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The Constituents of *Schizandra chinensis* Baill. VII.[1] The Structures of Three New Lignans, (−)-Gomisin K_1 and (+)-Gomisins K_2 and K_3

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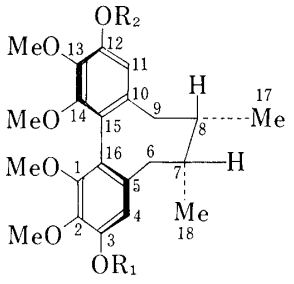
Three new dibenzocyclooctadiene lignans named (−)-gomisin K_1(**1**) and (+)-gomisins K_2 (**2**) and K_3 (**3**) were isolated from the fruits of *Schizandra chinensis* Baill. (Schizandraceae). Their structures were elucidated on the basis of chemical and spectral studies.

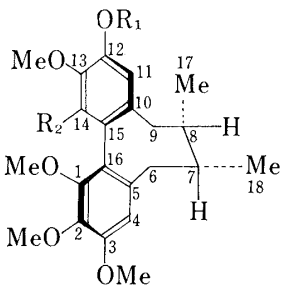
Keywords——*Schizandra chinensis* Baill.; Schizandraceae; dibenzocyclooctadiene; lignan; (−)-gomisin K_1; (+)-gomisin K_2; (+)-gomisin K_3; ^{13}C NMR

In the preceding paper, we reported the results of carbon nuclear magnetic resonance (^{13}C NMR) spectroscopy of dibenzocyclooctadiene lignans isolated from *Schizandra chinensis* Baill. (Schizandraceae).[1] This paper deals with the structure elucidation of three additional new lignans, named (−)-gomisin K_1 (**1**) and (+)-gomisins K_2 (**2**) and K_3 (**3**), isolated from the same source.

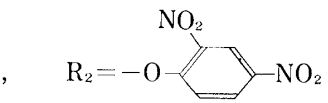
The dried fruits of the plants were extracted with petroleum ether and methanol, and the extracts were treated by the procedure described in the first paper of this series[3a] to give twelve fractions. Fraction 6 was rechromatographed on silica gel to give a mixture of **1** and **2**. Pure compounds **1** (yield 0.0063%) and **2** (0.0009%) were separated by fractional crystallization of their *p*-bromobenzoyl esters as described in the experimental section. Fraction (7—9)-d, which was described in the third paper of this series,[3c] was rechromatographed on silica gel to give **3** (yield 0.0068%) by the purification procedure *via* acetylation.



1 : R_1=Me, R_2=H
4 : R_1=R_2=Me
5 : R_1=Me, R_2=$COCH_3$
6 : R_1=R_2=H



2 : R_1=H, R_2=OMe
3 : R_1=Me, R_2=OH
7 : R_1=Me, R_2=OMe
8 : R_1=$COCH_3$, R_2=OMe



9 : R_1=Me, R_2=

10 : R_1=Me, R_2=$OCOCH_3$
11 : R_1=Me, R_2=H

Chart 1

1) Part VI: Y. Ikeya, H. Taguchi, H. Sasaki, K. Nakajima, and I. Yosioka, *Chem. Pharm. Bull.*, **28**, 2414 (1980).
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Table I. ^{1}H NMR Spectral Data for **1**, **2**, **3** and **11** (δ in $CDCl_3$, 60 MHz)

Compd.	Solvent	4-H, s 11-H, s	OCH_3 s	OH[b] s	6-H	9α-H (J=Hz)	9β-H (J=Hz)	7-H 8-H	$C_{(7)}$-Me (d, J= 7 Hz)	$C_{(8)}$-Me (d, J= 7 Hz)
1	$CDCl_3$[a]	6.58 6.65	3.58(×2), 3.92(×2) 3.93	5.72	2.57 (center, 2H, m)	2.26, dd, (13.5/8.5)	2.02, dd, (13.5/1)	1.85 (2H, m)	0.75	0.93
	C_6D_6	6.45 6.78	3.50, 3.56, 3.62, 3.67, 3.88	4.22	1.85—2.67 (4H, m)			1.77 (2H, m)	0.68	0.88
2	$CDCl_3$	6.58 6.65	3.55(×2), 3.90(×2), 3.93	5.75	2.10 (center, 2H, m)	2.60 (center, 2H, m)		1.85 (2H, m)	0.93	0.75
	C_6D_6	6.50 6.78	3.52(×2), 3.63(×2), 3.87	Not clear	1.88—2.67 (4H, m)			1.74 (2H, m)	0.90	0.70
3	$CDCl_3$	6.58 6.38	3.63, 3.90(×2), 3.92(×2)	5.72	2.13 (center, 2H, m)	2.53 (center, 2H, m)		1.82 (2H, m)	1.00	0.74
	C_6D_6	6.50 6.27	3.50(×2), 3.70(×2), 3.85	5.83	1.92—2.68 (4H, m)			1.77 (2H, m)	0.93 (6.5)	0.74
11	$CDCl_3$	6.57[c] 6.75 6.77	3.50, 3.87 3.93(×3)	—	2.10 (center, 2H, m)	2.58 (center, 2H, m)		1.88 (2H, m)	1.02	0.79

a) Measured at 100 MHz.
b) Hydroxy signals were confimred by the addition of D_2O.
c) δ in acetone-d_3: 6.67, 6.70, and 6.82 (each singlet).
d) d=doublet, m=multiplet, s=singlet.

(−)-Gomisin K_1 (**1**) was isolated as colorless prisms (from ether–hexane), $C_{23}H_{30}O_6$, mp 99—101°, $[\alpha]_D^{23}$ −96.7° (in $CHCl_3$). The ultraviolet (UV) spectrum, with absorption maxima at 217 (log ε 4.74), 250 (4.21), 276 (sh 3.57) and 285 nm (sh 3.48), and the infrared (IR) spectrum, with bands at 3475 (OH), 1610 and 1583 (aromatic) cm^{-1}, indicate that **1** is a dibenzocyclooctadiene lignan having a hydroxy group. The proton (^{1}H) NMR spectrum of **1** (Table I) shows the presence of two secondary methyls, two benzylic methylenes, five methoxyls, a phenolic hydroxyl (δ 5.72, 1H, br s, D_2O-exchangeable) and two aromatic protons. The appearance of two distinct methyl signals and two upfield methoxy signals (δ 3.58, 6×H) suggests that one methyl (δ 0.75)[1,4] and two methoxyls (δ 3.58)[1,5] are shielded by the aromatic rings, and therefore that **1** has a *cis*-dimethyl moiety on the cyclooctadiene ring and two methoxyls at C-1 and C-14 on the aromatic rings.

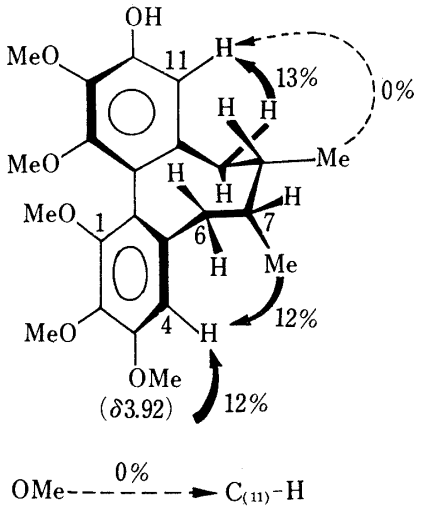

Fig. 1. NOE in **1** (in $CDCl_3$)

On methylation, **1** afforded a monomethyl ether (**4**) as colorless prisms (from ether–hexane), $C_{24}H_{32}O_6$, mp 113.5—115°, $[\alpha]_D^{23}$ −73.2° (in $CHCl_3$); this compound was identified as dimethyl-

3) *a*) Y. Ikeya, H. Taguchi, I. Yosioka, and H. Kobayashi, *Chem. Pharm. Bull.*, **27**, 1383 (1979); *b*) Y. Ikeya, H. Taguchi, I. Yosioka, Y. Iitaka, and H. Kobayashi, *ibid.*, **27**, 1395 (1979); *c*) Y. Ikeya, H. Taguchi, I. Yosioka, and H. Kobayashi, *ibid.*, **27**, 1576 (1979); *d*) *Idem*, *ibid.*, **27**, 1583 (1979); *e*) *Idem*, *ibid.*, **27**, 2695 (1979).
4) E. Ghera, Y. Ben. Dabid, and D. Becker, *Tetrahedron Lett.*, **1977**, 463.
5) A.F.A. Wallis, *Tetrahedron Lett.*, **1968**, 5287.

gomisin J (**4**)[3d] (*S*-biphenyl configuration) by direct comparison (IR, ^{1}H NMR, mixed mp and $[\alpha]_D$). On acetylation, **1** afforded a monoacetate (**5**) as an amorphous powder, $C_{25}H_{32}O_7$, $[\alpha]_D^{24}$ −75.5° (in $CHCl_3$). These results indicate that **1** corresponds to a monomethyl ether of gomisin J (**6**).

The position of the phenolic hydroxy group in **1** was elucidated by measurements of intramolecular nuclear Overhauser effects (NOE) (in $CDCl_3$), as shown in Fig. 1. Irradiation of a methoxy signal (δ 3.92) and an upfield methyl signal (δ 0.75, $C_{(7)}$-methyl) caused a 12% increase in the integrated intensity of the upper field aromatic proton (δ 6.58, $C_{(4)}$–H) in each case. On the other hand, irradiation of a methylene proton signal (δ 2.02, dd, J=13.5/1 Hz, $C_{(9\beta)}$–H) caused a 13% increase in the integrated intensity of the downfield aromatic proton signal (δ 6.65, $C_{(11)}$–H), while irradiation of each methoxy signal did not affect the downfield aromatic proton signal. These findings indicate that the hydroxy group is located at C-12 and that the $C_{(7)}$ methyl group and $C_{(4)}$ proton are close to each other. Irradiation of the downfield methyl signal (δ 0.93, $C_{(8)}$-methyl) did not affect the aromatic protons. On the basis of the above results and the J values between $C_{(9)}$ methylene and $C_{(8)}$ methine protons ($J_{8,9\beta}$= 1 Hz, $\phi_{8,9\beta} \fallingdotseq 90°$; $J_{8,9\alpha}$=8.5 Hz, $\phi_{8,9\alpha} \fallingdotseq 150°$),[3] the structure of (−)-gomisin K_1 was elucidated as **1**.[6]

(+)-Gomisin K_2 (**2**) was obtained as an amorphous powder, $C_{23}H_{30}O_6$, $[\alpha]_D^{24}$ +81.7° (in $CHCl_3$). The UV and IR spectra indicate that **2** is a dibenzocyclooctadiene lignan having a hydroxy group. The ^{1}H NMR spectral analysis of **2** (Table I) suggests that **2** possesses the same skeleton as **1**. In fact, on methylation, **2** afforded a monomethyl ether (**7**) as colorless prisms (from ether–hexane), $C_{24}H_{32}O_6$, mp 115.5—117°, $[\alpha]_D^{24}$ +97.5° (in $CHCl_3$), which was identified as (+)-deoxyschizandrin (**7**)[3e] (*R*-biphenyl configuration) by direct comparison

Table II. ^{13}C NMR Spectral Data for **2**, **3**, **7**, **8**, **10** and **11** [δ in $CDCl_3$, ^{13}C: 20 MHz at 25°]

Carbon		Compound (*R*-biphenyl configuration)					
		2	**3**	**7**	**8**	**10**	**11**[a]
	1	151.5[b]	151.3	151.6	151.4[b]	151.3[b]	151.0
	2	139.9	139.9	140.3	139.9	139.6	140.1
	3	152.9	153.2	153.0[b]	153.3	153.2	152.6
	4	107.4	107.3	107.3	107.4	107.5	107.7
	5	139.4	139.8	139.1	139.1	140.2	139.3
	6	35.6	35.8	35.7	35.6	35.5	35.7
	7	40.9	40.9	40.9	40.8	40.6	40.5
	8	33.8	33.8	33.8	33.8	33.8	33.4
	9	38.8	39.2	39.2	38.6	39.2	38.8
	10	134.7	134.3	133.9	134.2	134.0	128.5
	11	113.1	107.9	110.6	120.4	113.1	114.7[b]
	12	147.6	150.6	151.7[b]	142.5	151.5[b]	147.2
	13	137.7	134.0	139.9	142.8	139.4	146.4
	14	150.4[b]	146.9	151.5	151.7[b]	142.3	114.0[b]
	15	122.6	117.0	123.5	129.0	123.5	130.3
	16	122.3	121.3	122.4	121.9	120.9	126.5
	17	12.6	12.8	12.7	12.5	13.0	12.8
	18	21.8	21.7	21.8	21.8	21.6	21.6
OCH_3	C-1, 14	60.5, 60.1	61.0, —	60.3(×2)	60.6, 60.3	60.7, —	60.5, —
OCH_3	C-2, 13	61.0, 60.9	61.1, 61.0	60.7(×2)	60.9, 60.8	60.9, 56.2	61.1, 55.9
OCH_3	C-3, 12	55.9, —	56.0, 55.9	55.7(×2)	56.0, —	56.1, 55.9	55.9, 56.0
	$COCH_3$	—	—	—	169.1, 20.8	168.4, 20.5	—

a) Measured at 15.04 MHz.
b) Assignments within any vertical column may be reversed.

6) The ^{13}C NMR spectral data are described in the preceding paper.[1]

(IR. ^{1}H NMR, mixed mp and $[\alpha]_D$). The appearance of two upfield methoxy signals (δ 3.55, 6×H) in the ^{1}H NMR spectrum (in $CDCl_3$) of **2** shows that two methoxy groups are located at C-1 and C-14 on the aromatic rings.[5] On the other hand, the appearance of an upfield methoxy (δ 55.9) and four downfield methoxy (δ 60.1—61.0) carbons in the ^{13}C NMR spectrum of **2** (Table II) indicates the presence of one methoxy group and one hydroxy group at C-3 and C-12 in **2**, as mentioned in the preceding paper.[1] To confirm the position of the hydroxy group, the chemical shifts of protonated aromatic carbons in **2** and its acetate (**8**) were compared with those of **7**. The signals at δ 107.4 in **2** and **8**, which have essentially the same value as the C-4 shift of **7** (δ 107.3),[1] are assignable to C-4, indicating that one methoxy group (δ 55.9) is located at C-3. The other signals at δ 113.1 in **2** and δ 120.4 in **8** are consequently assigned to C-11, which shows downfield shifts of 2.5 ppm and 9.8 ppm, respectively, compared with the C-11 shift in **7**. The above results indicate that the hydroxy group in **2** is at C-12 (axial methyl side).[1] Thus, the structure of (+)-gomisin K_2 was elucidated as **2**.

(+)-Gomisin K_3 (**3**) was obtained as colorless needles (from ether–hexane), $C_{23}H_{30}O_6$, mp 100—101°, $[\alpha]_D^{23}$ +60.8° (in $CHCl_3$). The UV and IR spectra indicate that **3** is a dibenzocyclooctadiene lignan having a hydroxy group. The ^{1}H NMR spectrum of **3** (Table I) indicates the presence of two secondary methyls, two benzylic methylenes, five methoxyls, a phenolic hydroxyl (δ 5.72, 1H, br s, D_2O-exchangeable) and two aromatic protons. The ^{13}C NMR spectrum also supports the presence of the above functional groups in **3** (Table II). The presence of an upfield methoxy signal (δ 3.63) in the ^{1}H NMR spectrum suggests that one methoxy group is shielded by an aromatic ring, and therefore **3** has one methoxyl and one hydroxyl at C-1 and C-14 on the aromatic rings. On methylation, **3** afforded a monomethyl ether as colorless prisms (from ether–hexane), $C_{24}H_{32}O_6$, mp 117—118°, $[\alpha]_D^{23}$ +80.0° (in $CHCl_3$), which was identified as **7** by direct comparison (IR, ^{1}H and ^{13}C NMRs, mixed mp and $[\alpha]_D$). Treatment of **3** with 2,4-dinitrofluorobenzene (2,4-DNFB) in a mixture of benzene and dimethylformamide (DMF) in the presence of sodium hydride as a catalyst afforded the 2,4-dinitrophenyl ether (**9**) of **3** as an oil. Catalytic hydrogenation of **9** over platinum oxide followed by cleavage with sodium in liquid ammonia[3c] afforded compound **11** (deoxy-(+)-gomisin K_3), $C_{23}H_{30}O_5$, mp 114—115°, $[\alpha]_D^{25}$ +106.0° (in $CHCl_3$), which shows three singlets due to aromatic protons in the ^{1}H NMR spectrum, indicating that the hydroxy group in **3** is located at the *para*-position (C-1 or C-14) relative to an aromatic proton. The position of the hydroxy group in **3** was elucidated by ^{13}C NMR spectral analysis.

On comparison of the chemical shifts of protonated aromatic carbons of **3** and its derivatives [the monoacetate (**10**) and deoxy compound (**11**)] with those of **7**,[1] the signal at around δ 107.3—107.7 in each compound (**3**, **10** and **11**) is assignable to C-4 and the other protonated aromatic carbon is thus C-11. The C-11 shift of **3** shows an upfield shift of 2.8 ppm, but that of **10** shows a downfield shift of 2.8 ppm, compared with the C-11 shift of **7**. The above results suggest that the hydroxy group in **3** is located at C-14.[1] In addition, the appearance of the protonated aromatic carbons at δ 114.0 and δ 114.7 in the spectrum of **11** indicates the presence of a proton at C-14. On the basis of the above observations, the structure of (+)-gomisin K_3 was elucidated as **3**. The other carbon shifts in the ^{13}C NMR spectra of **2** and **3**, and their derivatives (**8**, **10** and **11**) are consistent with the structures **2** and **3** (Table II).

Although direct comparison was not carried out, (+)-gomisin K_3 seems to be identical with schisanthenol isolated from *Schisandra hentyi* Clarke by Liu *et al.*[7]

Experimental

All melting points were determined on a Yanagimoto micro-melting point apparatus (a hot-stage type) and are uncorrected. The UV spectra were recorded with a Hitachi 624 digital spectrophotometer and the IR spectra with a Hitachi EPI-G2 machine. The ^{1}H NMR spectra were recorded with Varian T-60 and

7) C-S. Liu, M-F. Huang, and Y-L. Kao, *Hua Hsueh Hsueh Pao*, **36**, 193 (1978) [*C.A.*, **90**, 103711*v* (1979)].

JEOL PS-100 spectrometers and the ^{13}C NMR spectra were recorded with Varian FT-80, JEOL FX-100 and JEOL FX-60 spectrometers with tetramethylsilane as an internal standard. Mass spectra were measured with a Hitachi double-focusing mass spectrometer. The specific rotations were measured with a JASCO DIP-SL unit and the CD spectra with a JASCO J-20 unit. For silica gel column chromatography, Kieselgel 60 (Merck) was used. TLC was carried out on Merck plates precoated with Kieselgel 60 F_{254}. Preparative layer chromatography (PLC) was carried out on plates (20×20 cm, 0.75 mm thick) coated with Kieselgel GF_{254} (Merck).

Isolation of 1 and 2——i) Isolation of a Mixture of **1** and **2**: In the previous papers,[3a,c] it was reported that the petroleum ether and methanol extracts of the fruits of *Schizandra chinensis* (4.67 kg) were column chromatographed on silica gel, developing with hexane, acetone–benzene and acetone solvent systems, to give twelve fractions (fr 1—12). Fr. 6 (10.97 g) was rechromatographed on silica gel (240 g) with an EtOAc–hexane solvent system. The fractions eluted with 14% EtOAc–hexane were combined and concentrated to give a gum (972 mg), which was separated by PLC [ether–hexane (2: 1), *Rf* 0.53] to give a mixture (510 mg) of **1** and **2** as an oil. The fractions eluted with 16% EtOAc–hexane were combined and concentrated to give a gum (875 mg), which was subjected to PLC [EtOAc–hexane (2: 3), *Rf* 0.58] to give a gum (560 mg). The gum obtained here was separated by PLC [ether–hexane (2: 1), *Rf* 0.53] to give a mixture (240 mg) of **1** and **2** as an oil.

ii) Isolation of **1**: The mixture (750 mg) of **1** and **2** was added to a solution of *p*-bromobenzoyl chloride (800 mg) in dry pyridine (8 ml). The reaction mixture was stirred at room temperature for 12 hr and then dissolved in a mixture of CH_2Cl_2 and ether (1: 2) (60 ml). The total mixture was washed successively with 2 N NaOH, 1 N HCl, and H_2O, dried over Na_2SO_4 and concentrated to give a residue, which was purified by PLC [acetone–hexane (3: 7), *Rf* 0.80] to give a mixture (815 mg) of the *p*-bromobenzoyl esters of **1** and **2**. Repeated recrystallization of this mixture from a mixture of CH_2Cl_2 and MeOH gave the *p*-bromobenzoyl ester (**12**) of **1** as colorless needles (406 mg), mp 211—214°, $[\alpha]_D^{24}$ −79.3° (c=0.807, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 1742 (ester), 1589, 1574 (aromatic). ^1H NMR [δ in C_6D_6–$CDCl_3$ (3: 1)]: 0.69 (3H, d, J=7 Hz, H–C$_{(7)}$–C$\underline{H}_3$), 0.92 (3H, d, J=7 Hz, H–C$_{(8)}$–C$\underline{H}_3$), 1.78 (2H, m, 2×H–C–), 1.98—2.65 (4H, m, 2×Ar–C$\underline{H}_2$–), 3.57, 3.62, 3.67, 3.82, 3.87 (each 3H, s, 5×OCH_3), 6.46 (1H, s, arom.-H), 6.83 (1H, s, arom.-H), 7.83 (2H, d, J=8.5 Hz), 8.00 (2H, d, J=8.5 Hz) (*p*-Br–$C_6\underline{H}_4$CO–). MS *m/e* (%): 586 (58), 584 [$C_{30}H_{33}O_7{}^{79}Br(M^+)$ 59], 183 (^{79}Br–C_6H_4CO, 100).

Compound **12** (396 mg) was dissolved in 3% KOH–EtOH (12 ml). The reaction mixture was kept at 75° for 4 hr, then diluted with H_2O and extracted with a mixture of CH_2Cl_2 and ether (1: 1) (40 ml×2). The CH_2Cl_2–ether extract was washed with H_2O, dried over Na_2SO_4 and concentrated to give **1** (294 mg, yield 0.0063%) as colorless prisms (from ether–hexane), mp 99—101°, $[\alpha]_D^{23}$ −96.7° (c=1.73, $CHCl_3$). UV λ_{max}^{EtOH} nm (log ε): 217 (4.74), 250 (4.21), 276 (sh 3.57), 285 (sh 3.48). IR ν_{max}^{KBr} cm^{-1}: 3475 (OH), 1610, 1583 (aromatic). MS *m/e* (%): 402 (M^+, 100), 167 (4.6). *Anal.* Calcd for $C_{23}H_{30}O_6$: C, 68.63; H, 7.51. Found: C, 68.80; H, 7.59.

iii) Isolation of **2**: The first mother liquor of recrystallization of a mixture of the *p*-bromobenzoyl esters of **1** and **2** was concentrated to give a residue (114 mg), which was dissolved in 3% KOH–EtOH (4 ml). The reaction mixture was kept at 75° for 4 hr, then dissolved in a mixture of CH_2Cl_2 and ether (1: 1) (40 ml). The total mixture was washed with H_2O, dried over Na_2SO_4, and concentrated to give a residue (74 mg), which was dissolved in a mixture of pyridine (0.8 ml) and Ac_2O (0.4 ml). The reaction mixture was allowed to stand at room temperature overnight, then diluted with H_2O and extracted with ether. The ethereal extract was washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [benzene–ether (3: 1), *Rf* 0.67] to give **8** (from ether–hexane) as colorless needles [47 mg, Calcd yield of **2**: 43 mg (0.0009%)], mp 114—116°, $[\alpha]_D^{24}$ ≃0° (c=1.72, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 1750 (C=O), 1595, 1575 (aromatic). ^1H NMR (δ in C_6D_6): 0.72 (3H, d, J=7 Hz, C$\underline{H}_3$–CH), 1.07 (3H, d, J=7 Hz, C$\underline{H}_3$–CH), 1.77 (2H, m, 2×–CH), 1.97 (3H, s, COC$\underline{H}_3$), 1.87—2.60 (4H, m, 2×ArC$\underline{H}_2$), 3.50 (3H, s), 3.55 (3H, s), 3.62 (3H, s), 3.85 (6H, s) (5×OCH_3), 6.48 (1H, s, arom.-H), 6.78 (1H, s, arom.-H). *Anal.* Calcd for $C_{25}H_{32}O_7$: C, 67.55; H, 7.26. Found: C, 67.63; H, 7.28. Compound **8** (42 mg) was dissolved in 3% KOH–EtOH (2 ml) and the reaction mixture was kept at 50° for 2 hr, then diluted with H_2O (10 ml) and extracted with ether (15 ml×3). The ethereal extract was washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [acetone–hexane (3: 7), *Rf* 0.68] to give **2** (35 mg) as a white amorphous powder, $[\alpha]_D^{24}$ +81.7° (c=1.81, $CHCl_3$). UV λ_{max}^{EtOH} nm (log ε): 216 (4.74), 250 (4.21), 276 (sh 3.55), 285 (sh 3.46). IR ν_{max}^{KBr} cm^{-1}: 3410 (OH), 1596, 1581 (aromatic). *Anal.* Calcd for $C_{23}H_{30}O_6$: C, 68.63; H, 7.51. Found: C, 68.65; H, 7.42.

Isolation of 3——Fr. (7—9)-d (5.11 g)[3c] was rechromatographed on silica gel, developing with an acetone–hexane solvent system. The fractions eluted with 10% acetone–hexane were combined and concentrated to dryness. The residue (948 mg) was purified by PLC [ether–hexane (2: 1), *Rf* 0.42] to give crude **3** (476 mg), which was dissolved in a mixture of pyridine (1.5 ml) and Ac_2O (0.75 ml). The reaction mixture was allowed to stand at room temperature overnight, then diluted with H_2O (10 ml) and extracted with ether (15 ml×3). The ethereal extract was washed with H_2O, dried over Na_2SO_4, and concentrated. The residue was purified by PLC [benzene–ether (3: 1)] to give **10** (350 mg) as colorless needles (from ether–hexane), mp

159—160.5°, $[\alpha]_D^{23}$ +38.6° (c=1.12, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 1760 (C=O), 1610, 1595, 1580 (aromatic). ^1H NMR (δ in C_6D_6): 0.70 (3H, d, J=7 Hz, CH_3–CH), 0.92 (3H, d, J=6 Hz, CH_3–CH), 1.72 (3H, s, $COCH_3$), 1.87 (2H, m, 2×–CH), 1.93—2.73 (4H, m, 2×ArCH_2–), 3.50 (6H, s), 3.65 (3H, s), 3.86 (3H, s), 3.91 (3H, s) (5×OCH_3), 6.50 (1H, s, arom.-H), 6.57 (1H, s, arom.-H). *Anal.* Calcd for $C_{25}H_{32}O_7$: C, 67.55; H, 7.26. Found: C, 67.72; H, 7.36. Compound **10** (347 mg) was dissolved in 3% KOH–EtOH (3 ml) and the reaction mixture was kept at 70° for 2 hr, then diluted with H_2O (10 ml) and extracted with ether (15 ml×3). The ethereal extract was washed with H_2O, dried over Na_2SO_4, and concentrated to give **3** (308 mg, 0.0068%) as colorless needles (from ether–hexane), mp 100—101°, $[\alpha]_D^{23}$ +60.8°(c=0.937, $CHCl_3$). UV λ_{max}^{EtOH} nm (log ε): 219 (4.71), 251 (sh 4.21), 277 (3.58), 281—284 (sh 3.56). IR ν_{max}^{KBr} cm^{-1}: 3430 (OH), 1608, 1592, 1579 (aromatic). MS m/e (%): 402 (M^+, 100), 181 (1.5). *Anal.* Calcd for $C_{23}H_{30}O_6$: C, 68.63; H, 7.51. Found: C, 68.39; H, 7.54.

Methylation of 1——$(CH_3)_2SO_4$ (0.4 ml) and K_2CO_3 (500 mg) were added to a solution of **1** (42 mg) in dry acetone (5 ml) and the reaction mixture was stirred at 45° for 3 hr, then diluted with ether (50 ml). The ethereal solution was washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [benzene–ether (5: 1), Rf 0.54] to give a monomethyl ether of **1** (41 mg) as colorless prisms (from ether–hexane), mp 113.5—115°, $[\alpha]_D^{23}$ −73.2° (c=1.75, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 1591, 1577 (aromatic). MS m/e (%): 416 (M^+, 100), 370 (5). CD (c=0.0188, MeOH), $[\theta]^{23}$(nm): +83000 (213), −48000 sh (236), −66000(247), −11000 sh(274). *Anal.* Calcd for $C_{24}H_{32}O_6$: C, 69.21; H, 7.74. Found: C, 69.43; H, 7.71. This compound was identified as dimethylgomisin J (**4**)[1d] by direct comparison with an authentic sample (IR, ^1H NMR, mixed mp and $[\alpha]_D$).

Acetylation of 1——A solution of **1** (55 mg) in a mixture of Ac_2O (0.3 ml) and pyridine (0.6 ml) was allowed to stand at room temperature overnight, then diluted with H_2O (10 ml) and extracted with ether. The ethereal extract was washed with 1 N HCl, 5% $NaHCO_3$, then H_2O, dried over Na_2SO_4, and concentrated. The residue was purified by PLC [benzene–ether (7: 3), Rf 0.67] to give a monoacetate (**5**) as a white amorphous powder (51 mg), $[\alpha]_D^{24}$ −75.5° (c=1.84, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 1765 (ester), 1592, 1575 (aromatic). *Anal.* Calcd for $C_{25}H_{32}O_7$: C, 67.55; H, 7.26. Found: C, 67.20; H, 7.23.

Methylation of 2——$(CH_3)_2SO_4$ (0.2 ml) and K_2CO_3 (200 mg) were added to a solution of **2** (12 mg) in dry acetone (2 ml) and the reaction mixture was stirred at 45° for 3 hr, then diluted with H_2O (20 ml) and extracted with ether. The ethereal extract was washed with H_2O, dried over Na_2SO_4, and concentrated to dryness. The residue was purified by PLC [benzene–ether (5: 1), Rf 0.54] to give a monomethyl ether (12 mg) as colorless prisms (from ether–hexane), mp 115.5—117°, $[\alpha]_D^{24}$ +97.5° (c=0.605, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 1591, 1576 (aromatic). *Anal.* Calcd for $C_{24}H_{32}O_6$: C, 69.21; H, 7.74. Found: C, 69.45; H, 7.72. This compound was identified as (+)-deoxyschizandrin (**7**)[1e] by direct comparison with an authentic sample (IR, ^1H NMR, mixed mp and $[\alpha]_D$).

Methylation of 3——$(CH_3)_2SO_4$ (0.2 ml) and K_2CO_3 (300 mg) were added to a solution of **3** (21 mg) in dry acetone (2 ml) and the reaction mixture was treated as described for the methylation of **2** to give a monomethyl ether (20 mg) as colorless prisms (from ether–hexane), mp 117—118°, $[\alpha]_D^{23}$ +80.0° (c=0.500, $CHCl_3$). *Anal.* Calcd for $C_{24}H_{32}O_6$: C, 69.21; H, 7.74. Found: C, 69.42; H, 7.81. This compound was identified as **7** by direct comparison with an authentic sample (IR, ^1H NMR, mixed mp and $[\alpha]_D$).

Dinitrophenylation of 3——A solution of **3** (48 mg) in dry benzene (3 ml) was stirred under N_2 with NaH (20 mg) until the evolution of H_2 ceased. 2,4-Dinitrofluorobenzene (100 mg) and dry benzene (2 ml) were added, and then DMF (1.5 ml) was added over a period of 10 min. The reaction mixture was stirred for 30 min, refluxed for 30 min, cooled, diluted with H_2O (10 ml) and extracted with ether. The ethereal extract was washed with H_2O, dried over Na_2SO_4 and concentrated. The residue was purified by PLC [EtOAc–hexane (2: 3)] to give **9** (65 mg, 96%) as a yellow oil, $[\alpha]_D^{26}$ +54.2° (c=0.489, $CHCl_3$). UV λ_{max}^{EtOH} nm (log ε): 212 (4.71), 248(sh 4.31), 284(4.06). IR ν_{max}^{KBr} cm^{-1}: 1602(aromatic), 1532, 1345(NO_2). ^1H NMR (δ in $CDCl_3$): 0.80 (3H, d, J=7 Hz, CH_3–$C_{(8)}$–H), 1.00 (3H, d, J=7 Hz, CH_3–$C_{(7)}$–H), 1.85 (1H, m, –$C_{(7)}$–H), 1.93 (1H, m, –$C_{(8)}$–H), 2.03 (center) (2H, m, ArCH_2–), 2.63 (center) (2H, m, ArCH_2–), 3.57 (3H, s), 3.73 (3H, s), 3.83 (6H, s), 3.95 (3H, s) (5×OCH_3), 6.40 (1H, s, arom.-H), 6.83 (1H, s, arom.-H), 6.77 (1H, d, J=9 Hz), 8.15 (1H, d,d, J=9/3 Hz), 8.62 (1H, d, J=3 Hz) [–$C_6H_3(NO_2)_2$].

Preparation of 11——Compound **9** (57 mg) in a mixture of MeOH (2 ml) and tetrahydrofuran (4 ml) was hydrogenated over PtO_2 (25 mg) at atmospheric pressure for 1 hr. The colorless solution was filtered and concentrated to dryness under reduced pressure. The residue was dissolved in a mixture of liquid ammonia (8 ml) and dry ether (2 ml) and treated with small pieces of sodium at −65° until the solution showed a permanent blue color. After standing briefly, NH_4Cl was added to the solution, then NH_3 was evaporated off at room temperature under an N_2 stream. After addition of H_2O (30 ml), the reaction mixture was extracted with ether (20 ml×3). The combined ethereal extract was washed with H_2O, dried over Na_2SO_4 and concentrated. The residue was purified by PLC [EtOAc–hexane (2: 3)] to give **11** (17 mg, 44%) as colorless needles (from ether–hexane), mp 114—115°, $[\alpha]_D^{25}$ +106° (c=0.905, $CHCl_3$). UV λ_{max}^{EtOH} nm (log ε): 215 (4.89), 253 (4.40), 280 (4.05). IR ν_{max}^{KBr} cm^{-1}: 1600, 1592 (aromatic). *Anal.* Calcd for $C_{23}H_{30}O_5$: C, 71.48; H, 7.82. Found: C, 71.63; H, 7.90.