Studies on the Constituents from the Aerial Part of *Baccharis dracunculifolia* DC. II

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Ten new glycosides were obtained along with five known compounds from the aerial part of *Baccharis dracunculifolia* DC. (Compositae). The structures of these glycosides were determined based on spectral and chemical evidence. These new compounds consisted of β-D-glucopyranose or β-D-apiofuranosyl-(1→6)-β-D-glucopyranose, and most possessed an (*E*)-caffeoyl group the same as dracunculifosides A—J.

Key words *Baccharis dracunculifolia* DC.; Compositae; dracunculifoside; pinoresinol; α-terpineol

In the course of our research on the constituents of Brazilian plants, we started investigation of the glycosides from *Baccharis dracunculifolia* DC. (Compositae); we previously reported the structures of dracunculifosides A—J from the aerial part of this plant.[1] Recently, ten new glycosides were isolated along with five known compounds identified by their NMR spectral data [**1**: 3,4-*O*-dicaffeoylquinic acid methyl ester,[2] **2**: pinoresinol *O*-β-D-glucopyranoside,[3] **3**: syringaresinol *O*-β-D-glucopyranoside,[4] **12**, **13** (mixtures): (4*R*,*S*)-α-terpineol *O*-β-D-glucopyranosides[5]]. This paper also describes the isolation and structural elucidation of these new compounds.

The extraction of the constituents from *B. dracunculifolia* DC. was described in a previous paper.[1] The adsorbed material on the Mitsubishi Diaion HP-20 column was eluted with 50% MeOH in water, 70% MeOH in water and MeOH, continuously. The residues of the 50% and 70% MeOH eluates gave compounds **1**—**15**.

Compound **4** was suggested to have the molecular formula, $C_{35}H_{38}O_{14}$ based on a high resolution (HR)-FAB-MS [positive HR-FAB-MS ion at *m*/*z* 705.2175 $[M+Na]^+$]. The ^{1}H-NMR spectrum showed AMX type-aromatic proton signals [δ 7.06 (1H, d, *J*=2.0 Hz), 6.95 (1H, dd, *J*=8.0, 2.0 Hz), 6.80 (1H, d, *J*=8.0 Hz)] and two *trans*-olefinic proton signals [δ 7.54 (1H, d, *J*=16.0 Hz), 6.26 (1H, d, *J*=16.0 Hz)]. The ^{13}C-NMR spectrum exhibited one carbonyl carbon signal (δ 168.8), two sp^2 carbon signals (δ 147.1, 115.2), six aromatic carbon signals (δ 149.7, 147.0, 127.8, 123.0, 116.7, 115.3) and six carbon signals due to the sugar moiety (δ 102.6, 77.9, 75.6, 74.9, 72.2, 64.7) along with the signal due to the aglycone moiety. Thus, compound **4** was believed to consist of an aglycone, one monosaccharide and an (*E*)-caffeoyl group.

Concerning the aglycone moiety, the ^{13}C-NMR spectrum showed twenty carbon signals including twelve aromatic carbon signals and the methoxyl carbon signals, and in the ^{1}H-NMR spectrum, the AMX type- [δ 7.05 (1H, d, *J*=8.0 Hz), 6.96 (1H, d, *J*=2.0 Hz), 6.70 (1H, dd, *J*=8.0, 2.0 Hz)] and AA′X type-aromatic proton signals [δ 6.78 (2H, br s), 6.93 (1H, br s)]. Therefore, the aglycone of **4** was deduced to be a lignan derivative.

Mild alkaline hydrolysis of compound **4** afforded **4a** which was identified as pinoresinol *O*-β-D-glucopyranoside (**2**)[3,6] by the HPLC analysis and ^{1}H-NMR spectrum. On comparison of the ^{1}H-NMR spectrum of **4** with that of **2**, the H-6 signal of β-D-glucopyranose of **4** was shifted downfield, indicating that the caffeoyl group was bound to C-6 of β-D-glucopyranose of **2**. This linkage was confirmed by the ^{1}H-detected heteronuclear multiple-bond connectivity (HMBC) spectrum. Based on the above results, compound **4** was concluded to be pinoresinol *O*-[6-*O*-(*E*)-caffeoyl]-β-D-glucopyranoside. The aglycone moiety of **4** was determined to be (+)-pinoresinol, according to consistency of the optical rotation value of **4a** with that of **2**.

The molecular formulae of dracunculifosides K (**5**) and L (**6**) were expected to be $C_{25}H_{28}O_{11}$ and $C_{28}H_{30}O_{13}$ by the HR-FAB-MS. The ^{1}H- and ^{13}C-NMR spectra of **5** and **6** displayed the signals due to glucopyranose and an (*E*)-caffeoyl group in addition to the signal due to each aglycone. The similarity of the ^{13}C-NMR spectral data of **5** to those of myzodendrone[7] and dracunculifoside I[1] let us to guess that the aglycone of **5** was 4-(3,4-dihydroxyphenyl)-butan-2-one. Similarly, comparison of the ^{1}H- and ^{13}C-NMR spectral data of **6** with those of dracunculifoside J[1] indicated the presence of dracunculifoside J and the (*E*)-caffeoyl group in **6**. Production of myzodendrone and (*E*)-caffeic acid from **5**, and dracunculifoside J and (*E*)-caffeic acid from **6** by mild alkaline hydrolysis confirmed the above presumption. Consistency of the ^{1}H- and ^{13}C-NMR spectral data of the sugar and ester moieties in **5** and **6** with those in **4** suggested that the (*E*)-caffeoyl group was attached to the C-6 position of β-D-glucopyranose. Accordingly, the structures of dracunculifosides K (**5**) and L (**6**) were determined as shown in Chart 1.

Dracunculifoside M (**7**) had the molecular formula, $C_{30}H_{44}O_{11}$, on a HR-FAB-MS [positive HR-FAB-MS ion at *m*/*z* 603.2781 $[M+Na]^+$]. The ^{1}H- and ^{13}C-NMR spectra of **7** also showed the signals due to glucopyranose and an (*E*)-caffeoyl group. The *J* value of the anomeric proton signal of glucopyranose (*J*=8.0 Hz) and GC analysis after acid hydrolysis indicated that this glucopyranose had a β-D-configuration. With regard to the aglycone moiety, fifteen carbon signals were observed in the ^{13}C-NMR spectra, so the aglycone of **7** was deduced to be a sesquiterpene derivative.

The ^{1}H-NMR spectrum showed a singlet methyl proton signal at δ 1.50 (3H, s), which showed long-range correlations to four carbon signals at δ 87.0, 46.1, 39.2 and 35.3 in the HMBC experiment. Thus, this methyl signal was characteristic of an angular methyl group in the eudesmane-type sesquiterpene. Based on the results of the two-dimensional (2D)-NMR [^{1}H–^{1}H correlation spectroscopy (^{1}H–^{1}H COSY),

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^{1}H-detected heteronuclear multiple quantum coherency (HMQC) and HMBC] experiments, the carbon and proton signals of the aglycone moiety were assigned as shown in Tables 2 and 3. The *J* value of the H-1 signal (J=12.0, 4.0 Hz) suggested that H-1 was axial and the C-1-OH group had a β-orientation. In the nuclear Overhauser effect (NOE) difference spectra measured in MeOH-d_4 solution, NOEs were observed as follows, δ 1.00 (3H, s, H-14)/1.87 (1H, qd, J=13.5, 3.5 Hz, H-2$_{ax}$) and 1.61 (1H, t, J=13.5 Hz, H-6$_{ax}$), δ 0.99 (3H, s, H-15)/1.42 (1H, dd, J=13.0, 3.0 Hz, H-5) and 1.49 (overlapping with other signals, H-6eq). These facts indicated that H-5 was axial and C-15 had an α-orientation. In the HMBC experiment, the two doublet methyl proton signals (δ 1.06, 1.05) exhibited long-range correlations to the carbinol carbon signal due to C-7 (δ 73.4), suggesting that the isopropyl group was bound to the C-7 position. Moreover, the ^{13}C-NMR spectral data of this aglycone were in good agreement with those of 1β,4β,7α-trihydroxyeudesumane[8] except for the data of C-1, C-2 and C-10. Therefore, the aglycone of **7** was thought to be 1β,4β,7α-trihydroxyeudesumane.

In the NOE difference experiment, irradiation of the anomeric proton signal of β-D-glucopyranose [δ 4.92 (1H, d, J=8.0 Hz)] showed an NOE to the H-1 signal of the aglycone [δ 3.80 (1H, dd, J=12.0, 4.0 Hz)], and the HMBC experiment displayed long-range correlations between carbonyl carbon signal of the (*E*)-caffeoyl group (δ 167.6) and the H-6 signals of β-D-glucopyranose [δ 5.16 (1H, dd, J=12.0, 2.0 Hz), 4.91 (1H, dd, J=12.0, 6.0 Hz)]. On the basis of the above evidence, the structure of dracunculifoside M (**7**) was deduced to be 1β-[[6-*O*-(*E*)-caffeoyl]-β-D-glucopyranosyl]-oxy-4β,7α-dihydroxyeudesumane.

The molecular formulae of dracunculifosides N (**8**), O (**9**), P (**10**) and Q (**11**) were suggested to be $C_{30}H_{36}O_{14}$, $C_{28}H_{34}O_{13}$, $C_{26}H_{36}O_{13}$ and $C_{25}H_{36}O_{13}$ based on the HR-FAB-MS. Compounds **8**—**11** had a [5-*O*-(*E*)-caffeoyl]-β-D-apiofuranosyl-(1→6)-β-D-glucopyranosyl group as the sugar and ester moieties, because of the similarities of the ^{1}H- and ^{13}C-NMR spectral data of **8**—**11** to those of osmanthusides I and J,[9] except for the aglycone moieties.

As to the aglycone moiety of compound **8**, the ^{1}H-NMR spectrum showed AMX type-aromatic proton signals [δ 7.07

Table 1. ^{13}C- and ^{1}H-NMR Spectral Data of Compound **4**

	C		H
Aglycone moiety			
-1	137.4		—
-2	111.8	-2	6.96 (d, 2.0)
-3	150.8		—
-4	147.3[a]		—
-5	118.1	-5	7.05 (d, 8.0)
-6	119.6	-6	6.70 (dd, 8.0, 2.0)
-7	86.9	-7	4.59 (d, 5.5)
-8	55.3[b]	-8	2.89 (m)
-9	72.6[c]	-9	4.13 (dd, 9.5, 7.0)
			3.37 (dd, 9.5, 4.0)
-1′	133.8		—
-2′	111.1	-2′	6.93 (br s)
-3′	149.1		—
-4′	147.2[a]		—
-5′	116.2	-5′	6.78 (br s)
-6′	120.2	-6′	6.78 (br s)
-7′	87.5	-7′	4.63 (d, 5.5)
-8′	55.5[b]	-8′	2.96 (m)
-9′	72.4[c]	-9′	4.08 (dd, 9.5, 7.0)
			3.78 (dd, 9.5, 4.0)
-OMe	56.8	-OMe	3.84 (3H, s)
	56.6		3.86 (3H, s)
Suger moiety			
Glc-1″	102.6	Glc-1″	4.85 (d, 8.0)
-2″	74.9	-2″	3.53 (t, 8.0)
-3″	77.9	-3″	3.49 (t, 8.0)
-4″	72.2	-4″	3.38 (t, 8.0)
-5″	75.6	-5″	3.70 (m)
-6″	64.7	-6″	4.55 (dd, 11.5, 2.0)
			4.38 (dd, 11.5, 7.5)
Ester moiety			
C-1‴	168.8		—
-2‴	115.2[d]	H-2‴	6.26 (d, 16.0)
-3‴	147.1	-3‴	7.54 (d, 16.0)
-4‴	127.8		—
-5‴	115.3[d]	-5‴	7.06 (d, 2.0)
-6‴	149.7		—
-7‴	147.0		—
-8‴	116.7	-8‴	6.80 (d, 8.0)
-9‴	123.0	-9‴	6.95 (dd, 8.0, 2.0)

Measured in MeOH-d_4 solution at 35 °C. *a*—*d*) Interchangeable in each column. Glc: β-D-glucopyranosyl.

Table 2. ^{13}C-NMR Spectral Data of Compounds **5**—**11** and **14**

No.	**5**	**6**	**7**[a]	**8**	**9**	**10**	**11**	**14**[a]
C-1	134.1	—	87.0	136.6	140.1	70.6	22.1	133.8
-2	119.2	92.2	24.1	114.3	129.3	28.8	77.8[b]	121.5
-3	146.4	77.3	40.7	150.8	130.0	125.9	40.1	27.3
-4	146.7	115.8	70.5	146.3	127.2	134.5	19.6	44.2
-5	117.1	158.6	46.1	118.5	130.0	21.5	14.5	24.3
-6	124.5	121.0	29.9[b]	122.2	129.3	14.6	—	31.3
-7	30.2	110.8	73.4	40.7	37.3	—	—	23.5
-8	45.8	153.3	30.2[b]	138.9	71.8	—	—	79.4
-9	211.2	139.6	35.3	115.9	—	—	—	25.2[b]
-10	29.9	144.1	39.2	—	—	—	—	23.0[b]
-11	—	114.6	40.0	—	—	—	—	—
-12	—	70.4	17.5	—	—	—	—	—
-13	—	205.8	17.5	—	—	—	—	—
-14	—	27.1	13.2	—	—	—	—	—
-15	—	—	30.2	—	—	—	—	—
-OMe	—	—	—	56.8	—	—	—	—
Sugar moiety								
Glc-1″	104.4	103.8	102.8	103.2	104.4	104.4	104.1	98.6
-2″	74.9	75.1	75.2	74.9[b]	75.1[b]	75.1	75.3	75.4
-3″	77.5	78.0	78.6	77.9	78.1	78.1	78.2[b]	78.8
-4″	71.9	71.8	72.0	71.8	71.8	71.8	71.9	72.0
-5″	75.9	75.6	75.2	77.0	76.8	76.8	76.7	76.6
-6″	64.7	64.7	64.7	68.7	68.6	68.6	68.8	69.1
Api-1‴	—	—	—	110.7	110.7	110.7	110.7	111.1
-2‴	—	—	—	78.5	78.5	78.5	78.5	77.9
-3‴	—	—	—	78.9	79.3	79.0	79.0	80.4
-4‴	—	—	—	75.1[b]	75.0[b]	75.1	75.0	75.1
-5‴	—	—	—	67.4	67.5	67.6	67.6	65.9
Ester moiety								
C-1⁗	169.0	169.2	167.6	168.9	168.9	168.9	168.9	—
-2⁗	114.9	115.0	115.2	114.8	114.8	114.8	114.8	—
-3⁗	147.3	147.2	145.9	147.4	147.4	147.4	147.4	—
-4⁗	127.7	127.8	126.9	127.7	127.8	127.8	127.8	—
-5⁗	115.3	115.2	116.2	115.3	115.3	115.3	115.3	—
-6⁗	149.7	149.7	[c]	149.6	149.7	149.7	149.6	—
-7⁗	146.8	146.9	147.5	146.8	146.8	146.9	146.9	—
-8⁗	116.6	116.6	116.8	116.5	116.5	116.5	116.5	—
-9⁗	123.1	123.0	122.0	123.1	123.0	123.0	123.0	—

Measured in MeOH-d_4 solution at 35 °C. *a*) Measured in pyridine-d_5 solution at 35 °C. *b*) Interchangeable in each column. *c*) Overlapping with solvent signals. Glc: β-D-glucopyranosyl; Api: β-D-apiofuranosyl.

Table 3. ^{1}H-NMR Spectral Data of Compounds **5**—**11** and **14**

No.	**5**	**6**	**7**[a)]	**8**
Aglycone moiety				
H-1	—	—	3.80 (dd, 12.0, 4.0)	—
-2	6.98 (d, 2.0)	5.00 (d, 4.5)	2.41 (qd, 13.5, 3.5)	6.78 (d, 2.0)
-3	—	5.27 (d, 4.5)	1.09 (dt, 13.5, 3.5)	—
			1.50[c)]	—
-4	—	6.92 (s)	—	—
-5	6.73 (d, 8.0)	—		7.07 (d, 8.0)
-6	6.71 (dd, 8.0, 2.0)	—		6.69 (dd, 8.0, 2.0)
-7	2.64 (2H, m)	7.22 (s)		3.26 (2H, d, 6.5)
-8	2.64 (2H, m)	—	1.74[c)]	5.90 (ddt, 16.5, 10.0, 6.5)
-9	—	—	2.35 (dt, 13.5, 3.5)	5.01 (br d, 16.5)
			2.06[c)]	4.98 (br d, 10.0)
-10	2.01 (3H, s)	—	—	—
-11	—	5.29 (2H, s)	1.73[c)]	—
-12	—	4.43 (d, 12.5)	1.05 (3H, d, 6.0)[b)]	—
		4.30 (d, 12.5)	—	—
-13	—	—	1.06 (3H, d, 6.0)[b)]	—
-14	—	2.55 (3H, s)	1.50 (3H, s)	—
-15	—	—	1.27 (3H, s)	—
-OMe	—	—	—	3.81 (3H, s)
Sugar moiety				
Glc-1″	4.73 (d, 8.0)	4.34 (d, 8.0)	4.92 (d, 8.0)	4.78 (d, 8.0)
-2″	3.50[c)]	3.24 (t, 8.0)	4.05 (t, 8.0)	3.47[c)]
-3″	3.50[c)]		4.25 (t, 8.0)	3.49[c)]
-4″	3.41[c)]		4.14 (t, 8.0)	3.34[c)]
-5″	3.71 (m)	3.51 (m)	4.11[c)]	3.55[c)]
-6″	4.58 (dd, 12.0, 2.0)	4.50 (dd, 12.0, 2.0)	5.16 (dd, 12.0, 2.0)	4.03 (br d, 11.0)
	4.37 (dd, 12.0, 6.5)		4.91 (dd, 12.0, 6.0)	3.62 (dd, 11.0, 6.5)
Api-1‴	—	—	—	5.00 (d, 1.5)
-2‴	—	—	—	3.94 (d, 1.5)
-4‴	—	—	—	4.00 (d, 10.0)
	—	—	—	3.82 (d, 10.0)
-5‴	—	—	—	4.26 (2H, s)
Ester moiety				
H-2⁗	6.30 (d, 16.0)	6.30 (d, 16.0)	6.62 (d, 16.0)	6.28 (d, 16.0)
H-3⁗	7.58 (d, 16.0)	7.58 (d, 16.0)	7.98 (d, 16.0)	7.58 (d, 16.0)
-5⁗	7.04 (d, 2.0)	7.04 (br s)	7.57[c)]	7.03 (br s)
-8⁗	6.78 (d, 8.0)	6.77 (d, 8.0)	7.18 (d, 8.0)	6.77[c)]
-9⁗	6.93 (dd, 8.0, 2.0)	6.94 (br d, 8.0)	7.15 (dd, 8.0, 2.0)	6.93 (br d, 8.0)

(1H, d, J=8.0 Hz), 6.78 (1H, d, J=2.0 Hz), 6.69 (1H, dd, J=8.0, 2.0 Hz)], the proton signals due to the allyl group [δ 5.90 (1H, ddt, J=16.5, 10.0, 6.5 Hz), 5.01 (1H, br d, J=16.5 Hz), 4.98 (1H, br d, J=10.0 Hz), 3.26 (2H, d, J=6.5 Hz)], a methoxyl proton signal [δ 3.81 (3H, s)]. The ^{13}C-NMR spectrum exhibited six aromatic carbon signals (δ 150.8, 146.3, 136.6, 122.2, 118.5, 114.3), the carbon signals due to the allyl group (δ 138.9, 115.9, 40.7) and a methoxyl carbon signal (δ 56.8). These results let us to conclude that the aglycone of **8** was eugenol.

The ^{13}C-NMR spectra of compound **9** showed one carbinol carbon signal (δ 71.8), one methylene carbon signal (δ 37.3) and six aromatic carbon signals (δ 140.1, 130.0×2, 129.3×2, 127.2) in addition to the signals due to the sugar and ester moieties. Thus, the aglycone of **9** was deduced to be phenethyl alcohol.

Regarding the aglycone moiety of compound **10**, the ^{1}H- and ^{13}C-NMR spectra showed one methyl proton and carbon signals [δ0.93 (3H, t, J=7.5 Hz) and δ 14.6], two methylene proton and carbon signals [δ 2.04 (2H, br quintet, J=7.5 Hz), 2.35 (2H, br q, J=7.5 Hz) and δ 21.5, 28.8], a set of carbinol proton and carbon signals [δ 3.81 (1H, dt, J=9.5 7.5 Hz), 3.52 (1H, dt, J=9.5, 7.5 Hz) and δ 70.6] and two olefinic proton and carbon signals [δ 5.41 (1H, m), 5.35 (1H, m) and δ 134.5, 125.9]. Consistency of the ^{13}C-NMR spectral data of the aglycone moiety in **10** with those of *Z*-hex-3-en-1-ol β-D-xylopyranosyl-(1→6)-β-D-glucopyranoside[10)] revealed the presence of *Z*-hex-3-en-1-ol as the aglycone of **10**; this was supported by the ^{1}H–^{1}H COSY and ^{1}H-decoupling experiments.

The ^{1}H- and ^{13}C-NMR spectra of compound **11** showed two methyl proton and carbon signals [δ 1.20 (3H, d, J=6.0 Hz), 0.89 (3H, t, J=7.0 Hz) and δ 22.1, 14.5], two methylene carbon signals (δ 40.1, 19.6) and one carbinol proton and carbon signal [δ 3.76 (1H, m) and δ 77.8], suggesting that compound **11** had 2-pentanol as the aglycone. Because the ^{13}C-NMR spectral data of the aglycone moiety of **11** were consistent with those of shimaurinoside B[11)] and (*S*)-2-pentanol-2-*O*-β-D-glucopyranoside,[11)] and different from those of (*R*)-2-pentanol-2-*O*-β-D-glucopyranoside,[11)] the absolute configuration of the C-2 position in 2-pentanol was determined to be *S*-form.

Therefore, the structures of dracunculifosides N—Q (**8**—**11**) were identified as shown in Chart 1. The glycosidic linkages of each compound were confirmed by the NOE difference experiments involving irradiation of the anomeric pro-

Table 3. (Continued)

No.	9	10	11	14[a]
Aglycone moiety				
H-1	—	3.81 (dt, 9.5, 7.5)	1.20 (3H, d, 6.0)	—
		3.52 (dt, 9.5, 7.5)		—
-2	7.22[c]	2.35 (2H, br q, 7.5)	3.76 (m)	5.37 (br s)
-3	7.22[c]	5.35 (m)		
	—	—		
-4	7.13 (m)	5.41 (m)		
-5	7.22[c]	2.04 (br quint, 7.5)	0.89 (3H, t, 7.0)	
-6	7.22[c]	0.93 (3H, t, 7.5)	—	
-7	2.91 (2H, t, 7.5)	—	—	1.62 (3H, s)
-8	4.03[c]	—	—	—
	3.75 (dt, 9.5 7.5)	—		
-9	—	—	—	1.32 (3H, s)[b]
	—	—	—	—
-10	—	—	—	1.41 (3H, s)[b]
-11	—	—	—	—
-12	—	—	—	—
	—	—	—	—
-13	—	—	—	—
-14	—	—	—	—
-15	—	—	—	—
-OMe	—	—	—	—
Sugar moiety				
Glc-1″	4.28 (d, 8.0)	4.25 (d, 8.0)	4.29 (d, 8.0)	4.95 (d, 8.0)
-2″	3.19 (t, 8.0)	3.18 (t, 8.0)	3.15 (t, 8.0)	3.92 (t, 8.0)
-3″		3.34[c]	3.31[c]	4.17[c]
-4″	3.28[c]	3.27[c]	3.25 (t, 8.0)	3.98[c]
-5″	3.41 (m)	3.41 (m)	3.40 (m)	3.98[c]
-6″	4.01[c]	4.00 (dd, 11.5, 2.0)	3.99 (dd, 11.0, 2.0)	4.62 (br d, 10.5)
	3.63 (dd, 11.0, 6.0)	3.62 (dd, 11.5, 6.0)	3.60 (dd, 11.0, 6.5)	4.10 (dd, 10.5, 6.0)
Api-1‴	5.03 (d, 2.0)	5.03 (br s)	5.03 (d, 2.0)	5.71 (d, 2.0)
-2‴	3.94 (d, 2.0)	3.94 (br s)	3.92 (d, 2.0)	4.68 (d, 2.0)
-4‴	4.02 (d, 10.0)	4.04 (d, 9.5)	4.03 (d, 10.0)	4.54 (d, 10.0)
	3.84 (d, 10.0)	3.85 (d, 9.5)	3.84 (d, 10.0)	4.34 (d, 10.0)
-5‴	4.25 (2H, s)	4.27 (2H, s)	4.26 (2H, s)	4.16 (2H, s)
Ester moiety				
H-2⁗	6.27 (d, 16.0)	6.29 (d, 16.0)	6.29 (d, 16.0)	—
-3⁗	7.57 (d, 16.0)	7.59 (d, 16.0)	7.58 (d, 16.0)	—
-5⁗	7.04 (br s)	7.06 (br s)	7.05 (d, 2.0)	—
-8⁗	6.78 (d, 8.0)	6.78 (d, 8.0)	6.78 (d, 8.0)	—
-9⁗	6.94 (br d, 8.0)	6.96 (br d, 8.0)	6.95 (dd, 8.0, 2.0)	—

Measured in MeOH-d_4 solution at 35 °C. *a*) Measured in pyridine-d_5 solution at 35 °C. *b*) Interchangeable in each column. *c*) Overlapping with other signals. Glc: β-D-glucopyranosyl; Api: β-D-apiofuranosyl.

ton signals, and the aglycone moiety of each compound was identified by HPLC and/or GC analysis after acid hydrolysis.

Compound **14** ($C_{21}H_{36}O_{10}$) showed $[M+Na]^+$ ion peak at *m*/*z* 471.2211 on the positive HR-FAB-MS. The ^{1}H- and ^{13}C-NMR and HMQC spectral data for **14** showed the presence of one trisubstituted double bond, three methyls, three methylenes, one methine and one oxygenated quaternary carbon in addition to one β-D-apiofuranosyl-(1→6)-β-D-glucopyranosyl group.[12] Acid hydrolysis of compound **14** afforded α-terpineol together with glucose and apiose. In the ^{13}C-NMR spectral data measured in D_2O solution, the signals due to the aglycone of **14** were consistent those of (4*S*)-α-terpineol *O*-α-L-rhamnopyranosyl-(1→6)-β-D-glucopyranoside.[13] But the chemical shifts of the C-9 and -10 signals were different from those of (4*R*)-α-terpineol *O*-β-D-apiofranosyl-(1→6)-β-D-glucopyranoside[14] and (4*R*)-α-terpineol *O*-α-L-rhamnopyranosyl-(1→6)-β-D-glucopyranoside.[13] These facts indicated that the aglycone of **14** was (4*S*)-α-terpineol. Thus, the structure of compound **14** was determined to be (4*S*)-α-terpineol *O*-β-D-apiofuranosyl-(1→6)-β-D-glucopyranoside.

The molecular formula of dracunculifoside R (**15**) was $C_{36}H_{44}O_{15}$ as the result of HR-FAB-MS measurement [positive HR-FAB-MS ion at *m*/*z* 739.2550 $[M+Na]^+$]. Comparison of the ^{13}C-NMR spectral data of **15** with those of **2** suggested the presence of pinoresinol. The ^{1}H- and ^{13}C-NMR spectra of **15** showed three proton and six carbon signals assignable to an aromatic ring, four carbinol proton and three carbinol carbon signals, one methoxyl group and signals of β-D-glucopyranose, in addition to the signals due to the pinoresinol group. Thus, compound **15** was deduced to be a sesquilignan glycoside consisting of pinoresinol, 3-(4-hydroxy-3-methoxyphenyl)-propan-1,2,3-triol and β-D-glucopyranose. In the NOE difference experiment involving irradiation of the H-8″ signal [δ 4.50 (1H, q, J=5.0 Hz)], an NOE was observed at the H-5 signal of the guaiacyl group in pinoresinol [δ 7.03 (1H, d, J=8.0 Hz)], suggesting 3-(4-hydroxy-3-methoxyphenyl)-propan-1,2,3-triol was bound to the C-4 position of pinoresinol. The J value of H-7″ signal (J=5.0 Hz) indicated that the relative configuration of the

Table 4. ^{13}C- and ^{1}H-NMR Spectral Data of Compound **15**

	C		H
Aglycone moiety			
-1	136.9		—
-2	111.7	-2	6.99 (d, 2.0)
-3	151.8		—
-4	148.9[a)]		—
-5	118.9	-5	7.03 (d, 8.0)
-6	119.8	-6	6.85 (dd, 8.0, 2.0)
-7	87.2	-7	4.71[d)]
-8	55.5[b)]	-8	3.12[d)]
-9	72.7	-9	4.24[d)]
			3.85[d)]
-1′	133.8[c)]		—
-2′	111.1	-2′	6.94 (d, 2.0)
-3′	149.2		—
-4′	147.4		—
-5′	116.1	-5′	6.77 (d, 8.0)
-6′	120.1	-6′	6.81 (dd, 8.0, 2.0)
-7′	87.5	-7′	4.71[d)]
-8′	55.4[b)]	-8′	3.12[d)]
-9′	72.7	-9′	4.24[d)]
			3.85[d)]
-1″	133.9[c)]		
-2″	112.1	-2″	7.06 (d, 2.0)
-3″	148.8[a)]		—
-4″	147.1		—
-5″	115.9	-5″	6.74 (d, 8.0)
-6″	120.7	-6″	6.90 (dd, 8.0 2.0)
-7″	73.8	-7″	4.98 (d, 5.0)
-8″	85.1	-8″	4.50 (q, 5.0)
-9″	69.4	-9″	4.12 (dd, 10.5, 5.0)
			3.53 (dd, 10.5, 5.0)
-OMe	56.7	-OMe	3.86 (6H, s)
	56.5×2		3.82 (3H, s)
Sugar moiety			
Glc-1‴	104.8	-1‴	4.21 (d, 8.0)
-2‴	75.1	-2‴	3.20 (t, 8.0)
-3‴	78.0	-3‴	
-4‴	71.7	-4‴	
-5‴	78.0	-5‴	
-6‴	62.8	-6‴	3.83[d)]
			3.64 (dd, 12.0, 5.5)

Measured in MeOH-d_4 solution at 35 °C. *a*—*c*) Interchangeable in each column. *d*) Overlapping with other signals. Glc: β-D-glucopyranosyl.

glycerol part at the C-7″ and C-8″ positions was *erythro* orientation.[15,16)] Accordingly, the aglycone of compound **15** was deduced as in Chart 1, and the attached position of β-D-glucopyranose was determined by the consequence of the NOE difference spectrum irradiating at the anomeric proton signals [δ 4.21 (1H, d, J=8.0 Hz)]. The absolute configuration of the pinoresinol unit in compound **15** remains to be clarified, because of the impossibility of producing pinoresinol from a small amount of **15** by hydrolysis.

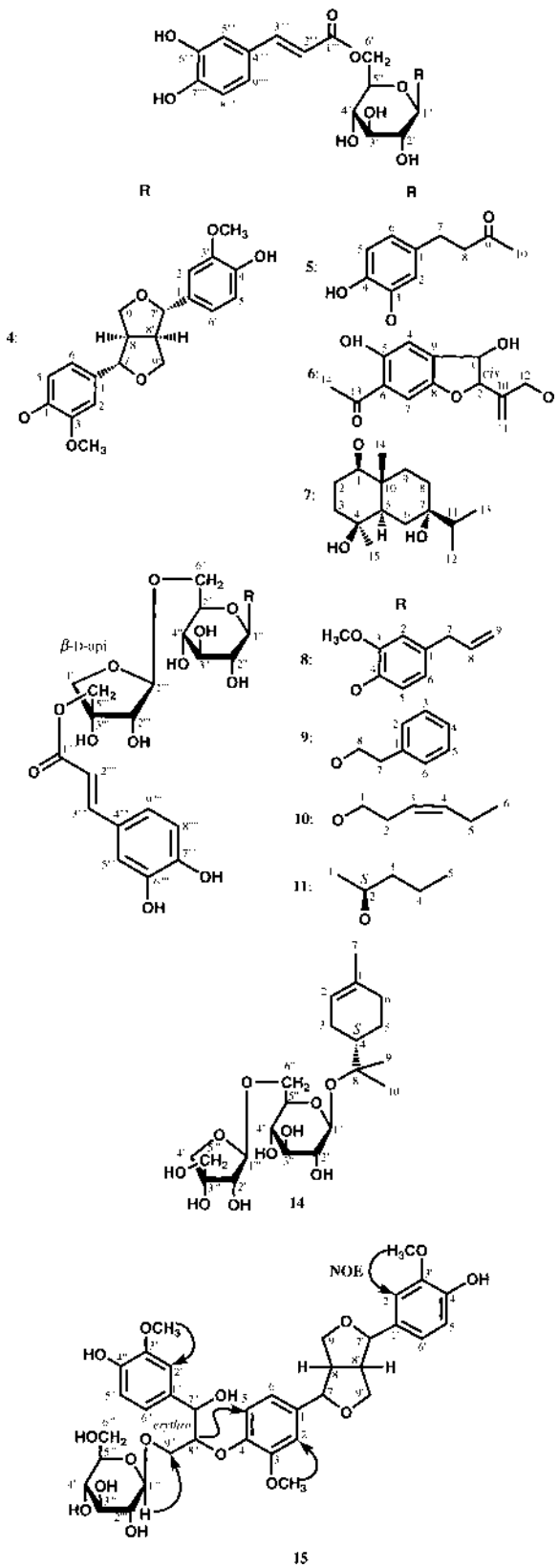

Chart 1

Experimental

General Procedure Instrumental analyses were carried out as described previously.[17)]

Extraction and Isolation The procedure of the extraction and isolation of the constituents from the aerial part of *Baccharis dracunculifolia* DC. (644 g) was described in a previous paper.[1)] The adsorbed material on the Mitsubishi Diaion HP-20 column was eluted with 50% MeOH in water, 70% MeOH in water and MeOH, continuously. Each eluate was concentrated, and the residues of the 50% MeOH and 70% MeOH eluates separately rechromatographed on a silica gel column with a $CHCl_3$–MeOH–EtOAc–H_2O system and semi-preparative HPLC (Develosil-ODS-15/30 and -ODS-T-5: 10—23% MeCN in water, 10—22.5% MeCN in water +2% AcOH, 35—40% MeOH in water and 35—40% MeOH in water +2% AcOH). Compounds **1** (7 mg), **2** (9 mg), **3** (4 mg), **4** (16 mg), **5** (38 mg), **6** (2 mg), **7** (3 mg), **8** (26 mg), **9** (16 mg), **10** (5 mg), **11** (3 mg), **12**, **13** (mixtures: 30 mg) and **15** (3 mg) were afforded from the residue of the 70% MeOH eluate, and compound **14** (3 mg) was given from the residue of the 50% MeOH eluate.

Pinoresinol *O*-β-D-Glucopyranoside (**2**): Amorphous powder. $[\alpha]_D^{22}$ −3.5°

(c=0.88, MeOH). UV λ_{max}^{MeOH} nm (log ε): 202 (4.82), 205 (4.78), 229 (4.20), 279 (3.74).

Syringaresinol *O*-β-D-Glucopyranoside (**3**): Amorphous powder. $[\alpha]_D^{22}$ −18° (c=0.42, MeOH). UV λ_{max}^{MeOH} nm (log ε): 208 (4.89), 231 (sh), 272 (3.47).

Pinoresinol *O*-[6-*O*-(*E*)-Caffeoyl]-β-D-glucopyanoside (**4**): Amorphous powder. $[\alpha]_D^{22}$ +39° (c=0.69, MeOH). UV λ_{max}^{MeOH} nm (log ε): 203 (4.95), 204 (4.91), 221 (4.38), 230 (sh), 284 (4.07), 300 (4.03), 330 (4.16). FAB-MS m/z: 705 $[M+Na]^+$. HR-FAB-MS m/z: 705.2175 (Calcd for $C_{35}H_{38}O_{14}Na$: 705.2159). ^{13}C- and ^{1}H-NMR: shown in Table 1.

Dracunculifoside K (**5**): Amorphous powder. $[\alpha]_D^{22}$ −49° (c=0.55, MeOH). UV λ_{max}^{MeOH} nm (log ε): 218 (4.26), 243 (sh), 288 (4.01), 304 (sh), 330 (4.16). FAB-MS m/z: 505 $[M+H]^+$, 527 $[M+Na]^+$. HR-FAB-MS m/z: 505.1707 (Calcd for $C_{25}H_{29}O_{11}$: 505.1710). ^{13}C- and ^{1}H-NMR: shown in Tables 2 and 3.

Dracunculifoside L (**6**): Amorphous powder. $[\alpha]_D^{22}$ −28° (c=0.23, MeOH). UV λ_{max}^{MeOH} nm (log ε): 204 (4.42), 215 (4.38), 228 (4.34), 301 (4.02), 331 (4.15). FAB-MS m/z: 597 $[M+Na]^+$. HR-FAB-MS m/z: 597.1577 (Calcd for $C_{28}H_{30}O_{13}Na$: 579.1584). ^{13}C- and ^{1}H-NMR: shown in Tables 2 and 3.

Dracunculifoside M (**7**): Amorphous powder. $[\alpha]_D^{22}$ −35° (c=0.35, MeOH). UV λ_{max}^{MeOH} nm (log ε): 202 (4.24), 216 (4.19), 235 (sh), 245 (4.07), 302 (4.11), 329 (4.21). FAB-MS m/z: 603 $[M+Na]^+$. HR-FAB-MS m/z: 603.2781 (Calcd for $C_{30}H_{44}O_{11}Na$: 603.2781). ^{13}C- and ^{1}H-NMR: shown in Tables 2 and 3. ^{13}C-NMR (MeOH-d_4 at 35 °C): δ 169.2 (C-1‴), 149.7 (C-6‴), 147.2 (C-3‴), 146.9 (C-7‴), 127.7 (C-4‴), 123.0 (C-9‴), 116.6 (C-8‴), 115.4 (C-5‴), 115.1 (C-2‴), 101.8 (C-1″), 86.6 (C-1), 78.3 (C-3″), 75.3, 75.2 (C-2″, -5″), 75.0 (C-7), 72.3 (C-4″), 72.0 (C-4), 64.8 (C-6″), 46.6 (C-5), 40.5×2 (C-3, -11), 39.5 (C-10), 35.6 (C-9), 30.0 (C-8), 29.6, 29.5 (C-6, -15), 23.7 (C-2), 17.4, 17.5 (C-12, -13), 12.8 (C-14). ^{1}H-NMR (MeOH-d_4 at 35 °C): δ 7.58 (1H, d, J=16.0 Hz, H-3‴), 7.09 (1H, d, J=2.0 Hz, H-5‴), 6.97 (1H, dd, J=8.0, 2.0 Hz, H-9‴), 6.78 (1H, d, J=8.0 Hz, H-8‴), 6.29 (1H, d, J=16.0 Hz, H-2‴), 4.32 (1H, d, J=8.0 Hz, H-1″), 4.50 (1H, dd, J=11.5, 2.5 Hz, H-6″), 4.33 (1H, dd, J=11.5, 6.5 Hz, H-6″), 3.47 (1H, m, H-5″), 3.37 (1H, t, J=8.0 Hz, H-3″), 3.18 (1H, t, J=8.0 Hz, H-2″), 1.87 (1H, qd, J=13.5, 3.5 Hz, H-2_{ax}), 1.61 (1H, t, J=13.0 Hz, H-6_{ax}), 1.49 (overlapping with other signals, H-6_{eq}), 1.42 (1H, dd, J=13.0, 3.0 Hz, H-5), 1.00 (3H, s, H-14), 0.99 (3H, s, H-15), 0.92 (6H, d, J=6.5 Hz, H-12, -13).

Dracunculifoside N (**8**): Amorphous powder. $[\alpha]_D^{22}$ −71° (c=0.54, MeOH). UV λ_{max}^{MeOH} nm (log ε): 202 (4.83), 204 (4.67), 216 (4.30), 244 (sh), 287 (sh), 302 (sh), 330 (4.19). FAB-MS m/z: 643 $[M+Na]^+$. HR-FAB-MS m/z: 643.2029 (Calcd for $C_{30}H_{36}O_{14}Na$: 643.2003). ^{13}C- and ^{1}H-NMR: shown in Tables 2 and 3.

Dracunculifoside O (**9**): Amorphous powder. $[\alpha]_D^{22}$ −51° (c=0.36, MeOH). UV λ_{max}^{MeOH} nm (log ε): 237 (sh), 245 (3.94), 305 (4.06), 329 (4.18). FAB-MS m/z: 601 $[M+Na]^+$. HR-FAB-MS m/z: 601.1925 (Calcd for $C_{28}H_{34}O_{13}Na$: 601.1897). ^{13}C- and ^{1}H-NMR: shown in Tables 2 and 3.

Dracunculifoside P (**10**): Amorphous powder. $[\alpha]_D^{22}$ −49° (c=0.39, MeOH). UV λ_{max}^{MeOH} nm (log ε): 203 (4.15), 218 (4.14), 236 (sh), 245 (3.98), 304 (4.09), 329 (4.22). FAB-MS m/z: 579 $[M+Na]^+$. HR-FAB-MS m/z: 579.2075 (Calcd for $C_{26}H_{36}O_{13}Na$: 579.2054). ^{13}C- and ^{1}H-NMR: shown in Tables 2 and 3.

Dracunculifoside Q (**11**): Amorphous powder. $[\alpha]_D^{22}$ −58° (c=0.16, MeOH). UV λ_{max}^{MeOH} nm (log ε): 202 (4.17), 218 (4.07), 235 (sh), 244 (3.91), 302 (4.00), 330 (4.12). FAB-MS m/z: 567 $[M+Na]^+$. HR-FAB-MS m/z: 567.2048 (Calcd for $C_{25}H_{36}O_{13}Na$: 567.2054). ^{13}C- and ^{1}H-NMR: shown in Tables 2 and 3.

(4*S*)-α-Terpineol *O*-β-D-Apiofuranosyl-(1→6)-β-D-glucopyranoside (**14**): Amorphous powder. $[\alpha]_D^{22}$ −65° (c=0.28, MeOH). FAB-MS m/z: 471 $[M+Na]^+$. HR-FAB-MS m/z: 471.2211 (Calcd for $C_{21}H_{36}O_{10}Na$: 471.2206). ^{13}C- and ^{1}H-NMR: shown in Tables 2 and 3. ^{13}C-NMR (D_2O): δ 136.7 (C-1), 121.7 (C-2), 109.7 (C-1‴), 97.3 (C-1″), 82.7 (C-8), 80.2 (C-3‴), 77.6, 76.7 (C-3″, -2‴), 75.1 (C-5″), 74.3, 74.1 (C-2″, -4‴), 70.6 (C-4″), 68.4 (C-6″), 64.6 (C-5‴), 43.5 (C-4), 31.1 (C-6), 27.5 (C-3), 24.2 (C-5), 23.3 (C-7), 24.7, 22.5 (C-9, -10) (The signal of dioxane at δ 67.3 was used as the internal standard in D_2O solution.).

Dracunculifoside R (**15**): Amorphous powder. $[\alpha]_D^{22}$ +8.5° (c=0.30, MeOH). UV λ_{max}^{MeOH} nm (log ε): 204 (4.88), 231 (4.31), 279 (3.88). FAB-MS m/z: 739 $[M+Na]^+$. HR-FAB-MS m/z: 739.2550 (Calcd for $C_{36}H_{44}O_{15}Na$: 739.2578). ^{13}C- and ^{1}H-NMR: shown in Table 4.

Acid Hydrolysis of Compound 2 Compound **2** (4 mg) was dissolved in 0.05 N HCl and dioxane (each 100 μl) and heated at 95 °C for 4 h. After hydrolysis, H_2O and EtOAc was added to the solution, and partitioned between the H_2O and EtOAc layers. EtOAc layer was concentrated to dryness, and purification of this residue using HPLC (YMC-ODS 10 mm×25 cm, 30% MeCN in water) afforded (+)-pinoresinol (**2a**, 0.6 mg) which was identified by the ^{1}H-, ^{13}C-NMR spectral data[18] and optical rotation value ($[\alpha]_D^{26}$ +62° (c=0.057, $CHCl_3$)).[19]

Mild Alkaline Hydrolysis of Compound 4 Compound **4** (10 mg) in 0.1% NaOH (1 ml) was treated for 6 h at room temperature with stirring under a N_2 gas atmosphere. The reaction mixture was passed through an Amberlite IR-120B column and the eluate was concentrated to dryness. The residue was partitioned between EtOAc and H_2O. Both layers were concentrated to dryness, and HPLC analysis of the residue from the EtOAc layer suggested that (*E*)-caffeic acid was produced from **4**. Conditions: column; YMC-ODS 4.6 mm×25 cm. flow rate; 1.0 ml/min. 15% MeCN+0.05% TFA; t_R, (*E*)-caffeic acid 12.4 min. Purification of the residue from the H_2O layer using HPLC (YMC-ODS 10 mm×25 cm, 15% MeCN in water) afforded pinoresinol *O*-β-D-glucopyranoside (**4a**, 0.2 mg) which was identified by the ^{1}H-NMR spectral data and HPLC analysis. The optical rotation value of **4a** [$[\alpha]_D^{22}$ −3° (c=0.02, MeOH)] was consistent with that of **2**.

Alkaline and Acid Hydrolysis of Compounds 5—11 Compounds **5**—**11** (*ca.* 0.5—2.0 mg) were dissolved in 0.1% NaOH, and stirred for 2 h at room temperature under a N_2 gas atmosphere. The procedures after alkaline hydrolysis were carried out as described above. (*E*)-Caffeic acid was detected from the residue of the EtOAc layer of each compound by HPLC analysis under the same conditions. Myzodendrone and dracunculifoside J were detected from the residue of the H_2O layer of compounds **5** and **6**, respectively, by HPLC analysis. Conditions: column; YMC-ODS 4.6 mm×25 cm, flow rate; 1.0 ml/min. 12.5% MeCN+0.05% TFA; t_R myzodendrone 17.0 min, 17.5% MeCN; t_R dracunculifoside J 12.8 min.

The residues of the H_2O layers from compounds **8**—**11** were divided into two parts, which were dissolved in dioxane and 2 N HCl (50 μl each). One was heated at 100 °C for 5 min. After hydrolysis, H_2O and EtOAc were added to the reaction mixture, and the H_2O layer was reducted with $NaBH_4$ (*ca.* 1 mg) for 1 h at room temperature. The reaction mixture was passed through an Amberlite IR-120B column, and the eluate was concentrated to dryness. Boric acid was removed by co-distillation with MeOH, and the residue was acetylated with acetic anhydride and pyridine overnight at room temperature. After evaporation of the regents under a stream of air, apiitol acetate was detected by GC analysis. GC conditions: column; Supelco SP-2380™ capillary column 0.25 mm×30 m, carrier gas N_2, column temperature 250 °C; t_R apiitol acetate 8.9 min.

The remaining residue of compounds **8**—**11** and the residue of **7** were heated at 100 °C for 1 h. After hydrolysis, H_2O and EtOAc were added to the reaction mixture, and the EtOAc layer was subjected to HPLC and/or GC analysis. Eugenol, phenethyl alcohol, *Z*-hex-3-en-1-ol (aoba alcohol) and 2-pentanol were detected from the EtOAc layer of compounds **8**—**11**, respectively. HPLC conditions: column; YMC-ODS 4.6 mm×25 cm. flow rate; 1.0 ml/min. 42.5% MeCN in water; t_R eugenol 14.4 min, 30% MeCN in water; t_R phenethyl alcohol 9.8 min, *Z*-hex-3-en-1-ol 11.0 min. GC conditions: column; GL capillary column TC-1 (GL Science, Inc.) 0.25 mm×30 m, carrier gas N_2, column temperature 55 °C; t_R *Z*-hex-3-en-1-ol 7.5 min, 50 °C; t_R 2-pentanol 4.0 min.

The H_2O layer was neutralized with an Amberlite IRA-60E column and the eluate was concentrated to dryness. The residue was stirred with D-cysteine methyl ester hydrochloride (3 mg) in pyridine (25 μl) at 60 °C for 1.5 h. Subsequently, hexamethyldisilazane (10 μl) and trimethylsilylchloride (10 μl) was added into the solution, and stirring was continued at 60 °C for 30 min. The precipitate was removed with centrifugation, and the supernatant next subjected to GC analysis.[20,21] GC conditions: column; GL capillary column TC-1 (GL Science, Inc.) 0.25 mm×30 m, carrier gas N_2, column temperature 230 °C; t_R D-glucose 21.3 min, L-glucose 20.4 min. D-Glucose was detected from compounds **7**—**11**.

Acid Hydrolysis of Compounds 14 and 15 Compounds **14** and **15** (*ca.*0.5 mg) were dissolved in dioxane and 2 N HCl (50 μl each), and heated at 100 °C for 1 h. The procedures to analyze the aglycone and sugar moieties were the same as described above. α-Terpineol was detected from compound **14** and D-glucose was detected from **14** and **15**. HPLC conditions: column YMC-ODS 4.6 mm×25 cm. flow rate; 1.0 ml/min. 47.5% MeCN in water; t_R α-terpineol 16.0 min. Moreover, compound **14** (*ca.*0.2 mg) was also dissolved in dioxane and 2 N HCl (50 μl each) and heated at 100 °C for 5 min. Apiitol acetate was detected using the same procedures for the analysis of each sugar moiety in compounds **8**—**11**.

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