Tannins of Rosaceous Plants. VIII.[1] Hydrolyzable Tannin Monomers Having a Valoneoyl Group from Flower Petals of *Rosa rugosa* THUNB.

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Three new hydrolyzable tannins, rugosins A (1), B (2) and C (3), were isolated from flower petals of *Rosa rugosa* THUNB. (Rosaceae), and their structures, including the orientation of the valoneoyl group, were established based on chemical evidence and spectroscopic analysis, utilizing two-dimensional nuclear magnetic resonance spectral data.

Keywords tannin; hydrolyzable tannin; *Rosa rugosa*; flower petal; Rosaceae; rugosin A; rugosin B; rugosin C; valoneoyl group; 2D-NMR

Oligomeric hydrolyzable tannins comprise a large group of natural polyphenolic compounds that are of both chemically and biologically.[2] Structure elucidation of those bearing a valoneoyl group has been largely based on the structures of the monomeric tannins, rugosins A (**1**), B (**2**) and C (**3**),[3,4] or those of their regioisomers,[4] isorugosins A (**4**) and B.[2,5-8] Very recently, an alternative structure **4** was suggested[9] for rugosin A, based on a theoretical study of the mode of self-association of tellimagrandin II (**5**),[10-12] which may lead to a dimer, rugosin D.[5] We present here detailed evidence for the structure **1** of rugosin A, including the orientation[4] of its valoneoyl group. The structures of related tannins, rugosins B and C, and the nuclear magnetic resonance (NMR) and circular dichroism (CD) spectroscopic data relevant to the orientation and absolute configuration[13] of the valoneoyl group in these tannins, are also presented.

Results and Discussion

Flower petals of *Rosa rugosa* THUNB. (Rosaceae) have been used as an oriental folk medicine for diarrhoea and bleeding.[14] Rugosins A, B and C were isolated from the ethyl acetate-soluble portion of the aqueous acetone homogenate of the flower petals.

Rugosin A (**1**) was obtained as a light brown powder. The fast-atom bombardment mass spectrum (FAB-MS) of **1** showed the $[M+Na]^+$ ion, m/z 1129, indicating its molecular formula to be $C_{48}H_{34}O_{31}$. The proton nuclear magnetic resonance (^{1}H-NMR) spectrum of **1** (500 MHz, in acetone-d_6 + D_2O) showed the presence of three galloyl

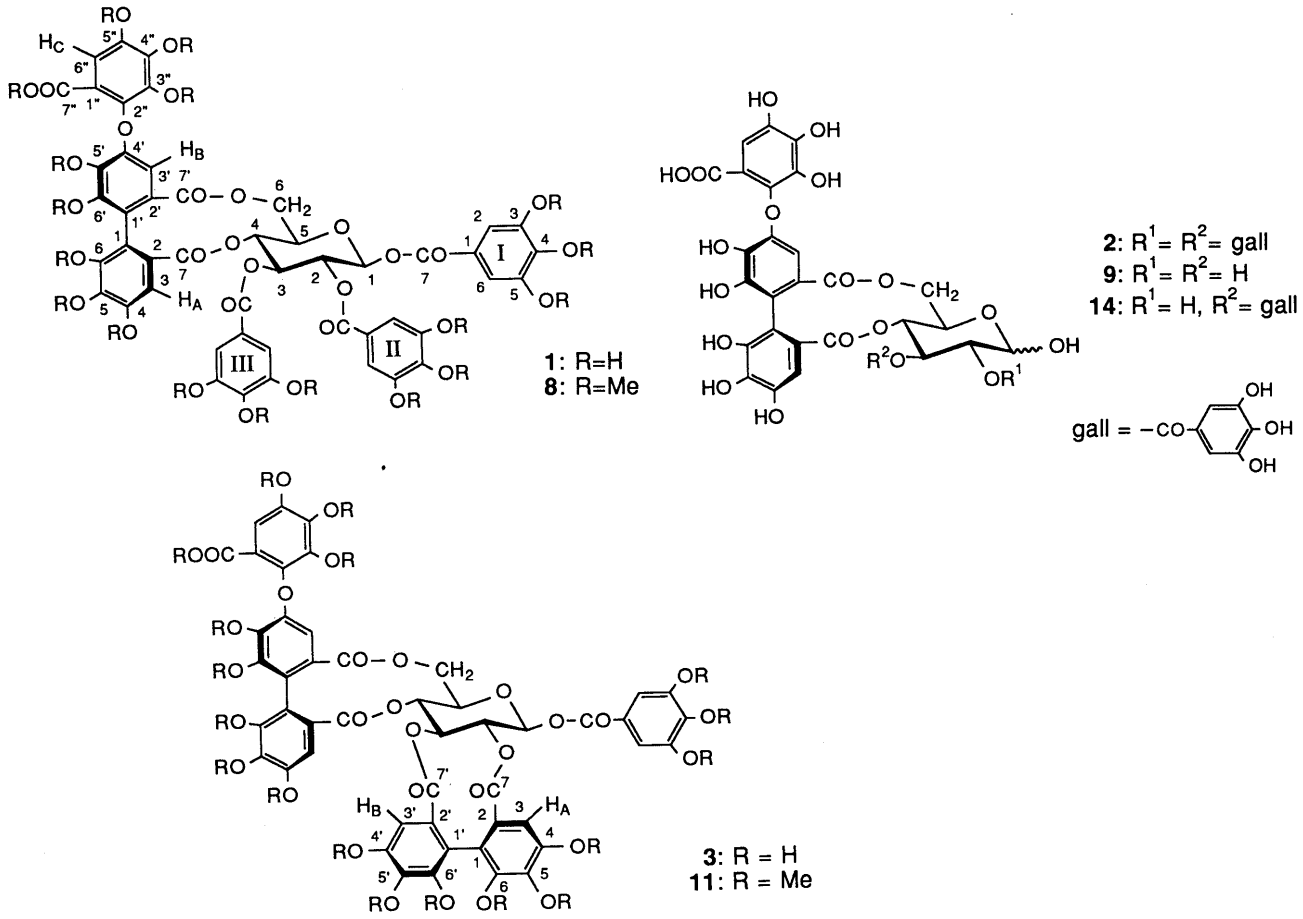

Chart 1

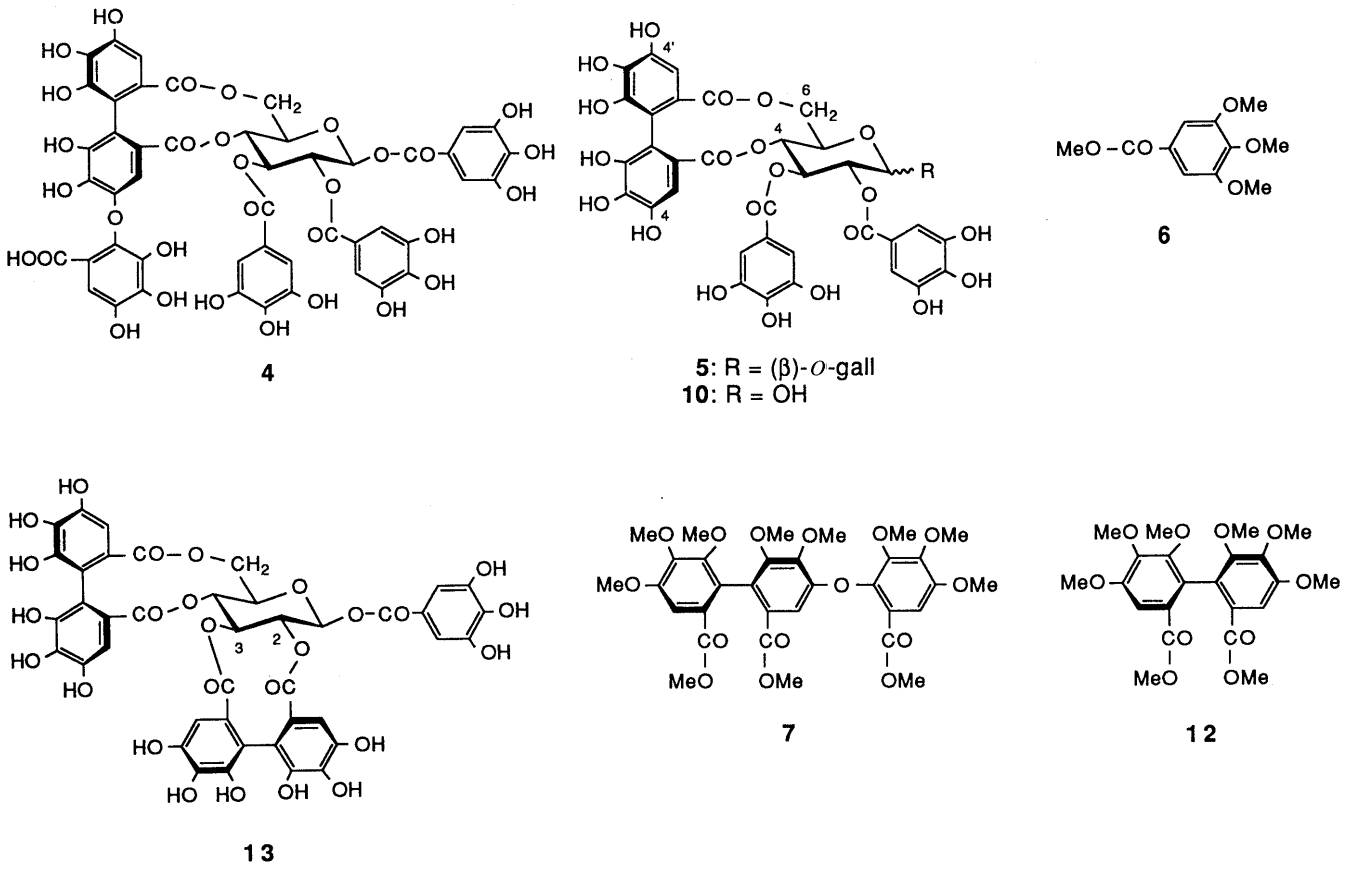

Chart 2

groups (δ 7.09, 7.00 and 6.98, 2H each, s), a valoneoyl group (δ 7.14, 6.47 and 6.32, 1H each, s) and a β-D-glucopyranose core [δ 6.17, d, J=8 Hz, (H-1); 5.57, dd, J=8, 10 Hz (H-2); 5.82, t, J=10 Hz (H-3); 5.16, t, J=10 Hz (H-4); 4.50, dd, J=6.5, 10 Hz (H-5); 5.29, dd, J=6.5, 13.5 Hz (H-6); 3.78, d, J=13.5 Hz (H-6)]. The presence of these acyl groups and glucose in the molecule was substantiated by the production of methyl tri-*O*-methylgallate (**6**), trimethyl (*S*)-octa-*O*-methylvaloneate (**7**) and glucose upon methanolysis of the octadecamethyl derivative (**8**) of this tannin.

The large difference of the ^{1}H chemical shifts between the two H-6 protons ($\Delta\delta$ 1.51) of **1** indicates[10] that the hexahydroxydiphenoyl (HHDP) moiety of the valoneoyl group is on O-4—O-6 of the glucopyranose core, since the $^4C_1$ conformation of the glucose core is shown by the coupling constants of the glucose protons described above. The chemical shifts of these glucose protons also indicate that all the hydroxyl groups on the glucopyranose core are acylated, and therefore that the remaining three galloyl groups should be on O-1, O-2 and O-3 of glucose.

These locations of the acyl groups were substantiated by the treatment of **1** with a phosphate buffer[4] of pH 5.8, which yielded **5**, and also by the treatment of **1** with tannase,[15] affording 4,6-*O*-(*S*)-valoneoyl-D-glucose (**9**). The production of **5** having an (*S*)-HHDP group,[11] formed by cleavage of the ether linkage in the valoneoyl group,[2,16] also indicates the (*S*)-configuration of the valoneoyl group in **1**. This configuration was in accord with the positive Cotton effect of large amplitude in the short-wavelength region[13] of the CD spectrum of **1** ($[\theta]_{224}$ $+1.6\times10^5$).

The orientation of the valoneoyl group in **1** was described in a previous report, along with the structures of its regioisomer, isorugosin A (**4**), and related tannins from *Liquidambar formosana*.[4] However, the proposal of structure **4** for rugosin A[9] prompted us to seek further evidence for the orientation of the valoneoyl group in rugosin A.

Among the valoneoyl carbon signals in the carbon-13 nuclear magnetic resonance (^{13}C-NMR) spectrum of **1**, the signals at δ 146.8 and 145.2 were assigned to C-4 (or C-4′) and C-4′ (or C-4). These assignments were based on the coupling of each of these carbons (*via* two bonds) with a valoneoyl proton (H_A or H_B), as indicated by the cross peaks [δ_H 6.32–δ_C 146.8] and [δ_H 6.47–δ_C 145.2] in the long-range ^{1}H–^{13}C shift correlation (COLOC) spectrum of **1** (see Table I). The C-4 and C-4′ signals of the HHDP group in the ^{13}C-NMR spectrum of **5** are at δ 145.2 (2×C).[17,18] The carbon signal at higher field (δ 145.2) in the ^{13}C-NMR spectrum of **1** was hence assigned to C-4 of the valoneoyl group, and the signal at lower field (δ 146.8) was assigned to C-4′. The cross peaks described above therefore indicate that the proton signals at δ 6.32 and 6.47 are those of H_B and H_A of the valoneoyl group, respectively. These assignments of the valoneoyl protons coincide with those based on the changes in the chemical shifts of the valoneoyl protons upon the addition of increasing amounts of pyridine-d_5.[4]

The valoneoyl protons H_A and H_B were also shown to be respectively correlated with the glucose protons H-4 and H-6, by two sets of two three-bond couplings (valoneoyl proton–ester carbonyl carbon–glucose proton) in the COLOC

spectrum,[4] and therefore we assigned the orientation of the valoneoyl group of rugosin A as shown in formula **1**.

The COLOC spectrum previously presented,[4] recorded with the average J_{CH} value for two- or three-bond couplings set at 10 Hz, did not show the cross peaks which are expected to indicate the locations of galloyl groups. In the present study, we changed the above value to 7 Hz, and obtained the COLOC spectrum, which showed the connectivity between each ester carbonyl carbon of the three galloyl group, and H-1, H-2 or H-3 of the glucose core [δ_C 164.9 (galloyl I, C-7)–δ_H 6.17 (H-1); δ_C 165.5 (galloyl II, C-7)–δ_H 5.57 (H-2); δ_C 166.2 (galloyl III, C-7)–δ_H 5.82 (H-3)] (see formula **1**).

The H_B signal (δ 6.32) of the valoneoyl group (on the side of glucose O-6) in the ^{1}H-NMR spectrum of **1** showed a remarkable upfield shift, relative to the HHDP proton on the glucose O-6 side in **5** (δ 6.67),[9,19] while the chemical shift of the H_A signal (δ 6.47) of the valoneoyl group in **1** is the same as that of the HHDP proton on the glucose O-4 side in **5** (δ 6.47). Such comparisons of the chemical shifts of HHDP protons of the valoneoyl group (H_A and H_B, protons of the HHDP part of the valoneoyl group) with those of an HHDP group located on the same oxygen of the glucopyranose ring, as in **1** and **5**, will also facilitate the assignment of the orientation of the valoneoyl group in other tannins.

Rugosin B (**2**), a light brown powder, is an anomer mixture ($\alpha:\beta=5:3$) as indicated by duplication of each signal in its ^{1}H-NMR spectrum (500 MHz, in acetone-d_6+D_2O). The spectrum showed signals of two galloyl groups (δ 7.05 and 6.99, α-anomer; δ 7.04 and 6.95, β-anomer) and a valoneoyl group [δ 7.15 (H_C), 6.48 (H_A) and 6.25 (H_B), α-anomer; δ 7.15 (H_C), 6.46 (H_A) and 6.25 (H_B), β-anomer], and glucose protons (Table II) in a pattern similar to that of tellimagrandin I (**10**).[20] The large differences of the chemical shifts between the two H-6 protons of each anomer of **2** [$\Delta\delta$ 1.50 (α-anomer) and 1.45 (β-anomer)] indicate that the HHDP moiety of the valoneoyl group is on O-4—O-6 of the glucopyranose core.[10] The downfield shifts of the H-2 and H-3 signals of both anomers of **2**, relative to the corresponding protons of **9** (Table II), indicate that two galloyl groups in **2** are on O-2 and O-3 of the glucose core.

The ^{13}C-NMR spectrum (125.7 MHz, in acetone-d_6+D_2O) of **2** also indicated that this tannin consists of two galloyl groups, a valoneoyl group and glucose (Table III). The chemical shift of each glucose carbon, which is similar

Table I. One-bond and Long-range ^{1}H–^{13}C Correlation Data for Rugosin A (**1**)

	δ_C	δ_H	
		Proton coupled *via* one bond	Proton coupled *via* two or three bonds[a]
Glucose			
C-1	93.6	6.17	5.57 (glucose H-2)
C-2	71.7	5.57	5.82 (glucose H-3)
C-3	73.1	5.82	5.16 (glucose H-4)
C-4	70.7	5.16	5.82 (glucose H-3)
C-5	73.0	4.50	5.16 (glucose H-4)
			3.78 (glucose H-6)
C-6	63.0	5.29	
		3.78	
Galloyl I			
C-1	119.8[b]		
C-2, C-6	110.3	7.09	
C-3, C-5	146.1		7.09 (galloyl I)
C-4	139.8		7.09 (galloyl I)
C-7	164.9		7.09 (galloyl I)
			6.17 (glucose H-1)
Galloyl II			
C-1	120.5[b]		
C-2, C-6	110.1	7.00	
C-3, C-5	145.9		7.00 (galloyl II)
C-4	139.3		7.00 (galloyl II)
C-7	165.5		7.00 (galloyl II)
			5.57 (glucose H-2)
Galloyl III			
C-1	120.6[b]		
C-2, C-6	110.2	6.98	
C-3, C-5	145.8		6.98 (galloyl III)
C-4	139.1		6.98 (galloyl III)
C-7	166.2		6.98 (galloyl III)
			5.82 (glucose H-3)
Valoneoyl			
C-1	115.9		6.47 (valoneoyl H_A)
C-2	125.5[c]		
C-3	107.7	6.47	
C-4	145.2		6.47 (valoneoyl H_A)
C-5	136.7		6.47 (valoneoyl H_A)
C-6	144.7		
C-7	167.6		6.47 (valoneoyl H_A)
			5.16 (glucose H-4)
C-1′	117.8		6.32 (valoneoyl H_B)
C-2′	126.1[c]		
C-3′	106.1	6.32	
C-4′	146.8		6.32 (valoneoyl H_B)
C-5′	137.4		6.32 (valoneoyl H_B)
C-6′	144.7		
C-7′	167.8[d]		6.32 (valoneoyl H_B)
C-1″	115.3		
C-2″	137.5		7.14 (valoneoyl H_C)
C-3″	140.4		
C-4″	139.8		7.14 (valoneoyl H_C)
C-5″	143.3		7.14 (valoneoyl H_C)
C-6″	110.1	7.14	
C-7″	166.3		7.14 (valoneoyl H_C)

500 MHz for ^{1}H-NMR and 125.7 MHz for ^{13}C-NMR, in acetone-d_6+D_2O. *a*) The COLOC spectrum was recorded under the average J_{CH} value of 7 Hz for two- or three-bond couplings. *b, c*) Values with same superscript may be interchanged. *d*) The cross peak due to the correlation of this carbon with the signals of one of the H-6 protons of the glucose core was observed in the long-range ^{1}H–^{13}C correlation spectrum, when the average J_{CH} value for two- or three-bond couplings was set at 10 Hz (see ref. 4).

Table II. ^{1}H-NMR Spectral Data for Glucose Residue in Rugosin B (**2**) and 4,6-*O*-(*S*)-Valoneoyl-D-glucose (**9**)

	2	**9**
α-Anomer		
H-1	5.49 (d, J=3.5 Hz)	5.06 (d, J=4 Hz)
H-2	5.08 (dd, J=3.5, 10 Hz)	3.47 (dd, J=4, 9.5 Hz)
H-3	5.83 (t, J=10 Hz)	3.80 (t, J=9.5 Hz)
H-4	5.06 (t, J=10 Hz)	4.66 (t, J=10 Hz)
H-5	4.61 (dd, J=6.5, 10 Hz)	4.28 (ddd, J=1, 6.5, 10 Hz)
H-6	5.18 (dd, J=6.5, 13 Hz)	4.99 (dd, J=6.5, 13 Hz)
	3.68 (d, J=13 Hz)	3.55[a]
β-Anomer		
H-1	5.03 (d, J=8 Hz)	4.49 (d, J=8 Hz)
H-2	5.23 (dd, J=8, 10 Hz)	3.26 (dd, J=8, 9.5 Hz)
H-3	5.57 (t, J=10 Hz)	3.59 (t, J=9.5 Hz)
H-4	5.05 (t, J=10 Hz)	4.72 (t, J=10 Hz)
H-5	4.21 (dd, J=6.5, 10 Hz)	3.79 (ddd, J=1, 6.5, 10 Hz)
H-6	5.20 (dd, J=6.5, 13 Hz)	5.02 (dd, J=6.5, 13 Hz)
	3.75 (d, J=13 Hz)	3.62 (dd, J=1, 13 Hz)

500 MHz, in acetone-d_6+D_2O. *a*) Overlapped by the HDO signal.

TABLE III. ^{13}C-NMR Data for Rugosin B (**2**)

	α-Anomer	β-Anomer		α-Anomer	β-Anomer
Glucose			Valoneoyl		
C-1	91.0	96.5	C-1	115.8	115.8
C-2	72.9	74.0	C-2	125.4[d]	125.4[d]
C-3	71.3	73.6	C-3	107.6	107.6
C-4	71.0	71.0	C-4	145.1	145.1
C-5	66.9	71.8	C-5	136.5	136.5
C-6	63.5	63.5	C-6	144.8[e]	144.8[e]
			C-7	167.8	167.8
Galloyl II[a]			C-1′	117.6	117.6
C-1	120.4[c]	120.4[c]	C-2′	126.0[d]	125.9[d]
C-2, C-6	109.9	109.9	C-3′	105.4	105.4
C-3, C-5	145.9	145.9	C-4′	146.8	146.9
C-4	139.2	139.2	C-5′	137.0	137.0
C-7	166.2	165.8	C-6′	144.5[e]	144.5[e]
			C-7′	168.1	168.0
Galloyl III[b]			C-1″	115.2	115.2
C-1	120.5[c]	120.8[c]	C-2″	137.2	137.2
C-2, C-6	110.0	110.0	C-3″	140.1	140.1
C-3, C-5	145.7	145.7	C-4″	139.9	139.9
C-4	139.0	139.0	C-5″	143.1	143.1
C-7	166.8	166.5	C-6″	109.8	109.8
			C-7″	166.8	166.8

125.7 MHz, in acetone-d_6+D_2O. *a*) Galloyl group at O-2 of the glucose core. *b*) Galloyl group at O-3 of the glucose core. *c*—*e*) Values with the same superscript in each column may be interchanged.

to that of the corresponding carbon of **10**,[20] also indicated that rugosin B has the structure in which the valoneoyl group substitutes for the HHDP group in **10**.

The absolute configuration of the valoneoyl group in **2** is assigned as *S*, based on a positive Cotton effect in the short-wavelength region ($[\theta]_{220}+1.4\times10^5$) in the CD spectrum.

The orientation of the valoneoyl group in **2** is the same as that in **1**, as shown by the upfield shifts of H_B (δ 6.25, α- and β-anomer) of the valoneoyl group in the ^{1}H-NMR spectrum, relative to the corresponding proton (glucose O-6 side) in **10** [δ 6.68 (α-anomer) and δ 6.69 (β-anomer)], and also by the chemical shifts of H_A [δ 6.48 (α-anomer) and δ 6.46 (β-anomer)], which are comparable to those of the corresponding proton (glucose O-4 side) in **10** [δ 6.50 (α-anomer) and δ 6.48 (β-anomer)]. This assignment was confirmed by the connectivities [δ_H 6.48 (valoneoyl H_A)–δ_C 167.8–δ_H 5.06 (glucose H-4)] and [δ_H 6.25 (valoneoyl H_B)–δ_C 168.1–δ_H 5.18, 3.68 (glucose H-6)] in the COLOC spectrum of **2**, where the average $^3J_{CH}$ or $^2J_{CH}$ value was set at 7 Hz.

These structural assignments were substantiated by the formation of **2** upon the partial hydrolysis of **1** with tannase.

Rugosin C (**3**), a light brown powder, showed the $[M+Na]^+$ ion, *m/z* 1127, in its FAB-MS, indicating its molecular formula to be $C_{48}H_{32}O_{31}$. The ^{1}H-NMR spectrum of **3** (500 MHz, in acetone-d_6+D_2O) showed that this tannin consists of a galloyl group (δ 7.12, 2H, s), an HHDP group (δ 6.43 and 6.37, 1H each, s), a valoneoyl group [δ 7.09 (H_C), 6.53 (H_A) and 6.23 (H_B), 1H each, s] and a β-D-glucopyranose core [δ 6.13, d, J=8.5 Hz (H-1); 5.12, t, J=9 Hz (H-2); 5.39, t, J=9.5 Hz (H-3); 5.06, t, J=10 Hz (H-4); 4.42, dd, J=7, 10 Hz (H-5); 5.22, dd, J=7, 13 Hz (H-6); 3.76, d, J=13 Hz (H-6)]. The presence of these acyl groups and glucose in the molecule was also

TABLE IV. One-bond and Long-range ^{1}H–^{13}C Correlation Data for Rugosin C (**3**)

	δ_C	δ_H	
		Proton coupled *via* one bond	Proton coupled *via* two or three bonds[a]
Glucose			
C-1	91.9	6.13	5.12 (glucose H-2)
C-2	75.8	5.12	5.39 (glucose H-3)
C-3	77.1	5.39	
C-4	69.0	5.06	
C-5	73.1	4.42	
C-6	63.0	5.22	
		3.76	
Galloyl			
C-1	119.3		
C-2, C-6	110.1	7.12	
C-3, C-5	146.1		7.12 (galloyl)
C-4	140.0		7.12 (galloyl)
C-7	165.1		7.12 (galloyl)
			6.13 (glucose H-1)
Hexahydroxydiphenoyl (HHDP)			
C-1	114.9		6.43 (HHDP H_A)
C-2	125.7[b]		
C-3	107.1	6.43	
C-4	145.0		
C-5	136.4		6.43 (HHDP H_A)
C-6	144.3[c]		
C-7	168.7		6.43 (HHDP H_A)
			5.12 (glucose H-2)
C-1′	114.3		6.37 (HHDP H_B)
C-2′	126.0[b]		
C-3′	107.1	6.37	
C-4′	145.0		6.37 (HHDP H_B)
C-5′	136.2		6.37 (HHDP H_B)
C-6′	144.4[c]		
C-7′	169.3		6.37 (HHDP H_B)
			5.39 (glucose H-3)
Valoneoyl			
C-1	115.9		6.53 (valoneoyl H_A)
C-2	125.7[b]		
C-3	107.3	6.53	
C-4	145.2		6.53 (valoneoyl H_A)
C-5	136.6		6.53 (valoneoyl H_A)
C-6	145.0[d]		
C-7	168.0		6.53 (valoneoyl H_A)
			5.06 (glucose H-4)
C-1′	117.6		6.23 (valoneoyl H_B)
C-2′	125.1[b]		
C-3′	105.4	6.23	
C-4′	147.0		6.23 (valoneoyl H_B)
C-5′	137.0		6.23 (valoneoyl H_B)
C-6′	144.6[d]		
C-7′	167.9		6.23 (valoneoyl H_B)
			3.76 (glucose H-6)
C-1″	115.2		
C-2″	137.1		7.09 (valoneoyl H_C)
C-3″	139.9		
C-4″	139.9		7.09 (valoneoyl H_C)
C-5″	143.1		7.09 (valoneoyl H_C)
C-6″	109.7	7.09	
C-7″	167.0		7.09 (valoneoyl H_C)

500 MHz for ^{1}H-NMR and 125.7 MHz for ^{13}C-NMR, in acetone-d_6+D_2O. *a*) The COLOC spectrum was recorded under the average J_{CH} value of 7 Hz for two- or three-bond couplings. *b*—*d*) Values with same superscript may be interchanged.

proved by methanolysis of its octadecamethyl derivative (**11**), which afforded **6**, **7**, dimethyl (*S*)-hexamethoxydiphenate (**12**) and glucose. The (*S*)-configuration of both the valoneoyl group and the HHDP group in **3** was also

indicated by a broad positive peak in the short-wavelength region ($[\theta]_{221}+1.5\times10^5$, $[\theta]_{231}+1.6\times10^5$) of the CD spectrum.

The characteristic upfield shifts of H-2 and H-3 of the glucose core in the ^{1}H-NMR spectrum of **3**, relative to the corresponding protons of **1** [δ 5.57 (**1**)→5.12 (**3**) (H-2); δ 5.82 (**1**)→5.39 (**3**) (H-3)], are ascribable to the anisotropic effect of the HHDP group located on O-2—O-3 of the glucose core in **3**, in place of two galloyl groups in **1**. In fact, the H-2 and H-3 signals of the glucose core of casuarictin (**13**),[12] in which one of the two HHDP groups is on O-2—O-3, also showed upfield shifts, relative to the corresponding protons of **5** [δ 5.61 (**5**)→5.18 (**13**) (H-2); δ 5.86 (**5**)→5.45 (**13**) (H-3)].

The locations of the acyl groups in **3** were finally established by the two-dimensional nuclear magnetic resonance (2D-NMR) data summarized in Table IV. The correlations involving the ester carbonyl carbons observed in the COLOC spectrum, [δ_H 7.12 (galloyl H-2, H-6)–δ_C 165.1 (galloyl C-7)–δ_H 6.13 (glucose H-1)], [δ_H 6.43 (HHDP H_A)–δ_C 168.7 (HHDP C-7)–δ_H 5.12 (glucose H-2)], [δ_H 6.37 (HHDP H_B)–δ_C 169.3 (HHDP C-7′)–δ_H 5.39 (glucose H-3)], [δ_H 6.53 (valoneoyl H_A)–δ_C 168.0 (valoneoyl C-7)–δ_H 5.06 (glucose H-4)] and [δ_H 6.23 (valoneoyl H_B)–δ_C 167.9 (valoneoyl C-7′)–δ_H 3.76 (glucose H-6)], clearly indicated that the locations of the acyl groups on the glucose core of rugosin C are as in formula **3**, and that the orientation of the valoneoyl group in **3** is the same as that in **1**.

Among the tannins isolated from *Rosa rugosa*, **3** was also isolated from *Stachyurus praecox*, together with related tannins, including some having a depsidone-forming valoneoyl group.[3] Details of these studies will be published elsewhere.

Experimental

Optical rotations were measured on a JASCO DIP-4 polarimeter. Ultraviolet (UV) and infrared (IR) spectra were recorded on a Hitachi 200-10 spectrophotometer and a JASCO A-102 spectrometer, respectively. ^{1}H- and ^{13}C-NMR spectra were recorded on a Varian VXR-500 instrument (500 MHz for ^{1}H-NMR and 125.7 MHz for ^{13}C-NMR) in acetone-d_6 or in acetone-d_6 containing D_2O (*ca.* 3%). Chemical shifts are given in δ values (ppm) from tetramethylsilane. A Hitachi R22-FTS spectrometer was also used for measurements of the ^{1}H-NMR spectra (90 MHz). CD spectra were recorded on a JASCO J-20 spectrometer. Electron-impact-mass spectra (EI-MS) were recorded on a Shimadzu LKB-9000 instrument, and FAB-MS were recorded on a JEOL GMS-HX100 or VG 70-SE mass spectrometer. Gas liquid chromatography (GLC) was performed on a Hitachi 163 gas chromatograph equipped with a glass column (3 mm × 2 m) packed with 2.5% OV-17 or 3% OV-1 on Chromosorb W. The injection temperature and column temperature were set at 220 and 170 °C, respectively. High-performance liquid chromatography (HPLC) was performed on a Nomura Develosil 60-5 column (4 × 150 mm) with *n*-hexane–MeOH–tetrahydrofuran–formic acid (55 : 33 : 11 : 1) containing oxalic acid (450 mg/l). Light petroleum refers to that fraction boiling in the range of 85—120 °C.

Isolation of Tannins from Flower Petals of *Rosa rugosa* Dried flower petals (280 g) of *Rosa rugosa* THUNB., which were collected in June 1981, at Ishikari-hama, Hokkaido, were homogenized in a mixture of acetone and water (7 : 3) (12.7 l). The concentrated filtrate from the homogenate was extracted with diethyl ether and with ethyl acetate, successively, and then each solvent was evaporated off. A portion (4.1 g) of the ethyl acetate extract (28.8 g) was subjected to column chromatography on Sephadex LH-20, developing with EtOH→EtOH–MeOH (4 : 1)→EtOH–MeOH (1 : 1)→EtOH–MeOH (1 : 3). The eluate with EtOH afforded 1,2,3-tri-*O*-galloyl-β-D-glucose[7] (26 mg) and **10**[10-12] (580 mg). Isostrictinin[21] (13 mg), 1,2,6-tri-*O*-galloyl-β-D-glucose[7,22] (9 mg) and strictinin[12] (9 mg) were also isolated from the eluate after further purification by preparative thin layer chromatography (PTLC) [Avicel SF (Funakoshi) cellulose plates with 2% acetic acid, for isostrictinin and 1,2,6-trigalloylglucose; Kieselgel 60 HF_{254} silanisiert (Merck) plates with 20% MeOH, for strictinin]. The eluate with EtOH–MeOH (4 : 1) from Sephadex LH-20 afforded **5**[10,11] (180 mg). Pedunculagin[12] (5 mg) and **2** (28 mg) were also isolated from this eluate after further purification by PTLC (Avicel SF, 2% acetic acid). The eluate with EtOH–MeOH (1 : 1) from Sephadex LH-20 afforded **1** (0.41 g). The eluate with EtOH–MeOH (1 : 3) afforded **3** (98 mg) and **13**[12] (5 mg), which was isolated after purification by PTLC (Avicel SF, water).

Rugosin A (1) A light-brown powder, $[\alpha]_D$ +110° (c=1, acetone). *Anal.* Calcd for $C_{48}H_{34}O_{31}\cdot5H_2O$: C, 48.17; H, 3.71. Found: C, 48.15; H, 3.85. UV λ_{max}^{MeOH} nm (log ε): 218 (5.01), 275 (4.65). IR ν_{max}^{KBr} cm^{-1}: 1730, 1620. CD (MeOH): $[\theta]_{224}+1.6\times10^5$, $[\theta]_{256}-2.3\times10^4$, $[\theta]_{281}+4.9\times10^4$. ^{1}H-NMR: see text. ^{13}C-NMR: see Table I.

Rugosin B (2) A light-brown powder, $[\alpha]_D$ +124° (c=1, EtOH). *Anal.* Calcd for $C_{41}H_{30}O_{27}\cdot4H_2O$: C, 47.96; H, 3.73. Found: C, 48.24; H, 4.01. UV λ_{max}^{MeOH} nm (log ε): 217 (4.91), 269 (4.55). IR ν_{max}^{KBr} cm^{-1}: 1710, 1610. CD (MeOH): $[\theta]_{220}+1.4\times10^5$, $[\theta]_{256}-4.1\times10^4$, $[\theta]_{285}+6.7\times10^4$. ^{1}H-NMR: see text and Table II. ^{13}C-NMR: see Table III.

Rugosin C (3) A light-brown powder, $[\alpha]_D$ +90° (c=1, acetone). *Anal.* Calcd for $C_{48}H_{32}O_{31}\cdot7H_2O$: C, 46.84, H, 3.77. Found: C, 46.99; H, 3.80. UV λ_{max}^{MeOH} nm (log ε): 218 (4.92), 263 (4.60). IR ν_{max}^{KBr} cm^{-1}: 1735, 1615. CD (MeOH): $[\theta]_{221}+1.5\times10^5$, $[\theta]_{231}+1.6\times10^5$, $[\theta]_{259}-6.0\times10^4$, $[\theta]_{280}+2.0\times10^4$. ^{1}H-NMR: see text. ^{13}C-NMR: see Table IV.

Methylation of Rugosin A (1) Dimethyl sulfate (63 μl) and potassium carbonate (134 mg) were added to a solution (1.6 ml) of **1** (26 mg) in acetone. The mixture was stirred at room temperature for 24 h, and then refluxed for 1 h. After centrifugation, the supernatant was evaporated, and the residue was subjected to PTLC on Kieselgel 60 PF_{254} (Merck) with light petroleum–CH_2Cl_2–acetone (4 : 6 : 3), to give the octadecamethyl derivative (**8**) (10 mg), $[\alpha]_D$ +46° (c=1, acetone). *Anal.* Calcd for $C_{66}H_{70}O_{31}\cdot H_2O$: C, 57.56; H, 5.27. Found: C, 57.71; H, 5.11. EI-MS *m/z*: 660, 614, 570 [ion peaks from octa-*O*-methylvaloneoyl (OMV) group]; 212, 197, 195 [ion peaks from tri-*O*-methylgalloyl (TMG) group]. ^{1}H-NMR (500 MHz, in acetone-d_6) δ: 7.31, 7.24, 7.23 (2H each, s, TMG H-2 × 3, H-6 × 3), 7.26 (s, OMV H-6″), 6.77 (s, OMV H-3), 6.48 (s, OMV H-3′), 6.28 [d, J=8 Hz, H-1 of glucose (Glc)], 5.94 (t, J=9.5 Hz, Glc H-3), 5.66 (dd, J=8, 9.5 Hz, Glc H-2), 5.29 (t, J=10 Hz, Glc H-4), 5.25 (dd, J=6.5, 13.5 Hz, Glc H-6), 4.62 (ddd, J=1, 6.5, 10 Hz, Glc H-5), 4.02, 3.91, 3.90 (3H each, s), 3.88 (6H, s), 3.87, 3.85 (3H each, s), 3.81 (6H, s), 3.78, 3.77 (3H each, s), 3.77 (6H, s), 3.75, 3.72, 3.71, 3.70, 3.67 (3H each, s) (18 × OMe). The signal of one of the C-6 methylene protons of the glucose core is overlapped by the methoxyl signals.

Methylation of Rugosin C (3) A solution (1.5 ml) of **3** (25 mg) was treated with dimethyl sulfate (60 μl) and potassium carbonate (125 mg) in a way analogous to the methylation of **1**, to afford the octadecamethyl derivative (**11**) (10 mg), $[\alpha]_D$ +12° (c=0.9, acetone). *Anal.* Calcd for $C_{66}H_{68}O_{31}\cdot H_2O$: C, 57.64; H, 5.13. Found: C, 57.20; H, 5.07. EI-MS *m/z*: 660, 614, 570 (ion peaks from OMV group); 450, 404, 360 [ion peaks from hexamethoxydiphenoyl (HMDP) group]; 212, 197, 195 (ion peaks from TMF group). ^{1}H-NMR (500 MHz, in acetone-d_6) δ: 7.33 (2H, s, TMG H-2, H-6), 7.24 (s, OMV H-6″), 6.83, 6.80, 6.67 (each s, OMV H-3, HMDP H-3, H-3′), 6.49 (s, OMV H-3′), 6.25 (d, J=8 Hz, Glc H-1), 5.66 (dd, J=8, 9.5 Hz, Glc H-2), 5.51 (t, J=9.5 Hz, Glc H-3), 5.29 (t, J=10 Hz, Glc H-4), 5.25 (dd, J=6.5, 13.5 Hz, Glc H-6), 4.62 (ddd, J=1, 6.5, 10 Hz, Glc H-5), 4.02, 3.91, 3.90 (3H each, s), 3.88 (6H, s), 3.87, 3.85 (3H each, s), 3.81 (6H, s), 3.78, 3.77 (3H each, s), 3.77 (6H, s), 3.75, 3.72, 3.71, 3.70, 3.67 (3H each, s) (18 × OMe). The signal of one of the C-6 methylene protons of the glucose core is overlapped by the methoxyl signals.

Methanolysis of 8 and 11 1) The octadecamethyl derivative (**8**) of rugosin A was treated with 0.5% NaOMe in MeOH overnight. Then, the solution was neutralized with acetic acid, and the solvent was evaporated off. The residue was further treated with CH_2N_2–Et_2O for 30 min. After evaporation of the solvent, the residue was separated by PTLC on Kieselgel 60 PF_{254} with light petroleum–CH_2Cl_2–acetone (6 : 3 : 1) to give **6** (5 mg), mp 84 °C, and **7**[23,24] (3 mg), $[\alpha]_D$ −17° (c=1, acetone). EI-MS *m/z*: 660. ^{1}H-NMR (90 MHz, in $CDCl_3$) δ: 7.32, 7.29, 6.92 (1H each, s), 4.06—3.47 (11 × OCH_3). The octadecamethyl derivative (**11**) of rugosin C (17 mg) was treated in an analogous way, to give **6** (2 mg), **7** (5 mg) and **12**[12] (4 mg), $[\alpha]_D$ −35° (c=1.1, EtOH).

2) Compound **8** (1 mg) was treated with 0.2% NaOMe in MeOH overnight, and then the solution was neutralized with acetic acid. After

removal of the solvent by evaporation, the residue was partitioned between EtOAc and water, and each solvent was evaporated off. The presence of glucose in the residue from the aqueous layer was shown by GLC analysis after trimethylsilylation. Glucose was also detected in the mathanolyzates of **11**, in an analogous way.

Degalloylation of 1 with Tannase An aqueous solution of **1** was treated with tannase, and production of **9** *via* **2** and coriariin F (**14**)[6] was monitored by HPLC. Purification of a reaction mixture from 20 mg of **1**, over a column of Sephadex LH-20 with 50% EtOH, afforded 7 mg of **9**.

4,6-*O*-(*S*)-Valoneoyl-D-glucose (9) A light-brown powder, $[\alpha]_D$ +3° ($c=1$, MeOH). *Anal.* Calcd for $C_{27}H_{22}O_{19}\cdot 3H_2O$: C, 46.03; H, 4.01. Found: C, 45.97; H, 4.19. UV λ_{max}^{MeOH} nm (log ε): 216 (4.59), 254 (infl.) (4.36). CD (MeOH): $[\theta]_{218}+1.0\times10^5$, $[\theta]_{257}-3.6\times10^4$, $[\theta]_{280}+1.7\times10^4$. ^{1}H-NMR (500 MHz, in acetone-d_6+D_2O) δ: 7.09 (valoneoyl H_C), 6.68 (H_A), 6.18 (H_B) (α-anomer); 7.09 (valoneoyl H_C), 6.67 (H_A), 6.19 (H_B) (β-anomer). Glucose protons: see Table II.

Partial Degradation of 1 into 5 A solution (5 ml) of **1** (11 mg) in 0.03 M KH_2PO_4–Na_2HPO_4 buffer (pH 5.8) was kept at 37 °C for 12 h, and then extracted with ethyl acetate, and the solvent of the organic layer was evaporated off. The residue was re-dissolved in water, and then the solution was acidified with 1 N HCl (to pH 2), and passed through an Analytichem BondElute C18 cartridge. The adsorbed materials were eluted with 20% MeOH and then with 40% MeOH. The eluate with 40% MeOH afforded **5** (1 mg), which was identified from the ^{1}H-NMR and CD spectra.

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