Glycosides of *Atractylodes japonica*

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From the water-soluble portion of the methanol extract of the fresh rhizome of *Atractylodes japonica*, five new sesquiterpenoid glycosides, including a compound having a secoguaiane skeleton, and a new aromatic compound glycoside were isolated together with ten known compounds. Their structures were clarified by spectral investigation.

Key words byaku-jutsu; *Atractylodes japonica*; sesquiterpenoid glycoside; guaiane-type; secoguaiane-type; 4-hydroxyphenol glycoside

The rhizome of the Atractylodes plant (Compositae) has been used as an important crude drug (Japanese name "jutsu") since antiquity.[1] It is listed in the Japanese Pharmacopoeia as Atractylodes Rhizome (*Atractylodes japonica* and *A. ovata*; "byaku-jutsu") and Atractylodes Lancea Rhizome (*A. lancea* and *A. chinensis*; "so-jutsu"), and both products are used for the same clinical purpose, as a diuretic and stomachic.[1] The constituents of the rhizome of *A. japonica* have been investigated, and atractylon and its derivatives,[2,3] sesquiterpenoids,[4] diacetyl atractylodiol and its derivatives[5,6] were isolated from the non-polar fraction. Furthermore, three glycans, atractan A, B, and C, were reported as the water-soluble constituents.[7] On the other hand, nine sesquiterpenoid glycosides (atractyloside A to I) were isolated, together with L-tryptophan and syringin, as the polar constituents of the rhizome of *A. lancea*.[8] So, we undertook a detailed investigation of the water-soluble portion of *A. japonica* in the hope of isolating sesquiterpenoid glycosides. In this paper, we discuss the isolation and characterization of five new sesquiterpenoid glycosides, including a compound having a secoguaiane skeleton, and a new aromatic compound glycoside.

The fresh rhizome of *A. japonica*, which was cultivated in the medical plant garden of Showa University, was extracted with methanol, and the methanolic extract was suspended in water and successively extracted with ether and ethyl acetate. The aqueous layer was chromatographed on Amberlite XAD-II to give water and methanol eluate fractions. The methanol eluate fraction was chromatographed on Sephadex LH-20, and subjected to a combination of silica gel, Lobar RP-8 column chromatography and HPLC to isolate seven sesquiterpenoid glucosides (**1**—**7**), a monoterpenoid glucoside (**8**), seven aromatic compound glycosides (**9**—**15**) and L-phenylalanine (**16**). Among them, five sesquiterpenoid glucosides (**2**, **4**—**7**) and an aromatic compound glycoside (**11**) are new compounds. All new glucosides were suggested to be β-D-glucopyranosides by their ^{1}H- and ^{13}C-NMR data (Tables 1 and 2), and this was confirmed by comparison of the $[M]_D$ values between the glucosides and their aglycones.[9,10] Their molecular formulae were suggested from the accurate mass number of the $[M+H]^+$ or $[M+Na]^+$ ion peaks in the high-resolution positive FAB-MS.

Glycosides **1** and **3** were identified as atractyloside A [(1*S*,4*S*,5*R*,7*R*,10*R*)-4,10,11,14-tetrahydroxyguai-3-one 11-*O*-β-D-glucopyranoside] and atractyloside B [(1*S*,3*S*,4*S*,5*R*,7*R*,10*R*)-guai-3,4,10,11,14-pentol 11-*O*-β-D-glucopyranoside] by their physical and NMR spectral data.[8]

Glycoside **2** ($C_{21}H_{36}O_{10}$, an amorphous powder, $[\alpha]_D^{22}$ $+14°$) showed $[M+H]^+$ and $[M-C_6H_{12}O_6+H]^+$ ion peaks at *m/z* 449 and 269, respectively, in the positive FAB-MS, and enzymatic hydrolysis of **2** gave an aglycone (**2a**; $C_{15}H_{26}O_5$, an amorphous powder, $[\alpha]_D^{22}$ $+3°$) and D-glucose. It showed similar NMR spectral features to those of **1** (Tables 1 and 2), and from the analysis of HMBC spectral data (see Experimental), **2** was clarified to be a β-D-glucopyranoside which has the same planar structure as **1**. On comparison of the ^{1}H- and ^{13}C-NMR data of **1** and **2**, the H-1_{ax} and H_2-14, and C-1, C-5 and C-9 signals of **2** appeared significantly downfield from those of **1**, and the H-5_{ax} and C-14 signals of **2** appeared significantly upfield from those of **1**. So, the stereochemical relationship between **1** and **2** was considered to be an epimer at C-10. This was also supported by the observed nuclear Overhauser effect (NOE) interaction between H-1/H-6_{ax}, H_3-15 and between H-14b/H-5, H-7 in the NOE spectroscopy (NOESY) spectrum (Fig. 1). Since **1** and **2** showed positive Cotton effect in the circular dichroism (CD) at 306 nm (**1**; $\Delta\varepsilon$ $+2.03$, **2**; $\Delta\varepsilon$ $+1.43$), and they were considered to have the same molecular configuration except at C-10, the absolute structure of the aglycone moiety of **2** was determined to be the same as that of **1**.[11,12] Therefore, **2** was characterized as 10-*epi*-atractyloside A [(1*S*,4*S*,5*R*,7*R*,10*S*)-4,10,11,14-tetrahydroxyguai-3-one 11-*O*-β-D-glucopyranoside].

Glycoside **4** ($C_{21}H_{36}O_9$, an amorphous powder, $[\alpha]_D^{22}$ $+3°$) showed $[M+H]^+$ and $[M-C_6H_{12}O_6+H]^+$ ion peaks at *m/z* 433 and 253, respectively, in the positive FAB-MS, and the NMR spectral data (Tables 1 and 2) showed the presence of three *tert*-methyls, one hydroxymethyl, four methylenes, four methines, one hydroxylated quaternary carbon and one carbonyl carbon, in addition to the β-D-glucopyranosyl moiety. Enzymatic hydrolysis of **4** with naringinase gave an aglycone (**4a**; $C_{15}H_{26}O_4$, an amorphous powder, $[\alpha]_D^{22}$ $+22°$) and D-glucose. The result of a HMBC experiment (see Experimental) indicated the aglycone of **4** was 10,11,14-trihydroxyguai-3-one, and the glucosyl group was located at C-11. The observed NOE interaction between H-1/H-4, H-6_{ax}, H_2-14, and

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between H-5/H-7, H3-15 in their NOESY spectra suggested that the ring juncture was trans, the same as **1** to **3**, while the configuration of C-7 hydroxyisopropyl and C-10 hydroxymethyl was β-equatorial, and that of C-4 methyl was α-equatorial (Fig. 1). Then, **4** was revealed to be 1β,5α-H-10α,11,14-trihydroxyguai-3-one 11-*O*-β-D-glucopyranoside. The absolute structure of the aglycone moiety was determined to be the same as that of **1**, since **4** showed positive Cotton effect in the CD spectrum [295 nm ($\Delta\varepsilon$ +3.10)]. Therefore, **4** was characterized as (1*S*,4*S*,5*S*,7*R*,10*R*)-10,11,14-trihydroxyguai-3-one 11-*O*-β-D-glucopyranoside.

Glycoside **5** ($C_{21}H_{36}O_8$, mp 98—100 °C, $[\alpha]_D^{22}$ +34°) showed $[M+H]^+$ and $[M-C_6H_{12}O_6+H]^+$ ion peaks at *m/z* 417 and 237 in the positive FAB-MS, and hydrolyzed with β-glucosidase to an aglycone (**5a**; $C_{15}H_{26}O_3$, an amorphous powder, $[\alpha]_D^{22}$ +57°) and D-glucose. Glycoside **5** was considered to be a 10-dehydroxylated derivative of **4** by comparison of its NMR spectral data with those of **4**, and the results of the HMBC experiment (see Experimental) supported this conclusion. As NOE interactions between the signals of H-1/H-6_{ax}, between H-5/H-7, H_3-14 and H_3-15, and between H-6_{eq}/H_3-15 were observed in the NOESY spectrum of **5** (Fig. 2), the ring juncture was suggested to be trans, and the configurations of H-5, H-7, C-4 methyl and C-10 hydroxymethyl were α, while that of H-1 was β (Fig. 1). The absolute structure of the aglycone moiety was determined to be the same as that of **1** to **4** from the result of a CD spectrum which showed a positive Cotton effect [296 nm ($\Delta\varepsilon$ +3.97)]. Therefore, **5** was characterized as (1*S*,4*S*,5*R*,7*R*,10*R*)-11,14-dihydroxyguai-3-one 11-*O*-β-D-glucopyranoside.

Glycoside **6** ($C_{21}H_{34}O_{10}$, an amorphous powder, $[\alpha]_D^{22}$ +36°) showed $[M+H]^+$ and $[M-C_6H_{10}O_5+H]^+$ ion peaks at *m/z* 447 and 285 in the positive FAB-MS, and an $[M-H]^-$ ion peak in the negative FAB-MS. It hydrolyzed with β-glucosidase to an aglycone (**6a**; $C_{15}H_{24}O_5$, an amorphous powder, $[\alpha]_D^{22}$ +39°) and D-glucose, and the NMR and ^{1}H–^{13}C COSY spectral data (Tables 1 and 2) of **6** showed the presence of two *tert*-methyls, one hydroxymethyl, four methylenes, three methines, two hydroxylated quaternary carbons, one carbonyl carbon and one acetyl group, in addition to the β-D-glucopyranosyl moiety. From analysis of the HMBC spectral data of **6** and **6a** (see Experimental), **6** was considered to be a secoguaiane-type glucoside with cleavaging of the bond between C-3 and C-4, and a new lactone ring. The position of the glucosyl unit was found to be C-11 by the observed cross-peak between the glucosyl H-1 and C-11 in the HMBC spectrum. As **6a** gave a monoacetate by acetylation using Ac_2O and pyridine, and the signal of H_2-14 was shifted to downfield to that of **6a** (**6a**; δ 4.11, 4.05, **6a-Ac**; δ 4.57), a δ-lactone ring should be formed between C-3 and C-10. Then the planar structure of **6a** could be described as Fig. 2, and named secoatractylolactone. The stereochemistry of **6** was examined by the results of its NOESY spectrum. The NOE interactions between H-5/H-7 and H-9_{ax} suggested that the configurations of the C-5 acetyl group and C-7 hydroxyisopropyl were β-equatorial, while that between H_2-14/H-1 and H-6_{ax} suggested the configurations of H-1 and C-10 hydroxymethyl should be β-axial, respectively (Fig. 1). Furthermore, the glycosylation shift of C-7, C-11, C-12 and C-13 of **6** showed almost identical values to those of **2**, **4** and **5** (Table 2). As the glycosylation shift values of C-12 and C-13 in the hydroxyisopropyl group are supposed to reflect the absolute configuration at C-7,[13] **6** was considered to be the same (1*S*,5*R*,7*R*)-form as **1** to **5**. Thus, the structure of **6** was considered to be (1*S*,5*R*,7*R*,10*R*)-secoatractylolactone 11-*O*-β-D-glucopyranoside as shown in Fig. 1.

Glycoside **7** ($C_{21}H_{30}O_9$, an amorphous powder, $[\alpha]_D^{22}$ +95°) showed an $[M+H]^+$ ion peak at *m/z* 427 in the positive FAB-MS, and an $[M-H]^-$ ion peak at *m/z* 425 in the negative FAB-MS. The NMR spectral data (Tables 1 and 2) of **7** showed the presence of one β-glucopyranosyl group, and two *tert*-methyls, four methylenes, one methine, one terminal-methylene, one tetrasubstituted double bond conjugated to a carbonyl carbon, one quaternary carbon, one hydroxylated methine and one acetal carbon in the aglycone moiety. Enzymatic hydrolysis of **7** with β-glucosidase gave an aglycone (**7a**; $C_{15}H_{20}O_4$, an amorphous powder, $[\alpha]_D^{22}$ +286°) and D-glucose. Comparison of the ^{1}H-NMR of **7a** with that of atractylenolide I[2,7] suggested that **7** was a β-D-glucopyranoside of a hydroxylated derivative of dihydroatractylenolide I. Analysis of the HMBC spectrum of **7** and **7a** (see Experimental) supported this conclusion, and an additional hydroxyl group was indicated to be located at C-3 and C-8. The position of the glucosyl unit was also found to be C-3 by the HMBC experiment. As NOE interactions between H-3/H-5, between H_3-14/H-2_{ax} and H-6_{ax} were observed in the NOESY spectrum of **7** (Fig. 1), and the H-3 signal was found as a broad double doublet (J=5.0, 12.0 Hz) in its ^{1}H-NMR spectrum, the conformation of the A,B-ring should be a chair form having a trans relation, and the configuration of H-3, H-5 and C-10 methyl should be axial, respectively. By comparison of the C-10 methyl signal chemical shift (δ 1.25) with that of officinoside C [**17** (Fig. 2); δ 0.71],[14] the configuration of C-8 hydroxyl was suggested to be axial, the same as atractylenolide III.[15,16] Further comparison of the ^{13}C-chemical shift of glucosyl C-1 (**7**; δ 103.2; **17**; δ 103.1) and the glucosylation shift values of α-carbon [glucoside (pyridine-d_5)-aglycone ($CDCl_3$)[17]; **7**; +5.4, **17**; +4.7] indicated that the absolute configuration of C-3 should be *S*, the same as that of **17**. Therefore, **7** was characterized as (3*S*)-3-hydroxyatractylenolide III 3-*O*-β-D-glucopyranoside [(3*S*,5*R*,8*R*,10*R*)-3,8-dihydroxyeudesma-4(15),7(11)-diene-8,12-olide 3-*O*-β-D-glucopyranoside] as described in Fig. 1.

Glycosides **8**—**10**, **12**—**15** were identified as (1*R*,2*R*,4*S*)-2-hydroxy-1,8-cineole β-D-glucopyranoside,[18] 4-hydroxy-3-methoxyphenol β-D-glucopyranoside,[19] 4-hydroxy-3-methoxyphenol β-D-apiopyranosyl(1→6)-β-D-glucopyranoside,[20] seguinoside B [4-hydroxyphenyl 1-*O*-β-D-apiopyranosyl-(1→6)-β-D-glucopyranoside],[21] icariside F_2 [benzyl β-D-apiopyranosyl(1→6)-β-D-glucopyranoside],[22] icariside D_1 [phenethyl β-D-apiopyranosyl(1→6)-β-D-glucopyranoside],[23] and phenethyl α-L-rhamnopyranosyl(1→6)-β-D-glucopyranoside,[24] respectively, by comparison with authentic compounds or published physical and spectral data.

Glycoside **11** ($C_{18}H_{26}O_{12}$, an amorphous powder, $[\alpha]_D^{22}$ −67°) showed an $[M+H]^+$ ion peak at *m/z* 435 in the positive FAB-MS. Acid hydrolysis of **11** gave glucose and xylose as sugar components, and comparison of its ^{13}C-NMR spectral data with those of **9** and **10** indicated that **11** was 4-hydroxy-3-methoxyphenyl β-xylopyranosyl(1→6)-β-glucopyranoside.[25,26] The NOE interaction which was observed be-

Table 1. ^{1}H-NMR Chemical Shifts of **1**, **2**, **4**—**7** (in Pyridine-d_5, 500 MHz)

	1	**2**	**4**	**5**
H-1_{ax} (β)	2.38 ddd (10.0, 10.0, 10.0)	2.63 ddd (9.0, 9.0, 9.5)	2.26 ddd (10.0, 10.0, 10.0)	1.73 br ddd (7.0, 10.0, 10.0)
H-2_{ax} (β)	2.71 dd (10.0, 19.0)	2.94 dd (9.0, 19.0)	2.65 dd (10.0, 19.0)	2.01 dd (10.0, 18.5)
H-2_{eq} (α)	3.14 dd (10.0, 19.0)	3.05 dd (9.0, 19.0)	3.09 dd (10.0, 19.0)	2.81 dd (7.0, 18.5)
H-4_{ax} (β)	—	—	1.89 dd (7.0, 11.0)	1.79 dd (6.5, 11.0)
H-5_{ax} (α)	2.79 br dd (10.0, 11.0)	2.57 br dd (9.5, 11.5)	2.13 br ddd (10.0, 11.0, 11.0)	1.53 br ddd (10.0, 11.0, 11.0)
H-6_{ax} (β)	1.47 ddd (11.0, 13.0, 13.0)	1.46 ddd (11.5, 13.0, 13.0)	1.24 ddd (11.0, 13.0, 13.0)	1.10 ddd (11.0, 13.0, 13.0)
H-6_{eq} (α)	2.86 br dd (3.0, 13.0)	2.86 br d (13.0)	2.42 br dd (3.0, 13.0)	2.40 br d (13.0)
H-7_{ax} (α)	2.29 br ddd (5.0, 11.0, 13.0)	2.23 dddd (3.0, 3.0, 11.0, 13.0)	2.04 br ddd (4.0, 11.0, 13.0)	1.90 dddd (3.0, 3.0, 11.0, 13.0)
H-8_{ax} (β)	1.75 br ddd (8.0, 11.0, 14.5)	1.81 br ddd (8.0, 11.0, 14.5)	1.64 br ddd (11.0, 11.0, 14.0)	1.68 dddd (3.0, 11.0, 11.0, 13.0)
H-8_{eq} (α)	2.44 br ddd (4.0, 8.5, 14.5)	2.27 m	2.43 br dd (10.0, 14.0)	2.12 br dd (10.0, 13.0)
H-9_{ax} (β)	2.53 br dd (11.0, 14.0)	2.20 ddd (3.0, 11.0, 13.0)	1.99 br dd (11.0, 13.0)	1.90 m
H-9_{eq} (α)	2.14 br dd (8.5, 14.0)	2.48 ddd (3.0, 8.0, 13.0)	2.69 br dd (10.0, 13.0)	2.12 m
H-10_{eq} (β)	—	—	—	1.72 m
H_3-12	1.41 s	1.37 s	1.44 s	1.43 s
H_3-13	1.49 s	1.48 s	1.45 s	1.44 s
H_2-14	3.85 br s (2H)	4.08 d (11.0)	3.79 br s (2H)	3.67 dd (6.5, 10.5)
		4.14 d (11.0)		3.80 dd (3.5, 10.5)
H_3-15	1.36 s	1.33 s	1.15 d (7.0)	1.16 d (6.5)
Glc H-1	5.04 d (8.0)	5.03 d (7.5)	5.05 d (7.5)	5.07 d (7.5)

	6		**7**
H-1_{ax} (β)	3.25 ddd (10.0, 10.0, 10.0)	H-1_{ax} (α)	1.18 ddd (3.5, 13.0, 13.0)
H-2_{ax} (α)	2.46 dd (10.0, 19.0)	H-1_{eq} (β)	1.37 ddd (3.5, 3.5, 13.0)
H-2_{eq} (β)	3.25 dd (10.0, 19.0)	H-2_{ax} (β)	1.85 dddd (3.5, 12.0, 13.0, 13.0)
H-5_{ax} (α)	3.11 br dd (10.0, 10.0)	H-2_{eq} (α)	2.11 dddd (3.5, 3.5, 5.0, 13.0)
H-6_{ax} (β)	1.31 ddd (13.0, 13.0, 13.0)	H-3_{ax} (α)	4.58 dd (5.0, 12.0)
H-6_{eq} (α)	2.63 ddd (3.0, 3.0, 13.0)	H-5_{ax} (α)	1.82 dd (3.0, 9.5)
H-7_{ax} (α)	2.06 dddd (3.0, 3.0, 13.0, 13.0)	H-6_{ax} (β)	2.71 dd (9.5, 13.0)
H-8_{ax} (β)	1.38 br ddd (13.0, 13.0, 13.0)	H-6_{eq} (α)	2.79 dd (3.0, 13.0)
H-8_{eq} (α)	2.04 m	H-9_{ax} (α)	1.54 d (13.0)
H-9_{ax} (α)	1.99 br dd (13.0, 13.0)	H-9_{eq} (β)	2.48 d (13.0)
H-9_{eq} (β)	2.38 br dd (7.5, 13.0)	H_3-12	1.86 s
H_3-12	1.25 s	H_3-14	1.25 s
H_3-13	1.41 s	H-15a	5.01 d (1.0)
H_2-14a	4.01 d (12.0)	H-15b	6.29 d (1.0)
H_2-14b	4.07 d (12.0)	Glc H-1	5.11 d (8.0)
H_3-15	2.32 s		
Glc H-1	5.03 d (8.0)		

δ in ppm from TMS [coupling constants (J) in Hz are given in parentheses].

Table 2. ^{13}C-NMR Chemical Shifts of **1**—**7**, **2a**, **4a**, **5a**, **6a** and **7a** (in Pyridine-d_5, 125 MHz)

	1	**2**	**2a**	**3**	**4**	**4a**	**5**	**5a**	**6**	**6a**	**7**	**7a**
C-1	43.58	48.10	47.82	43.97	46.80	47.08	43.62	43.82	41.15	41.24	39.34	39.64
C-2	36.13	37.20	36.95	31.26	39.38	39.40	45.64	45.61	37.43	37.35	30.85	32.73
C-3	220.47	219.84	220.20	79.66	219.73	219.73	218.99	218.89	176.02	175.98	78.18	72.48
C-4	80.96	80.89	80.85	81.32	52.27	52.32	52.36	52.30	210.16	209.49	148.56	153.07
C-5	46.58	49.09	49.17	45.97	44.17	44.26	48.93	48.98	55.54	55.62	50.16	50.27
C-6	29.83	29.38	30.19	31.97	36.71	36.78	35.80	35.76	31.85	32.08	24.88	25.03
C-7	48.85	48.98 (−2.0)	52.00	52.59	50.80 (−1.8)	52.58	50.13 (−1.8)	51.96	52.19 (−1.8)	53.98	161.72	161.90
C-8	23.25	24.13	23.92	24.52	23.45	23.59	25.60	25.94	25.25	25.33	104.56	104.64
C-9	36.05	39.26	39.24	38.00	37.13	37.09	28.79	28.80	32.85	32.68	51.31	51.41
C-10	74.35	75.51	75.59	75.37	74.60	74.57	48.11	48.37	91.57	91.54	36.96	37.03
C-11	81.02	80.92 (+8.3)	72.61	80.70	80.42 (+8.0)	72.39	80.46 (+8.2)	72.30	79.68 (+8.2)	71.47	121.77	121.70
C-12	24.45	23.85 (−3.4)	27.29	24.06[a)]	23.98 (−3.4)	27.33	24.21 (−3.3)	27.52	22.74 (−3.3)	26.05	8.32	8.23
C-13	24.45	24.58 (−3.1)	27.71	25.03[a)]	24.48 (−3.4)	27.92	24.21 (−3.4)	27.61	25.52 (−3.3)	28.59	172.65	172.68
C-14	70.07	66.70	66.96	68.64	69.74	69.86	65.99	66.00	68.76	68.75	17.14	17.28
C-15	19.11	19.01	19.24	16.08	12.95	12.87	12.70	12.59	28.86	28.68	106.04	104.27
Glc-1	98.65	98.73		98.65	98.63		98.71		98.94		103.18	
Glc-2	75.43	75.42		75.85	75.39		75.46		75.42		75.60	
Glc-3	78.84	78.82		78.87	78.92		78.98		78.99		78.77	
Glc-4	71.67	71.48		71.81	71.97		72.06		72.09		71.86	
Glc-5	78.16	78.15		78.29	78.10		78.18		78.39		78.72	
Glc-6	62.70	62.50		62.86	62.05		63.12		63.00		62.91	

δ in ppm from TMS. $\Delta\delta$ (δ glucoside$-\delta$ aglycone) are given in parentheses. *a*) Assignments may be interchanged.

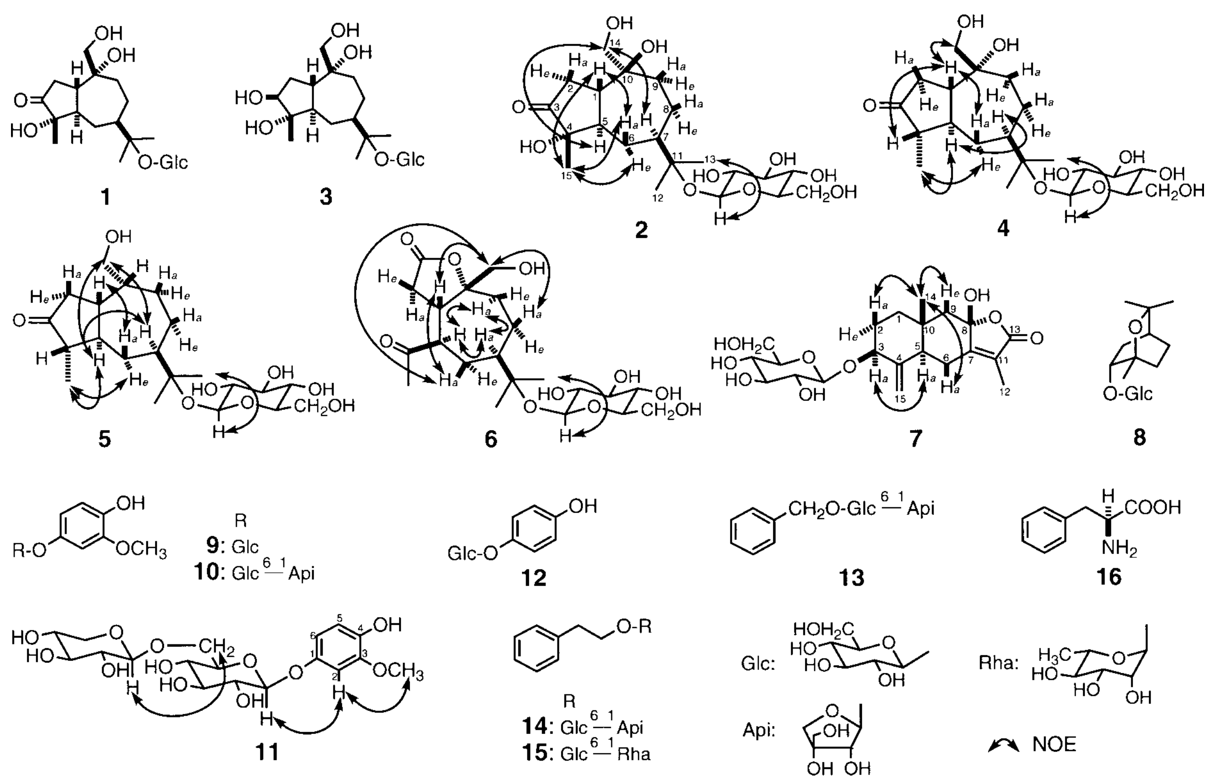

Fig. 1. Structures of **1**—**16**, and NOE Interactions Observed in the NOESY Spectra of **2**, **4**—**7** and **11**

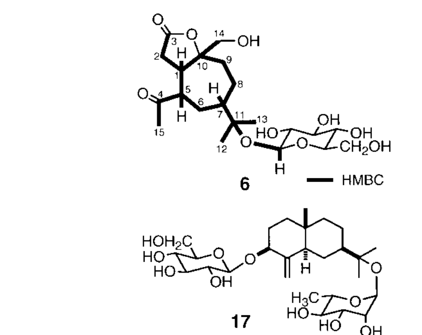

Fig. 2. HMBC Correlations of **6** and the Structure of **17**

tween H-2/O-CH_3 and glucosyl H-1, between H-6/glucosyl H-1, and between glucosyl H_2-6/xylosyl H-1 in the NOESY spectrum also supported this conclusion. Since this glucose was considered to be the same D-form as **9** and **10**, and the $[M]_D$ value ($[M]_D$ value of **11**-$[M]_D$ value of **9**$=-125°$) showed the same minus value as methyl β-D-xylopyranoside ($[M]_D=-108°$),[9,10] the sugar moiety was considered to be β-D-xylopyranosyl(1→6)-β-D-glucopyranoside. Therefore, **11** was characterized as 4-hydroxy-3-methoxyphenyl β-D-xylopyranosyl(1→6)-β-D-glucopyranoside.

The rhizomes of *A. japonica* and *A. lancea* contained a guaiane-type sesquiterpenoid, atractyloside A, as a main glycoside, and seem to have similar glucosyl constituents. On the other hand, L-phenylalanine for *A. japonica*, and L-tryptopane for *A. lancea* were obtained as the main amino acids of their rhizomes.

Experimental

Melting points were determined on a Yanagimoto micromelting point apparatus and are uncorrected. Optical rotations were measured on a JASCO DIP-370 digital polarimeter. FAB-MS were recorded with a JEOL HX-110 spectrometer using glycerol as a matrix. ^{1}H- and ^{13}C-NMR spectra were taken on a JEOL A-500 spectrometer with tetramethylsilane as an internal standard, and chemical shifts were recorded in δ values. Column chromatography (C.C.) was carried out under TLC monitoring using Kieselgel 60 (70—230 mesh, Merck), Sephadex LH-20 (25—100 μm, Pharmacia), a Lobar RP-8 column (Merck) and Amberlite XAD-II (Organo). TLC was performed on silica gel (Merck 5721), and spots were detected with *p*-anisaldehyde-H_2SO_4 reagent. HPLC separation was carried out with Symmetryprep C_{18} 7 μm [Waters; column size, 7.8×300 mm; ODS], carbohy-

Table 3. ^{13}C-NMR Chemical Shifts of **9**—**11** (in Pyridine-d_5, 125 MHz)

	9	**10**	**11**
C-1	152.13	152.25	152.20
C-2	103.72	103.73	103.72
C-3	149.02	148.97	148.98
C-4	143.32	143.49	143.50
C-5	116.42	116.52	116.55
C-6	109.42	109.93	110.00
OCH_3	55.79	55.93	55.89
Glc-1	103.41	104.11	104.13
Glc-2	75.16	75.04	75.01
Glc-3	78.98	78.59	78.27
Glc-4	71.53	71.73	71.47
Glc-5	78.67	77.27	78.52
Glc-6	62.51	69.03	70.20
Api-1		111.14	
Api-2		77.79	
Api-3		80.42	
Api-4		75.04	
Api-5		65.49	
Xyl-1			106.10
Xyl-2			75.00
Xyl-3			77.43
Xyl-4			71.18
Xyl-5			67.17

δ in ppm from TMS.

drate analysis [Waters; column size, 3.9×300 mm; CHA] columns. Acetylation was done in the usual way using Ac_2O and pyridine.

Extraction and Separation The fresh rhizome of *A. japonica* (1.4 kg), which was cultivated in the medical plant garden of Showa University (Fujiyoshida City, Yamanashi Prefecture, Japan), was extracted with methanol (3 l×3) for 2 weeks, and the extract (205.4 g) was partitioned into ether–water and ethyl acetate–water, respectively. The aqueous portion (172.5 g) was chromatographed over Amberlite XAD-II (H_2O→MeOH) to give water eluate (153.6 g) and methanol eluate (18.9 g) fractions.

The methanol eluate fraction was subjected to Sephadex LH-20 (MeOH) to give five fractions (frs. A—E). Fraction B (6.87 g) was chromatographed over silica gel [$CHCl_3$–MeOH–H_2O (17 : 3 : 0.2→7 : 3 : 0.5→6 : 4 : 0.5)→MeOH] to give ten fractions (frs. B_1—B_{10}). Fraction B_2 (0.23 g) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17—3 : 7)] to give eleven fractions (frs. $B_{2\text{-}1}$—$B_{2\text{-}11}$), and fr. $B_{2\text{-}4}$ and fr. $B_{2\text{-}5}$ were subjected to HPLC [ODS, MeCN–H_2O (3 : 17)] to give **7** (24 mg) and **8** (7 mg), respectively. Fraction B_3 (0.54 g) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give eleven fractions (frs. $B_{3\text{-}1}$—$B_{3\text{-}11}$), and fr. $B_{3\text{-}3}$ was subjected to HPLC [ODS, MeCN–H_2O (1 : 9)] to give **6** (15 mg). Fraction $B_{3\text{-}9}$ was subjected to HPLC [ODS, MeCN–H_2O (3 : 17)] to give **5** (6 mg), and fr. $B_{3\text{-}10}$ was subjected to HPLC [ODS, MeCN–H_2O (1 : 7)] to give **15** (14 mg). Fraction B_4 (0.54 g) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give nine fractions (frs. $B_{4\text{-}1}$—$B_{4\text{-}9}$), and fr. $C_{4\text{-}4}$ was subjected to HPLC [ODS, MeCN–H_2O (1 : 7)] to give **4** (35 mg). Fraction B_6 (0.89 g) was subjected to a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give ten fractions (frs. $B_{6\text{-}1}$—$B_{6\text{-}10}$), and fr. $B_{6\text{-}3}$ was subjected to repeated HPLC [ODS, MeCN–H_2O (1 : 7) and CHA, MeCN–H_2O (9 : 1)] to give **16** (8 mg), **2** (10 mg) and **1** (100 mg). Fraction B_8 (0.34 g) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give nine fractions (frs. $B_{8\text{-}1}$—$B_{8\text{-}9}$), and fr. $B_{8\text{-}3}$ was subjected to HPLC [ODS, MeCN–H_2O (1 : 16)] to give **3** (10 mg). Fraction C (0.99 g) was subjected to silica gel column chromatography [$CHCl_3$–MeOH–H_2O (7 : 3 : 0.5→1 : 1 : 0.1)→MeOH] to give eight fractions (frs. C_1—C_8). Fraction C_3 (0.16 g) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give nine fractions (frs. $C_{3\text{-}1}$—$C_{3\text{-}9}$), and fr. $C_{3\text{-}3}$ was subjected to HPLC [ODS, MeCN–H_2O (1 : 39)] to give **9** (2 mg). Fraction $C_{3\text{-}6}$ was subjected to HPLC [ODS, MeCN–H_2O (1 : 9)] to give **13** (10 mg), and fr. $C_{3\text{-}8}$ was subjected to HPLC [ODS, MeCN–H_2O (1 : 7)] to give **14** (2 mg). Fraction C_5 (0.10 g) was passed through a Lobar RP-8 column [MeCN–H_2O (3 : 17)] to give five fractions (frs. $C_{5\text{-}1}$—$C_{5\text{-}5}$), and fr. $C_{5\text{-}3}$ was subjected to repeated HPLC [ODS, MeCN–H_2O (1 : 39), CHA, MeCN–H_2O (14 : 1)] to give **10** (4 mg), **12** (3 mg) and **11** (4 mg), respectively.

The following compounds were identified by comparison with authentic compounds or published physical and spectral data: atractyloside A (**1**; the ^{1}H- and ^{13}C-NMR spectral data were described in Tables 1 and 2), atractyloside B (**3**; the ^{13}C-NMR spectral data was described in Table 2), (1*R*,2*R*,4*S*)-2-hydroxy-1,8-cineole β-D-glucopyranoside (**8**), 4-hydroxy-3-methoxyphenol β-D-glucopyranoside (**9**; the ^{13}C-NMR spectral data was described in Table 3), 4-hydroxy-3-methoxyphenol β-D-apiopyranosyl(1→6)-β-D-glucopyranoside (**10**; the ^{13}C-NMR spectral data was described in Table 3), seguinoside B (**12**), icariside F_2 (**13**), icariside D_1 (**14**), phenethyl α-L-rhamnopyranosyl(1→6)-β-D-glucopyranoside (**15**) and L-phenylalanine (**16**).

10-*epi*-Atractyloside A (2) An amorphous powder, $[\alpha]_D^{22}$ +14° (*c*=1.2, MeOH). Positive FAB-MS *m/z*: 471 $[M+Na]^+$, 449.2379 $[M+H]^+$ (base, Calcd for $C_{21}H_{37}O_{10}$; 449.2386), 431 $[M-H_2O+H]^+$, 269 $[M-C_6H_{12}O_6+H]^+$. ^{1}H-NMR (pyridine-d_5, 500 MHz) δ: Table 1. ^{13}C-NMR (pyridine-d_5, 125 MHz) δ: Table 2. HMBC correlations: H-1_{ax}/C-2, C-5, C-6, C-9, C-10, C-14; H-2_{ax}/C-1, C-3, C-4, C-5, C-10; H-2_{eq}/C-1, C-3, C-4, C-10; H-5_{ax}/C-1, C-4, C-6, C-7, C-10, C-15; H_2-6/C-1, C-4, C-5, C-7, C-8, C-11; H-7_{ax}/C-5, C-6, C-8, C-9, C-11; H_2-8/C-6, C-7, C-9, C-10, C-11; H_2-9/C-1, C-7, C-8, C-10, C-14; H_3-12/C-7, C-11, C-13; H_3-13/C-7, C-11, C-12; H_2-14/C-1, C-9, C-10; H_3-15/C-3, C-4, C-5; Glc H-1/C-11). CD: (*c*=0.0092 M, MeOH) $\Delta\varepsilon$ (nm): +1.43 (306).

Enzymatic Hydrolysis of 2 A mixture of **2** (8 mg) and β-glucosidase (5 mg; TOYOBO Co. Ltd., Lot 93240) in water (5 ml) was shaken in a water bath at 37 °C for 10 d. The mixture was concentrated *in vacuo* to dryness and the residue was chromatographed over silica gel [$CHCl_3$–MeOH (4 : 1 to 1 : 1)] to afford **2a** (3 mg) and a sugar fraction. The sugar fraction was passed through Sephadex LH-20 (MeOH) to give a syrup, and HPLC [carbohydrate analysis (Waters), detector; JASCO RI-930 detector and JASCO OR-990 chiral detector, solv.; MeCN–H_2O (17 : 3), 2 ml/min; t_R 4.50 min (same location as that of D-glucose)] showed the presence of D-glucose.

(1*S*,4*S*,5*R*,7*R*,10*S*)-4,10,11,14-Tetrahydroxyguai-3-one (2a) An amorphous powder, $[\alpha]_D^{22}$ +3° (*c*=0.3, MeOH). ^{1}H-NMR (pyridine-d_5, 500 MHz) δ: 4.10 (1H, d, *J*=11.0 Hz, H-14b), 4.02 (1H, d, *J*=11.0 Hz, H-14a), 3.08 (1H, dd, *J*=9.5, 19.0 Hz, H-2_{eq}), 2.97 (1H, dd, *J*=9.5, 19.0 Hz, H-2_{ax}), 2.82 (1H, br d, *J*=13.0 Hz, H-6_{eq}), 2.69 (1H, ddd, *J*=9.5, 9.5, 11.5 Hz, H-1_{ax}), 2.58 (1H, br dd, *J*=11.5, 11.5 Hz, H-5_{ax}), 2.47 (1H, br dd, *J*=8.0, 13.0 Hz, H-9_{eq}), 2.30 (1H, m, H-8_{eq}), 2.25 (1H, ddd, *J*=3.0, 11.0, 13.0 Hz, H-9_{ax}), 1.99 (1H, m, H-8_{ax}), 1.94 (1H, m, H-7_{ax}), 1.59 (1H, ddd, *J*=11.0, 13.0, 13.0 Hz, H-9_{ax}), 1.41 (6H, s, H_3-12, H_3-13), 1.39 (3H, s, H_3-15). ^{13}C-NMR (pyridine-d_5, 125 MHz) δ: Table 2.

(1*S*,4*S*,5*S*,7*R*,10*R*)-10,11,14-Trihydroxyguai-3-one 11-*O*-β-D-Glucopyranoside (4) An amorphous powder, $[\alpha]_D^{22}$ +3° (*c*=1.2, MeOH). Positive FAB-MS *m/z*: 455 $[M+Na]^+$, 433.2439 $[M+H]^+$ (base, Calcd for $C_{21}H_{37}O_9$; 433.2437), 415 $[M-H_2O+H]^+$, 253 $[M-C_6H_{12}O_6+H]^+$. ^{1}H-NMR (pyridine-d_5, 500 MHz) δ: Table 1. ^{13}C-NMR (Pyridine-d_5, 125 MHz) δ: Table 2. CD: (*c*=0.0231 M, MeOH) $\Delta\varepsilon$ (nm): +3.14 (295). HMBC Correlations: H-1_{ax}/C-2, C-5, C-9, C-10, C-14; H-2_{ax}/C-1, C-3, C-4, C-5, C-10; H-2_{eq}/C-1, C-3, C-5, C-10; H-4_{ax}/C-1, C-3, C-5, C-6, C-15; H-5_{ax}/C-1, C-4, C-6, C-7, C-10, C-15; H-6_{ax}/C-1, C-5, C-7, C-8, C-11; H-6_{eq}/C-1, C-4, C-5, C-7, C-8, C-11; H-7_{ax}/C-5, C-8, C-9, C-11, C-12, C-13; H_2-8/C-7, C-9, C-10, C-11; H_2-9/C-1, C-7, C-8, C-10, C-14; H_3-12/C-7, C-11, C-13; H_3-13/C-7, C-11, C-12; H_2-14/C-1, C-9, C-10; H_3-15/C-3, C-4, C-5; Glc H-1/C-11.

Enzymatic Hydrolysis of 4 A mixture of **4** (11 mg) and naringinase (5 mg; ICN Biomedicals Inc., Lot 24210) in water (5 ml) was shaken in a water bath at 37 °C for 14 d. The mixture was treated in the same way as described for **2** to afford an aglycone **4a** (6 mg) and a sugar fraction. From the sugar fraction, D-glucose was detected as described for **2**.

(1*S*,4*S*,5*S*,7*R*,10*R*)-10,11,14-Trihydroxyguai-3-one (4a) An amorphous powder, $[\alpha]_D^{22}$ +22° (*c*=0.5, MeOH). ^{1}H-NMR (pyridine-d_5, 500 MHz) δ: 3.84 (2H, br s, H_2-14), 3.11 (1H, dd, *J*=10.5, 19.0 Hz, H-2_{eq}), 2.72 (1H, br dd, *J*=10.0, 14.5 Hz, H-9_{eq}), 2.68 (1H, dd, *J*=10.5, 19.0 Hz, H-2_{ax}), 2.49 (1H, br dd, *J*=4.0, 13.0 Hz, H-6_{eq}), 2.38 (1H, br ddd, *J*=4.0, 10.0, 14.0 Hz, H-8_{eq}), 2.32 (1H, ddd, *J*=10.5, 10.5, 10.5 Hz, H-1_{ax}), 2.15 (1H, br ddd, *J*=10.5, 10.5, 10.5 Hz, H-5_{ax}), 2.06 (1H, br dd, *J*=10.0, 14.5 Hz, H-9_{ax}), 1.90 (1H, m, H-7_{ax}), 1.72 (1H, br ddd, *J*=10.0, 10.0, 14.5 Hz, H-8_{ax}), 1.99, 1.42 (3H, s, H_3-13), 1.41 (3H, s, H_3-12), 1.35 (1H, ddd, *J*=11.0, 13.0, 13.0 Hz, H-6_{ax}), 1.14 (3H, d, *J*=7.0, H_3-15). ^{13}C-NMR (pyridine-d_5, 125 MHz) δ: Table 2.

(1*S*,4*S*,5*R*,7*R*,10*R*)-11,14-Dihydroxyguai-3-one 11-*O*-β-D-Glucopyranoside (5) Colorless needles (MeOH), mp 98—100 °C, $[\alpha]_D^{22}$ +34° (*c*=0.5, MeOH). Positive FAB-MS *m/z*: 417.2486 $[M+H]^+$ (Calcd for $C_{21}H_{37}O_8$; 417.2489), 399 $[M-H_2O+H]^+$, 237 $[M-C_6H_{12}O_6+H]^+$ (base). ^{1}H-NMR (pyridine-d_5, 500 MHz) δ: Table 1. ^{13}C-NMR (pyridine-d_5, 125 MHz) δ: Table 2. CD: (*c*=0.0084 M, MeOH) $\Delta\varepsilon$ (nm): +3.97 (296). HMBC Correlations: H-1_{ax}/C-10, C-14; H-2_{ax}/C-1, C-3, C-10; H-2_{eq}/C-1, C-3, C-4, C-5, C-10; H-4_{ax}/C-1, C-3, C-5, C-6, C-15; H-5_{ax}/C-1, C-4, C-10, C-15; H_2-6/C-1, C-4, C-5, C-7, C-8, C-11; H-7_{ax}/C-5, C-6, C-8, C-9, C-10, C-11, C-12, C-13; H-8_{ax}/C-6, C-7, C-9, C-10, C-11; H-8_{eq}/C-6, C-7, C-9, C-11; H-9_{ax}/C-1, C-7, C-8, C-10, C-14; H-9_{eq}/C-1, C-8, C-10, C-14; H_3-12/C-7, C-11, C-13; H_3-13/C-7, C-11, C-12; H_2-14/C-1, C-9, C-10; H_3-15/C-3, C-4, C-5; Glc H-1/C-11.

Enzymatic Hydrolysis of 5 A mixture of **5** (6 mg) and β-glucosidase (5 mg) in water (5 ml) was shaken in a water bath at 37 °C for 15 d. The mixture was treated in the same way as described for **2** to afford an aglycone **5a** (4 mg) and a sugar fraction. From the sugar fraction, D-glucose was detected as described for **2**.

(1*S*,4*S*,5*R*,7*R*,10*R*)-11,14-Dihydroxyguai-3-one (5a) An amorphous powder, $[\alpha]_D^{22}$ +57° (*c*=0.3, MeOH). ^{1}H-NMR (pyridine-d_5, 500 MHz) δ: 3.84 (1H, dd, *J*=3.5, 10.5 Hz, H-14b), 3.72 (1H, dd, *J*=6.5, 10.5 Hz, H-14a), 2.84 (1H, dd, *J*=7.5, 18.5 Hz, H-2_{eq}), 2.45 (1H, ddd, *J*=3.0, 3.0, 13.0 Hz, H-6_{eq}), 2.19 (1H, br ddd, *J*=5.0, 8.0, 14.5 Hz, H-9_{eq}), 2.03 (1H, dd, *J*=10.5, 18.5 Hz, H-2_{ax}), 2.02 (1H, br ddd, *J*=3.0, 11.0, 13.0 Hz, H-8_{eq}), 1.94 (1H, br ddd, *J*=5.0, 10.0, 14.5 Hz, H-9_{ax}), 1.83 (1H, dd, *J*=7.0, 11.0 Hz, H-4_{ax}), 1.79 (1H, dddd, *J*=3.0, 3.0, 13.0, 13.0 Hz, H-7_{ax}), 1.77 (2H, overlapped, H-1_{ax}, H-8_{ax}), 1.73 (1H, m, H-10_{eq}), 1.51 (1H, ddd, *J*=11.0, 11.0, 11.0 Hz, H-5_{ax}), 1.39 (6H, s, H_3-12, H_3-13), 1.23 (1H, ddd, *J*=11.0, 13.0, 13.0 Hz, H-6_{ax}), 1.13 (3H, d, *J*=7.0 Hz, H_3-15). ^{13}C-NMR (pyridine-d_5, 125 MHz) δ: Table 2.

(1*S*,5*R*,7*R*,10*R*)-Secoatractylolactone 11-*O*-β-D-Glucopyranoside (6) An amorphous powder, $[\alpha]_D^{22}$ +36° (*c*=1.3, MeOH). Positive FAB-MS *m/z*: 469 $[M+Na]^+$, 447.2234 $[M+H]^+$ (Calcd for $C_{21}H_{35}O_{10}$; 447.2231), 285 $[M-C_6H_{10}O_5+H]^+$ (base), 267 $[M-C_6H_{12}O_6+H]^+$. Negative FAB-MS *m/z*: 445 $[M-H]^-$ (base). ^{1}H-NMR (pyridine-d_5, 500 MHz) δ: Table 1. ^{13}C-NMR (pyridine-d_5, 125 MHz) δ: Table 2. HMBC correlations: H-1/C-2, C-3, C-4, C-5, C-6, C-9, C-10, C-14; H_2-2/C-1, C-3, C-5, C-10; H-5/C-1, C-2, C-4, C-6, C-7, C-10; H-6_{ax}/C-1, C-5, C-7, C-11; H-6_{eq}/C-1, C-4, C-5, C-7, C-8, C-

11; H-7/C-5, C-6, C-8. C-9, C-11, C-12; H-8_{ax}/C-6, C-7, C-9, C-10; H-8_{eq}/C-6, C-7, C-10, C-11; H_2-9/C-1, C-7, C-8, C-10, C-14; H_3-12/C-7, C-11, C-13; H_3-13/C-7, C-11, C-12; H_2-14/C-1; H_3-15/C-4, C-5; Glc H-1/C-11.

Enzymatic Hydrolysis of 6 A mixture of **6** (15 mg) and β-glucosidase (5 mg) in water (5 ml) was shaken in a water bath at 37 °C for 20 d. The mixture was treated in the same way as described for **2** to afford an aglycone **6a** (6 mg) and a sugar fraction. From the sugar fraction, D-glucose was detected as described for **2**.

(1*S*,5*R*,7*R*,10*R*)-Secoatractylolactone (6a) An amorphous powder, $[\alpha]_D^{22}$ +39° (c=0.5, MeOH). Positive FAB-MS m/z: 569 $[2M+H]^+$, 285.1708 $[M+H]^+$ (base, Calcd for $C_{15}H_{25}O_5$; 285.1702), 267 $[M-H_2O+H]^+$, 231 $[M-2H_2O+H]^+$. Negative FAB-MS m/z: 283 $[M-H]^-$ (base). ^{1}H-NMR (pyridine-d_5, 500 MHz) δ: 4.11 (1H, d, J=12.0 Hz, H-14b), 4.05 (1H, d, J=12.0 Hz, H-14a), 3.28 (1H, ddd, J=10.0, 10.0, 10.0 Hz, H-1_{ax}), 3.26 (1H, dd, J=10.0, 18.5 Hz, H-2_{eq}), 3.00 (1H, br dd, J=10.0, 19.0 Hz, H-5_{ax}), 2.54 (1H, ddd, J=3.0, 3.0, 13.0 Hz, H-6_{eq}), 2.47 (1H, m, H-2_{ax}), 2.43 (1H, br dd, J=7.0, 13.0 Hz, H-9_{eq}), 2.20 (3H, s, H_3-15), 2.09 (1H, m, H-8_{eq}), 2.01 (1H, br dd, J=13.0, 13.0 Hz, H-9_{ax}), 1.77 (1H, dddd, J=3.0, 3.0, 13.0, 13.0 Hz, H-7_{ax}), 1.47 (1H, br ddd, J=13.0, 13.0, 13.0 Hz, H-6_{ax}), 1.35 (3H, s, H_3-13), 1.26 (3H, s, H_3-12). ^{1}H-NMR (pyridine-d_5, 270 MHz) δ; 4.57 (2H, br s, H_2-14), 2.22 (3H, s, H_3-15), 2.02 (3H, s, OAc), 1.36 (3H, s, H_3-13), 1.27 (3H, s, H_3-12). ^{13}C-NMR (pyridine-d_5, 125 MHz) δ: Table 2. HMBC correlations: H-1_{ax}/C-2, C-3, C-4, C-5, C-6, C-9, C-10, C-14; H_2-2/C-1, C-3, C-5, C-10; H-5_{ax}/C-1, C-2, C-4, C-6, C-7, C-10, C-15; H-6_{ax}/C-1, C-2, C-5, C-7, C-8, C-11; H-6_{eq}/C-1, C-2, C-4, C-5, C-7, C-8, C-11; H-7_{ax}/C-5, C-6, C-8. C-9, C-11, C-12, C-13; H-8_{ax}/C-6, C-7, C-9, C-10, C-11; H-8_{eq}/C-6, C-9; H_2-9/C-7, C-8, C-10, C-14; H_3-12/C-7, C-11, C-13; H_3-13/C-7, C-11, C-12; H-14a/C-1, C-9, C-10; H-14b/C-1, C-9; H_3-15/C-4, C-5.

(3*S*)-3-Hydroxyatractylenolide III 3-*O*-β-D-Glucopyranoside (7) An amorphous powder, $[\alpha]_D^{22}$ +95° (c=1.1, MeOH). Positive FAB-MS m/z: 427.1985 $[M+H]^+$ (base, Calcd for $C_{21}H_{31}O_9$; 427.1968), 409 $[M-H_2O+H]^+$, 391 $[M-2H_2O+H]^+$. Negative FAB-MS m/z: 425 $[M-H]^-$ (base). ^{1}H-NMR (pyridine-d_5, 500 MHz) δ: Table 1. ^{13}C-NMR (pyridine-d_5, 125 MHz) δ: Table 2. HMBC correlations: H-1_{ax}/C-2, C-3, C-9, C-10, C-14; H-1_{eq}/C-2, C-3, C-5, C-9, C-10, C-14; H-2_{ax}/C-1, C-3; H-2_{eq}/C-1, C-3, C-4, C-10; H-3/C-2, C-4, C-15, glc C-1; H-5/C-3, C-4, C-6, C-9, C-10, C-14, C-15; H_2-6/C-4, C-5, C-7, C-8, C-10, C-14; H-9_{ax}/C-1, C-5, C-7, C-8, C-10, C-14; H-9_{eq}/C-1, C-5, C-8, C-10, C-14; H_3-12/C-7, C-11, C-13; H_3-14/C-1, C-5, C-9, C-10; H_2-15/C-3, C-4, C-5; glc H-1/C-3.

Enzymatic Hydrolysis of 7 A mixture of **7** (7 mg) and β-glucosidase (5 mg) in water (5 ml) was shaken in a water bath at 37 °C for 20 d. The mixture was treated in the same way as described for **2** to afford an aglycone **7a** (3 mg) and a sugar fraction. From the sugar fraction, D-glucose was detected as described for **2**.

(3*S*)-3-Hydroxyatractylenolide III (7a) An amorphous powder, $[\alpha]_D^{22}$ +286° (c=0.2, MeOH). ^{1}H-NMR (pyridine-d_5, 500 MHz) δ: 5.84 (1H, br s, H-15b), 5.01 (1H, br s, H-15a), 4.35 (1H, dd, J=3.5, 13.0 Hz, H-3_{ax}), 2.77 (1H, dd, J=10.0, 13.0 Hz, H-6_{ax}), 2.75 (1H, dd, J=4.0, 13.0 Hz, H-6_{eq}), 2.53 (1H, d, J=13.0 Hz, H-9_{eq}), 2.17 (1H, dddd, J=3.5, 3.5, 3.5, 13.0 Hz, H-2_{eq}), 1.96 (1H, dd, J=4.0, 13.0 Hz, H-5_{ax}), 1.90 (1H, dddd, J=3.5, 13.0, 13.0, 13.0 Hz, H-2_{ax}), 1.82 (3H, s, H_3-12), 1.60 (1H, d, J=13.0 Hz, H-9_{ax}), 1.50 (1H, ddd, J=3.5, 3.5, 13.0 Hz, H-1_{eq}), 1.37 (1H, ddd, J=3.5, 13.0, 13.0 Hz, H-1_{ax}), 1.32 (3H, s, H_3-14). ^{13}C-NMR (pyridine-d_5, 125 MHz) δ: Table 2, ($CDCl_3$; 125 Hz) δ: 39.07 (C-1), 31.78 (C-2), 72.72 (C-3), 150.55 (C-4), 50.74 (C-5), 24.41 (C-6), 160.21 (C-7), 104.07 (C-8), 50.74 (C-9), 36.49 (C-10), 122.60 (C-11), 5.28 (C-12), 171.82 (C-13), 16.71 (C-14), 103.22 (C-15). HMBC correlations: H-1_{ax}/C-2, C-3. C-9, C-10, C-14; H-1_{eq}/C-2, C-3, C-5, C-9, C-10, C-14; H-2_{ax}/C-1, C-3; H-2_{eq}/C-1, C-3, C-4, C-10; H-5_{ax}/C-1, C-3, C-4, C-6, C-7, C-10, C-14, C-15; H_2-6/C-4, C-5, C-7, C-8, C-10, C-11; H-9_{ax}/C-1, C-5, C-8, C-10, C-14; H-9_{eq}/C-4, C-5, C-7, C-8, C-10, C-14; H_3-12/C-7, C-11, C-13; H_3-13/C-7, C-11, C-12; H_3-14/C-1, C-5, C-9, C-10; H-15a/C-3, C-5; H-15b/C-3, C-4, C-5.

4-Hydroxy-3-methoxyphenyl β-D-Xylopyranosyl(1-6)-β-D-glucopyranoside (11) An amorphous powder, $[\alpha]_D^{22}$ −67° (c=0.3, MeOH). Positive FAB-MS m/z: 435.1507 $[M+H]^+$ (base, Calcd for $C_{18}H_{27}O_{12}$; 435.1502). ^{1}H-NMR (pyridine-d_5, 500 MHz) δ: 7.21 (1H, d, J=8.5 Hz, H-5), 7.18 (1H, dd, J=2.5, 8.5 Hz, H-6), 7.13 (1H, d, J=2.5 Hz, H-2), 3.72 (3H, s, OCH_3), 5.47 (1H, d, J=7.5 Hz, Glc H-1), 4.98 (1H, d, J=7.5 Hz, Xyl H-1). ^{13}C-NMR (pyridine-d_5, 125 MHz) δ: Table 3. ^{13}C-NMR (D_2O, 125 MHz) δ: 151.81 (C-1), 151.77 (C-3), 147.1 (br, C-4), 118.95 (C-5), 112.05 (C-6), 106.10 (C-2), 105.85 (Xyl-1), 104.06 (Glc-1), 78.31 (Xyl-3), 78.25 (Glc-3), 78.10 (Glc-5), 75.70 (Xyl-2), 75.66 (Glc-2), 72.07 (Glc-4), 71.92 (Xyl-4), 70.87 (Glc-6), 67.82 (Xyl-5), 58.71 (OCH_3).

Acid Hydrolysis of 11 Glycoside **11** (3 mg) was dissolved in aq. 2 N H_2SO_4 (5 ml) and heated in a water bath for 3 h. The hydrolysate was neutralized with $NaHCO_3$ and the salt filtered off, then the filtrate was subjected to TLC [silica gel, solv.; $CHCl_3$–MeOH–H_2O (7 : 3 : 0.5)] to show the presence of glucose and xylose [*Rf* 0.17 (glucose), 0.31 (xylose)].

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