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PSEUDOGUAIANOLIDES AND SESQUITERPENE GLUCOSIDE FROM *GAILLARDIA COAHUILENSIS*

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IN MEMORY OF TONY SWAIN, 1922–1987

Key word Index—*Gaillardia coahuilensis*; Asteraceae, sesquiterpene lactones; pseudoguaianolides; sesquiterpene glucoside; gaillardoside.

Abstract—From the aerial parts of *Gaillardia coahuilensis*, one secopseudoguaianolide, 12 pseudoguaianolides and one acyclic sesquiterpene glucoside, named gaillardoside, were isolated. Four of the compounds were previously unreported. This is the first isolation of a glycoside from the genus *Gaillardia*. Structures of all the compounds were elucidated by the spectral data including 2D COSY, ^{1}H–^{13}C correlation spectroscopy and some chemical transformations.

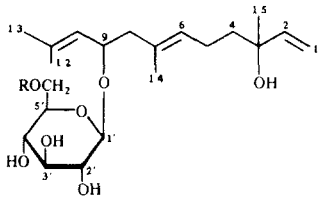
INTRODUCTION

The genus *Gaillardia* consists of *ca* 20 species. Most of the species occur in North America but a few also occur in South America. Chemical investigation of the genus was initiated by W. Herz and his colleague in 1963 starting with the species *G. pulchella* [1]. In 1965, reproducible inhibitory activity against human carcinoma of the nasophorynx in cell culture was reported from the ethanol extracts of *G. pulchella* Foug. [2]. Up to now, *ca* 12 of the species of the *Gaillardia* have been examined chemically [3–7]. Sesquiterpene lactones, especially pseudoguaianolides, were predominant in most of the species studied with only a couple of novel compounds isolated. Thus, two pseudoguaianolide alkaloids, pulchellidine and neopulchellidine [8, 9] and one pseudotwistane, pulchellon [10] were reported from *G. pulchella*. In a continuation of our systematic investigation of the Asteraceae, we have investigated an annual species native to northern Mexico and adjacent Texas, *G. coahuilensis* B. Turner, which superficially resembles the widespread *G. pulchella*, but appears to be more closely related to *G. mexicana*, a perennial species of central Nuevo Leon, Mexico [11]. Earlier chemical studies of the latter species yielded two lactones including spathulin, a compound widespread in the genus *Gaillardia* [12]. However, another investigation of *G. mexicana* collected in Nuevo Leon, Mexico reported only one pseudoguaianolide and no spathulin was isolated [13]. Unfortunately, no voucher material was cited for the latter study, and consequently the identification can not be verified. While the previous report [12] stated that "spathulin was the only crystalline substance isolated from a collection of Rio Grande Form of *G. pulchella* Foug., an observation which further demonstrates the great variability of this species", the present study suggests that the collection of the 'Rio Grande Form' reported upon by Herz was probably the same as *G. coahuilensis* B. Turner. Our collections came from the same area as the Rio Grande Form; further, *G. pulchella* is not observed to occur in this area.

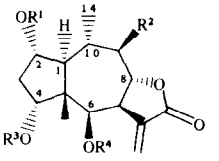
RESULTS AND DISCUSSION

The dichloromethane extracts of the aerial parts of *Gaillardia coahuilensis* yielded a sesquiterpene glucoside (**1**), 12 pseudogaianolides (**2–13**) and a secopseudogaianolide (**14**). Compounds **1–4**, to our knowledge, have not been previously reported while **5–14** are known compounds.

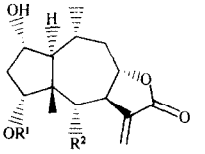
In the positive-ion FAB mass spectrum of compound **1**, a positive ion at *m/z* 465 $[M+Na]^+$ (100%) and a protonated ion at *m/z* 443 $[M+H]^+$ (33%) were in accord with a molecular formula of $C_{23}H_{38}O_8$. A cluster of *m/z* 595 $[M+matrix]^-$ (100%) and an ion at *m/z* 441 $[M-H]^-$ (82%) in its negative FAB mass spectrum also agreed with $C_{23}H_{38}O_8$ for **1**. The EI mass spectrum of **1** gave no molecular ion. However, fragments at *m/z* 220 $[M-acetyl-glucosyl]^+$, 205 $[220-Me]^+$ and 187 $[205-H_2O]^+$ did provide some useful information. The IR spectrum of **1** showed strong hydroxyl absorption (3420 cm^{-1}). Acetate absorption was also evident at 1740 cm^{-1} and double bond absorptions were indicated at 3070, 1660 and 1640 cm^{-1}. In the ^{1}H NMR spectrum of **1** (500 MHz, $CDCl_3$), signals were almost all resolved except those for H-4, H-5, H-8b. An ABX pattern appeared at δ 5.21 (*dd*, $J=1$, 17 Hz), 5.06 (*dd*, $J=1$, 11 Hz) and 5.87 (*dd*, $J=11$, 17 Hz). The coupling pattern of H-2 was in accord with a three-proton singlet signal at δ 1.25 which indicated a tertiary hydroxyl group at the C-3 position. In the 2D-COSY spectrum (500 MHz, $CDCl_3$) of **1**, all signals were well defined (Table 1). A broadened doublet signal at δ 5.27 (H-10) coupled with a doublet of doublet of doublet signal at 4.57 (H-9) and two vinylic methyl signals at δ 1.69 and 1.73. The H-9 signal coupled with two high field signals at δ 2.31 (*dd*, $J=9$, 14 Hz) and 2.14 (this signal was overlapped by a signal for H-5). The signal for H-6 appeared at δ 5.37 (*br t*, $J=7$ Hz) was coupled with a signal at 2.14 (H-5) and a vinylic methyl signal at 1.69 (*br s*) (integration indicated one vinylic methyl for δ 1.73 and two for 1.69). While an anomeric proton signal for a sugar moiety was suggested by the



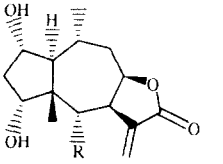
1 R = Ac
1a R = H



	R^1	R^2	R^3	R^4
2a	Ang	OAc	Ac	Ac
3	Ang	OH	*i*Val	H
3a	Ang	OAc	*i*Val	Ac
4	MeBu	OH	*i*Val	H
4a	MeBu	OAc	*i*Val	Ac
5	H	OAc	H	Ac
6	H	H	H	Ac



	R^1	R^2
7	*i*Val	OAng
8	H	OAng
9	H	OH
10	Ang	OH
11	H	H



	R
12	H
13	OH

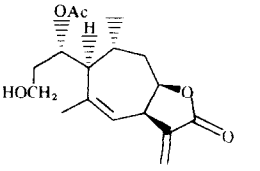


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Table 1. ^{1}H NMR spectral data of compounds **1** and **1a** (500 MHz, in $CDCl_3$, TMS)*

	H	1	1a
	1a	5.21 *dd* (1, 17)	5.19
	1b	5.06 *dd* (1, 11)	5.04
	2	5.87 *dd* (11, 17)	5.85
	4a	1.65 *m*	1.52–1.65
	4b	1.65 *m*	1.52–1.65
	5a	2.14 *m*	2.0–2.1
	5b	2.14 *m*	2.0–2.1
	6	5.37 *brt* (7)	5.32
	8a	2.31 *dd* (9, 14)	2.30
	8b	2.14 ——	2.0–2.1
	9	4.57 *ddd* (4, 9, 9)	4.50
	10	5.27 *br d* (9)	5.21
	12	1.69 *br s*	1.65
	13	1.73 *br s*	1.70
	14	1.69 *br s*	1.64
	15	1.25 *s*	1.29; 1.23
Sugar	1′	4.28 *d* (8)	4.24
	2′	3.34 *dd* (8, 9)	3.47
	3′	3.51 *t* (9)	3.47
	4′	3.42 *t* (9)	3.29
	5′	3.39 *m*	3.23
	6′a	4.37 *dd* (4, 12)	3.79 *dd* (3, 12)
	6′b	4.28 *br d* (12)	3.70 *dd* (5, 12)
OAc		2.09 *s*	

*Coupling patterns and coupling constants for **1a** are not repeated if identical with those for **1**.

signal at δ 4.28 (*d*, $J = 8$ Hz), the other signals for the rest of a glucosyl moiety were completely established by the 2D COSY. Signals for the two C-6′ protons appeared at δ 4.37 and 4.28 as a distorted AB pattern. Comparing all signals within the sugar moiety, chemical shifts for H-6′ were the lowest. This was consistant with an acetyl singlet signal at δ 2.09 (IR also agreed with an acetate) and that the acetate must be attached to the C-6′ of the sugar moiety judging from the comparisons. When **1** was hydrolysed with $KOCH_2Me$, compound **1a** was obtained and established to be the epimerization product at the C-3 position. Signals for H-6′ shifted upfield dramatically (from δ 4.37 and 4.28 in **1** to 3.79 and 3.70, respectively, in **1a**). This further confirmed that the acetyl group was attached at the C-6′ in **1**. Acid hydrolysis of **1a** yielded decomposed aglycone and glucose (see Experimental). The ^{1}H–^{13}C NMR chemical shift correlation (recorded at 500–125 MHz, $CDCl_3$) gave additional structure information and confirmed the signal assignments. For example, the proton doublet signal at δ 4.28 was correlated with a carbon signal at 102.2 which could only be assigned to an anomeric carbon signal of a sugar moiety. In the region of δ 60–80, there were an additional seven carbon signals which were all in accord with a hexapyranose moiety and C-9, C-3 oxygenated carbon signals based on the APT results (see Table 5) and the correlations. Moreover, the obscure signals for H-4, H-5 and H-8b in its ^{1}H NMR spectrum were assigned by the correlation spectrum. The C-6 double bond was assigned to be *trans* (6E-configuration) on the basis of the chemical shifts of C-14 (δ 16.7) and H-14 (δ 1.69) in the ^{13}C and ^{1}H NMR spectra of **1** [14]. Although the ^{13}C chemical shift assignments for C-12 and C-14 might be reversed, they could not affect the configuration assignment for the C-6, C-7 double bond on the basis of the chemical shift(δ 25.8) for a *cis*-double bond [14]. The glycosidic linkage was assigned to be β based upon the coupling constant of H-1′ (8 Hz).

No attempt has been made to assign the stereochemistry at the C-3 position. However, all the available data support the structure of **1** as depicted. Since there are no reports of the isolation of a sesquiterpene glycoside from the genus *Gaillardia*, we name compound **1** as gaillardoside.

Compounds **5** (spathulin), **10** and **11** (pulchellin)were the main components in this taxon. Their structures were assigned by high field NMR spectra including 2D-COSY (500 MHz, $CDCl_3$), or by comparing the spectral data with the published values [5].

Compound **10** was also isolated [6] from a collection of *G. pulchella* from Leander, Texas. The ^{1}H NMR data recorded in a different solvent showed considerable variations for the signals. However, the high field ^{1}H NMR and 2D COSY spectra established the structure independently. Therefore, the ^{1}H NMR data for **10** are also included in Table 2.

Structures for compounds **6–9**, **12–14** were deduced from their high field NMR data (^{1}H and 2D COSY, 500 MHz), or by comparing their spectra with published data [5].

^{1}H NMR data (Table 2) for compound **2** indicated that it was a pseudoguaianolide with a structure similar to that of spathulin. However, compound **2** differed from spathulin in that instead of the two acetyl groups in spathulin, **2** had one acetyl group and one angelate side chain (MS fragments at *m/z* 85 (100%) and 55; ^{1}H NMR 6.09, 1.99, and 1.87). While a 2D COSY spectrum recorded at 500 MHz confirmed all signal assignments, the coupling pattern and coupling constants of H-7, H-8, H-9, H-10, H-1 and H-2 established that all these protons were *trans*-located. The C-6 proton can also be assigned based on the small coupling between H-6 and H-7. While C-4 hydroxyl substitution could be deduced by comparing the relevant spectral data [5], the chemical shift for H-6 at δ 4.87 was unusually low for a proton attached to a carbon bearing a free-hydroxyl group. However, the C-6 hydroxyl group could be confirmed by acetylation which shifted the H-6 signal to δ 5.81 (**2a**, Table 3). The remaining assignments were the relative location at C-2 and C-9 of the angelate and the acetate groups. As the chemical shifts for H-2 (δ 5.02) and H-9 (δ 4.82) were rather close, compound **2** was partially hydrolysed to remove the acetate but not the angelate

Table 3. ^{1}H NMR spectral data of compounds **2a** (recorded at 360 MHz), **3a** and **4a** (recorded at 500 MHz) ($CDCl_3$, TMS)*

H	2a	3a	4a
1α	2.48 *dd* (7, 11)	2.43	2.44
2β	5.12 *ddd* ', 7, 9)	5.03	5.09
3α	1.67 *dd* (2, 16)	1.52	1.56
3β	2.70 *ddd* (5, 9, 16)	2.63	
4β	4.83 *d* (5)	4.79	4.82
6α	5.81 *d* (4)	5.79	5.81
7α	3.31 *m*	3.27	3.27
8β	4.62 *t* (10)	4.56	4.58
9α	4.91 *t* (10)	4.88	4.89
10β	2.03 *m*	2.01	2.03
13a	6.32 *d* (3.6)	6.28	6.28
13b	5.49 *d* (3.1)	5.42	5.42
14	0.99 *d* (6.6)	1.16	1.15
15	0.94 *s*	0.90	0.90
R'	6.10 *qq* (1.5, 7)	6.05	2.41 *m*
	1.98 *dq* (1.5, 7)	1.94	1.68 *m*
	1.80 *dq* (1.5, 1.5)	1.81	1.52 *m*
			0.96 *t*
			1.15 *d*
R''		2.08 *dd* (7, 15)	2.08
		2.04 *m*	2.04
		0.96 *d* (7)	0.96
		0.96 *d* (7)	0.96
OAc	2.03 *s*	2.13	2.13
	2.12 *s*	1.98	1.99
	2.17 *s*		

*Coupling pattern and coupling constants are not repeated if identical with the preceding column.

Table 2. ^{1}H NMR spectral data of compounds **2–4** and **10** (500 MHz, in $CDCl_3$, TMS)*

H	2	3	4	10
1α	2.39 *dd* (7, 11)	2.24	2.30	2.22 *dd* (8, 10)
2β	5.02 *ddd* (2, 7.9)	5.07	5.12	4.19 *ddd* —
3α	1.62 *dd* (2, 16)	1.52	1.58	1.70 *dd* —
3β	2.67 *ddd* (5, 9, 16)	2.69	2.71	2.59 *ddd* (5, 8, 15)
4β	3.83 *d* (5)	4.92	4.95	5.04 *dd* (4, 6)
6	4.87 *br d* (4)	4.41	4.41	3.75 *dd* (7, 10)
7α	3.11 *m*	3.02	3.00	3.11 *dddd* (3, 3, 10, 10)
8β	4.67 *t* (10)	4.59	4.61	4.18 —
9α	4.82 *t* (10)	3.34 *m*	3.34	1.50 *ddd* (10, 10, 13)
9β				2.34 *ddd* (3.5, 3.5, 13)
10β	2.02 *m*	1.90	1.90	1.88*m*
13	6.40 *d* (3.6)	6.42	6.42	6.24 *dd* (1, 3.5)
13'	5.68 *d* (3.1)	5.55	5.55	6.10 *dd* (0.9, 3.1)
14	0.97 *d* (6.6)	1.15	1.15	1.25 *d* (6.8)
15	0.94 *s*	1.01	1.03	1.04 *s*
R'	6.09 *qq* (1.5, 7)	6.08	2.40 *m*	6.15 *qq* (1.5, 7)
	1.99 *dq* (1.5, 7)	1.98	1.67 *m*	2.03 *dq* (1.5, 7)
	1.87 *dq* (1.5, 1.5)	1.86	1.48 *m*	1.91 *dq* (1.5, 1.5)
			0.92 *t* (7)	
			1.14 *d* (7)	
R''	2.13 *s* (OAc)	2.13 *dd* (7, 15)	2.14 *dd*	2.92 *d* (7) (6-OH)
		2.09 *m*	2.09	1.66 *s* (2-OH)
		0.92–0.93 *d* (7)	0.92–0.93	
		0.92–0.93 *d* (7)	0.92–0.93	

*Coupling pattern and coupling constants for **3** and **4** are not repeated if identical with the preceding column.

group. This reaction yielded compounds **2b** and **2c**. In the ^{1}H NMR spectra of **2b** and **2c** (Table 4), signals for H-9 shifted to high field (δ 3.19 for **2b** and δ 3.10 for **2c**) while signals for H-2 remained almost unchanged. These data confirmed that the angelate was located at C-2 and the acetyl group was at the C-9 position. Although the mass spectrum for **2** did not show a molecular ion, all fragments appeared to be logically derived (see Experimental). A ^{1}H–^{13}C NMR chemical shift correlation spectrum for **2** recorded at 500–125 MHz confirmed the structure for **2** as depicted and the spectrum allowed all carbon signal assignments except the signals for the three carbonyl carbons (Table 5).

Compunds **3** and **4** were inseparable even by repeated HPLC runs. However, the ^{1}H NMR, 2D COSY and ^{1}H–^{13}C chemical shift correlation spectra (recorded at 500 MHz) established their structures, both of which had skeletons similar to that of compound **2**. The 6β-hydroxyl group was assigned by the acetylation products (**3a** and **4a**) which shifted the signals for H-6 to low field (δ 5.79 and 5.81, *d*, $J = 4$ Hz). Also, the signal for H-9 in **3a** and **4a** appeared at δ 4.88 and 4.89 (*t*, $J = 10$ Hz). This indicated that a 9β-hydroxyl group was present in both **3** and **4**. The different side chains in **3** and **4** were indicated by all the data (chemical shifts, coupling patterns, signal intensity, etc.) of the NMR spectra. The CIMS strongly supported

Table 4. ^{1}H NMR spectral data of compounds **2b** and **2c**. (360 MHz, $CDCl_3$, TMS)*

H	2b	2c
1α	2.19 *dd* (7, 11)	2.14
2β	5.07 *ddd* (2, 7, 9)	5.06
3α	1.62 *dd* (2, 15)	1.58
3β	2.66 *ddd* (5, 9, 15)	2.68
4β	3.87 *br d* (4.5)	3.94
6α	4.68 *br d* (5.3)	5.02 *d* (10)
7α	2.44 *ddd* (5.4, 11, 12)	2.80 *dt* (10, 10)
8β	4.56 *dd* (9.5, 11)	3.50 *t* (10)
9α	3.19 *t* (9.5)	3.10 *t* (10)
10β	1.87 *m*	1.74
11	3.29 *ddd* (3.3, 8, 12)	2.94 *ddd* (3.5, 10, 10)
13a	3.84 *dd* (3.3, 10)	3.99
13b	3.59 *dd* (8, 10)	3.78 *t* (10)
14	1.16 *d* (6, 4)	1.13
15	0.93 *s*	0.85
R′		
3′	6.08 *qq* (1.5, 7)	6.08
4′	2.01 *dq* (1.5, 7)	2.02
5′	1.89 *dq* (1.5, 1.5)	1.89
OMe	3.41 *s*	3.48

*Coupling pattern and coupling constants are not repeated if identical with the preceding column.

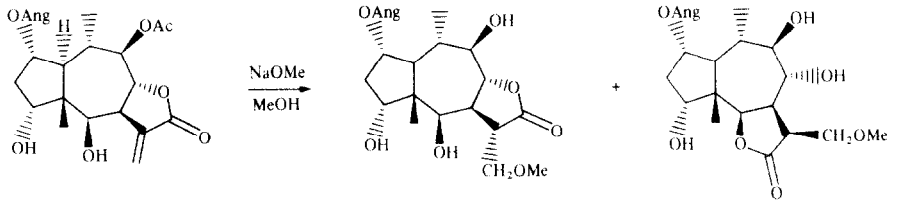
Table 5. ^{13}C NMR spectral data of compounds **1–4** (125 MHz, $CDCl_3$, TMS)*

C	1	2	3	4
1	111.8 P	48.28	49.85	49.91
2	144.7 N	78.03	77.09	77.07
3	74.1 P	40.22	38.04	38.13
4	41.1 P	78.59	81.89	81.92
5	23.0 P	52.20	51.39	51.34
6	127.4 N	63.90	64.47	64.47
7	134.5 P	46.88	46.48	46.48
8	45.6 P	77.41	80.06	80.06
9	75.7 N	79.33	79.68	79.59
10	125.8 N	34.94	36.07	36.22
11	132.4 P	135.56	135.82	135.82
12	18.1 N	167.60	167.16	167.16
13	25.8 N	122.55	122.17	122.17
14	16.7 N	16.71	16.65	16.94
15	27.6 N	17.75	17.67	17.67
R′ 1′	102.2 N	169.58	168.90	175.92
2′	73.5 N	127.42	127.29	46.40
3′	76.2 N	138.71	138.59	22.32
4′	73.7 N	15.70	15.71	16.97
5′	70.0 N	20.41	20.42	11.75
6′	63.9 P			
R″ 1″	171.3 P	170.67	172.40	172.40
2″	20.9 N	20.96	43.54	43.54
3″			25.68	25.68
4″			22.42	22.42
5″			22.42	22.42

*Most of the assignments were confirmed by ^{1}H–^{13}C chemical shift correlation spectra (recorded at 500–125 MHz, $CDCl_3$, TMS) except C-12 and C-14 in **1** due to overlapping proton signal.

P and N under compound **1** represent APT results. N = negative signal (one or three protons attached). P = positive signal (no proton or two protons attached).

the structures assigned to **3** and **4** by the presence of an ion at *m/z* 467 $[M+H]^+$ for $C_{25}H_{38}O_8$ for **4** and an ion at *m/z* 465 $[M+H]^+$ for $C_{25}H_{36}O_8$ for **3**. Careful analysis of other fragments from both the CI and EI mass spectra were best accounted for by structures of **3** and **4**. Thus, most of the sesquiterpene lactones containing an angelate side chain usually give fragments at either *m/z* 83 or 55 (from angelate) as a base peak. In the present spectra, the base peaks were at *m/z* 103 (CI mode) and 57 (EI mode). Because the population of isovalerate and methylbutanoate, both of which produced *m/z* 103 (CI) and 57 (EI) fragments, was more than the angelate. By comparing their ^{1}H NMR spectral data with those of compounds **2**, **7**, and **10**, the angelate in **3** and the



2 **2b** **2c**

methylbutanoate in **4** were probably attached at the C-2 position.

EXPERIMENTAL

Plant materials. Flowering material of *Gaillardia coahuilensis* was collected on June 1, 1987 by Dr B. L. Turner in Langtry, Texas (voucher specimen, Turner *s.n.*, Plant Resources Center, University of Texas at Austin, Austin, Texas U.S.A.).

Cut stems, leaves and flowers (680 g) were extracted with CH_2Cl_2 (2 × 8 l). The extracted plant material was further extracted with MeOH, but no significant spots were detected on TLC analysis of the latter extract. The CH_2Cl_2 extract was evaporated under red. pres. to yield a residue (16.5 g). The residue was defatted to yield, after work-up, a syrup (14.4 g). The syrup was applied on top of a silica gel column and the column was eluted with a hexane–EtOAc gradient with increasing amounts of EtOAc. Finally, the column was eluted with MeOH until no significant spots could be observed from the eluate on TLC. A total of 145 fractions were collected. Spathulin (720 mg) was crystallized from fractions 118–125 of the silica gel column (more spathulin could have been obtained had it been needed). Final separation for the other compounds was achieved by Sephadex LH-20 CC, HPLC (silica gel 10 mm × 25 cm. hexane EtOAc), and/or crystallization. Compounds **1** (60 mg), **2** (119 mg), **3** and **4** (360 mg), **6** (24 mg), **7** (330 mg), **8** (22 mg), **9** (47 mg), **10** (600 mg), **11** (500 mg), **12** (12 mg), **13** (24 mg) and **14** (64 mg) were obtained.

Gaillardoside (**1**). Colourless gum. IR ν_{max}^{nujol} cm^{-1}: 3420 (OH), 3070, 1660, 1640 (C=C), 1740 (OAc), 1450, 1375, 1240, 1080 and 1040. EIMS (probe) 70 ev, *m/z* (rel. int.): 220 [$C_{15}H_{24}O$, M − acetyl glucosyl − H]$^+$ (4), 205 [220 − Me]$^+$ (14), 202 [220 − H_2O]$^+$ (9), 187 [205 − H_2O]$^+$ (24), 93 (100), 55 [Me_2C=CH]$^+$ (52), 43 [C_3H_7]$^+$ (86). FAB (fast atom bombardment) MS, Xe was used as collision gas, ion gun condition: 8 kV and 40 mA. Nitrobenzyl alcohol was used as matrix. Positive ion spectrum: 465 [M + Na]$^+$ (100%), 443 [M + H]$^+$ (33%). Negative ion spectrum: 595 [M + matrix]$^-$ (100%), 441 [M − H]$^-$ (82%).

Alcoholic hydrolysis of gaillardoside (**1**). Compound **1** (40 mg) was dissolved in 5 ml of EtOH and 5 ml of 2% KOH–EtOH was added. The mixture was stirred at 50° for 30 min. After the reaction was complete, H_2O was added and the reaction mixture was extracted with EtOAc. The usual work-up afforded 20 mg **1a**. EIMS (probe) 70 eV, *m/z* (rel. int.): 220 [M − glucosyl − H]$^+$ (3), 205 [220 − Me]$^+$ (3), 187 [205 − H_2O]$^+$ (5), 55 [Me_2C =CH]$^+$ (50), 43 [C_3H_7]$^+$ (100).

Acid hydrolysis of **1a**. Compound **1a** (10 mg) was added to 2 ml of 1M HCl and the mixture was stirred at 50°. After reaction was completed, the mixture was extracted with CH_2Cl_2. The CH_2Cl_2 extract yielded decomposed aglycone. The water layer was co-spotted with different standard sugars on a cellulose TLC plate (20 × 20 cm). The plate was developed in pyridine–EtOAc–HOAc–H_2O, 36:36:7:21. Glucose was detected.

(1S, 2S, 4R, 5S, 6R, 7S, 8R, 9R, 10S)-2-*Angeloyloxy*-4,6-*dihydroxy*-9-*acetoxypseudoguaian*-11(13)-*en*-8, 12-*olide* (**2**). IR ν_{max}^{nujol} cm^{-1}: 3480 (OH), 3050 and 1640 (C=C), 1760 *br* and 1240 (COOR). EIMS (probe) 70 eV, *m/z* (rel. int.): 362 [M − HOAc]$^+$, (1.3), 323 [M − ang]$^+$ (1.4), 305 [M − ang − H_2O]$^+$ (2), 262 [M − ang − HOAc]$^+$ (4), 244 [M − ang − HOAc − H_2O]$^+$ (19), 83 [C_5H_7O]$^+$ (100), 55 [C_4H_7]$^+$ (42), 43 [MeCO]$^+$ (32).

Acetylation of **2**. Compound **2** (15 mg) was acetylated with acetic anhydride and pyridine at room temp. for 5 hr. The usual work-up yielded 13 mg of **2a**. EIMS (probe) 70 eV. *m/z* (rel. int.): 347 [M − ang − acetyl]$^+$ (9), 304 [347 − MeCO]$^+$ (6), 287 [347 − HOAc]$^+$ (23), 245 [M − ang − 2xMeCOO − MeCO]$^+$ 227 [245 − H_2O]$^+$ (35), 83 [C_5H_7O]$^+$ (100), 55 [C_4H_7]$^+$ (60), 43 [MeCO]$^+$ (87).

Partial hydrolysis of **2**. Compound 2 (16 mg) was reacted with NaOMe in MeOH at room temp. for 4 hr. The usual work-up yielded, after HPLC purification, 5 mg of **2b** and 3 mg of **2c**. EIMS of **2b** (probe), 70 eV, *m/z* (rel. int.): 294 [M − ang − H_2O]$^+$ (9), 83 [C_5H_7O]$^+$ (91), 55 [C_4H_7]$^+$ (100). **2c**: 294 [M − ang − H_2O]$^+$ (14), 276 [294 − H_2O]$^+$ (7), 245 [276 − OMe]$^+$ (5). 83 [C_3H_7O]$^+$ (100), 55 [C_4H_7]$^+$ (79).

(1S, 2S, 4R, 5S, 6R, 7S, 8R, 9R, 10S)-2-*Angeloyl*-*oxy*-4-*isovalerate*-6,9-*dihydroxypseudoguaian*-11 (13)-*en*-8, 12-*olide* (**3**) *and* (1S, 2S, 4R, 5S, 6R, 7S, 8R, 9R, 10S)-2-*Methyl*-*butanoate*-4-*isovalerate*-6,9-*dihydroxypseudoguaian*-11(13)-*en*-8,12-*olide* (**4**). EIMS (probe) 70 eV, *m/z* (rel. int.): 364 [**3**-ang, or **4**-MeBut]$^+$ (2.3), 262 [**3**-ang-*iv*al or **4**-MeBut-*iv*al]$^+$ (16), 244 [262 − H_2O] (4.5), 107 (63), 85 [C_5H_9O]$^+$ (48) (from **4**) 83 [C_5H_7O]$^+$ (45) (from **3**), 57 [C_4H_9]$^+$ (100) (from *iv*al of **3** and **4** and also from MeBut of **4**) 55 [C_4H_7]$^+$ (32.5) (from **3**). CIMS of **3** and **4**, direct inject. of sample, CH_4, $CHCl_3$, *m/z* (rel. int.): 467 [M + H]$^+$ (15) (from **4**), 465 [M + H]$^+$ (9) (from **3**). 449 [M − H_2O + H]$^+$ (5) (from **4**), 447 [M − H_2O + H]$^+$ (3) (from **3**), 365 [**3**-ang or **4**-MeBut or **4**-*iv*al + H]$^+$ (10), 363 [**3**-*iv*al + H]$^+$ (3). 347 [365 − H_2O]$^+$ (9), 345 [363 − H_2O]$^+$ (2), 263 [M − *iv*al and ang or MeBut + H]$^+$ (28) (from both **3** and **4**), 245 [263 − H_2O]$^+$ (20), 103 [*iv*al from **3** and **4** or MeBut from **4** + H]$^+$ (100). 101 [ang from **3** + H]$^+$ (31), 85 [C_5H_9O]$^+$ (21) 83 [C_5H_7O]$^+$ (76).

Acetylation of compounds **3** *and* **4**. Compounds **3** and **4** (10 mg) were acetylated with acetic anhydride and pyridine at room temp. for 4 hr. The usual work-up yielded 9 mg of **3a** and **4a**. EIMS (probe) 70 eV, *m/z* (rel. int.): 262 [M-side chains]$^+$ (6), 244 [262 − H_2O]$^+$ (12), 85 [C_5H_9O]$^+$ (69) 55 [C_4H_7]$^+$ (26), 43 [MeCO]$^+$ (100).

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