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A New Triterpene Glucoside from *Terminalia arjuna*. Arjunglucoside III

Takahiko TSUYUKI, Yuriko HAMADA, Tadashi HONDA, Takeyoshi TAKAHASHI,* and Kazuhiro MATSUSHITA**

Department of Chemistry, Faculty of Science, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113
***Application Center, Scientific Instrument Project, JEOL Ltd., Nakagami, Akishima, Tokyo 196*

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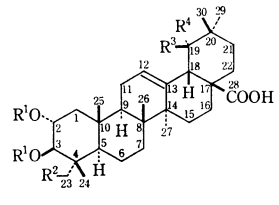
Synopsis. The structure of a new triterpene glucoside, arjunglucoside III, isolated from *Terminalia arjuna* was found to be β-D-glucopyranosyl 2α,3β,19α-trihydroxy-11-oxoolean-12-en-28-oate.

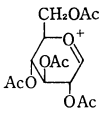
The isolation and structure determination of sitosterol, ellagic acid, D-(+)-mannitol, (+)-leucocyanidin, (+)-leucodelphinidin, oleanolic acid, arjunic acid (**1**), arjunolic acid (**2**), and arjunetin (**3**) from *Terminalia arjuna* have been reported.[1,2] In a previous paper,[3] a report was given on three new constituents, arjungenin (**4**) and arjunglucosides I (**5**) and II (**6**) from the bark of plant. We describe the structure determination of a minor glucoside, arjunglucoside III (**7**), isolated from the same plant.

Arjunglucoside III (**7**) was obtained from the methanol extract of the bark of *Terminalia arjuna* in *ca.* 0.01% yield based on the bark. Crystallization from methanol gave a crystal, mp 241.5—243.5 °C, $[\alpha]_D^{19}$ +4.8°; UV λ_{max} 255.5 nm (ε 9600). The ^{13}C NMR spectra of arjunglucoside III (**7**) together with those of arjunetin (**3**) and arjunglucoside II (**6**) are given in Table 1. The results led to the proposal[4,5] that the structure of arjunglucoside III (**7**) can be formulated as glucopyranosyl 2,3,19-trihydroxy-11-oxoolean-12-en-28-oate.

The ^{13}C NMR spectrum of methyl 3β-acetoxy-11-oxoolean-12-en-29-oate shows its C-9 signal at δ 61.9, C-11 signal at δ 200.2, and C-12 signal at δ 128.9, while that of the corresponding 11-deoxo derivative, methyl 3β-acetoxyolean-12-en-29-oate shows its C-9 signal at δ 47.7, C-11 signal at δ 23.6, and C-12 signal at δ 123.0.[5] The ^{13}C NMR and UV spectra strongly suggest the 11-oxoolean-12-ene structure for arjunglucoside III (**7**); this was confirmed by the following evidence.



	R^1	R^2	R^3	R^4
1	H	H	H	OH
2	H	OH	H	H
4	H	OH	H	OH



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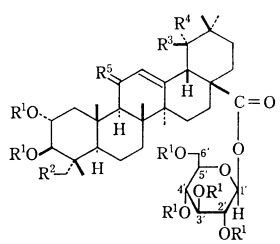

	R^1	R^2	R^3	R^4	R^5
3	H	H	H	OH	H_2
5	H	OH	H	OH	H_2
6	H	OH	H	H	H_2
7	H	H	H	OH	O
8	Ac	H	H	OH	O
10	Ac	H		=O	O
11	Ac	H	H	OH	H_2

Arjunglucoside III (**7**) was treated with acetic anhydride in pyridine to afford an acetate (**8**), mp

TABLE 1. CARBON-13 CHEMICAL SHIFTS δ_c OF ARJUNGLUCOSIDE III (**7**) ARJUNETIN (**3**), AND ARJUNGLUCOSIDE II (**6**)

Carbon number	**7**	**3**	**6**	Carbon number	**7**	**3**	**6**
C-1	48.3	47.5	46.9	C-19	80.3	80.9	46.1
C-2	68.3	68.5	68.8	C-20	35.6	35.5	30.7
C-3	83.4	83.7	78.2	C-21	28.3	29.9	34.0
C-4	39.9	39.8	43.5	C-22	32.1	32.1	32.5
C-5	55.6	55.9	48.1	C-23	28.7	28.7	66.6
C-6	17.9	19.0	18.5	C-24	17.5	16.8	14.2
C-7	33.4	32.9	32.8	C-25	17.9	17.5	17.5
C-8	44.5	39.8	40.0	C-26	19.6	17.5	17.4
C-9	62.6	48.3	47.6	C-27	24.3	28.9	26.0
C-10	38.9	38.6	38.4	C-28	176.7	177.1	176.3
C-11	200.1	24.2	23.9	C-29	29.2	29.9	33.0
C-12	129.0	123.4	122.8	C-30	22.9	24.6	23.6
C-13	170.7	144.2	144.0	C-1′	95.9	95.7	95.6
C-14	45.9	42.1	42.2	C-2′	74.0	74.0	74.0
C-15	28.3	29.2	28.1	C-3′	79.2	79.1	79.0
C-16	27.6	24.9	23.3	C-4′	71.0	71.0	71.1
C-17	46.6	46.3	48.0	C-5′	78.7	78.7	78.7
C-18	45.5	44.5	41.7	C-6′	62.1	62.1	62.2

^{13}C FT NMR spectra were measured with a JEOL FX-100 spectrometer at 25.05 MHz using pyridine-d_5 solutions (*ca.* 100 mg/cm³) in 10 mm o.d. egg-shape cells. FT conditions: spectral width, 5 kHz; pulse flipping angle, 60°; pulse repetition time, 1.0 s; number of data points, 4 K; number of transients, 5 K—40 K. Chemical shifts are expressed by δ (ppm downfield from internal TMS).

272—275 °C, UV λ_{max} 250 nm (ε 11500). The mass spectrum showed a molecular ion peak at *m/e* 916 and a base peak at *m/e* 331. The molecular ion peak together with elemental analysis led to the molecular formula, $C_{48}H_{68}O_{17}$, the base peak due to a fragment ion (**9**)[6] suggesting the presence of a glucosyl moiety in the molecule. The ^1H NMR spectrum showed the presence of seven tertiary methyls, two acetoxyls, an α-proton (at C-9) adjacent to the carbonyl group, an allylic proton (at C-18β), and a proton attached to a carbon atom (C-19) bearing a hydroxyl group (the presence of which was supported by the IR spectrum at 3540 cm^{-1}), besides a tetra-*O*-acetyl-D-glucopyranosyl moiety (*cf.* Experimental). The acetate (**8**), on oxidation with the Collins reagent,[7] gave an oxidation product (**10**), mp 215—218 °C, which was found to be identical with the 11,19-dioxoolean-12-ene derivative obtained by the same oxidation reaction of known arjunetin hexaacetate

(**11**), tetra-*O*-acetyl-β-D-glucopyranosyl 2α,3β-diacetoxy-19α-hydroxyolean-12-en-28-oate.[1,3] Arjunglucoside III should be β-D-glucopyranosyl 2α,3β,19ξ-trihydroxy-11-oxoolean-12-en-28-oate.

Since the tetra-*O*-acetyl-D-glucopyranosyl group preferentially exists as C1 form, the ^{1}H NMR spectrum of the hexaacetate (**8**) ($J_{1',2'}$=8 Hz) provides support for the presence of a β-glucosyl linkage in the molecule.[8] The α-orientation of the hydroxyl group at C-19 was suggested from the ^{1}H NMR spectrum of the acetate (**8**), which showed a broad signal ($W_{1/2}$ 6 Hz) at δ 3.20 due to a proton on C-18 (β-axial) and a triplet-like signal ($W_{1/2}$ 6 Hz) at δ 3.47 (β-equatorial) due to a proton on C-19. The values are in good accord with those of 18β- and 19β-protons of arjunetin hexaacetate (**11**) and arjungenin methyl ester triacetate,[3,9] suggesting the α(axial)-orientation of the hydroxyl group of arjunglucoside III (**7**).

In conclusion, the structure of arjunglucoside III (**7**) is β-D-glucopyranosyl 2α,3β,19α-trihydroxy-11-oxo-olean-12-en-28-oate.

Experimental

The general procedure is the same as described in a previous paper[3] except UV measurement, which was carried out on a Hitachi 340 spectrometer. High resolution mass spectrum was taken on a JEOL JMS-D300 mass spectrometer.

Isolation of Arjunglucoside III (7). The bark (1.5 kg) of *Terminalia arjuna* was pulverized and extracted with methanol (8 l) for 10 days. The methanol extract afforded a residue (10.5 g), which was subjected to separation by column chromatography on silica gel (500 g). Elution was carried out with chloroform containing methanol of the following concentration: frs 1—13, 2%, each 200 ml; frs 14—17, 4%, each 250 ml; frs 18 and 19, 6%, each 500 ml; frs 20—24, 8%, each 200 ml; frs 25—30, 10%, each 200 ml; frs 31—35, 12%, each 160 ml; frs 36—43, 14%, each 200 ml; frs 44—51, 16%, each 200 ml; frs 52—60, 18%, each 160 ml. After arjunic acid (**1**), arjunolic acid (**2**), and arjungenin (**4**) had been eluted, arjunetin (**3**; 2.4 g) was eluted in frs 41—49 and a mixture (102 mg) of arjunetin (**3**) and arjunglucoside III (**7**) was eluted in fr 50. Fr 51 mainly consisted of arjunglucoside III (**7**; 96 mg) and frs 52—58 afforded arjunglucoside II (**6**; 1.4 g). The mixture containing arjunglucoside III (**7**) was subjected to separation by column chromatography under the same conditions as above to give additional arjunglucoside III (**7**; *ca.* 20 mg). Two crops of crude arjunglucoside III were combined and purified by crystallization from methanol to give 64 mg of arjunglucoside III (**7**), mp 241.5—243.5 °C (with decomposition); $[\alpha]_D^{19}$ +4.8° (*c* 0.83, C_2H_5OH); IR (Nujol) 3380, 1725, and 1630 cm^{-1}; UV (C_2H_5OH) λ_{max} 255.5 nm (ε 9600); ^{13}C NMR (Table 1); MS *m/e* 470, 455, 410, 395, and 69 (base peak) (no molecular ion peak was observed), characterized as its hexaacetate (**8**).

Acetylation of Arjunglucoside III (7). Arjunglucoside III (**7**; 45 mg) was treated with acetic anhydride (0.2 ml) and pyridine (0.2 ml) at room temperature overnight. After the usual treatment, crystallization from ethanol gave arjunglucoside III hexaacetate (**8**; 42 mg), mp 272—275 °C; $[\alpha]_D^{20}$ +12.6° (*c* 1.9, $CHCl_3$); IR (Nujol) 3540, 1765, 1755, 1730, 1660, and 1240 cm^{-1}; UV ($CHCl_3$) λ_{max} 250 nm (ε 11500); ^{1}H NMR (100 MHz) δ ($CDCl_3$) 0.92 (6H, s), 0.96, 1.25 (each 3H, s), 0.99 (9H, s), 1.99 (3H, s), 2.05 (9H, s), 2.08 (6H, s), 2.55 (1H, s), 3.20 (1H, br s), 3.47 (1H, t-like, $W_{1/2}$ 6 Hz), 3.82 (1H, m), 4.06 (1H, as A part of ABX-system, $J_{6',6'}$=12 and $J_{5',6'}$=2 Hz), 4.32 (1H, as B part of ABX-system, $J_{6',6'}$=12 and $J_{5',6'}$=4 Hz), 4.74 (1H, d, $J_{2\beta,3\alpha}$=10 Hz), 5.20 (4H, m), 5.62 (1H, d, $J_{1',2'}$=8 Hz), and 5.77 (1H, s); MS *m/e* 916 (M$^+$), 856, 796, 649, 483, 465, 335, 331 (base peak), 271, and 169; Found: C, 62.76; H, 7.62%. Calcd for $C_{48}H_{68}O_{17}$: C, 62.87; H, 7.47%.

Oxidation of Arjunglucoside III Hexaacetate (8). Chromium trioxide (160 mg) was added to a mixture of pyridine (0.4 ml) and dichloromethane (4 ml) with stirring for 15 min.[7] To the solution was added arjunglucoside III hexaacetate (**8**; 28 mg) in dichloromethane (0.3 ml) and the reaction mixture was stirred at room temperature for 1.5 h. The usual treatment and crystallization from ethanol gave tetra-*O*-acetyl-β-D-glucopyranosyl 2α,3β-diacetoxy-11,19-dioxoolean-12-en-28-oate (**10**; *ca.* 20 mg), as white needles, mp 215—218 °C; $[\alpha]_D^{23}$ +21° (*c* 0.85, $CHCl_3$); the IR, UV, ^{1}H NMR, and MS spectra were identical with those of the sample prepared from arjunetin hexaacetate (**11**).

Oxidation of Arjunetin Hexaacetate (11). Arjunetin hexaacetate[1,3] (**11**; 36 mg, mp 233.5—235.5 °C) was oxidized with the Collins reagent according to the same procedure as above. The reaction product was crystallized from ethanol to give tetra-*O*-acetyl-β-D-glucopyranosyl 2α,3β-diacetoxy-11,19-dioxoolean-12-en-28-oate (**10**; *ca.* 20 mg) as white needles, mp 215—218 °C; $[\alpha]_D^{23}$ +13° (*c* 0.93, $CHCl_3$); IR (Nujol) 1760, 1750, 1712, 1663, and 1230 cm^{-1}; UV ($CHCl_3$) λ_{max} 246 nm (ε 8300); ^{1}H NMR (100 MHz) δ ($CDCl_3$) 0.92 (9H, s), 1.17, 1.25 (each 3H, s), 1.22 (6H, s), 1.99 (3H, s), 2.02 (9H, s), 2.08 (6H, s), 2.53 (1H, s), 3.82 (1H, m), 4.06 (1H, as A part of ABX-system, $J_{6',6'}$=12 and $J_{5',6'}$=2 Hz), 4.30 (1H, as B part of ABX-system, $J_{6',6'}$=12 and $J_{5',6'}$=4 Hz), 4.72 (1H, d, $J_{2\beta,3\alpha}$=10 Hz), 5.23 (4H, m), 5.60 (1H, s), and 5.68 (1H, d, $J_{1',2'}$=8 Hz); MS *m/e* 914 (M$^+$), 854, 794, 647, and 522; Found: *m/e* 914.4162. Calcd for $C_{48}H_{66}O_{17}$: M 914.4298; Found: C, 62.40; H, 7.22%. Calcd for $C_{48}H_{66}O_{17}\cdot 1/2\ H_2O$: C, 62.39; H, 7.31%.

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