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MEDICINAL FLOWERS. XXVIII.¹ STRUCTURES OF FIVE NEW GLYCOSIDES, EVERLASTOSIDES A, B, C, D, AND E, FROM THE FLOWERS OF *HELICHRYSUM ARENARIUM*

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Abstract — Five new glycosides, everlastosides A (1), B (2), C (3), D (4), and E (5), were isolated from the methanolic extract of the flowers of *Helichrysum arenarium*. Their structures were elucidated on the basis of chemical and physicochemical evidence.

During the course of our studies on medicinal flowers,¹⁻¹⁷ we found that the methanolic extract of the flowers of *Helichrysum arenarium* L. MOENCH (Asteraceae, Everlasting in English) was found to inhibit on tumor necrosis factor- α (TNF- α)-induced cytotoxicity in L929 cells.¹ Furthermore, from the methanolic extract, four flavanone and chalcone glycosides, arenariumosides I—IV, were isolated together with 46 known compounds.¹ As a continuing study on the constituents from *H. arenarium*, we additionally isolated five new glycosides called everlastosides A (1), B (2), C (3), D (4), and E (5). This paper deals with the isolation and structure elucidation of 1—5.

The methanolic extract from the dried flowers of *H. arenarium* (19.8% from the dried flowers) was partitioned into an EtOAc–H₂O (1:1, v/v) mixture to furnish an EtOAc-soluble fraction (7.6%) and

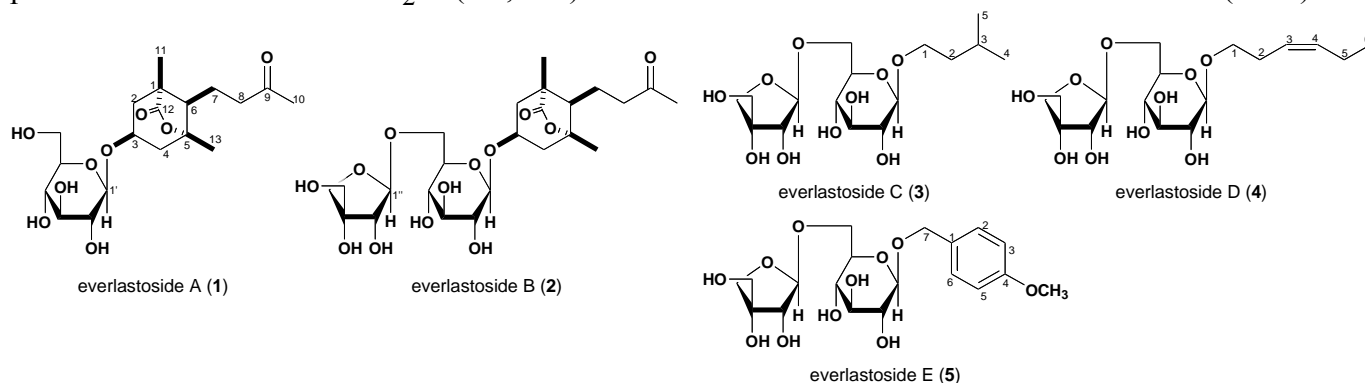


Chart 1

anaqueous phase. The aqueous phase was subjected to Diaion HP-20 column chromatography (H₂O → MeOH) to give H₂O- and MeOH-eluted fractions (8.6% and 3.2%, respectively), which was described previously.¹ From the MeOH-eluted fraction, **1** (0.0005%), **2** (0.0032%), **3** (0.0042%), **4** (0.0015%), and **5** (0.0060%) were purified using normal- and reversed-phase silica gel chromatographies and finally HPLC.

Structures of Everlastosides A (**1**), B (**2**), C (**3**), D (**4**), and E (**5**)

Everlastoside A (**1**) was obtained as a white powder and exhibited a negative optical rotation ($[\alpha]_D^{27}$ -14.6° in MeOH). The IR spectrum of **1** showed absorption bands at 1736 and 1718 cm⁻¹ assignable to ester carbonyl and carbonyl functions in addition to strong absorption bands at 3450 and 1064 cm⁻¹ suggestive of a glycoside moiety. In the positive-ion FAB-MS of **1**, a quasimolecular ion peak was observed at m/z 425 (M+Na)⁺, and high-resolution FAB-MS analysis revealed the molecular formula of **1** to be C₁₉H₃₀O₉. Acid hydrolysis of **1** with 1.0 M hydrochloric acid (HCl) liberated D-glucose, which was identified by HPLC analysis using an optical rotation detector.^{1,3,11,12} The ¹H- and ¹³C-NMR (pyridine-*d*₅, Table 1) spectra of **1**, which were assigned by various NMR experiments,¹⁸ showed signals assignable to three methyls [δ 1.14, 1.33, 2.08 (3H each, all s, 11, 13, 10-H₃)], four methylenes [δ 1.68, 1.72 (1H each, both m, 7-H₂), 1.76 (1H, m, 3 β -H), 2.34 (1H, dd, J = 7.1, 13.7 Hz, 3 α -H), 1.82 (1H, dd, J = 11.0, 13.7 Hz, 2 β -H), 2.10 (1H, dd, J = 7.9, 13.7 Hz, 2 α -H), 2.46 (2H, m, 8-H₂)], two methines [δ 1.78 (1H, m,

Table 1. ¹H- (600 MHz) and ¹³C-NMR (150 MHz) Data of **1** and **2**

position	1		2	
	δ_H (J Hz)	δ_C	δ_H (J Hz)	δ_C
1		45.8		45.9
2 α	2.10 (dd, 7.9, 13.7)	35.0	2.26 (dd, 7.0, 13.6)	35.1
2 β	1.82 (dd, 11.0, 13.7)		1.88 (dd, 11.0, 13.6)	
3	4.32 (m)	72.5	4.27 (m)	73.2
4 α	2.34 (dd, 7.1, 13.7)	35.5	2.24 (m)	35.6
4 β	1.76 (m)		1.73 (m)	
5		85.3		85.3
6	1.78 (m)	53.5	1.75 (m)	53.5
7	1.68 (m)	18.8	1.68 (m)	18.8
	1.72 (m)		1.73 (m)	
8	2.46 (2H, m)	42.0	2.45 (2H, m)	41.9
9		206.8		206.8
10	2.08 (s)	29.7	2.06 (s)	29.7
11	1.14 (s)	19.9	1.22 (s)	19.9
12		179.1		179.3
13	1.33 (s)	24.0	1.31 (s)	24.0
	(3- <i>O</i> -Glc)		(3- <i>O</i> -Glc ^b - ¹ Api)	
1'	4.84 (d, 7.7)	103.5	4.75 (d, 7.7)	103.9
2'	3.96 (dd, 7.7, 8.9)	75.2	3.92 (dd, 7.7, 8.9)	75.1
3'	4.19 (dd, 8.9, 9.1)	78.5	4.13 (m)	78.5
4'	4.26 (dd, 9.1, 9.2)	71.5	3.99 (dd, 8.9, 9.3)	71.8
5'	3.82 (m)	78.3	3.96 (m)	77.0
6'	4.34 (dd, 5.0, 12.0)	62.5	4.12 (dd, 6.4, 11.3)	68.8
	4.38 (dd, 2.6, 12.0)		4.59 (dd, 1.9, 11.3)	
			(3- <i>O</i> -Glc ^b - ¹ Api)	
1''			5.69 (d, 2.2)	111.1
2''			4.66 (d, 2.2)	77.9
3''				80.4
4''			4.31 (d, 9.3)	75.1
			4.52 (d, 9.3)	
5''			4.15 (2H, m)	65.9

Measured in pyridine-*d*₅

6-H), 4.32 (1H, m, 3-H)], and quaternary carbons (1, 5, 9, 12-C) together with a β -D-glucopyranosyl moiety [δ 4.84 (1H, d, $J = 7.7$ Hz, Glc-1-H)]. As shown in Figure 1, the ^1H - ^1H correlation spectroscopy (^1H - ^1H COSY) experiment on **1** indicated the presence of partial structures written in bold line, and in the heteronuclear multiple-bond correlations (HMBC)

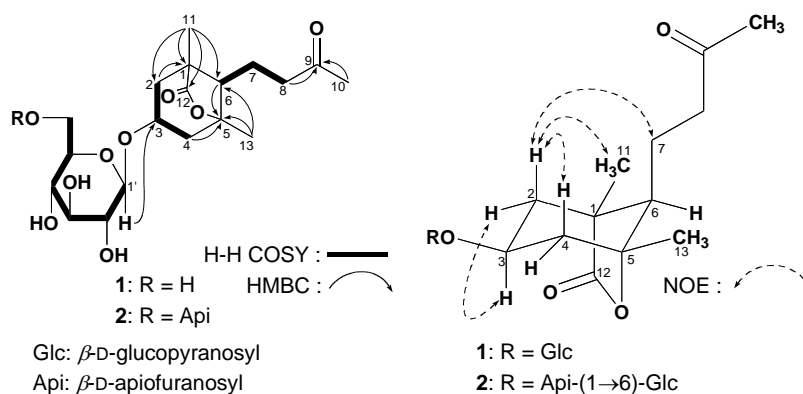


Figure 1

experiment, long-range correlations were observed between the following protons and carbons (2- H_2 and 1-C; 4- H_2 and 5-C; 6-H and 5-C; 8- H_2 and 9-C; 10- H_3 and 9-C; 11- H_3 and 1, 2, 6, 12-C; 13- H_3 and 5, 6-C). The stereostructure of **1** was characterized by nuclear Overhauser enhancement spectroscopy (NOESY) experiment, which showed NOE correlations between the following proton pairs (2 α -H and 3-H; 2 β -H and 4 β -H, 7- H_2 , 11- H_3). On the basis of this evidence, the structure of **1**, having a γ -lactone linkage between the C-5 and C-12,^{19,20} was determined to be as shown.

Everlastoside B (**2**) was also isolated as a white powder with negative optical rotation ($[\alpha]_{\text{D}}^{26} -33.6^\circ$ in MeOH). The molecular formula, $\text{C}_{24}\text{H}_{38}\text{O}_{13}$, of **2** was determined by the quasimolecular ion peak [m/z 557 ($\text{M}+\text{Na}^+$)] in positive-ion FAB-MS and high-resolution FAB-MS measurements. Acid hydrolysis of **2** with 1.0 M HCl liberated D-apiose^{21,22} and D-glucose, which were identified by HPLC analysis. The proton and carbon signals in the ^1H - and ^{13}C -NMR (pyridine- d_5 , Table 1) spectra¹⁸ of **2** were very similar to those of **1**, except for an apiofuranosyl part [δ 4.98 (1H, d, $J = 2.5$ Hz, Api-1-H)]. The position of the apiofuranosyl part in **2** was confirmed by the HMBC experiment, which showed a long-range correlation between the Api-1-H and the Glc-6-C (δ_{C} 68.7). The NOESY experiment of **2** showed NOE correlations between the same proton pairs as those of **1**. Consequently, the structure of everlastoside B (**2**) was determined.

Everlastoside C (**3**) was obtained as a white powder with negative optical rotation ($[\alpha]_{\text{D}}^{28} -53.2^\circ$ in pyridine). In the positive-ion FAB-MS of **3**, a quasimolecular ion peak was observed at m/z 405 ($\text{M}+\text{Na}^+$), and high-resolution FAB-MS analysis revealed the molecular formula of **3** to be $\text{C}_{16}\text{H}_{30}\text{O}_{10}$. Acid hydrolysis of **3** with 1.0 M HCl liberated 3-methyl-1-butanol,²³ D-apiose and D-glucose, which were identified by HPLC analysis. The ^1H - (CD_3OD) and ^{13}C -NMR (Table 2) spectra¹⁸ of **3** showed signals assignable to 3-methyl-1-butanol part [δ 0.78 (6H, d, $J = 6.4$ Hz, 4, 5- H_3), 1.48 (2H, m, 2- H_2), 1.70 (1H, m, 3-H), 3.64 (1H, m, 1-H)] together with glucopyranosyl and apiofuranosyl moieties [δ 4.72 (1H, d, $J = 7.3$ Hz, Glc-1-H), 5.75 (1H, br s, Api-1-H)]. Furthermore, in the HMBC experiment of **3**, long-range correlations were observed between the Api-1-H and the Glc-6-C (δ_{C} 68.9) and between the Glc-1-H and the 1-carbon (δ_{C} 68.6). Consequently, the structure of everlastoside C (**3**) was elucidated to be as shown.

Everlastosides D (**4**) and E (**5**) were obtained as white powders with negative optical rotations (**4**: $[\alpha]_{\text{D}}^{26} -71.3^\circ$; **5**: $[\alpha]_{\text{D}}^{23} -70.5^\circ$, both in MeOH). The molecular formulas of **4** ($\text{C}_{17}\text{H}_{30}\text{O}_{10}$) and **5** ($\text{C}_{19}\text{H}_{28}\text{O}_{11}$) were determined from the positive-ion FAB-MS [**4**: m/z 417 ($\text{M}+\text{Na}^+$), **5**: m/z 455 ($\text{M}+\text{Na}^+$)] and high-

resolution FAB-MS measurements. Acid hydrolysis of **4** and **5** with 1.0 M HCl liberated (*Z*)-3-hexenol²³ (from **4**), *p*-methoxybenzyl alcohol²³ (from **5**), D-apiose and D-glucose, which were identified by HPLC analysis, respectively. The ¹H- (CD₃OD) and ¹³C-NMR (Table 2) spectra¹⁸ of **4** indicated the presence of the following functions: a (*Z*)-3-hexenol part [δ 0.97 (3H, t, *J* = 6.8 Hz, 6-H₃), 2.07 (1H, br q, *J* = ca. 7 Hz, 5-H₂), 2.38 (2H, dd-like, *J* = ca. 8, 8 Hz, 2-H₂), 3.54, 3.83 (1H each, both m, 1-H₂), 5.39 (1H, m, 3-H), 5.44 (1H, m, 4-H)] together with a glucopyranosyl and an apiofuranosyl moieties [δ 4.25 (1H, d, *J* = 8.0 Hz, Glc-1-H), 5.00 (1H, d, *J* = 2.1 Hz, Api-1-H)]. On the other hand, the proton and carbon signals in the ¹H- (CD₃OD) and ¹³C-NMR (Table 2) spectra¹⁸ of **5** were superimposable with those for **4** except for the aglycone part [δ 3.77 (3H, s, -OCH₃), 4.58, 4.80 (1H each, both d, *J* = 11.3 Hz, 7-H₂), 6.88, 7.34 (2H each, both d, *J* = 8.6 Hz, 3,5, 2,6-H)].

In the HMBC experiment of **4** and **5**, long-range

correlations were observed between the following proton and carbon pairs: [**4**: Api-1-H and Glc-6-C and Glc-1-H and 1-C; **5**: Api-1-H and Glc-6-C and Glc-1-H and 7-C]. Consequently, the structures of everlastosides D (**4**) and E (**5**) were determined. In conclusion, five new glycosides, everlastosides A—E (**1—5**), were isolated from the flowers of *H. arenarium* and their structures were determined on the basis of chemical and physicochemical evidence.

EXPERIMENTAL

The following instruments were used to obtain physical data: specific rotations, Horiba SEPA-300 digital polarimeter (*l* = 5 cm); UV spectra, Shimadzu UV-1600 spectrometer; IR spectra, Shimadzu FTIR-8100 spectrometer; FAB-MS and high-resolution MS, JEOL JMS-SX 102A mass spectrometer; ¹H-NMR spectra, JEOL JNM-ECA600 (600 MHz), JNM-LA500 (500 MHz), and EX-270 (270 MHz) and spectrometers; ¹³C-NMR spectra, JEOL JNM-ECA600 (150 MHz), JNM-LA500 (125 MHz), and EX-270 (68 MHz) spectrometers with tetramethylsilane as an internal standard; and HPLC detector, Shimadzu RID-6A refractive index and SPD-10A_{VP} UV-VIS detectors. HPLC column, Cosmosil 5C₁₈-MS-II (Nacalai Tesque Inc., 250 × 4.6 mm i.d.) and (250 × 20 mm i.d.) columns were used for analytical and preparative purposes, respectively.

The following experimental conditions were used for chromatography: ordinary-phase silica gel column chromatography, Silica gel BW-200 (Fuji Silysia Chemical, Ltd., Aichi, Japan, 150–350 mesh); reversed-phase silica gel column chromatography, Chromatorex ODS DM1020T (Fuji Silysia Chemical, Ltd., Aichi, Japan, 100–200 mesh); TLC, precoated TLC plates with Silica gel 60F₂₅₄ (Merck, 0.25 mm) (ordinary phase) and Silica gel RP-18 F₂₅₄S (Merck, 0.25 mm) (reversed phase); reversed-phase HPTLC,

Table 2. ¹³C-NMR (125 MHz) Data of **3—5**

Position	3 δ_C	4 δ_C	5 δ_C
1	68.6	70.5	130.7
2	38.9	28.9	131.0
3	25.0	125.9	114.6
4	22.6*	134.4	160.8
5	22.7*	21.5	114.6
6		14.6	131.0
7			71.7
OCH ₃			55.6
Glc			
1'	104.4	104.3	102.8
2'	75.0	75.5	75.0
3'	78.5	77.9	78.0
4'	71.6	71.8	71.6
5'	77.1	76.8	76.8
6'	68.9	68.7	68.6
Api			
1''	111.1	110.9	110.9
2''	77.8	78.0	78.0
3''	80.5	80.5	80.5
4''	74.9	75.0	74.9
5''	65.5	65.5	65.5

Measured in CD₃OD, *may be interchangeable

precoated TLC plates with Silica gel RP-18 WF_{254S} (Merck, 0.25 mm); and detection was achieved by spraying with 1% Ce(SO₄)₂–10% aqueous H₂SO₄ followed by heating.

Plant Material

This item was described in a previous report.¹

Extraction and Isolation

The dried flowers of *H. arenarium* (3.0 kg) were extracted three times with MeOH under reflux for 3 h. Evaporation of the solvent under reduced pressure provided a methanolic extract (593.8 g, 19.8%). The methanolic extract (543.8 g) was partitioned between an EtOAc–H₂O (1:1, v/v) mixture, and removal of the solvents *in vacuo* yielded an EtOAc-soluble fraction (210.0 g, 7.6%) and an aqueous phase. The aqueous phase was subjected to Diaion HP-20 column chromatography (3.0 kg, H₂O → MeOH) to give H₂O-eluted fraction (237.2 g, 8.6%) and MeOH-eluted fraction (88.6 g, 3.2%). The MeOH-eluted fraction (68.6 g) was subjected to normal-phase silica gel column chromatography [2.5 kg, CHCl₃–MeOH–H₂O (20:3:1 → 10:3:1 → 7:3:1, lower layer → 6:4:1, v/v/v) → MeOH] to give 12 fractions [Fr. 1 (0.85 g), Fr. 2 (1.20 g), Fr. 3 (0.90 g), Fr. 4 (1.80 g), Fr. 5 (6.40 g), Fr. 6 (11.00 g), Fr. 7 (5.40 g), Fr. 8 (4.00 g), Fr. 9 (7.10 g), Fr. 10 (5.80 g), Fr. 11 (6.10 g), and Fr. 12 (17.10 g)] as reported previously.¹

Fraction 4 (1.80 g) was subjected to reversed-phase silica gel column chromatography [70 g, MeOH–H₂O (15:85 → 80:20, v/v) → MeOH] and HPLC [MeOH–H₂O (30:70, v/v)] to give everlastoside A (**1**, 2.3 mg, 0.0005%) together with 7-hydroxy-5-methoxyphthalide 7-*O*-β-D-glucopyranoside (476.8 mg, 0.12%).¹

Fraction 7 (5.40 g) was subjected by reversed-phase silica gel column chromatography [300 g, MeOH–H₂O (15:85 → 70:30, v/v) → MeOH] and HPLC [MeOH–H₂O (10:90–40:60, v/v)] to furnish everlastosides B (**2**, 12.9 mg, 0.0032%), C (**3**, 16.9 mg, 0.0042%), D (**4**, 6.2 mg, 0.0015%), and E (**5**, 23.0 mg, 0.0060%) together with (2*S*)-helichrysin (223.0 mg, 0.055%), (2*R*)-helichrysin (17.0 mg, 0.0042%), chalconaringenin 2'-*O*-β-D-glucopyranoside (305.5 mg, 0.076%), quercetin 3-*O*-β-D-glucopyranoside (40.0 mg, 0.010%), (7*R*,8*S*)-dihydrodehydrodiconiferyl alcohol 4-*O*-β-D-glucopyranoside (10.0 mg, 0.0025%), oricinol β-D-glucopyranoside (12.2 mg, 0.0035%), phenethyl alcohol β-D-xylopyranosyl-(1→6)-β-D-glucopyranoside (6.2 mg, 0.0015%), icaraside D₁ (90.0 mg, 0.017%), and adenosine (22.0 mg, 0.0055%).¹

Everlastoside A (**1**): a white powder, [α]_D²⁷ –14.6° (*c* 0.15, MeOH). High-resolution positive-ion FAB-MS: Calcd for C₁₉H₃₀O₉Na (M+Na)⁺: 425.1787. Found: 425.1780. IR (KBr): 3450, 1736, 1718, 1458, 1064 cm⁻¹. ¹H-NMR (600 MHz, pyridine-*d*₅) δ : given in Table 1, (600 MHz, CD₃OD) δ : 1.16, 1.44, 2.15 (3H each, all s, 11, 13, 10-H₃), 1.68 (1H, m, 2β-H), 1.70, 1.81 (1H each, both m, 7-H₂), 1.72 (1H, m, 2α-H), 1.81 (1H, m, 6-H), 1.85 (1H, dd, *J* = 6.8, 13.7 Hz, 4β-H), 2.23 (1H, dd, *J* = 6.2, 13.7 Hz, 4α-H), 3.86 (1H, m, 3-H), 4.30 (1H, d, *J* = 7.6 Hz, 1'-H). ¹³C-NMR (150 MHz, pyridine-*d*₅) δ _C: given in Table 1, (150 MHz, CD₃OD) δ _C: 19.3 (7-C), 19.8 (11-C), 24.2 (13-C), 29.7 (10-C), 35.0 (4-C), 35.3 (2-C), 42.5 (8-C), 47.1 (1-C), 54.3 (7-C), 62.4 (6'-C), 71.4 (4'-C), 73.1 (3-C), 74.9 (2'-C), 77.7 (5'-C), 77.8 (3'-C), 87.1 (5-C), 102.8 (1'-C), 181.4 (12-C), 210.1 (9-C). Positive-ion FAB-MS *m/z*: 425 (M+Na)⁺.

Everlastoside B (**2**): a white powder, $[\alpha]_D^{26} -33.6^\circ$ (c 0.86, MeOH). High-resolution positive-ion FAB-MS: Calcd for $C_{24}H_{38}O_{13}Na$ ($M+Na$)⁺ 557.2210. Found: 557.2205. IR (KBr): 3430, 1736, 1718, 1458, 1064 cm^{-1} . ¹H-NMR (600 MHz, pyridine-*d*₅) δ : given in Table 1, (600 MHz, CD₃OD) δ : 1.17, 1.44, 2.15 (3H each, all s, 11, 13, 10-H₃), 1.68 (1H, m, 2 β -H), 1.72, 1.80 (1H each, both m, 7-H₂), 1.72 (1H, m, 2 α -H), 1.81 (1H, m, 6-H), 1.90 (1H, dd, $J = 8.1, 13.5$ Hz, 4 β -H), 2.22 (1H, dd, $J = 5.4, 13.5$ Hz, 4 α -H), 3.84 (1H, m, 3-H), 4.30 (1H, d, $J = 7.6$ Hz, 1'-H), 4.98 (1H, d, $J = 2.5$ Hz, 1''-H). ¹³C-NMR (150 MHz, pyridine-*d*₅) δ_C : given in Table 1, (150 MHz, CD₃OD) δ_C : 19.4 (7-C), 20.0 (11-C), 24.3 (13-C), 29.9 (10-C), 35.3 (4-C), 35.5 (2-C), 42.6 (8-C), 47.1 (1-C), 54.3 (7-C), 65.6 (5''-C), 68.7 (6'-C), 71.7 (4'-C), 73.6 (3-C), 74.9 (2'-C), 74.9 (4''-C), 76.8 (5'-C), 77.9 (3'-C), 78.0 (2''-C), 80.5 (3''-C), 87.4 (5-C), 103.2 (1'-C), 110.9 (1''-C), 181.7 (12-C), 210.1 (9-C). Positive-ion FAB-MS m/z : 557 ($M+Na$)⁺.

Everlastoside C (**3**): a white powder, $[\alpha]_D^{28} -53.2^\circ$ (c 1.10, pyridine). High-resolution positive-ion FAB-MS: Calcd for $C_{16}H_{30}O_{10}Na$ ($M+Na$)⁺ 405.1737. Found: 405.1743. IR (KBr): 3560, 1057 cm^{-1} . ¹H-NMR (500 MHz, CD₃OD) δ : 0.78 (6H, d, $J = 6.4$ Hz, 4, 5-H₃), 1.48 (2H, m, 2-H₂), 1.70 (1H, m, 3-H), 3.64 (1H, m, 1-H), 3.97 (3H, m, Glc-2, 4, 5-H), 4.11, 4.17 (1H each, both m, Api-5-H₂), 4.17 (1H, m, Glc-3-H), 4.17, 4.72 (1H each, both m, Glc-6-H₂), 4.30, 4.53 (1H each, both d, $J = 9.2$ Hz, Api-4-H₂), 4.72 (1H, d, $J = 7.3$ Hz, Glc-1-H), 5.75 (1H, br s, Api-1-H). ¹³C-NMR (125 MHz, CD₃OD) δ_C : given in Table 2. Positive-ion FAB-MS m/z : 405 ($M+Na$)⁺.

Everlastoside D (**4**): a white powder, $[\alpha]_D^{26} -71.3^\circ$ (c 0.40, MeOH). High-resolution positive-ion FAB-MS: Calcd for $C_{17}H_{30}O_{10}Na$ ($M+Na$)⁺ 417.1737. Found: 417.1743. IR (KBr): 3420, 1655, 1078 cm^{-1} . ¹H-NMR (500 MHz, CD₃OD) δ : 0.97 (3H, t, $J = 6.8$ Hz, 6-H₃), 2.07 (1H, br q, $J = ca. 7$ Hz, 5-H₂), 2.38 (2H, dd-like, $J = ca. 8, 8$ Hz, 2-H₂), 3.16, 3.97 (1H each, both m, Api-4-H₂), 3.27 (1H, m, Glc-4-H), 3.38 (1H, m, Glc-5-H), 3.54, 3.83 (1H each, both m, 1-H₂), 3.57 (2H, br s, Api-5-H₂), 3.58, 3.97 (1H each, both m, Glc-6-H₂), 3.76 (1H, m, Glc-2-H), 3.90 (1H, d, $J = 2.1$ Hz, Api-2-H), 4.25 (1H, d, $J = 8.0$ Hz, Glc-1-H), 5.00 (1H, d, $J = 2.1$ Hz, Api-1-H), 5.39 (1H, m, 3-H), 5.44 (1H, m, 4-H). ¹³C-NMR (125 MHz, CD₃OD) δ_C : given in Table 2. Positive-ion FAB-MS m/z : 417 ($M+Na$)⁺.

Everlastoside E (**5**): a white powder, $[\alpha]_D^{23} -70.5^\circ$ (c 0.35, MeOH). High-resolution positive-ion FAB-MS: Calcd for $C_{19}H_{28}O_{11}Na$ ($M+Na$)⁺ 455.1529. Found: 455.1526. UV [MeOH, nm (log ϵ): 226 (3.82). IR (KBr): 3568, 1560, 1508, 1078 cm^{-1} . ¹H-NMR (500 MHz, CD₃OD) δ : 3.22, 3.99 (1H each, both m, Api-4-H₂), 3.22 (1H, m, Glc-2-H), 3.28 (2H, m, Glc-3, 4-H), 3.30 (1H, m, Glc-5-H), 3.60 (2H, m, Api-5-H₂), 3.77 (3H, s, -OCH₃), 3.94 (1H, d, $J = 2.5$ Hz, Api-2-H), 3.99 (2H, m, Glc-6-H₂), 4.28 (1H, d, $J = 7.0$ Hz, Glc-1-H), 4.58, 4.80 (1H each, both d, $J = 11.3$ Hz, 7-H₂), 5.05 (1H, d, $J = 2.5$ Hz, Api-1-H), 6.88, 7.34 (2H each, both d, $J = 8.6$ Hz, 3,5, 2,6-H). ¹³C-NMR (125 MHz, CD₃OD) δ_C : given in Table 2. Positive-ion FAB-MS m/z : 455 ($M+Na$)⁺.

Acid Hydrolysis of 1—5

A solution of **1—5** (each 1.0 mg) in 1 M HCl (1.0 mL) was heated at 80 °C for 3 h. After cooling, the reaction mixture was neutralized with Amberlite IRA-400 (OH⁻ form) and then the resin was removed by filtration. Then the reaction mixture was extracted with EtOAc. The EtOAc-soluble fraction was subjected to HPLC analysis under the following conditions, respectively: HPLC column, Cosmosil 5C₁₈-

MS-II, 4.6 mm i.d. × 250 mm; detection, RI; mobile phase, MeOH-H₂O [(a) 35:65 or (b) 40:60, v/v]; flow rate 1.0 mL/min]. 3-Methyl-1-butanol²³ [from **3**, *t*_R 18.4 min, condition (a)], (*Z*)-3-hexenol²³ [from **4**, *t*_R 12.4 min, condition (a)], and *p*-methoxybenzyl alcohol²³ [from **5**, *t*_R 9.9 min, condition (b)] presents in the EtOAc-soluble fraction were identified by comparison of their retention times with those of authentic samples. On the other hand, the aqueous layers were subjected to HPLC analysis under the following conditions: HPLC column, Kaseisorb LC NH₂-60-5, 4.6 mm i.d. × 250 mm (Tokyo Kasei Co., Ltd., Tokyo, Japan); detection, optical rotation [Shodex OR-2 (Showa Denko Co., Ltd., Tokyo, Japan)]; mobile phase, CH₃CN-H₂O (85:15, v/v); flow rate 0.8 mL/min]. Identification of D-apiose²⁴ (**i**, from **2**—**5**) and D-glucose (**ii**, from **1**—**5**) present in the aqueous layer was carried out by comparison of their retention times and optical rotations with those of authentic samples. *t*_R: (**i**) 6.6 min (positive optical rotation) and (**ii**) 13.9 min (positive optical rotation), respectively.

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