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TETRAHEDRON

Absolute Configurations of Some Oligostilbenes from *Vitis coignetiae* and *Vitis vinifera* 'Kyohou'

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Abstract: Hepatotoxic oligostilbenes, (+)-vitisin A and (+)-*cis*-vitisin A were isolated as a pure form, respectively, by the method of recycled HPLC. The structure of *cis*-vitisin A was confirmed by the photochemical transformation of vitisin A. The absolute configurations of (+)-ampelopsin A, (+)-ampelopsin B, (+)-vitisin A, (+)-*cis*-vitisin A and (+)-vitisin D were also determined by chemical and spectroscopic methods.

Keywords: Benzofurans; Biologically active compounds; Natural products.

INTRODUCTION

In previous papers,[1,2] one of us (Y. O.) reported a mixture of two new hydroxystilbene tetramers named vitisin A and *cis*-vitisin A as strongly hepatotoxic constituents of *Vitis coignetiae* (Vitaceae). Continuous thorough efforts for the isolation of each compound from the mixture were made. Use of the recycled HPLC technique effected a very successful separation of (+)-vitisin A (**1**) and (+)-*cis*-vitisin A (**2**). Furthermore, we found the presence of only (+)-vitisin A (**1**) without accompanying (+)-*cis*-vitisin A (**2**) in the corks of *Vitis vinifera* 'Kyohou' cultivated in Wakayama Prefecture. The relative structure of (+)-*cis*-vitisin A was confirmed by the photochemical transformation of (+)-vitisin A. The absolute configurations of (+)-vitisin A (**1**) and (+)-*cis*-vitisin A (**2**) together with those of (+)-ampelopsin A (**3**), (+)-ampelopsin B (**4**) and (+)-vitisin D (**5**) were respectively determined by the chemical and spectroscopic evidence.

RESULTS AND DISCUSSION

Isolation of (+)-vitisin A (1) and (+)-*cis*-vitisin A (2) A mixture of vitisin A and *cis*-vitisin A from *V. coignetiae* [1] was subjected to preparative recycled HPLC on reversed phase silica gel (YMC-Pack C8-5; ϕ20 x 250 mm) using a solvent system of methanol/water (60/40) to give (+)-vitisin A (**1**) ($[\alpha]_D$ +195.1° (*c* 1.1, MeOH), *m/z* 907 [MH^+]) and (+)-*cis*-vitisin A (**2**) ($[\alpha]_D$ +184.0° (*c* 0.5, MeOH), *m/z* 907 [MH^+]), respectively. The chromatograms are shown in Fig. 1. The former peak corresponded to (+)-*cis*-vitisin A (**2**) and the latter one

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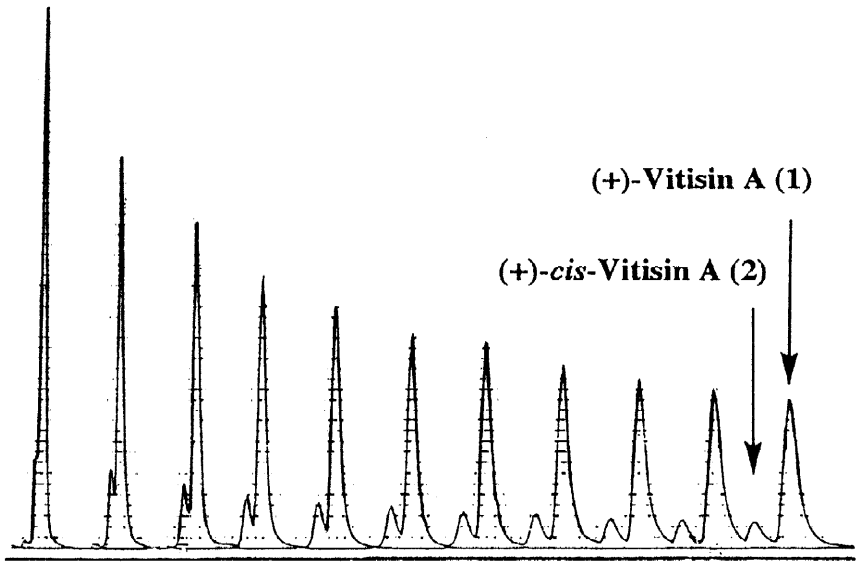
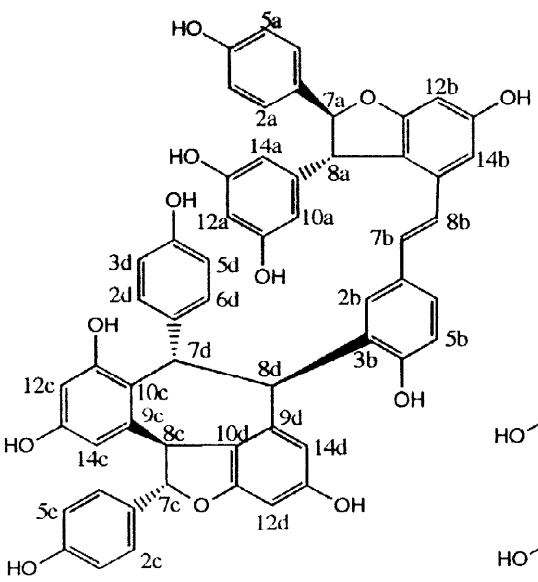
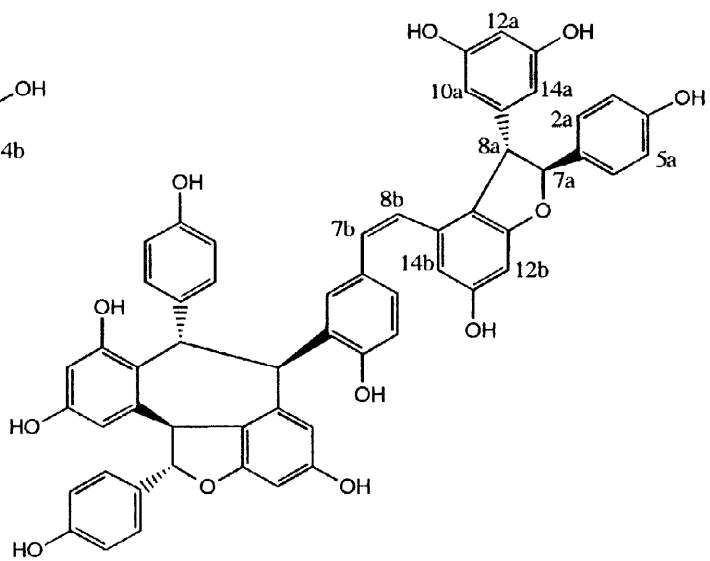


Fig. 1. Recycled HPLC of a mixture of (+)-vitisin A (**1**) and (+)-*cis*-vitisin A (**2**).



(+)-Vitisin A (1)



(+)-*cis*-Vitisin A (2)

Table 1. ^{1}H- and ^{13}C-NMR Data of Vitisin A (**1**) and *cis*-Vitisin A (**2**)[3] in Acetone-d6

	Vitisin A (**1**)		*cis*-Vitisin A (**2**)	
Position	^{13}C-NMR	^{1}H-NMR	^{13}C-NMR	^{1}H-NMR
1a	133.8 (s)		133.7 (s)	
2a,6a	127.9 (d)	7.18 (d, 8.4)	127.8 (d)	7.11 (d, 8.8)
3a,5a	116.1 (d)	6.82 (d, 8.4)	116.0 (d)	6.83 (d, 8.8)
4a	158.1 (s)		158.0 (s)	
7a	93.8 (d)	5.35 (d, 5.5)	93.7 (d)	5.26 (d, 5.1)
8a	57.0 (d)	4.40 (d, 5.5)	56.5 (d)	4.07 (d, 5.1)
9a	147.2 (s)		147.1 (s)	
10a,14a	106.8 (d)	6.16 (d, 2.2)	106.6 (d)	6.02 (d, 2.2)
11a,13a	159.7 (s)		159.5 (s)	
12a	102.0 (d)	6.21 (d, 2.2)	101.8 (d)	6.19 (t, 2.2)
1b	128.81 (s)		128.4 (s)	
2b	132.5 (d)	6.07 (d, 2.2)	132.7 (d)	5.94 (d, 2.2)
3b	132.7 (s)		132.5 (s)	
4b	155.1 (s)		154.3 (s)	
5b	115.4 (d)	6.68 (d, 8.4)	114.5 (d)	6.52 (d, 8.1)
6b	123.5 (d)	6.87 (dd, 8.4, 2.2)	127.1 (d)	6.67 (dd, 8.1, 2.2)
7b	122.5 (d)	6.38 (brs)	125.3 (d)	5.79 (brs)
8b	130.9 (d)	6.38 (brs)	132.0 (d)	5.79 (brs)
9b	136.5 (s)		136.8 (s)	
10b	119.0 (s)		119.85 (s)	
11b	162.4 (s)		162.1 (s)	
12b	96.5 (d)	6.25 (d, 2.2)	96.4 (d)	6.27 (d, 2.2)
13b	159.5 (s)		158.5 (s)	
14b	104.3 (d)	6.50 (d, 2.2)	109.0 (d)	6.17 (d, 2.2)
1c	130.9 (s)		130.9 (s)	
2c,6c	130.0 (d)	7.14 (d, 8.4)	129.9 (d)	7.10 (d, 8.8)
3c,5c	115.9 (d)	6.77 (d, 8.4)	115.8 (d)	6.75 (d, 8.8)
4c	158.5 (s)		158.4 (s)	
7c	88.4 (d)	5.87 (d, 11.4)	88.3 (d)	5.81 (d, 11.7)
8c	49.4 (d)	4.23 (d, 11.4)	49.3 (d)	4.22 (d, 11.7)
9c	142.2 (s)		142.1 (s)	
10c	120.3 (s)		120.5 (s)	
11c	157.9 (s)		158.4 (s)	
12c	100.8 (d)	6.02 (d, 2.2)	100.9 (d)	6.11 (d, 2.2)
13c	156.9 (s)		156.8 (s)	
14c	104.9 (d)	6.24 (d, 2.2)	104.8 (d)	6.18 (d, 2.2)
1d	135.3 (s)		135.4 (s)	
2d,6d	128.76 (d)	7.02 (d, 8.4)	128.7 (d)	7.03 (d, 8.1)
3d,5d	115.4 (d)	6.65 (d, 8.4)	115.3 (d)	6.65 (d, 8.1)
4d	155.9 (s)		155.8 (s)	
7d	40.6 (d)	5.38 (d, 3.3)	40.8 (d)	5.34 (d, 3.7)
8d	41.3 (d)	5.47 (d, 3.3)	41.2 (d)	5.50 (d, 3.7)
9d	141.1 (s)		141.1 (s)	
10d	120.0 (s)		119.94 (s)	
11d	158.7 (s)		157.8 (s)	
12d	96.0 (d)	6.08 (d, 1.8)	96.0 (d)	6.08 (d, 2.2)
13d	160.2 (s)		160.1 (s)	
14d	110.0 (d)	6.04 (d, 1.8)	110.1 (d)	6.10 (d, 2.2)

Assignments were achieved on the basis of ^{1}H-^{1}H COSY, HSQC and HMBC spectra.

corresponded to (+)-vitisin A (**1**). The ^{1}H- and ^{13}C-NMR data of (+)-vitisin A (**1**) isolated by using the recycled HPLC technique are identical to the reported data.[1,3] Catalytic hydrogenation of **1** gave the same dihydro compound (**6**) (FABMS: *m/z* 909 [MH$^+$], $[\alpha]_D$ +197.5° (MeOH)) as the reported one derived from the mixture.[1]

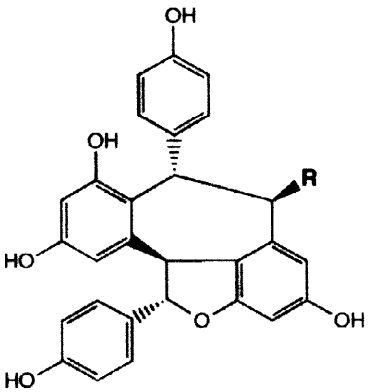
Isolation of (+)-vitisin A from *Vitis vinifera* 'Kyohou' The ethyl acetate soluble fraction of the acetone extract of the plant described previously[4] was subjected to medium-pressure column chromatography (MPCC) on silica gel to give five fractions. The second fraction was then subjected to preparative HPLC (YMC-Pack C8-5; ϕ20 x 250 mm, methanol/water (60/40)) to give (+)-vitisin A (**1**), in which (+)-*cis*-vitisin A (**2**) was not entirely detected by an analysis of the ^{1}H-NMR spectrum (600 MHz).

Structure of (+)-*cis*-vitisin A (2) As shown in Table 1, the ^{1}H- and ^{13}C-NMR spectra of (+)-*cis*-vitisin A (**2**) resembled very closely those of vitisin A (**1**) except for the olefinic signals (**1**; δ_H 6.38 (brs, H-7b and H-8b), δ_C 122.5 (C-7b), 130.9 (C-8b) in acetone-d6, δ_H 6.32 (d, *J*=16.3 Hz, H-7b), 6.27 (d, *J*=16.3 Hz, H-8b) in methanol-d4, **2**; δ_H 5.79 (brs, H-7b and H-8b), δ_C 125.3 (C-7b), 132.0 (C-8b) in acetone-d6, δ_H 5.72 (d, *J*=12.1 Hz, H-7b), 5.76 (d, *J*=12.1 Hz, H-8b) in methanol-d4. These indicated that they were geometrical isomers on the double bond (C-7b and C-8b), and this was unambiguously substantiated by the following evidence. Catalytic hydrogenation of **2** gave the same dihydro compound (**6**) (FABMS: *m/z* 909 [MH$^+$]) derived from **1**.[1] Furthermore, (+)-vitisin A (**1**) was photochemically transformed to (+)-*cis*-vitisin A (**2**).

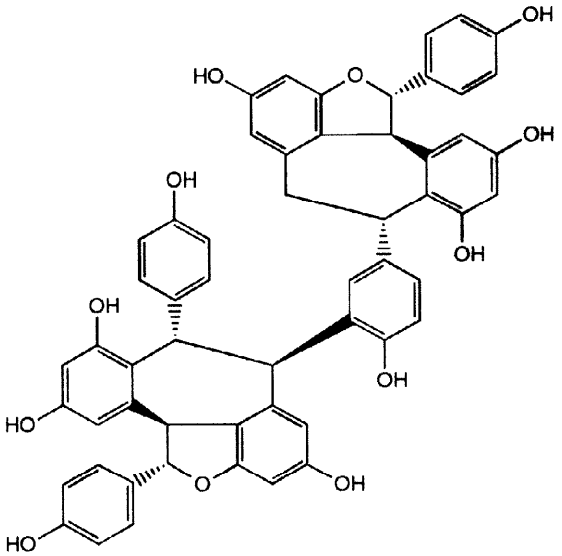
Absolute configuration of (+)-ampelopsin A (+)-Ampelopsin A (**3**) is a stilbene dimer isolated from roots of *Ampelopsis brevipedunculata* var. *hancei* and its absolute configuration is still unknown.[5] (+)-Ampelopsin A (**3**) was methylated with methyl iodide and potassium carbonate in acetone to give a penta- methyl ether (**7**) (FABMS: *m/z* 541 [MH$^+$]), which was oxidized with pyridinium chlorochromate (PCC) in dichloromethane to give the corresponding ketone (**8**) (FABMS: *m/z* 539 [MH$^+$]).[6] The observation of NOE between H-8c and H-2d(6d) suggests the conformation of the 4-methoxyphenyl group at C-7d to be pseudo-axial against the adjacent carbonyl group (C-8d). Namely, **8a** and **8b** will show positive and negative cotton effects, respectively.[8] The CD spectrum of the ketone (**8**) showed a positive Cotton effect at 357 nm. This suggests that the ketone has the absolute structure of **8a**. Consequently, the absolute configuration of (+)-ampelopsin A should be represented as **3**.

Absolute configuration of (+)-ampelopsin B (+)-Ampelopsin B (**4**) is a stilbene dimer isolated from roots of *Ampelopsis brevipedunculata* var. *hancei* and the structure corresponds to that of deoxyampelopsin A at the position of C-8d.[5] The CD spectrum of **4** has three positive absorption maxima at 211, 236 and 288 nm and it has a strong resemblance to that of (+)-ampelopsin A (**3**) at 208, 233 and 287 nm. These facts showed the absolute configuration of (+)-ampelopsin B to be represented as **4**.

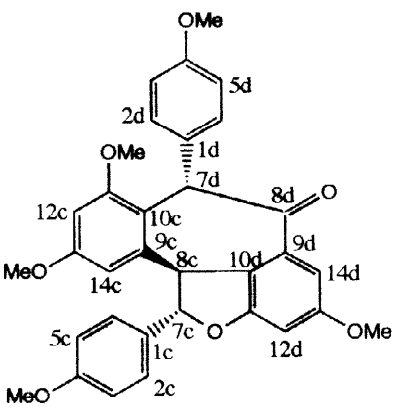
Absolute configurations of (+)-vitisin A and (+)-*cis*-vitisin A (+)-Vitisin A (**1**) was methylated with methyl iodide and potassium carbonate in acetone to give a decamethyl ether (**9**) (FAB MS: *m/z* 1047 [MH$^+$]), which was oxidized with ozone followed by treatment with dimethyl sulfide to give two degradative products (**10** and **11**). One degradative product, $[\alpha]_D$ +135.1° (*c* 0.6, $CHCl_3$), was identical in all respects with the aldehyde (**10**) previously obtained from vitisin C (**12**) by the same reactions and its absolute configuration



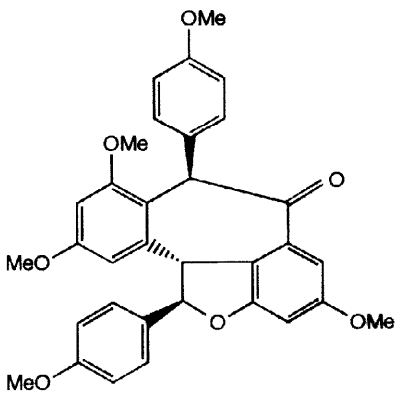
R= OH: (+)-Ampelopsin A (3)
R= H : (+)-Ampelopsin B (4)



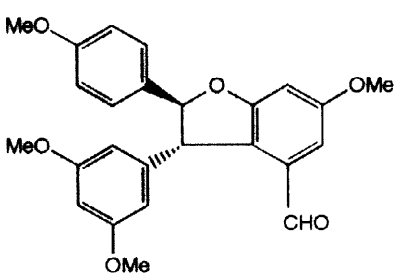
(+)-Vitisin D (5)



8a



8b



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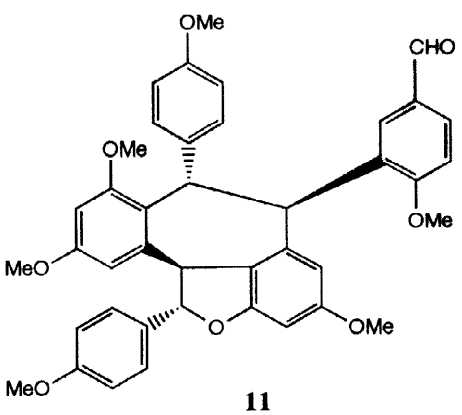

11

was represented as **10**.[9] The other degradative product **11** ($[\alpha]_D$ +254.6° (*c* 0.5, $CHCl_3$), FAB MS: *m/z* 659 [MH^+]) was a seven-membered ring aldehyde resembling (+)-ampelopsin A (**3**). The wavelengths and signs of the CD spectrum of **11** were similar to those of (+)-ampelopsin A (**3**). This showed that the absolute configuration of the aldehyde (**11**) is analogous to that of (+)-ampelopsin A (**3**). Consequently, the absolute configurations of (+)-vitisin A and (+)-*cis*-vitisin A are shown as **1** and **2**, respectively.

Absolute configuration of (+)-vitisin D (+)-Vitisin D (**5**) is a stilbene tetramer isolated from *Vitis coignetiae*,[10] which is an oxidatively condensed compound of two moles of (+)-ampelopsin B (**4**). Both compounds **4** and **5** have the same chromophores in their molecules. The CD spectrum of **5** having three positive absorption maxima at 214, 234 and 290 nm is very similar to that of (+)-ampelopsin B (**4**). These facts suggested the absolute configuration of (+)-vitisin D to be represented as **5**.

EXPERIMENTAL

General procedure. IR spectra were recorded on JASCO FT/IR-5000 and FT/IR-410 infrared spectrophotometers. UV spectra were recorded on a JASCO UVIDEC-610 spectrophotometer (cell length 10 mm, unless otherwise indicated). Optical rotations were determined on a JASCO DIP-370 digital polarimeter (cell length 100 mm, unless otherwise indicated). CD spectra were taken on a JASCO J-600 spectropolarimeter (cell length 10 mm, unless otherwise indicated). FABMS were measured with a JEOL HX-110 using *m*-nitrobenzyl alcohol as a matrix. ^{1}H- and ^{13}C-NMR spectra were recorded on a JEOL A-600 spectrometer.

Isolation of (+)-vitisin A and (+)-cis-vitisin A by recycled HPLC. A mixture (3 mg) of (+)-vitisin A (**1**) and (+)-*cis*-vitisin A (**2**) from *Vitis coignetiae*,[1] was subjected to recycled HPLC (YMC-C8 (φ20 x 250 mm), MeOH - H_2O (6 : 4), flow rate: 2.5 ml/min) to give (+)-vitisin A (**1**) (1.7 mg) and (+)-*cis*-vitisin A (**2**) (0.4 mg), respectively.

1: $[\alpha]_D$ +195.1° (*c* 1.1, MeOH),); UV (MeOH) λ_{max} nm (log ε): 208 (4.99), 229 sh (4.84), 285 (4.28), 313 sh (4.32), 330 (4.36); CD (MeOH) Δε (nm); +62 (235), +50 (210); IR ν_{max} (KBr) cm^{-1}: 3300 br, 1615; HR-FABMS *m/z*: 907.2757 (MH^+; $C_{56}H_{43}O_{12}$), calcd. 907.2755; ^{1}H-NMR (Acetone-d6) given in Table 1; ^{1}H-NMR (CD_3OD) δ 7.07 (2H, d, *J*=8.5 Hz, H-2a,6a), 6.77 (2H, d, *J*=8.5 Hz, H-3a,5a), 5.31 (1H, d, *J*=6.3 Hz, H-7a), 4.26 (1H, d, *J*=6.3 Hz, H-8a), 6.10 (2H, d, *J*=2.2 Hz, H-10a,14a), 6.19 (1H, t, *J*=2.2 Hz, H-12a), 5.92 (1H, d, *J*=2.0 Hz, H-2b), 6.60 (1H, d, *J*=8.8 Hz, H-5b), 6.73 (1H, dd, *J*=8.8, 2.0 Hz, H-6b), 6.32 (1H, d, *J*=16.3 Hz, H-7b), 6.27 (1H, d, *J*=16.3 Hz, H-8b), 6.19 (1H, d, *J*=2.2 Hz, H-12b), 6.44 (1H, d, *J*=2.2 Hz, H-14b), 7.07 (2H, d, *J*=8.8 Hz, H-2c,6c), 6.71 (2H, d, *J*=8.8 Hz, H-3c,5c), 5.81 (1H, d, *J*=11.5 Hz, H-7c), 4.12 (1H, d, *J*=11.5 Hz, H-8c), 5.96 (1H, d, *J*=2.2 Hz, H-12c), 6.13 (1H, d, *J*=2.2 Hz, H-14c), 7.00 (2H, d, *J*=8.8 Hz, H-2d,6d), 6.62 (2H, d, *J*=8.8 Hz, H-3d,5d), 5.25 (1H, d, *J*=3.2 Hz, H-7d), 5.42 (1H, d, *J*=3.2 Hz, H-8d), 6.07 (1H, d, *J*=2.0 Hz, H-12d), 6.05 (1H, d, *J*=2.0 Hz, H-14d); ^{13}C-NMR (Acetone-d6) given in Table 1.

2: $[\alpha]_D$ +184.0° (*c* 0.5, MeOH),); UV (MeOH) λ_{max} nm (log ε); 210 (4.97), 228 sh (4.85), 284 (4.30), 313 sh (3.91); CD (MeOH) Δε (nm); +68 (235), +60 (210); IR ν_{max} (KBr) cm^{-1}: 3300 br, 1615; HR-FABMS *m/z*: 907.2751 (MH^+; $C_{56}H_{43}O_{12}$), calcd. 907.2755; ^{1}H-NMR (Acetone-d6) given in Table 1; ^{1}H-NMR (CD_3OD) δ 7.04 (2H, d, *J*=8.8 Hz, H-2a,6a), 6.77 (2H, d, *J*=8.8 Hz, H-3a,5a), 5.20 (1H, d, *J*=5.5 Hz, H-7a), 3.95 (1H, d, *J*=5.5 Hz, H-8a), 5.93 (2H, d, *J*=2.2 Hz, H-10a,14a), 6.08 (1H, t, *J*=2.2 Hz, H-12a), 5.83 (1H, d, *J*=2.2

Hz, H-2b), 6.44 (1H, d, *J*=8.4 Hz, H-5b), 6.59 (1H, dd, *J*=8.4, 2.2 Hz, H-6b), 5.72 (1H, d, *J*=12.1 Hz, H-7b), 5.76 (1H, d, *J*=12.1 Hz, H-8b), 6.18 (1H, d, *J*=2.2 Hz, H-12b), 6.06 (1H, d, *J*=2.2 Hz, H-14b), 7.02 (2H, d, *J*=8.4 Hz, H-2c,6c), 6.68 (2H, d, *J*=8.4 Hz, H-3c,5c), 5.74 (1H, d, *J*=11.4 Hz, H-7c), 4.09 (1H, d, *J*=11.4 Hz, H-8c), 6.00 (1H, d, *J*=2.2 Hz, H-12c), 6.07 (1H, d, *J*=2.2 Hz, H-14c), 6.99 (2H, d, *J*=8.8 Hz, H-2d,6d), 6.61 (2H, d, *J*=8.8 Hz, H-3d,5d), 5.25 (1H, d, *J*=3.7 Hz, H-7d), 5.40 (1H, d, *J*=3.7 Hz, H-8d), 6.05 (1H, d, *J*=2.2 Hz, H-12d), 6.01 (1H, d, *J*=2.2 Hz, H-14d); ^{13}C-NMR (Acetone-d6) given in **Table** 1.

Catalytic hydrogenation of (+)-vitisin A. A mixture of (+)-vitisin A (**1**) (25 mg), trifluoroacetic acid (1 drop) and PtO_2 (6 mg) in MeOH (10 ml) was stirred under hydrogen atmosphere overnight at room temperature. After filtration, the reaction mixture was subjected to preparative TLC [Merck, 05744 (0.5 mm, 20 x 20 cm), $CHCl_3$ - MeOH (5 : 1)] to give a dihydro derivative (**6**) (10 mg). **6**: $[\alpha]_D$ +197.5° (*c* 0.7, MeOH); FABMS *m/z*: 909 (MH^+); ^{1}H- and ^{13}C-NMR spectral data of **6** were identical with those of the reported data.[1]

Catalytic hydrogenation of (+)-cis-vitisin A. A mixture of (+)-*cis*-vitisin A (**2**) (5 mg), trifluoroacetic acid (1 drop) and PtO_2 (2 mg) in MeOH (4 ml) was stirred under hydrogen atmosphere overnight at room temperature. After filtration, the reaction mixture was subjected to preparative TLC (Merck, 05715 (0.25 mm, 20 x 20 cm), $CHCl_3$ - MeOH (5 : 1)) to give a reductive product (2 mg), which was identified with **6**.

Isolation of (+)-vitisin A from Vitis vinifera 'Kyohou'. A part (0.96 g) of the second fraction (1.96 g) of the ethyl acetate soluble fraction of the acetone extract of the cork of the above plant described previously[4] was subjected to reversed phase MPCC (Nomura Chemical Ltd., Develosil Lop C8-45S (ϕ4.5 x 45 cm, MeOH - H_2O (6 : 4), flow rate: 5 ml/min)) to give 6 fractions (1 mg, 17 mg, 445 mg, 150 mg, 265 mg and 39 mg, respectively). The third fraction (445 mg) was mainly composed of (+)-ampelopsin A. The fifth fraction (265 mg) was again subjected to reversed phase MPCC [Nomura Chemical Ltd., Develosil Lop C8-45S {ϕ4.5 x 45 cm, MeOH - H_2O (6 : 4), flow rate: 2 ml/min}] to give (+)-vitisin A (**1**) (45 mg). All spectral data including the positive sign of the optical rotation were identical with those of (+)-vitisin A isolated from *Vitis coignetiae*.

Photochemical Isomerization of (+)-vitisin A to (+)-cis-vitisin A. A solution of (+)-vitisin A (**1**) (11 mg) in MeOH (10 ml) was irradiated with a low-pressure mercury lamp (30 W) (Riko Science & Industry Ltd., Funabashi) at 10 °C for 4 hr under nitrogen atmosphere. After removal of the solvent, the residue was subjected to preparative recycled HPLC (YMC-C8 (ϕ20 x 250 mm), MeOH - H_2O (6 : 4), flow rate: 2.5 ml/min) to give (+)-vitisin A (**1**) (2.8 mg) and (+)-*cis*-vitisin A (**2**) (6.5 mg). All spectral data of the product as well as the positive optical rotation were identical with those of natural (+)-*cis*-vitisin A (**2**) from *Vitis coignetiae*.

Physical Properties of (+)-ampelopsin A.[5] **3**: $[\alpha]_D$ +167.0° (*c* 2.1, MeOH); UV (MeOH) λ_{max} nm (log ε): 209 (4.66), 227 sh (4.42), 283 (3.80), 298 sh (3.49); CD (MeOH) Δε (nm): +3.4 (287), +12.9 (233), +12.2 (208).

Physical Properties of (+)-ampelopsin B.[5] **4**: $[\alpha]_D$ +123.0° (*c* 0.93, MeOH); UV (MeOH) λ_{max} nm (log ε): 202 (4.83), 228 sh (4.47), 281 (3.88); CD (MeOH) Δε (nm): +4.0 (288), +24.3 (236), +28.1 (211).

Methylation of (+)-ampelopsin A. A mixture of (+)-ampelopsin A (**4**) ($[\alpha]_D$ +202.9° (*c* 1.9, MeOH), 39 mg, 84 μmol), methyl iodide (800 μl, 14 mmol) and anhydrous potassium carbonate (1.83 g, 13 mmol) in acetone (10 ml) was refluxed for 2 hr under nitrogen atmosphere. The mixture was diluted with water (25 ml) and then extracted with chloroform. The extract was washed by brine, dried over sodium sulfate, concentrated, and separated by preparative TLC [Merck, 05744 (0.5 mm, 20 x 20 cm), benzene - acetone (20 : 1)] to give pentamethyl ampelopsin A (**7**) (24 mg, 53% yield).

7: $[\alpha]_D$ +167.3° (*c* 1.8, $CHCl_3$); UV (CH_3CN) λ_{max} nm (log ε): 212 (4.74), 226 sh (4.59), 285 (3.91), 295 sh (3.65); CD (CH_3CN) Δε (nm): +8.36 (287), +28.9 (237), +15.2 (211); IR ν_{max} (film) cm^{-1}:3450 br, 3005, 1610; FABMS *m/z*: 541 [MH^+]; ^{1}H-NMR ($CDCl_3$) δ 7.15 (2H, d, *J*=8.8 Hz, H-2c,6c), 6.81 (2H, d, *J*=8.8 Hz, H-3c,5c), 5.83 (1H, d, *J*=11.5 Hz, H-7c), 4.16 (1H, d, *J*=11.5 Hz, H-8c), 6.47 (1H, d, *J*=2.2 Hz, H-12c), 6.27 (1H, d, *J*=2.2 Hz, H-14c), 6.87 (2H, d, *J*=8.8 Hz, H-2d,6d), 6.67 (2H, d, *J*=8.8 Hz, H-3d,5d), 5.58 (1H, d, *J*=5.4 Hz, H-7d), 5.44 (1H, d, *J*=5.4 Hz, H-8d), 6.30 (1H, d, *J*=2.2 Hz, H-12d), 6.64 (1H, d, *J*=2.2 Hz, H-14d), 3.76 (3H, s, MeO-4c), 3.88 (3H, s, MeO-11c), 3.70 (3H, s, MeO-13c), 3.71 (3H, s, MeO-4d), 3.79 (3H, s, MeO-13d); ^{13}C-NMR ($CDCl_3$) δ 130.1 (s, C-1c), 129.0 (d, C-2c,6c), 114.1 (d, C-3c,5c), 160.0 (s, C-4c), 87.9 (d, C-7c), 48.6 (d, C-8c), 142.1 (s, C-9c), 119.2 (s, C-10c), 160.7 (s, C-11c), 96.4 (d, C-12c), 159.4 (s, C-13c), 103.9 (d, C-14c), 131.8 (s, C-1d), 127.8 (d, C-2d,6d), 113.5 (d, C-3d,5d), 157.7 (s, C-4d), 42.6 (d, C-7d), 70.8 (d, C-8d), 135.3 (s, C-9d), 118.9 (s, C-10d), 159.4 (s, C-11d), 96.2 (d, C-12d), 160.9 (s, C-13d), 107.9 (d, C-14d), 55.3 (q, OMe-4c*), 56.4 (q, OMe-11c), 55.1 (q, OMe-13c*), 55.2 (q, OMe-4d*), 55.5 (q, OMe-13d). *Assignments may be reversed.

Oxidation of (+)-pentamethyl ampelopsin A. A mixture of (+)-pentamethyl ampelopsin A (**7**) (23 mg, 43 μmol), pyridinium chlorochromate (46 mg, 214 μmol) in dichloromethane (5 ml) was stirred at room temperature for 1 hr under nitrogen atmosphere. The mixture was diluted with ether (8 ml) and then filtered through celite. The filtrate was concentrated and separated by column chromatography over silica gel (Fuji silysia Chemical Ltd., BW-820MH, 6 g) using benzene - acetone (20 : 1) to give a ketone (**8**) (22 mg, 97% yield).

8: $[\alpha]_D$ +186.5° (*c* 1.7, $CHCl_3$); UV (CH_3CN) λ_{max} nm (log ε): 209 (4.67), 226 (4.59), 274 (3.97), 339 (3.60); CD (CH_3CN) Δε (nm): +7.17 (367), -1.38 (328), +11.1 (291), +9.64 (252), +23.4 (237), +8.16 (210); IR ν_{max} (film) cm^{-1}: 2930, 1615; FABMS *m/z*: 539 [MH^+]; ^{1}H-NMR ($CDCl_3$) δ 7.21(2H, d, *J*=8.8 Hz, H-2c,6c), 6.85 (2H, d, *J*=8.8 Hz, H-3c,5c), 5.95 (1H, d, *J*=10.6 Hz, H-7c), 4.54 (1H, d, *J*=10.6 Hz, H-8c), 6.45 (1H, d, *J*=2.2 Hz, H-12c), 6.37 (1H, d, *J*=2.2 Hz, H-14c), 6.82 (2H, dd, *J*=8.4, 1.1 Hz, H-2d,6d), 6.69 (2H, d, *J*=8.4 Hz, H-3d,5d), 6.14 (1H, t, *J*=1.1 Hz, H-7d), 6.51 (1H, d, *J*=2.2 Hz, H-12d), 7.21 (1H, d, *J*=2.2 Hz, H-14d), 3.79 (3H, s, MeO-4c), 3.84 (3H, s, MeO-11c), 3.74 (3H, s, MeO-13c), 3.72 (3H, s, MeO-4d), 3.82 (3H, s, MeO-13d); ^{13}C-NMR ($CDCl_3$) δ 130.0 (s, C-1c), 128.8 (d, C-2c,6c), 114.2 (d, C-3c,5c), 160.1 (s, C-4c), 88.1 (d, C-7c), 50.2 (d, C-8c), 141.1 (s, C-9c), 116.5 (s, C-10c), 159.9 (s, C-11c), 96.6 (d, C-12c), 159.8 (s, C-13c), 103.6 (d, C-14c), 128.4 (s, C-1d), 127.6 (d, C-2d,6d), 113.8 (d, C-3d,5d), 158.4 (s, C-4d), 54.1 (d, C-7d), 195.2 (s, C-8d), 132.7 (s, C-9d), 124.8 (s, C-10d), 159.5 (s, C-11d), 102.1 (d, C-12d), 160.7 (s, C-13d), 103.9 (d, C-14d), 55.33 (q, OMe-4c*), 56.3 (q, OMe-11c), 55.28 (q, OMe-13c*), 55.25 (q, OMe-4d*), 55.8 (q, OMe-13d). *Assignments may be reversed.

Methylation of (+)-vitisin A. A mixture of (+)-vitisin A (**1**) (458 mg, 0.506 mmol), methyl iodide (10 ml, 152 mmol) and anhydrous potassium carbonate (20 g, 148 mmol) in acetone (20 ml) was refluxed for 42 hr

under nitrogen atmosphere. The mixture was diluted with water (40 ml) and then extracted with chloroform. The extract was washed by brine, dried over sodium sulfate, concentrated, and separated by column chromatography over silica gel (Fuji silysia Chemical Ltd., BW-820MH, 10 g) using chloroform to give (+)-decamethyl vitisin A (**9**) (371 mg, 73% yield).

Ozonolysis of (+)-decamethyl vitisin A. A solution of (+)-decamethyl vitisin A (**9**) (200 mg, 191 mmol) in ethyl acetate (60 ml) was cooled at -78 °C, treated with ozone for 5 min, and then worked up with dimethyl sufide (1 ml) to give the resulting mixture. The mixture was separated by column chromatography over silica gel (Katayama Chemical Ltd., 60K230, 10 g) using chloroform and then by preparative TLC (Merck 05744, chloroform) to give two compounds (**10** and **11**) [53 mg (66% yield) and 34 mg (27% yield), respectively].

10: $[\alpha]_D$ +135.1° (*c* 0.6, $CHCl_3$); IR ν_{max} (film) cm^{-1}: 1695, 1595; FABMS *m/z*: 421 [MH^+]; ^{1}H-NMR ($CDCl_3$) δ 7.22 (2H, d, *J*=8.8 Hz, H-2a,6a), 6.87 (2H, d, *J*=8.8 Hz, H-3a,5a), 5.56 (1H, d, *J*=5.1 Hz, H-7a), 4.77 (1H, d, *J*=5.1 Hz, H-8a), 6.25 (2H, d, *J*=2.2 Hz, H-10a,14a), 6.32 (1H, d, *J*=2.2 Hz, H-12a), 9.74 (1H, s, H-8b), 6.76 (1H, d, *J*=2.2 Hz, H-12b), 6.94 (1H, *J*=2.2 Hz, H-14b), 3.79 (3H, s, MeO-4a), 3.71 (3H, s, MeO-11a), 3.71 (3H, s, MeO-13a), 3.85 (3H, s, MeO-13b); ^{13}C-NMR ($CDCl_3$) δ 133.0 (s, C-1a), 126.9 (d, C-2a,6a), 114.1 (d, C-3a,5a), 159.7 (s, C-4a), 93.8 (d, C-7a), 55.9 (d, C-8a), 145.8 (s, C-9a), 105.7 (d, C-10a,14a), 161.2 (s, C-11a,13a), 98.7 (d, C-12a), 190.3 (d, C-8b), 133.0 (s, C-9b), 123.9 (s, C-10b), 161.4 (s, C-11b), 102.1 (d, C-12b), 162.3 (s, C-13b), 106.4 (d, C-14b), 55.3 (q, OMe-4a), 55.3 (q, OMe-11a), 55.3 (q, OMe-13a), 55.8 (q, OMe-13b). The spectral data of **10** as well as the positive optical rotation were identical with those of the reported aldehyde derived from (+)-vitisin C (**12**).[8]

11: $[\alpha]_D$ +254.6° (*c* 0.5, $CHCl_3$); UV (CH_3CN) λ_{max} nm (log ε): 208 (4.83), 226 sh (4.73), 278 (4.09); CD (CH_3CN) Δε (nm): +11.0 (287), -4.8 (265), +54.0 (232), +33.0 (212), -21.0 (201); IR ν_{max} (film) cm^{-1}: 1685, 1600; FABMS *m/z*: 659 [MH^+]; ^{1}H-NMR ($CDCl_3$) δ 6.52 (1H, d, *J*=2.2 Hz, H-2b), 6.95 (1H, d, *J*=8.8 Hz, H-5b), 7.64 (1H, dd, *J*=8.8, 2.2 Hz, H-6b), 9.37 (1H, s, H-7b), 7.17 (2H, d, *J*=8.8 Hz, H-2c,6c), 6.82 (2H, d, *J*=8.8 Hz, H-3c,5c), 5.94 (1H, d, *J*=11.7 Hz, H-7c), 4.23 (1H, d, *J*=11.7 Hz, H-8c), 5.98 (1H, d, *J*=2.2 Hz, H-12c), 6.23 (1H, d, *J*=2.2 Hz, H-14c), 7.06 (2H, d, *J*=8.1 Hz, H-2d,6d), 6.72 (2H, d, *J*=8.1 Hz, H-3d,5d), 5.38 (1H, d, *J*=4.4 Hz, H-7d), 5.50 (1H, d, *J*=4.4 Hz, H-8d), 6.27 (1H, d, *J*=2.2 Hz, H-12d), 6.16 (1H, d, *J*=2.2 Hz, H-14d), 4.00 (3H, s, MeO-4b), 3.76 (3H, s, MeO-4c), 3.18 (3H, s, MeO-11c), 3.61 (3H, s, MeO-13c), 3.75 (3H, s, MeO-4d), 3.68 (3H, s, MeO-13d); ^{13}C-NMR ($CDCl_3$) δ 128.9 (s, C-1b), 133.9 (d, C-2b), 133.9 (s, C-3b), 161.5 (s, C-4b), 109.3 (d, C-5b), 128.0 (d, C-6b), 191.1 (d, C-7b), 130.2 (s, C-1c), 129.1 (d, C-2c,6c), 114.1 (d, C-3c,5c), 159.9 (s, C-4c), 87.8 (d, C-7c), 48.5 (d, C-8c), 140.6 (s, C-9c), 121.9 (s, C-10c), 159.0 (s, C-11c), 95.3 (d, C-12c), 158.9 (s, C-13c), 103.1 (d, C-14c), 134.6 (s, C-1d), 127.9 (d, C-2d,6d), 113.5 (d, C-3d,5d), 157.5 (s, C-4d), 39.4 (d, C-7d), 40.9 (d, C-8d), 138.4 (s, C-9d), 120.7 (s, C-10d), 159.3 (s, C-11d), 94.7 (d, C-12d), 160.6 (s, C-13d), 108.0 (d, C-14d), 55.9 (q, OMe-4b), 55.33 (q, OMe-4c), 55.4 (q, OMe-11c), 55.1 (q, OMe-13c), 55.30 (q, OMe-4d), 55.27 (q, OMe-13d).

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