[Chem. Pharm. Bull. 33(9)3645—3650(1985)]

Studies on the Constituents of Cistanchis Herba. VI. Isolation and Structure of a New Iridoid Glycoside, 6-Deoxycatalpol

HIROMI KOBAYASHI,*[,a] HIROKO KARASAWA,[a] TOSHIO MIYASE,[b] and SEIGO FUKUSHIMA[b]

Central Research Laboratories, Yomeishu Seizo Co., Ltd.,[a] 2132–37 Nakaminowa, Minowa-cho, Kamiina-gun, Nagano 399–46, Japan and Shizuoka College of Pharmacy,[b] 2–2–1, Oshika, Shizuoka-shi 422, Japan

(Received December 27, 1984)

Seven iridoid glycosides (I—VII) have been isolated from Cistanchis Herba, the whole plant of *Cistanche salsa* (C. A. MEY.) G. BECK (Orobanchaceae). The structure of a new compound, 6-deoxycatalpol (V), and the identity of the other glycosides have been established by chemical transformations and spectral analyses of the compounds and their derivatives. Mussaenosidic acid (I) was isolated for the first time as a natural product.

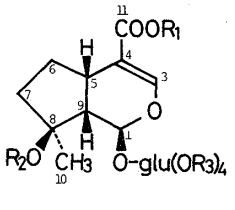
Keywords——*Cistanche salsa*; Cistanchis Herba; Orobanchaceae; iridoid glycoside; mussaenosidic acid; 6-deoxycatalpol; ^{13}C-NMR

Cistanchis Herba (Japanese name: Nikujuyou, 肉蓯蓉) is the whole plant of *Cistanche salsa* (C. A. MEY.) G. BECK (Orobanchaceae), and has been used as a staminal tonic in Oriental medicine. In previous papers, we have reported the isolation of iridoids[1] and phenylpropanoid glycosides[2] from this crude drug. The present paper describes the isolation and structure elucidation of a new iridoid glycoside, 6-deoxycatalpol (V), as well as the isolation of six known iridoid glycosides, mussaenosidic acid (I),[3,4] geniposidic acid (II),[5] leonuride (ajugol) (III),[6] 8-epideoxyloganic acid (IV),[7] gluroside (VI)[8] and bartsioside (VII).[9] The hot methanolic extract of the dried whole plants was separated into the EtOAc-soluble fraction and the H_2O-soluble one. The latter was further fractionated by a combination of various column chromatographies to give compounds I—IV and a mixture of compounds V—VII, which were isolated as the corresponding acetates. Compounds I—VII gave black polymers on acid treatment, a property which has been shown to be characteristic of most iridoid compounds, and they were assumed to be iridoid glycosides on the basis of their ultraviolet (UV), infrared (IR), ^{1}H-nuclear magnetic resonance (^{1}H-NMR) and ^{13}C-nuclear magnetic resonance (^{13}C-NMR) spectra.

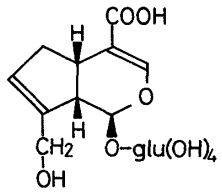
Mussaenosidic acid (I) was isolated as a white powder, $[\alpha]_D^{18}$ −186.3° (MeOH). It showed an absorption maximum at 234 nm (log ε 3.95) in the UV spectrum and absorption bands at 3400, 1690, 1650 cm^{-1} in the IR spectrum. The ^{1}H-NMR spectrum showed a singlet at δ 1.90 assignable to a tertiary methyl group attached to a hydroxyl-bearing carbon, a double doublet (J=10, 4 Hz) at δ 2.82 due to the H-9 proton, a doublet (J=8 Hz) at δ 5.43 due to the anomeric proton, a doublet (J=4 Hz) at δ 6.01 arising from the H-1 proton and a broad singlet at δ 7.93 characteristic of the H-3 proton. Acetylation of I with acetic anhydride and pyridine under mild conditions afforded the tetraacetate (Ia), $C_{24}H_{32}O_{14}$, $[\alpha]_D^{20}$ −93.0° ($CHCl_3$), which showed a broad band due to a free tertiary hydroxyl group (3400 cm^{-1}) in the IR spectrum. On further acetylation under forcing conditions, Ia gave the pentaacetate (Ib), $C_{26}H_{34}O_{15}$, $[\alpha]_D^{20}$ −76.9° ($CHCl_3$). The molecular weight of I was confirmed by the observation of the peak at m/z 377 ($M^+ + 1$) in the field desorption mass spectrum (FD-MS). Methylation of I with diazomethane afforded the methyl ester (Ic), $[\alpha]_D^{20}$ −105.5° (MeOH),

showing a signal at δ 49.3 assignable to a carbomethoxy group in the ^{13}C-NMR spectrum. Compound Ic was identified as mussaenoside[10] by direct comparison [thin layer chromatography (TLC), IR and ^{1}H-NMR] with an authentic sample. From these chemical and spectroscopic findings, I was determined to be mussaenosidic acid, which had previously been obtained by alkaline hydrolysis of 2′-*p*-hydroxybenzoyl mussaenosidic acid[3] and negundoside.[4] This is the first report of the isolation of I as a natural product.

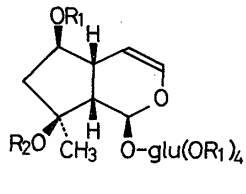
Geniposidic acid (II) was isolated as a white powder and was identified by direct comparison (TLC and IR) with an authentic sample. Leonuride (III) was isolated as a white



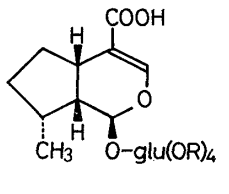
I: $R_1=R_2=R_3=H$
Ia: $R_1=R_2=H$, $R_3=Ac$
Ib: $R_1=H$, $R_2=R_3=Ac$
Ic: $R_1=CH_3$, $R_2=R_3=H$



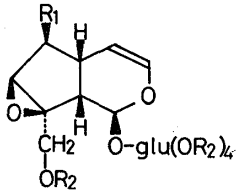
II



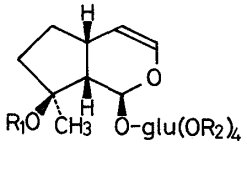
III: $R_1=R_2=H$
IIIa: $R_1=Ac$, $R_2=H$
IIIb: $R_1=R_2=Ac$



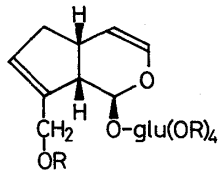
IV: R=H
IVa: R=Ac



V: $R_1=R_2=H$
Va: $R_1=H$, $R_2=Ac$
VIII: $R_1=OH$, $R_2=H$



VI: $R_1=R_2=H$
VIa: $R_1=H$, $R_2=Ac$
VIb: $R_1=R_2=Ac$



VII: R=H
VIIa: R=Ac

Chart 1

powder, which gave the pentaacetate (IIIa) and the hexaacetate (IIIb). These compounds (IIIa and IIIb) were identified as leonuride pentaacetate and hexaacetate, respectively, by direct comparison (mixed mp, TLC and IR) with authentic samples. 8-Epideoxyloganic acid (IV) was isolated as a white powder, and its tetraacetate (IVa) was identified as 8-epideoxyloganic acid tetraacetate by direct comparison (TLC and IR) with an authentic sample. Gluroside (VI) was obtained as the tetraacetate (VIa), which, on alkaline hydrolysis, regenerated VI as a white powder. On further acetylation, VIa gave the pentaacetate (VIb). Compounds VIa and VIb were identified as gluroside tetraacetate and pentaacetate, respectively, by direct comparison (mixed mp, TLC and IR) with authentic samples.

Bartsioside (VII) was also obtained as the pentaacetate (VIIa), $C_{25}H_{32}O_{13}$, colorless needles, mp 107—108 °C, which gave the original glycoside (VII), colorless needles, mp 118—120 °C, $[\alpha]_D^{25}$ −89.0° (MeOH), on alkaline hydrolysis; it showed the spectral properties of a non-conjugated iridoid enol–ether grouping, UV: 209 nm (log ε 3.25), IR cm^{-1}: 3400 (OH), 1652 (>C=C<), ^{1}H-NMR (D_2O) δ: 5.40 (1H, dd, J=6, 2 Hz, H-4), 6.24 (1H, d, J=2 Hz, H-1), 6.70 (1H, d, J=6 Hz, H-3). The FD-MS of VII exhibited an ion peak at m/z 331 ($M^+ + 1$). From the above data, VII was assumed to be bartsioside, which has been isolated from *Bartsia trixago* (Scrophulariaceae).[9] The ^{13}C-NMR spectrum of VII supported the above assumption.

6-Deoxycatalpol (V) was obtained as the pentaacetate (Va), $C_{25}H_{32}O_{14}$, colorless

TABLE I. ^{13}C-NMR Chemical Shifts of I—IX

Carbon No.	I[a]	Ib[b]	II[a]	III[c]	IV[a]	V[c]	VI[c]	VII[c]	VIII[c]	IX[c]
1	95.4	95.5	97.9	94.5	95.6	95.8	94.9	96.0	96.1	94.4
3	150.6	152.0	151.8	140.1	151.3	140.8	139.2	140.1	141.9	139.8
4	113.6	113.5	112.9	106.5	113.4	107.2	109.9	110.1	104.6	109.7
5	31.9	32.1	36.0	40.3	34.2	32.1	31.1	33.6	38.7	32.5
6	30.5	30.8	39.3	77.1	31.8	35.4	30.1	39.5	79.0	30.1
7	40.9	40.9	126.9	49.6	32.6	62.8	41.5	130.1	63.5	36.4
8	79.3	80.5	145.3	79.9	36.6	70.2	81.0	142.6	67.2	83.9
9	52.3	51.9	47.1	51.1	43.7	43.8	52.5	48.8	43.2	52.5
10	25.2	24.7	60.8	25.6	16.5	61.9	25.0	60.8	61.5	67.4
11	169.3	169.3	169.5		169.3					
glu-1	100.5	99.9	97.9	99.5	100.4	100.0	99.4	99.8	100.0	99.6
2	74.7	74.8	74.8	74.2	74.8	74.2	74.1	74.2	74.2	74.3
3	78.5	78.3	78.4	77.6	78.6	77.6	77.5	77.5	77.6	77.6
4	71.6	71.8	71.5	71.1	71.8	71.0	71.1	71.0	71.0	71.2
5	78.3	78.1	78.2	77.4	78.4	77.1	77.1	77.1	77.1	77.2
6	62.7	63.0	62.5	62.3	63.0	62.1	62.2	62.1	62.2	62.4
OCH_3		49.3								

a) In pyridine-d_5. *b*) In methanol-d_4. *c*) In D_2O (TMS external reference).

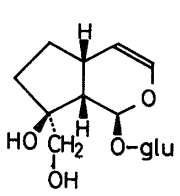
needles, mp 134—135 °C $[\alpha]_D^{20}$ −22.4° ($CHCl_3$), which, on alkaline hydrolysis, regenerated V as colorless needles, $C_{15}H_{22}O_9$, mp 204—206 °C, $[\alpha]_D^{18}$ −50.0° (MeOH). Compound V showed a UV absorption maximum at 205 nm (log ε 3.51) characteristic of a non-conjugated iridoid enol–ether grouping, and IR bands at 3400 (OH) and 1660 (>C=C<) cm^{-1}. In the FD-MS, V exhibited ion peaks at *m/z* 346 (M^+) and 369 $(M+Na)^+$. The ^{1}H-NMR spectrum (Table II) of V confirmed an iridoid structure and indicated a close relationship with catalpol (VIII).[11] The major differences between the spectra of V and VIII are as follows: the former shows signals at δ 1.3—1.9 and 2.2—2.7 (masked by H-5 and H-9 signals) (1H each) due to the H-6 proton, while the latter shows a corresponding signal at δ 4.13 (1H, dd, *J*=8, 1 Hz). The ^{13}C-NMR spectrum of V shows rather similar chemical shifts to those of VIII, except for the signal assignable to C-6 at δ 35.4. These data together with the molecular formula of V, which differs from that of VIII ($C_{15}H_{22}O_{10}$) by one oxygen atom, indicated that the new iridoid has the structure V with unknown stereochemistry of the epoxide at the C-7 and C-8 positions. The configuration of the epoxide was determined by means of the following reaction. Reduction of Va with lithium aluminium hydride gave IX by regiospecific cleavage of the epoxide ring to provide the alcohol at C-8. The β-configuration of the hydroxyl group at C-8 of IX was confirmed by the C-9 resonance value, which is diagnostic[12,13] for establishing the configuration at C-8 in epimeric couples at this chiral center. In fact, the C-9 resonance of IX (52.5 ppm) was in good agreement with that of 6,7-dihydrogardenoside (X) (50.4 ppm)[12] but, by contrast, was rather different from that (45.7 ppm)[12] of splendoside (XI). It follows therefore that the epoxide at the C-7 and C-8 positions of V is β-oriented, as in catalpol (VIII). The presence of glucose in the acid hydrolysate with 10% sulfuric acid was proved by gas chromatography (GC). Furthermore, β-linkage of the glucose moiety in V was demonstrated by the appearance of the anomeric signal as a doublet at δ 4.92 (*J*=7 Hz) in the ^{1}H-NMR spectrum of V. On the basis of the above-mentioned observations, the structure of V was determined to be 6-deoxycatalpol.

On TLC, glycosides V, VI and VII regenerated from the corresponding acetates showed the same *Rf* and coloration as the respective glycosides detected in the extract.

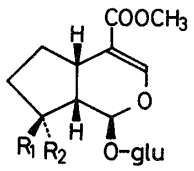
TABLE II. ^{1}H-NMR Chemical Shifts[a] of V and VIII (in D_2O)

Compound	H-1	H-3	H-4	H-5	H-6	H-7	H-9	H-10
V	5.12 d (J=10)	6.38 dd (J=6, 1)	5.10 dd (J=6, 4)	2.2—2.7	1.3—1.9 and 2.2—2.7	3.65 s-like	2.2—2.7	3.90 and 4.35 AB (J=13)
VIII	5.14 d (J=10)	6.46 dd (J=6, 2)	5.22 dd (J=6, 4)	2.36 m	4.13 dd (J=8, 1)	3.67 s-like	2.69 dd (J=9, 7)	3.83 and 4.33 AB (J=13)

a) δ ppm relative to external TMS and J value in Hz.



IX



X: R_1=OH, R_2=CH_2OH
XI: R_1=CH_2OH, R_2=OH

Chart 2

Experimental

Melting points were determined on a Mitamura micro-melting point apparatus and are uncorrected. Optical rotations were measured with a JASCO DIP-140 digital polarimeter. IR spectra were recorded with a Hitachi 270-30 infrared spectrophotometer and UV spectra with a Hitachi 200-20 spectrometer. ^{1}H- and ^{13}C-NMR spectra were recorded with a JEOL FX-90Q machine (89.55 and 22.5 MHz, respectively). Chemical shifts are given on the δ (ppm) scale with tetramethylsilane (TMS) as an internal standard (s, singlet; d, doublet; dd, double doublet; m, multiplet; br, broad). FD-MS were measured with a JEOL JMSDX-300 mass spectrometer. GC was run on a Shimadzu GC-4CM instrument with a flame ionization detector [conditions: column, 1.5% OV-17, 3 mm i.d. × 1.5 m; column temp., 180 °C; carrier gas, N_2 (30 ml/min)]. Silica gel (Wako gel C-300, Wako Pure Chemical) was used for column chromatography and Kieselgel 60 F_{254} (Merck) precoated plates were used for TLC. Iridoid glycosides were developed with $CHCl_3$–MeOH–H_2O (7:3:0.1) and acetates of glycosides with benzene–acetone (5:1). The spots were detected by spraying with a mixture of *p*-anisaldehyde (0.5 ml), conc. H_2SO_4 (10 ml) and 50% EtOH (90 ml) followed by heating.

Extraction and Isolation——The dried whole plants of *Cistanche salsa* (C. A. MEY.) G. BECK (10 kg, commercial crude drug produced in China) were sliced and extracted with MeOH (36 l × 2) under reflux. The extract was concentrated *in vacuo* and the resulting viscous solution was shaken with a mixture of H_2O (2 l) and EtOAc (4 l). The aqueous layer was transfered to a Diaion HP-20 (Nippon Rensui Co.) column and eluted with H_2O (5 l) and MeOH (1 l) successively. The MeOH eluate, after concentration, was applied to a polyamide C-200 (Wako Pure Chemical) column and eluted with H_2O (1 l). After concentration of the eluate, the residue was chromatographed on a silica gel column with $CHCl_3$–MeOH–H_2O (7:2:0.2) to give three fractions (Fr. 1—3). Fraction 1 was further chromatographed on a Toyopearl HW-40 (Toyo Soda Co.) column with H_2O–MeOH (1:1) to give a mixture of three glycosides (950 mg) (Fr. 1—1) [TLC: bartsioside (VII) (*Rf* 0.61), 6-deoxycatalpol (V) (*Rf* 0.56), gluroside (VI) (*Rf* 0.55)]. Fraction 1—1 was acetylated and the reaction product was chromatographed on a silica gel column with $CHCl_3$–MeOH (100:1) to give the following acetates.

6-Deoxycatalpol Pentaacetate (Va): Colorless needles (from MeOH), mp 134—135 °C, $[\alpha]_D^{20}$ −22.4° (c=0.5, $CHCl_3$). *Anal.* Calcd for $C_{25}H_{32}O_{14}$: C, 53.96; H, 5.80. Found: C, 54.00; H, 5.81. IR ν_{max}^{KBr} cm^{-1}: 1758, 1654. ^{1}H-NMR ($CDCl_3$) δ: 2.00, 2.02, 2.04, 2.10 and 2.12 (3H each, s, OAc), 5.16 (1H, d, J=8 Hz, H-1), 5.17 (1H, d, J=7 Hz, H-4), 6.24 (1H, d, J=7 Hz, H-3). *Rf* 0.35.

Gluroside Tetraacetate (VIa): Colorless needles (from MeOH), mp 132—133 °C, $[\alpha]_D^{20}$ −145.0° (c=0.5, $CHCl_3$). *Anal.* Calcd for $C_{23}H_{32}O_{12}$: C, 55.19; H, 6.45. Found: C, 55.05; H, 6.40. IR ν_{max}^{KBr} cm^{-1}: 3510, 1760, 1660. *Rf* 0.22. Compound VIa (100 mg) was acetylated to give the pentaacetate (VIb) (75 mg) as colorless needles (from MeOH). mp 112—113 °C, $[\alpha]_D^{20}$ −120.1° (c=0.5, $CHCl_3$). *Anal.* Calcd for $C_{25}H_{34}O_{13}$: C, 55.34; H, 6.32. Found: C, 55.25; H, 6.35. IR ν_{max}^{KBr} cm^{-1}: 1760, 1662. *Rf* 0.65.

Bartsioside Pentaacetate (VIIa): Colorless needles (from MeOH), mp 107—108 °C, $[\alpha]_D^{25}$ −110.2° [c=0.5, $(CH_3)_2CO$]. *Anal.* Calcd for $C_{25}H_{32}O_{13}$: C, 55.54; H, 5.97. Found: C, 55.31; H, 5.92. IR ν_{max}^{KBr} cm^{-1}: 1758, 1662. *Rf* 0.45.

Repeated chromatography of Fr. 2 and Fr. 3 on a silica gel column with $CHCl_3$–MeOH–HCOOH–H_2O (7:2:0.1:0.1) and then on a Sephadex LH-20 column with H_2O–MeOH (1:1) gave 8-epideoxyloganic acid (IV) (260 mg) and leonuride (III) (540 mg) from Fr. 2, and mussaenosidic acid (I) (250 mg) and geniposidic acid (II) (230 mg) from Fr. 3.

8-Epideoxyloganic Acid (IV): White powder, $[\alpha]_D^{20}$ −115.2° (c=1.2, MeOH). ^{13}C-NMR: Table I. Compound IV (100 mg) was acetylated and the reaction product was chromatographed on a silica gel colum with $CHCl_3$–MeOH (50:1) to give the tetraacetate (IVa) (75 mg) as a white powder, $[\alpha]_D^{20}$ −90.5° (c=1.0, $CHCl_3$). *Anal.* Calcd for $C_{24}H_{32}O_{13}$: C, 54.54; H, 6.10. Found: C, 54.65; H, 6.15. IR ν_{max}^{KBr} cm^{-1}: 1762, 1724, 1650. *Rf* 0.18.

Leonuride (III): White powder, $[\alpha]_D^{20}$ −165.0° (c=0.5, MeOH). ^{13}C-NMR: Table I. Compound III (100 mg) was acetylated and the reaction product was chromatographed on a silica gel column with benzene–acetone (5:1) to give the pentaacetate (IIIa) (25 mg) and hexaacetate (IIIb) (60 mg). IIIa: Colorless needles (from MeOH), mp 125—126 °C, $[\alpha]_D^{20}$ −65.5° (c=0.5, $CHCl_3$). *Anal.* Calcd for $C_{25}H_{34}O_{14}$: C, 53.76; H, 6.14. Found: C, 53.85; H, 6.20. IR ν_{max}^{KBr} cm^{-1}: 3520, 1760, 1662. *Rf* 0.20. IIIb: Colorless needles (from MeOH), mp 172.0—172.5 °C, $[\alpha]_D^{20}$ −155.1° (c=0.5, $CHCl_3$). *Anal.* Calcd for $C_{27}H_{36}O_{15}$: C, 54.00; H, 6.04. Found: C, 54.25; H, 6.01. IR ν_{max}^{KBr} cm^{-1}: 1752, 1660. *Rf* 0.45.

Geniposidic Acid (II): White powder, $[\alpha]_D^{24}$ +20.1° (c=1.1, MeOH). IR ν_{max}^{KBr} cm^{-1}: 3400, 1686, 1634. *Rf* 0.24. ^{13}C-NMR: Table I.

Compounds VIa, VIb, IVa, IIIa, IIIb and II were identified as gluroside tetraacetate, gluroside pentaacetate, 8-epideoxyloganic acid tetraacetate, leonuride pentaacetate, leonuride hexaacetate and geniposidic acid, respectively, by direct comparison (VIa, VIb, IIIa, IIIb: mixed mp, TLC and IR. IVa, II: TLC and IR) with authentic samples.

Mussaenosidic Acid (I)——White powder, $[\alpha]_D^{18}$ −186.3° (c=0.7, MeOH). IR ν_{max}^{KBr} cm^{-1}: 3400, 1690, 1650. UV λ_{max}^{MeOH} nm (log ε): 234 (3.95). FD-MS m/z: 377 (M^++1). ^{1}H-NMR (pyridine-d_5) δ: 1.90 (3H, s, CH_3), 2.82 (1H, dd, J=10, 4 Hz, H-9), 5.43 (1H, d, J=8 Hz, anomeric H), 6.01 (1H, d, J=4 Hz, H-1), 7.93 (1H, br s, H-3). ^{13}C-NMR: Table I.

Acetylation of I——Compound I (100 mg) was dissolved in pyridine (1 ml) and acetic anhydride (1 ml), and the solution was left for 2 h at room temperature. The reaction product was chromatographed on a silica gel column with $CHCl_3$–MeOH (10:1) to give the tetraacetate (Ia) (65 mg) as a white powder, $[\alpha]_D^{20}$ −93.0° (c=0.8, $CHCl_3$). *Anal.* Calcd for $C_{24}H_{32}O_{14}$: C, 52.94; H, 5.92. Found: C, 53.19; H, 5.95. IR ν_{max}^{KBr} cm^{-1}: 3400, 1760, 1644. ^{1}H-NMR ($CDCl_3$) δ: 1.34 (3H, s, CH_3), 1.98, 2.02, 2.05 and 2.13 (3H each, s, OAc), 2.34 (1H, dd, J=10, 3 Hz, H-9), 3.10 (1H, m, H-5), 5.33 (1H, d, J=3 Hz, H-1), 7.44 (1H, br s, H-3). Mussaenosidic acid tetraacetate (Ia) (50 mg) was dissolved in pyridine (1 ml) and acetic anhydride (1 ml) and the solution was allowed to stand overnight at 40 °C. The reaction mixture was treated in the same manner as described above to give the pentaacetate (Ib) (45 mg) as a white powder. $[\alpha]_D^{20}$ −76.9° (c=0.3, $CHCl_3$). *Anal.* Calcd for $C_{26}H_{34}O_{15}$: C, 53.24; H, 5.84. Found: C, 53.41; H, 5.90. IR ν_{max}^{KBr} cm^{-1}: 1756, 1644. ^{1}H-NMR ($CDCl_3$) δ: 1.51 (3H, s, CH_3), 1.95, 2.04 and 2.12 (3H each, s, OAc), 2.02 (6H, s, OAc×2), 2.70 (1H, dd, J=9, 2 Hz, H-9), 2.98 (1H, m, H-5), 5.72 (1H, d, J=2 Hz, H-1), 7.48 (1H, br s, H-3).

Methylation of I——A methanolic solution of I (50 mg) was methylated with ethereal CH_2N_2 overnight and the reaction product was purified on a silica gel column with $CHCl_3$–MeOH–H_2O (8:2:0.2) to give the methyl ester (Ic) (27 mg) as a white powder. $[\alpha]_D^{20}$ −105.5° (c=0.6, MeOH). UV λ_{max}^{MeOH} nm (log ε): 238 (3.80). IR ν_{max}^{KBr} cm^{-1}: 3430, 1696, 1644. ^{1}H-NMR (methanol-d_4) δ: 1.34 (3H, s, CH_3), 2.26 (1H, dd, J=10, 4 Hz, H-9), 3.71 (3H, s, $COOCH_3$), 4.69 (1H, d, J=8 Hz, anomeric H), 5.47 (1H, d, J=4 Hz, H-1), 7.41 (1H, d, J=1 Hz, H-3). ^{13}C-NMR: Table I. This compound was found to be identical with an authentic sample of mussaenoside by direct comparison (TLC, IR and ^{1}H-NMR).

Hydrolysis of Va——A solution of Va (100 mg) and NaOH (1.5 g) in 75% MeOH (50 ml) was stirred for 1 h at room temperature. The reaction mixture was concentrated *in vacuo* to give the residue, which was applied to a Diaion HP-20 column. The column was washed with H_2O (1 l) and then eluted with MeOH (300 ml). The MeOH eluate was concentrated *in vacuo* to give V (45 mg). 6-Deoxycatalpol (V): Colorless needles (from MeOH), mp 204—206 °C, $[\alpha]_D^{18}$ −50.0° (c=1.0, MeOH). *Anal.* Calcd for $C_{15}H_{22}O_9$: C, 52.02; H, 6.40. Found: C, 51.79; H, 6.38. IR ν_{max}^{KBr} cm^{-1}: 3400, 1660. UV λ_{max}^{MeOH} nm (log ε): 205 (3.51). FD-MS m/z: 346 (M^+), 369 (M+Na)$^+$. ^{1}H-NMR (D_2O) δ: 1.3—1.9 (1H, m, H-6), 2.2—2.7 (3H, m, H-5, H-6 and H-9), 3.64 (1H, s-like, H-7), 3.90 and 4.35 (2H, AB system, J=13 Hz, H-10), 4.92 (1H, d, J=7 Hz, anomeric H), 5.10 (1H, dd, J=6, 4 Hz, H-4), 5.12 (1H, d, J=10 Hz, H-1), 6.38 (1H, dd, J=6, 1 Hz, H-3). ^{13}C-NMR: Table I.

Acid Hydrolysis of V——A solution of V (*ca.* 2 mg) in 10% H_2SO_4 (1 ml) was heated in a boiling water bath for 30 min. The solution was passed through an Amberlite IR-45 column and concentrated to give the residue, which was reduced with sodium borohydride (*ca.* 3 mg) for 1 h. The reaction mixture was passed through an Amberlite IR-120 column and concentrated to dryness. Boric acid was removed by distillation with MeOH and the residue was acetylated with acetic anhydride (1 drop) and pyridine (1 drop) at 100 °C for 1 h. The reagents were evaporated off *in vacuo*. Glucitol acetate was detected by GC. t_R (min) 5.5.

Reduction of Va with $LiAlH_4$——6-Deoxycatalpol pentaacetate (Va) (100 mg) was dissolved in dry tetrahydro-

furan (THF) (10 ml) and then treated with $LiAlH_4$ (50 mg) at 70 °C with stirring for 10 h. The mixture was cooled in an ice-bath, MeOH was added (3 ml), and the whole was concentrated *in vacuo*. After addition of H_2O, the solution was neutralized with 6 N HCl, applied to a Diaion HP-20 column and eluted with H_2O (1 l) and MeOH (300 ml) successively. The MeOH eluate was concentrated *in vacuo* and the residue was chromatographed on a silica gel column with $CHCl_3$–MeOH–H_2O (8:2:0.1) to give the reduction product (IX) (15 mg) as a white powder. $[\alpha]_D^{22}$ −82.1° (c=0.8, MeOH). IR ν_{max}^{KBr} cm^{-1}: 3420, 1646. UV λ_{max}^{MeOH} nm (log ε): 204 (3.44). ^{1}H-NMR (D_2O) δ: 4.93 (1H, dd, J=7, 3.5 Hz, H-4), 5.58 (1H, d, J=3 Hz, H-1), 6.28 (1H, d, J=7 Hz, H-3). ^{13}C-NMR: Table I.

Acknowledgement We are grateful to Prof. Dr. H. Inouye, Faculty of Pharmaceutical Sciences, Kyoto University, and to Prof. Dr. O. Sticher, Pharmazeutisches Institute, Eidgenössische Technischule Hochschule, Zürich, for providing standard samples. We are also grateful to Prof. Dr. S. R. Jensen, Institute of Organic Chemistry, The Technical University of Denmark, for providing copies of spectral charts.

References and Notes

1) *a*) H. Kobayashi and J. Komatsu, *Yakugaku Zasshi*, **103**, 508 (1983); *b*) H. Kobayashi, H. Karasawa, T. Miyase and S. Fukushima, *Chem. Pharm. Bull.*, **32**, 1729 (1984).
2) *a*) H. Kobayashi, H. Karasawa, T. Miyase and S. Fukushima, *Chem. Pharm. Bull.*, **32**, 3009 (1984); *b*) *Idem, ibid.*, **32**, 3880 (1984); *c*) *Idem, ibid.*, **33**, 1452 (1985).
3) C. K. Sehgal, S. C. Taneja, K. L. Dhar and C. K. Atal, *Phytochemistry*, **21**, 363 (1982).
4) P. K. Dutta and U. S. Chowdhury, *Tetrahedron*, **39**, 3067 (1983).
5) R. Guarnaccia, K. M. Madyastha, E. Tegtmeyer and C. J. Coscia, *Tetrahedron Lett.*, **1972**, 5125.
6) *a*) K. Weinges, P. Kloss and W. D. Henkels, *Justus Liebigs Ann. Chem.*, **1973**, 566; *b*) M. Guiso, R. Marini-Bettolo and A. Agostini, *Gazz. Chim. Ital.*, **104**, 25 (1974).
7) F. Murai, M. Tagawa, S. Damtoft, S. R. Jensen and B. J. Nielsen, *Chem. Pharm. Bull.*, **32**, 2809 (1984).
8) O. Sticher, E. Rogenmoser and A. Weisflog, *Tetrahedron Lett.*, **1975**, 291.
9) A. Bianco, M. Guiso, C. Iavarone and C. Trogolo, *Gazz. Chim. Ital.*, **106**, 725 (1976).
10) Y. Takeda, H. Nishimura and H. Inouye, *Phytochemistry*, **16**, 1401 (1977).
11) *a*) R. B. Duff, J. S. D. Bacon, C. M. Mundie, U. C. Farmer, J. D. Russel and A. R. Forrester, *Biochem. J.*, **96**, 1 (1965); *b*) J. M. Bobbitt, D. W. Spiggle, S. Mohboob, H. Schmid and W. von Philipsborn, *J. Org. Chem.*, **31**, 500 (1966).
12) S. Damtoft, S. R. Jensen and B. J. Nielsen, *Phytochemistry*, **20**, 2717 (1981).
13) R. K. Chaudhuri, F. Ü. Afifi-Yazer and O. Sticher, *Tetrahedron*, **36**, 2317 (1980).