Water-Soluble Constituents of *Glehnia littoralis* Fruit

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From the water-soluble portion of the methanol extract of the fruit of *Glehnia littoralis* Fr. Schmidt ex Miq. (Umbelliferae; "hamabōfu" in Japanese), thirty compounds, including three new monoterpenoids and a new monoterpenoid glucoside, a new benzofuran glucoside, a new alkyl glucoside, and a new glucide, were obtained. Their structures were clarified by spectral investigation.

Key words *Glehnia littoralis* fruit; monoterpenoid triol; monoterpenoid glucoside; benzofuran glucoside; alkyl glucoside; glucide

Glehnia root is listed in the Japanese and Chinese Pharmacopoeia and is used as a diaphoretic, antipyretic and analgesic medicine. In previous papers,[1)] we reported the isolation of twelve coumarin glycosides, seven monoterpenoid glycosides and others from the root and rhizoma of *Glehnia littoralis* Fr. Schmidt ex Miq. (Umbelliferae; "hamabōfu" in Japanese) collected in Niigata Prefecture. In continuation of our studies on the water-soluble constituents of *Glehnia littoralis*, we carried out the isolation and structural elucidation of monoterpenoid triols, monoterpenoid glycosides, aromatic compound glycosides, alkyl glycosides, glucides and nucleosides from the fruit collected in Niigata Prefecture.

The methanolic extract of the fresh fruit was suspended in water and then extracted successively with ether and ethyl acetate. From the ether extract, imperatorin[1c)] which showed antiplatelet aggregation,[2)] antitumor,[3)] antidermatophytic[4)] and anti-human immunodeficiency virus (HIV) activities,[5)] and isoimperatorin[1c)] showing analgesic[6)] and antitumor-promoting activities[3)] were isolated as the main coumarin constituent. The aqueous layer was chromatographed over Amberlite XAD-II to separate the water and methanol eluate fractions. The fractions were subjected to Sephadex LH-20, silica gel, Lobar RP-8, octadecyl silica (ODS) and carbohydrate analysis column chromatographies, and seven monoterpenoids and monoterpenoid glycosides (**1** to **7**), eleven aromatic compound glycosides (**8** to **18**), six alkyl glycosides (**19** to **24**) and adenosine (**30**) were obtained from the methanol eluate fraction, and glucides (**25** to **29**) came from the water eluate fraction. Their molecular formulae were suggested from the accurate mass number of $[M+H]^+$ or $[M+Na]^+$ ion peaks in the high-resolution positive FAB-MS. All glycosides except **10** and **16** were determined to be β-D-glucopyranosides by their ^{13}C-NMR data and optical rotations, and this was confirmed by hydrolysis to yield D-glucose.

Momoterpenoid **1** ($C_{10}H_{20}O_4$, a colorless syrup) was identified as 3,7-dimethyloct-3(10)-ene-1,2,6,7-tetrol (a mixture of two stereoisomers, **1a** and **1b**, in a ratio of about 5 : 4).[7)] Enzymatic hydrolysis of monoterpenoid glycoside **2** ($C_{16}H_{30}O_9$, an amorphous powder, $[\alpha]_D^{24}$ −21°) gave (2*S*,6ζ)-3,7-dimethyloct-3(10)-ene-1,2,6,7-tetrol (**1a**)[8)] as an aglycone. The position of attachment of the glucosyl unit was revealed to be C-1 of **1a** from the H–C long-range correlation between the glucosyl anomeric proton signal and the C-1 carbon in the heteronuclear multiple-bond correlation (HMBC) spectrum. Therefore, **2** was determined to be (2*S*,6ζ)-3,7-dimethyloct-3(10)-ene-1,2,6,7-tetrol 1-*O*-β-D-glucopyranoside.

Monoterpenoid **3** ($C_{10}H_{18}O_3$, an amorphous powder, $[\alpha]_D^{24}$ +13°) and **4** ($C_{10}H_{18}O_3$, an amorphous powder, $[\alpha]_D^{24}$ +26°) were stereoisomers and showed the presence of two *tert*-methyls, three methylenes (one of them was hydroxylated), one methine, two hydroxylated quaternary carbons, and one disubstituted double bond in their ^{1}H- and ^{13}C-NMR data (Table 1). The planar structures were confirmed from the results of the HMBC experiment, as described in Table 1. Thus, they were concluded to be *p*-menth-2-ene-1,7,8-triol, respectively. The stereochemical relationship between **3** and **4** was determined by comparison of their ^{13}C-NMR spectra with those of *trans*- and *cis*- pairs of *p*-menthane-1,7,8-triol (**31a**, **b**),[9)] (4*R*)-*p*-menthane-1,2α,8-triol (**32a**, **b**),[10)] and (4*R*)-*p*-menthane-1,2β,8-triol (**33a**, **b**),[10)] where C-3 and C-5 signals in *trans*-forms (**31a**; $\delta_{C3,5}$ 23.1, **32a**; δ_{C3} 32.6, δ_{C5} 22.9, **33a**; δ_{C3} 30.9, δ_{C5} 22.8) appeared significantly upfield to those in the *cis*-forms (**31b**; $\delta_{C3,5}$ 25.2, **32b**; δ_{C3} 33.4, δ_{C5} 25.1, **33b**; δ_{C3} 31.5, δ_{C5} 25.0), and C-7 in *trans*-forms (**31a**; δ 71.0, **32a**; δ 27.7, **33a**; δ 28.2) appeared significantly downfield to that of the *cis*-forms (**31b**; δ 66.3, **32b**; δ 19.3, **33b**; δ 24.5). For **3** and **4**, the ^{13}C chemical shift at C-5 of **3** (δ 21.25) was upfield to that of **4** (δ 23.44), whereas C-7 of **3** (δ 71.28) was downfield to that of **4** (δ 68.77). Thus, the stereochemical relationship between C-1 and C-4 was considered to be 7,8-*trans* in **3** and 7,8-*cis* in **4** as in the pairs of **31**, **32** and **33**. So, **3** and **4** were characterized as *trans*-*p*-menth-2-ene-1,7,8-triol and *cis*-*p*-menth-2-ene-1,7,8-triol, respectively.

Monoterpenoid **5** ($C_{10}H_{20}O_3$, an amorphous powder, $[\alpha]_D^{25}$ +21°) showed the presence of three *tert*-methyls, three methylenes, two methine (one of them was hydroxylated) and two hydroxylated quaternary carbons in the ^{1}H- and ^{13}C-NMR data (Table 1), and the planar structure was suggested to be *p*-menthane-1,2,8-triol from the results of the HMBC experiment (Table 1). The stereochemistry of **5** was found to be 7,8-*trans* form from the observed cross peaks between H_3-7 and H-6eq(α), H_3-7 and H-6ax(β), H_3-9 and H-5ax(α), H_3-9 and H-5eq(β), H_3-10 and H-3ax(α), H_3-10 and H-3eq(β), H-3ax(α) and H-5ax(α) in the nuclear Overhauser enhancement and exchange spectroscopy (NOESY) spectrum (Fig. 1). This was supported by comparison of the ^{1}H signal chemical shift of its H-5ax(α) (**5**; δ 2.09) with that of **3** and **4** (**3**; δ 2.09, **4**; δ 1.92). The configuration of the C-2 hydroxyl was suggested to be *axial* (β) by the H-2 signal which formed a narrow triplet with half bandwidth of 3 Hz in its ^{1}H-NMR

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Table 1. ^{13}C- and ^{1}H-NMR Chemical Shifts of **3**—**5**, and HMBC Data for **3** and **5** (in Pyridine-d_5)

	3			**4**		**5**		
	δ_C (ppm)	δ_H (ppm)	HMBC	δ_C (ppm)	δ_H (ppm)	δ_C (ppm)	δ_H (ppm)	HMBC
C-1	69.79	—		71.63	—	70.82	—	
C-2	132.41	6.31 (1H, d, 10.5)	C-3, C-4, C-6	131.02	6.19 (1H, d, 10.5)	74.47	4.22 (1H, t, 3.0, eq)	
C-3	132.60	6.48 (1H, br d, 10.5)	C-1, C-2, C-4, C-5	134.26	6.36 (1H, br d, 10.5)	31.48	2.39 (1H, ddd, 3.0, 12.5, 12.5, ax)	C-1, C-4, C-5
							2.32 (1H, ddd, 3.0, 3.0, 12.5, eq)	C-1, C-2, C-5
C-4	49.19	2.45 (1H, br dd, 5.0, 13.0, ax)	C-2, C-3	48.38	2.52 (1H, m, ax)	42.31	2.44 (1H, dddd, 3.0, 3.0, 12.5, 12.5, ax)	
C-5	21.25	2.09 (1H, dddd, 3.0, 13.0, 13.0, 13.0, ax)	C-6	23.44	1.72 (1H, dddd, 3.0, 13.0, 13.0, 13.0, ax)	23.26	2.09 (1H, dddd, 3.0, 12.5, 12.5, 12.5, ax)	C-3, C-4, C-6
		1.98 (1H, br ddd, 3.0, 5.0, 13.0, eq)	C-6		1.97 (1H, m, eq)		1.98 (1H, br ddd, 3.0, 3.0, 12.5, eq)	
C-6	33.74	1.96 (1H, ddd, 3.0, 13.0, 13.0, ax)	C-1, C-4, C-5, C-7	33.45	1.96 (1H, ddd, 3.0, 13.0, 13.0, ax)	34.97	2.23 (1H, ddd, 3.0, 12.5, 12.5, ax)	C-4, C-5
		2.25 (1H, ddd, 3.0, 3.0, 13.0, eq)	C-1, C-2, C-4		2.61 (1H, ddd, 3.0, 3.0, 13.0, eq)		1.89 (1H, ddd, 3.0, 3.0, 12.5, eq)	C-1, C-2, C-4, C-5
C-7	71.28	3.94 (1H, d, 11.0)	C-1, C-2, C-6	68.77	3.98 (1H, d, 11.0)	28.87	1.69 (3H, s)	C-1, C-2, C-6
		4.00 (1H, d, 11.0)	C-1, C-2, C-6		4.03 (1H, d, 11.0)			
C-8	71.55	—		71.55	—	71.63	—	
C-9	28.50	1.41 (3H, s)	C-4, C-8, C-10	28.38	1.37 (3H, s)	27.77[a)]	1.40 (3H, s)	C-4, C-8, C-10
C-10	26.52	1.36 (3H, s)	C-4, C-8, C-9	26.35	1.33 (3H, s)	27.93[a)]	1.40 (3H, s)	C-4, C-8, C-9

δ in ppm from TMS [coupling constants (J) in Hz are given in parentheses]. *a*) Assignments may be interchanged.

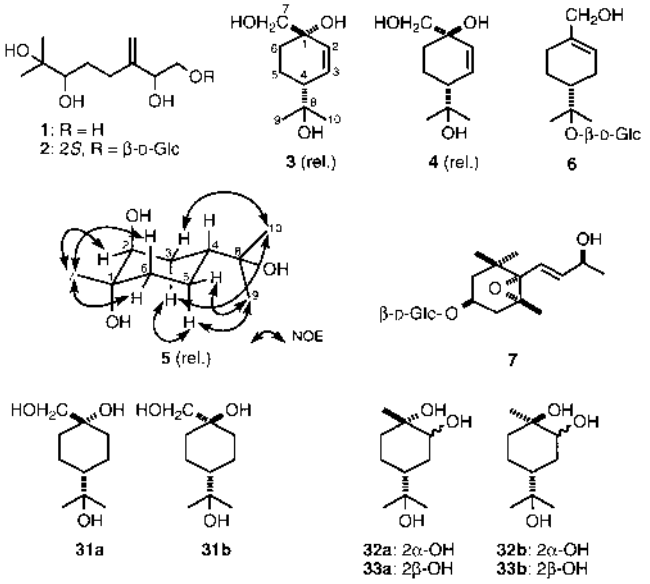

Fig. 1. Structures of **1**—**7** and **31a**—**33b**, and NOE Interactions Observed in the NOESY Spectrum of **5**

Table 2. ^{13}C- and ^{1}H-NMR Chemical Shifts and HMBC Data for **8** (in D_2O)

	δ_C (ppm)	δ_H (ppm)	HMBC
C-2	147.07	7.64 (1H, br s)	C-3, C-8, C-9
C-3	106.87	6.96 (1H, br s)	C-2, C-4, C-8, C-9
C-4	96.60	7.12 (1H, s)	C-5, C-6, C-8, C-9
C-5	155.90		
C-6	119.91		
C-7	152.97		
C-8	157.41		
C-9	116.43		
C-1′	23.21	2.99 (2H, br t, 8.0)	C-5, C-6, C-7, C-2′, C-3′
C-2′	40.72	2.38 (2H, m)	C-6, C-1′, C-3′
C-3′	185.99		
7-OCH_3	63.44	4.03 (3H, s)	C-7
Glc-1	103.59	5.06 (1H, d, 7.5)	C-5
Glc-2	75.57		
Glc-3	78.32		
Glc-4	72.16		
Glc-5	78.80		
Glc-6	63.30		

δ in ppm from sodium 3-(trimethylsilyl)-1-propanesulfonate [coupling constants (J) in Hz are given in parentheses].

spectrum. Therefore, **5** was characterized as *trans-p*-menthane-1α,2β,8-triol.

Glycoside **6** ($C_{16}H_{28}O_7$, an amorphous powder, $[\alpha]_D^{24}$ +8°) was identified as (4*R*)-*p*-menth-1-ene-7,8-diol 8-*O*-β-D-glucopyranoside by direct comparison with an authentic sample,[9] and glycoside **7** ($C_{19}H_{32}O_8$, an amorphous powder, $[\alpha]_D^{24}$ −55°) was identified as corchoionoside A by comparison of the NMR data and optical rotation with those published.[11]

Glycoside **8** ($C_{18}H_{22}O_{10}$, an amorphous powder, $[\alpha]_D^{21}$ −60°) showed the presence of one pentasubstituted benzene, one disubstituted double bond, one carboxyethyl, one methoxyl and one β-glucopyranosyl unit in the ^{1}H- and ^{13}C-NMR data (Table 2). Comparison of its NMR data with that of cnidioside A,[1c] which was isolated from the root, suggested that **8** is a glucopyranoside of a benzofuran derivative. The positions of the carboxyethyl, methoxyl and glucosyl units were located at C-6, C-7 and C-5, respectively, from the results of the HMBC experiments, as described in Table 2. Thus, **8** was characterized as 6-carboxyethyl-7-methoxy-5-hydroxybenzofuran 5-*O*-β-D-glucopyranoside.

Coumarin glycosides **9** ($C_{15}H_{16}O_8$, an amorphous powder, $[\alpha]_D^{24}$ −48°) and **10** ($C_{26}H_{34}O_{13}$, an amorphous powder, $[\alpha]_D^{24}$ −48°) were identified as umbelliferone 7-*O*-β-D-glucopyranoside[12] and osthenol 7-*O*-β-gentibioside.[13] Furocoumarin glycosides **11** ($C_{20}H_{24}O_9$, mp 259—260 °C, $[\alpha]_D^{24}$ −44°), **12**

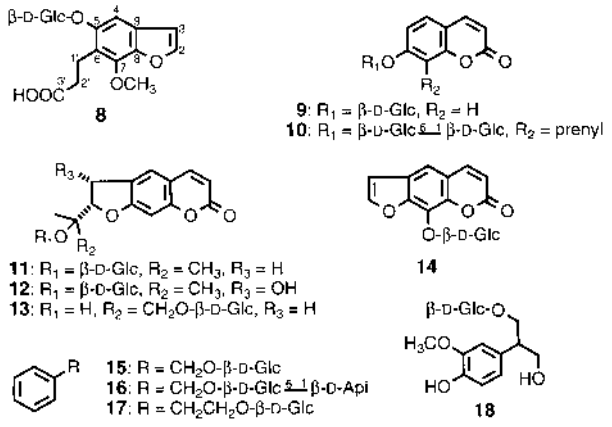

Fig. 2. Structures of **8**—**18**

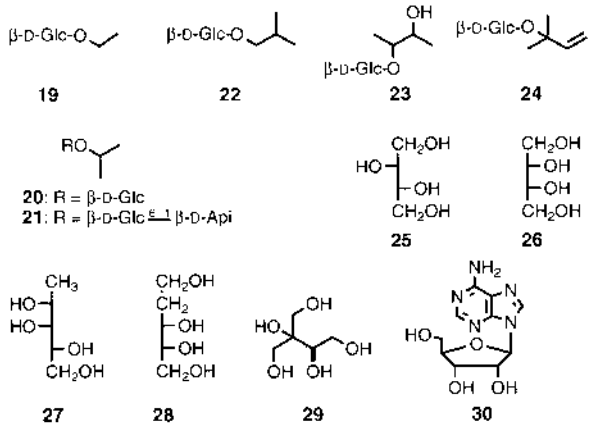

Fig. 3. Structures of **19**—**30**

($C_{20}H_{24}O_{10}$, mp 267—269 °C, $[\alpha]_D^{22}$ −19°), **13** ($C_{20}H_{24}O_{10}$, mp 184—188 °C, $[\alpha]_D^{22}$ −48°) and **14** ($C_{17}H_{16}O_9$, an amorphous powder, $[\alpha]_D^{22}$ −24°) were identified as marmesinin,[1a] (3′*R*)-hydroxymarmesinin 4′-*O*-*β*-D-glucopyranoside,[1a] oxymarmesinin 5′-*O*-*β*-D-glucopyranoside[1a] and xanthotoxol 8-*O*-*β*-D-glucopyranoside,[8] and alkyl benzene glycosides **15** ($C_{13}H_{18}O_6$, mp 120—121 °C, $[\alpha]_D^{21}$ −53°), **16** ($C_{18}H_{24}O_{10}$, mp 133—135 °C, $[\alpha]_D^{22}$ −98°), **17** ($C_{14}H_{20}O_6$, an amorphous powder, $[\alpha]_D^{23}$ −37°) and **18** ($C_{16}H_{24}O_9$, an amorphous powder, $[\alpha]_D^{22}$ −18°) were identified as benzyl *β*-D-glucopyranoside,[14] benzyl *β*-D-apiofuranosyl-(1→6)-*β*-D-glucopyranoside [icariside F_2],[14] phenethyl *β*-D-glucopyranoside[14] and junipediol A 2′-*O*-*β*-D-glucopyranoside,[15] respectively. Glycoside **2** and **8**, and monoterpenoids **3**, **4**, **5** are new compounds and have not been previously described.

Alkyl glycosides **19** ($C_8H_{16}O_6$, a colorless syrup, $[\alpha]_D^{23}$ −26°), **20** ($C_9H_{18}O_6$, mp 129—131 °C, $[\alpha]_D^{21}$ −36°), **21** ($C_{14}H_{24}O_{10}$, an amorphous powder, $[\alpha]_D^{24}$ −66°), **23** ($C_{10}H_{20}O_8$, amorphous powder, $[\alpha]_D^{23}$ −32°) and **24** ($C_{11}H_{20}O_6$, an amorphous powder, $[\alpha]_D^{24}$ −19°) were identified as ethyl *β*-D-glucopyranoside,[16] isopropyl *β*-D-glucopyranoside,[16] isopropyl *β*-D-apiofuranosyl-(1→6)-*β*-D-glucopyranoside,[17] butane-2,3-diol 2-*O*-*β*-D-glucopyranoside[16] and 2-methyl-3-buten-2-ol *β*-D-glucopyranoside,[18] respectively.

Alkyl glycoside **22** ($C_{10}H_{20}O_6$, an amorphous powder, $[\alpha]_D^{24}$ −19°) showed, in addition to the *β*-glucopyranosyl moiety, two *sec*-methyls, one hydroxylated methylene and one methine, in the ^{1}H- and ^{13}C-NMR data. This suggested that **22** was a *β*-D-glucopyranoside of isobutanol, and it was characterized as isobutyl *β*-D-glucopyranoside.

Glucide **25** ($C_4H_{10}O_4$, an amorphous powder, $[\alpha]_D^{23}$ −7°), **26** ($C_4H_{10}O_4$, an amorphous powder, $[\alpha]_D^{23}$ 0°), **28** ($C_5H_{12}O_5$, a colorless syrup, $[\alpha]_D^{22}$−17°) and **29** ($C_5H_{12}O_5$, a colorless syrup, $[\alpha]_D^{22}$ +4°) were identified as D-threitol,[19] erythritol,[19] 2-deoxy-D-ribitol[19] and (3*R*)-2-hydroxymethylbutane-1,2,3,4-tetrol,[20] respectively.

Glucide **27** ($C_5H_{12}O_4$, a colorless syrup, $[\alpha]_D^{24}$ −23°) was made up of one *sec*-methyl, one hydroxylated methylene, three hydroxylated methines, and was suggested to be 1-deoxypentol. Meanwhile 1-deoxypentitol has four possible relative structures, among which 1-deoxy-ribitol and 1-deoxy-xylitol were ruled out by comparison of their NMR spectra.[19] On the other hand, ^{1}H-NMR data of synthetic 1-deoxy-L-lyxitol (**34**)[21] was identical with that of **27**, and the optical rotation of **27** ($[\alpha]_D$ +10° (H_2O)) exhibited an opposite value to that of **34** ($[\alpha]_D$ −9.5° (H_2O)). Thus, **27** was characterized as 1-deoxy-D-lyxitol. Though **22** and **27** were very simple compounds, this is the first report of their isolation from natural sources.

Imperatorin and isoimperatorin are the main coumarin in both the underground part and the fruit of *G. littoralis*, while peucedanol glycosides, angelicoidenol glycosides which are listed as the main glycoside of the root and rhizoma,[1a] were not found in the fruit. Though glycoside **10** and adenosine were not found in the underground part of the sample collected in Niigata Prefecture, **10** was reported to be the main glycoside of the root of this plant by Sasaki *et al.*,[13] and adenosine was isolated as the main glycoside of the root and rhizoma of *G. littoralis* collected by us in Okinawa Prefecture.[22] These differences in constituents were considered to be attributed to the geographical variation of this plant.[23]

Experimental

Melting points were determined on a Yanagimoto micromelting point apparatus and are uncorrected. Optical rotations were measured on a JASCO DIP-370 digital polarimeter. FAB-MS were recorded with a JEOL HX-110 spectrometer using glycerol as a matrix. ^{1}H- and ^{13}C-NMR spectra were taken on JEOL JNM GX-270 and A-500 spectrometers with tetramethylsilane as an internal standard, and chemical shifts were recorded in δ values. ^{1}H–^{13}C correlation spectroscopy (COSY), HMBC and NOESY spectra were obtained with the usual pulse sequence, and data processing was performed with standard JEOL software. Column chromatography (C.C.) was carried out under TLC monitoring using Kieselgel 60 (70—230 mesh, Merck), Sephadex LH-20 (25—100 mm, Pharmacia), a Lobar RP-8 column (Merck) and Amberlite XAD-II (Organo). TLC was performed on silica gel (Merck 5721), and spots were detected with *p*-anisaldehyde–H_2SO_4 reagent. HPLC separation was carried out on a JASCO chromatograph (980-system) with a JASCO 930 RI detector, and ODS-3251-D [Senshu Pak; column size, 8×250 mm; ODS], Carbohydrate Analysis [Waters; column size, 3.9×300 mm; CHA] and Wakobeads T-100s [Wako; column size, 6.0×150 mm; WBT] were used as columns.

Extraction and Separation *G. littoralis* Fr. SCHMIDT ex MIQ. was collected at Kakizaki in Niigata Prefecture, Japan, in October 1995. The fresh fruit (1.3 kg) were extracted with methanol (10 l) at room temperature. After evaporation of the solvent, the residue (128.9 g) was partitioned into ether–water and ethyl acetate–water. The ether-soluble portion (48.0 g) was chromatographed over silica gel [hexane–EtOAc (4 : 1→3 : 1→2 : 1→1 : 1)→EtOAc→MeOH] to give 10 fractions (frs. 1—10). From fraction 5 (7.0 g), isoimperatorin (0.72 g) and imperatorin (2.90 g) were isolated by repeated silica gel C.C. [hexane–EtOAc (4 : 1→7 : 3→3 : 2) and Sephadex LH-20 (MeOH). The aqueous portion (80.2 g) was subjected to Amberlite XAD-II (H_2O→MeOH). The methanol eluate (8.0 g) was chromatographed over Sephadex LH-20 (MeOH) to give five fractions (frs. A—E). Fraction B (5.5 g) was chromatographed over silica gel [$CHCl_3$–MeOH–H_2O (17 : 3 : 0.2→4 : 1 : 0.1→7 : 3 : 0.5)→MeOH] to give 26 fractions (frs. B_1—B_{26}). Fraction B_7 (119 mg) was passed through a Lobar RP-8 column

[MeCN–H_2O (3 : 17)] to give 15 fractions (frs. $B_{6\text{-}1}$—$B_{6\text{-}15}$). Fraction $B_{6\text{-}4}$ was subjected to HPLC [ODS, MeCN–H_2O (1 : 19)] to give **3** (4 mg) and **4** (2 mg). Fraction B_7 (390 mg) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give 19 fractions (frs. $B_{7\text{-}1}$—$B_{7\text{-}19}$). Fraction $B_{7\text{-}4}$ was subjected to HPLC [ODS, MeCN–H_2O (3 : 97)] and silica gel C.C. [$CHCl_3$–MeOH (17 : 3)] to give **5** (10 mg). Fraction $B_{7\text{-}5}$[24] was acetylated with Ac_2O and pyridine, and the acetylated fraction was subjected to HPLC [ODS, MeCN–H_2O (1 : 1)] to give two fractions. These two fractions were deacetylated by heating in a water bath with 5% NH_4OH–MeOH for 2 h, then passed through Sephadex LH-20 (MeOH) to give **22** (2 mg) and **24** (2 mg), respectively. Fraction $B_{7\text{-}7}$ was subjected to HPLC [ODS, MeCN–H_2O (3 : 17)] to give **15** (30 mg). Fraction $B_{7\text{-}11}$ was passed through a Sephadex LH-20 (MeOH) to give **14** (6 mg). Fraction $B_{7\text{-}13}$ was subjected to silica gel C.C. [$CHCl_3$–MeOH (17 : 3)] and HPLC [CHA, MeCN–H_2O (49 : 1)] to give **17** (5 mg). Fraction $B_{7\text{-}17}$ was repeatedly subjected to Sephadex LH-20 (MeOH) to give **11** (70 mg). Fraction B_8 (94 mg) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give 10 fractions (frs. $B_{8\text{-}1}$—$B_{8\text{-}10}$), and from fr. $B_{8\text{-}2}$, **1** (30 mg) was obtained by HPLC [CHA, MeCN–H_2O (49 : 1)]. Fraction B_9 (269 mg) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give 12 fractions (frs. $B_{9\text{-}1}$—$B_{9\text{-}12}$). Fraction $B_{9\text{-}2}$ was subjected to HPLC [ODS, MeCN–H_2O (3 : 17) and CHA, MeCN–H_2O (49 : 1)] to give **20** (10 mg). Fraction $B_{9\text{-}4}$ was subjected to HPLC [ODS, MeCN–H_2O (3 : 37)] to give **9** (8 mg). Fraction $B_{9\text{-}8}$ was subjected to HPLC [CHA, MeCN–H_2O (14 : 1)] to give **12** (12 mg). Fraction B_{10} (147 mg) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give 10 fractions (frs. $B_{10\text{-}1}$—$B_{10\text{-}10}$). Fraction $B_{10\text{-}2}$ was subjected to HPLC [ODS, MeCN–H_2O (3 : 197)] to give **19** (12 mg) and **30** (20 mg). Fraction $B_{10\text{-}5}$, fr. $B_{10\text{-}6}$ and fr. $B_{10\text{-}7}$ were subjected to HPLC [ODS, MeCN–H_2O (3 : 17)] to give **6** (8 mg), **7** (7 mg) and **13** (8 mg), respectively. Fraction B_{14} (146 mg) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give 11 fractions (frs. $B_{14\text{-}1}$—$B_{14\text{-}11}$), and from fr. $B_{14\text{-}2}$, **23** (30 mg) was isolated by HPLC [CHA, MeCN–H_2O (49 : 1)]. Fraction B_{17} (116 mg) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give 15 fractions (frs. $B_{17\text{-}1}$—$B_{17\text{-}15}$). Fraction $B_{17\text{-}5}$ was subjected to HPLC [ODS, MeCN–H_2O (1 : 19)] to give **18** (24 mg). Fraction $B_{17\text{-}12}$ was subjected to HPLC [ODS, MeCN–H_2O (3 : 17)] to give **16** (4 mg). Fraction B_{19} (308 mg) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give 10 fractions (frs. $B_{19\text{-}1}$—$B_{19\text{-}10}$). Fraction $B_{19\text{-}3}$ was subjected to HPLC [ODS, MeCN–H_2O (3 : 97)] to give **21** (7 mg). Fraction $B_{19\text{-}4}$ was subjected to Sephadex LH-20 (MeOH) and HPLC [ODS, MeCN–H_2O (1 : 19)] to give **2** (15 mg). Fraction $B_{19\text{-}10}$ was subjected to Sephadex LH-20 (MeOH) and HPLC [ODS, MeCN–H_2O (1 : 4)] to give **10** (21 mg). Fraction B_{26} (244 mg) was subjected to a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give **8** (68 mg).

The water eluate (72.2 g) was chromatographed over Sephadex LH-20 (MeOH) to give five fractions (frs. F—J). Fraction H (40.9 g) was chromatographed over silica gel [$CHCl_3$–MeOH–H_2O (17 : 3 : 0.2→4 : 1 : 0.1→7 : 3 : 0.5)→MeOH] to give 17 fractions (frs. H_1—H_{17}). Fraction H_8 (403 mg) was passed through a Lobar RP-8 column (H_2O), and the main fraction[24] was acetylated with Ac_2O and pyridine. The acetylated compounds were subjected to HPLC [ODS, MeCN–H_2O (1 : 1)], then deacetylated as described in **22** and **24** to get **27** (250 mg). Fraction H_{10} (643 mg) was chromatographed over silica gel [$CHCl_3$–MeOH–H_2O (7 : 3 : 0.5)→MeOH] to give 13 fractions (frs. $H_{10\text{-}1}$—$H_{10\text{-}13}$). Fraction $H_{10\text{-}5}$ was subjected to HPLC [Wakobeads T-100s×2, MeCN–H_2O (17 : 3)] and silica gel C.C. [$CHCl_3$–MeOH–H_2O (7 : 3 : 0.5)] to give **28** (3 mg). Fraction $H_{10\text{-}5}$ was subjected to HPLC [CHA, MeCN–H_2O (19 : 1)] to give frs. $H_{10\text{-}9\text{-}1}$, $H_{10\text{-}9\text{-}2}$ and **29** (22 mg). Fraction $H_{10\text{-}9\text{-}2}$[24] was acetylated with Ac_2O and pyridine, and the acetylated fraction was subjected to HPLC [ODS, MeCN–H_2O (1 : 1)] to give peracetates of **25** and **26**. These were deacetylated in the same way described for **22** and **24** to give **25** (2 mg) and **26** (2 mg), respectively.

The following compounds were identified by comparison with authentic compounds or with published physical and spectral data. 3,7-Dimethyloct-3(10)-ene-1,2,6,7-tetrol (**1**), (4*R*)-*p*-menth-1-ene-7,8-diol 8-*O*-*β*-D-glucopyranoside (**6**), corchoionoside A (**7**), umbelliferone 7-*O*-*β*-D-glucopyranoside (**9**), osthenol 7-*O*-*β*-D-gentiobioside (**10**), marmesinin (**11**), (3′*R*)-hydroxymarmesin 4′-*O*-*β*-D-glucopyranoside (**12**), oxymarmesin 5′-*O*-*β*-D-glucopyranoside (**13**), xanthotoxol 8-*O*-*β*-D-glucopyranoside (**14**), benzyl *β*-D-glucopyranoside (**15**), icariside F_2 (**16**), phenethyl *β*-D-glucopyranoside (**17**), junipediol A 2′-*O*-*β*-D-glucopyranoside (**18**), ethyl *β*-D-glucopyranoside (**19**), isopropyl *β*-D-glucopyranoside (**20**), isopropyl *β*-D-apiofranosyl-(1-6)-*β*-D-glucopyranoside (**21**), butane-2,3-diol 2-*O*-*β*-D-glucopyranoside (**23**), 2-methyl-3-buten-2-ol *β*-D-glucopyranoside (**24**), D-threitol (**25**), erythritol (**26**), 2-deoxy-D-ribitol (**28**), (3*R*)-2-hydroxymethylbutane-1,2,3,4-tetrol (**29**) and adenosine (**30**).

(2*S*,6*ζ*)-3,7-Dimethyloct-3(10)-ene-1,2,6,7-tetrol 1-*O*-*β*-D-Glucopyranoside (2) An amorphous powder $[\alpha]_D^{24}$ −21° (*c*=0.5, MeOH). Positive FAB-MS *m/z*: 405 $[M+K]^+$, 389 $[M+Na]^+$ (base), 367.1956 $[M+H]^+$ (Calcd for $C_{16}H_{31}O_9$; 367.1968), 187 $[M-C_6H_{12}O_6+H]^+$. ^{1}H-NMR (Pyridine-d_5, 500 MHz) *δ*: 4.01 (1H, dd, *J*=8.0, 10.5 Hz, H-1a), 4.44 (1H, dd, *J*=3.5, 10.5 Hz, H-1b), 4.84 (1H, dd, *J*=3.5, 8.0 Hz, H-2), 2.43 (1H, ddd, *J*=6.0, 10.0, 15.5 Hz, H-4a), 2.97 (1H, ddd, *J*=4.5, 10.5, 15.5 Hz, H-4b), 1.91 (1H, m, H-5a), 2.21 (1H, m, H-5b), 3.79 (1H, dd, *J*=1.5, 10.5 Hz, H-6), 1.46, 1.50 (each 3H, s, H_3-8, H_3-9), 5.14, 5.46 (each 1H, br s, H_2-10), 5.02 (1H, d, *J*=8.0 Hz, Glc H-1). ^{13}C-NMR (pyridine-d_5, 125 MHz) *δ*: 75.08 (C-1), 74.69 (C-2), 150.96 (C-3), 30.47 (C-4), 30.91 (C-5), 78.54 (C-6), 72.67 (C-7), 25.94, 26.04 (C-8, C-9), 110.33 (C-10), 105.67 (Glc C-1), 75.40 (Glc C-2), 78.55 (Glc C-3), 71.65 (Glc C-4), 78.64 (Glc C-5), 62.74 (Glc C-6).

Enzymatic Hydrolysis of 2 A mixture of **2** (6 mg) and hesperidinase (3 mg) in water (5 ml) was shaken in a water bath at 37 °C for 20 d. The mixture was evaporated *in vacuo* to dryness and the residue was chromatographed over silica gel [$CHCl_3$–MeOH–H_2O (4 : 1 : 0.1 and 7 : 3 : 0.5)] to afford **2a** (3 mg) and a sugar fraction. The sugar fraction was passed through Sephadex LH-20 (MeOH) to give a syrup, and HPLC [carbohydrate analysis (waters), detector; JASCO RI-930 detector and JASCO OR-990 chiral detector, solv.; MeCN–H_2O (17 : 3), 2 ml/min; t_R 4.53 min (same location as that of D-glucose)] shows the presence of D-glucose.

(2*S*,6*ζ*)-3,7-Dimethyloct-3(10)-ene-1,2,6,7-tetrol (2a) A colorless syrup, $[\alpha]_D^{24}$ −25° (*c*=0.2, MeOH). Positive FAB-MS *m/z*: 205 $[M+H]^+$, 187 $[M-H_2O+H]^+$, 169 $[M-2H_2O+H]^+$ (base). ^{1}H-NMR (pyridine-d_5, 500 MHz) *δ*: 4.08 (1H, dd, *J*=7.5, 11.0 Hz, H-1a), 4.18 (1H, dd, *J*=4.0, 11.0 Hz, H-1b), 4.76 (1H, dd, *J*=4.0, 7.5 Hz, H-2), 2.50 (1H, ddd, *J*=6.0, 10.5, 15.5 Hz, H-4a), 3.05 (1H, ddd, *J*=4.0, 10.5, 15.5 Hz, H-4b), 1.95 (1H, m, H-5a), 2.24 (1H, m, H-5b), 3.82 (1H, br d, *J*=9.0 Hz, H-6), 1.47, 1.50 (each 3H, s, H_3-8, H_3-9), 5.20, 5.55 (each 1H, br s, H_2-10). ^{13}C-NMR (pyridine-d_5, 125 MHz) *δ*: 66.75 (C-1), 76.56 (C-2), 151.88 (C-3), 30.54 (C-4), 30.97 (C-5), 78.66 (C-6), 72.71 (C-7), 25.94, 25.94 (C-8, C-9), 109.85 (C-10).

***trans-p*-Menth-2-ene-1*α*,7,8-triol (3)** An amorphous powder, $[\alpha]_D^{24}$ +13° (*c*=0.3, MeOH). Positive FAB-MS *m/z*: 187.1335 $[M+H]^+$ (Calcd for $C_{10}H_{19}O_3$; 187.1334), 169 $[M-H_2O+H]^+$, 151 $[M-2H_2O+H]^+$ (base), 133 $[M-3H_2O+H]^+$. ^{1}H-NMR (pyridine-d_5, 500 MHz) *δ*: Table 1. ^{13}C-NMR (pyridine-d_5, 125 MHz) *δ*: Table 1.

***cis-p*-Menth-2-ene-1*α*,7,8-triol (4)** An amorphous powder, $[\alpha]_D^{24}$ +26° (*c*=0.1, MeOH). Positive FAB-MS *m/z*: 187.1337 $[M+H]^+$ (Calcd for $C_{10}H_{19}O_3$; 187.1334), 169 $[M-H_2O+H]^+$, 151 $[M-2H_2O+H]^+$ (base), 133 $[M-3H_2O+H]^+$. ^{1}H-NMR (pyridine-d_5, 500 MHz) *δ*: Table 1. ^{13}C-NMR (pyridine-d_5, 125 MHz) *δ*: Table 1.

***trans-p*-Menth-2-ene-1*α*,2*β*,8-triol (5)** An amorphous powder, $[\alpha]_D^{25}$ +21° (*c*=0.1, MeOH). Positive FAB-MS *m/z*: 377 $[2M+H]^+$, 281 $[M+gly+H]^+$, 211.1305 $[M+Na]^+$ (Calcd for $C_{10}H_{20}NaO_3$; 211.1311), 189 $[M+H]^+$, 171 $[M-H_2O+H]^+$, 153 $[M-2H_2O+H]^+$ (base). ^{1}H-NMR (pyridine-d_5, 500 MHz) *δ*: Table 1. ^{13}C-NMR (pyridine-d_5, 125 MHz) *δ*: Table 1.

6-Carboxyethyl-7-methoxy-5-hydroxybenzofuran 5-*O*-*β*-D-Glucopyranoside (8) An amorphous powder, $[\alpha]_D^{21}$ −60° (*c*=1.8, H_2O). Positive FAB-MS *m/z*: 421 $[M+Na]^+$, 399.1310 $[M+H]^+$ (Calcd for $C_{18}H_{23}O_{10}$; 399.1291), 237 $[M-C_6H_{10}O_5+H]^+$. ^{1}H-NMR (D_2O, 500 MHz) *δ*: Table 2. ^{13}C-NMR (D_2O, 125 MHz) *δ*: Table 2.

Isobutyl *β*-D-Glucopyranoside (22) An amorphous powder, $[\alpha]_D^{24}$ −19° (*c*=0.1, MeOH). Positive FAB-MS *m/z*: 495 $[2M+Na]^+$, 259 $[M+Na]^+$ (base), 237.1335 $[M+H]^+$ (Calcd for $C_{10}H_{21}O_6$; 237.1338). ^{1}H-NMR (pyridine-d_5, 500 MHz) *δ*: 3.40 (1H, dd, *J*=6.5, 9.5 Hz, H-1a), 3.86 (1H, dd, *J*=6.5, 9.5 Hz, H-1b), 1.94 (1H, sept, *J*=6.5 Hz, H-2), 0.89, 0.90 (each 3H, d, *J*=6.5 Hz, H_3-3, H_3-4), 4.83 (1H, d, *J*=7.5 Hz, Glc H-1). ^{13}C-NMR (pyridine-d_5, 125 MHz) *δ*: 76.50 (C-1), 28.98 (C-2), 19.51, 19.54 (C-3, C-4), 104.98 (Glc C-1), 75.29 (Glc C-2), 78.65 (Glc C-3), 71.76 (Glc C-4), 78.58 (Glc C-5), 62.89 (Glc C-6).

1-Deoxy-D-lyxitol (27) A colorless syrup, $[\alpha]_D^{24}$ −23° (*c*=1.1, MeOH). Positive FAB-MS *m/z*: 159 $[M+Na]^+$, 137.0806 $[M+H]^+$ (base, Calcd for $C_5H_{13}O_4$; 137.0814). ^{1}H-NMR (pyridine-d_5, 500 MHz) *δ*: 1.69 (3H, d, *J*=6.5 Hz, H_3-1), 4.53 (1H, dq, *J*=6.5, 6.5 Hz, H-2), 4.14 (1H, dd, *J*=2.5, 6.5 Hz, H-3), 4.76 (1H, ddd, *J*=2.5, 6.0, 6.0 Hz, H-4), 4.33, 4.37 (each 1H, dd, *J*=6.0, 11.0 Hz, H_2-5). ^{13}C-NMR (pyridine-d_5, 125 MHz) *δ*: 21.35 (C-1), 68.69 (C-2), 76.41 (C-3), 72.26 (C-4), 65.12 (C-5).

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