[Chem. Pharm. Bull. 26(7)2111—2121(1978)]

UDC 547.918.02.05 : 581.192

The Glycosides of *Martynia louisiana* Mill. A New Phenylpropanoid Glycoside, Martynoside

Hiroshi Sasaki, Heihachiro Taguchi, Tohru Endo, Itiro Yosioka,[1a] Kimio Higashiyama, and Hirotaka Otomasu[1b]

Tsumura Laboratory[1a] and Hoshi College of Pharmacy[1b]

(Received December 27, 1977)

A new phenylpropanoid glycoside, martynoside (**1**), was isolated from the leaves and stems of *Martynia louisiana* Mill. (syn. *Proboscidea Jussieui* Steud.)(Martyniaceae) together with acteoside (**2**), roseoside (**3**), cornoside (**4**), ajugol (**5**) and mioporoside (**6**). The structure of martynoside was elucidated to be **1** by chemical and spectral evidence. The isolation of catalpol (**7**) and cornoside (**4**) from the fresh unripe fruits was also described.

Keywords——*Martynia louisiana* Mill.; Martyniaceae; phenylpropanoid glycoside; martynoside; acteoside; roseoside; cornoside; ajugol; mioporoside; catalpol

Martynia louisiana Mill. (syn., *Proboscidea Jussieui* Steud., Japanese name, Tsunogoma) (Martyniaceae) is a native plant from Indiana to Utah, Texas and New Mexico in USA.[2] The present paper describes the structure of a new phenylpropanoid glycoside[3] named mar-

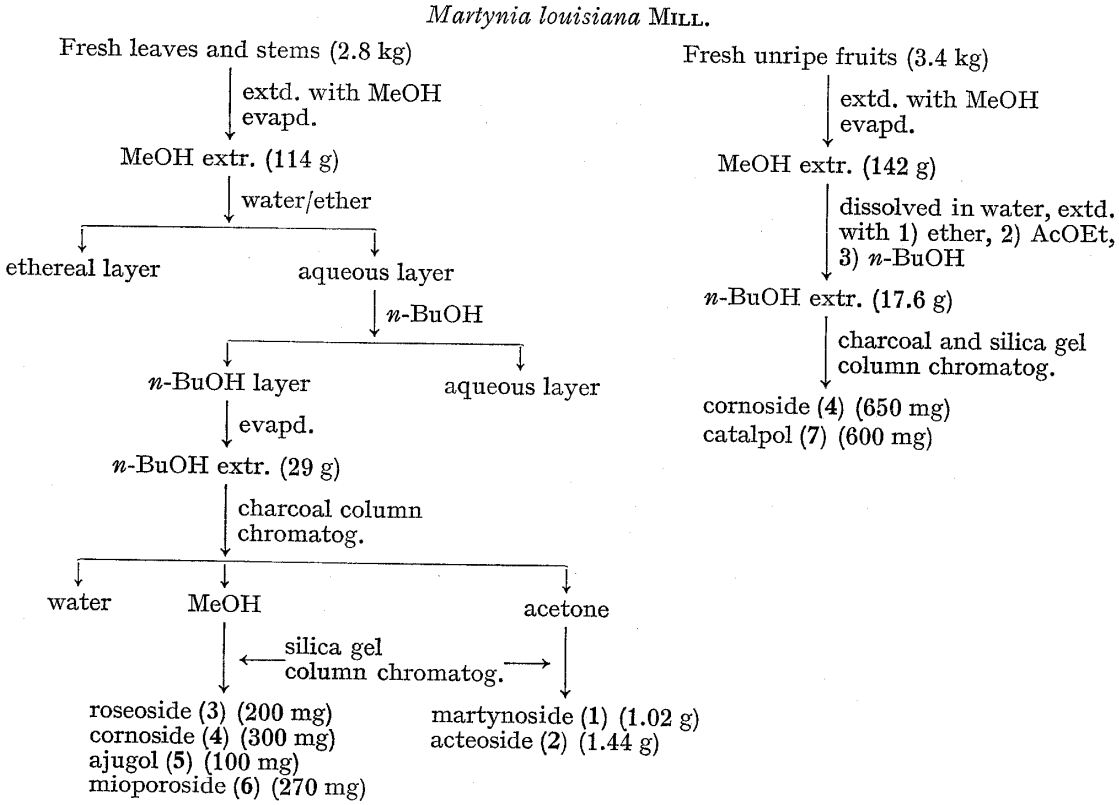
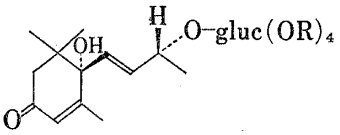


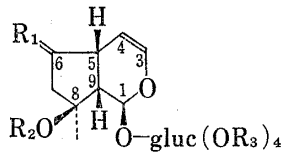
Chart 1. Isolation Procedure of Glycosides

1) Location: *a*) *1421, Izumi, Komae-shi, Tokyo*; *b*) *Ebara, 2-4-41, Shinagawa-ku, Tokyo.*
2) L.H. Bailey, "The Standard Cyclopedia of Horticulture," Vol. II, the 20th printing, The Macmillan Company, New York, 1963, p. 2005.
3) *a*) A. Stoll, J. Renz, and A. Brack, *Helv. Chim. Acta*, **33**, 1877 (1950); *b*) L. Birkofer, C. Kaiser, and U. Thomas, *Z. Naturforsh.*, **1968**, 1051; *c*) K.V. Rao and R.J. Juneau, *Lloydia*, **38**, 339 (1975); *d*) G. Nonaka and I. Nishioka, *Phytochemistry*, **16**, 1265 (1977).

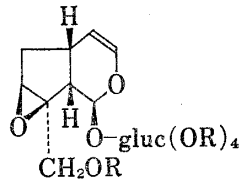
tynoside (**1**) isolated from the fresh leaves and stems of this plant as well as the isolation of a known phenylpropanoid glycoside, acteoside (**2**),[3b,d] a glucoside of abscisic acid analogous, roseoside (**3**),[4] a quinol glucoside, cornoside (**4**),[5] two iridoid glucosides, ajugol (leonuride) (**5**)[6] and mioporoside (**6**),[7] and also describes the isolation of catalpol (**7**)[8] from the fresh fruits. The glycosides were isolated by the procedure shown in Chart 1.



3 : R=H
3a : R=−COCH$_3$



5 : R$_1$=α-OH, β-H R$_2$=R$_3$=H
5a : R$_1$=α-OCOCH$_3$, β-H R$_2$=H R$_3$=−COCH$_3$
5b : R$_1$=α-OCOCH$_3$, β-H R$_2$=R$_3$=−COCH$_3$
6 : R$_1$=α-H, β-OH R$_2$=R$_3$=H
6a : R$_1$=α-H, β-OCOCH$_3$ R$_2$=H R$_3$=−COCH$_3$
6b : R$_1$=α-H, β-OCOCH$_3$ R$_2$=R$_3$=−COCH$_3$



7 : R=H
7a : R=−COCH$_3$

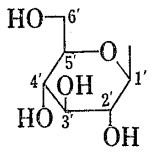
gluc = 

Chart 2

The fresh leaves and stems were extracted with hot methanol and the extract, after concentration, was defatted with ether and then extracted with *n*-butanol. The *n*-butanolic extract was purified by column chromatography on charcoal developing with water, methanol and acetone. The methanol eluate was rechromatographed on silica gel developing with chloroform–methanol mixture to furnish roseoside (**3**) (yield, 0.007%), cornoside (**4**) (0.01%), ajugol (**5**) (0.004%) and mioporoside (**6**) (0.01%). The acetone eluate gave martynoside (**1**) (0.04%) and acteoside (**2**) (0.05%) by silica gel column chromatography developing with chloroform–methanol mixture. Catalpol (**7**) (0.02%) was isolated from the fresh unripe fruits as well as cornoside (0.02%) by the same procedure as in the case of ajugol and mioporoside.

Roseoside (**3**) was isolated as a colourless amorphous powder, which gave the tetraacetate (**3a**), $C_{27}H_{38}O_{12}$, colourless needles, mp 158—159°, $[\alpha]_D^{28}$ +80.4° (c=0.67, $CHCl_3$), possessing the similar physical constants to those of roseoside tetraacetate. **3a** was thus identified with the authentic sample of roseoside tetraacetate by the direct comparison (mixed mp and IR).

Cornoside (**4**) was obtained as a colourless amorphous powder. **4** shows an absorption maximum at 226 nm (log ε, 3.99) in the ultraviolet (UV) spectrum and the absorption bands at 3375 (OH), 1670 (>C=O) and 1620 cm^{-1} (>C=C<) in the infrared (IR) spectrum, indicating the presence of the α,β-unsaturated ketone. On acetylation, **4** afforded the tetraacetate (**4a**), $C_{22}H_{28}O_{12}$, amorphous powder, $[\alpha]_D^{31}$ −10.2° (c=0.35, EtOH), IR (in $CHCl_3$): 3500 (OH), and

4) D.S. Bhakuni, P.P. Joshi, H. Uprety, and R.S. Kapil, *Phytochemistry*, **13**, 2541 (1974).
5) S.R. Jensen, A. Kjoer, and B.J. Nielsen, *Acta Chem. Scand.*, **27**, 367 (1973).
6) K. Weniges, P. Kloss, and W-D. Henkels, *Ann. Chem.*, **1973**, 566; M. Guiso, R. Marini-Bettolo, and A. Agostini, *Gazz. Chim. Ital.*, **104**, 25 (1974).
7) A. Bianco, M. Guiso, C. Iavarone, and C. Trogolo, *Gazz. Chim. Ital.*, **105**, 175 (1975).
8) J.M. Bobbitt, D.W. Spiggle, S. Mahboob, H. Schmid, and W. von Philipsborn, *J. Org. Chem.*, **31**, 500 (1966); I. Kitagawa, K. Hino, T. Nishimura, E. Iwata, and I. Yosioka, *Chem. Pharm. Bull.* (Tokyo), **19**, 2534 (1971).

the pentaacetate (**4b**), $C_{24}H_{30}O_{13}$, amorphous powder, $[\alpha]_D^{30}$ −18.4° (c=1.99, EtOH), IR (in $CHCl_3$): no OH. Enzymatic hydrolysis of **4** with β-glucosidase followed by acetylation (Ac_2O/pyridine) afforded **4c**, $C_{10}H_{12}O_4$ (*m/e*: 136, M^+–AcOH), IR (in $CHCl_3$): no OH, 1740 (ester), 1690 (>C=O), as a colourless oil. From the above data, **4** was assumed to be cornoside. The ^{13}C nuclear magnetic resonance (CMR) spectrum of **4** also supports the above assumption (Chart 3).

Ajugol (**5**) was isolated as an amorphous powder, which gave the pentaacetate (**5a**), colourless needles, mp 125.5—126.5°, and the hexaacetate (**5b**), colourless needles, mp 172—174°. The both compounds (**5a** and **5b**) were identified with the authentic samples by the direct comparison (mixed mp, IR, ^1H NMR (PMR) and TLC).[9]

Mioporoside (**6**) was isolated as an amorphous powder and gave the pentaacetate (**6a**), $C_{25}H_{34}O_{14}$, colourless needles, mp 167.5—168.5° and the hexaacetate (**6b**), $C_{27}H_{36}O_{15}$, colourless prisms, mp 177.5—179°, by acetylation with acetic anhydride and pyridine. **6a** was identified with the authentic sample of mioporoside pentaacetate by the direct comparison (mixed mp and IR).

Catalpol (**7**) was isolated as colourless needles, $C_{15}H_{22}O_{10}$, mp 210—212°, $[\alpha]_D^{27}$ −97.4° (c=0.58, MeOH). Its hexaacetate (**7a**), mp 143—144.5°, was identified with catalpol hexaacetate by the direct comparison (mixed mp, IR and TLC).

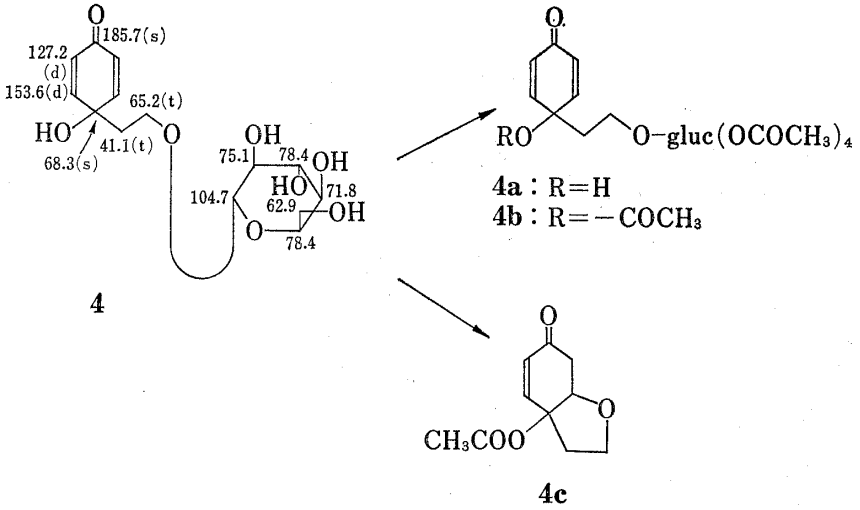


Chart 3. CMR Spectrum was taken in C_6D_5N at 25° (δ ppm from TMS)

Martynoside (**1**) was isolated as an amorphous powder and gives a brown colouration with ethanolic ferric chloride. **1** shows the absorption maxima at 220, 287 and 330 nm in the UV spectrum and shows the absorption bands at 3400 (OH), 1700 (ester), 1625 (>C=C<), 1590 and 1510 (aromatic) in the IR spectrum. On acetylation with acetic anhydride and pyridine at room temperature, **1** afforded the colourless amorphous heptaacetate (**8**), $C_{45}H_{54}O_{22}$, $[\alpha]_D^{25}$ −21.4° (c=0.26, $CHCl_3$), whose PMR spectrum (in $CDCl_3$) revealed a doublet methyl (δ 1.05, J=6 Hz), assignable to the methyl group of rhamnose, five alcoholic acetoxyl (δ 1.80—2.10), two phenolic acetoxyl (δ 2.31, s), two methoxyl (δ 3.82, 3.83, s), a benzylic methylene (δ 2.81, t, J=7 Hz) and two olefinic protons (δ 6.37 and 7.70) with the coupling constant J=16 Hz. The mass spectrum of **8** revealed the strong peak at *m/e* 273 due to the terminal acetylated rhamnose moiety.

Partial hydrolysis of **1** with 2.5% sodium methoxide afforded ferulic acid methyl ester and desacyl-glycoside (**9**), which gave a brown colouration with ethanolic ferric chloride.

9) **5b** was prepared from ajugol (leonuride) isolated from *Leonurus sibiricus* L. (Labiatae). The author's unpublished data.

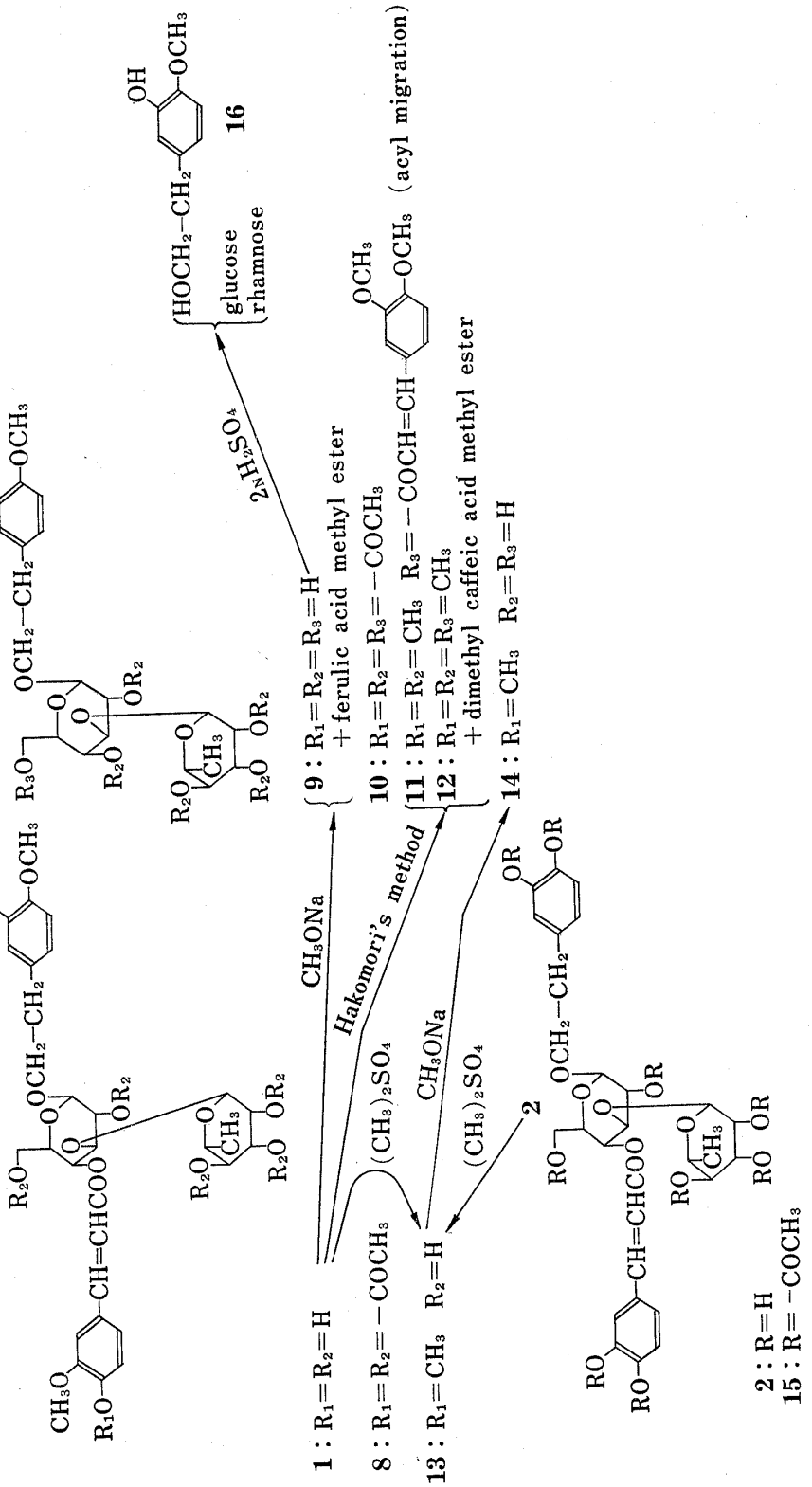


Chart 4

The heptaacetate of **9** (**10**), $C_{35}H_{46}O_{19}$, $[\alpha]_D^{26}$ −27.5° (c=0.24, $CHCl_3$) revealed six alcoholic acetoxyl (δ 1.95—2.12), a phenolic acetoxyl (δ 2.30), a methoxyl (δ 3.82), and three aromatic protons (δ 6.8—7.2) in its PMR spectrum (in $CDCl_3$), and showed the lack of the olefinic proton signals observed at δ 6.37 and 7.70 in **8**. These data suggested that **1** might be a phenylpropanoid glycoside such as echinacoside, acteoside and conandroside described in the literature.[3)]

Acid hydrolysis of **9** with 2N-sulfuric acid afforded 2-(3′-hydroxy-4′-methoxy-phenyl)-ethanol (**16**), which was identified with the authentic sample prepared by the procedure shown in Chart 5. On the other hand, the presence of glucose and rhamnose in the hydrolysate in the ratio 1:1 was proved by gas–liquid chromatography (GLC). From the above results, it was suggested that **1** should be 2-(3′-hydroxy-4′-methoxy-phenyl)-ethanol-1-O-rhamnosyl-(feruloyl)-glucoside.

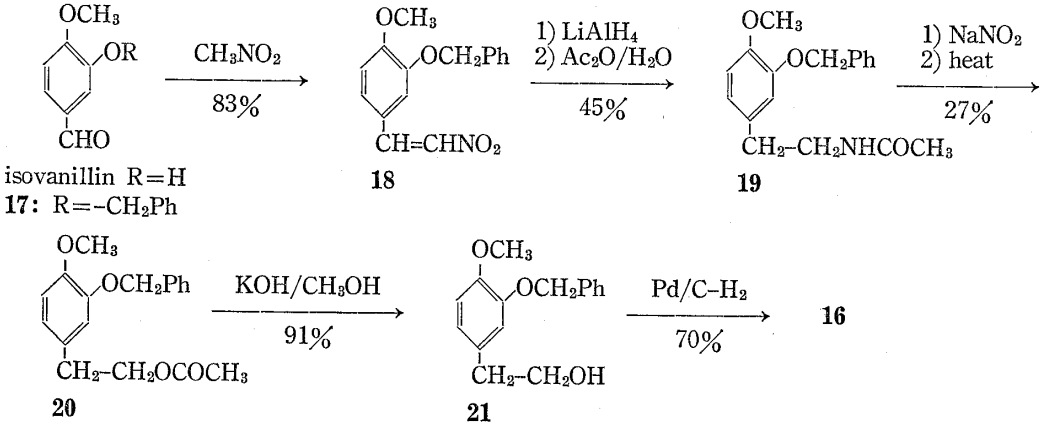


Chart 5

Next step, methylation of **1** by the Hakomori's method[10)] gave the colourless amorphous heptamethyl ether (**11**), $C_{38}H_{54}O_{15}$, $[\alpha]_D^{32}$ −52.0° (c=0.42, $CHCl_3$), IR(in $CHCl_3$): no OH, the colourless amorphous heptamethyl ether of **9** (**12**), $C_{28}H_{46}O_{12}$, $[\alpha]_D^{32}$ −29.4° (c=0.39, $CHCl_3$), and dimethyl caffeic acid methyl ester. The PMR spectrum of **11** showed the signal (δ 4.43, d-like, 2H, J=3 Hz) assignable to the acylated $C_{(6)}$-methylene protons of the glucose moiety, whereas **12** showed no such a signal in the same region, suggesting that dimethyl caffeic acid is linked to the $C_{(6)}$ hydroxyl group of the glucose moiety in **11**. **11** was hydrolyzed by 85% formic acid and the products were converted into the alditol acetates.[11)] The presence of 1,5-di-O-acetyl-2,3,4-tri-O-methyl-rhamnitol and 1,3,5,6-tetra-O-acetyl-2,4-di-O-methyl-glucitol were revealed by GLC.

On the other hand, methanolysis of **12** with 5% methanolic hydrochloric acid furnished methyl 2,3,4-tri-O-methyl-rhamnopyranoside and methyl 2,4,6-tri-O-methyl-glucopyranoside, which were identified with the authentic samples by GLC and TLC. The alditol acetates prepared from **12** also revealed the presence of 1,5-di-O-acetyl-2,3,4-tri-O-methyl-rhamnitol and 1,3,5-tri-O-acetyl-2,4,6-tri-O-methyl-glucitol. On the basis of the above data, the structure of the major heptamethyl ether prepared from **1** by the Hakomori's method was elucidated to be **11**.

However, since the migration of the acyl group from the $C_{(4)}$- to $C_{(6)}$-position of the glucose moiety was reported in the several glycosides during partial hydrolysis and permethylation with the Kuhn's method,[3b,d)] the position of the feruloyl group in **1** is not certain. In order to confirm the real position of the feruloyl group, **1** was methylated with dimethyl-

10) S. Hakomori, *J. Biochem.* (Tokyo), **55**, 205 (1964).
11) J.S. Sawardeker, J.H. Sloneker, and A. Jeanes, *Anal. Chem.*, **37**, 1602 (1965); H. Björndal, B. Lindberg, and S. Svensson, *Acta Chem. Scand.*, **21**, 1801 (1967); *Carbohydrate Res.*, **5**, 433 (1967).

TABLE I. ^{13}C Chemical Shifts of Sugar Moieties of **1**, **14**, Methyl Glucoside and Methyl Rhamnoside (δ ppm from TMS in C_5D_5N at 25°)

		1[a]	14[b]		Me-Gluc[c]	Me-Rham[c]
Gluc	C-1	103.9	104.3	C-1	105.5	102.4
	C-2	73.6	74.1	C-2	74.9	72.6
	C-3	80.5	83.9	C-3	78.3	72.0
	C-4	70.1	69.9	C-4	71.6	73.7
	C-5	76.0	78.3	C-5	78.3	69.4
	C-6	61.9	62.6	C-6	62.7	18.5
Rham	C-1	102.8[d]	102.9			
	C-2	72.2	72.7			
	C-3	72.2	72.5			
	C-4	75.5	75.5			
	C-5	70.1	69.9			
	C-6	19.0	18.6			

a) Assigned by PRFT method.
b) ^{13}C Chemical shifts of the aglycone part of **14**: C-1 (70.8, t), C-2 (36.1, t), C-1′ (132.1, s), C-2′ (113.8, d), C-6′ (121.5, d), C-3′ and -4′ (unclear due to overlapping with pyridine signals).
c) Me-Gluc: methyl β-D-glucopyranoside, Me-Rham: methyl α-L-rhamnopyranoside.[14]
d) $J_{C_1\text{-}H_1}$=172.7 Hz.

sulfate. The resulted dimethyl ether (**13**), amorphous powder, was identified with acteoside tetramethyl ether (**13**)[3d] by the comparison of IR, PMR and TLC, indicating that ferulic acid links to the $C_{(4)}$-hydroxyl group of the glucose moiety.

Furthermore, the CMR spectral analysis of **1** comparing with **14**, which was prepared from **13** by hydrolysis with sodium methoxide, also supports the structure **1** (Table I). A down field shift (+5.4 ppm) of C-3 and the high field shifts of C-2 and C-4(−0.7——0.8 ppm) of the glucose moiety in **14**, comparing with the spectrum of methyl glucoside, indicate that its C-3 hydroxyl group is combined with rhamnose (glycosidation shift[12]). The spectrum of **1** shows a down field shift (+0.2 ppm) of C-4 and the high field shifts of C-3 (−3.4) and C-5 (−2.3) of the glucose moiety, comparing with the spectrum of **14**. On the other hand, the chemical shift of C-6 of the glucose moiety in **1** appears in the almost same region with that of **14**. Considering with the esterification shift, which was investigated in the several acylated glycosides,[13] ferulic acid must link to the $C_{(4)}$-hydroxyl group of the glucose moiety in **1**. In addition, the chemical shifts of C-3 and C-5 carbons as well as the coupling constant of the 1-^{13}C-1-^{1}H of the rhamnose moiety shows the α-linkage between the rhamnose and glucose moieties.[14] The β-linkage between the glucose moiety and the aglycone is proved by the coupling constants of the anomeric protons of glucose moieties in the PMR spectra of **11** (δ 4.32, d, J=7.5 Hz), **12** (δ 4.25, d, J=7.5 Hz) and **13** (δ 4.43, d, J=7.5 Hz).

The structure of martynoside was thus elucidated to be 2-(3′-hydroxy-4′-methoxyphenyl)-ethanol-1-O-α-L-rhamnosyl(1→3)-(4-feruloyl)-β-D-glucoside (**1**).

12) T. Usui, N. Yamaoka, K. Matsuda, K. Tuzimura, H. Sugiyama, and S. Seto, *J. Chem. Soc. Perkin I*, **1973**, 2425; R. Kasai, M. Suzuo, J. Asakawa, and O. Tanaka, *Tetrahedron Lett.*, **1977**, 175; K. Tori, S. Seo, Y. Yoshimura, H. Arita, and Y. Tomita, *ibid.*, **1977**, 179.
13) V.M. Chari, M. Jordan, H. Wagner, and P.W. Thies, *Phytochemistry*, **16**, 1110 (1977); S. Asen and R.M. Horowitz, *ibid.*, **16**, 147 (1977); H. Ishii, S. Seo, K. Tori, T. Tozyo, and Y. Yoshimura, *Tetrahedron Lett.*, **1977**, 1227; K. Yamasaki, R. Kasai, Y. Masaki, M. Okihara, O. Tanaka, H. Oshio, S. Takagi, M. Yamaki, K. Masuda, G. Nonaka, M. Tsuboi, and I. Nishioka, *ibid.*, **1977**, 1231.
14) K. Bock, I. Lundt, and C. Pedersen, *Tetrahedron Lett.*, **1973**, 1037; T.E. Walker, R.E. London, T.W. Whaley, R. Barker, and N.A. Matwiyoff, *J. Am. Chem. Soc.*, **98**, 5807 (1976); P.A.J. Gorin and M. Mazurek, *Can. J. Chem.*, **53**, 1212 (1975); I. Sakamoto, K. Yamasaki, and O. Tanaka, *Chem. Pharm. Bull.* (Tokyo), **25**, 844 (1977).

Acteoside (**2**) was isolated as an amorphous powder (no OAc in the PMR) and gave the nonaacetate (**15**), $C_{47}H_{54}O_{24}$, amorphous powder, $[\alpha]_D^{28}$ −25.1° (c=0.31, $CHCl_3$) by acetylation with acetic anhydride and pyridine, and gave the tetramethyl ether (**13**) by methylation with dimethyl sulfate. The both compounds (**13** and **15**) were identified with the authentic samples by the direct comparison (IR, PMR and TLC).

Experimental

All melting points were determined on the Yanagimoto Micromelting Point Apparatus (a hot stage type) and uncorrected. The UV spectra were recorded with the Hitachi Digital Spectrophotometer Model 624 and the IR spectra with the Hitachi Model EPI-G2. The PMR spectra were recorded with the Varian Model T-60 and JEOL Model PS-100, and CMR spectra were recorded with the Varian Model FT-80 and JEOL Model FX-100 Spectrometers. Mass spectra were measured with the Hitachi Double Focusing Mass Spectrometer and JEOL-JMS-01SG-2. The specific rotations were measured with the JASCO Model DIP-SL. The Gas Chromatograph used was the Hitachi Gas Chromatograph Model 073 with a hydrogen flame ionization detector. TLC plates were made with silica gel (Kieselgel HF_{254}, Merck). Silica gel (Kieselgel 70—325 mesh, Merck) was used for column chromatography.

Extraction——i) The fresh leaves and stems (2.8 kg) of the plant, collected in September, 1976, were homogenized in MeOH and then extracted with MeOH under reflux for 5 times. The combined extract was concentrated under reduced pressure to give a black mass (114 g), which was dissolved in water and extracted with ether and then *n*-BuOH. The *n*-BuOH extract (29 g) was chromatographed on charcoal (90 g) developing with water, MeOH and acetone. The MeOH eluate (3 g) was rechromatographed on charcoal (10 g) developing with water and then MeOH. The fractions eluted with MeOH were combined and concentrated to give the non-phenolic crude glucosides (1.7 g), which were chromatographed on silica gel (50 g) using $CHCl_3$–MeOH ($CHCl_3$→10% MeOH in $CHCl_3$) successively (each fraction 100 ml) to give roseoside (**3**) (yield, 200 mg, 0.007%, from fr. 18—26, 7% MeOH in $CHCl_3$), cornoside (**4**) (300 mg, 0.01%, from fr. 27—38, 7—8% MeOH in $CHCl_3$), ajugol (**5**) (100 mg, 0.004%, from fr. 39—48, 8—9% MeOH in $CHCl_3$), and mioporoside (**6**) (270 mg, 0.01%, from fr. 49—75, 9—10% MeOH in $CHCl_3$). The acetone eluate (5 g) was rechromatographed on silica gel (100 g) developing with $CHCl_3$–MeOH ($CHCl_3$→10% MeOH in $CHCl_3$) successively (each fraction 250 ml). The fractions eluted with 6—8% MeOH in $CHCl_3$ (fr. 31—56) gave martynoside (**1**) (1.02 g, 0.04%) and the fractions eluted with 10% MeOH in $CHCl_3$ (fr. 76—84) gave acteoside (**2**) (1.44 g, 0.05%).

ii) The fresh unripe fruits (3.4 kg) were homogenized in MeOH and then extracted with MeOH under reflux for 4 times. The combined extract was concentrated under reduced pressure. The residue (142 g) was dissolved in water and extracted with ether, AcOEt, and *n*-BuOH. *n*-BuOH extract (17.6 g) was chromatographed on charcoal (55 g) developing with water, MeOH and acetone. The fractions eluted with MeOH gave the crude glucosides (2.37 g), which were rechromatographed on silica gel (40 g) developing with $CHCl_3$–MeOH ($CHCl_3$→10% MeOH in $CHCl_3$) to give cornoside (**4**) (650 mg, 0.02%) and catalpol (**7**) (600 mg, 0.02%).

Roseoside Tetraacetate (**3a**)——**3** (amorphous powder) (30 mg) was acetylated with Ac_2O and pyridine by the usual method to give colourless needles (from EtOH) (28 mg). *Anal.* Calcd. for $C_{27}H_{38}O_{12}$: C, 54.48; H, 6.91. Found: C, 54.48; H, 6.96. mp 158—159°, $[\alpha]_D^{28}$ +80.4° (c=0.67, $CHCl_3$), UV λ_{max}^{EtOH} nm (log ε): 236 (3.94). IR ν_{max}^{KBr} cm^{-1}: 3400, 1755, 1640. PMR (δ in $CDCl_3$): 1.03 (3H, s), 1.08 (3H, s) (2×–C(CH$_3$)$_2$–), 1.23 (3H, d, J=6 Hz, HO–CH(CH$_3$)–), 1.88 (3H, d, J=1.5 Hz, –HC=C(CH$_3$)–), 2.00—2.08 (12H, each s, 4×OAc), 2.32 (2H, m, $-COCH_2-$), 2.42 (1H, s, OH, D_2O exchangeable), 3.70 (1H, m, $C_{(5')}$–H), 4.17 (1H, m), 4.18 (2H, d-like, $C_{(6')}$–H), 4.57 (1H, d, J=8 Hz, $C_{(1')}$–H), 4.7—5.3 (3H, m, $C_{(2'-4')}$–H), 5.77—5.93 (3H, m, olefinic protons). The compound obtained here was identified with roseoside tetraacetate (**3a**) by the direct comparison (mixed mp and IR).

Cornoside (**4**)——**4** was isolated as a colourless powder. UV λ_{max}^{EtOH} nm (log ε): 226 (3.99). IR ν_{max}^{KBr} cm^{-1}: 3375 (OH), 1670 (>C=O), 1620 (>C=C<). PMR (δ in CD_3OD): 2.03 (2H, t, J=6 Hz, $-CH_2CH_2-O-$), 6.08 (2H, d, J=10.5 Hz), 7.02 (2H, d, J=10.5 Hz) (2×–CH=CH–).

i) Acetylation of Cornoside (**4**), giving Tetraacetate (**4a**) and Pentaacetate (**4b**): A solution of **4** (68 mg) in Ac_2O (1 ml) and pyridine (1 ml) was allowed to stand at room temperature overnight, poured into ice-water, and extracted with AcOEt for 3 times. The combined AcOEt extract was washed with water, dried over Na_2SO_4 and concentrated under reduced pressure. The resulted residue was purified by prep.-TLC developing with ether to give tetraacetate (**4a**) (17 mg) and pentaacetate (**4b**) (23 mg). Cornoside tetraacetate (**4a**): colourless powder. *Anal.* Calcd. for $C_{22}H_{28}O_{12}$: C, 54.54; H, 5.83. Found: C, 54.16; H, 5.99. $[\alpha]_D^{31}$ −10.2° (c=0.35, EtOH), UV λ_{max}^{EtOH} nm (log ε): 228 (3.96). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 3500 (OH), 1760 (ester), 1670 (>C=O), 1625 (>C=C<). PMR (δ in $CDCl_3$): 2.00—2.10 (14H, 4×OAc and $-CH_2-$), 4.50 (1H, d, J=7.5 Hz, $C_{(1')}$–H), 6.15 (2H, d, J=10 Hz), 6.88 (2H, d, J=10 Hz) (2×–CH=CH–).

Cornoside pentaacetate (**4b**): colourless powder. *Anal.* Calcd. for $C_{24}H_{30}O_{13}$: C, 54.75; H, 5.74. Found: C, 54.37; H, 5.87. $[\alpha]_D^{30}$ −18.4° (c=1.99, EtOH). UV λ_{max}^{EtOH} nm (log ε): 238 (3.92). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: no OH, 1760 (ester), 1670 (>C=O), 1625 (>C=C<). PMR (δ in $CDCl_3$): 1.98—2.07 (15H, each s, 5×OAc), 2.12

(2H, t, J=6 Hz, $-C\underline{H}_2CH_2O-$), 4.45 (1H, d, J=7.5 Hz, $C_{(1')}$–H), 6.23 (2H, d, J=10.5 Hz), 6.85 (2H, d, J=10.5 Hz) (2×–CH=CH–).

ii) Enzymatic Hydrolysis of Cornoside (**4**), giving **4c**: To a solution of **4** (53 mg) in an acetate buffer solution (pH 5.0, 20 ml) was added β-glucosidase (MILES LABORATORIES (PTY) LTD.) (6 mg) and the mixture was allowed to stand at 37° for 24 hr, and then extracted with AcOEt. The AcOEt extract was concentrated under reduced pressure and the residue was acetylated with Ac_2O and pyridine by the usual method. The product was purified by prep.-TLC developing with ether to give a colourless oil (**4c**) (17 mg), $C_{10}H_{12}O_4$ [*m/e*: 136 (M^+−AcOH), 97%]. UV λ_{max}^{EtOH}: 215 nm. IR $\nu_{max}^{CHCl_3}$ cm^{-1}: no OH, 1740 (ester), 1690 (>C=O). PMR (δ in C_6D_6): 1.57 (3H, s, OAc), 1.97 (2H, t, J=7 Hz, $-CH_2-$), 2.70 (2H, d, J=4 Hz, $-\underset{|}{C}H-C\underline{H}_2CO$), 3.50 (2H, t, J=7 Hz, $-CH_2C\underline{H}_2-O-$), 4.03 (1H, d/t, J=2/4 Hz, $-\underset{|}{C}H$), 5.70 (1H, d, J=10 Hz), 6.53 1H, d/d, J=10/2 Hz) (–CH=CH–).

Acetylation of Ajugol (5), giving Pentaacetate (5a) and Hexaacetate (5b)——A solution of **5** (21 mg), which was isolated as a colourless powder (PMR, no OAc), in Ac_2O (1 ml) and pyridine (1 ml) was allowed to stand at room temperature overnight and poured into ice-water, and then extracted with AcOEt. The AcOEt extract was concentrated and the residue was purified by prep.-TLC developing with ether to give pentaacetate (**5a**) (5 mg) and hexaacetate (**5b**) (8 mg). Pentaacetate (**5a**): colourless needles (from EtOH), mp 125.5—126.5°. IR ν_{max}^{KBr} cm^{-1}: 3500, 1760, 1660. PMR (δ in $CDCl_3$): 1.37 (3H, s, $-\underset{|}{C}-CH_3$), 1.97—2.10 (15H, each s, 5×OAc), 2.0—2.3 (2H, m, $C_{(7)}$–H), 2.5—3.0 (2H, m, $C_{(5)(9)}$–H), 3.6—3.90 (1H, m, $C_{(5')}$–H), 4.22 (2H, m, $C-_{(6')}H$), 4.67—5.33 (6H, m), 5.38 (1H, d, J=1.5 Hz, $C_{(1)}$–H), 6.15 (1H, d/d, J=6.5/1.5 Hz, $C_{(3)}$–H). This compound was identified with ajugol pentaacetate (**5a**) by the direct comparison (mixed mp, IR, PMR and TLC). Hexaacetate (**5b**): colourless needles (from EtOH), mp 172—174°. IR ν_{max}^{KBr} cm^{-1}: no OH, 1750, 1655. This compound was identified with ajugol hexaacetate (**5b**) by the direct comparison (mixed mp, IR and TLC).

Acetylation of Mioporoside (6), giving Pentaacetate (6a) and Hexaacetate (6b)——A solution of **6** (36 mg) in Ac_2O (1 ml) and pyridine (1 ml) was allowed to stand at room temperature overnight. The reaction mixture was treated as in the case of ajugol (**5**) to give pentaacetate (**6a**) (20 mg) and hexaacetate (**6b**) (5 mg). Pentaacetate (**6a**): colourless needles (from EtOH). *Anal.* Calcd. for $C_{25}H_{34}O_{14}$: C, 53.75; H, 6.14. Found: C, 53.83; H, 6.13. mp 167.5—168.5°. IR ν_{max}^{KBr} cm^{-1}: 3530, 1755, 1735, 1660. PMR (δ in $CDCl_3$): 1.40 (3H, s, $-\underset{|}{C}-CH_3$), 1.73—2.50 (2H, m, $C_{(7)}$–H), 1.93—2.10 (15H, each s, 5×OAc), 2.83—3.27 (2H, m, $C_{(5)(9)}$–H), 3.6—3.93 (1H, m, $C_{(5')}$–H), 4.23 (2H, m, $C_{(6')}$–H), 4.70—5.30 (7H, m), 6.25 (1H, d/d, J=6.5/1.5 Hz, $C_{(3)}$–H). This compound was identified with mioporoside pentaacetate (**6a**) by the direct comparison (mixed mp, IR and TLC). Hexaacetate (**6b**): colourless prisms (from EtOH). *Anal.* Calcd. for $C_{27}H_{36}O_{15}$: C, 53.99; H, 6.04. Found: C, 54.19; H, 6.02. mp 177.5—179°. IR ν_{max}^{KBr} cm^{-1}: 1750, 1730, 1660. PMR (δ in $CDCl_3$): 1.59 (3H, s, $-\underset{|}{C}-CH_3$), 1.90—2.40 (2H, m, $C_{(7)}$–H), 2.00—2.17 (18H, each s, 6×OAc), 2.60—3.20 (2H, m, $C_{(5)(9)}$–H), 3.50—4.08 (1H, m, $C_{(5')}$–H), 4.25 (2H, m, $C_{(6')}$–H), 4.67—5.40 (6H, m), 5.75 (1H, br s, $C_{(1)}$–H), 6.27 (1H, d/d, J=6.5/1.5 Hz, $C_{(3)}$–H).

Catalpol (7)——Colourless needles (from MeOH–AcOEt). *Anal.* Calcd. for $C_{15}H_{22}O_{10}$: C, 49.72; H, 6.12. Found: C, 49.77; H, 6.17. mp 210—212°. $[\alpha]_D^{27}$ −97.4° (c=0.58, MeOH). IR ν_{max}^{KBr} cm^{-1}: 3325, 1660. A solution of **7** (68 mg) in Ac_2O (1 ml) and pyridine (1 ml) was allowed to stand at room temperature overnight and poured into ice-water. The resulted precipitates were collected and recrystallized from EtOH to give colourless needles (**7a**) (113.5 mg), mp 143—144.5°, which was identified with catalpol hexaacetate (**7a**) by the direct comparison (mixed mp, IR and TLC).

Martynoside (1)——Colourless powder. UV λ_{max}^{EtOH}: 220, 287, 330 nm. IR ν_{max}^{KBr} cm^{-1}: 3400 (OH), 1700 (ester), 1625 (>C=C<), 1590, 1510 (aromatic). Gibbs test: blue, $FeCl_3$ in EtOH: brown.

Acetylation of Martynoside (1), giving Heptaacetate (8)——A solution of **1** (120 mg) in Ac_2O (1 ml) and pyridine (2 ml) was allowed to stand at room temperature and poured into ice-water. The resulted precipitates were collected and purified by prep.-TLC developing with ether to give a colourless powder (**8**) (100 mg). *Anal.* Calcd. for $C_{45}H_{54}O_{22}$: C, 57.08; H, 5.75. Found: C, 56.48; H, 5.69. $[\alpha]_D^{25}$ −21.4° (c=0.26, $CHCl_3$). UV λ_{max}^{EtOH} nm (log ε): 225 (4.39), 282 (4.37), 314 (4.10). IR ν_{max}^{KBr} cm^{-1}: 1750, 1630, 1595, 1510. PMR (δ in $CDCl_3$): 1.05 (3H, d, J=6 Hz, CH_3 of rham.), 1.80—2.10 (15H, each s, 5×OAc), 2.31 (6H, s, 2×OAc), 2.81 (2H, t, J=7 Hz, Ar–$C\underline{H}_2CH_2-$), 3.82 (3H, s, OCH_3), 3.87 (3H, s, OCH_3), 6.37 (1H, d, J=16 Hz), 7.70 (1H, d, J=16 Hz) (Ar–$C\underline{H}$=$C\underline{H}$–CO). MS *m/e* (%): 946 (M^+, 1.5), 273 (terminal acetylated rhamnose, $C_{12}H_{17}O_7$, 100).

Alkaline Hydrolysis of Martynoside (1) with MeONa, giving 9——To a solution of **1** (100 mg) in absolute MeOH (4 ml) was added 2.5% MeONa–MeOH (0.1 ml) and the reaction mixture was refluxed for 1.5 hr. The mixture was passed through an Amberlite IR-120 (H^+) column and the eluate was concentrated under reduced pressure. The residue was purified by prep.-TLC developing with $CHCl_3$–MeOH (3:1) to give ferulic acid methyl ester as colourless prisms (from petr.ether–ether) (26 mg), mp 65.5—66.5°, and **9** as a colourless powder (58 mg). The former was identified with the authentic sample by the direct comparison (mixed mp and IR). The latter (25 mg) was acetylated with Ac_2O and pyridine by the usual method to give the colourless amorphous heptaacetate (**10**). *Anal.* Calcd. for $C_{35}H_{46}O_{19}$: C, 54.54; H, 6.02. Found: C, 54.60; H, 6.08. $[\alpha]_D^{26}$ −27.5° (c=0.24, $CHCl_3$). UV λ_{max}^{EtOH} nm (log ε): 222 (3.96), 275 (3.29). IR ν_{max}^{KBr} cm^{-1}:

1750, 1615, 1510. PMR (δ in $CDCl_3$): 1.15 (3H, d, J=6 Hz, CH_3 of rham.), 1.95—2.12 (18H, each s, 6×OAc), 2.30 (3H, s, OAc), 2.80 (2H, t, J=7 Hz, Ar–C$\underline{H}_2$CH_2–), 3.82 (3H, s, OCH_3), 7.2—6.8 (3H, m, 3×arom.-H). MS *m/e* (%): 770 (M^+, 2.6), 273 (terminal acetylated rhamnose, 73), 151 (100).

Acid Hydrolysis of 9 with 2 N H_2SO_4——A solution of **9** (33 mg) in 2 N H_2SO_4 (3 ml) was heated in an oil bath (100—110°) for 2 hr and after cooling, extracted with $CHCl_3$. The $CHCl_3$ extract was washed with water, dried over Na_2SO_4 and concentrated under reduced pressure. The residue was recrystallized from petr.ether–ether to give colourless needles (**16**) (5.2 mg). *Anal.* Calcd. for $C_9H_{12}O_3$: C, 64.27; H, 7.19. Found: C, 64.40; H, 7.20. mp 70—71°. UV λ_{max}^{EtOH} nm (log ε): 222 (3.97), 280 (3.62). IR ν_{max}^{KBr} cm^{-1}: 3425, 3240, 1590, 1510, 1500. PMR (δ in $CDCl_3$): 1.70, 5.80 (each br. s, 2×OH, D_2O exchangeable), 2.75 (2H, t, J=7 Hz, Ar–C$\underline{H}_2$CH_2–), 3.78 (2H, t, J=7 Hz, –CH_2C$\underline{H}_2$O–), 3.85 (3H, s, OCH_3), 6.5—6.8 (3H, m, arom.-H). Gibbs test: blue, $FeCl_3$ in EtOH: brown. The compound obtained here was identified with 2-(3′-hydroxy-4′-methoxy-phenyl)-ethanol (**16**) prepared from isovanillin. The aqueous layer was neutralized with $Ba(OH)_2$, filtered and concentrated to give a brown residue, which was trimethylsilylated by the usual method. The presence of equimolecular rhamnose and glucose was demonstrated by GLC. Condition: column, 2% OV-17 on Uniport Q (80—100 mesh), 3 mm×2 m, column temperature, 150—220°, programmed 3°/min, carrier gas, N_2, 20 ml/min, injection temperature, 240°. Rhamnose: t_R (min), 6.6, 7.8; glucose: t_R (min), 12.9, 15.3.

Permethylation of Martynoside (1) by The Hakomori's Method[10]——NaH (1 g, defatted with *n*-pentane beforehand) was warmed with dimethylsulfoxide (DMSO, 10 ml) at 50—60° for 2 hr with stirring under N_2 gas flow. To a solution of **1** (100 mg) in DMSO (6 ml) was added the above prepared reagent (1.5 ml) and the total mixture was kept stirring at room temperature for 2 hr under N_2 gas flow, treated with CH_3I (1.5 ml) and stirred for further 2 hr. The reaction mixture was poured into ice-water (100 ml) and extracted with AcOEt for 3 times (each 50 ml). The combined AcOEt extract was washed with water, dried over Na_2SO_4 and concentrated under reduced pressure. The products were separated by prep.-TLC developing with ether to give dimethyl caffeic acid methylester (11 mg), the heptamethyl ether of **1** (**11**) (81 mg) and the heptamethyl ether of **9** (**12**) (23 mg). Dimethyl caffeic acid methyl ester: colourless prisms (from petr.ether–ether), mp 69—70°. This compound was identified with the authentic sample by mixed mp and IR spectra. Heptamethyl ether of **1** (**11**): colourless powder. *Anal.* Calcd. for $C_{38}H_{54}O_{15}$: C, 60.79; H, 7.25. Found: C, 60.55; H, 7.23. $[\alpha]_D^{32}$ −52.0° (c=0.42, $CHCl_3$). UV λ_{max}^{EtOH} nm (log ε): 232 (4.18), 287 (4.07), 324 (4.18). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: no OH, 1710, 1630, 1600, 1510. PMR (δ in $CDCl_3$): 1.28 (3H, d, J=6 Hz, CH_3 of rham.), 3.50 (6H, s), 3.52 (6H, s), 3.55 (3H, s), 3.85 (6H, s), 3.93 (6H, s), (9×OCH_3), 4.32 (1H, d, J=7.5 Hz, gluc.-$C_{(1)}$–H), 4.43 (2H, d, J=3 Hz, gluc.-$C_{(6)}$–H), 5.33 (1H, br. s, rham.-$C_{(1)}$–H), 6.35 (1H, d, J=16 Hz), 7.65 (1H, d, J=16 Hz) (Ar–C$\underline{H}$=C$\underline{H}$–), 6.75—7.33 (6H, m, arom.-H). Heptamethyl ether of **9** (**12**): colourless powder. *Anal.* Calcd. for $C_{28}H_{46}O_{12}$: M^+, *m/e* 574.2994. Found: *m/e*, 574.2977. $[\alpha]_D^{32}$ −29.4° (c=0.39, $CHCl_3$). UV λ_{max}^{EtOH} nm (log ε): 230 (4.13), 280 (3.67). IR $\nu_{max}^{CHCl_3}$ cm^{-1}: no OH, 1600, 1590, 1510. PMR (δ in $CDCl_3$): 1.27 (3H, d, J=6 Hz, CH_3 of rham.), 3.40 (3H, s), 3.43 (3H, s), 3.47 (6H, s), 3.50 (3H, s), 3.55 (3H, s), 3.85 (6H, s) (8×OCH_3), 4.25 (1H, d, J=7.5 Hz, gluc.-$C_{(1)}$–H), 5.30 (1H, br. s, rham.-$C_{(1)}$–H), 6.75 (3H, m, arom.-H). MS *m/e* (%): 574 (M^+, 5.7), 189 (terminal methylated rham., 40.8), 164 (100).

Preparation of Alditol Acetate from 11——A solution of **11** (2.5 mg) in 85% HCOOH (1 ml) was heated in a boiling water bath for 3 hr and then concentrated under reduced pressure. The residue was further heated with 0.5 N H_2SO_4 (1 ml) in a boiling water bath for 3 hr, neutralized with $BaCO_3$ and filtered. The filtrate was passed through an Amberlite IR-120 (H^+) column and concentrated to give a brown residue, which was reduced with $NaBH_4$ (30 mg) in water (3 ml) for 15 hr. The reaction mixture was passed through an Amberlite IR-120 (H^+) and concentrated to dryness. Boric acid was removed by codistillation with MeOH and the residue was acetylated with Ac_2O (0.4 ml) and pyridine (0.4 ml) at 100° for 1 hr. The reaction mixture was diluted with water and then concentrated. The presence of 1,5-di-O-acetyl-2,3,4-tri-O-methyl-rhamnitol (t_R (min), 4.5) and 1,3,5,6-tetra-O-acetyl-2,4-di-O-methyl-glucitol (t_R (min), 49.0, MS *m/e*: 189, 129, 117, 87) in this residue was demonstrated by GLC. Condition: column, 3% ECNSS on Gaschrom Q (100—120 mesh), 3 mm×2 m; column temperature, 180°. carrier gas, N_2, 40 ml/min; injection temperature, 250°.

Preparation of Alditol Acetate from 12 and Methanolysis of 12——i) **12** (2.5 mg) was treated as in the case of **11** to give alditol acetates. The presence of 1,5-di-O-acetyl-2,3,4-tri-O-methyl-rhamnitol (t_R (min), 4.5) and 1,3,5-tri-O-acetyl-2,4,6-tri-O-methyl-glucitol (t_R (min), 19.6) was proved by GLC.

ii) A solution of **12** in 5% HCl–MeOH (1 ml) was refluxed in an oil bath for 3 hr and then neutralized with Ag_2CO_3. The precipitates were removed by filtration and the filtrate was concentrated to dryness. The presence of methyl 2,3,4-tri-O-methyl-rhamnopyranoside and methyl 2,4,6-tri-O-methyl-glucopyranoside in this residue was proved by TLC (benzene–acetone, 4: 1) and GLC. GLC condition 1: column, 5% PNGS on Chromosorb W AW-DMCS (60—80 mesh), 3 mm×2 m; column temperature, 180°; carrier gas, N_2, 30 ml/min; injection temperature, 220°; GLC condition 2: 5% BDS on Chromosorb W AW-DMCS (60—80 mesh), 3 mm×2 m; column temperature, 170°; carrier gas, N_2, 30 ml/min; injection temperature, 220°. Methyl 2,3,4-tri-O-methyl-rhamnopyranoside: TLC, *Rf*, 0.51, 0.37; GLC, condition 1: t_R (min), 1.3, 1.9; condition 2: t_R (min), 1.0, 1.6. Methyl 2,4,6-tri-O-methyl-glucopyranoside: TLC, *Rf*, 0.15, 0.08; GLC, condition 1: t_R (min), 6.8, 9.7; condition 2: t_R (min), 6.8, 10.0.

Partial Methylation of Martynoside (1), giving Dimethyl Ether (13)——To a solution of **1** (58 mg) in dry acetone (7 ml) containing K_2CO_3 (500 mg) was added a few drops of $(CH_3)_2SO_4$. The reaction mixture

was refluxed in an oil bath for 1 hr, filtered and concentrated. The residue was purified by prep.-TLC developing with $CHCl_3$–MeOH (5: 1) to give a colourless powder (**13**) (8.5 mg). $[\alpha]_D^{31}$ −43.5° (c=0.2, MeOH), UV λ_{max}^{EtOH} nm (log ε): 230 (4.26), 287 (4.13), 325 (4.27). IR ν_{max}^{KBr} cm^{-1}: 3420, 1710, 1630. PMR (δ in d_6-acetone): 1.12 (3H, d, J=6 Hz, CH_3 of rham.), 2.87 (2H, t, J=7 Hz, Ar–C$\underline{H}_2$C$\underline{H}_2$–), 3.77 (3H, s), 3.80 (3H, s), 3.87 (6H, s) (4×OCH_3), 4.43 (1H, d, J=7.5 Hz, gluc.-C$_{(1)}$–H), 5.30 (1H, br. s, rham.-C$_{(1)}$–H), 6.40 (1H, d, J=16 Hz), 7.67 (1H, d, J=16 Hz) (Ar–C$\underline{H}$=C$\underline{H}$–), 6.8—7.4 (6H, m, arom.-H). The compound obtained here was identified with acteoside tetramethyl ether (**13**) by the direct comparison (IR, PMR and TLC).

Acetylation of Acteoside (2), giving Nonaacetate (15)——**2** (80 mg), which was isolated as an amorphous powder, was acetylated with Ac_2O (1 ml) and pyridine (2 ml) by the usual method and the product was purified by prep.-TLC developing $CHCl_3$–MeOH (20: 1) to give a colourless powder (**15**) (30 mg). *Anal.* Calcd. for $C_{47}H_{54}O_{24}$: C, 56.43; H, 5.43. Found: C, 56.40; H, 5.45. $[\alpha]_D^{28}$ −25.1° (c=0.31, $CHCl_3$). UV λ_{max}^{EtOH} nm (log ε): 283 (4.26). IR ν_{max}^{KBr} cm^{-1}: 1755, 1640, 1500. PMR (δ in $CDCl_3$): 1.05 (3H, d, J=6 Hz, CH_3 of rham.), 1.87—2.10 (15H, s, 5×OAc), 2.30 (12H, s, 4×OAc), 2.87 (2H, t, J=7 Hz, Ar–C$\underline{H}_2$C$\underline{H}_2$–), 6.33 (1H, d, J=16 Hz), 7.67 (1H, d, J=16 Hz), (Ar–C$\underline{H}$=C$\underline{H}$–), 7.08 (3H, m, arom.-H), 7.37 (3H, m, arom.-H). The compound obtained here was identified with the authentic sample of acteoside nonaacetate (**15**) by the direct comparison (IR, PMR and TLC).

Partial Methylation of Acteoside (2), giving Tetramethyl Ether (13)——**2** (108 mg) was methylated with $(CH_3)_2SO_4$ and K_2CO_3 in acetone as in the case of **1**, to give a colourless powder (**13**) (53 mg). UV λ_{max}^{MeOH} nm (log ε): 231 (4.20), 287 (4.07), 324 (4.21). IR ν_{max}^{KBr} cm^{-1}: 3420, 1710, 1630, 1600, 1515. The compound obtained here was identified with acteoside tetramethyl ether (**13**)[3d] by the direct comparison (IR, PMR and TLC).

Partial Hydrolysis of Acteoside Tetramethyl Ether (13), giving 14——To a solution of **13** (30 mg) in absolute MeOH (3 ml) was added 2% MeONa–MeOH (0.1 ml). The reaction mixture was refluxed for 1 hr and concentrated to dryness. The residue was purified by prep.-TLC developing with $CHCl_3$–MeOH (5: 1) to give colourless needles (**14**) (13 mg). *Anal.* Calcd. for $C_{22}H_{34}O_{12}\cdot H_2O$: C, 51.96; H, 7.13. Found: C, 51.92; H, 6.88. mp 115—117°. $[\alpha]_D^{25}$ −50.6° (c=0.96, MeOH). UV λ_{max}^{MeOH} nm (log ε): 229 (3.80), 279 (3.34). IR ν_{max}^{KBr} cm^{-1}: 3400, 1595, 1510. PMR (δ in d_6-acetone): 1.22 (3H, d, J=6 Hz, CH_3 of rham.), 2.85 (2H, t, J=7 Hz, Ar–C$\underline{H}_2$C$\underline{H}_2$–), 3.73 (3H, s), 3.77 (3H, s), (2×OCH_3), 5.13 (1H, br. s, rham.-C$_{(1)}$–H), 6.77—6.87 (3H, m, arom.-H).

Preparation of 2-(3′-Hydroxy-4′-methoxy-phenyl)-ethanol (16)——i) Isovanillin Benzyl Ether (**17**): To a solution of isovanillin (5 g) in a cetone (30 ml) was added K_2CO_3 (4.2 g) and benzylchloride (6 ml). The reaction mixture was refluxed for 3 hr, filtered and concentrated. The residue was chromatographed on silica gel using benzene–ether mixture to give colourless needles (**17**) (6.6 g, 84%). *Anal.* Calcd. for $C_{15}H_{14}O_3$: C, 74.36; H, 5.83. Found: C, 74.38; H, 5.89. mp 62—63°. IR ν_{max}^{KBr} cm^{-1}: 1675, 1595, 1580, 1500.

ii) Treatment of **17** with Nitromethane, giving **18**:[15] To a solution of **17** (3 g) in AcOH (15 ml) was added CH_3NO_2 (1.2 ml) and $CH_3CO_2NH_4$ (1 g), and the mixture was refluxed for 2.5 hr. The resulted precipitates were collected and recrystallized from benzene to afford yellow needles (**18**) (2.93 g, 83%), mp 129—130°. *Anal.* Calcd. for $C_{16}H_{15}NO_4$: C, 67.36; H, 5.30; N, 4.91. Found: C, 67.12; H, 5.33; N, 4.71. IR ν_{max}^{KBr} cm^{-1}: 3090, 1620, 1595, 1575, 1510, 1480, 1430, 1390, 1340.

iii) Treatment of **18** with $LiAlH_4$ followed by Acetylation, giving **19**:[16] A solution of **18** (1.4 g) in tetrahydrofuran (THF) (12 ml) was added to a mixture of THF (12 ml) and $LiAlH_4$ (600 mg) with stirring. The mixture was refluxed for 2 hr, treated with water to decompose excessive $LiAlH_4$, filtered and concentrated. The residue (920 mg) was acetylated with Ac_2O (5 ml) and water (5 ml) at 130—140° in an oil bath for 3 hr to give colourless needles (from n-hexane–AcOEt) (**19**) (675 mg, 45%). mp 128—129°. *Anal.* Calcd. for $C_{18}H_{21}NO_3$: C, 72.21; H, 7.07; N, 4.67. Found: C, 71.92; H, 7.05; N, 4.48. IR ν_{max}^{KBr} cm^{-1}: 3290, 1640, 1600, 1590, 1550, 1515. PMR (δ in d_6-acetone): 1.93 (3H, s, –COC$\underline{H}_3$), 2.85 (2H, q-like, Ar–C$\underline{H}_2$C$\underline{H}_2$–), 2.90 (1H, s, NH, D_2O exchangeable), 3.47 (2H, q-like, Ar–CH_2C$\underline{H}_2$NH–), 3.90 (3H, s, OCH_3), 5.17 (2H, s, Ph–C$\underline{H}_2$O–), 6.8—7.2 (3H, arom.-H), 7.3—7.7 (5H, m, arom.-H).

iv) Treatment of **19** with $NaNO_2$, giving **20**:[17] To a solution of **19** (300 mg) in a mixture of Ac_2O (25 ml) and AcOH (1 ml) was added $NaNO_2$ (1.5 g) at 0° during *ca.* 5 hr and the reaction mixture was allowed to stand at 0° for 17 hr. The temperature of the reaction mixture was allowed to rise to room temperature. The mixture was poured into ice-water and extracted with benzene for 3 times (each 50 ml), washed with water, 5% Na_2CO_3, water, successively, and then dried over Na_2SO_4. After filtration, the solution was refluxed for 19 hr, concentrated to *ca.* 50 ml, washed with an aqueous solution saturated with $NaHCO_3$ and water, and dried over Na_2SO_4. After filtration, the solvent was removed under reduced pressure and the residue was recrystallized from n-hexane–AcOEt to give colourless needles (**20**) (83 mg, 27%), mp 83.5-84.5°. *Anal.* Calcd. for $C_{18}H_{20}O_4$: C, 71.98; H, 6.71. Found: C, 72.11; H, 6.73. IR ν_{max}^{KBr} cm^{-1}: 1740, 1600,

15) F. Benigton, R.D. Morin, and L.C. Clark, Jr., *J. Org. Chem.*, **20**, 102 (1955).
16) J. Finkelstein, *J. Am. Chem. Soc.*, **73**, 550 (1951).
17) T. Fujii, M. Tashiro, K. Ohara, and M. Kumai, *Chem. Pharm. Bull.* (Tokyo), **8**, 266 (1960); E.H. White, *J. Am. Chem. Soc.*, **77**, 6008, 6011, 6014 (1955).

1590, 1515. PMR (δ in $CDCl_3$): 1.97 (3H, s, OAc), 2.80 (2H, t, J=7 Hz, Ar–C$\underline{H}_2$CH_2–), 3.83 (3H, s, OCH_3), 4.17 (2H, t, J=7 Hz, –CH_2C$\underline{H}_2$O–), 5.10 (2H, s, Ph–C$\underline{H}_2$O–), 6.77 (3H, br. s, arom.-H), 7.2—7.6 (5H, m, arom.-H).

v) Preparation of **16** from **20**: A solution of **20** (42 mg) in 5% KOH–MeOH (2 ml) was refluxed for 20 min. The product was purified by prep.-TLC using $CHCl_3$–MeOH (20: 1) to give colourless needles (**21**) (from *n*-hexane–ether) (33 mg, 91%). *Anal.* Calcd. for $C_{16}H_{18}O_3$: C, 74.39; H, 7.02. Found: C, 74.28; H, 7.04. mp 57.5—58.5°. IR ν_{max}^{KBr} cm^{-1}: 3290, 1600, 1585, 1515. PMR (δ in $CDCl_3$): 1.60 (1H, br. s, OH, D_2O exchangeable), 2.72 (2H, t, J=7 Hz, Ar–C$\underline{H}_2$CH_2–), 3.73 (2H, t, J=7 Hz, –CH_2C$\underline{H}_2$O–), 3.83 (3H, s, OCH_3), 5.10 (2H, s, Ph–C$\underline{H}_2$O–), 6.77 (3H, m, arom.-H), 7.2—7.6 (5H, m, arom.-H).

21 (33 mg) was shaken with H_2 in MeOH in the presence of 10% Pd-C for 45 min. After filtration, filtrate was concentrated to dryness and the residue was purified by prep.-TLC using $CHCl_3$–MeOH (20: 1) to give colourless needles (**16**) (15 mg, 70%). *Anal.* Calcd. for $C_9H_{12}O_3$: C, 64.27; H, 7.19. Found: C, 64.27; H, 7.14. mp 69—70.5°. IR ν_{max}^{KBr} cm^{-1}: 3425, 3240, 1590, 1510, 1500. PMR (δ in $CDCl_3$): 2.77 (2H, t, J=7 Hz, Ar–C$\underline{H}_2$CH_2–), 3.82 (2H, t, J=7 Hz, –CH_2C$\underline{H}_2$O–), 3.87 (3H, s, OCH_3), 6.6—6.9 (3H, m, arom.-H), 5.72, 1.60 (each s, OH, D_2O exchangeable).

Acknowledgement The authors would like to express their sincere thanks for the authentic specimens to Prof. I. Nishioka of Kyūshū University (acteoside, tetramethyl acteoside and acteoside nonaacetate), to Prof. T. Miyazaki of Tokyo College of Pharmacy (alditol acetates), to Dr. R.S. Kapil of Central Drug Institute in India (roseoside tetraacetate), and to Dr. M. Guiso of University of Rome (ajugol pentaacetate and mioporoside pentaacetate). They are also grateful to Assoc. Prof. I. Kitagawa of Osaka University for identification of methyl 2,4,6-tri-O-methyl-glucopyranoside, to Mr. Y. Shida of Tokyo College of Pharmacy for mass spectral measurements and Mr. K. Aoki of Nippon Electric Company-Varian Associate for CMR spectral measurements. Thanks are due to Mr. K. Tanaka of Herbal Garden of Tokyo Metropolitan Government and Mr. T. Shibata of this Laboratory for supplying plant materials.