Pergamon

0031-9422(95)-00668-0

Phytochemistry, Vol. 41, No. 2, pp. 651 656, 1996

0031-9422/96 $15.00 + 0.00

ACYLATED TETRAHYDROISOQUINOLINE-MONOTERPENE GLUCOSIDES FROM *ALANGIUM LAMARCKII*

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(*Received* 20 *June* 1995)

Key Word Index—*Alangium lamarckii*; Alangiaceae; fruits; tetrahydroisoquinoline-monoterpene glucosides; 2′-*O*-acyl-demethylalangisides; 2′-*O*-acyl-alangisides; 2′-*O*-acyl-3-*O*-demethyl-2-*O*-methyl-alangisides.

Abstract—From the fruits of *Alangium lamarckii*, seven novel tetrahydroisoquinoline-monoterpene glucosides, 2′-*O*-*trans*-feruloyldemethylalangiside, 2′-*O*-*trans*-feruloylalangiside, 2′-*O*-*trans*-feruloyl-3-*O*-demethyl-2-*O*-methylalangiside, 2′-*O*-*trans*-sinapoyldemethylalangiside, 2′-*O*-*trans*-sinapoylalangiside, 2′-*O*-*trans*-sinapoyl-3-*O*-demethyl-2-*O*-methylalangiside and 2′-*O*-*trans*-[4-(1,3-dihydroxypropoxy)-3-methoxycinnamoyl]alangiside, were isolated and their structures determined on the basis of spectroscopic methods.

INTRODUCTION

Alangium lamarckii Thwaites is a deciduous shrub distributed in India and southeast Asia. The root bark of this species has been used in Indian folk medicine as an anthelmintic, purgative, emetic and febrifuge, and also for the treatment of leprosy and other skin diseases. Previous phytochemical investigations revealed that it is a rich source of alkaloids, including ipecac alkaloids, e.g. emetine and cephaeline, and benzopyridoquinolizidine alkaloids [1,2]. It is also known to produce alangiside, a tetrahydroisoquinoline-monoterpene glucoside, whose structure is closely related to these alkaloids [3]. In the course of our chemical studies on nitrogenous glycosides, we have recently investigated the constituents of the fruits of *A. lamarckii*. We have isolated a variety of nitrogenous glucosides and characterized seven of them [4–6]. In continuation of this study, we now report the structural elucidation of a further seven new tetrahydroisoquinoline-monoterpene-glucosides (**1–7**), with an acyl group in their glucose moieties.

RESULTS AND DISCUSSION

Compound **1** was isolated as a colourless crystalline solid, mp 175–177°. The HR-SI mass spectrum of **1** exhibited a strong $[M + H]^+$ at *m/z* 668.2359 indicating a molecular formula of $C_{34}H_{37}NO_{13}$ for **1**. The compound showed UV maxima at 221, 232.5, 295 and 329 nm, and IR bands at 3407 (OH), 1703 (COO), 1655 (NCO), 1630 (C=C), 1591 (Ar) and 1514 (Ar) cm^{-1}. Together with a SI fragment ion at *m/z* 330 due to the aglycone moiety (Fig. 1), several distinctive features of the ^1H NMR spectrum immediately indicated that **1** possessed a demethylalangiside (**8**) or demethylisoalangiside (**9**) skeleton, viz., two singlets for aromatic protons at δ6.43 and 6.59, a doublet for an olefinic proton at δ7.36 (J = 2.5 Hz), signals for a terminal vinyl group at δ5.16 (*dd*, J = 10.0 and 2.0 Hz), 5.25 (*dd*, J = 17.0 and 2.0 Hz) and 5.46 (*dt*, J = 17.0 and 10.0 Hz), and an acetal proton signal at δ5.44 (*d*, J = 1.5 Hz). Careful inspection of the coupling constants between H_2-13 and H-13a ($J_{13\alpha,13a}$ = 11.5 Hz, $J_{13\beta,13a}$ = 3.0 Hz), as well as the chemical shifts of C-6, C-12a and C-13 suggested that **1** possessed an *R*-configuration at C-13a, as in **8**, but not an *S*-configuration, as in **9** [5]. The ^1H NMR spectrum, moreover, showed additional signals for a methoxyl group at δ3.85, a pair of *trans*-olefinic protons at δ6.30 and 7.60 (each *d*, J = 16.0 Hz), and an AMX spin-system attributable to three aromatic protons at δ6.76 (*d*, J = 8.0 Hz), 7.02 (*dd*, J = 8.0 and 2.0 Hz) and 7.15 (*d*, J = 2.0 Hz). Both the ^1H–^1H COSY spectrum and NOESY spectrum, which displayed interactions between the olefinic proton at δ7.60 and the aromatic proton at δ7.15, and between the latter signal and the methoxyl signal, allowed us to assign all of these signals to a *trans*-feruloyl group. The presence of the *trans*-feruloyl moiety was also supported by a SI fragment ion at *m/z* 177 (Fig. 1), a UV maximum at 329 nm, IR bands at 1703 and 1630 cm^{-1}, and carbon signals assignable to a *trans*-feruloyl moiety [7]. These spectral features indicated a structural similarity to 6′-*O*-feruloyldemethylalangiside (**10**) [7], although the glucoside **10** was not isolated as a pure *trans*-form, but consisted of a mixture of geometric

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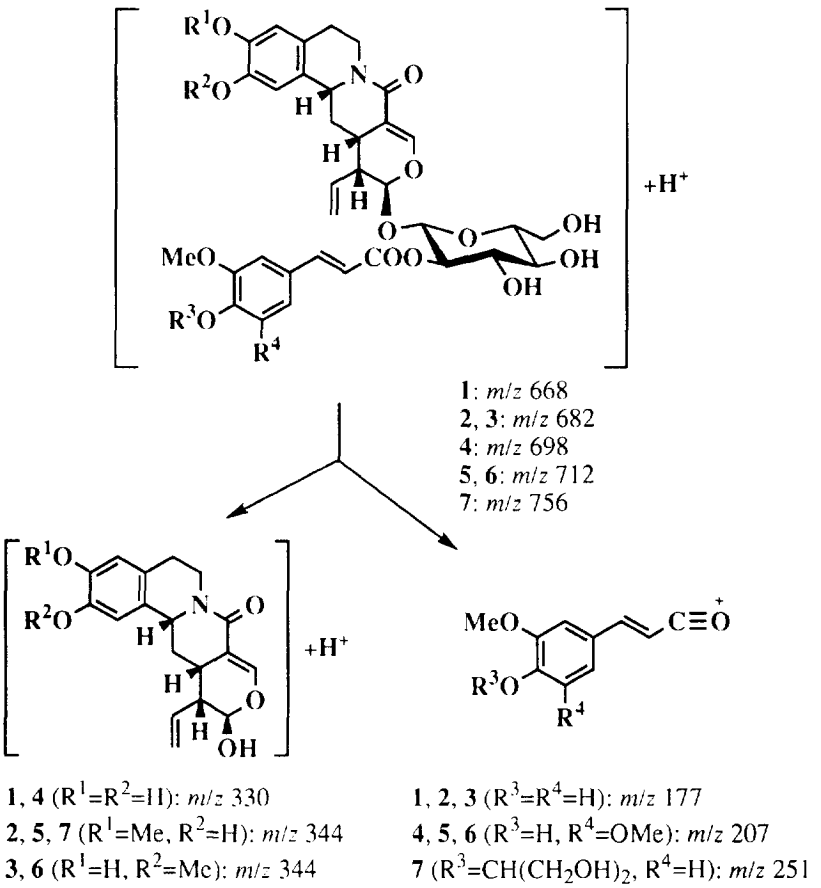


Fig. 1. SI mass spectral fragmentation of glucosides 1–7.

isomers. Comparison of the ^{13}C NMR spectra of **1**, **8** and **10** showed that **1** and **10** differed in the position of their ester linkage, with significant differences between the carbon resonances arising from their glucose moieties. The upfield shifts of C-1′ and C-3′ in **1** relative to those in **8** were ascribable to an acylation effect, suggesting that the hydroxyl group at C-2′ was esterified in place of the one at C-6′ in **10** [8]. Thus, the glucoside **1** was characterized as 2′-*O*-*trans*-feruloyldemethylalangiside.

Two other glucosides, **2** and **3**, were also obtained as amorphous powders. HR-SI mass spectral measurements of **2** and **3** revealed the same molecular formula, $C_{35}H_{39}NO_{13}$. The ^1H and ^{13}C NMR (Table 1) spectral features of **2** and **3** were similar to those of **1**, except for the presence of one additional aromatic methoxyl signal and the chemical shifts of the signals arising from the aromatic ring in their aglycone portions. These results suggested that **2** and **3** were probably methylates of **1**. The SI mass spectra of both compounds showed a fragment ion peak at *m/z* 344, 14 mu more than the corresponding peak of **1**, which could be explained by methylation of a phenolic hydroxyl group in the demethylalangiside (**8**) skeleton (Fig. 1). The placement of the methoxyl groups was deduced from the comparison of ^{13}C NMR spectral data with those of alangiside (**11**) and 3-*O*-demethyl-2-*O*-methylalangiside (**12**) (Table 1). The chemical shifts of carbon signals due to the aromatic moieties of **2** and **3** were in accordance with those of **11** and **12**, respectively, indicating a methoxyl group at C-3 in **2** and at C-2 in **3**. Accordingly, the structures of **2** and **3** were established as 2′-*O*-*trans*-feruloylalangiside and 2′-*O*-*trans*-feruloyl-3-*O*-demethyl-2-*O*-methylalangiside, respectively.

Another set of the related glucosides (**4**–**6**) had spectral features closely similar to those of **1**–**3**. The differences between the two groups of compounds could be accounted for by substitution of their *O*-acylating units. In the ^1H NMR spectra of **4**–**6**, none showed signals due to a *trans*-feruloyl group, such as was observed in **1**–**3**, but they exhibited signals corresponding to a *trans*-sinapoyl moiety, viz., a two-methoxyl signal (**4**: δ3.79; **5**: δ3.789; **6**: δ3.78), a pair of *trans*-olefinic protons [**4**: δ6.33 and 7.60 (each *d*, J = 15.5 Hz); **5**: δ6.33 and 7.61 (each *d*, J = 15.5 Hz); **6**: δ6.33 and 7.61 (each *d*, J = 16.0 Hz)] and a two-proton singlet (**4**: δ6.85; **5**: δ6.86; **6**: δ6.85). The existence of a *trans*-sinapoyl moiety was further substantiated by a SI fragment ion at *m/z* 207 (Fig. 1) and carbon signals ascribed to a *trans*-sinapoyl group (Table 1) [7]. Detailed ^{13}C NMR analyses indicated that the sinapoyl group was linked to the 2′-hydroxyl group of the glucose

Table 1. ^{13}C NMR data for compounds **1–8**, **11** and **12** in CD_3OD

C	8*	11*	12*	1*	2†	3*	4*	5†	6*	7*
1	113.4	113.3	110.3	113.4	113.3	110.3	113.4	113.3	110.4	113.3
2	145.3	146.4	148.2	145.2	146.3	148.1	145.2	146.3	148.1	146.4
3	145.3	148.0	146.5	145.2	147.9	146.3	145.2	147.9	146.4	147.9
4	116.0	112.6	116.1	115.9[b]	112.5[e]	115.9[h]	115.9[k]	112.5	116.0[m]	112.6[p]
4a	127.4	127.3	128.9[a]	127.4[c]	127.2[f]	128.6[i]	127.4	127.2	128.7[n]	127.3
5	29.3	29.5	29.4	29.1	29.3	29.2	29.1	29.3	29.2	29.3
6	41.1	41.0	40.8	40.4	40.3	40.0	40.2	40.2	39.9	40.3
8	166.0	166.0	166.0	165.1	165.0	165.0	165.1	165.1	165.1	165.1
8a	109.3	109.3	109.3	109.8	109.7	109.7	109.7	109.7	109.7	109.7
9	148.7	148.8	148.8	147.9	147.9	147.9	147.9	147.9	148.0	148.0
11	97.5	97.5	97.6	96.5[d]	96.4[g]	96.5[j]	96.3[l]	96.3	96.4[o]	96.5[q]
12	44.5	44.5	44.5	44.0	43.9	43.9	43.9	43.9	43.9	44.0
12a	27.7	27.8	27.9	28.3	28.2	28.3	28.4	28.3	28.5	28.3
13	35.0	35.1	35.3	35.2	35.2	35.4	35.3	35.3	35.6	35.2
13a	57.0	57.0	57.3	56.7	56.7	57.0	56.7	56.7	57.1	56.8
13b	129.1	130.3	128.8[a]	128.8	129.9	128.7[i]	128.6	129.8	128.5[n]	129.9[r]
14	134.0	134.0	134.0	133.6	133.5	133.5	133.5	133.5	133.5	133.5
15	120.3	120.4	120.4	120.5	120.6	120.5	120.5	120.6	120.5	120.6
1′	99.7	99.7	99.7	96.2[d]	96.2[g]	96.2[j]	96.1[l]	96.1	96.1[o]	96.2[q]
2′	74.8	74.9	74.9	74.7	74.6	74.6	74.6	74.6	74.7	74.8
3′	78.0	78.0	78.1	75.5	75.5	75.5	75.4	75.4	75.5	75.5
4′	71.6	71.6	71.6	72.0	71.9	71.9	71.9	71.9	71.9	71.9
5′	78.3	78.4	78.4	78.7	78.7	78.7	78.7	78.7	78.7	78.8
6′	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7
OMe	—	56.4	56.7	56.5	56.4	56.4	56.9	56.4	56.7	56.4
OMe	—	—	—	—	56.5	56.6	56.9	56.9	56.9	56.6
OMe	—	—	—	—	—	—	—	56.9	56.9	—
CO	—	—	—	168.9	168.8	168.8	168.8	168.8	168.8	168.6
α	—	—	—	115.4[b]	115.3	115.3[h]	115.8[k]	115.8	115.8[m]	116.8
β	—	—	—	147.2	147.2	147.1	147.4	147.4	147.4	146.6
1″	—	—	—	127.6[c]	127.5[f]	127.5	126.4	126.4	126.4	129.6[r]
2″	—	—	—	112.2	112.1[e]	112.1	107.4	107.3	107.4	112.8[p]
3″	—	—	—	149.5	149.4	149.4	149.5	149.5	149.5	151.5[s]
4″	—	—	—	150.9	150.9	150.9	140.0	139.9	140.0	152.0[s]
5″	—	—	—	116.5	116.4	116.4	149.5	149.5	149.5	117.5
6″	—	—	—	124.6	124.7	124.6	107.4	107.3	107.4	124.2
1‴	—	—	—	—	—	—	—	—	—	62.0
2‴	—	—	—	—	—	—	—	—	—	82.6
3‴	—	—	—	—	—	—	—	—	—	62.0

*Measured at 125 MHz.
†Measured at 75 MHz.
[a–s]Values with same superscript are interchangeable.

moiety in each glucoside and that a methoxyl group was placed at C-3 in **5** and at C-2 in **6**. The sites of the methoxyl groups were further corroborated by NOESY experiments, where the methoxyl signal at δ3.792 showed interaction with H-4 at δ6.58 in **5**, while the methoxyl at δ3.83 correlated with H-1 at δ6.76 in **6**. Thus, glucosides **4–6** were characterized as 2′-*O*-*trans*-sinapoyldemethylalangiside, 2′-*O*-*trans*-sinapoylalangiside and 2′-*O*-*trans*-sinapoyl-3-*O*-demethyl-2-*O*-methylalangiside, respectively.

The last new glucoside **7** was isolated as a crystalline solid, mp 166–169°. Its HR-SI mass spectrum showed a $[M + H]^+$ at *m/z* 756.2869 consistent with the molecular formula $C_{38}H_{46}NO_{15}$. The UV and IR spectral features of this compound were analogous to those of **2**. The ^1H and ^{13}C NMR (Table 1) spectral data, excluding the signals attributable to the acyl group, were in good agreement with those for **2**, suggesting that the glucoside **7** possessed the same 2′-*O*-acylated alangiside skeleton as in **2**, but that the acyl group had been replaced. This hypothesis received further support from the fact that the SI mass spectrum of **7** exhibited the same fragment ion peak due to the aglycone moiety at *m/z* 344, as for **2**, but a fragment ion peak arising from the acyl group at *m/z* 251, indicating $C_3H_6O_2$ more than the corresponding peak of **2** (Fig. 1). The residual signals in the ^1H and ^{13}C NMR spectra of **7** showed the nature of this acyl group. The ^1H NMR spectrum exhibited signals

assignable to a *trans*-caffeoyl moiety [a pair of doublets for *trans*-olefinic protons at δ6.37 and 7.63 (J = 16.0 Hz) and an aromatic AMX spin-system at δ7.04 (*d*, J = 8.5 Hz), 7.10 (*dd*, J = 8.5 and 2.0 Hz) and 7.22 (*d*, J = 2.0 Hz)], together with signals for methoxyl at δ3.86, methylene protons at δ3.71–3.77 (4H) and a methine proton at δ4.33 (1H, *quint.*, J = 5.0 Hz). Analysis of the ^{13}C NMR spectrum showed a trisubstituted benzene ring with two substituents attached through oxygen. An unsaturated acid group and an aromatic methoxyl group accounted for two of these three substituents, while the carbon signals at δ82.6 (CH) and 62.0 ($CH_2 \times 2$) suggested that the third was a glycerol residue. The order of substituents around the ring was established from NOESY experiments. The NOE interaction between a methoxyl group at δ3.86 and H-2″ at δ7.22 was indicative of the attachment of the methoxyl at C-3″, as in a feruloyl group. Another important NOE interaction observed between the methine proton of the glycerol moiety and H-5″ at δ7.04, together with the downfield shift of C-2‴ by 6.2 ppm and upfield shifts of C-1‴ and C-3‴ by 4.9 ppm relative to glycerol [9, 10], allowed us to conclude that the C-2‴ of the glycerol unit and the C-4″ of the benzene ring should share a single oxygen to constitute an ether linkage. Consequently, the structure of the compound was represented by **7** and designated as 2′-*O*-*trans*-[4-(1,3-dihydroxypropoxy)-3-methoxycinnamoyl] alangiside.

All of the new tetrahydroisoquinoline-monoterpene glucosides isolated possessed a lactam ring, as well as a glucose moiety with an *O*-acyl group at C-2′. The occurrence of such glucosides is interesting from a biosynthetic point of view. Previous biosynthetic and phytochemical investigations demonstrated that deacetylipecoside (**13**) could be metabolically inactivated mainly by N-acylation and partially by lactamization in *Cephaelis ipecacuanha*, in which **8**, ipecoside (**14**) and their related glucosides had co-occurred [11–13]. In contrast, the present findings suggest that lactam formation could be a predominant mechanism and that acylation can take place exclusively at the C-2′ hydroxyl group in *A. lamarckii*.

EXPERIMENTAL

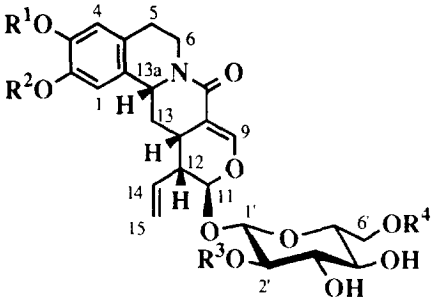
Mps: uncorr. ^{1}H (500 MHz) and ^{13}C (75 or 125 MHz) NMR: TMS as int. standard. SIMS: glycerol as matrix.

Plant material and isolation of glucosides. The source of plant material and isolation of glucosides are as described in a previous publication [6]. Compounds **A**, **B**, **C**, **D**, **F**, **G** and **I** in ref. [6] correspond to **6**, **3**, **5**, **2**, **4**, **1** and **7**, respectively.

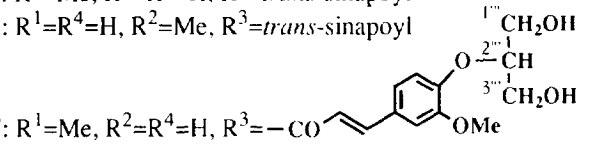
2′-O-trans-*Feruloyldemethylalangiside* (**1**). Crystalline solid, mp 175–177° (H_2O). $[\alpha]_D^{27}$ − 162° (MeOH; *c* 0.44). UV λ_{max}^{MeOH} nm (log ε): 221 (4.47), 232.5 (4.48), 295 (4.17), 329 (4.27). IR ν_{max}^{KBr} cm^{-1}: 3407, 1703, 1655, 1630, 1591, 1514, 905. ^{1}H NMR (CD_3OD): δ1.22 (1H, *td*, J = 13.0, 11.5 Hz, H-13), 1.81 (1H, *ddd*, J = 12.5, 11.0, 3.5 Hz, H-6), 2.17 (1H, *dt*, J = 13.0, 3.0 Hz, H-13), 2.20 (1H, *dt*, J = 15.5, 3.5 Hz, H-5), 2.40 (1H, *ddd*, J = 15.5, 11.0, 3.5 Hz, H-5), 2.63 (1H, *ddd*, J = 10.0, 5.5, 1.5 Hz, H-12), 2.85 (1H, *dddd*, J = 13.0, 5.5, 3.0, 2.5 Hz, H-12a), 3.85 (3H, *s*, OMe), 3.93 (1H, *br d*, J = 12.0 Hz, H-6′), 4.04 (1H, *dt*, J = 12.5, 3.5 Hz, H-6), 4.36 (1H, *dd*, J = 11.5, 3.0 Hz, H-13a), 5.16 (1H, *dd*, J = 10.0, 2.0 Hz, H-15), 5.25 (1H, *dd*, J = 17.0, 2.0 Hz, H-15), 5.44 (1H, *d*, J = 1.5 Hz, H-11), 5.46 (1H, *dt*, J = 17.0, 10.0 Hz, H-14), 6.30 (1H, *d*, J = 16.0 Hz, H-α), 6.43 (1H, *s*, H-4), 6.59 (1H, *s*, H-1), 6.76 (1H, *d*, J = 8.0 Hz, H-5″), 7.02 (1H, *dd*, J = 8.0, 2.0 Hz, H-6″), 7.15 (1H, *d*, J = 2.0 Hz, H-2″), 7.36 (1H, *d*, J = 2.5 Hz, H-9), 7.60 (1H, *d*, J = 16.0 Hz, H-β). ^{13}C NMR: Table 1. SIMS *m/z*: 668 [M + H]$^+$, 330, 177; HR-SIMS Found 668.2359 [M + H]$^+$; $C_{34}H_{38}NO_{13}$ requires 668.2344.

2′-O-trans-*Feruloylalangiside* (**2**). Amorphous powder. $[\alpha]_D^{24}$ − 153° (MeOH; *c* 1.0). UV λ_{max}^{MeOH} nm (log ε): 221sh (4.45), 232 (4.47), 293 (4.12), 328.5 (4.22). IR ν_{max}^{KBr} cm^{-1}: 3405, 1713, 1655, 1630, 1593, 1514, 901. ^{1}H NMR (CD_3OD): δ1.20 (1H, *td*, J = 13.0, 11.5 Hz, H-13), 1.80 (1H, *ddd*, J = 12.5, 11.5, 3.0 Hz, H-6), 2.18 (1H, *dt*, J = 13.0, 3.5 Hz, H-13), 2.29 (1H, *dt*, J = 15.5, 3.0 Hz, H-5), 2.47 (1H, *ddd*, J = 15.5, 11.5, 4.5 Hz, H-5), 2.63 (1H, *ddd*, J = 10.0, 5.5, 1.5 Hz, H-12), 2.86 (1H, *dddd*, J = 13.0, 5.5, 3.5, 2.5 Hz, H-12a), 3.79 and 3.86 (6H, each *s*, 2 × OMe), 3.93 (1H, *br d*, J = 12.0 Hz, H-6′), 4.08 (1H, *ddd*, J = 12.5, 4.5, 3.0 Hz, H-6), 4.38 (1H, *dd*, J = 11.5, 3.5 Hz, H-13a), 5.16 (1H, *dd*, J = 10.0, 2.0 Hz, H-15), 5.25 (1H, *dd*, J = 17.0, 2.0 Hz, H-15), 5.44 (1H, *d*, J = 1.5 Hz, H-11), 5.45 (1H, *dt*, J = 17.0, 10.0 Hz, H-14), 6.30 (1H, *d*, J = 15.5 Hz, H-α), 6.58 (1H, *s*, H-4), 6.63 (1H, *s*, H-1), 6.76 (1H, *d*, J = 8.0 Hz, H-5″), 7.02 (1H, *dd*, J = 8.0, 2.0 Hz, H-6″), 7.16 (1H, *d*, J = 2.0 Hz, H-2″), 7.37 (1H, *d*, J = 2.5 Hz, H-9), 7.60 (1H, *d*, J = 15.5 Hz, H-β). ^{13}C NMR: Table 1. SIMS *m/z*: 704 [M + Na]$^+$, 682 [M + H]$^+$, 344, 178, 177; HR-SIMS Found 682.2497 [M + H]$^+$; $C_{35}H_{40}NO_{13}$ requires 682.2501.

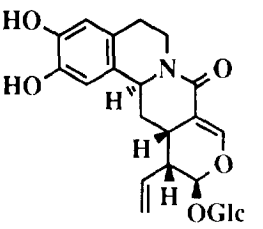
2′-O-trans-*Feruloyl*-3-O-*demethyl*-2-O-*methylalangiside* (**3**). Amorphous powder. $[\alpha]_D^{28}$ − 115° (MeOH; *c* 0.43). UV λ_{max}^{MeOH} nm (log ε): 221 (4.45), 231.5 (4.46), 287sh (4.09), 292.5 (4.10), 328.5 (4.20). IR ν_{max}^{KBr} cm^{-1}: 3384, 1705, 1655, 1628, 1593, 1516, 905. ^{1}H NMR (CD_3OD): δ1.22 (1H, *td*, J = 13.0, 11.5 Hz, H-13), 1.74 (1H, *ddd*, J = 12.5, 11.5, 3.0 Hz, H-6), 2.24 (1H, *dt*, J = 15.5, 3.0 Hz, H-5), 2.26 (1H, *dt*, J = 13.0, 3.5 Hz, H-13), 2.43 (1H, *ddd*, J = 15.5, 11.5, 4.5 Hz, H-5), 2.64 (1H, *ddd*, J = 10.0, 5.5, 2.0 Hz, H-12), 2.88 (1H, *dddd*, J = 13.0, 5.5, 3.5, 2.5 Hz, H-12a), 3.83 and 3.85 (6H, each *s*, 2 × OMe), 3.93 (1H, *dd*, J = 12.0, 1.5 Hz, H-6′), 4.12 (1H, *ddd*, J = 12.5, 4.5, 3.0 Hz, H-6), 4.44 (1H, *br d*, J = 11.5 Hz, H-13a), 5.16 (1H, *dd*, J = 10.0, 2.0 Hz, H-15), 5.26 (1H, *dd*, J = 17.0, 2.0 Hz, H-15), 5.45 (1H, *d*, J = 2.0 Hz, H-11), 5.46 (1H, *dt*, J = 17.0, 10.0 Hz, H-14), 6.30 (1H, *d*, J = 16.0 Hz, H-α), 6.46 (1H, *s*, H-4), 6.75 (1H, *s*, H-1), 6.75 (1H, *d*, J = 8.0 Hz, H-5″), 7.01 (1H, *dd*, J = 8.0, 2.0 Hz, H-6″), 7.15 (1H, *d*, J = 2.0 Hz, H-2″), 7.38 (1H, *d*, J = 2.5 Hz, H-9), 7.61 (1H, *d*, J = 16.0 Hz, H-β). ^{13}C NMR: Table 1. SIMS *m/z*: 682 [M + H]$^+$, 506, 344, 177; HR-SIMS Found 682.2500 [M + H]$^+$; $C_{35}H_{40}NO_{13}$ requires 682.2501.



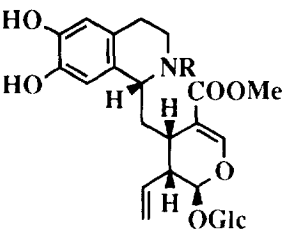
1: R^1=R^2=R^4=H, R^3=*trans*-feruloyl
2: R^1=Me, R^2=R^4=H, R^3=*trans*-feruloyl
3: R^1=R^4=H, R^2=Me, R^3=*trans*-feruloyl
4: R^1=R^2=R^4=H, R^3=*trans*-sinapoyl
5: R^1=Me, R^2=R^4=H, R^3=*trans*-sinapoyl
6: R^1=R^4=H, R^2=Me, R^3=*trans*-sinapoyl



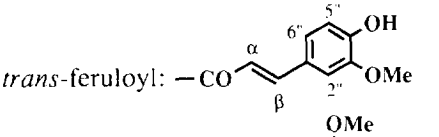
7: R^1=Me, R^2=R^4=H, R^3=—CO—
8: R^1=R^2=R^3=R^4=H
10: R^1=R^2=R^3=H, R^4=feruloyl
11: R^1=Me, R^2=R^3=R^4=H
12: R^1=R^3=R^4=H, R^2=Me



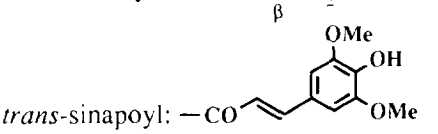
9



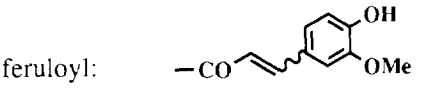
13: R=H
14: R=Ac



trans-feruloyl: —CO—



trans-sinapoyl: —CO—



feruloyl: —CO—

2′-O-trans-*Sinapoyldemethylalangiside* (**4**). Crystalline solid, mp 183.5–186° (H_2O). $[\alpha]_D^{26}$ −155° (MeOH; *c* 0.43). UV λ_{max}^{MeOH} nm (log ε): 230 (4.52), 235sh (4.51), 297 (4.02), 332 (4.25). IR ν_{max}^{KBr} cm^{-1}: 3397, 1699, 1655, 1635, 1595, 1516, 905. ^1H NMR (CD_3OD): δ1.22 (1H, *td*, *J* = 13.0, 11.5 Hz, H-13), 1.75 (1H, *ddd*, *J* = 12.5, 11.5, 3.5 Hz, H-6), 2.16 (1H, *dt*, *J* = 13.0, 3.5 Hz, H-13), 2.21 (1H, *dt*, *J* = 15.5, 3.5 Hz, H-5), 2.40 (1H, *ddd*, *J* = 15.5, 11.5, 3.5 Hz, H-5), 2.62 (1H, *ddd*, *J* = 10.0, 5.5, 1.5 Hz, H-12), 2.85 (1H, *dddd*, *J* = 13.0, 5.5, 3.5, 2.5 Hz, H-12a), 3.79 (6H, *s*, 2 × OMe), 3.93 (1H, *br d*, *J* = 12.0 Hz, H-6′), 4.07 (1H, *dt*, *J* = 12.5, 3.5 Hz, H-6), 4.35 (1H, *dd*, *J* = 11.5, 3.5 Hz, H-13a), 5.16 (1H, *dd*, *J* = 10.0, 2.0 Hz, H-15), 5.25 (1H, *dd*, *J* = 17.0, 2.0 Hz, H-15), 5.45 (1H, *d*, *J* = 1.5 Hz, H-11), 5.46 (1H, *dt*, *J* = 17.0, 10.0 Hz, H-14), 6.33 (1H, *d*, *J* = 15.5 Hz, H-α), 6.43 (1H, *s*, H-4 or H-1), 6.60 (1H, *s*, H-1 or H-4), 6.85 (2H, *s*, H-2″ and H-6″), 7.37 (1H, *d*, *J* = 2.5 Hz, H-9), 7.60 (1H, *d*, *J* = 15.5 Hz, H-β). ^{13}C NMR: Table 1. SIMS *m/z*: 698 $[M + H]^+$, 330, 207; HR-SIMS Found 698.2435 $[M + H]^+$; $C_{35}H_{40}NO_{14}$ requires 698.2450.

2′-O-trans-*Sinapoylalangiside* (**5**). Crystalline solid, mp 179–181° (H_2O). $[\alpha]_D^{23}$ −157° (MeOH; *c* 1.0). UV λ_{max}^{MeOH} nm (log ε): 231.5 (4.55), 294 (4.01), 333 (4.27). IR ν_{max}^{KBr} cm^{-1}: 3394, 1717, 1655, 1636, 1597, 1516, 899. ^1H NMR (CD_3OD): δ1.21 (1H, *td*, *J* = 13.0, 11.5 Hz, H-13), 1.73 (1H, *ddd*, *J* = 13.0, 11.5, 3.0 Hz, H-6), 2.17 (1H, *dt*, *J* = 13.0, 3.5 Hz, H-13), 2.30 (1H, *dt*, *J* = 15.5, 3.0 Hz, H-5), 2.47 (1H, *ddd*, *J* = 15.5, 11.5, 4.5 Hz, H-5), 2.63 (1H, *ddd*, *J* = 10.0, 5.5, 1.5 Hz, H-12), 2.85 (1H, *dddd*, *J* = 13.0, 5.5, 3.5, 2.5 Hz, H-12a), 3.789 (6H, *s*, 2 × OMe), 3.792 (3H, *s*, OMe), 3.93 (1H, *br d*, *J* = 12.0 Hz, H-6′), 4.12 (1H, *ddd*, *J* = 13.0, 4.5, 3.0 Hz, H-6), 4.37 (1H, *dd*, *J* = 11.5, 3.5 Hz, H-13a), 4.89 (1H, *d*, *J* = 8.0 Hz, H-1′), 4.92 (1H, *t*, *J* = 8.0 Hz, H-2′), 5.16 (1H, *dd*, *J* = 10.0, 2.0 Hz, H-15), 5.25 (1H, *dd*, *J* = 17.0, 2.0 Hz, H-15), 5.45 (1H, *dt*, *J* = 17.0, 10.0 Hz, H-14), 5.45 (1H, *d*, *J* = 1.5 Hz, H-11), 6.33 (1H, *d*, *J* = 15.5 Hz, H-α), 6.58 (1H, *s*, H-4), 6.64 (1H, *s*, H-1), 6.86 (2H, *s*, H-2″ and H-6″), 7.38 (1H, *d*, *J* = 2.5 Hz, H-9), 7.61 (1H, *d*, *J* = 15.5 Hz, H-β). ^{13}C NMR: Table 1. SIMS *m/z*: 712 $[M + H]^+$, 344, 326, 207, 178; HR-SIMS Found 712.2641 $[M + H]^+$, $C_{36}H_{42}NO_{14}$ requires 712.2607.

2′-O-trans-*Sinapoyl*-3-O-*demethyl*-2-O-*methylalangiside* (**6**). Amorphous powder. $[\alpha]_D^{28}$ −126° (MeOH; *c* 0.39). UV λ_{max}^{MeOH} nm (log ε): 230 (4.51), 284sh (3.92), 293.5 (3.96), 332 (4.20). IR ν_{max}^{KBr} cm^{-1}: 3415, 1715, 1655, 1632, 1593, 1516, 905. ^1H NMR (CD_3OD): δ1.23 (1H, *td*, *J* = 13.0, 11.5 Hz, H-13), 1.68 (1H, *ddd*, *J* = 12.5, 11.5, 3.0 Hz, H-6), 2.25 (2H, *m*, H-5 and H-13), 2.43 (1H, *ddd*, *J* = 15.5, 11.5, 4.0 Hz, H-5), 2.64 (1H, *ddd*, *J* = 10.0, 5.5, 1.5 Hz, H-12), 2.88 (1H, *dddd*, *J* = 13.0, 5.5, 3.5, 2.5 Hz, H-12a), 3.78 (6H, *s*, 2 × OMe), 3.83 (3H, *s*, OMe), 3.94 (1H, *br d*, *J* = 12.0 Hz, H-6′), 4.16 (1H, *ddd*, *J* = 12.5, 4.0, 3.0 Hz, H-6), 4.43 (1H, *br d*, *J* = 11.5 Hz, H-13a), 4.91 (1H, *d*, *J* = 8.0 Hz, H-1′), 5.16 (1H, *dd*, *J* = 10.0, 2.0 Hz, H-15), 5.26 (1H, *dd*, *J* = 17.0, 2.0 Hz, H-15), 5.46 (1H, *d*, *J* = 1.5 Hz, H-11), 5.46 (1H, *dt*, *J* = 17.0, 10.0 Hz, H-14), 6.33 (1H, *d*, *J* = 16.0 Hz, H-α), 6.46 (1H, *s*, H-4), 6.76 (1H, *s*, H-1), 6.85 (2H, *s*, H-2″ and H-6″), 7.39 (1H,

d, $J = 2.5$ Hz, H-9), 7.61 (1H, *d*, $J = 16.0$ Hz, H-β). ^{13}C NMR: Table 1. SIMS *m/z*: 734 $[M + Na]^+$, 712 $[M + H]^+$, 344, 326, 207; HR-SIMS Found 712.2594 $[M + H]^+$, $C_{36}H_{42}NO_{14}$ requires 712.2607.

2′-O-trans-[4-(1,3-*Dihydroxypropoxy*)-3-*methoxycinnamoyl*]*alangiside* (**7**). Crystalline solid, mp 166–169° (H_2O). $[\alpha]_D^{27} - 153°$ (MeOH; *c* 0.51). UV λ_{max}^{MeOH} nm (log ε): 222sh (4.45), 232 (4.48), 293 (4.22), 326 (4.22). IR ν_{max}^{KBr} cm^{-1}: 3400, 1705, 1655, 1632, 1597, 1581, 1510, 901; ^{1}H NMR (CD_3OD) : δ1.21 (1H, *td*, $J = 13.0$, 11.5 Hz, H-13), 1.75 (1H, *ddd*, $J = 12.5$, 12.0, 3.0 Hz, H-6), 2.18 (1H, *dt*, $J = 13.0$, 3.0 Hz, H-13), 2.31 (1H, *dt*, $J = 15.5$, 3.0 Hz, H-5), 2.47 (1H, *ddd*, $J = 15.5$, 12.0, 4.5 Hz, H-5), 2.63 (1H, *ddd*, $J = 10.0$, 5.5, 1.5 Hz, H-12), 2.85 (1H, *m*, H-12a), 3.71, 3.75 (2H, each *dd*, $J = 17.0$, 5.0 Hz, H_2-1‴ or H_2-3‴), 3.74, 3.77 (2H, each *dd*, $J = 17.0$, 5.0 Hz, H_2-3‴ or H_2-1‴), 3.79, 3.86 (6H, each *s*, 2 × OMe), 3.93 (1H, *dd*, $J = 12.0$, 1.0 Hz, H-6′), 4.09 (1H, *ddd*, $J = 12.5$, 4.5, 3.0 Hz, H-6), 4.33 (1H, *quint.*, $J = 5.0$ Hz, H-2‴), 4.37 (1H, *dd*, $J = 11.5$, 3.0 Hz, H-13a), 5.16 (1H, *dd*, $J = 10.0$, 2.0 Hz, H-15), 5.25 (1H, *dd*, $J = 17.0$, 2.0 Hz, H-15), 5.45 (1H, *d*, $J = 1.5$ Hz, H-11), 5.45 (1H, *dt*, $J = 17.0$, 10.0 Hz, H-14), 6.37 (1H, *d*, $J = 16.0$ Hz, H-α), 6.58 (1H, *s*, H-4), 6.63 (1H, *s*, H-1), 7.04 (1H, *d*, $J = 8.5$ Hz, H-5″), 7.10 (1H, *dd*, $J = 8.5$, 2.0 Hz, H-6″), 7.22 (1H, *d*, $J = 2.0$ Hz, H-2″), 7.38 (1H, *d*, $J = 2.5$ Hz, H-9), 7.63 (1H, *d*, $J = 16.0$ Hz, H-β). ^{13}C NMR: Table 1. SIMS *m/z*: 756 $[M + H]^+$, 413, 344, 326, 251, 178, 177; HR-SIMS Found 756.2869 $[M + H]^+$; $C_{38}H_{46}NO_{15}$ requires 756.2869.

Acknowledgements—The excellent technical assistance of Misses H. Uno, A. Obata, K. Takatani and N. Yamamoto is acknowledged. Thanks are also due to Dr M. Sugiura (Kobe Pharmaceutical University) for NMR spectra and to Dr K. Saiki (Kobe Pharmaceutical University) for MS measurements.

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