Diterpenes from the Heartwood of *Juniperus formosana* HAY. var. *concolor* HAY.

Yueh-Hsiung KUO*,[a,b] and Ming-Tsang YU[a]

Department of Chemistry, National Taiwan University,[a] Taipei, Taiwan, R.O.C. and National Research Institute of Chinese Medicine,[b] Taipei Hsien, Taiwan, R.O.C. Received December 11, 1995; accepted March 21, 1996

Three new diterpenes, 6β-hydroxyferruginol (1a), formosaninol (2a), and formosanin (2b), were isolated from the heartwood of *Juniperus formosana* HAY. var. *concolor* HAY. The structure of formosaninol was deduced to be a dimeric ferruginol with 6-*O*-7′ and 7-*O*-6′ linkages on the basis of spectroscopic analysis and chemical evidence. Formosanin was a dimethyl ether of formosaninol. 6α-Hydroxy-7-oxoferruginol can be converted to 6α- and 6β-hydroxyferruginols, 6-oxoferruginol and formosaninol by lithium aluminum hydride reduction and acidification. The structure of 6β-hydroxyferruginol isolated from *Cryptomeria japonica* was revised to 6α-hydroxyferruginol.

Key words *Juniperus formosana* var. *concolor*; Cupressaceae; abietane; 6β-hydroxyferruginol; formosaninol; formosanin

The *Juniperus* species contain a great variety of natural products.[1] Ten species of *Juniperus* are indigenous to Taiwan. We have studied the heartwood of *J. squamata* LAMB. var. *morrisonicola* (HAY.)[2] and *J. formosana* HAY.,[3] roots of *J. chinensis* LINN.,[4] and barks of *J. chinense* LINN. var. *kaizuca* HORT. ex. ENDL.[5] and *J. formosana* HAY. var. *concolor* HAY.[6] This paper deals with the chemical constituents of the methanolic extract of the heartwood of the last species. We describe herein three new ferruginol derivatives, 6β-hydroxyferruginol (**1a**), formosaninol (**2a**), and formosanin (**2b**).

The methanolic heartwood extract of *J. formosana* var. *concolor* on silica gel chromatography with 10% to 20% ethyl acetate in hexane gave three new diterpenes, formosanin (**2b**), formosaninol (**2a**), and 6β-hydroxyferruginol (**1a**), in that order. The first two compounds are new dimeric ferruginol derivatives with 6-*O*-7′ and 7-*O*-6′ linkages, and are the first naturally occurring dimeric abietane-type diterpenes with a 1,4-dioxane unit. We tried to prepare 6α-hydroxyferruginol (**1c**) and 6,7-dihydroxyferruginol (**3a**) from 6α-hydroxy-7-oxoferruginol (**3b**)[7] by reduction with lithium aluminum hydride in tetrahydrofuran (THF) under reflux followed by quenching with acid, and four products (**1a**—**c** and **2a**) were isolated.

6β-Hydroxyferruginol (**1a**), an amorphous solid, has the molecular formula $C_{20}H_{30}O_2$ on the basis of its high-resolution mass spectrum (HRMS), *m/z* 302.2247, and shows infrared (IR) absorption bands at 3353 (–OH), 3030, 1611, and 1496 cm^{-1} (aromatic absorption). The ^{1}H-NMR spectrum (Table 1) revealed that **1a** has an isopropyl group attached to a phenyl group, three singlet methyl groups, and two singlet *para* phenyl protons. Other signals at δ 1.37 (br s, H-5), 2.83 (br d, J=17.0 Hz), 3.08 (dd, J=17.0, 4.5 Hz), and 4.65 (br s, a carbinol proton) are present. From the ^{13}C-NMR [Table 1, assigned by ^{1}H detected heteronuclear multiple quantum coherence (HMQC)] data and the typical ferruginol derivative H_β-1 proton signal at δ 2.06 (br d, J=12.6 Hz), **1a** can be assigned as a derivative of ferruginol with an extra hydroxy group. On irradiation at δ 4.65, the signals at δ 1.37, 2.83, and 3.08 collapsed to a sharp singlet, a doublet (J=17.0 Hz), and a doublet (J=17.0 Hz), respectively. The signals at δ 2.83 and 3.08 were assigned to benzylic C-7 protons, and therefore the hydroxy group must be located at the C-6 position. The C-6 hydroxy group was assigned β-axial orientation from the small coupling constants of H-6 with H-5 and H-7 ($J_{5,6}$=br s and $J_{6,7}$=4.5 Hz). In ferruginol (**1d**),[8] the axial methyl groups, H_3-20 and H_3-19, show chemical shifts of δ 1.13 and 0.92, respectively. However the chemical shifts of H_3-20 (δ 1.52) and H_3-19 (δ 1.25) in compound **1a** are found at lower field than those in **1d**. This evidence supported the β-axial orientation[9] for the 6-hydroxy group in **1a**. Recently, Su[10] has isolated a compound assigned as 6β-hydroxyferruginol from the leaves of *Cryptomeria japonica*, but its physical data are different from those of **1a**. In the next section of this manuscript, we report the preparation of **1c** and **1a**. The assignment of the ^{1}H- and ^{13}C-NMR data (Tables 1 and 2) of **1c** was aided by ^{1}H–^{1}H correlation spectroscopy (COSY), HMQC, heteronuclear multiple bond correlation (HMBC), and decoupling experiments. The H-6 in **1a** exhibits a smaller $W_{1/2}$ value and lower-field signal than the corresponding proton in **1c**. This evidence supports a β-axial orientation of H-6 in **1c**. Furthermore, the chemical shifts of H_3-19 (δ 1.08) and H_3-20 (δ 1.14) in **1c** show no

Table 1. ^{1}H-NMR (δ-values) Data for **1a**—**c**, and **2b** (300 MHz in $CDCl_3$)

H	1a	1b	1c	2b
1β	2.06 br d (12.6)	2.20 br d (12.3)	2.06 br d (12.5)	2.17 br d (12.9)
5	1.37 br s	2.38 s	1.15 d (7.0)	1.55 d (9.6)
6	4.65 br s		4.28 br s	4.18 dd (9.6, 7.5)
7	2.83 br d (17.0)	3.54 s	2.65 dd (15.9, 3.2)	4.69 d (7.5)
	3.08 dd (17.0, 4.5)		3.23 dd (15.9, 6.6)	
11	6.66 s	6.73 s	6.58 s	6.68 s
14	6.82 s	6.83 s	6.89 s	7.44 s
15	3.10 septet (6.8)	3.15 septet (6.8)	3.10 septet (6.8)	3.18 septet (6.7)
16	1.21 d (6.8)	1.22 d (6.8)	1.22 d (6.8)	1.10 d (6.7)
17	1.22 d (6.8)	1.23 d (6.8)	1.23 d (6.8)	1.14 d (6.7)
18	1.02 s	1.11 s	1.07 s	1.20 s
19	1.25 s	1.06 s	1.08 s	1.10 s
20	1.52 s	1.28 s	1.14 s	1.24 s
OCH_3				3.78 s

Figures in parentheses are coupling constants.

* To whom correspondence should be addressed.

deshielding from the hydroxy group, and H-6 in **1c** has larger coupling constants, $J_{5,6}$ and $J_{6,7}$, supporting the view that the hydroxy group in **1c** has α-equatorial orientation. The physical data of **1c** were identical with those of the product named 6β-hydroxyferruginol isolated from the leaves of *C. japonica*. Therefore, the structure of the product must be revised to 6α-hydroxyferruginol, and the assignments of H-5, H-6, and C-8 in the literature[10] are incorrect.[11] The acetylation of **1a** and **1c** with Ac_2O and pyridine under the same conditions gave different results. Compound **1a** afforded two products, a diacetate **1e** [1752, 1725 cm^{-1} (no hydroxy absorption); δ 2.00, 2.29 (each 3H), 5.68 (1H, br d, J=5.3 Hz)] and a monoacetate **1f** [3552, 1748 cm^{-1}; δ 2.29 (3H, s) and 4.67 (1H, br d, J=4.6 Hz)], while **1c** gave only one diacetate **1g** [1751, 1728 cm^{-1}; δ 1.98, 2.29 (each 3H), 5.42 (1H, t d, J=7.8, 2.4 Hz)]. This result represents further proof

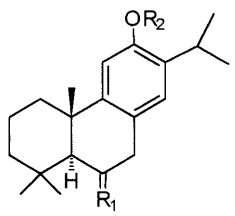
Table 2. ^{13}C-NMR (δ-Values) Data for **1a**—**c**, and **2b** (75 MHz in $CDCl_3$)

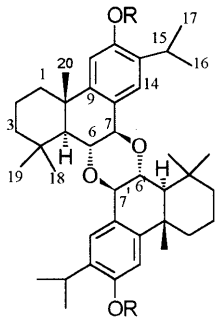
C	1a	1b	1c	2b
1	42.1	38.5	39.0	38.7
2	19.6	19.0	18.9	18.9
3	43.0	42.8	42.7	43.2
4	34.2	40.2	34.1	35.7
5	53.1	62.5	58.8	51.7
6	66.1	210.7	68.6	71.7
7	40.7	44.6	38.9	73.3
8	123.4	124.1	125.8	126.2
9	147.2	147.3	148.3	146.7
10	37.3	32.6	38.1	37.1
11	111.6	110.5	109.8	104.2
12	151.2	151.5	151.2	155.9
13	132.0	132.7	131.3	134.1
14	127.4	126.1	126.6	124.6
15	27.0	26.8	26.8	26.6
16	22.5	22.5	22.1	23.1
17	22.7	22.8	22.4	22.9
18	33.7	32.9	36.4	33.9
19	23.7	24.5	22.6	22.7
20	27.0	21.9	22.7	22.4
OCH_3				55.5

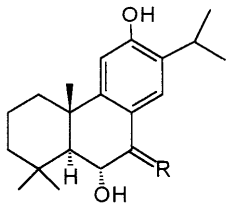
Table 3. ^{13}C- and ^{1}H-NMR (δ-Values) Data for Formosaninol (**2a**) and HMBC Correlations (300 and 75 MHz in $CDCl_3$)

C		H		Correlated carbons
1	38.6	1-Hb	2.10 br d (12.0)	3-C, 5-C
		1-Ha	1.58 m	2-C, 5-C, 10-C
2	18.9	2-Hb	1.64 m	4-C, 10-C
		2-Ha	1.78 m	4-C, 10-C
3	43.2	3-Ha	1.30 m	4-C, 18-C, 19-C
		3-Hb	1.52 m	4-C, 5-C, 18-C, 19-C
4	35.7			
5	51.8	5-H	1.54 d (9.5)	4-C, 7-C, 9-C, 10-C, 18-C, 19-C
6	71.8	6-H	4.16 dd (9.5, 7.6)	5-C, 8-C
7	73.2	7-H	4.69 d (7.6)	5-C, 8-C, 9-C
8	126.5			
9	147.1			
10	36.8			
11	108.8	11-H	6.60 s	8-C, 10-C, 12-C, 13-C
12	151.8			
13	131.3			
14	124.4	14-H	7.44 s	9-C, 12-C, 15-C
15	27.0	15-H	3.06 septet (6.8)	12-C, 13-C, 14-C, 16-C, 17-C
16	23.0	16-H	1.15 d (6.8)	13-C, 15-C, 17-C
17	23.0	17-H	1.19 d (6.8)	13-C, 15-C, 16-C
18	33.9	18-H	1.18 s	4-C, 5-C, 19-C
19	22.6	19-H	1.12 s	4-C, 5-C, 18-C
20	22.3	20-H	1.23 s	1-C, 5-C

Figures in parentheses are coupling constants.







1a R_1=β-OH, α-H, R_2=H
1b R_1=O, R_2=H
1c R_1=β-H, α-OH, R_2=H
1d R_1=H_2, R_2=H
1e R_1=β-OAc, α-H, R_2=Ac
1f R_1=β-OH, α-H, R_2=Ac
1g R_1=β-H, α-OAc, R_2=Ac

2a R=H
2b R=Me
2c R=Ac

3a R=β-OH, α-H
3b R=O

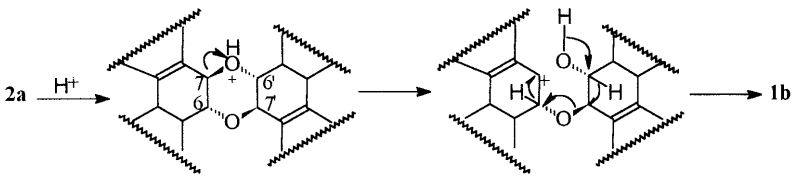


Chart 1

that the C-6 hydroxy group in **1a** is in the hindered axial orientation and that in **1c** has the equatorial orientation.

Formosaninol (**2a**), mp 162—163 °C, is less polar than **1a** and shows IR absorption bands due to hydroxyl and aromatic units. The ^{1}H-NMR spectrum (Table 3) of **2a** exhibited signals typical of a derivative of ferruginol: an isopropyl group attached to a phenyl group, two *para* aromatic protons, a typical $H_\beta-1$ proton at δ 2.10 (br d, $J=12.0$ Hz), as well as three singlet methyl groups. In addition, three contiguous protons were seen at δ 1.54 (1H, d, $J=9.5$ Hz, H-5), 4.16 (1H, dd, $J=9.5$, 7.6 Hz, H-6), and 4.69 (1H, d, $J=7.6$ Hz, H-7). On irradiation at δ 4.16, the signals at 1.54 and 4.69 collapsed to singlets. The structure of **2a** can be deduced to be a 6,7-dioxygenated ferruginol, but **2a** is not 6,7-dihydroxyferruginol (**3a**) for the following reasons. Firstly, **2a** is less polar than **1a** based on the order of elution on silica gel chromatography. Secondly, HRMS shows a molecular ion peak at *m/z* 600.4171 ($C_{40}H_{56}O_4$). Acetylation of **2a** with acetic anhydride in pyridine gave a product (amorphous), **2c**, which shows one phenyl acetoxy absorption [1755 cm^{-1}: MS *m/z*: 684 (M^+, 12%); δ 2.27 (3H, s); no hydroxyl absorption]. The chemical shifts of H-6 [δ 4.19 (dd, $J=7.9$, 7.3 Hz)] and H-7 [δ 4.74 (d, $J=7.3$ Hz)] in **2c** are similar to those of the corresponding protons in **2a**. The evidence indicates that **2a** is a dimeric derivative of ferruginol. The structure of formosaninol can be either as drawn in formula **2a** (6-*O*-7′ and 7-*O*-6′ linkage) or its isomer (6-*O*-6′ and 7-*O*-7′ linkage) as judged from the above evidence and the NMR data (Table 3). In order to establish the correct structure, **2a** was hydrogenated (TsOH and 10% Pd–C in methanol) to give only the rearranged product **1b** (6-oxoferruginol), which is different from sugiol (7-oxoferruginol).[3d] The NMR data of **1b** (Tables 1 and 2) supported the assigned structure [MS *m/z*: 300 (M^+, 100%); 3389, 3060, 1702, 1593, and 1505 cm^{-1}; ^{1}H- and ^{13}C-NMR: Tables 1 and 2]. The same result was observed when **2a** reacted with TsOH in methanol. The reaction mechanism of acidic rearrangement is proposed to be as shown in Chart 1. The result

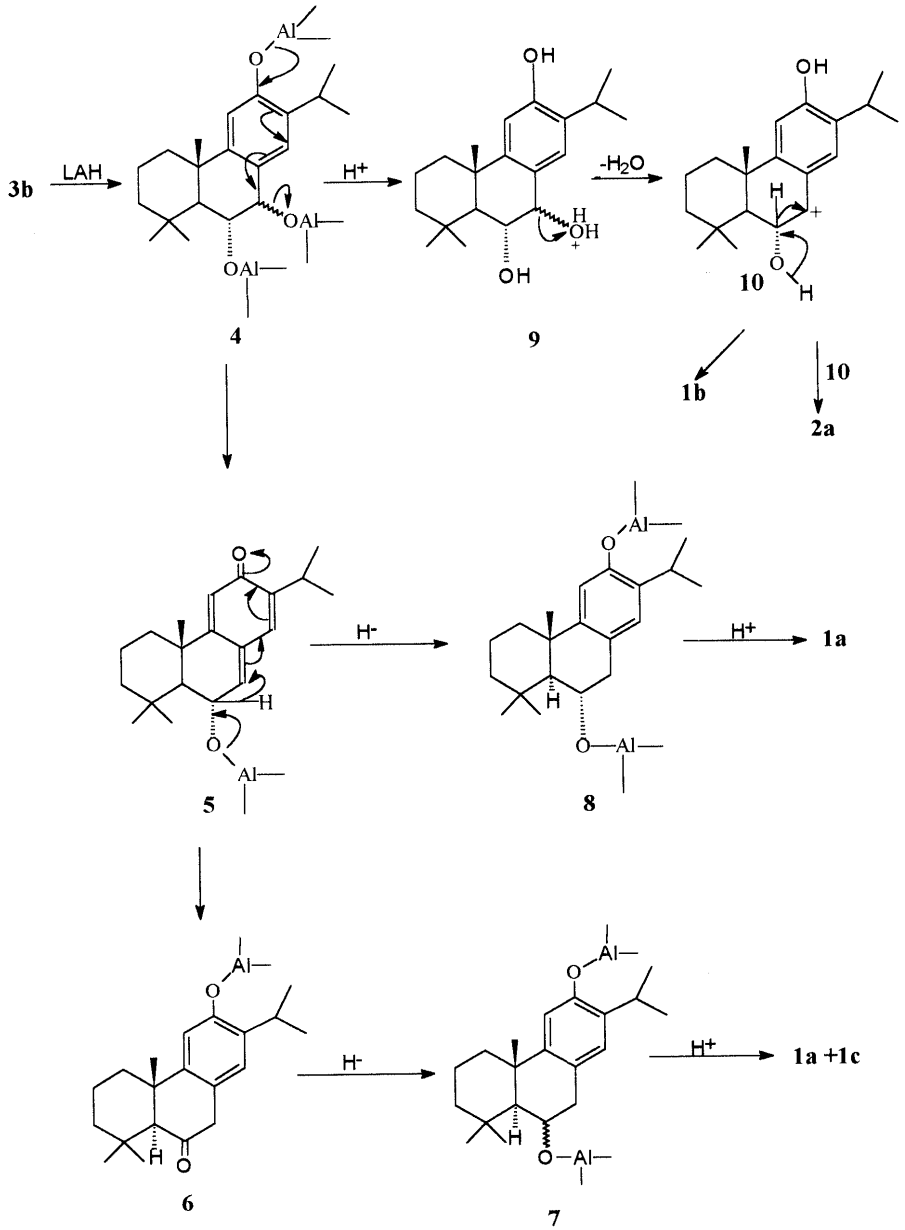


Chart 2

confirmed the structure of formosaninol as formula **2a**. If the structure of formosaninol were that of the other isomer (6-*O*-6′ and 7-*O*-7′ linkage), the rearrangement products would be equal amounts of 6-oxoferruginol and sugiol. The H-6 and H-7 in **2a** were assigned axial orientation in view of the large coupling constants, $J_{5,6}$ and $J_{6,7}$. Also H-14 in **2a** appeared at relatively lower field (δ 7.44) due to the effect of the equatorial oxygen at C-7.

Formosanin (**2b**), an amorphous solid, is also a dimeric diterpene as the HRMS molecular ion peak appeared at *m/z* 628.4509 ($C_{42}H_{60}O_4$). No hydroxyl absorption was present in its IR spectrum. The ^{1}H-NMR spectrum (Table 1) exhibited signals typical of a derivative of ferruginol containing an isopropyl group attached to a phenyl group, two singlet aromatic protons, three singlet methyl groups, and three contiguous protons at δ 1.55, 4.18, and 4.69 (H-5, H-6, and H-7). In addition, one aromatic methoxy group signal was present at δ 3.78. Based on the ^{1}H- and ^{13}C-NMR data (Tables 1 and 2), the structure of formosanin can be assigned as a dimethyl ether of **2a**. The methylation of **2a** with methyl iodide and K_2CO_3 in butanone under reflux yielded a product which was identical with formosanin (**2b**).

We tried to prepare **1c** and **3a** from 6α-hydroxy-7-oxoferruginol (**3b**)[7] by treatment with lithium aluminum hydride in THF under reflux, followed by quenching with acid. Four products, **1a**—**1c**, and **2a** were obtained from the reaction mixture. The formation of these products may be rationalized in terms of the mechanism depicted in Chart 2. The first product of reduction of **3b** is **4**, which is subsequently transformed to intermediate **5** *via* elimination[12] and then to **6** *via* hydride migration. Acidification of intermediate **7**, obtained from **6** by reduction, would yield **1a** and **1c**. Hydride reduction of intermediate **5** to **8**, followed by acidification, would give **1a**. Acidification of the intermediate **4** would generate **9** (maybe **3a** or its isomer), which then dehydrates to form cation **10**. Cation **10** affords **1b** *via* rearrangement, and self-coupling would give **2a**.

Experimental

A Yanagimoto micromelting point apparatus was used for measurement of uncorrected melting point. IR spectra were recorded on a Perkin–Elmer 781 spectrophotometer. ^{1}H- and ^{13}C-NMR spectra were run on a Bruker AM 300 spectrometer. Electron impact mass spectra (EIMS) and specific rotation were obtained with a JEOL-JMS-HX300 spectrometer and a JASCO DIP-180 spectrophotomer, respectively.

Extraction and Isolation The heartwood of *J. formosana* HAY. var. *concolor* HAY. (2 kg) was extracted with MeOH (20 l) at room temperature 3 times. The MeOH extract was evaporated *in vacuo* to leave a black residue (189 g), which was chromatographed on silica gel (2 kg) with hexane–EtOAc, EtOAc, and EtOAc /MeOH gradient solvent systems. The eluate with 20% AcOEt in hexane gave a 6.5 g residue, part of which (3.2 g) was again separated repeatedly by silica gel column chromatography. Three new diterpenes, formosanin (**2b**) (10 mg), formosaninol (**2a**) (35 mg), and 6β-hydroxyferruginol (**1a**) (10 mg), were eluted in that order (eluted with 10% EtOAc in hexane to 20% EtOAc in hexane).

6β-Hydroxyferruginol (**1a**): Amorphous solid, $[\alpha]_D^{30}$ +53.1° (c=0.8, $CHCl_3$). IR (KBr): 3327, 3030, 1611, 1505, 1413, 1372, 1226, 1082, 1036, 1000, 863 cm^{-1}. ^{1}H- and ^{13}C-NMR: Tables 1 and 2. HRMS exact mass for $C_{20}H_{30}O_2$ requires *m/z* 302.2246. Found: 302.2247 (M^+, 97%).

Formosaninol (**2a**): mp 162—163, $[\alpha]_D^{20}$ +65.0° (c=0.8, $CHCl_3$). IR (KBr): 3380 3072, 1630, 1521, 1396, 1379, 1206, 1191, 1139, 927 cm^{-1}. ^{1}H- and ^{13}C-NMR: Table 3. HRMS exact mass for $C_{40}H_{56}O_4$ requires *m/z* 600.4179. Found: 600.4171 (M^+, 100%).

Formosanin (**2b**): Amorphous solid, $[\alpha]_D^{18}$ +60.5° (c=0.9, $CHCl_3$). IR (KBr): 3055, 1600, 1595, 1490, 1356, 1255, 1095, 1066, 1052 cm^{-1}. ^{1}H- and ^{13}C-NMR: Tables 1 and 2. HRMS exact mass for $C_{42}H_{60}O_4$ requires *m/z* 628.4492. Found: 628.4509 (M^+, 63%).

Reduction of 1b with Lithium Aluminum Hydride ($LiAlH_4$) Excess $LiAlH_4$ was added to a solution of 6-oxoferruginol (**1b**) (20 mg) in dry THF (25 ml) and the reaction mixture was left at room temperature for 3 h. The reaction mixture was evaporated *in vacuo* to give a residue, which was quenched with wet ether (30 ml), and then 20 ml of 1 N H_2SO_4 was added to the reaction mixture. The product was purified on silica gel to give **1a** (14 mg) and **1c** (3 mg). Compound **1a** is less polar than **1c** as judged from the chromatographic eluting order.

Acetylation of 1a and 1c A solution of 6β-hydroxyferruginol (**1a**) (6 mg) in pyridine (0.5 ml) and acetic anhydride (0.5 ml) was left at room temperature for 16 h. The reaction mixture was treated by the usual method and purified by silica gel column chromatography to give the diacetate **1e** (3 mg) [amorphous solid. IR (KBr): 3026, 1752, 1727, 1602, 1492, 1360, 1245, 1201, 1167, 1030, 1016, 953, 913 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.01, 1.04 1.49, 2.00, 2.29 (each 3H, s), 1.17 and 1.14 (each 3H, d, J=6.9 Hz), 2.11 (1H, br d, J=12.3 Hz), 2.89 (1H, septet, J=6.9 Hz), 2.92 (1H, br d, J=18.3 Hz), 3.12 (1H, dd, J=18.3, 5.3 Hz), 5.68 (1H, br d, J=5.3 Hz), 6.88 and 6.89 (each 1H, s)] and the monoacetate **1f** (3 mg) as an amorphous solid. IR (KBr) 3552, 3025, 1748, 1489, 1455, 1363, 1203, 1163, 1090, 1039, 1014, 913, 859, 733 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.02 (s, 3H), 1.16 and 1.17 (each 3H, d, J=6.7 Hz), 1.25 and 1.53 (each 3H, s), 2.06 (1H, br d, J=12.4 Hz), 2.29 (3H, s), 2.89 (1H, septet, J=6.7 Hz), 2.90 (1H, br d, J=17.4 Hz), 3.02 (1H, dd, J=17.4, 4.6 Hz), 4.67 (1H, br d, J=4.6 Hz), 6.87 and 6.93 (each 1H, s)].

On acetylation of **1c** (4 mg) under the same conditions as used for **1a**, only the diacetate **1g** (4 mg) was obtained, amorphous solid. IR (KBr); 3035, 1751, 1728, 1620, 1489, 1239, 1206, 1015, 969 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 0.98, 1.07, 1.17 (each 3H, s), 1.15, 1.17 (each 3H, d, J=6.8 Hz), 1.50 (1H, d, J=7.8 Hz, H-5), 1.98 and 2.29 (each 3H, s), 2.69 (1H, dd, J=17.1, 2.4 Hz), 2.90 (1H, septet, J=6.8 Hz), 3.34 (1H, dd, J=17.1, 7.8 Hz), 5.41 (1H, td, J=7.8, 2.4 Hz), 6.78 and 6.93 (each 1H, s).

Acetylation of 2a Acetylation of formosaninol (**2a**) (5 mg) under the above conditions yielded the diacetate **2c** (5 mg) as an amorphous solid. IR (KBr): 3045, 1755, 1600, 1478, 1316, 1220, 1175, 1053, 1020 cm^{-1}. EIMS (70 eV) (rel. int.%) *m/z*: 684 (M^+, 12). ^{1}H-NMR ($CDCl_3$) δ: 1.13 and 1.14 (each 3H, d, J=6.8 Hz), 1.14, 1.17, 1.21, and 2.27 (each 3H, s), 2.88 (1H, septet, J=6.8 Hz), 4.19 (1H, dd, J=7.9, 7.3 Hz), 4.74 (1H, d, J=7.3 Hz), 6.79 and 7.54 (each 1H, s).

Acidic Isomerization of 2a A mixture of formosaninol (**2a**) (10 mg), TsOH (5 mg) and 10% Pd–C (10 mg) in 15 ml of MeOH was saturated with H_2. After 18 h, the catalyst was removed by filtration and washed several times with MeOH. The combined filtrate and washings yielded **1b** (8 mg), an amorphous solid: IR (KBr): 3389, 3060, 1702, 1593, 1505, 1375, 1296, 1267, 1225, 1172 cm^{-1}. EIMS (70 eV) (rel. int.%) *m/z*: 300 (M^+, 100). ^{1}H- and ^{13}C-NMR: Tables 1 and 2. Under similar conditions without Pd–C and H_2, **2a** (10 mg) also gave only **1b** (8 mg).

Methylation of 2a Formosaninol (**2a**) (7 mg), methyl iodide (0.5 ml), and potassium carbonate (300 mg) in butanone (10 ml) were heated under reflux for 6 h. After evaporation of the reaction mixture, the residue was taken up in 50 ml of water and the mixture was extracted with ether (30 ml) three times. Purification by silica gel chromatography gave formosanin (**2b**) (5 mg).

Reduction of 3b Compound **3b** (40 mg) and $LiAlH_4$ (50 mg) were refluxed in dry THF (40 ml) for 6 h. The reaction mixture was evaporated *in vacuo* to give a residue, which was quenched with wet diethyl ether (40 ml), and then 30 ml of 1 N H_2SO_4 was added. The product was purified on silica gel to give **2a** (9 mg), **1b** (16 mg), **1a** (9 mg), and **1c** (3 mg) in that order of elution.

Acknowledgement This research was supported by the National Science Council of the R.O.C.

References and Notes

1) Ho L. K., *Chemistry*, **53**, 94—114 (1995).
2) *a*) Kuo Y. H., Yang I. C., Chen C. S., Lin Y. T., *Experientia*, **32**, 686—687 (1976); *b*) Kuo Y. H., Hsieh S. H., Kuo S. T., Lin Y. T., *ibid.*, **32**, 827—828 (1976); *c*) Kuo Y. H., Lin Y. T., *J. Chin. Chem. Soc.*, **27**, 15—18 (1980); *d*) Kuo Y. H., Yang I. C., Chen C. S., Lin Y. T., *ibid.*, **34**, 125—134 (1987).

3) *a*) Kuo Y. H., Lin N. H., Lin Y. T., *J. Chin. Chem. Soc.*, **27**, 19—22 (1980); *b*) Kuo Y. H., Chen W. C., Wu T. R., *ibid.*, **31**, 417—419 (1984); *c*) *Idem*, *ibid.*, **32**, 377—379 (1985); *d*) Kuo Y. H., Wu T. R., Cheng M. C., Wang Y., *Chem. Pharm. Bull.*, **38**, 3195—3201 (1990).
4) *a*) Kuo Y. H., Chen W. C., *J. Chem. Research* (*S*), 382—383 (1992); *b*) *Idem*, *Chem. Express*, **7**, 833—836 (1992); *c*) *Idem*, *Chem. Pharm. Bull.*, **42**, 1774—1776, 2187—2189 (1994).
5) Lee S. M., Chen W. C., Lai J. S., Kuo Y. H., *Chem. Express*, **7**, 829—832 (1992).
6) Kuo Y. H., Yu M. T., *Heterocycles*, **36**, 529—535 (1993).
7) Lin Y. T., Kuo Y. H., Chang B. H., *J. Chin. Chem. Soc.*, **22**, 331—334 (1975).
8) Kuo Y. H., Chang B. H., Lin Y. T., *J. Chin. Chem. Soc.*, **22**, 49—52 (1975).
9) Kuo Y. H., Shih J. S., Lin Y. T., Lin Y. T., *J. Chin. Chem. Soc.*, **26**, 71—73 (1979); *b*) Hensch M., Rued P., Engster C. H., *Helv. Chim. Acta*, **59**, 1921—1943 (1975); *c*) Kuo Y. H., Lin Y. T., Lin Y. T., *Chem. Express*, **2**, 217—220 (1987).
10) Su W. C., Fang J. M, Cheng Y. S., *Phytochemistry*, **35**, 1279—1284 (1994).
11) We have communicated with the senior author, Prof. Y. S. Cheng, and checked in detail the original spectrum, which was assigned without using the ^{1}H–^{13}C COSY technique.
12) *a*) Bell K. H., *Aust. J. Chem.*, **22**, 601—605 (1969); *b*) McLoughlin B. J., *J. Chem. Soc., Chem. Commun.*, **1969**, 540—541.