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SESQUITERPENE GLUCOSIDES AND A PHENYLBUTANOID GLYCOSIDE FROM *HYPOCHOERIS RADICATA*

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Key Word Index—*Hypochoeris radicata*; Compositae; sesquiterpene glucosides; phenylbutanoid glucoside; hypochoerosides.

Abstract—*Hypochoeris radicata* afforded in addition to seven known sesquiterpenes, a new germacrane-type, eight new guaiane-type and three new eudesmane-type sesquiterpene glucosides and a new phenylbutanoid glucoside. The structures were elucidated by spectroscopic methods and chemical evidence.

INTRODUCTION

In connection with a study on the sesquiterpene glycosides of some plants in Compositae, we have also investigated *Hypochoeris radicata*. Three guaianolides have been isolated from this plant [1]. Whole plants of *H. radicata* afforded 12 new sesquiterpene glucosides and a new phenylbutanoid glucoside in addition to seven known sesquiterpenes.

RESULTS AND DISCUSSION

The extract of whole plants of *H. radicata* afforded picriside B (**1**) [2], sonchuside A (**2**) [3], cichorioside C (**3**) [4], ixerin D (**5**) [5], ixerin F (**6**) [5], 11,13-dihydrolactucin (**7**) [2], cichorioside B (**8**) [4], 12 new sesquiterpenes **4**, **9**–**19** and a new phenylbutanoid glucoside **20**. The structures of the known compounds were elucidated by comparison of ^{1}H and ^{13}C NMR spectra with those of authentic materials.

Hypochoeroside A (**4**) showed a ^{1}H NMR spectrum which was similar to that of **3** and afforded an aglycone **4a** by enzymatic hydrolysis, which was identical with an aglycone of **3**. The ^{13}C NMR spectrum of **4** showed glycosylation shifts at C-8 ($\Delta + 10.0$ ppm) and C-9 ($\Delta - 1.8$ ppm), compared with that of **4a**. Thus, the glycosylation position was deduced to be at C-8.

Hypochoeroside B (**9**) showed a similar ^{13}C NMR spectrum to that of **8**, but four more signals which were assigned to a methacrylate were observed. The ^{13}C NMR spectrum of **9** showed acylation shifts at C-8 ($\Delta + 2.0$ ppm), C-7 ($\Delta - 3.3$ ppm) and C-9 ($\Delta - 4.7$ ppm), compared with that of **8** [4]. Thus, methacrylic acid was attached to C-8.

Hypochoeroside C (**10**) showed a similar ^{13}C NMR spectrum to that of picriside A (**10b**) [2], but four more signals due to methacrylate were observed. The position of an acyl residue was deduced to be at C-8 as in the case of **9**.

Hypochoeroside D (**11**) showed the presence of cinnamate instead of methacrylate in the ^{1}H and ^{13}C NMR spectra.

Hypochoeroside E (**12**) showed a doublet methyl signal at δ 0.99 in the ^{1}H NMR spectrum instead of a down-field shifted vinyl methyl signal in that of **10** and afforded an aglycone **12a**, by enzymatic hydrolysis, which was identical with hyporadiolide-8-*O*-[2-methylacrylate] [1].

Hypochoeroside F (**13**) was thought to be a glucoside of hyporadiolide-8-*O*-cinnamate [1] by comparison of the ^{13}C NMR spectrum with that of **12**.

Hypochoeroside G (**14**) showed a similar ^{1}H NMR spectrum to that of **12**, but a doublet methyl signal was observed at δ 1.34 instead of two doublet signals which are characteristic of an exocyclic α-methylene-γ-lactone. The orientation of the methyl group was decided to be α by comparison of the chemical shifts of the methyl signal in the ^{1}H and ^{13}C NMR spectra with those of **9**.

Hypochoeroside H (**15**) was acidic and showed a UV spectrum which had a maximum at 282 nm, suggesting that an $\alpha,\beta,\gamma,\delta$-unsaturated ketone was presented in the molecule [6]. From the detailed decoupling experiment, the signals at δ 6.10 (1H, *br d*, $J = 3$ Hz) and at δ 3.18 (1H, *br s*) were assigned to H-6 and H-1, respectively. In the ^{1}H NMR spectrum of **15a** which was obtained from enzymatic hydrolysis, difference-NOE was observed at the signal of H-8 on irradiation at the doublet methyl signal, to show that the methyl group was β.

Hypochoeroside I (**16**) showed a maximum at 280 nm in the UV spectrum and two doublet methyl signals at δ 0.69 ($J = 7$ Hz) and 1.30 ($J = 7$ Hz) in the ^{1}H NMR spectrum and afforded an aglycone **16a**. In the ^{1}H NMR spectrum of **16a**, difference-NOE were observed at the signal at δ 4.32 (1H, *dt*, $J = 10$, 3 Hz, H-8) on irradiation at the signal at δ 0.77 (3H, *d*, $J = 7$ Hz, H_3-14) and at the signal at δ 5.94 (1H, *dd*, $J = 2.5$, 1 Hz, H-6) on irradiation at the signal at δ 1.30 (H_3-13). Thus, the methyl group at C-10 was β and that at C-11 was also β.

Hypochoeroside J (**17**) was acidic and afforded an aglycone **17a** by enzymatic hydrolysis, and glucose by acid hydrolysis. In the ^{1}H NMR spectrum of **17a**, the signal at δ 0.73 for the angular methyl group at C-10 is characteristic of a *trans*-fused eudesmane [7] and the signal at δ 3.49 (1H, *dd*, $J = 11$, 5 Hz) suggested the presence of an equatorial hydroxyl group at C-1 or C-9. Furthermore, two *exo* methylene signals were observed at δ 4.51 (*br s*); 4.79 (*br s*) and δ 5.72 (*br s*); 6.37 (*br s*), the latter being conjugated with a carbonyl group. By comparison of the ^{13}C NMR spectrum of **17** with that of

sonchuside D [3], the position of a glucosyloxy group was ascribed to C-1.

Hypochoeroside K (**18**) afforded an aglycone **18a**, by enzymatic hydrolysis, the ^{1}H NMR spectrum of which suggested that it also had a eudesmane skeleton. An angular methyl (δ 1.04), a vinyl methyl [1.78 (*br s*)], two *exo* methylene [δ 4.85 (1H, *br s*), 5.78 (1H, *br s*); 4.89 (2H, *br s*)] and two axial carbinyl proton signals [δ 3.78 (*dd*, J = 12, 4.5 Hz), 4.48 (*br dd*, J = 12, 6 Hz)] were observed. A carbinyl proton signal (δ 4.48) was long range coupled with an *exo* methylene proton signal at δ 5.78, suggesting that this could be assigned to H-3. In the ^{13}C NMR spectrum of **18**, glycosylation shifts were observed at C-2 (Δ *ca* −2 ppm), C-3 (Δ *ca* +6 ppm) and C-4 (Δ −4.6 ppm), but there was little shift at C-10, compared with that of **18a**. The glucosylation position, therefore, was assigned to C-3.

Hypochoeroside L (**19**) afforded an aglycone **19a**, by enzymatic hydrolysis, the ^{1}H NMR spectrum showing an angular methyl at δ 0.83 (*s*), a vinyl methyl at δ 1.74 (*s*), an axial carbinyl proton at δ 3.56 (*dd*, J = 10, 6 Hz), an *exo* methylene proton at δ 4.71 (2H, *br s*) and an olefinic proton signal at δ 6.72 (1H, *m*, $W_{1/2}$ = 9 Hz). The last signal was assigned to the β proton of a carbonyl group (namely H-3) because of its downfield shift.

4-(3-Glucopyranosyloxy-4-hydroxylphenyl)-(*E*)-3-buten-2-one (**20**) showed absorption maxima at 238, 298 sh and 327 nm and afforded an aglycone **20a** by enzymatic hydrolysis. The structure of **20a** was established by chemical synthesis from protocatechualdehyde and acetone. In the ^{13}C NMR spectrum of **20**, C-6 showed a downfield shift of 3.0 ppm but C-1 showed little shift compared with **20a**. In the ^{1}H NMR spectrum of **20**, NOE was observed at H-2 (7%) on irradiation at an anomeric proton signal. Therefore, the glucosylation position was C-3.

The cytotoxic activity of aglycones was much higher than that of glucosides **10** and **12** as reported previously [4] (Table 1).

EXPERIMENTAL

Mps: uncorr. The instruments used in this studied were the same as those described in ref. [4].

Plant material. H. radicata collected in Komagane, Nagano Prefecture in June 1986. Plants were identified by Dr A. Ueno and a voucher specimen has been deposited in the Herbarium, School of Pharmaceutical Sciences, University of Shizuoka.

Extraction and isolation. Dried whole plants (800 g) were extd with hot MeOH under reflux. The methanolic ext was partitioned between Et_2O and H_2O after concn. The H_2O layer was passed through an Amberlite XAD-2 column and the MeOH eluate was concd under red pres. The residue obtained (10 g) was chromatographed on a silica gel column with $CHCl_3$–MeOH (19:1) and each fraction was purified by HPLC, YMC Pack ODS-7 20 mm × 25 cm; MeCN–H_2O (2:23–9:31) to give 1.5 mg **1**, 5 mg **2**, 6 mg **3**, 2 mg **4**, 3 mg **5**, 4 mg **6**, 11 mg **7**, 2 mg **8**, 3 mg **9**, 99 mg **10**, 7 mg **11**, 95 mg **12**, 5 mg **13**, 12 mg **14**, 10 mg **15**, 4 mg **16**, 4 mg **17**, 3 mg **18**, 5 mg **19**, 5 mg **20**.

Hypochoeroside A (**4**). Amorphous powder, $[\alpha]_D^{20}$ + 90.0° (MeOH; *c* 0.40); FABMS (MeOH + glycerol) *m/z* (rel. int.): 451 $[M + Na]^+$ (13). ^{1}H NMR (C_5D_5N): δ 1.69 (3H, *s*, H_3-15), 1.70 (3H, *br s*, H_3-14), 1.83 (3H, *d*, J = 7 Hz, H_3-13), 5.10 (1H, *d*, J = 7 Hz, H-1'). ^{13}C NMR: Table 2.

Hypochoeroside B (**9**). Amorphous powder, $[\alpha]_D^{20}$ − 13.1° (MeOH; *c* 0.31). (Found: C, 57.06; H, 6.40. $C_{25}H_{32}O_{11}\cdot H_2O$ requires: C, 57.03; H, 6.51%). UV λ_{max}^{MeOH} nm (log ε): 254 (3.08). ^{1}H and ^{13}C NMR: Tables 1 and 2.

Hypochoeroside C (**10**). Amorphous powder, $[\alpha]_D^{23}$ + 39.2° (MeOH; *c* 0.88). (Found: C, 57.34; H, 5.98. $C_{25}H_{30}O_{11}\cdot H_2O$ requires: C, 57.25; H, 6.15%). UV λ_{max}^{MeOH} nm (log ε): 255 (4.12). ^{1}H and ^{13}C NMR: Tables 1 and 2.

Hypochoeroside D (**11**). Amorphous powder, $[\alpha]_D^{21}$ + 25.7°

Table 1. ^{1}H NMR spectra

	9	**10**	**11**	**12**
Aglycone moiety				
1	—	—	—	—
3	6.79 (*br s*)	6.91 (*br s*)	6.95 (*br s*)	6.94 (*br s*)
6	—	—	—	—
8	—	—	—	—
12	—	—	—	—
13	1.34 (*d*, 7)	5.64 (*m*) 6.20 (*br s*)	5.74 (*d*, 2) 6.26 (*d*, 2.5)	5.79 (*d*, 2.5) 6.30 (*d*, 3.0)
14	2.49 (*s*)	2.49 (*s*)	2.53 (*s*)	0.99 (*d*, 7)
15	—	—	—	—
Sugar moiety				
1	4.95 (*d*, 7)	4.93 (*d*, 7)	4.97 (*d*, 7)	4.97 (*d*, 7)
Ester moiety				
β	—	—	6.83 (*d*, 16)	—
γ	1.98 (*br s*)	1.98 (*br s*)	8.04 (*d*, 16)	1.99 (*br s*)
δ	5.67 (*br s*) 6.22 (*br s*)	5.64 (*m*) 6.20 (*br s*)	—	5.66 (*m*) 6.23 (*br s*)
2–6	—	—	7.43 (*m*)	

Run at 89.55 MHz in pyridine-d_5 solution.

(MeOH; *c* 0.35). FABMS (MeOH + glycerol) *m/z* (rel. int.): 591 $[M+Na]^+$ (2). UV λ_{max}^{MeOH} nm (log ε): 276 (4.72). ^1H and ^{13}C NMR: Tables 1 and 2.

Hypochoeroside E (**12**). Amorphous powder, $[\alpha]_D^{21}$ + 133.3° (MeOH; *c* 0.36). (Found: C, 56.17; H, 6.34. $C_{25}H_{32}O_{11}\cdot 3/2\ H_2O$ requires: C, 56.07; H, 6.59%). UV λ_{max}^{MeOH} nm (log ε): 208 (4.36). ^1H and ^{13}C NMR: Tables 1 and 2.

Hypochoeroside F (**13**). Amorphous powder, $[\alpha]_D^{21}$ + 102.8° (MeOH; *c* 0.18). FABMS (MeOH + glycerol) *m/z* (rel. int.): 593 $[M+Na]^+$ (2). UV λ_{max}^{MeOH} nm (log ε): 278 (4.66). ^1H and ^{13}C NMR: Tables 1 and 2.

Hypochoeroside G (**14**). Amorphous powder, $[\alpha]_D^{25}$ + 50.0° (pyridine; *c* 0.26). FABMS (MeOH + glycerol) *m/z* (rel. int.): 533 $[M+Na]^+$ (18). ^1H and ^{13}C NMR: Tables 1 and 2.

Hypochoeroside H (**15**). Amorphous powder, $[\alpha]_D^{20}$ + 177.8° (MeOH; *c* 0.90). FABMS (MeOH + glycerol) *m/z* (rel. int.): 509 $[M+H]^+$ (11). UV λ_{max}^{MeOH} nm (log ε): 282 (4.13). ^1H and ^{13}C NMR: Tables 1 and 2.

Hypochoeroside I (**16**). Amorphous powder, $[\alpha]_D^{20}$ + 27.5° (MeOH; *c* 0.29). (Found: C, 58.11; H, 6.59. $C_{21}H_{28}O_9\cdot 1/2\ H_2O$ requires: C, 58.19; H, 6.74%). UV λ_{max}^{MeOH} nm (log ε): 280 (4.00). ^1H and ^{13}C NMR: Tables 1 and 2.

Hypochoeroside J (**17**). Amorphous powder, $[\alpha]_D^{20}$ − 15.9° (MeOH; *c* 1.10) FABMS [MeOH + glycerol) *m/z* (rel. int.): 435 $[M+Na]^+$ (35). ^1H NMR (C_5D_5N): δ 0.90 (3H, *s*, H_3-14), 4.56 (1H, *br s*, H-15a), 4.77 (1H, *br s*, H-15b), 4.92 (1H, *d*, *J* = 7 Hz, H-1'), 5.66 (1H, *br s*, H-13a), 6.53 (1H, *br s*, H-13b). ^{13}C NMR: Table 2.

Hypochoeroside K (**18**). Amorphous powder, $[\alpha]_D^{20}$ − 29.2° (MeOH; *c* 0.77). (Found: C, 61.82; H, 8.48. $C_{21}H_{34}O_7\cdot 1/2\ H_2O$ requires: C, 61.90; H, 8.66%). ^1H NMR (C_5D_5N): δ 0.98 (3H, *s*, H_3-14), 1.79 (3H, *s*, H_3-12), 4.85 (1H, *br s*, H-15a), 4.91 (3H, *br s*, H_3-13), 5.18 (1H, *d*, *J* = 7 Hz, H-1'), 6.24 (1H, *br s*, H-15b). ^{13}C NMR: Table 2.

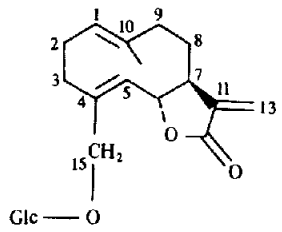
Hypochoeroside L (**19**). Amorphous powder, $[\alpha]_D^{21}$ −64.1° (MeOH; *c* 0.32). FABMS (MeOH + glycerol) *m/z* (rel. int.): 435 $[M+Na]^+$ (57). ^1H NMR (C_5D_5N): δ 0.96 (3H, *s*, H_3-14), 1.69 (3H, *s*, H_3-12), 4.79 (2H, *m*, H_2-13), 4.92 (1H, *d*, *J* = 7 Hz, H-1'), 6.87 (1H, *m*, H-3). ^{13}C NMR: Table 2.

4-(3-Glucopyranosyloxy-4-hydroxyphenyl)-(E)-3-buten-2-one (**20**). Pale yellowish amorphous powder, $[\alpha]_D^{22}$ − 57.5° (MeOH; *c* 0.53). (Found: C, 54.44; H, 6.18. $C_{16}H_{20}O_8\cdot 3/2\ H_2O$ requires: C, 54.31; H, 6.12%). UV λ_{max}^{MeOH} nm (log ε): 220 (sh 3.84), 238 (3.97), 298 (sh 4.00), 327 (4.22). ^1H NMR (CD_3OD): δ 2.34 (3H, *s*, H_3-10), 4.8 (partially overlapped with H_2O signal), 6.66 (1H, *d*, *J* = 16 Hz, H-8), 6.87 (1H, *d*, *J* = 8.5 Hz, H-5), 7.19 (1H, *dd*, *J* = 8.5, 1.5 Hz, H-6), 7.52 (1H, *d*, *J* = 16 Hz, H-7), 7.55 (1H, *d*, *J* = 1.5 Hz, H-2). ^{13}C NMR (CD_3OD): δ (C-1–15; G-1–6) 128.0, 118.4, 147.1, 151.4, 117.5, 126.5, 145.9, 125.5, 201.4, 27.3; 104.2, 74.9, 78.3, 71.5, 77.6, 62.6.

Enzymatic hydrolysis. A soln of glycoside in H_2O (1 ml) was treated with cellulase (Sigma type II) (*ca.* equal to glycoside) at 38° for 3 hr. The reaction mixt was dild with H_2O and ext with EtOAc × 3. The EtOAc was evapd and the residue purified by HPLC (YMC Pack ODS-7, MeCN–H_2O) to give an aglycone in a yield of *ca* 30%. **4a**: amorphous powder. EIMS *m/z* (rel. int.): 266 $[M]^+$ (18), 220 (30), 147 (48), 95 (83), 71 (85), 44 (100). ^1H NMR ($CDCl_3$): δ 1.43 (3H, *d*, *J* = 7 Hz, H_3-13), 1.49 (3H, *br s*, H_3-14), 1.69 (3H, *br s*, H_3-15), 3.93 (1H, *dt*, *J* = 10, 3 Hz, H-8), 4.27 (1H, *dd*, *J* = 10, 6 Hz, H-3), 4.68 (2H, *m*, H-5, H-6), 4.96 (1H, *dd*, *J* = 11, 5 Hz, H-1). **10a**: amorphous powder, $[\alpha]_D^{25}$ + 150.6° (MeOH; *c* 0.80). EIMS *m/z* (rel. int.): 344 $[M]^+$ (7), 258 (16), 229 (10), 212 (8), 183 (8), 145 (7), 69 (100). UV λ_{max}^{MeOH} nm (log ε): 255 (4.18). ^1H NMR ($CDCl_3$): δ 2.00 (3H, *br s*, H_3-γ), 2.49 (3H, *s*, H_3-14), 3.35 (1H, *m*, H-7), 4.58 (1H, *d*, *J* = 16 Hz, H-15a), 4.87 (1H, *d*, *J* = 16 Hz, H-15b), 5.00 (1H, *dt*, *J* = 10, 3 Hz, H-8), 5.65 (1H, *d*, *J* = 3.0 Hz, H-13a), 5.72 (1H, *br s*, H-δa), 6.19 (1H, *br s*, H-δb), 6.20 (1H, *d*, *J* = 3.2 Hz, H-13b), 6.47 (1H, *br s*, H-3). **12a**: colourless needles from MeOH, mp 202–204°. $[\alpha]_D^{25}$ + 284° (MeOH; *c* 0.57). EIMS *m/z* (rel. int.): 346 $[M]^+$ (4), 260 (15), 242 (10), 229 (14), 149 (20), 112 (24), 69 (100). ^1H NMR ($CDCl_3$): δ 0.99 (3H, *d*, *J* = 7 Hz, H_3-14), 1.98 (3H, *br s*, H_3-γ), 4.41 (1H, *dd*, *J* = 11, 9 Hz, H-6), 4.62 (1H, *br d*, *J* = 18 Hz, H-15a), 4.78 (1H, *br d*, *J* = 18 Hz, H-15b), 5.24 (1H, *dt*, *J* = 10, 4 Hz, H-8), 5.70

of compounds **9–16**

13	14	15	16
—	—	3.18 (*br s*)	3.12 (*br s*)
6.94 (*br s*)	6.96 (*d*, 1.5)	6.83 (*br s*)	6.76 (*br s*)
—	—	6.10 (*br d*, 3)	6.00 (*br d*, 2.5)
—	5.43 (*dt*, 4, 10)	5.68 (*br t*, 10)	4.53 (*dt*, 10, 2)
—	—	—	—
5.93 (*d*, 3.0)	1.34 (*d*, 7)	5.97 (*br s*)	1.30 (*d*, 7)
6.34 (*d*, 3.0)		6.10 (*m*)	
1.01 (*d*, 7)	0.87 (*d*, 7)	0.91 (*d*, 7)	0.69 (*d*, 7)
			4.92 (*d*, 16)
—	—	—	5.17 (*d*, 16)
—	4.99 (*d*, 7)	4.99 (*d*, 7)	5.01 (*d*, 7)
6.83 (*d*, 16)	—	—	—
8.03 (*d*, 16)	1.97 (*br s*)	1.94 (*br s*)	—
	5.64 (*m*)	5.52 (*m*)	—
—	6.22 (*br s*)	6.28 (*br s*)	—
7.41 (*m*)	—	—	—



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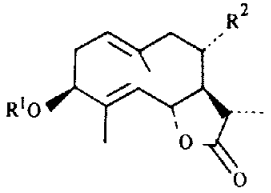
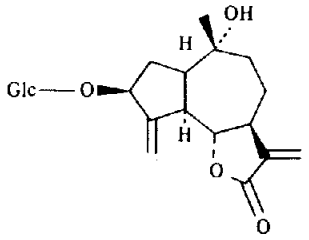


2 R^1 = Glc R^2 = H
3 R^1 = Glc R^2 = OH
4 R^1 = H R^2 = OGlc
4a R^1 = H R^2 = OH



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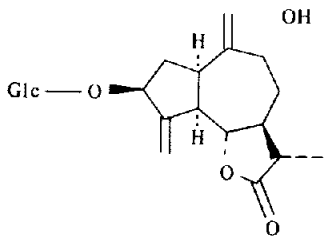

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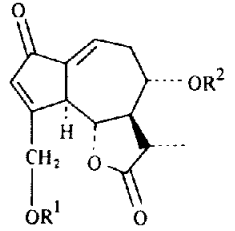
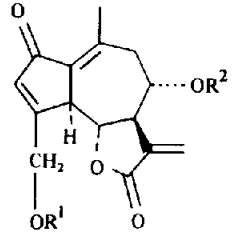
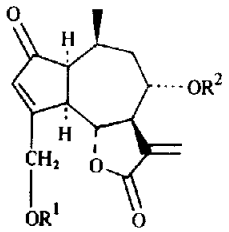


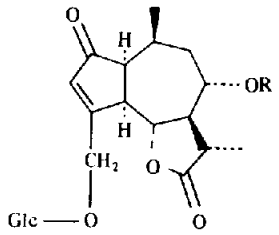
7 R^1 = H R^2 = H
8 R^1 = Glc R^2 = H
9 R^1 = Glc R^2 = M



10 R^1 = Glc R^2 = M
10a R^1 = H R^2 = M
10b R^1 = Glc R^2 = H
11 R^1 = Glc R^2 = C



12 R^1 = Glc R^2 = M
12a R^1 = H R^2 = M
13 R^1 = Glc R^2 = C



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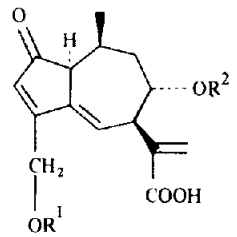

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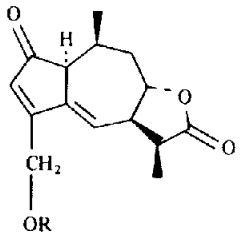
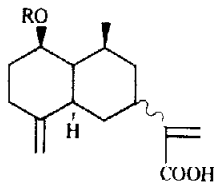
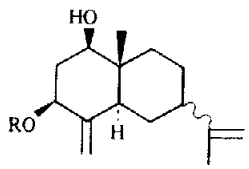
15a R^1 = H R^2 = M



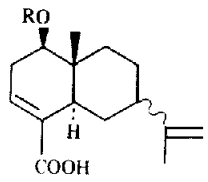
16 R = Glc
16a R = H



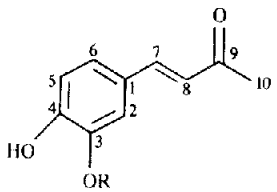
7 R = Glc
17a R = H



18 R = Glc
18a R = H



19 R = Glc
19a R = H



20 R = Glc
20a R = H

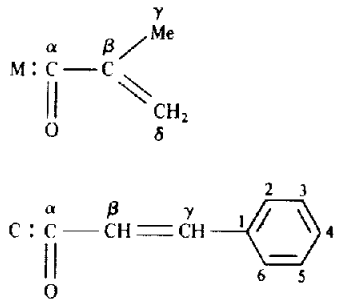


Table 2. ^{13}C NMR spectra of compounds **4**, **4a**, **9–19**, **10a**, **12a**, **15a**, **17a**, **18a**

	4*	**4a***	**9***	**10***	**10a†**	**11***	**12***	**12a†**	**13***	**14***	**15***	**15a***	**16***	**17***	**17a***	**18***	**18a***	**19***
Aglycone moiety																		
1	127.8	127.7	133.3	133.5	132.7	133.5	48.8	49.1	48.9	50.3	49.4	49.4	39.0	84.8	78.5	76.4[g]	76.8	80.2
2	35.6	35.7	194.5	194.3	194.2	194.6	207.1	206.9	207.1	207.5	205.5	205.5	205.1	28.5[h]	32.6	41.0[h]	42.7	27.9
3	77.4	77.5[a]	134.8	134.9	133.6	‡	131.1	130.1	131.0	130.9	130.9	130.0	131.3	34.4	34.8	76.7[g]	70.5	*
4	143.9	143.4	169.6	169.3	171.2	169.4	178.1	179.8	178.1	178.7	169.0	174.8	169.1	150.8	‡	149.4	154.0	*
5	125.3	125.2	48.7	48.6	48.4	48.7	50.0	49.7	50.0	52.8	143.4	143.4	143.1	48.4	48.3	45.9[i]	45.9[k]	46.1
6	79.3	77.7[a]	80.8	81.2	80.8	81.3	78.5	78.0	78.5	77.6	126.7[d]	126.3	120.0	30.1	30.3	29.4[j]	29.4[j]	29.8
7	60.5	60.3	58.5	54.6	54.9	54.5	53.3	52.8	53.2	54.5	53.5	53.7	53.6	39.9	40.0	45.3[i]	45.5[k]	45.1
8	81.6	71.6	71.0	69.8	69.3	69.7	72.5	71.7	72.1	73.1	71.2[e]	71.1	76.7	27.5[f]	27.7	27.1[j]	27.0[l]	26.9
9	51.6	53.4	44.4	44.0	44.3	44.3	40.1	40.0	40.4	40.9[b]	43.6	43.6	47.3	37.6	37.9	37.9	37.9	37.4
10	134.2	136.8	145.6	145.1	146.0	145.6	30.9	30.5	31.0	31.8	30.6	30.6	29.8	40.2	41.1	40.7[h]	40.9	35.7
11	40.4	41.2	41.0	137.4	135.9	137.3	137.3	135.3	137.2	40.6[b]	140.7	141.0	41.3	149.5	147.9	150.7	150.7	150.7
12	179.9	179.7	176.7	168.3	168.0	168.6	169.0	168.6	168.9	177.5	170.0	168.8	178.8	169.8	169.9	21.1	21.0	21.0
13	18.5	18.3	15.1	120.9	122.2	121.3	‡	125.2	‡	15.8[c]	126.5[d]	126.3	11.6	121.9	121.9	109.0	108.7	108.7
14	17.3	17.2	21.0	21.0	21.3	21.1	17.0	16.6	16.9	16.1[e]	12.8	12.6	12.9	11.5	10.9	10.9	10.9	10.9
15	12.4	12.2	68.8	68.6	62.4	68.8	69.0	62.5	69.0	68.9	65.2	58.6	65.1	106.8	106.6	105.5	103.6	‡
Sugar moiety																		
1	106.8	—	104.2	104.2	—	104.1	104.4	—	104.4	104.5	104.4	—	104.4	102.3	—	103.3	—	102.0
2	75.6	—	75.3	75.2	—	75.1	75.3	—	75.3	75.3	75.1	—	75.1	75.3	—	75.6	—	75.3
3	78.6	—	78.5	78.4	—	78.3	78.5	—	78.5	78.5	78.7	—	78.7	78.7	—	78.7	—	78.7
4	71.6	—	71.6	71.5	—	71.5	71.5	—	71.5	71.5	71.6[e]	—	71.6	72.1	—	71.9	—	72.1
5	78.1	—	78.5	78.4	—	78.3	78.5	—	78.5	78.5	78.5	—	78.5	78.4	—	78.7	—	78.6
6	62.8	—	62.7	62.6	—	62.6	62.6	—	62.6	62.6	62.8	—	62.8	63.2	—	62.9	—	63.2
Ester moiety																		
α	—	—	166.0	166.0	165.8	165.8	166.1	165.8	165.8	166.3	166.2	166.1	—	—	—	—	—	—
β	—	—	‡	136.3	135.6	117.9	‡	135.8	118.3	‡	137.1	137.1	—	—	—	—	—	—
γ	—	—	18.3	18.2	18.2	146.5	18.4	18.2	146.2	18.4	18.3	18.2	—	—	—	—	—	—
δ	—	—	126.6	126.8	127.0		126.6	126.5		126.4	125.5	126.3	—	—	—	—	—	—
1	—	—	—	—	—	134.8	—	—	134.7	—	—	—	—	—	—	—	—	—
2, 6	—	—	—	—	—	128.8	—	—	128.8	—	—	—	—	—	—	—	—	—
3, 5	—	—	—	—	—	129.4	—	—	129.4	—	—	—	—	—	—	—	—	—
4	—	—	—	—	—	131.1	—	—	131.0	—	—	—	—	—	—	—	—	—

*Run at 22.5 MHz in $^*C_5D_5N$. † $CDCl_3$ solution.
[a–l]Assignments may have to be reversed.
‡Not observed.

Table 3. Cytotoxic activity against L5178Y cells

	ID_{50} (μg/ml)
10	66
10a	0.77
12	<100
12a	1.63

(1H, *m*, H-δa), 5.82 (1H, *d*, *J* = 3.0 Hz, H-13a), 6.17 (1H, *br s*, H-δb), 6.32 (1H, *d*, *J* = 3.3 Hz, H-13b), 6.42 (1H, *m*, H-3). Compound **15a**: amorphous powder, $[\alpha]_D^{19}$ + 166.0° (MeOH; *c* 0.50). EIMS *m/z* (rel. int.): 346 $[M]^+$ (7), 260 (57), 242 (57), 83 (69), 69 (72), 40 (100). ^{1}H NMR (CD_3OD) (400 MHz): δ 0.82 (3H, *d*, *J* = 6.5 Hz, H_3-14), 1.84 (3H, *br s*, H_3-γ), 2.04 (1H, *dt*, *J* = 13, 3 Hz, H-9α), 2.21 (1H, *dt*, *J* = 13, 4 Hz, H-9β), 2.53 (1H, *m*, H-10), 3.22 (1H, *br s*, H-1), 3.75 (1H, *dd*, *J* = 11, 4 Hz, H-7), 4.61 (2H, *br s*, H_2-15), 5.22 (1H, *dt*, *J* = 11, 3 Hz, H-8), 5.55 (1H, *t*, *J* = 1.5 Hz, H-3), 5.81 (1H, *s*, H-δa), 5.94 (1H, *dd*, *J* = 4, 1.5 Hz, H-6), 5.98 (1H, *s*, H-δb), 6.30 (2H, *s*, H_2-13). **16a**: amorphous powder, $[\alpha]_D^{20}$ + 98.5° (MeOH; *c* 0.14). EIMS *m/z* (rel. int.): 262 $[M]^+$ (31), 244 (70), 234 (32), 192 (28), 164 (100). ^{1}H NMR ($CDCl_3$) (400 MHz): δ 0.77 (3H, *d*, *J* = 7 Hz, H_3-14), 1.37 (3H, *d*, *J* = 7 Hz, H_3-13), 1.96 (1H, *dt*, *J* = 12.5, 4 Hz, H-9α), 2.51 (1H, *td*, *J* = 13, 3.5 Hz, H-9β), 2.72 (1H, *m*, H-10), 2.87 (1H, *quin*, *J* = 7 Hz, H-11), 3.1 (1H, *m*, H-7), 3.10 (1H, *br s*, H-1), 4.32 (1H, *dt*, *J* = 10, 3 Hz, H-8), 4.71 (2H, *br s*, H_2-15), 5.94 (1H, *dd*, *J* = 2.5, 1 Hz, H-6), 6.40 (1H, *br s*, H-3). **17a**: amorphous powder, $[\alpha]_D^{20}$ 0° (MeOH; *c* 0.40). EIMS *m/z* (rel. int.): 250 $[M]^+$ (1), 232 (28), 145 (41), 119 (56), 91 (66), 42 (100). ^{1}H NMR ($CDCl_3$): δ 0.73 (3H, *s*, H_3-14), 3.49 (1H, *dd*, *J* = 11, 5 Hz, H-1), 4.51 (1H, *br s*, H-15a), 4.79 (1H, *br s*, H-15b), 5.72 (1H, *s*, H-13a), 6.37 (1H, *s*, H-13b). ^{13}C NMR: Table 2. **18a**: amorphous powder, $[\alpha]_D^{21}$ + 28.3° (MeOH; *c* 0.23). EIMS *m/z* (rel. int.): 236 $[M]^+$ (8), 218 (18), 166 (34), 123 (67), 93 (69), 81 (67), 55 (88), 44 (100). ^{1}H NMR (C_5D_5N): δ 1.04 (3H, *s*, H_3-14), 1.78 (3H, *br s*, H_3-12), 3.78 (1H, *dd*, *J* = 12, 4.5 Hz, H-1), 4.48 (1H, *br dd*, *J* = 12, 6 Hz, H-3), 4.85 (1H, *br s*, H-15b), 4.89 (2H, *br s*, H_2-13), 5.78 (1H, *br s*, H-15a). ^{13}C NMR: Table 2. **19a**: amorphous powder, $[\alpha]_D^{22}$ − 107.0° (MeOH; *c* 0.033). EIMS *m/z* (rel. int.): 250 $[M]^+$ (33), 232 (48), 217 (18), 207 (36), 189 (36), 171 (36), 161 (26), 56 (100). ^{1}H NMR ($CDCl_3$): δ 0.83 (3H, *s*, H_3-14), 1.74 (3H, *s*, H_3-12), 3.56 (1H, *dd*, *J* = 10, 6 Hz, H-1), 4.71 (2H, *br s*, H_2-13), 6.72 (1H, *m*, $W_{1/2}$ = 9 Hz, H-3). **20a**: pale yellowish amorphous powder. EIMS *m/z* (rel. int.): 178 $[M]^+$ (80), 163 (100), 145 (21), 135 (19), 117 (26), 89 (41). ^{1}H NMR (CD_3OD): δ 2.33 (3H, *s*, H_3-10), 6.51 (1H, *d*, *J* = 16.5 Hz, H-8), 6.78 (1H, *d*, *J* = 8 Hz, H-5), 7.01 (1H, *dd*, *J* = 8, 2 Hz, H-6), 7.07 (1H, *d*, *J* = 2 Hz, H-2), 7.51 (1H, *d*, *J* = 16.5 Hz, H-7). ^{13}C NMR (CD_3OD): δ (C-1–10) 127.8, 115.3, 146.9, 150.0, 116.6, 123.5, 146.8, 124.8, 201.5, 27.0. This compound proved to be identical with a synthesized authentic sample.

Acid hydrolysis of glycosides **4**, **9**–**20**. A soln of glycoside (*ca* 0.1 mg) in 10% H_2SO_4 (2 drops) was heated at 100° for 30 min. The soln was passed through an Amberlite IR-45 column and concd to give a residue which was reduced with $NaBH_4$ (*ca* 1 mg) for 1 hr at room temp. The reaction mixt was passed through an Amberlite IR-120 column and concd to dryness. Boric acid was removed by dist with MeOH and the residue acetylated with Ac_2O (1 drop) and pyridine (1 drop) at 100° for 1 hr. The reagents were evapd *in vacuo*. Glucitol acetate was detected by GC from all glycosides. GC conditions; capillary column SPB-35, 0.75 mm × 30 m; column temp. 200°; carrier gas, N_2; R_t = 10.8 min.

Alkaline hydrolysis of **9**–**15**. A soln of each ester (*ca* 0.1 mg) in 5% NaOH (1 drop) was treated for 30 min at room temp. The reaction mixt. was acidified with 10% HCl and extd with CH_2Cl_2 and the ext. obtained treated with *O*-*p*-nitrobenzyl-*N*,*N*′-diisopropyl isourea in a sealed ampoule for 1 hr at 90°. The reaction product was identified as the *p*-nitrobenzyl ester by HPLC. Methacrylate (R_t = 6.2 min) was detected from **9**, **10**, **12**–**15** and cinnamate (R_t = 10.2 min) from **11** and **13**. Conditions: YMC Pack ODS-7 4.6 mm × 25 cm; eluent, H_2O–MeCN (7:13); flow rate, 1.3 ml/min.

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