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NOTE

Four new glucosides from the aerial parts of *Mediasia macrophylla*

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Abstract As part of our chemical studies on the medical plants in Uzbekistan aimed at searching for new drug leads, we have examined the aerial parts of *Mediasia macrophylla*. This has resulted in the isolation of four new glucosides, together with 30 known compounds. The structures of new compounds were elucidated as (1′*S*)-(4-hydroxyphenyl) ethane-1′,2′-diol 2′-*O*-*β*-glucopyranoside (**1**), 3-(4′-methoxyphenyl)-propanol 1-*O*-*β*-glucopyranoside (**2**), 2-methoxy-3-hydroxy-5-(*E*)-propenyl-phenol 1-*O*-*β*-glucopyranoside (**3**), 1-*O*-angeloyl-*β*-glucopyranose (**4**), on the basis of spectral analysis.

Keywords *Mediasia macrophylla* · Glucosides · Umbelliferae · Uzbekistan

Introduction

We have been investigating the herbal medicines of Uzbekistan with the aim of searching for novel drug leads (Umbelliferae [1–10], Compositae [11–14], Guttiferae [15, 16], Polygonaceae [17], Cupressaceae [18], Paeoniaceae [19]). The aerial parts of *Mediasia macrophylla* (Umbelliferae) have been used traditionally as a perfume; an appetite enhancer; a natural preservative; and for treatment of rheumatism, nephritis, eczema, herpes, and injury [20]. It is also used for treatment of hepatopathy as a decoction mixed with four other medicinal plants in Uzbekistan. As part of our study of medicinal plants in Uzbekistan, we previously investigated the constituents of *M. macrophylla*, and reported the isolation and structure determination of one structurally unique new C_{14}-polyacetylene glucoside possessing an α-pyrone moiety and four new C_{10}-polyacetylene glucosides from the MeOH extract of *M. macrophylla* [21]. The isolation of C_{10}-polyacetylene glucosides from the family Umbelliferae was the first example of this type of compound from this source. Further chemical examination of this plant has now resulted in the isolation of four new glucosides (**1**–**4**), together with 30 known compounds. We now report on the isolation and structure elucidation of these compounds.

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Results and discussion

The MeOH extract of the aerial parts of *M. macrophylla* (530 g) was successively partitioned with *n*-hexane, EtOAc, *n*-BuOH and H_2O. Repeated chromatography of the *n*-BuOH and EtOAc-soluble fractions on Diaion HP-20, Sephadex LH-20, MCI-gel CHP-20P, Toyopearl HW-40, silica gel, YMC-ODS-A, and reverse-phase HPLC gave four new glucosides (**1**–**4**) along with 30 known compounds.

The molecular formula of compound **1** was established as $C_{14}H_{19}O_8$ by HRESIMS. The glycosidic nature of **1** was indicated by anomeric resonances [δ_H 4.37 (1H, d, $J = 8.0$ Hz); δ_C 104.8]. The ^{1}H NMR spectrum revealed an oxygen-bearing methine signal [δ_H 4.24 (1H, dd, $J = 9.6$, 2.8 Hz)], and methylene signals [δ_H 4.01 (1H, dd, $J = 9.6$, 2.8 Hz) and 3.57 (1H, t, $J = 9.6$ Hz)], coupled with each other, and A_2B_2-type aromatic signals [δ_H 7.24 and 6.79 (each 2H, d, $J = 8.4$ Hz)], suggesting the existence of a 4-hydroxyphenyl ethane-1,2-diol structure.

Enzymatic hydrolysis of **1** gave glucose and an aglycone, which was identified as (1′*S*)-(4-hydroxyphenyl) ethane-1′,2′-diol [22] from spectroscopic evidence (^{1}H NMR, MS, specific optical rotation). The location of the glucosyl moiety was assigned to be the C-2′ hydroxy group from the HMBC correlation of the anomeric proton with C-2′. Based on these examinations, the structure of **1** was elucidated as shown (Fig. 1).

Compound **2** gave a pseudo molecular ion peak at *m*/*z* 351.1446 ($[M+Na]^+$, calcd for 351.1420) in positive-ion HRESIMS, suggesting the molecular formula $C_{16}H_{25}O_7$. The anomeric resonances [δ_H 4.83 (1H, d, $J = 8.0$ Hz); δ_C 104.8] indicated that **2** was also a glycoside. The ^{1}H NMR spectrum of **2** showed the presence of one 1,4-substituted aromatic ring [δ_H 7.15 and 6.91 (each 2H, d, $J = 8.8$ Hz)], an oxygenated methylene [δ_H 4.11 and 3.67 (each 1H, dt, $J = 9.6$, 6.4 Hz)], two methylenes [δ_H 2.67 and 1.95 (each 2H, m)], and a methoxy group [δ_H 3.64 (3H, s)]. The ^{13}C NMR spectrum displayed 16 carbon signals including six aromatic carbons [δ_C 158.4, 134.4, 129.8 (2C), 114.3 (2C)], an oxygen-bearing methylene (δ_C 68.9) and a methoxy group (δ_C 55.1), along with six carbon resonances assignable to a glucosyl moiety. The structure of the aglycone of **2** was elucidated as 3-(4′-methoxyphenyl)-propanol from the H–H COSY correlations of H_2-1–H_2-2–H_2-3, together with the HMBC correlations of H-3 with C-1′, C-2′ and C-6′, and of OMe with C-4′. The location of the glucosyl moiety was assigned as C-1 from the HMBC cross peak of the anomeric proton signal (H-1″) with C-1, and its mode of the linkage was concluded to be β from the J value (8.0 Hz) of H-1″. On the basis of these observations, the structure of **2** was assigned as shown in Fig. 1.

Compound **3** had the molecular formula of $C_{16}H_{20}O_8$ on the basis of the HRESIMS. The ^{1}H NMR spectrum of **3** displayed *meta*-coupled aromatic protons [δ_H 6.71 and 6.53 (each 1H, d, $J = 1.9$ Hz)], *trans*-coupled olefinic protons [δ_H 6.24 (1H, dt, $J = 15.7$, 1.3 Hz) and 6.12 (δ_H 1H, dt, $J = 15.7$, 6.4 Hz)], and a vinylic methyl group [δ_H 1.81 (3H, dd, $J = 6.4$, 1.3 Hz)], suggesting the presence of a 1,3,4,5-tetrasubstituted aromatic ring and an *E*-propenyl group, along with a methoxy signal [δ_H 3.82 (3H, s)]. The existence of a sugar moiety was indicated by an anomeric proton signal [δ_H 4.91 (1H, d, $J = 7.4$ Hz)]. The carbon resonances (δ_C 102.8, 78.3, 78.1, 75.0, 71.5 and 62.6) arising from the sugar moiety coincided with the presence of a glucopyranosyl moiety. The structure of the aglycone was elucidated as 1,3-dihydroxy-2-methoxy-4-(*E*)-propenyl benzene from the HMBC correlations of H-2 with C-3, H-6 with C-4, C-5 and C-1′, H-2′ with C-1, and of OMe with C-4. The location of the glucosyl moiety of **3** was assigned to be the C-1 hydroxy group from the HMBC cross peak of H-1″ with C-1 and the β-linkage was concluded from the coupling constant value (7.4 Hz) of the anomeric proton signal. From this evidence, the structure of **3** was characterized as shown in Fig. 1.

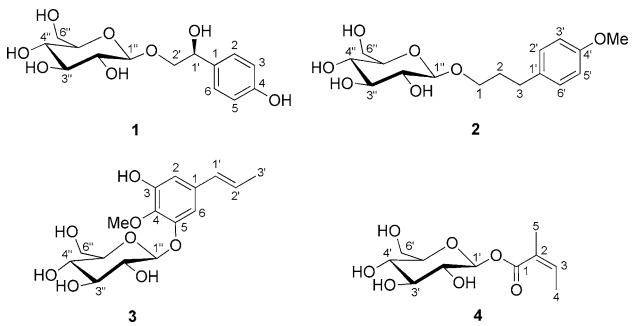

Fig. 1 Structures of compounds **1**–**4**

The molecular formula of compound **4** was established as $C_{11}H_{18}O_7$ by HRESIMS. The ^{1}H and ^{13}C NMR spectra of **4** indicated the presence of one α,β-unsaturated carboxyl group, two vinylic methyl groups and a glucosyl moiety. The existence of either angeloyl or tigloyl moiety was deduced from the HMBC correlations of Me-4 with C-2 and C-3, and of Me-5 with C-1, C-2 and C-3. The geometry of the double bond was established as *Z* by a NOE difference spectroscopy experiment, in which an NOE enhancement was observed in Me-5 upon irradiation of H-3, thus confirming the angeloyl group in **4**. The HMBC cross peak of the anomeric proton [δ_H 5.51 (1H, d, $J = 8.0$ Hz)] with C-1 (δ_C 167.8) indicated the location of the angeloyl group at the glucosyl C-1 position and its β-linkage was concluded from the J value (8.0 Hz) of the anomeric proton signal. From these observations, the structure of **4** was elucidated as shown in Fig. 1.

The structure of compound **5** was assigned as 2-*O*-β-glucopyranosyl-5-methoxy-benzoic acid methyl ester [23] by spectroscopic analysis, since the NMR spectroscopic data for this compound has not been reported previously.

The following known compounds were identified by comparison of their spectral data with those described in the literature: mudanpinoside F [24], (1*R*,4*R*,5*S*)-5-hydroxyfenchone 5-*O*-β-D-glucopyranoside [25], (1*R*,4*S*,6*R*)-6-hydroxyfenchone 6-*O*-β-D-glucopyranoside [25], (1*R*,2*R*,4*S*)-1,8-epoxy-2-hydroxy-*p*-menthan 2-*O*-β-D-glucopyranoside [26], (1*S*,2*S*,4*R*)-1,8-epoxy-2-hydroxy-*p*-menthan 2-*O*-β-D-glucopyranoside [26], betulalbuside A [27], 8-hydroxy-6,7-dihydrolinalol 8-*O*-glucopyranoside [28], 1-(3,4,5-trimethoxy-phenyl)-propane 1*R*,2*R* diol [29], 3-(3′,4′,5′-trimethoxyphenyl) prop-2-en-1-ol [30], chlorogenic acid [31], methyl 3-*O*-feruloylquinate [32], sphalleroside [33], (1′*S*)-(4-hydroxyphenyl) ethane-1′,2′-diol [22], ω-hydroxypropioguaiacone [34], benzyl-β-D-glucopyranoside [33], 3,4,5-trimethoxybenzyl alcohol (SDBS, http://riodb01.ibase.aist.go.jp/sdbs/cgi-bin/direct_frame_top.cgi), *p*-hydroxybenzaldehyde (Sigma-Aldrich, http://www.sigmaaldrich.com/spectra/fnmr/FNMR001261.PDF), 3,4,5-trimethoxybenzaldehyde

(SDBS, http://riodb01.ibase.aist.go.jp/sdbs/cgi-bin/direct_frame_top.cgi), tachioside [35], viridoside [36], salidroside [37], icariside D [38], 2-methoxy-2-(4′-hydroxyphenyl) ethanol [39], tyrosol [40], quercetin [41], hyperin [42], scopolin [43], (+)-syringaresinol [44], lariciresinol-4-*O*-*β*-D-glucopyranoside [45].

Experimental

General

Optical rotations were measured with a JASCO DIP-370 digital polarimeter. MS were obtained on a Waters LCT PREMIER 2695. NMR (^{1}H NMR: 400 MHz, ^{13}C NMR: 100 MHz, using TMS as an internal standard) spectra were measured on an AVANCE 400 Fourier transform spectrometer (Bruker). The HMBC spectra were run with the $^{2,3}J$ value of 7.7 Hz. Column chromatography: silica gel 60N (63–210 μm, Kanto Chemical), Diaion HP-20 (Mitsubishi Chemical), Sephadex LH-20 (GE Healthcare), Toyopearl HW-40 (TOSOH), MCI-gel: CHP-20P (75–150 μm, Mitsubishi Chemical), YMC-pack ODS-A (YMC). Preparative HPLC: ODS [Mightysil RP-18 GP (250 × 20 mm; 5 μm, Kanto Chemical), CAPCELL PACK C18 SG120 (250 × 20 mm; 5 μm, Shiseido), COSOMOSIL Cholester (250 × 20 mm; 5 μm, Nakarai Tesque), COSMOSIL πNAP (250 × 20 mm; 5 μm, Nakarai Tesque)], gel-permeation chromatography (GPC) [Asahi pack GS-310 2G (Asahi Chemical)]. Preparative HPLC was performed on a JASCO apparatus consisting of a PU-980 prep pump, UV-970UV/VIS (at a wavelength of 280 nm) and RI-930 refractive index detectors at a flow rate of 3.5 ml/min. TLC: silica gel 60 F_{254} (Merck). Avicel SF cellulose plate (Funakoshi).

Plant material

The aerial parts of *M. macrophylla* were collected at Tashkent region, Uzbekistan, in July 2002, and were identified by one of authors (O. K. K.). Herbarium specimens were deposited in the botanical garden of the University of Tokushima (specimen No.: UTP040003).

Extraction and isolation

The dried aerial parts of *M. macrophylla* (3.9 kg) were extracted three times with MeOH at 60°C. After concentration, the MeOH extract (530 g) was successively partitioned with *n*-hexane, EtOAc, *n*-BuOH and H_2O (2 L each × 3) to give an *n*-hexane-soluble fraction (188 g), an EtOAc-soluble fraction (24 g), an *n*-BuOH-soluble fraction (77 g) and an H_2O-soluble fraction (241 g). The *n*-BuOH-soluble fraction (77 g) was subjected to chromatography over Diaion HP-20 [MeOH–H_2O (0:1 →1:0)] to give 12 fractions. Fraction 2 was applied to a Sephadex LH-20 column [MeOH–H_2O (0:1 → 1:0)] to give chlorogenic acid (133 mg) and fractions 2.1–2.3. Fraction 2.3 was separated by YMC ODS-A column chromatography (CC) [MeOH–H_2O (0:1 → 1:0)] to give fractions 2.3.1–2.3.8. Fraction 2.3.4 was purified by GPC (MeOH) to afford tachioside (10 mg). Fraction 2.3.5 was also purified by GPC (MeOH) to give compound **1** (12 mg). Purification of fraction 2.3.8 by GPC (MeOH) gave compound **4** (1.0 mg) and mudanpinoside F (4 mg). Fraction 5 was separated by YMC ODS-A CC [MeOH–H_2O (0:1 → 1:0)] to give 8 fractions (5.1–5.8). Fraction 5.5 was purified by GPC (MeOH) to yield scopolin (9 mg). Fraction 5.6 was separated by silica gel CC ($CHCl_3$–MeOH–H_2O, 8:2:0.2) and GPC (MeOH) to give benzyl-*β*-D-glucopyranoside (5 mg). Fraction 5.7 was further applied to silica gel CC ($CHCl_3$–MeOH–H_2O, 8:2:0.2) and GPC (MeOH) to afford compound **5** (6 mg). Repeated CC of fraction 5.8 with silica gel CC ($CHCl_3$–MeOH–H_2O, 8:2:0.2), GPC (MeOH) followed by ODS HPLC (CAPCELL PAK C_{18} SG120) (MeOH–H_2O, 3:7) gave sphalleroside (18 mg). Hyperin (5 mg) was obtained by crystallization of fraction 6. Fraction 7 was fractionated by Sephadex LH-20 CC [MeOH–H_2O (2:3 → 1:0)] to give 14 fractions (7.1–7.14). Fraction 7.4 was further subjected to an MCI CHP-20P column [MeOH–H_2O (3:7 → 1:0)] to give 6 fractions (7.4.1–7.4.6). Fraction 7.4.4 was purified by ODS HPLC (CAPCELL PAK C_{18} SG120) (MeOH–H_2O, 2:3) and GPC (MeOH) to yield viridoside (14 mg) and lariciresinol-4-*O*-*β*-D-glucopyranoside (2 mg). Fraction 7.4.5 was purified by ODS HPLC (CAPCELL PAK C_{18} SG120) (MeOH–H_2O, 2:3) to give compound **2** (9 mg). Fraction 7.6 was separated by MCI CHP-20P CC [MeOH–H_2O (2:3 → 1:0)] and GPC (MeOH) to give methyl 3-*O*-feruloylquinate (7 mg). Purification of fraction 7.14 by GPC (MeOH) afforded quercetin (21 mg).

The EtOAc-soluble fraction (24 g) was subjected to a silica gel column and eluted with solvents of increasing polarity (*n*-hexane–EtOAc–MeOH) to give 27 fractions. Fraction 5 was separated by Toyo pearl HW-40 chromatography ($CHCl_3$–H_2O, 2:1) to give 5 fractions (5.1–5.5). Fraction 5.2 was subjected to silica gel chromatography [$CHCl_3$–MeOH (98:2 → 0:1)] to give *p*-hydroxybenzaldehyde (2 mg). Fraction 5.3 was separated by silica gel CC ($CHCl_3$–MeOH, 95:5) and GPC (MeOH) to yield 3,4,5-trimethoxybenzaldehyde (27 mg). Fraction 9 was further fractionated by Sephadex LH-20 chromatography [MeOH–H_2O (1:1 → 1:0)] to afford 7 fractions (9.1–9.7). Repeated CC of fraction 9.1 with YMC ODS-A [MeOH–H_2O (3:2 → 1:0)], HPLC COSMOSIL πNAP (MeOH–H_2O, 3:2) and GPC (MeOH) gave 3,4,5-trimethoxybenzyl

alcohol (9 mg). Fraction 9.2 was separated by YMC ODS-A chromatography [MeOH–H_2O (1:1 → 1:0)] to give 5 fractions (9.2.1–9.2.5). Fractions 9.2.1, 9.2.3, and 9.2.5 were purified by GPC (MeOH) to afford 3-(3′,4′,5′-trimethoxyphenyl) prop-2-en-1-ol (12 mg), 2-methoxy-2-(4′-hydroxyphenyl) ethanol (38 mg), tyrosol (1 mg), respectively. Fraction 10 was subjected to a Sephadex LH-20 column [MeOH–H_2O (7:3 → 1:0)], and then a YMC ODS-A column [MeOH–H_2O (3:2 → 1:0)] to give 3 fractions (10.1–10.3). Purification of fraction 10.1 by GPC (MeOH) gave (1′*S*)-(4-hydroxyphenyl) ethane-1′,2′-diol (17 mg). Fraction 10.2 was purified by GPC (MeOH) to yield *ω*-hydroxypropioguaiacone (1 mg). Fraction 10.3 was purified by GPC (MeOH) to give (+)-syringaresinol (1 mg). Fraction 14 was repeatedly separated by Sephadex LH-20 [MeOH–H_2O (3:2 → 1:0)], YMC ODS-A [MeOH–H_2O (3:2 → 1:0)] and GPC (MeOH) to give fraction 14.1–14.8. Fraction 14.3 was purified by silica gel chromatography ($CHCl_3$–MeOH–H_2O, 8:2:0.2) to give compound **4** (9 mg) and 1-(3,4,5-trimethoxy-phenyl)-propane-1*R*,2*R*-diol (6 mg). Fraction 14.5 was chromatographed over a silica gel column ($CHCl_3$–MeOH–H_2O, 8:2:0.2) to yield sphalleroside (13 mg). Fraction 14.6 was purified by silica gel chromatography ($CHCl_3$–MeOH–H_2O, 8:2:0.2) to yield compound **2** (19 mg). After removal of the MeOH-insoluble portion of fraction 17, the filtrate was applied on a Sephadex LH-20 column [MeOH–H_2O (3:2 → 1:0)] to give 8 fractions (17.1–17.8). Fraction 17.1 was further separated by MCI CHP-20P chromatography [MeOH–H_2O (1:1 → 1:0)] and silica gel CC [$CHCl_3$–MeOH–H_2O (9:1:0 → 8:2:0.2)] to give fractions 17.1.1–17.1.3. Fraction 17.1.1 was purified by HPLC COSMOSIL *π*NAP (MeOH–H_2O, 3:2) to afford (1*R*,4*R*,5*S*)-5-hydroxyfenchone *β*-D-glucopyranoside (4 mg), (1*R*,4*S*,6*R*)-6-hydroxyfenchone *β*-D-glucopyranoside (17 mg), (1*R*,2*R*,4*S*)-1,8-epoxy-2-hydroxy-*p*-menthan 2-*O*-*β*-D-glucopyranoside (7 mg) and (1*S*,2*S*,4*R*)-1,8-epoxy-2-hydroxy-*p*-menthan 2-*O*-*β*-D-glucopyranoside (5 mg). Fraction 17.1.3 was purified by HPLC ODS (Mightysil RP-18 GP) (MeOH–H_2O, 3:2) to yield betulalbuside A (5 mg) and 8-hydroxy-6,7-dihydrolinalol 8-*O*-glucopyranoside (6 mg). Fraction 17.2 was applied to an MCI CHP-20P column [MeOH–H_2O (1:1 → 1:0)] to give 5 fractions (17.2.1–17.2.5). Fraction 17.2.1 was purified by GPC (MeOH) to give salidroside (10 mg). Fraction 17.2.2 was separated by GPC (MeOH) to give compound **5** (6 mg) and fractions 17.2.2.1–17.2.2.5. Fraction 17.2.2.4 was purified by HPLC ODS (Mightysil RP-18 GP) (MeOH–H_2O, 7:13) to give benzyl-*β*-D-glucopyranoside (5 mg). Fraction 17.2.3 was purified by GPC (MeOH) and HPLC COSMOSIL *π*NAP (MeOH–H_2O, 1:1) to give viridoside (22 mg). The MeOH-soluble part from fraction 18 was repeatedly fractionated with Sephadex LH-20 [MeOH–H_2O (1:1 → 1:0)] and an MCI CHP-20P column [MeOH–H_2O (2:3 → 1:0)] to give 9 fractions (18.1–18.9). Fraction 18.3 was applied to GPC (MeOH) and silica gel CC [$CHCl_3$–MeOH–H_2O (9:1:0 → 8:2:0.2)] to give icariside D (2 mg). Crystallization of fraction 19 with MeOH gave hyperin (82 mg).

*(1′S)-(4-Hydroxyphenyl) ethane-1′,2′-diol 2′-O-β-glucopyranoside (**1**)*

An off-white amorphous powder; $[\alpha]_D$ −6.0 (MeOH, *c* 0.2); ^{1}H NMR (400 MHz, CD_3OD): *δ* 7.24 (2H, d, *J* = 8.4 Hz, H-2 and 6), 6.79 (2H, d, *J* = 8.4 Hz, H-3 and 5), 4.37 (1H, d, *J* = 8.0 Hz, H-1″), 4.24 (1H, dd, *J* = 9.6, 2.8 Hz, H-1′), 4.01 (1H, dd, *J* = 9.6, 2.8 Hz, H-2′a), 3.89 (1H, dd, *J* = 11.2, 2.0 Hz, H-6″a), 3.69 (1H, dd, *J* = 11.2, 4.8 Hz, H-6″b), 3.57 (1H, t, *J* = 9.6 Hz, H-2′b), 3.42 (1H, t, *J* = 8.8 Hz, H-3″), 3.23 (2H, m, H-4″ and 5″), 3.29 (1H, dd, *J* = 8.8, 8.0 Hz, H-2″); ^{13}C NMR (100 MHz, CD_3OD): *δ* 158.3 (C-4), 132.8 (C-1), 128.7 × 2 (C-2 and 6), 116.1 × 2 (C-3 and 5), 104.8 (C-1″), 78.1 (C-5″), 77.8 (C-3″), 76.6 (C-2′), 75.3 (C-2″), 74.1 (C-1′), 71.6 (C-4″), 62.7 (C-6″); HRESIMS *m/z* 315.1091 $[M–H]^-$ (calcd for $C_{14}H_{19}O_8$, 315.1080).

*Enzymatic hydrolysis of **1***

A solution of compound **1** (4 mg) in water (1 mL) was treated with *β*-glucosidase from almonds (4.8 units/mg solid, Sigma) (4 mg) at 37°C for 4 days. The reaction mixture was diluted with MeOH, and the resulting precipitates were filtrated off. The filtrate was purified by silica gel column chromatography [$CHCl_3$–MeOH–H_2O (30:1:0 → 7:2:0.2)] to give an aglycone (**1a**) (1.2 mg), as a white amorphous powder, $[\alpha]_D$ +15.0 (MeOH, *c* 0.15); ^{1}H NMR (400 MHz, pyridine-d_5): *δ* 7.67 (2H, d, *J* = 8.4 Hz, H-2 and H-6), 7.22 (2H, d, *J* = 8.4 Hz, H-3 and H-5), 5.25 (1H, t, *J* = 5.2 Hz, H-1′), 4.17 (2H, br s, H_2-2′); HRESIMS *m/z* 153.0547 $[M–H]^-$ (calcd for $C_8H_9O_3$, 153.0552), which was identified as (1′*S*)-(4-hydroxyphenyl) ethane-1′,2′-diol [22], together with sugar. The sugar was identified as glucose by TLC analysis [R_f: 0.33, *n*-BuOH/pyridine/H_2O (6:4:3) on Avicel SF cellulose].

*3-(4′-Methoxyphenyl)-propanol 1-O-β-glucopyranoside (**2**)*

An off-white amorphous powder; $[\alpha]_D$ −25.9 (MeOH, *c* 0.4); ^{1}H NMR (400 MHz, pyridine-d_5): *δ* 7.15 (2H, d, *J* = 8.8 Hz, H-2 and 6), 6.91 (2H, d, *J* = 8.8 Hz, H-3′ and 5′), 4.83 (1H, d, *J* = 8.0 Hz, H-1″), 4.55 (1H, dd, *J* = 11.6, 2.4 Hz, H-6″a), 4.38 (1H, dd, *J* = 11.6, 5.2 Hz, H-6″b), 4.25 (2H, m, H-3″ and H-4″), 4.11 (1H, dt, *J* = 9.6, 6.4 Hz, H-1a), 4.07 (1H, m, H-2″), 3.94 (1H, ddd, *J* = 9.2, 5.2, 2.4 Hz, H-5″), 3.67 (1H, dt, *J* = 9.6, 6.4 Hz,

H-1b), 3.64 (3H, s, –OMe), 2.67 (2H, m, H-3), 1.95 (2H, m, H-2); ^{13}C NMR (100 MHz, pyridine-d_5): δ 158.4 (C-4′), 134.4 (C-1′), 129.8 × 2 (C-2′ and 6′), 114.3 × 2 (C-3′ and 5′), 104.8 (C-1″), 78.6 (C-3″), 78.5 (C-5″), 75.3 (C-2″), 71.7 (C-4″), 68.9 (C-1), 62.9 (C-6″), 55.1 (–OMe), 32.3 (C-2), 31.6 (C-3); HRESIMS *m/z* 351.1446 $[M+Na]^+$ (calcd for $C_{16}H_{24}O_7Na$, 351.1420).

*2-Methoxy-5-((E)-propenyl)-benzene-1,3-diol 1-O-β-glucopyranoside (**3**)*

An off-white amorphous powder; $[\alpha]_D$ −60.4 (MeOH, *c* 1.34); ^{1}H NMR (400 MHz, CD_3OD): δ 6.71 (1H, d, $J = 1.9$ Hz, H-9), 6.53 (1H, d, $J = 1.9$ Hz, H-6), 6.24 (1H, dd, $J = 15.7$, 1.3 Hz, H-1′), 6.12 (1H, dq, $J = 15.7$ Hz, 6.4 Hz, H-2′), 4.91 (1H, d, $J = 7.4$ Hz, H-1″), 3.88 (1H, dd, $J = 12.1$, 2.1 Hz, H-6″a), 3.82 (3H, s, –OMe), 3.68 (1H, dd, $J = 12.1$ Hz, 5.5 Hz, H-6″b), 3.48 (1H, m, H-2″), 3.47 (1H, m, H-3″), 3.41 (1H, m, H-5″), 3.38 (1H, m, H-4″), 1.81 (3H, dd, $J = 6.4$, 1.3 Hz, Me-3′); ^{13}C-NMR (CD_3OD): δ 152.3 (C-3), 151.7 (C-5), 137.6 (C-4), 135.6 (C-1), 131.9 (C-1′), 125.9 (C-2′), 109.0 (C-6), 106.8 (C-2), 102.8 (C-1″), 78.3 (C-5″), 78.1 (C-3″), 75.0 (C-2″), 71.5 (C-4″), 62.6 (C-6″), 61.6 (–OMe), 18.5 (Me-3″); HRESIMS *m/z* 365.1214 $[M+Na]^+$ (calcd for $C_{16}H_{20}O_8Na$, 365.1212).

*1-O-Angeloyl-β-glucopyranose (**4**)*

A white amorphous powder; $[\alpha]_D$ −1.3 (MeOH, *c* 0.1); ^{1}H NMR (400 MHz, CD_3OD): δ 6.26 (1H, brq, $J = 7.2$ Hz, H-3), 5.51 (1H, d, $J = 8.0$ Hz, H-1′), 3.89 (1H, dd, $J = 12.4$, 2.0 Hz, H-6′a), 3.72 (1H, dd, $J = 12.4$, 4.8 Hz, H-6′b), 3.50–3.37 (4H, m, H-2′, 3′, 4′ and 5′), 2.05 (3H, brd, $J = 7.2$ Hz, H-4), 1.96 (3H, brs, H-5); ^{13}C NMR (100 MHz, CD_3OD): δ 167.8 (C-1), 141.1 (C-3), 128.6 (C-2), 95.6 (C-1′), 78.9 (C-3′), 78.4 (C-5′), 74.0 (C-2′), 71.1 (C-4′), 62.4 (C-6′), 20.5 (C-5), 16.1 (C-4); HRESIMS *m/z* 285.0956 $[M+Na]^+$ (calcd for $C_{16}H_{20}O_8Na$, 285.0950).

*2-O-β-Glucopyranosyl-5-methoxy-benzoic acid methyl ester (**5**)*

A white amorphous powder; $[\alpha]_D$ −50.8 (MeOH, *c* 0.1); ^{1}H NMR (400 MHz, CD_3OD): δ 7.67 (1H, dd, $J = 8.4$, 2.0 Hz, H-4), 7.64 (1H, d, $J = 2.0$ Hz, H-6), 7.26 (1H, d, $J = 8.4$ Hz, H-3), 5.06 (1H, d, $J = 7.2$ Hz, H-1′), 3.94 (3H, s, 5-OMe), 3.92 (3H, s, 7-OMe), 3.92 (1H, m, H-6′a), 3.73 (1H, dd, $J = 12.0$, 5.6 Hz, H-6′b), 3.57 (1H, dd, $J = 8.8$, 7.2 Hz, H-2′), 3.52 (1H, m, H-3′), 3.51 (1H, m, H-5′), 3.44 (1H, dd, $J = 9.6$, 8.4 Hz, H-4′); ^{13}C NMR (100 MHz, CD_3OD): δ 168.3 (C-7), 152.1 (C-2), 150.4 (C-5), 125.4 (C-1), 124.5 (C-4), 116.4 (C-3), 114.1 (C-6), 101.9 (C-1′), 78.3 (C-5′), 77.8 (C-3′), 74.7 (C-2′), 71.2 (C-4′), 62.4 (C-6′), 56.7 (5-OMe), 52.6 (7-OMe); HRESIMS *m/z* 367.0992 $[M+Na]^+$ (calcd for $C_{15}H_{20}O_9Na$, 367.1005).

*Acid hydrolysis of **2–4***

Compounds **2–4** (1 mg each) were separately hydrolyzed with 1 M HCl for 12 h at 80°C. Each reaction mixture was diluted with H_2O, and extracted with EtOAc. The H_2O layer was neutralized with Amberlite IRA-400 resin and evaporated. The residue was directly analyzed by TLC [R_f: 0.33, *n*-BuOH/pyridine/H_2O (6:4:3) on Avicel SF cellulose] to detect glucose in each case.

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