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TERPENE AND LIGNAN GLYCOSIDES FROM *PLUCHEA INDICA*

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Key Word Index—*Pluchea indica*; Compositae; monoterpene glycoside; sesquiterpene glycoside; lignan glycoside.

Abstract—Investigation of the roots of *Pluchea indica* afforded a new monoterpene glycoside, plucheoside C, three new eudesmane-type sesquiterpenes, plucheols A, B, plucheoside E and three new lignan glycosides, plucheosides D_1, D_2, D_3 together with a known eudesmane-type sesquiterpene. The structures of new compounds were elucidated on the basis of chemical and spectral data.

INTRODUCTION

In connection with a study on the terpenic glycosides in some plants of the Compositae, we have investigated *Pluchea indica*. In a previous paper [1], we reported the isolation and structural elucidation of the constituents which were isolated from its aerial parts. Now, we report the structures of four new terpenoids and three new lignan glycosides which were isolated from its roots.

RESULTS AND DISCUSSION

The careful separation of the polar fraction of *P. indica* afforded eight polar compounds. The known compound was identified as pterocarptriol (**3**) [2] by comparison of spectral data with those reported for this compound.

Plucheoside C (**1**), amorphous powder, $[\alpha]_D -72.7°$ showed $[M+Na]^+$ at *m/z* 467 in the positive FAB mass spectrum. The ^1H NMR spectrum indicated the presence of an aryl methyl group [δ 2.32 (*br s*)], an aryl isopropyl group [δ 1.24; 1.27 (each 3H, *d*, $J=7$ Hz); 3.71 (1H, *m*)] and two anomeric protons [δ 5.46 (1H, *d*, $J=8$ Hz); 5.70 (1H, *d*, $J=3$ Hz)]. The ^{13}C NMR spectrum showed that **1** was a glycoside of thymol **2** having a glucose and an apiose as the sugar moiety. The C-6 of glucose was shifted downfield by *ca* 6 ppm, suggesting that an apiose was attached to the C-6 of glucose [3].

Plucheol A (**4**), amorphous powder, $[\alpha]_D +14.2°$ showed a molecular ion at *m/z* 254 in the EI mass spectrum. The ^1H NMR spectrum indicated the presence of three methyl groups [δ 0.86 (3H, *s*); 1.39; 1.40 (each 3H, *s*)], two carbinyl protons [δ 4.11 (1H, *dt*, $J=9$, 5 Hz); 4.34 (1H, *d*, $J=9$ Hz)] and exomethylene protons [δ 4.97; 5.87 (each 1H, *br s*)]. These data were identical with those of an aglycone of atractyloside G [4], but this was the first isolation from plants.

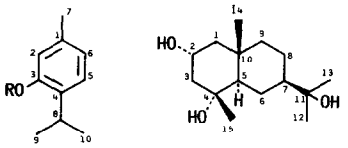
Plucheol B (**5**), amorphous powder, $[\alpha]_D +43.9°$ showed a molecular ion at *m/z* 254 in the EI mass spectrum. The ^1H NMR spectrum was similar to that of **4** except for two carbinyl protons. One hydroxyl group was assigned as 3β-equatorial because of a down-field shift of an olefinic proton [δ 5.80 (1H, *br s*)], as found in the spectrum of compound **4**, and the large coupling constants of the carbinyl proton (*dd*, $J=11$, 5 Hz). The other hydroxyl group was assigned as 1β-equatorial because of an upfield shift ($\Delta -2.9$ ppm) of the C-9 compared with that of **4** and from the splitting pattern of the carbinyl proton (*dd*, $J=12$, 4 Hz).

Plucheoside E (**6**), amorphous powder, $[\alpha]_D -2.8°$ showed $[M+Na]^+$ at *m/z* 423 and $[M+H]^+$ at *m/z* 401 in the positive FAB mass spectrum. The ^1H NMR spectrum indicated the presence of three methyl groups [δ 0.89; 1.34; 1.35 (each 3H, *s*)], a methyne proton [δ 3.78 (1H, *dd*, $J=11$, 4 Hz)], exomethylene protons [δ 4.62; 4.79 (each 1H, *br s*)] and an anomeric proton [δ 4.92 (1H, *d*, $J=8$ Hz)]. Acid hydrolysis gave glucose as the sugar moiety and in the ^{13}C NMR spectrum, 21 carbon signals, including six carbon signals due to a glucopyranosyl moiety, were observed. The C-9 was shifted upfield as in compound **5** and compared with that of **4**. Thus the glucosyl residue was decided to be 1β.

Plucheoside D_1 (**7**), amorphous powder, $[\alpha]_D -116.3°$ showed $[M+Na]^+$ at *m/z* 541 and $[M+H]^+$ at *m/z* 519 in the positive FAB mass spectrum. The UV spectrum showed the absorption maximum at 342 nm. The ^1H NMR spectrum indicated the presence of two methoxyl groups [δ 3.68; 3.84 (each 3H, *s*)], an anomeric proton [δ 4.92 (1H, *d*, $J=8$ Hz)], an α,β-unsaturated aldehyde group [δ 6.81 (1H, *dd*, $J=16$, 8 Hz); 7.30 (1H, *d*, $J=16$ Hz); 9.76 (1H, *d*, $J=8$ Hz)] and a methyne proton [δ 5.99 (1H, *d*, $J=6$ Hz)]. These data suggest that this compound is a dihydrobenzofuran-type lignan glycoside [5]. Acid hydrolysis gave glucose. In the ^{13}C NMR spectrum, the C-9 was shifted at δ 71.2 while an anomeric carbon was at δ 104.8, and thus the glucosyl linkage was at C-7. The CD spectrum of **7a**, obtained by reduction with $LiAlH_4$, showed negative Cotton effects $[\theta]_{267} -5900$ and $[\theta]_{287} -6600$, suggesting a 7*S*,8*R* configuration [6].

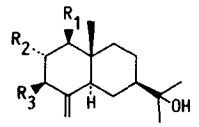
The ^1H NMR spectrum of plucheoside D_2 (**8**) was very similar to that of **7**, except for the presence of two equivalent methoxyl groups [δ 3.73 (6H, *s*)] and two equivalent aromatic protons [δ 7.39 (2H, *s*)].

Plucheoside D_3 (**9**), amorphous powder, $[\alpha]_D -56.8°$ showed $[M+Na]^+$ at *m/z* 557 and $[M+H]^+$ at *m/z* 534 in the positive FAB mass spectrum. Its UV spectrum

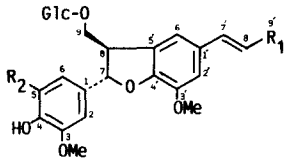


1 R=Glc $\xrightarrow{6}$ Api
2 R=H

3



4 R_1=H R_2=OH R_3=OH
5 R_1=OH R_2=H R_3=OH
6 R_1=O-Glc R_2=H R_3=H



7 R_1=CHO R_2=H
7a R_1=CH_2-OH R_2=H
8 R_1=CHO R_2=OMe
9 R_1=CH_2-OMe R_2=H

Table 1. ^{13}C NMR spectral data of compounds **1**, **2**, **4**–**9**

C	1†	1*	2*	4†	5†	6†	7†	8†	9†
Aglycone moiety									
1 (1′)	136.8	137.5	‡	49.8	77.2	85.3	132.5 (128.7)	‡ (128.7)	132.7 (132.7)
2 (2′)	116.6	117.6	117.4	73.5	42.9	28.7	111.1 (113.6)	105.0 (113.6)	111.1 (112.0)
3 (3′)	154.8	156.1	156.0	79.6	70.9	34.6	148.9 (145.3)	149.3 (145.1)	149.0 (145.0)
4 (4′)	132.9	136.6	136.8	152.3	154.5	150.1	‡ (152.1)	131.4 (152.0)	148.2 (152.1)
5 (5′)	126.7	126.7	126.1	48.5	45.9	48.5	116.6 (130.6)	149.3 (130.5)	116.6 (133.3)
6 (6′)	121.4	124.3	‡	22.6	23.1	22.8	119.8 (119.8)	105.0 (119.6)	119.7 (116.5)
7 (7′)	21.0	21.4	21.3	49.3	50.2	49.6	89.5 (153.8)	89.7 (153.3)	88.7 (131.4)
8 (8′)	27.5	27.2	26.7	25.6	25.4	25.1	51.6 (126.8)	51.6 (126.8)	52.2 (129.9)
9 (9′)	23.1	23.5	23.2	41.3	38.4	37.9	71.2 (193.5)	71.1 (193.3)	71.8 (73.4)
10	23.1	23.6	23.4	35.5	41.1	40.3			
11				71.5	71.7	72.2			
12				27.7	27.8	27.6			
13				28.1	28.3	28.2			
14				17.8	11.3	11.6			
15				104.8	103.8	106.7			
OMe							56.0, 56.3	56.3, 56.5, 56.5	56.0, 56.4, 57.7
Sugar moiety									
Glc-1	103.2	103.4				102.4	104.8	104.7	105.0
2	75.0	75.0				75.4	75.1	75.0	75.1
3	78.3	78.8				78.7	78.7	78.6	78.7
4	71.7	71.6				71.6	71.7	71.7	71.8
5	76.9	77.2				78.2	78.7	78.6	78.7
6	68.7	68.2				63.3	62.9	62.8	62.9
Api-1	110.9	111.0							
2	78.2	78.0							
3	80.5	80.5							
4	75.1	75.0							
5	65.9	65.8							

Run at 22.5 MHz in *methanol-d_4 and †pyridine-d_5 solution.
‡Overlapped with solvent.

showed the absorption maximum at 278 nm. The ^1H and ^{13}C NMR spectra indicated the presence of an aliphatic methoxyl group [δ3.34 (3H, *s*); 57.7], two aromatic methoxyl groups [δ3.68; 3.86 (each 3H, *s*), 56.0; 56.4] and two *trans*-olefinic protons [δ6.28 (1H, *dt*, $J=16$, 6 Hz); 6.68 (1H, *d*, $J=16$ Hz)]. The CD spectrum showed negative Cotton effects $[\theta]_{268}-7800$ and $[\theta]_{288}-10\,100$ and suggested that compound **9** has the 7*S*,8*R*-configuration.

EXPERIMENTAL

^1H and ^{13}C NMR spectra were recorded at 89.55 and 22.5 MHz, respectively, and also at 399.65 MHz. TMS was used as int. standard.

Plant material. Pluchea indica (L.) Less. was collected in Drigh Road, Karachi, Pakistan in 1988. Plants were identified by Prof. Dr S. I. Ali and Prof. Dr Muhammad Qaiser (Department of Botnay, University of Karachi).

Extraction and isolation. Dried roots (4.5 kg) were extracted ×2 with MeOH under reflux. The extract was concd under red. pres. and the residue suspended in H_2O. This suspension was extracted with Et_2O. The H_2O layer was passed through an Amberlite XAD-2 column and the MeOH eluate concd under red. pres. The residue (43 g) was chromatographed on a silica gel column with $CHCl_3$–MeOH (19:1–4:1) and semi-prep. HPLC [ODS, H_2O–MeCN (23:2–7:3)] to give 15 mg **1**, 4 mg **3**, 2 mg **4**, 10 mg **5**, 21 mg **6**, 14 mg **7**, 24 mg **8**, 9 mg **9** and 9 mg **10**.

Plucheoside C (**1**). Amorphous powder, $[\alpha]_D^{22}-72.7°$ (MeOH; *c* 1.50). FABMS *m/z* 467 $[M+Na]^+$. ^1H NMR pyridine-d_5: δ1.24; 1.27 (each 3H, *d*, $J=7$ Hz, H_3-9/H_3-10), 2.32 (3H, *br s*, H_3-7), 3. 71 (1H, *m*, H-8), 4.18 (2H, *s*, H_2-5 of apiose), 4.34; 4.57 (each 1H, *d*, $J=10$ Hz, H-4 of apiose), 4.75 (1H, *d*, $J=3$ Hz, H-2 of apiose), 5.46 (1H, *d*, $J=8$ Hz, H-1 of Glc), 5.70 (1H, *d*, $J=3$ Hz, H-1 of Api). ^1H NMR (CD_3OD): δ1.16 (6H, *d*, $J=7$ Hz, H_3-9; H_3-10), 2.30 (3H, *br s*, H_3-7), 4.96 (1H, *d*, $J=3$ Hz, H-1 of Api), 6.78 (1H, *br d*, $J=8$ Hz, H-6), 6.95 (1H, *br s*, H-2), 7.08 (1H, *d*, $J=8$ Hz, H-5). ^{13}C NMR: Table 1.

Plucheol A (**4**). Amorphous powder, $[\alpha]_D^{21}+14.2°$ (MeOH; *c* 0.67). EIMS *m/z* (rel. int.): 254 $[M]^+$ (5), 236 $[M-H_2O]^+$ (30), 218 $[M-2H_2O]^+$ (50), 175 (100). ^1H NMR(pyridine-d_5): δ0.86 (3H, *s*, H_3-14), 1.39; 1.40 (each 3H, *s*, H_3-12/H_3-13), 4.11 (1H, *dt*, $J=9$, 5 Hz, H-2), 4.34 (1H, *d*, $J=9$ Hz, H-3), 4.97; 5.87 (each 1H, *br s*, H-15). ^{13}C NMR: Table 1.

Plucheol B (**5**). Amorphous powder, $[\alpha]_D^{21}+43.9°$ (MeOH; *c* 1.71). EIMS *m/z* (rel. int.): 254 $[M]^+$ (6), 236 $[M-H_2O]^+$ (7), 218 $[M-2H_2O]^+$ (13), 160 (100). ^1H NMR (pyridine-d_5): δ1.08 (3H, *s*, H_3-14), 1.43 (6H, *s*, H_3-12; H_3-13), 3.79 (1H, *dd*, $J=12$, 4 Hz, H-1), 4.50 (1H, *dd*, $J=11$, 5 Hz, H-3), 4.99; 5.80 (each 1H, *br s*, H-15). ^{13}C NMR: Table 1.

Plucheoside E (**6**). Amorphous powder, $[\alpha]_D^{21}-2.8°$ (MeOH; *c* 1.09). FABMS *m/z*: 423 $[M+Na]^+$, 401 $[M+1]^+$. ^1H NMR (pyridine-d_5): δ0.89 (3H, *s*, H_3-14), 1.34; 1.35 (each 3H, *s*, H_3-12/H_3-13), 3.78 (1H, *dd*, $J=11$, 4 Hz, H-1), 4.62; 4.79 (each 1H, *br s*, H-15), 4.92 (1H, *d*, $J=8$ Hz, H-1 of Glc). ^{13}C NMR: Table 1.

Plucheoside D_1 (**7**). Amorphous powder, $[\alpha]_D^{21}-116.4°$ (MeOH; *c* 0.64). FABMS *m/z* 541 $[M+Na]^+$, 519 $[M+1]^+$. UV λ_{max}^{MeOH} nm (log ε): 342 (4.45). CD (MeOH; *c* 0.06) [θ] (nm): +28 500 (236), −15 500 (255), +3100 (279), −16 600 (338). ^1H NMR (pyridine-d_5): δ3.68; 3.84 (each 3H, *s*, OMe), 4.92 (1H, *d*, $J=8$ Hz, H-1 of glucose), 5.99 (1H, *d*, $J=6$ Hz, H-7), 6.81 (1H, *dd*, $J=16$, 8 Hz, H-8′), 7.30 (1H, *d*, $J=16$ Hz, H-7′), 9.76 (1H, *d*, $J=8$ Hz, H-9′). ^{13}C NMR: Table 1.

Plucheoside D_2 (**8**). Amorphous powder, $[\alpha]_D^{21}-67.5°$ (MeOH; *c* 0.40). FABMS *m/z* 549 $[M+1]^+$. UV λ_{max}^{MeOH} nm (log ε): 341 (4.33). CD (MeOH; *c* 0.06) [θ] (nm): +23 300 (240), −9600 (257), −4600 (281), −13 700 (337). ^1H NMR (pyridine-d_5): δ3.73 (6H, *s*, 2-OMe), 3.82 (3H, *s*, OMe), 4.96 (1H, *d*, $J=8$ Hz, H-1 of Glc), 6.01 (1H, *d*, $J=6$ Hz, H-7), 6.80 (1H, *dd*, $J=16$, 8 Hz, H-8′), 7.15 (1H, *d*, $J=16$ Hz, H-7′), 7.39 (2H, *s*, H-2; H-6), 9.75 (1H, *d*, $J=8$ Hz, H-9′). ^{13}C NMR: Table 1.

Plucheoside D_3 (**10**). Amorphous powder, $[\alpha]_D^{21}-56.8°$ (MeOH; *c* 0.22). FABMS *m/z* 557 $[M+Na]^+$, 534 $[M+H]^+$. UV λ_{max}^{MeOH} nm (log ε): 278 (4.36). CD (MeOH; *c* 0.06) [θ] (nm): −7800 (268), −10 100 (288). ^1H NMR (C_5D_5N): δ3.34 (3H, *s*, OMe at C-9′), 3.68; 3.86 (each 3H, *s*, OMe), 4.96 (1H, *d*, $J=8$ Hz, H-1 of Glc), 6.00 (1H, *d*, $J=6$ Hz, H-7), 6.28 (1H, *dt*, $J=16$, 6 Hz, H-8′), 6.68 (1H, *d*, $J=16$ Hz, H-7′). ^{13}C NMR: Table 1.

$LiAlH_4$ *reduction of* **7**. Compound **7** (2 mg) was dissolved in THF (1 ml) and reduced with $LiAlH_4$ (3 mg) at −20° for 1 hr. The reaction mixt. was acidified with dil. HCl and passed through a Diaion HP-20 column. The adsorbed material was eluted with MeOH after washing with H_2O. The MeOH eluate was purified by HPLC [Develosil Ph-7; H_2O–MeOH (3:2)] to give **7a** (1 mg) as amorphous powder. ^1H NMR (pyridine-d_5): δ3.68; 3.85 (each 3H, *s*, OMe), 4.98 (1H, *d*, $J=8$ Hz, H-1 of Glc), 6.01 (1H, *d*, $J=6$ Hz, H-7), 6.57 (1H, *dt*, $J=16$, 5 Hz, H-8′), 6.87 (1H, *d*, $J=16$ Hz, H-7′), 7.14 (1H, *br s*, H-2′), 7.18 (1H, *d*, $J=8$ Hz, H-5), 7.20 (1H, *br s*, H-6′), 7.25 (1H, *dd*, $J=8$, 2 Hz, H-6), 7.36 (1H, *d*, $J=2$ Hz, H-2). CD (MeOH; *c* 0.06 [θ] (nm): −5900 (267), −6600 (287).

Acid hydrolysis of glycosides **6–9**. A soln of each glycoside (*ca* 0.1 mg) in 5% 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 SP-2380, 0.25 mm × 30 m; column temp. 250°; carrier gas N_2; R_t 11.5 min.

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