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IRIDOID GLUCOSIDES FROM THE LEAVES AND STEMS OF *DURANTA ERECTA*

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Key Word Index—*Duranta erecta*; Verbenaceae; iridoid glucoside; duranterectosides A, B, C and D.

Abstract—From the leaves of *Duranta erecta*, four new iridoid glucosides, duranterectosides A, B, C and D, were isolated along with durantosides I and II, lamiide, lamiidoside and verbascoside. Duranterectoside A was also isolated from the stems together with durantosides I, II and III, and lamiidoside. The structures of the new compounds were elucidated based on the spectroscopic evidence.

INTRODUCTION

Duranta erecta L. (Verbenaceae) [1] came originally from South America. The fruits and leaves of *D. repens* were used for treatment of malaria and an abscess, respectively, in Chinese medicine [2]. From the genus *Duranta*, several iridoid glucosides such as durantosides I (**4**) [3], II (**5**) [3], III (**8**) [3] and IV [4], and lamiide (**7**) [3] were isolated. However, no reports were found, to our knowledge, on the constituents of *D. erecta*. During the course of our studies on the constituents of subtropical plants, we examined the consituents of the title plant collected in Okinawa Prefecture, Japan and isolated four new iridoid glucosides, duranterectosides A(**1**), B(**2**), C(**3**) and D (**9**) from the leaves together with the known compounds, **4, 5,** lamiidoside (**6**) [5], **7** and verbascoside (**12**) [6]. From the stems, duranterectoside A (**1**) was also isolated together with the known compounds, **4**, **5**, **6** and **8.** This paper deals with the isolation and structure elucidation of the new compounds.

RESULTS AND DISCUSSION

Methanolic extracts of the leaves and stems of *D. erecta* were separately fractionated as described in the Experimental section. From the *n*-butanol soluble fraction of the leaves, four new iridoid glucosides, duranterectosides A(**1**), B(**2**), C(**3**) and D(**9**) were isolated together with the five known compounds, **4**–**7** and **12**, by combination of silica gel chromatography and reversed phase HPLC. The *n*-butanol soluble fraction of the stems gave duranterectoside A(**1**) together with the four known compounds, **4**–**6** and **8.**

Duranterectoside A (**1**), $[\alpha]_D$ − 41.0° (MeOH), was obtained as an amorphous powder and the molecular formula was determined as $C_{27}H_{34}O_{15}$ based on its high resolution negative FAB mass spectrum. The ^1H and ^{13}CNMR spectra of **1** were very similar to those reported [7] for lamiide (**7**) except for a downfield shift (*ca* 1.3 ppm) for the C-7 proton, which in **1** was seen at δ4.83, as well as a downfield shift (3.0 ppm) for C-7 together with upfield shifts (1.0 and 0.3 ppm) for C-6 and C-8, respectively, showing the presence of an acylated oxygen at C-7 in **1.** In addition, signals were observed from a *trans*-isoferuloyl moiety (the latter proved by a differential NOE for the H-5″-signal at δ6.95 by irradiation of the aromatic methoxyl signal at δ3.89 and by isolation of methyl *trans*-isoferulate by methanolysis). Thus, duranterectoside A (**1**) was proved to be the 7-O-*trans*-isoferuloyl ester of lamiide (**7**).

Duranterectosides B (**2**) $[\alpha]_D$ − 87.1° (MeOH) and C(**3**), $[\alpha]_D$ − 68.0°, were obtained as amorphous powders and their molecular formulae were determined as $C_{28}H_{32}O_{13}$ and $C_{28}H_{32}O_{14}$ based on their HRFAB mass spectra. Both compounds showed similar ^1H and ^{13}CNMR spectra with those of duranterectoside A(**1**) except for the signals arising from the ester moiety. The data for duranterectoside B(**2**) and C(**3**) (see Experimental and Table 1) clearly demonstrated that the *trans*-isoferuloyl group in **1** was replaced by *cis*-cinnamoyl and *cis*-*p*-coumaroyl groups in the structures of duranterectosides B(**2**) and C(**3**). Thus, the structures of duranterectosides B and C were elucidated as **2** and **3**, respectively.

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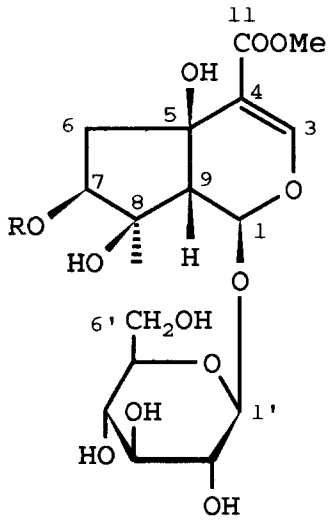

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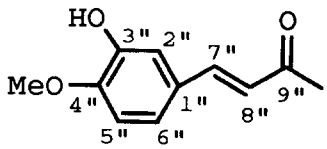

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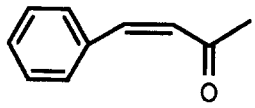

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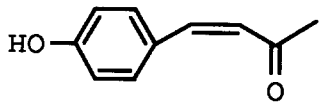

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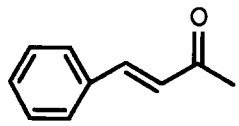

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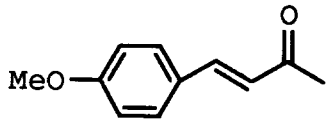

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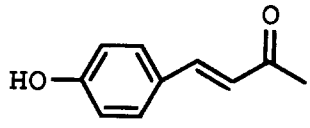

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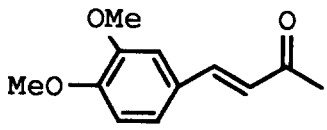
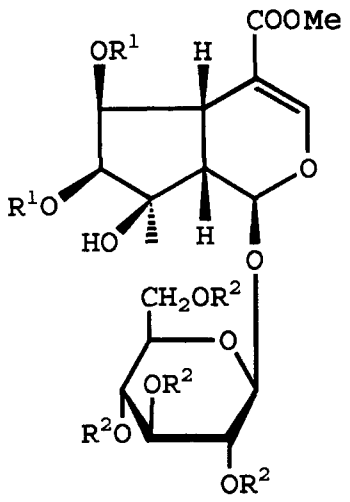


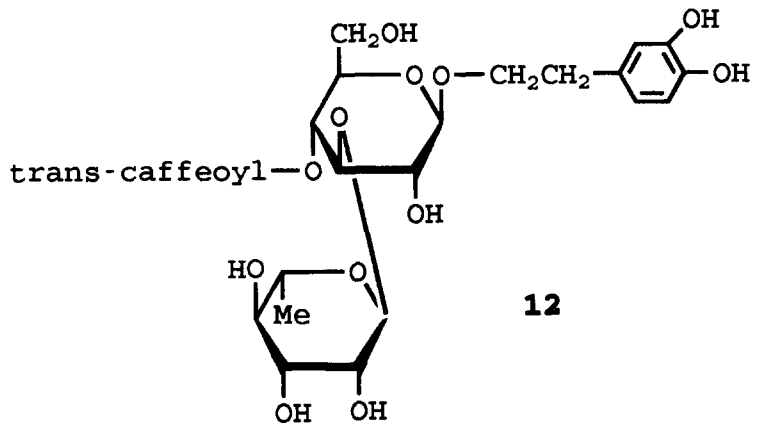
Duranterectoside D (**9**), $[\alpha]_D$ − 87.1° (MeOH) was isolated as an amorphous powder and the molecular formula was determined as $C_{21}H_{30}O_{14}$ based on its HRFAB mass spectrum. The ^1H and ^{13}C NMR spectra of **9** were very similar to those reported [8] for lamalbide (**10**) [9, 10] except for downfield shifts (1.0 and 1.2 ppm) for the protons at C-6 and C-7, which in **9** were seen at δ5.14 and 4.93, as well as downfield shifts (1.6 and 1.4 ppm) for C-6 and C-7, together with an upfield shift (1.3 ppm) for C-5, showing the presence of acylated oxygen at C-6 and C-7 in **9**. In addition, signals were seen arising from two acetyl groups (δ2.04 and 2.11). Based on the above mentioned discussions, duranterectoside D (**9**) was suggested to be the 6,7-diacetate of lamalbide (**10**). This was proved by differential NOEs for the proton signals at δ4.93 (H-7), 5.14 (H-6) and 5.62 (H-1) by the irradiation at δ1.28 (H_3-10) and by the formation of lamalbide hexaacetate (**11**) on acetylation of duranterectoside D (**9**).

EXPERIMENTAL

General. NMR: ^1H (400 MHz) and ^{13}C (100 MHz). TMS as int. standard; FABMS: glycerol as a matrix; CC:



	R^1	R^2
9	COMe	H
10	H	H
11	COMe	COMe



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silica gel 60 (230–400 mesh); TLC: silica gel plates F_{254} (0.25 mm in thickness); prep. HPLC (Cosmosil 10 C_{18}, 20 × 250 mm; solvent: MeOH–H_2O, flow rate, 6.5 ml min^{-1}; detection, 230 nm).

Plant material. The plant material used was collected in Nago City, Okinawa Prefecture, Japan in late August, 1991 and identified as *Duranta erecta* L. by one (A.T.) of the authors. A voucher specimen (91-OK-DE) was kept in the laboratory of one (H.O.) of the authors.

Isolation. Dried leaves (2.2 kg) of *Duranta erecta* were extracted with MeOH (30 l) at room temp. for 2 weeks. The extraction procedures were repeated once. The combined MeOH extracts were concd *in vacuo* and the residue was dissolved in 90% MeOH (1.1 l). The soln was washed with *n*-hexane (1 l × 3) and the aq. MeOH layer was concd *in vacuo*. The residue was suspended in H_2O (2 l), and the suspension was extracted with EtOAc (1.5 l × 3) and *n*-BuOH (1.5 l × 3), successively. The *n*-BuOH layer was concd *in vacuo* to give a residue (333 g), an aliquot (60 g) of which was chromatographed over silica gel (1 kg) with a mixt. of $CHCl_3$ and MeOH with increasing MeOH content [$CHCl_3$ (1.5 l), $CHCl_3$–MeOH (97:3, 2 l), $CHCl_3$–MeOH (19:1, 2 l), $CHCl_3$–MeOH (93:7, 4 l), $CHCl_3$–MeOH (9:1, 5 l), $CHCl_3$–MeOH (22:3, 3 l), $CHCl_3$–MeOH (17:3, 7 l), $CHCl_3$–MeOH (4:1, 6 l), $CHCl_3$–MeOH (3:1, 4 l), $CHCl_3$–MeOH (7:3, 4 l), and MeOH (2 l) was eluted successively, collecting 500 ml frs].

Frs 22–25 were combined and evapd *in vacuo* to give a residue (9.557 g), an aliquot (100 mg) of which was sepd by prep. HPLC (solvent: MeOH–H_2O, 1:1) to give durantoside I (**4**) [3] (29.1 mg) and durantoside II (**5**) [3] (7.0 mg) as amorphous powders.

Frs 29–32 were combined and evapd *in vacuo* to give a residue (2.846 g), an aliquot (250 mg) of which was sepd by repeated prep. HPLC (solvent: MeOH–H_2O, 9:11 and 7:13) to give duranterectoside A (**1**) (8.6 mg), duranterectoside B (**2**) (20.8 mg), durantoside I (**4**) (91.6 mg) [3], durantoside II (**5**) [3] (10.8 mg), lamiidoside (**6**) [5] (18.2 mg) and duranterectoside D (**9**) (3.5 mg) as amorphous powders.

Frs 33–41 were combined and evapd *in vacuo* to give a residue (4.0 g) which was re-chromatographed over silica gel (200 g) with a mixt. of $CHCl_3$ and MeOH with increasing MeOH content $CHCl_3$–MeOH (9:1, 2 l),

Table 1. ^{13}C NMR data* of duranterectoside A-D (1–3, 9)

C	1	2	3	9
1	94.1	94.0	94.1	94.4
3	152.3	152.3	152.3	153.1
4	115.7	115.6	115.7	111.0
5	69.1	69.0	69.0	34.9
6	45.7	45.4	45.5	78.0[a]
7	80.6	80.5	80.3	79.7[a]
8	78.8	78.7	78.7	76.8
9	58.5	58.2	58.3	48.5
10	21.4	21.3	21.4	22.3
11	167.9	167.9	167.6	168.6
COOMe	51.8	51.7	51.8	51.9
1′	99.7	99.6	99.7	99.3
2′	74.5	74.5	74.5	74.7
3′	78.4[a]	78.4[a]	78.4[a]	78.4[a]
4′	71.8	71.7	71.7	71.7
5′	77.5[a]	77.5[a]	77.5[a]	77.7[a]
6′	62.9	62.9	62.9	62.9
1″	129.1	136.3	127.7	
2″	112.6	129.1	133.9	
3″	151.5	131.1	115.9	
4″	148.1	130.2	160.1	
5″	114.8	131.1	115.9	
6″	122.9	129.1	133.9	
7″	146.7	145.0	145.5	
8″	166.6	120.7	116.9	
9″	168.6	167.1	168.0	
OMe	56.4			
OAc				20.7, 20.8 171.6, 172.0

*Measured at 100 MHz for methanol-d_4 solution.
[a]May be interchanged.

$CHCl_3$–MeOH (22:3, 3 l) and $CHCl_3$–MeOH (17:3, 2 l) were passed successively, collecting 100 ml frs. The residue (153.3 mg) from frs 25–27 was sepd by prep. HPLC (solvent: MeOH–H_2O, 9:11) to give durantoside I (**4**) [3] (40.3 mg), durantoside II (**5**) [3] (2.0 mg) and duranterectoside B (**2**) (24.3 mg). The residue (70.0 mg) from frs 28–29 was sepd by prep. HPLC (solvent: MeOH–H_2O, 9:11) to give duranterectoside D (**9**) (4.0 mg). The residue (452.8 mg) from frs 30–35 was sepd by prep. HPLC (solvent MeOH–H_2O, 9:11) to give duranterectoside A (**1**) (46.7 mg), duranterectoside C (**3**) (22.7 mg), lamiidoside (**6**) [5] (141.5 mg) and duranterectoside D (**9**) (12.2 mg).

Frs 49–53 were combined and evapd *in vacuo* to give a residue (2.06 g), an aliquot (250 mg) of which was repeatedly sepd by prep. HPLC (solvent: MeOH–H_2O, 2:3 and then 7:13) to give lamiide (**7**) [3,7] (5.6 mg) and verbascoside (**12**) [16] (31.2 mg).

Dried stems (7.1 kg) of *D. erecta* were extracted with MeOH (23 l) at room temp. for 12 days. The precedure was repeated once. The combined methanolic extracts were treated as before to give the *n*-BuOH soluble fr. (258 g), and an aliquot (23.62 g) of which was chromatographed over silica gel (500 g) with $CHCl_3$–MeOH as eluent with increasing amount of MeOH content [$CHCl_3$ (2.2 l), $CHCl_3$–MeOH (19:1, 1.5 l), $CHCl_3$–MeOH (9:1, 1.5 l), $CHCl_3$–MeOH (87:13, 3 l), $CHCl_3$–MeOH (21:4, 2.5 l), $CHCl_3$–MeOH (4:1, 2.5 l), and $CHCl_3$–MeOH (3:1, 2 l) were eluted successively, collecting 300 ml frs]. Frs 12–25 were combined and evapd *in vacuo* to give a residue (935 mg), an aliquot (200 mg) of which was sepd by prep. HPLC (solvent: MeOH–H_2O, 1:1) to give durantoside I (**4**) [3] (29.1 mg), durantoside II (**5**) [3] (38.5 mg) and durantoside III (**8**) [3] (18.5 mg). Frs 32–33 gave a residue (444.4 mg), an aliquot (200 mg) of which was sepd by prep. HPLC (solvent: MeOH–H_2O, 9:11) to give durantoside I (**4**) [3] (5.4 mg), durantoside II (**5**) [3] (1.5 mg), lamiidoside (**6**) [5] (12.4 mg) and duranterectoside A (**1**) (2.5 mg).

Among the isolated compounds, known compounds were identified by comparisons of spectral data with those reported. The physical properties of new compounds are as follows.

Duranterectoside A (**1**). Amorphous powder, $[\alpha]_D^{20.5}$ − 41.0° (MeOH, *c* 1.17). UV λ_{max}^{MeOH} nm (log ε): 222 (4.15), 233 (4.13), 298 (4.06) and 328 (4.09). IR ν_{max}^{KBr} cm^{-1}: 3400, 1700, 1630, 1580, 1510, 1440, 1270, 1160, 1130, 1070, 860 and 810. ^{1}H NMR (CD_3OD): δ1.17 (3H, *s*, H_3-10), 2.39 (1H, *dd*, *J* = 16.1 and 1.7 Hz, H_1-6), 2.48 (1H, *dd*, *J* = 16.1 and 5.0 Hz, H_1-6), 2.93 (1H, *s*, H-9), 3.73 (3H, *s*, COOMe), 3.89 (3H, *s*, OMe), 4.62 (1H, *d*, *J* = 7.9 Hz, H-1′), 4.83 (1H, *dd*, *J* = 5.0 and 1.7 Hz, H-7), 5.84 (1H, *d*, *J* = 0.7 Hz, H-1), 6.41 (1H, *d*, *J* = 15.9 Hz, H-8″), 6.95 (1H, *d*, *J* = 8.3 Hz, H-5″), 7.07 (*dd*, *J* = 8.3 and 1.9 Hz, H-6″), 7.10 (1H, *d*, *J* = 1.9 Hz, H-2″), 7.45 (1H, *s*, H-3) and 7.67 (1H, *d*, *J* = 15.9 Hz, H-7″). ^{13}C NMR (CD_3OD): see Table 1. Negative ion HRFABMS: *m/z* 597.1801 [M − H]$^-$. $C_{27}H_{33}O_{15}$ requires: 597.1819.

Duranterectoside B (**2**). Amorphous powder, $[\alpha]_D^{20.5}$ − 87.1° (MeOH, *c* 0.81). UV λ_{max}^{MeOH} nm (log ε): 218 (3.90), 223 (3.91) and 275 (3.73). IR ν_{max}^{KBr} cm^{-1}: 3370, 1700, 1630, 1575, 1495,1290, 1160, 1070, 870, 780 and 700. ^{1}H NMR (CD_3OD): δ1.15 (3H, *s*, H_3-10), 2.35 (1H, *dd*, *J* = 16.2 and 1.6 Hz, H_1-6), 2.46 (1H, *dd*, *J* = 16.2 and 5.1 Hz, H_1-6), 2.85 (1H, *s*, H-9), 3.67 (1H, *dd*, *J* = 11.9 and 5.9 Hz, H_1-6′), 3.73 (3H, *s*, COOMe), 3.89 (1H, *dd*, *J* = 11.9 and 2.0 Hz, H_1-6′), 4.61 (1H, *d*, *J* = 8.0 Hz, H-1′), 4.78 (1H, *dd*, *J* = 5.1 and 1.6 Hz, H-7), 5.82 (1H, *d*, *J* = 0.7 Hz, H-1), 6.09 (1H, *d*, *J* = 12.7 Hz, H-8″), 7.03 (1H, *d*, *J* = 12.7 Hz, H-7″), 7.32–7.37 (3H, m), 7.44 (1H, *s*, H-3) and 7.65 (2H, *m*). ^{13}C NMR (CD_3OD): see Table 1. Negative ion HRFABMS *m/z*: 551.1802 [M − H]$^-$. $C_{26}H_{31}O_{13}$ requires: 551.1764.

Duranterectoside C (**3**). Amorphous powder, $[\alpha]_D^{20.5}$ − 68.0° (MeOH; *c* 0.91). UV λ_{max}^{MeOH} nm (log ε): 229 (4.22) and 314 (4.17). IR ν_{max}^{KBr} cm^{-1}: 3370, 1700, 1630, 1605, 1515, 1290, 1160, 1070 and 870. ^{1}H NMR (CD_3OD): δ1.16 (3H, *s*, H_3-10), 2.37 (1H, *dd*, *J* = 16.1 and 1.7 Hz, H_1-6), 2.48 (1H, *dd*, *J* = 16.1 and 5.1 Hz, H_1-6), 2.88 (1H, *s*, H-9), 3.67 (1H, *dd*, *J* = 11.9 and 5.5 Hz, H_1-6′), 3.74 (3H, *s*, COOMe), 3.89 (1H, *dd*, *J* = 11.9 and 2.0 Hz, H_1-6′), 4.62 (1H, *d*, *J* = 7.9 Hz, H-1′), 4.79 (1H, *dd*, *J* = 5.1 and 1.7 Hz, H-7), 5.82 (1H, *d*, *J* = 0.7 Hz, H-1), 5.90 (1H, *d*, *J* = 12.8 Hz, H-8″), 6.76 (2H, *d*, *J* = 8.7 Hz, H_2-3″, 5″), 6.88 (1H, *d*, *J* = 12.8 Hz, H-7″), 7.44 (1H, *s*, H-3) and 7.70 (2H, *d*, *J*

= 8.7 Hz, H_2'', 6''). ^{13}CNMR (CD_3OD): see Table 1. Negative ion HRFABMS *m/z*: 567.1727 $[M - H]^-$. $C_{26}H_{31}O_{14}$ requires: 567.1714.

Duranterectoside D (**9**). Amorphous powder, $[\alpha]_D^{20.5}$ − 87.1° (MeOH, *c* 0.81). UV λ_{max}^{MeOH} nm (logε): 233 (4.09). IR λ_{max}^{KBr} cm^{-1}: 3400, 1730, 1700, 1635, 1250 and 1070. ^{1}H NMR (CD_3OD): δ1.28 (3H, *s*, H_3-10), 2.04 and 2.11 (each 3H, *s*, 2 × OAc), 2.83 (1H, *dd*, *J* = 11.0 and 2.3 Hz, H-9), 3.73 (3H, *s*, COOMe), 4.64 (1H, *d*, *J* = 7.9 Hz, H-1'), 4.93 (1H, *d*, *J* = 5.0 Hz, H-7), 5.14 (1H, *dd*, *J* = 5.0 and 5.0 Hz, H-6), 5.62 (1H, *d*, *J* = 2.3 Hz, H-1) and 7.44 (1H, *d*, *J* = 0.9 Hz, H-3). ^{13}C NMR (CD_3OD): see Table 1. Negative ion HRFABMS *m/z*: 505.1558 $[M - H]^-$. $C_{21}H_{29}O_{14}$ requires: 505.1557.

Alkaline methanolysis of duranterectoside A (**1**). To a soln of duranterectoside A (**1**) (44.3 mg) in MeOH (5 ml), 2 N NaOH aq. soln (3 drops) was added. After 3 hr at room temp, the reaction mixt. was neutralized with Amberlite IR-120B (H-form). The ion exchange resin was removed and the filtrate evapd *in vacuo*. The residue was partitioned between H_2O (10 ml) and EtOAc (10 ml × 2). The EtOAc extract gave methyl *trans*-isoferulate (8.6 mg) which was identified with authentic sample [11, 12] by direct comparison.

Acetylation of duranterectoside D (**9**). Duranterectoside D (**9**) (4.6 mg) was acetylated by Ac_2O and pyridine (0.5 ml each) for 3 hr at room temp. Excess MeOH was added and the solvent was evapd *in vacuo* to give **11** (7.6 mg). This compound was identified with lamalbide hexaacetate by comparison of spectral data with those reported [10].

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