaluated for these 10 compounds, but none showed positive activity.

Tarenna attenuata (Voigt) Hutch. (Rubiaceae) is a shrub or small tree occurring in India, Vietnam, Cambodia, and People's Republic of China.[1] In mainland China, this plant is used as an anodyne and antipyretic by indigenous communities in the traditional medicinal system of Guangxi Province.[2] We have investigated the chemical constituents and ethyl alcohol extract of this species, which resulted in the isolation of one new iridoid (**1**) and seven new iridoid glucosides (**2**−**8**). Two known compounds were identified as ixoside and 10-methylixoside, respectively, by comparison of their physical and spectroscopic data with published data.[3−5] This paper deals with the isolation and structure elucidation of compounds **1**−**8**. The antioxidant and cytotoxic activities of these 10 isolates were also evaluated.

Compound **1** exhibited a $[M + Na]^+$ ion peak at *m*/*z* 277.0688 in the positive HRESIMS, corresponding to the molecular formula $C_{12}H_{14}O_6$. The IR spectrum indicated the presence of carboxyl groups (a broad band from 2500 to 3431, 1690 cm^{-1}) and olefinic bonds (1623 and 1637 cm^{-1}). The ^{1}H NMR spectroscopic data of **1** displayed signals characteristic of an iridoid with protons at C-3 (δ_H 7.40 s) and C-1 (δ_H 5.28, d, J = 3.6 Hz).[6,7] In addition, signals were observed for an ethoxyl moiety with one oxygen-connected sp^3 methylene (δ_H 3.82, 1H, dq, J = 9.7, 7.1 Hz, H-1′a; 3.59, 1H, dq, J = 9.7, 7.1 Hz, H-1′b; δ_C 65.8) and a methyl group (δ_H 1.18, 3H, t, J = 7.1 Hz, H-2′; δ_C 15.4). These two fragments could be joined from the HMBC NMR spectrum as shown in Figure 1,

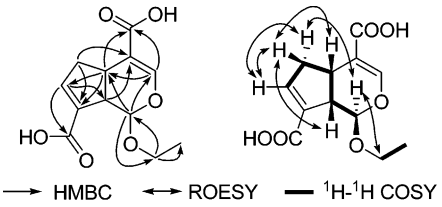
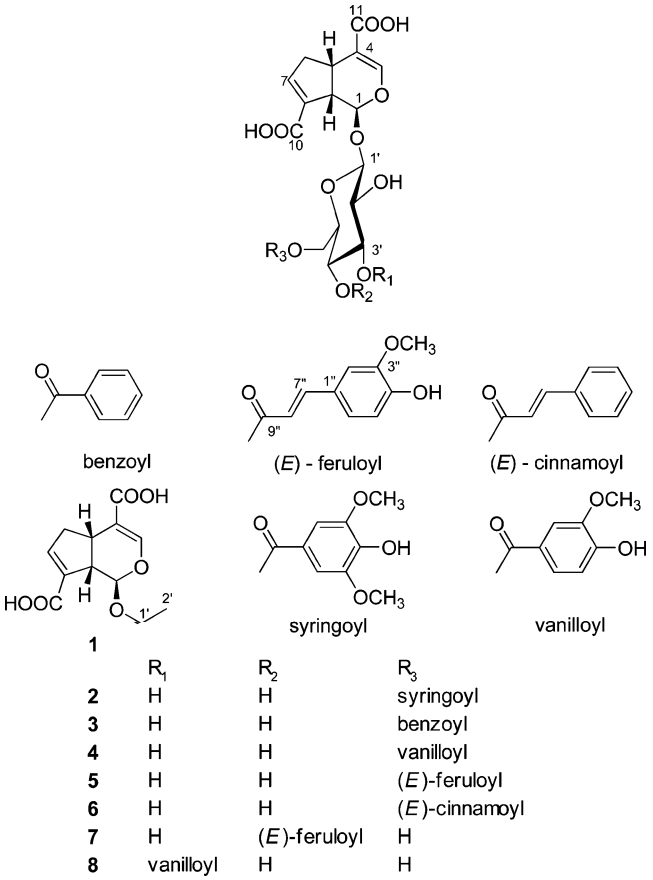


Figure 1. Key HMBC, ^{1}H−^{1}H COSY, and ROESY correlations of **1**.

showing correlations of H-1 (δ_H 5.28) to C-1′ (δ_C 65.8), and H$_2$-1′ (δ_H 3.59, 3.82) to C-1 (δ_C 100.3). Since the olefinic proton at C-3 (δ_H 7.40, s) was correlated with the carboxyl at C-11 (δ_C 172.0) in the HMBC spectrum, while the other olefinic proton (δ_H 6.57, brs) was correlated with another carboxyl at C-10 (δ_C 171.4), the signal



	R_1	R_2	R_3
2	H	H	syringoyl
3	H	H	benzoyl
4	H	H	vanilloyl
5	H	H	(*E*)-feruloyl
6	H	H	(*E*)-cinnamoyl
7	H	(*E*)-feruloyl	H
8	vanilloyl	H	H

at δ_H 6.57 was assigned to C-7. This was confirmed by the ^{1}H−^{1}H COSY correlations from H-7 through H-6b and H-6a to H-5, H-9, and then to H-1, and the other HMBC correlations are shown in Figure 1. The absolute configuration of **1** was determined to be the same as in other iridoids,[4,8,9] based on the ROESY correlations of H-1/H-6b, H-5/H-6a, and H-9/H-6a (Figure 1) and from its optical rotation value of +87.2. Thus, compound **1** was determined as 4,8-dicarboxy-1-ethoxygenipin and has been named tarennin. It is the first iridoid aglycon of its kind obtained from a plant source. To confirm whether tarennin (**1**) is artifactual because 95% EtOH was used as solvent for extraction, a further supply of the plant was obtained and extracted with MeOH and EtOH, respectively. By LC-MS, compound **1** was detected in the EtOH extract (2.0 mg/mL), while it was not detected in the MeOH extract (2.0 mg/

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Table 1. ^{13}C NMR Data of Compounds **1**−**8** (δ in ppm)

position	**1**[a]	**2**[a]	**3**[a]	**4**[b]	**5**[b]	**6**[a]	**7**[a]	**8**[a]
1	100.3	96.0	96.4	96.2	96.2	96.1	96.8	96.7
3	152.9	152.6	152.2[c]	152.6[c]	152.5[c]	152.6	152.5	152.6
4	113.6	113.8	114.8[d]	111.1[d]	[e]	113.9	[e]	[e]
5	34.8	35.3	35.4	35.5	35.5	35.3	35.2	35.3
6	40.1	40.0	40.1	40.0	40.0	40.0	40.1	40.1
7	142.0	144.6	141.5[c]	142.0[c]	145.6	144.0	142.2	142.0
8	140.4	138.6	138.6[d]	[e]	[e]	[e]	[e]	[e]
9	48.4	47.5	47.8	47.9	47.9	47.7	48.0	48.0
10	171.4[d]	[e]	[e]	[e]	[e]	[e]	[e]	[e]
11	172.0[d]	172.0[d]	[e]	[e]	[e]	[e]	[e]	[e]
1′	65.8	99.6	99.8	100.0	100.1	99.9	100.3	100.2
2′	15.4	74.6	74.6	74.6	74.6	74.5	74.7d	73.1
3′		77.6	77.7	77.8	77.7	77.6	76.3	79.0
4′		71.9	72.0	71.9	71.6	71.6	72.3	69.6
5′		75.7	75.6	75.8	75.6	75.5	75.6	78.1
6′		65.2	65.3	65.1	64.6	64.8	62.3	62.3
1″		121.2	131.3	122.4	128.0	135.6	127.7	122.8
2″		108.2	130.6	113.7	111.8	129.3	111.8	113.9
3″		148.8	129.6	148.7	149.4	130.0	149.4	148.6
4″		141.9	134.3	153.0	150.7	131.5	150.8	152.8
5″		148.8	129.6	116.1	116.6	130.0	116.5	115.8
6″		108.2	130.6	125.5	124.2	129.3	124.2	125.3
7″		167.9	168.0	167.9	146.9	146.5	147.6	168.1
8″					115.4	118.6	115.1	
9″					167.9	168.5	168.6	
OCH_3		56.4		56.5	56.5		56.5	56.4

[a] Recorded in CD_3OD (100 MHz). [b] Recorded in pyridine-d_5 (100 MHz). [c] Observed in the HMQC spectrum (500 MHz). [d] Observed in the HMBC spectrum (500 MHz). [e] Not observed.

mL). Thus, tarennin (**1**) was established unequivocally as an artifact of extraction.

Compound **2** was assigned the molecular formula $C_{25}H_{28}O_{15}$ from the $[M - H]^-$ ion peak at *m*/*z* 567.1348 in the negative HRESIMS. The IR spectrum displayed absorption bands for carboxyl groups (a broad band from 2500 to 3423, 1702 cm^{-1}), olefinic bonds (1622 cm^{-1}), and an aromatic moiety (1551, 1517 cm^{-1}). The ^1H NMR spectrum of **2** showed a singlet for H-7 at δ 6.65, a doublet (J = 3.8 Hz) for H-1 at δ 5.62, a singlet for the characteristic H-3 of iridoids at δ 7.43, and a doublet (J = 7.8 Hz) for H-1′ at δ 4.69, suggesting that the cyclopentanopyran ring system and the sugar moiety of **2** are identical to those of ixoside.[8] In addition, a singlet for two methoxyl groups at δ 3.73 and a singlet for two aromatic protons at δ 7.29 indicated the presence of a syringoyl group, which was supported by resonances in the ^{13}C NMR spectrum [δ_C 121.2 (C-1″), 108.2 (C-2″, 6″), 148.8 (C-3″, 5″), 141.9 (C-4″), and 56.4 (OCH_3-3″, 5″)]. Altogether, the ^{13}C NMR spectrum of **2** exhibited 23 carbon signals (Table 1), with eight from the aglycon, six from a glucopyranose unit, and nine from a syringoyl group. Acid hydrolysis of **2** afforded D-glucose, which was detected by TLC with an authentic sample, and the configuration was determined by measurement of the optical rotation value. The β-anomeric configuration for the glucose was judged from its large $^3J_{H1,H2}$ coupling constant (J = 7.8 Hz).[10] HMBC correlations between C-1/H-1′ and H-1/C-1′ suggested that the β-D-glucopyranose unit was attached at the C-1 position of the aglycon. The C-6′ downfield shift from δ_C 62.5 to 65.2, when compared with ixoside,[4] was used to establish the attachment of the syringoyl group to the C-6′ carbon. This assumption was confirmed by an HMBC correlation of H-6′ to the ester carbonyl at δ_C 167.9 of the syringoyl group (Figure 2). On the basis of the above evidence, tarenninoside A (**2**) was established as 6′-*O*-syringoylixoside.

Compound **3** was found to possess the molecular formula $C_{23}H_{24}O_{12}$ from the positive HRESIMS at *m*/*z* 515.1175 $[M + Na]^+$. Its UV, IR, and NMR data were very similar to those of **2** except for evidence of the presence of a benzoyl group [δ_H 7.99 (2H, d, J = 7.5 Hz, H-2″, 6″), 7.58 (1H, t, J = 7.0 Hz, H-4″), 7.46 (2H, dd, J = 7.5, 7.0 Hz, H-3″, 5″); δ_C 168.0 (C-7″), 131.3 (C-1″)], instead of a syringoyl group at the C-6′ position in **3**. This assumption was confirmed by detailed analysis of the 2D-NMR data. Therefore, tarenninoside B (**3**) was determined as 6′-*O*-benzoylixoside.

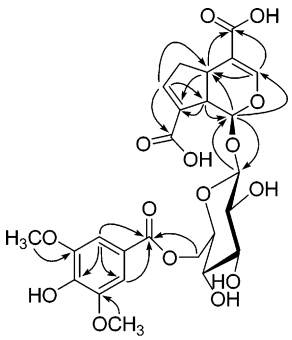

Figure 2. Selected HMBC correlations of **2**.

Compound **4** was assigned a molecular formula of $C_{24}H_{26}O_{14}$ from the HRESIMS (*m*/*z* 561.1210 $[M + Na]^+$). Inspection of the UV, IR, and NMR data of **4** indicated a considerable similarity to those of **2**. The only difference was that a vanilloyl group [δ_H 6.83 (1H, d, J = 7.2 Hz, H-5″), 7.51 (1H, s, H-2″), 7.54 (1H, d, J = 7.2 Hz, H-6″); δ_C 167.9 (C-7″), 122.4 (C-1″)] rather than a syringoyl group was located at C-6′ in **4**, which was confirmed by the HMBC correlation of H_2-6′ to the ester carbonyl at C-7″ (δ_C 167.9) of the vanilloyl group. Thus, tarenninoside C (**4**) was elucidated as 6′-*O*-vanilloylixoside.

Compound **5** exhibited a $[M + Na]^+$ ion peak at *m*/*z* 587.1371 in the positive HRESIMS, corresponding to the molecular formula $C_{26}H_{28}O_{14}$. Comparison of the spectroscopic data of **5** with those of **2** showed they are similar with the exception that the syringoyl group at C-6′ in **2** is replaced by an (*E*)-feruloyl group [δ_H 7.59 (1H, d, J = 14.9 Hz, H-7″), 7.17 (1H, brs, H-2″), 7.12 (1H, d, J = 7.7 Hz, H-6″), 6.81 (1H, d, J = 7.7 Hz, H-5″), 6.34 (1H, d, J = 14.9 Hz, H-8″); δ_C 167.9 (C-9″), 128.0 (C-1″)] in **5**. This was supported by the correlations of H_2-6′ (δ_H 4.49, m, 4.38, m; each 1H) to the ester carbonyl at C-9″ (δ_C 168.1) in the HMBC spectrum. Tarenninoside D (**5**) was therefore concluded to be 6′-*O*-(*E*)-feruloylixoside.

Compound **6** was assigned a molecular formula of $C_{25}H_{26}O_{12}$ (*m*/*z* 541.1327 $[M + Na]^+$ in the positive HRESIMS). The IR, UV, and NMR spectroscopic data of **6** were very similar to those of **5**, except that the C-6′ substituent group in **6** is a (*E*)-cinnamoyl group [δ_H 7.67 (1H, d, J = 16.0 Hz, H-7″), 7.57 (2H, J = 7.3 Hz, H-2″, 6″), 7.38 (3H, brs, H-3″, 4″, 5″), 6.54 (1H, d, J = 16.0 Hz, H-8″); δ_C 168.5 (C-9″), 135.6 (C-1″)] instead of an (*E*)-feruloyl group. Thus, tarenninoside E (**6**) was concluded to be 6′-*O*-(*E*)-cinnamoylixoside.

Compound **7** was assigned the same molecular formula, $C_{26}H_{28}O_{14}$, as **5**, from the positive HRESIMS at *m*/*z* 587.1367 $[M + Na]^+$ and exhibited physical and NMR data closely comparable to those of **5** except for the NMR data of the β-D-glucopyranosyl unit. Specifically, the significant upfield shift [(δ_C 62.3 from 64.6 of C-6′] and downfield shift [(δ_C 72.3 from 71.6) of C-4′ indicated that the (*E*)-feruloyl group was located at the C-4′ position. This was confirmed by the correlation of H-4′ to the ester carbonyl at δ_C 168.6 of the (*E*)-feruloyl group in the HMBC NMR spectrum. Therefore, tarenninoside F (**7**) was proposed as 4′-*O*-(*E*)-feruloylixoside.

Compound **8** was assigned the same molecular formula, $C_{24}H_{26}O_{14}$, as **4**, from the negative HRESIMS at *m*/*z* 537.1252 $[M - H]^-$, and exhibited closely comparable UV and IR data. Differences were evident in the NMR spectroscopic data (Table 1), as a result of an upfield shift of C-6′ (δ_C 62.3 from 65.1) and a downfield shift of C-3′ (δ_C 79.0 from 77.8). Thus, a vanilloyl group was assigned to the C-3′ hydroxyl group via an ester bond in **8**. The structure of this compound was confirmed by detailed analysis of the 2D-NMR

data including its HMQC, HMBC, ^{1}H−^{1}H COSY, and ROESY spectra. Consequently, tarenninoside G (**8**) was determined as 3′-*O*-vanilloylixoside.

The ^{13}C NMR spectra of compounds of this type showed certain characteristics that are worthy of note. The signals of the sp^2 quaternary carbons at C-10 and C-11 were mostly too weak to be observed even in three different solvents, including CD_3OD (**1**−**3**, **6**−**8**), pyridine-d_5 (**4** and **5**), and D_2O.[4] Fortunately, some could be observed in the HMBC NMR spectra (**1** and **2**). The other sp^2 quaternary carbons at C-4 and C-8 also gave weak signals (ixoside,[4] **3**−**8**). Furthermore, the signals of the sp^2 methines at C-3 and C-7 were much weaker than even the sp^2 quaternary carbon signals in the substituent groups, but these were visible in the HMQC NMR spectra (**3**−**5**).

The antioxidant effect against H_2O_2-induced impairment and cytotoxic activity in PC12 cells were evaluated for iridoid glucosides **1**−**8**, together with ixoside and 10-methylixoside from *T. attenuata*. However none of these compounds showed positive effects within the concentration range tested (0.4 to 50 μM).

Experimental Section

General Experimental Procedures. Optical rotations were measured with a Horiba SEPA-300 polarimeter or JASCO DIP-370 digital polarimeter. UV spectra were obtained using a Shimadzu UV-2401PC spectrometer. IR spectra were recorded on a Bio-Rad FTS-135 spectrometer with KBr pellets. ^{1}H and ^{13}C NMR experiments were performed on a Bruker AM-400 or DRX-500 NMR spectrometer with TMS as internal standard. ESIMS were measured on a Waters 2695 HPLC-Thermo Finnigan LCQ Advantage ion trap mass spectrometer. EIMS and HRESIMS were taken on a VG Auto Spec 3000 spectrometer. Column chromatography was performed with silica gel (200−300 mesh; Qingdao Marine Chemical, Inc., Qingdao, People's Republic of China), silica gel H (10−40 μm; Qingdao), Sephadex LH-20 (40−70 μm; Amersham Pharmacia Biotech AB, Uppsala, Sweden), and Lichroprep RP-18 gel (40−63 μm; Merck, Darmstadt, Germany). Zones of preparative TLC plates (1.0−1.5 mm; Qingdao) and TLC plates (0.20−0.25 mm; Qingdao) were visualized under UV light or by spraying with 10% H_2SO_4 in 95% EtOH, followed by heating.

Plant Material. The whole plant of *T. attenuata*, collected in Xishuangbanna of Yunnan Province, People's Republic of China, in October 2004, was identified by Prof. Jing-Yun Cui, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences. A voucher specimen (BN163) was deposited in Kunming Institute of Botany, Chinese Academy of Sciences.

Extraction and Isolation. The dried and powdered (17 kg) sample of *T. attenuata* was extracted with 95% ethanol (16 L) under reflux for 3 × 4 h. The extract was concentrated to dryness under reduced pressure. The residue was suspended in water and partitioned, sequentially, with petroleum ether, ethyl acetate, and *n*-butanol. The ethyl acetate extract (61 g) was separated into eight fractions (F_1−F_8) by column chromatography on silica gel (200−300 mesh) using a $CHCl_3$−MeOH gradient. Fraction F_2 was further separated using reversed-phase MPLC with a gradient of H_2O−MeOH, silica gel column chromatography with $CHCl_3$−MeOH (20:1), and preparative TLC with EtOAc−MeOH (50:1), to give **1** (10 mg). From fraction F_6, repeated column chromatography over silica gel, eluting with $CHCl_3$−MeOH (5:1) and EtOAc−MeOH (8:1), and Sephadex LH-20, eluting with MeOH, led to the isolation of **6** (35 mg) and **7** (15 mg). Fraction F_7 was subjected to passage over a RP-18 column with MeOH−H_2O (30:70) and further separation on silica gel columns, eluting with $CHCl_3$−MeOH (15:1) and EtOAc−MeOH (20:1), respectively, to yield 10-methylixoside (21 mg), **8** (8 mg), **2** (36 mg), and **3** (20 mg). Fraction F_8 was chromatographed on a silica gel column with EtOAc−MeOH (20:1), followed by purification using preparative TLC [$CHCl_3$−MeOH (5:1)], to give ixoside (88 mg), **4** (22 mg), and **5** (40 mg).

Tarennin (1): amorphous powder; $[\alpha]^{23}_D$ +87.2 (*c* 0.45, CH_3OH); UV (MeOH) λ_{max} (log ϵ) 325 (2.45), 342 (2.38) nm; IR (KBr) ν_{max} 3431, 1690, 1637, 1624, 1558, 1408, 1271, 1163, 1038, 743 cm^{-1}; ^{1}H NMR (CD_3OD, 400 MHz) δ 7.40 (1H, s, H-3), 6.57 (1H, brs, H-7), 5.28 (1H, d, J = 3.6 Hz, H-1), 3.82 (1H, dq, J = 9.7, 7.1 Hz, H-1′a), 3.59 (1H, dq, J = 9.7, 7.1 Hz, H-1′b), 3.21 (1H, m, H-5), 3.15 (1H, brs, H-9), 2.83 (1H, dd, J = 18.0, 7.8 Hz, H-6a), 2.35 (1H, d, J = 18.0 Hz, H-6b), 1.18 (3H, t, J = 7.1 Hz, H-2′); ^{13}C NMR, see Table 1; EIMS *m*/*z* 254 [M]$^+$ (20), 236 (52), 210 (41), 207 (60), 190 (100), 166 (62), 135 (63), 120 (66), 77 (76); HRESIMS (positive) *m*/*z* 277.0675 [M + Na]$^+$ (calcd for $C_{12}H_{14}O_6Na$, 277.0688).

Tarenninoside A (2): amorphous powder; $[\alpha]^{24}_D$ +42.0 (*c* 0.94, CH_3OH); UV (MeOH) λ_{max} (log ϵ) 214 (4.50), 278 (3.93) nm; IR (KBr) ν_{max} 3424, 1702, 1623, 1551, 1517, 1463, 1405, 1337, 1229, 1169, 1037, 764 cm^{-1}; ^{1}H NMR (CD_3OD, 400 MHz) δ 7.40 (1H, s, H-3), 7.29 (2H, s, H-2″, 6″), 6.65 (1H, brs, H-7), 5.62 (1H, d, J = 3.8 Hz, H-1), 4.69 (1H, d, J = 7.8 Hz, H-1′), 4.60 (1H, d, J = 11.6 Hz, H-6′a), 4.39 (1H, dd, J = 11.6, 6.4 Hz, H-6′b), 3.86 (6H, s, OCH_3-3″, 5″), 3.62 (1H, m, H-5′), 3.42 (1H, m, H-3′), 3.37 (1H, m, H-4′), 3.25 (1H, m, H-2′), 3.24 (1H, m, H-5), 3.16 (1H, brs, H-9), 2.80 (1H, dd, J = 18.0, 6.5 Hz, H-6a), 2.23 (1H, d, J = 18.0 Hz, H-6b); ^{13}C NMR, see Table 1; ESIMS (negative) *m*/*z* 567 [M − H] $^-$, ESIMS (positive) *m*/*z* 591 [M + Na]$^+$; HRESIMS (negative) *m*/*z* 567.1348 [M − H]$^-$ (calcd for $C_{25}H_{27}O_{15}$, 567.1349).

Tarenninoside B (3): amorphous powder; $[\alpha]^{19}_D$ +24.3 (*c* 1.03, CH_3OH); UV (MeOH) λ_{max} (log ϵ) 224 (4.20), 344 (2.55) nm; IR (KBr) ν_{max} 3424, 1714, 1629, 1406, 1282, 1079, 962, 714 cm^{-1}; ^{1}H NMR (CD_3OD, 400 MHz) δ 7.99 (2H, d, J = 7.5 Hz, H-2″, 6″), 7.58 (H, t, J = 7.0 Hz, H-4″), 7.46 (2H, dd, J = 7.5, 7.0 Hz, H-3″, 5″), 7.36 (1H, s, H-3), 6.54 (1H, brs, H-7), 5.58 (1H, brs, H-1), 4.68 (1H, d, J = 7.4 Hz, H-1′), 4.60 (1H, d, J = 11.5 Hz, H-6′a), 4.40 (1H, dd, J = 11.5, 6.1 Hz, H-6′b), 3.60 (1H, m, H-5′), 3.42 (1H, m, H-3′), 3.39 (1H, m, H-4′), 3.25 (1H, m, H-2′), 3.24 (1H, m, H-5), 3.15 (1H, brs, H-9), 2.81 (1H, m, H-6a), 2.22 (1H, m, H-6b); ^{13}C NMR, see Table 1; ESIMS (negative) *m*/*z* 491 [M − H]$^-$, 983 [2M − H]$^-$; HRESIMS (positive) *m*/*z* 515.1175 [M + Na]$^+$ (calcd for $C_{23}H_{24}O_{12}Na$, 515.1165).

Tarenninoside C (4): amorphous powder; $[\alpha]^{20}_D$ +37.0 (*c* 1.32, CH_3OH−pyridine, 1:1); UV (MeOH) λ_{max} (log ϵ) 220 (4.29), 251 (3.96), 292 (3.59), 362 (2.31) nm; IR (KBr) ν_{max} 3420, 1705, 1631, 1595, 1517, 1405, 1285, 1181, 1078, 763 cm^{-1}; ^{1}H NMR (pyridine-d_5, 500 MHz) δ 7.54 (1H, d, J = 7.2 Hz, H-6″), 7.51 (1H, s, H-2″), 7.42 (1H, s, H-3), 6.83 (1H, d, J = 7.2 Hz, H-5″), 6.64 (1H, brs, H-7), 5.72 (1H, brs, H-1), 4.71 (1H, d, J = 7.6 Hz, H-1′), 4.60 (1H, m, H-6′a), 4.37 (1H, m, H-6′b), 3.84 (3H, s, OCH_3-3″), 3.62 (1H, m, H-5′), 3.46 (1H, m, H-3′), 3.43 (1H, m, H-4′), 3.30 (1H, m, H-2′), 3.26 (1H, brs, H-5), 3.20 (1H, brs, H-9), 2.81 (1H, m, H-6a), 2.30 (1H, m, H-6b); ^{13}C NMR, see Table 1; ESIMS (positive) *m*/*z* 561 [M + Na]$^+$; HRESIMS (positive) *m*/*z* 561.1210 [M + Na]$^+$ (calcd for $C_{24}H_{26}O_{14}Na$, 561.1220).

Tarenninoside D (5): amorphous powder; $[\alpha]^{20}_D$ +23.5 (*c* 1.69, CH_3OH−pyridine, 1:1); UV (MeOH) λ_{max} (log ϵ) 263 (3.67), 325 (4.02) nm; IR (KBr) ν_{max} 3426, 1698, 1631, 1596, 1516, 1441, 1402, 1356, 1282, 1162, 1082, 754 cm^{-1}; ^{1}H NMR (pyridine-d_5, 500 MHz) δ 7.59 (1H, d, J = 14.9 Hz, H-7″), 7.45 (1H, s, H-3), 7.17 (1H, s, H-2″), 7.12 (1H, d, J = 7.7 Hz, H-6″), 6.81 (1H, d, J = 7.7 Hz, H-5″), 6.65 (1H, brs, H-7), 6.34 (1H, d, J = 14.9 Hz, H-8″), 5.78 (1H, brs, H-1), 4.74 (1H, d, J = 7.2 Hz, H-1′), 4.49 (1H, m, H-6′a), 4.38 (1H, m, H-6′b), 3.82 (3H, s, OCH_3-3″), 3.59 (1H, m, H-5′), 3.52 (1H, m, H-3′), 3.48 (1H, m, H-4′), 3.30 (1H, m, H-2′), 3.28 (1H, brs, H-5), 3.19 (1H, brs, H-9), 2.81 (1H, brs, H-6a), 2.38 (1H, brs, H-6b); ^{13}C NMR, see Table 1; ESIMS (positive) *m*/*z* 587 [M + Na]$^+$; ESIMS (negative) *m*/*z* 563 [M − H]$^-$; HRESIMS (positive) *m*/*z* 587.1371 [M + Na]$^+$ (calcd for $C_{26}H_{28}O_{14}Na$, 587.1376).

Tarenninoside E (6): amorphous powder; $[\alpha]^{24}_D$ +36.9 (*c* 0.45, CH_3OH); UV (MeOH) λ_{max} (log ϵ) 279 (4.24), 371 (2.49) nm; IR (KBr) ν_{max} 3415, 1702, 1634, 1551, 1517, 1450, 1403, 1313, 1204, 1080, 1038, 769 cm^{-1}; ^{1}H NMR (CD_3OD, 400 MHz) δ 7.67 (1H, d, J = 16.0 Hz, H-7″), 7.57 (2H, J = 7.3 Hz, H-2″, 6″), 7.43 (1H, s, H-3), 7.38 (3H, brs, H-3″, 4″, 5″), 6.65 (1H, brs, H-7), 6.54 (1H, d, J = 16.0 Hz, H-8″), 5.66 (1H, brs, H-1), 4.68 (1H, d, J = 6.8 Hz, H-1′), 4.48 (1H, m, H-6′a), 4.35 (1H, m, H-6′b), 3.56 (1H, m, H-5′), 3.40 (1H, m, H-3′), 3.38 (1H, m, H-4′), 3.25 (2H, m, H-5, 2′), 3.18 (1H, brs, H-9), 2.81 (1H, brs, H-6a), 2.35 (1H, brs, H-6b); ^{13}C NMR, see Table 1; ESIMS (positive) *m*/*z* 541 [M + Na]$^+$; HRESIMS (positive) *m*/*z* 541.1327 [M + Na]$^+$ (calcd for $C_{25}H_{26}O_{12}Na$, 541.1321).

Tarenninoside F (7): amorphous powder; $[\alpha]^{20}_D$ +7.3 (*c* 0.68, CH_3OH−pyridine, 1:1); UV (MeOH) λ_{max} (log ϵ) 216 (3.96), 325 (3.83) nm; IR (KBr) ν_{max} 3431, 1605, 1517, 1364, 1282, 1159, 1087, 1033, 775 cm^{-1}; ^{1}H NMR (CD_3OD, 400 MHz) δ 7.65 (1H, d, J = 15.8 Hz, H-7″), 7.42 (1H, s, H-3), 7.18 (1H, d, J = 1.5 Hz, H-2″), 7.08 (1H, d, J = 8.2 Hz, H-6″), 6.81 (1H, d, J = 8.2 Hz, H-5″), 6.60 (1H, brs, H-7), 6.39 (1H, d, J = 15.8 Hz, H-8″), 5.66 (1H, brs, H-1), 4.85 (1H,

m, H-4′), 4.69 (1H, d, $J = 7.8$ Hz, H-1′), 3.88 (3H, s, OCH_3-3″), 3.63 (1H, m, H-5′), 3.62 (1H, m, H-6′a), 3.52 (1H, m, H-2′), 3.51 (1H, m, H-6′b), 3.32 (1H, m, H-3′), 3.28 (1H, brs, H-5), 3.20 (1H, brs, H-9), 2.86 (1H, m, H-6a), 2.37 (1H, d, $J = 16.4$ Hz, H-6b); ^{13}C NMR, see Table 1; ESIMS (positive) *m*/*z* 587 $[M + Na]^+$; HRESIMS (positive) *m*/*z* 587.1367 $[M + Na]^+$ (calcd for $C_{26}H_{28}O_{14}Na$, 587.1376).

Tarenninoside G (8): amorphous powder; $[\alpha]^{24}_D$ +26.4 (*c* 0.42, CH_3OH); UV (MeOH) λ_{max} (log ϵ) 217 (4.36), 260 (3.98), 292 (3.69), 391 (2.49) nm; IR (KBr) ν_{max} 3430, 1698, 1633, 1602, 1553, 1519, 1403, 1285, 1107, 1081, 762 cm^{-1}; ^{1}H NMR (CD_3OD, 400 MHz) δ 7.61 (1H, d, $J = 8.0$ Hz, H-6″), 7.60 (1H, s, H-2″), 7.42 (1H, s, H-3), 6.84 (1H, d, $J = 8.0$ Hz, H-5″), 6.59 (1H, brs, H-7), 5.67 (1H, brs, H-1), 5.15 (1H, t, $J = 9.4$ Hz, H-3′), 4.76 (1H, d, $J = 7.7$ Hz, H-1′), 3.89 (3H, s, OCH_3-3″), 3.85 (1H, brs, H-6′a), 3.71 (1H, m, H-6′b), 3.63 (1H, m, H-4′), 3.49 (1H, m, H-2′), 3.41 (1H, m, H-5′), 3.28 (1H, brs, H-5), 3.18 (1H, brs, H-9), 2.86 (1H, d, $J = 17.4$ Hz, H-6a), 2.36 (1H, d, $J = 17.4$ Hz, H-6b); ^{13}C NMR, see Table 1; ESIMS (positive) *m*/*z* 561 $[M + Na]^+$; ESIMS (negative) *m*/*z* 537 $[M - H]^-$; HRESIMS (negative) *m*/*z* 537.1252 $[M - H]^-$ (calcd for $C_{24}H_{25}O_{14}$, 537.1244).

Absolute Configuration of the Glucose Moiety in 2. Compound **2** (10 mg) was refluxed with 6% HCl (5 mL) at 75 °C for 2 h. The reaction mixture was extracted with EtOAc, and the aqueous phase was concentrated under reduced pressure to yield 2 mg of D-glucose, which was detected by TLC with an authentic sample, and the configuration was determined by measurement of the optical rotation value, $[\alpha]^{16}_D$ +101.8 (*c* 0.49, pyridine).

Assays for Antioxidant and Cytotoxic Activities. Experiments of antioxidant activity against H_2O_2-induced impairment and the cytotoxic activity in PC12 cells were conducted according to the reported protocols.[11,12]

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Supporting Information Available: The 1D and 2D NMR spectra for compound **1** and ^{1}H, ^{13}C, HSQC, and HMBC NMR spectra for compound **2**. This information is available free of charge via the Internet at http://pubs.acs.org.

References and Notes

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