Caffeoyl, Coumaroyl, Galloyl, and Hexahydroxydiphenoyl Glucoses from *Balanophora japonica*

Zhi-Hong JIANG, Yoko HIROSE, Hiromi IWATA, Saori SAKAMOTO, Takashi TANAKA, and Isao KOUNO*

School of Pharmaceutical Sciences, Nagasaki University, 1–14 Bunkyo-machi, Nagasaki 852–8521, Japan.
Received February 22, 2001; accepted April 12, 2001

Eighteen new and sixteen known acyl glucoses having caffeoyl, coumaroyl, galloyl, and hexahydroxydiphenoyl groups were isolated from a medicinal parasitic plant, *Balanophora japonica.* Their structures were determined by spectroscopic and chemical methods. Caffeoyl ellagitannins, which have been rarely found in nature, were major phenolic constituents of this plant, and this is the first report of the isolation of ellagitannins from Balanophoraceae.

Key words *Balanophora japonica*; Balanophoraceae; polyphenol; tannin; caffeic acid

Balanophora japonica MAKINO is a parasitic plant growing on the roots of *Symplocos* plants (Symplocaceae), and is distributed in the southern part of Japan and China. Its underground parts become adhesive when exposed to the air and have been used as birdlime. The whole plant is medicinally used as an antipyretic, an antidote and a hemostatic agent in China. Previous chemical studies revealed the presence of triterpenes, phenylpropanoids, lignans, methyl gallate, and palmatic acid;[1] however, the occurrence of significant amounts of polyphenolic compounds was suggested by TLC analysis on our preliminary experiment. In a subsequent study in large scale, we have isolated thirty-four acyl glucoses having caffeoyl, coumaroyl, galloyl, and hexahydroxydiphenoyl (HHDP) groups. This paper describes the isolation and structures of these compounds.

Results and Discussion

The underground and aboveground parts of the plant were separately extracted with MeOH. The extract of underground parts was fractionated by silica gel column chromatography, and the fractions containing polar compounds were further separated by a combination of chromatography of MCI gel CHP20P, Sephadex LH-20, Chromatorex ODS, Bondapak ODS, and silica gel to give caffeic acid and eight acyl glucoses, **1**, **2**, **4**, **6**—**9**, and **14**. Among them, compounds **1** and **2** were easily determined to be 1-*O*-(*E*)-*p*-coumaroyl and 1-*O*-(*E*)-caffeoyl-*β*-D-glucopyranoses,[2] respectively, by ^{1}H- and ^{13}C-NMR analysis.

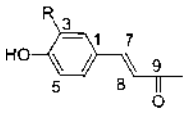
Extracts of the aboveground parts were suspended in water and successively partitioned with hexane and ethyl acetate. The ethyl acetate and aqueous layers were separately chromatographed over MCI gel CHP20P, Sephadex LH-20, Toyopearl HW40F, Chromatorex ODS, and Bondapak ODS to afford caffeic acid, methyl caffeate, gallic acid and twenty-nine acyl glucopyranoses, **1**—**3**, **5**, and **10**—**34**, among which fourteen were identified as 1-*O*-(*E*)-feruloyl-*β*-D-glucopyranose (**3**),[2a] 1-*O*-(*E*)-caffeoyl-4-*O*-galloyl-*b*-D-glucopyranose (**10**),[3] 1-*O*-(*E*)-caffeoyl-6-*O*-galloyl-*β*-D-glucopyranose (**11**),[3] 1,4-di-(**20**),[4] 1,2,4-tri-(**22**),[5] 1,2,6-tri-(**23**),[6] 1,3,4-tri-(**24**),[5] 1,4,6-tri-(**25**),[7] and 1,3,4,6-tetra-(**27**)[8]-*O*-galloyl-*β*-D-glucopyranoses, 2,6-di-(**21**)[9] and 3,4,6-tri-(**26**)[10] *O*-galloyl-D-glucopyranoses, 1-*O*-galloyl-4,6-(*S*)-HHDP-*β*-D-glucopyranose (strictinin) (**32**),[11] 3-*O*-galloyl-4,6-(*S*)-HHDP-*β*-D-glucopyranose (gemin D) (**33**),[4] and 1,3-di-*O*-galloyl-4,6-(*S*)-HHDP-*β*-D-glucopyranose (**34**)[12] by direct comparison with authentic samples or comparison of spectral data with those in literature.

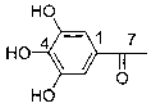
Compounds **1**—**9** were acyl glucoses with hydroxycinnamoyl group(s), and **4**—**9** have not been reported so far in literature (Table 1). Compounds **4** and **5** were shown to be dicaffeoyl glucoses by FAB-MS and ^{1}H-NMR spectral comparison with those of **2**. The location of caffeoyl groups was indicated to be at C-1 and C-2 in **4** [δ 5.79 (H-1), 5.06 (H-2)] and C-1 and C-3 in **5** [δ 5.77 (H-1), 5.20 (H-3)] by the observation of large down field shifts of the corresponding methine signals. The circular dichroism (CD) spectrum of **4** showed a split Cotton effect arising from two caffeoyl groups (negative Cotton at 370 nm and a positive one at 353 nm), confirming that the absolute configuration of the glucose core was D form.[13] The ^{1}H-NMR spectrum of **6** was related to the spectra of **1** and **4**, and indicated the presence of an (*E*)-*p*-coumaroyl and a caffeoyl group at the glucose C-1 and C-2 positions [δ 5.82 (H-1), 5.09 (H-2)]. The location of each acyl group on glucose core was determined by heteronuclear multiple bond coherence (HMBC) showing a long-range H–C correlation of anomeric proton and glucose H-2 with carboxyl carbons of *p*-coumaroyl (δ 167.2) and caffeoyl (δ 168.3) groups, respectively. Assignment of the carboxyl carbons was easily established by the correlation with respective *p*-hydroxybenzene and catechol ring protons through olefinic carbons. Related 1,6-diacyl glucoses having caffeoyl and coumaroyl groups had been isolated from a *Prunus* sp.[14] Compound **7** was characterized as 1,2,6-tricaffeoyl glucose by the FAB-MS [*m*/*z*: 665 $(M-Na)^-$] and the ^{1}H-NMR spectrum, which showed three sets of signals arising from caffeoyl groups and glucose H-1, H-2 and H_2-6 signals in the lower fields [δ 5.84 (H-1), 5.11 (H-2), 4.56, 4.38 (H-6)].

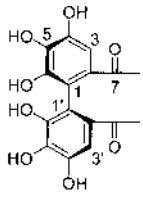
The ^{1}H- and ^{13}C-NMR spectra of **8** resembled those of **2**, however, the presence of an additional hexose moiety was indicated by the appearance of twelve aliphatic carbon signals in the ^{13}C-NMR spectrum and the $[M+Na]^+$ peak at *m*/*z*: 527 in the FAB-MS. The large down field shift of one of the hexoses, C-6 (δ 69.1), indicated glycosidation at this position, and chemical shift comparison of the sugar carbon signals with those described in literature[15] revealed that the sugar part was *β*-gentiobiose (6-*O*-glucopyranosyl-*β*-glucopyranose). Location of the caffeoyl group at the anomeric

* To whom correspondence should be addressed. e-mail: ikouno@net.nagasaki-u.ac.jp

Table 1. Acyl Glucoses Isolated from *Balanophora japonica* M







No	Yield (%)[a]	Yield (%)[b]	glc-1	glc-2	glc-3	glc-4	glc-6
1	0.0088	0.0035	*β* Coumaroyl	H	H	H	H
2	0.7069	0.0827	*β* Caffeoyl	H	H	H	H
3		0.0044	*β* Feruloyl	H	H	H	H
4[c]	0.0287		*β* Caffeoyl	Caffeoyl	H	H	H
5[c]		0.0014	*β* Caffeoyl	H	Caffeoyl	H	H
6[c]	0.0032		*β* Coumaroyl	Caffeoyl	H	H	H
7[c]	0.0150		*β* Caffeoyl	Caffeoyl	H	H	Caffeoyl
8[c]	0.0012		*β* Caffeoyl	H	H	H	Glucosyl
9[c]	0.0026		*β* 3-glc-caffeoyl	H	H	H	H
10		0.0376	*β* Caffeoyl	H	H	Galloyl	H
11		0.0243	*β* Caffeoyl	H	H	H	Galloyl
12[c]		0.0304	*β* Caffeoyl	H	Galloyl	H	H
13[c]		0.0039	H	H	Caffeoyl	Galloyl	H
14[c]	0.0859	0.1069	*β* Caffoyl	H	Caffeoyl	Galloyl	H
15[c]		0.0294	*β* Galloyl	H	Caffeoyl	Galloyl	H
16[c]		0.0035	*β* Caffeoyl	H	Galloyl	Galloyl	H
17[c]		0.0421	*β* Caffeoyl	H	H	Galloyl	Galloyl
18[c]		0.0283	*β* Galloyl	H	Galloyl	Galloyl	Caffeoyl
19[c]		0.0353	*β* Galloyl	H	Galloyl	H	H
20		0.0026	*β* Galloyl	H	H	Galloyl	H
21		0.0003	H	Galloyl	H	H	Galloyl
22		0.0010	*β* Galloyl	Galloyl	H	Galloyl	H
23		0.0047	*β* Galloyl	Galloyl	H	H	Galloyl
24		0.0009	*β* Galloyl	H	Galloyl	Galloyl	H
25		0.0007	*β* Galloyl	H	H	Galloyl	Galloyl
26		0.0101	H	H	Galloyl	Galloyl	Galloyl
27		0.0028	*β* Galloyl	H	Galloyl	Galloyl	Galloyl
28[c]		0.2231	*β* Caffeoyl	H	H	HHDP	
29[c]		0.0008	*β* Coumaroyl	H	H	HHDP	
30[c]		0.1245	*β* Caffeoyl	H	Galloyl	HHDP	
31[c]		0.0092	*β* Caffeoyl	H	Caffeoyl	HHDP	
32		0.0158	*β* Galloyl	H	H	HHDP	
33		0.0045	H	H	Galloyl	HHDP	
34		0.0687	*β* Galloyl	H	Galloyl	HHDP	

a) Isolation yields from underground parts (1.01 kg, fresh weight). *b*) Isolation yields from aboveground parts (1.73 kg, fresh weight). *c*) New compounds.

position was obvious from the chemical shift of the anomeric proton [δ 5.67 (d, J=8 Hz, H-1)]; thus, compound **8** was characterized as 1-*O*-(*E*)-caffeoyl-*β*-gentiobiose.

Compound **9** was shown to be an isomer of **8** by FAB-MS [*m*/*z*: 527 $(M+Na)^+$] and the ^{13}C-NMR spectrum, which indicated the presence of a caffeoyl and two hexose moieties. The chemical shifts of one of the hexoses were analogous to those of *β*-glucose of **2**; however, the signals of the other sugar moiety were similar to those of the terminal *β*-glucosyl moiety of **8**. The location of this glycosidic glucose moiety was determined to be phenolic oxygen at C-3 of the caffeoyl group by a differential nuclear Overhauser effect (NOE) experiment, which showed NOE between the anomeric proton and H-2 of the caffeoyl group. Thus, the structure of **9** was concluded to be 1-*O*-(3′-*O*-*β*-D-glucopyranosyl)-(*E*)-caffeoyl-*β*-D-glucopyranose.

Compounds **10**—**18** were acyl glucoses having caffeoyl and galloyl groups, in which seven (**12**—**18**) were new compounds. Assignments of the sugar proton signals of these compounds were achieved by ^{1}H–^{1}H correlation spectroscopy (COSY) or a spin-decoupling technique, and the chemical shifts of the glucose ring protons revealed the positions of acylation in each molecule. In addition, the location of each acyl group was unambiguously established by selective hydrolysis of galloyl esters with tannase. Namely, on the enzymatic hydrolysis, 1-*O*-caffeoyl-*β*-D-glucopyranose (**2**) was obtained from **10**—**12**, **16**, and **17**, 3-*O*-(*E*)-caffeoylglucopyranose (**13a**) from **13** and **15**, 1,3-di-*O*-(*E*)-caffeoyl-*β*-D-glucopyranose (**5**) from **14**, and 6-*O*-(*E*)-caffeoylglucopyranose (**18a**)[14] from **18**. These results unequivocally confirmed the location of galloyl and caffeoyl groups in each molecule. Some related acyl glucoses with galloyl and phenylpropanoid esters were isolated from rhubarb;[16] however, cinnamoyl or coumaroyl groups were attached only to C-2 or C-6 positions and no caffeoyl esters were found in the acyl glucoses of rhubarb.

Compounds **19**—**27** were gallotannins and were characterized as di-, tri- and tetra-*O*-galloyl-*β*-D-glucoses, as shown in

Table 1. Among these compounds, 1,3-di-*O*-gallyol-β-D-glucopyranose (**19**) was isolated for the first time from nature. This compound was characterized by ^{1}H-NMR analysis including a spin-decoupling technique. Furthermore, compounds **32**—**34** were known ellagitannins having (*S*)-HHDP esters at the glucose 4,6-positions. Although ellagitannins having a 4,6-(*S*)-HHDP group are rather widely distributred in the plant kingdom,[17] this is the first report of hydrolysable tannins from Balanophoraceae (Santalales).

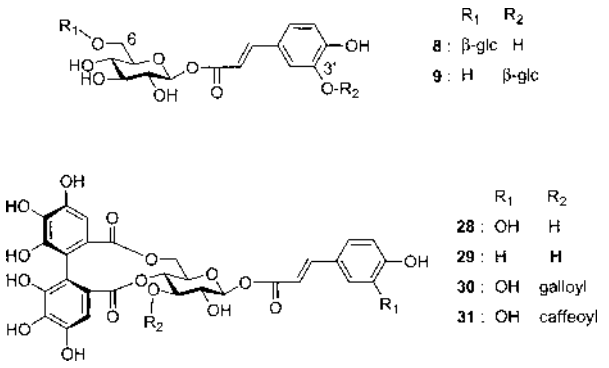
In addition to these known ellagitannins, four new (*S*)-HHDP glucoses with caffeoyl or coumaroyl groups, **28**—**31**, were isolated. The ^{1}H-NMR spectrum of **28** was closely related to that of 1-*O*-galloyl-4,6-(*S*)-HHDP-β-D-glucopyranose (**32**). The only difference in the spectra was the appearance of a set of signals due to a caffeoyl group in the spectrum of **28** instead of the galloyl group of **32**. The FAB-MS [*m*/*z*: 643 $(M-Na)^-$] and the ^{13}C-NMR spectral comparison also indicated this compound to be a caffeoyl-HHDP-glucose. Furthermore, strong deshielding of one of the glucose H_2-6 signals [δ 5.23 (1H, dd, J=6, 13 Hz)] is peculiar to the (*S*)-HHDP group attached to the C-4 and C-6 positions.[18] This was confirmed by acid hydrolysis with 2.5% HCl yielding 4,6-(*S*)-HHDP-D-glucopyranose (**28a**)[19] and caffeic acid. The (*S*)-configuration of the HHDP group was also confirmed by measurement of the CD spectrum showing a negative Cotton effect at 266 nm ($\Delta\varepsilon$ −7.2) and a positive one at 240 nm ($\Delta\varepsilon$ 31.5).[20] Accordingly, compound **28** was characterized as 1-*O*-(*E*)-caffeoyl-4,6-(*S*)-HHDP-β-D-glucopyranose.

Compound **29** was characterized as 1-*O*-(*E*)-*p*-coumaroyl-4,6-(*S*)-HHDP-β-D-glucopyranose by FAB-MS [*m*/*z*: 627 $(M-H)^-$] and NMR spectral comparison with **28**. The ^{1}H- and ^{13}C-NMR spectra exhibited signals due to an (*E*)-*p*-coumaroyl group instead of a caffeoyl group, and the remaining signals in each spectrum were superimposable on those of **28**.

Compound **30** was deduced to be glucose having caffeoyl, galloyl and HHDP esters from the ^{1}H-NMR and FAB-MS [*m*/*z*: 795 $(M-H)^-$] comparison with those of **28**. The down field shift of glucose H-1, H-3, H-4 and H_2-6 protons [δ 5.85 (d, J=8 Hz, H-1), 5.48 (t, J=9 Hz, H-3), 5.33 (dd, J=6, 13 Hz, H-6), 5.04 (t, J=10 Hz, H-4)] indicated acylation at these positions. The structure of **30** was finally established as 1-*O*-(*E*)-caffeoyl-3-*O*-galloyl-4,6-(*S*)-HHDP-δ-D-glucopyranose by selective hydrolysis of the galloyl ester with tannase yielding **28**.

Compound **31** was shown to be dicaffeoyl-HHDP glucose by comparison of the ^{1}H- and ^{13}C-NMR spectra with those of **28**—**30** and observation of the $[M-H]^-$ peak at *m*/*z*: 805 in the FAB-MS. The proton and carbon signals due to a β-glucopyranose core was almost identical to those of **30**; especially, the chemical shifts of the glucose H_2-6 signals [δ 5.32 (dd, J=6, 13 Hz) and 3.81 (br d, J=13 Hz)], which were similar to those of **28**, indicated that the HHDP group was attached to the C-4 and C-6 positions.[18] On the basis of these spectral analyses, **31** was characterized as 1,3-di-*O*-(*E*)-caffeoyl-4,6-(*S*)-HHDP-β-D-glucopyranose.

Since only one caffeoyl ellagitannin (gemin F) had been determined as a minor constituent of *Geum* sp. before this work,[21] the caffeoyl ellagitannins **28**—**31** would be regarded as characteristic constituents of *B. japonica*. In addition, it



was notable that compounds **28** and **30** were the major phenolic metabolites of the above ground part (isolation yield: 0.22 and 0.12%, respectively, from fresh aboveground part), and these were not isolated from underground part. On the other hand, a simple caffeoylglucose, **2**, was abundantly isolated from the underground part (0.71%). In this work, only three compounds, **1**, **2**, and **14**, were isolated as common acyl glucoses in the under- and aboveground parts (Table 1). Further study on other minor phenolic metabolites of this plant is now in progress.

Experimental

Optical rotations were measured with a JASCO DIP-370 digital polarimeter. ^{1}H- and ^{13}C-NMR spectra were recorded in CD_3OD with Varian Unity plus 500 and Varian Gemini 300 spectrometers operating at 500 and 300 MHz for ^{1}H, and 125 and 100 MHz for ^{13}C, respectively. Coupling constants were expressed in Hz, and chemical shifts were given on a δ (ppm) scale with tetramethylsilane as an internal standard. MS were recorded on a JEOL JMS DX-303 spectrometer, and glycerol was used as a matrix for FAB-MS measurement. Column chromatographies were performed with Kieselgel 60 (70—230 mesh, Merck), MCI-gel CHP 20P (75—150 μm, Mitsubishi Chemical Co.), Sephadex LH-20 (25—100 μm, Pharmacia Fine Chemical Co. Ltd.), TSK gel Toyopearl HW-40F (Tosoh), Bondapak C_{18} (125 Å, Waters) and Chromatorex ODS (100—200 mesh, Fuji Silysia Chemical, Ltd.). TLC was performed on precoated Kieselgel 60 F_{254} plates (0.2 mm thick, Merck) or on a precoated cellulose plate (Merck), and spots were detected by ultraviolet (UV) illumination and by spraying with 2% ethanolic $FeCl_3$ and 10% sulfuric acid reagent.

Extraction and Isolation. a) From the Underground Part The underground part (1.01 kg) of fresh *B. japonica* collected in Nagasaki prefecture was cut into small pieces and extracted with MeOH at room temperature. After filtration, the filtrate was concentrated, and the residue (131 g) was separated into four fractions by silica gel column chromatography first with $CHCl_3$–MeOH (97 : 3—91 : 9) and then with $CHCl_3$–MeOH–water (90 : 10 : 1—80 : 20 : 2—70 : 30 : 5—6 : 4 : 1). The third fraction, which was positive to a $FeCl_3$ reagent, was further fractionated into six fractions (frs. 1—6) by chromatography on MCI-gel CHP 20P with water containing MeOH. From fr. 2, compound **2** (7.14 g) was isolated by silica gel column chromatography with $CHCl_3$–MeOH–water (70 : 30 : 5). Fraction 3 was chromatographed over Chromatorex ODS (30—50% MeOH) to give **1** (89 mg). Fraction 5 was subjected to column chromatographies over Chromatorex ODS, Sephadex LH-20 (20—100% MeOH) and Bondapak C18 (0—40% MeOH) to afford caffeic acid (119 mg), **4** (290 mg), and **14** (868 mg). Similar separation of fr. 6 yielded **6** (32 mg) and **7** (151 mg). The last fraction obtained by the first silica gel chromatography was chromatographed over MCI-gel CHP20P and then Chromatorex ODS and Toyopearl HW-40 (water–MeOH) to yield **8** (12.2 mg) and **9** (26.8 mg).

b) From the Aboveground Part The aboveground part (1.73 kg) of fresh *B. japonica* was extracted with MeOH at room temperature. The extract (223.7 g) was suspended in water and successively partitioned with *n*-hexane and EtOAc. The aqueous layer was subjected to MCI-gel CHP20P column chromatography (water–MeOH) to give three fractions. The first fraction (140 g) mostly consisted of sugars. The second fraction (19.5 g) was repeatedly chromatographed over Chromatorex ODS, MCI-gel CHP20P, and Sephadex LH-20 to give **12** (149 mg), **19** (500 mg), **32** (240 mg), and **34** (614 mg). On similar column chromatographies, from the third fraction

(13.75 g) caffeic acid (53 mg), **2** (813 mg), **3** (51 mg), **10** (210 mg), **11** (320 mg), and **28** (2.3 g) were isolated. The EtOAc layer was applied to a column of TSK gel Toyopearl HW-40F (water–MeOH) to give two fractions. The first fraction (6.7 g) was separated by a combination of Chromatorex ODS, silica gel, Sephadex LH-20, and MCI-gel CHP20P column chromatographies to yield gallic acid (88 mg), caffeic acid (1.23 g), **1** (60 mg), **2** (624 mg), **3** (25 mg), **10** (441 mg), **19** (110 mg), **28** (1.56 g), and **33** (77 mg). The second fraction (58.0 g) of the EtOAc layer was repeatedly chromatographed over columns similar to those used for the first fraction to furnish methyl caffeate (674 mg), **5** (24 mg), **11** (100 mg), **12** (377 mg), **13** (68 mg), **14** (1.85 g), **15** (509 mg), **16** (60 mg), **17** (728 mg), **18** (489 mg), **20** (45 mg), **21** (5 mg), **22** (17 mg), **23** (82 mg), **24** (16 mg), **25** (12 mg), **26** (175 mg), **27** (48 mg), **29** (13 mg), **30** (2.15 g), **31** (160 mg), **32** (32 mg), and **34** (574 mg).

1,2-Di-*O*-(*E*)-caffeoyl-*β*-D-glucopyranose (**4**): A yellow amorphous powder, $[\alpha]_D^{15}$ −11.7° (*c*=0.8, MeOH), FAB-MS *m/z*: 527 $(M+Na)^+$, ^{1}H-NMR (500 MHz, CD_3OD) *δ*: 7.58, 7.57 [each 1H, d, *J*=16 Hz, caffeoyl(caf)-7], 7.04 (2H, d, *J*=2 Hz, caf-2), 6.93, 6.91 (each 1H, dd, *J*=2, 8 Hz, caf-6), 6.76, 6.75 (each 1H, d, *J*=8 Hz, caf-5), 6.27, 6.18 (each 1H, d, *J*=16 Hz, caf-8), 5.79 [1H, d, *J*=8 Hz, glucose (glc)-1], 5.06 (1H, dd, *J*=8, 9 Hz, glc-2), 3.94 (1H, dd, *J*=2, 12 Hz, glc-6), 3.74 (1H, dd, *J*=5, 12 Hz, glc-6), 3.72 (1H, t, *J*=9 Hz, glc-3), 3.53 (1H, t, *J*=9 Hz, glc-4), 3.49 (1H, m, glc-5). Assignments were confirmed by ^{1}H–^{1}H COSY spectral analyses. ^{13}C-NMR (75 MHz, CD_3OD) *δ*: caffeoyl: 127.4, 127.2 (C-1, 1′), 115.2, 115.3 (C-2, 2′), 146.7 (2C) (C-3, 3′), 149.6, 149.9 (C-4, 4′), 116.5 (2C) (C-5, 5′), 123.1, 123.4 (C-6, 6′), 147.7, 148.9 (C-7, 7′), 113.7, 114.6 (C-8, 8′), 167.2, 168.3 (C-9, 9′); glucose: 93.9 (C-1), 74.2 (C-2), 75.9 (C-3), 71.1 (C-4), 78.9 (C-5), 62.2 (C-6). CD (3.0×10^{-4} M, MeOH) $\Delta\varepsilon_{370}$ −40.8, $\Delta\varepsilon_{353}$ 20.8. *Anal.* Calcd for $C_{24}H_{24}O_{12}\cdot 3/2H_2O$: C, 54.24; H, 5.12. Found: C, 54.52; H, 5.00.

1,3-Di-*O*-(*E*)-caffeoyl-*β*-D-glucopyranose (**5**): A yellow amorphous powder, $[\alpha]_D^{15}$ −33.4° (*c*=0.6, MeOH), FAB-MS (negative ion mode) *m/z*: 503 $(M-H)^-$, ^{1}H-NMR (300 MHz, acetone-d_6) *δ*: 7.58, 7.65 (each 1H, d, *J*=16 Hz, caf-7), 7.18 (2H, br s, caf-2), 7.07 (2H, m, caf-6), 6.89 (2H, br d, *J*=8 Hz, caf-5), 6.32, 6.30 (each 1H, d, *J*=16 Hz, caf-8), 5.77 (1H, d, *J*=8 Hz, glc-1), 5.20 (1H, t, *J*=9 Hz, glc-3), 3.88 (1H, dd, *J*=2, 12 Hz, glc-6), 3.77 (1H, dd, *J*=5, 12 Hz, glc-6), 3.74 (1H, t, *J*=9 Hz, glc-4), 3.69 (1H, dd, *J*=8, 9 Hz, glc-2), 3.61 (1H, ddd, *J*=2, 5, 9 Hz, glc-5). Assignments were achieved by a spin decoupling technique. ^{13}C-NMR (75 MHz, acetone-d_6) *δ*: caffeoyl: 127.3, 127.6 (C-1, 1′), 114.7, 115.1, 115.2, 115.8 (C-2, 8), 145.8, 146.28, 146.32, 147.2 (C-3, 7), 148.7, 149.1 (C-4), 116.3, 116.7 (C-5), 122.5, 122.8 (C-6), 165.9, 167.5 (C-9, 9′); glucose: 95.2 (C-1), 72.2 (C-2), 78.2, 78.8 (C-3, 5), 69.4 (C-4), 62.1 (C-6). *Anal.* Calcd for $C_{24}H_{24}O_{12}\cdot 2H_2O$: C, 53.34; H, 5.22. Found: C, 53.52; H, 5.18.

2-*O*-(*E*)-Caffeoyl-1-*O*-*p*-(*E*)-coumaroyl-*β*-D-glucopyranose (**6**): A yellow amorphous powder, $[\alpha]_D^{15}$ −268.6° (*c*=0.8, MeOH), FAB-MS (negative ion mode) *m/z*: 487 $(M-H)^-$, ^{1}H-NMR (500 MHz, CD_3OD) *δ*: 7.65 [1H, d, *J*=16 Hz, coumaroyl(coum)-7], 7.58 (1H, d, *J*=16 Hz, caf-7), 7.43 (2H, br d, *J*=9 Hz, coum-2, 6), 7.01 (1H, d, *J*=2 Hz, caf-2), 6.91 (1H, dd, *J*=2, 8 Hz, caf-6), 6.78 (2H, br d, *J*=9 Hz, coum-3, 5), 6.74 (1H, d, *J*=8 Hz, caf-5), 6.27 (1H, d, *J*=16 Hz, caf-8), 6.25 (1H, d, *J*=16 Hz, coum-8), 5.82 (1H, d, *J*=8 Hz, glc-1), 5.09 (1H, dd, *J*=8, 9 Hz, glc-2), 3.90 (1H, dd, *J*=2, 12 Hz, glc-6), 3.76 (1H, dd, *J*=5, 12 Hz, glc-6), 3.73 (1H, t, *J*=9 Hz, glc-3), 3.56 (1H, t, *J*=9 Hz, glc-4), 3.54 (1H, m, glc-5). Assignments were achieved by ^{1}H–^{1}H COSY spectral analyses. ^{13}C-NMR (125 MHz, CD_3OD) *δ*: caffeoyl: 127.5 (C-1), 115.2 (C-2), 146.6 (C-3), 149.5 (C-4), 116.4 (C-5), 123.1 (C-6), 148.5 (C-7), 115.2 (C-8), 168.3 (C-9); coumaroyl: 126.8 (C-1), 131.4 (C-2, 6), 116.8 (C-3, 5), 161.5 (C-4), 147.7 (C-7), 114.6 (C-8), 167.2 (C-9); glucose: 93.8 (C-1), 74.1 (C-2), 75.9 (C-3), 71.1 (C-4), 78.9 (C-5), 62.1 (C-6). *Anal.* Calcd for $C_{24}H_{24}O_{11}\cdot 1/2H_2O$: C, 57.95; H, 5.07. Found: C, 57.56; H, 5.08.

1,2,6-Tri-*O*-(*E*)-caffeoyl-*β*-D-glucopyranose (**7**): A yellow amorphous powder, $[\alpha]_D^{15}$ −218.6° (*c*=0.4, MeOH), FAB-MS (negative ion mode) *m/z*: 665 $(M-H)^-$, ^{1}H-NMR (300 MHz, CD_3OD) *δ*: 7.60, 7.58 (2H and 1H, respectively, each d, *J*=16 Hz, caf-7), 7.07 (1H, d, *J*=2 Hz, caf-2), 7.02 (2H, br s, caf-2), 6.96, 6,92 (1H and 2H respectively, dd, *J*=2, 8 Hz, caf-6), 6.79, 6.76 (1H and 2H, respectively, d, *J*=8 Hz, caf-5), 6.32, 6.30, 6.20 (each 1H, d, *J*=16 Hz, caf-8), 5.84 (1H, d, *J*=8 Hz, glc-1), 5.11 (1H, dd, *J*=8, 9 Hz, glc-2), 4.56 (1H, dd, *J*=2, 12 Hz, glc-6), 4.38 (1H, dd, *J*=5, 12 Hz, glc-6), 3.80 (1H, ddd, *J*=2, 5, 9 Hz, glc-5), 3.79 (1H, t, *J*=9 Hz, glc-3), 3.60 (1H, t, *J*=9 Hz, glc-4). Assignments were confirmed by a spin decoupling technique. ^{13}C-NMR (75 MHz, CD_3OD) *δ*: caffeoyl: 127.4, 127.6, 127.7 (C-1), 113.6, 114.5, 114.7, 115.2 (2C), 115.3 (C-2, 8), 146.7 (2C), 147.3 (2C), 147.8, 149.0 (C-3, 7), 149.5, 149.6, 149.9 (C-4), 116.5 (3C) (C-5), 123.1, 123.2, 123.5 (C-6), 167.1, 168.3, 169.1 (C-9); glucose: 93.8 (C-1), 74.1 (C-2), 75.8, 76.4 (C-3, 5), 71.4 (C-4), 64.2 (C-6). *Anal.* Calcd for $C_{33}H_{30}O_{15}\cdot 3/2H_2O$: C, 57.15; H, 4.80. Found: C, 57.25; H, 4.65.

1-*O*-(*E*)-Caffeoyl-*β*-gentiobiose (**8**): A yellow amorphous powder, $[\alpha]_D^{15}$ −26.0° (*c*=0.3, MeOH), FAB-MS *m/z*: 527 $(M+Na)^+$, ^{1}H-NMR (300 MHz, D_2O) *δ*: 7.73 (1H, d, *J*=16 Hz, caf-7), 7.17 (1H, br s, caf-2), 7.12 (1H, br d, *J*=8 Hz, caf-6), 6.92 (1H, d, *J*=8 Hz, caf-5), 6.38 (1H, d, *J*=16 Hz, caf-8), 5.67 (1H, d, *J*=8 Hz, glc-1), 4.48 (1H, d, *J*=8 Hz, glc-1′), 4.21 (1H, d, *J*=12 Hz, glc-6), 3.89 (1H, dd, *J*=5, 12 Hz, glc-6). ^{13}C-NMR (75 MHz, D_2O) *δ*: caffeoyl: 127.7 (C-1), 116.2 (C-2), 145.3 (C-3), 149.0 (C-4, 7), 117.1 (C-5), 124.1 (C-6), 114.1 (C-8), 168.6 (C-9); glucose: 95.0 (C-1), 74.1 (C-2), 76.6 (C-3), 70.6 (C-4), 76.4 (C-5), 69.1 (C-6), 103.5 (C-1′), 73.0 (C-2′), 76.8 (C-3′), 70.0 (C-4′), 76.9 (C-5′), 61.7 (C-6′).

1-*O*-(3′-*O*-*β*-D-Glucopyranosyl)-(*E*)-caffeoyl-*β*-D-glucopyranose (**9**): A yellow amorphous powder, $[\alpha]_D^{15}$ −438.4° (*c*=0.5, MeOH), FAB-MS *m/z*: 527 $(M+Na)^+$, ^{1}H-NMR (500 MHz, D_2O) *δ*: 7.70 (1H, d, *J*=16 Hz, caf-7), 7.40 (1H, d, *J*=2 Hz, caf-2), 7.22 (1H, dd, *J*=2, 8 Hz, caf-6), 6.94 (1H, d, *J*=8 Hz, caf-5), 6.38 (1H, d, *J*=16 Hz, caf-8), 5.64 (1H, d, *J*=8 Hz, glc-1), 5.00 (1H, d, *J*=7 Hz, glc-1′), 3.92 (2H, m, glc-6, 6′), 3.76 (2H, m, glc-6, 6′). ^{13}C-NMR (75 MHz, D_2O) *δ*: caffeoy: 127.7 (C-1), 117.0 (C-2), 145.9 (C-3), 148.5, 149.7 (C-4, 7), 117.5 (C-5), 126.6 (C-6), 114.6 (C-8), 168.4 (C-9); glucos: 95.2 (C-1), 73.9 (C-2), 76.5 (C-3), 70.5 (C-4), 77.8 (C-5), 61.5 (C-6), 102.3 (C-1′), 73.1 (C-2′), 76.6 (C-3′), 70.2 (C-4′), 77.4 (C-5′), 61.6 (C-6′).

1-*O*-(*E*)-Caffeoyl-3-*O*-galloyl-*β*-D-glucopyranose (**12**): A yellow amorphous powder, $[\alpha]_D^{15}$ −48.9° (*c*=0.8, MeOH), FAB-MS (negative ion mode) *m/z*: 493 $(M-H)^-$, ^{1}H-NMR (300 MHz, CD_3OD) *δ*: 7.67 (1H, d, *J*=16 Hz, caf-7), 7.14 (2H, s, galloyl-2, 6), 7.06 (1H, d, *J*=2 Hz, caf-2), 6.97 (1H, dd, *J*=2, 8 Hz, caf-6), 6.78 (1H, d, *J*=8 Hz, caf-5), 6.30 (1H, d, *J*=16 Hz, caf-8), 5.71 (1H, d, *J*=8 Hz, glc-1), 5.22 (1H, t, *J*=9 Hz, glc-3), 3.88 (1H, dd, *J*=2, 12 Hz, glc-6), 3.74 (1H, dd, *J*=5, 12 Hz, glc-6), 3.69 (1H, t, *J*=9 Hz, glc-4), 3.68 (1H, dd, *J*=8, 9 Hz, glc-2), 3.55 (1H, ddd, *J*=2, 5, 9 Hz, glc-5). Assignments were confirmed by a spin decoupling technique. ^{13}C-NMR (75 MHz, CD_3OD) *δ*: caffeoyl: 127.5 (C-1), 115.3 (C-2), 146.4 (C-3), 148.6 (C-4), 116.6 (C-5), 123.3 (C-6), 148.6 (C-7), 114.2 (C-8), 168.3 (C-9); galloyl: 121.7 (C-1), 110.5 (C-2, 6), 146.4 (C-3, 5), 139.8 (C-4), 167.7 (C-7); glucose: 95.7 (C-1), 79.1, 78.7 (C-3, 5), 72.6 (C-2), 69.4 (C-4), 62.0 (C-6). *Anal.* Calcd for $C_{22}H_{22}O_{13}\cdot H_2O$: C, 51.57; H, 4.72. Found: C, 51.57; H, 4.99.

Tannase Hydrolysis of 12 A solution of **12** (10 mg) in water (2 ml) was shaken with tannase (kindly provided by Dr. M. Kanaoka, Sankyo Co., Ltd.) at 37 °C for 30 min. The mixture was applied to MCI-gel CHP20P column chromatography with water containing increasing proportions of MeOH to yield gallic acid (1.5 mg) and compound **2** (4 mg).

3-*O*-(*E*)-Caffeoyl-4-*O*-galloyl-D-glucopyranose (**13**): A yellow amorphous powder, $[\alpha]_D^{15}$ −144.2° (*c*=0.7, MeOH), FAB-MS (negative ion mode) *m/z*: 493 $(M-H)^-$, ^{1}H-NMR (300 MHz, acetone-d_6) *δ*: 7.48 (1H, d, *J*=16 Hz, caf-7), 7.10 (1H, d, *J*=2 Hz, caf-2), 7.08, 7.07 (2H in total, each s, galloyl-2, 6), 6.99, 6.98 (1H in total, each dd, *J*=2, 8 Hz, caf-6), 6.83 (1H, d, *J*=8 Hz, caf-5), 6.19 (1H, d, *J*=16 Hz, caf-8), 5.64 (3/5H, t, *J*=9 Hz, *α*-glc-3), 5.64 (2/5H, t, *J*=9 Hz, *β*-glc-3), 5.32 (3/5H, d, *J*=4 Hz, *α*-glc-1), 5.17 (3/5H, t, *J*=9 Hz, *α*-glc-4), 5.13 (2/5H, t, *J*=9 Hz, *β*-glc-4), 4.79 (2/5H, d, *J*=8 Hz, *β*-glc-1), 4.17 (2/5H, ddd, *J*=2, 5, 9 Hz, *β*-glc-5), 3.75 (3/5H, ddd, *J*=2, 5, 9 Hz, *α*-glc-5), 3.56—3.68 (m, glc-6, *α*-glc-2), 3.56 (3/5H, dd, *J*=8, 9 Hz, *β*-glc-2). Assignments were achieved by a spin decoupling technique. ^{13}C-NMR (75 MHz, acetone-d_6) *δ*: caffeoyl: 127.4 (C-1), 115.2, 115.3 (C-2), 146.0, 146.2 148.7 (C-3, 4, 7), 116.3 (C-5), 122.5 (C-6), 115.1 (C-8), 166.9, 167.2 (C-9); galloyl: 120.4, 120.9 (C-1), 110.1 (C-2, 6), 145.9, 146.0 (C-3, 5), 139.1 (C-4), 166.2 (C-7); *α*-glucose: 93.5 (C-1), 73.7, 71.9, 71.0, 70.4 (C-2, 3, 4, 5), 62.0 (C-6); *β*-glucose: 98.2 (C-1), 75.7, 75.6, 74.5, 70.5 (C-2, 3, 4, 5), 62.1 (C-6). *Anal.* Calcd for $C_{22}H_{22}O_{13}\cdot 2H_2O$: C, 49.82; H, 4.94. Found: C, 49.99; H, 4.85.

Tannase Hydrolysis of 13 A solution of **13** (10 mg) in water (1 ml) was hydrolyzed in a manner similar to that described for **12** to yield gallic acid (3.2 mg) and **13a** (5.7 mg).

3-*O*-(*E*)-Caffeoyl-D-glucopyranose (**13a**): a yellow amorphous powder, ^{1}H-NMR (300 MHz, acetone-d_6+D_2O) *δ*: 7.61 (1H, d, *J*=16 Hz, caf-7), 7.18 (1H, d, *J*=2 Hz, caf-2), 7.05 (1H, dd, *J*=2, 8 Hz, caf-6), 6.90 (1H, d, *J*=8 Hz, caf-5), 6.38 (1H, d, *J*=16 Hz, caf-8), 5.32 (2/5H, t, *J*=9 Hz, *α*-glc-3), 5.27 (2/5H, d, *J*=4 Hz, *α*-glc-1), 5.09 (3/5H, t, *J*=9 Hz, *β*-glc-3), 4.74 (3/5H, d, *J*=8 Hz, *β*-glc-1), 3.96 (2/5H, ddd, *J*=2, 5, 9 Hz, *α*-glc-5), 3.92 (3/5H, dd, *J*=2, 12 Hz, *β*-glc-6), 3.87 (2/5H, dd, *J*=2, 12 Hz, *α*-glc-6), 3.76 (2/5H, dd, *J*=5, 12 Hz, *α*-glc-6), 3.74 (3/5H, dd, *J*=5, 12 Hz, *β*-glc-6), 3.67 (2/5H, dd, *J*=4, 9 Hz, *α*-glc-2), 3.65 (3/5H, t, *J*=9 Hz, *β*-glc-4), 3.63 (2/5H, t, *J*=9 Hz, *α*-glc-4), 3.55 (3/5H, ddd, *J*=2, 5, 9 Hz, *β*-glc-5), 3.43 (3/5H, dd, *J*=8, 9 Hz, *β*-glc-2).

1,3-Di-*O*-(*E*)-caffeoyl-4-*O*-galloyl-*β*-D-glucopyranose (**14**): A yellow amorphous powder, $[\alpha]_D^{15}$ −100.4° (*c*=0.7, MeOH), FAB-MS *m/z*: 679 $(M+Na)^+$, ^{1}H-NMR (500 MHz, CD_3OD) *δ*: 7.69, 7.50 (each 1H, d, *J*=16 Hz, caf-7), 7.08, 6.99 (each 1H, d, *J*=2 Hz, caf-2), 7.01 (2H, s, galloyl-2, 6), 6.89, 6.98 (each 1H, dd, *J*=2, 8 Hz, caf-6), 6.75, 6.80 (each 1H, d, *J*=8 Hz, caf-5), 6.20, 6.33 (each 1H, d, *J*=16 Hz, caf-8), 5.81 (1H, d, *J*=8 Hz, glc-1), 5.45 (1H, t, *J*=9 Hz, glc-3), 5.25 (1H, t, *J*=9 Hz, glc-4), 3.88 (1H, ddd, *J*=2, 5, 9 Hz, glc-5), 3.82 (1H, dd, *J*=8, 9 Hz, glc-2), 3.71 (1H, dd, *J*=2, 12 Hz, glc-6), 3.59 (1H, dd, *J*=5, 12 Hz, glc-6). Assignments were confirmed by ^{1}H–^{1}H COSY spectral analysis. ^{13}C-NMR (75 MHz, CD_3OD) *δ*: caffeoyl: 127.5, 127.6 (C-1), 115.2, 115.3 (C-2), 146.6, 146.7 (C-3), 149.5, 149.9 (C-4), 116.4, 116.6 (C-5), 123.1, 123.3 (C-6), 147.6, 148.6 (C-7), 114.0, 114.5 (C-8), 167.4, 168.5 (C-9); galloyl: 120.5 (C-1), 110.4 (C-2, 6), 146.4 (C-3, 5), 140.2 (C-4), 167.3 (C-7); glucose: 95.5 (C-1), 76.6, 76.2 (C-3, 5), 72.3, 70.1 (C-2, 4), 61.7 (C-6). *Anal.* Calcd for $C_{31}H_{28}O_{16}\cdot 3/2H_2O$: C, 54.47; H, 4.57. Found: C, 54.85; H, 4.55.

Tannase Hydrolysis of 14 A solution of **14** (20 mg) in water (2 ml) was hydrolyzed in a manner similar to that described for **12** to yield gallic acid (4 mg) and **5** (11 mg).

3-*O*-(*E*)-Caffeoyl-1,4-di-*O*-galloyl-*β*-D-glucopyranose (**15**): A yellow amorphous powder, $[\alpha]_D^{15}$ −123.7° (*c*=0.7, MeOH), FAB-MS (negative ion mode) *m/z*: 645 $(M-H)^-$, ^{1}H-NMR (300 MHz, acetone-d_6) *δ*: 7.52 (1H, d, *J*=16 Hz, caf-7), 7.12 (1H, d, *J*=2 Hz, caf-2), 7.22, 7.09 (each 2H, s, galloyl-2, 6), 6.98 (1H, dd, *J*=2, 8 Hz, caf-6), 6.85 (1H, d, *J*=8 Hz, caf-5), 6.23 (1H, d, *J*=16 Hz, caf-8), 5.94 (1H, d, *J*=8 Hz, glc-1), 5.57 (1H, t, *J*=9 Hz, glc-3), 5.24 (1H, t, *J*=9 Hz, glc-4), 3.96 (1H, m, glc-5), 3.93 (1H, dd, *J*=8, 9 Hz, glc-2), 3.72 (1H, dd, *J*=2, 12 Hz, glc-6), 3.69 (1H, dd, *J*=5, 12 Hz, glc-6). Assignments were confirmed by a spin decoupling technique. ^{13}C-NMR (75 MHz, acetone-d_6) *δ*: caffeoyl: 127.1 (C-1), 114.9, 114.7 (C-2, 8), 146.2, 146.5, 148.9 (C-3, 4, 7), 116.2 (C-5), 122.5 (C-6), 167.1 (C-9); galloyl: 120.5, 120.6 (C-1), 110.0, 110.2 (C-2, 6), 145.9, 146.0 (C-3, 5), 139.2, 139.5 (C-4), 165.5, 165.3 (C-7); glucose: 95.3 (C-1), 76.3, 75.6, 72.0, 69.9 (C-2, 3, 4, 5), 61.6 (C-6). *Anal.* Calcd for $C_{29}H_{26}O_{17}\cdot 5/2H_2O$: C, 50.37; H, 4.52. Found: C, 50.29; H, 4.62.

Tannase Hydrolysis of 15 A solution of **15** (7 mg) in water (1 ml) was hydrolyzed in a manner similar to that described for **12** to yield gallic acid (1 mg) and **13a** (1.4 mg), which was identified by ^{1}H-NMR comparison.

1-*O*-(*E*)-Caffeoyl-3,4-di-*O*-galloyl-*β*-D-glucopyranose (**16**): A yellow amorphous powder, $[\alpha]_D^{15}$ −74.9° (*c*=0.4, MeOH), FAB-MS (negative ion mode) *m/z*: 645 $(M-H)^-$, ^{1}H-NMR (300 MHz, acetone-d_6) *δ*: 7.70 (1H, d, *J*=16 Hz, caf-7), 7.22 (1H, d, *J*=2 Hz, caf-2), 7.08 (1H, dd, *J*=2, 8 Hz, caf-6), 7.08, 7.05 (each 2H, s, galloyl-2, 6), 6.89 (1H, d, *J*=8 Hz, caf-5), 6.36 (1H, d, *J*=16 Hz, caf-8), 5.89 (1H, d, *J*=8 Hz, glc-1), 5.61 (1H, t, *J*=9 Hz, glc-3), 5.29 (1H, t, *J*=9 Hz, glc-4), 3.98 (1H, m, glc-5), 3.92 (1H, dd, *J*=8, 9 Hz, glc-2), 3.72 (1H, dd, *J*=2, 12 Hz, glc-6), 3.62 (1H, dd, *J*=5, 12 Hz, glc-6). Assignments were confirmed by a spin decoupling technique. ^{13}C-NMR (75 MHz, acetone-d_6) *δ*: caffeoyl: 127.0 (C-1), 114.2, 115.0 (C-2, 8), 146.0, 146.3, 147.8 (C-3, 4, 7), 116.2 (C-5), 122.9 (C-6), 166.5 (C-9); galloyl: 120.4, 121.1 (C-1), 110.0 (4C) (C-2, 6), 145.8, 145.9 (C-3, 5), 138.7, 139.2 (C-4), 166.1, 166.3 (C-7); glucose: 95.0 (C-1), 76.3, 75.9, 72.0, 69.8 (C-2, 3, 4, 5), 61.5 (C-6). *Anal.* Calcd for $C_{29}H_{26}O_{17}\cdot 5/2H_2O$: C, 50.37; H, 4.52. Found: C, 50.54; H, 4.84.

Tannase Hydrolysis of 16 A solution of **16** (1 mg) in water (0.5 ml) was hydrolyzed with tannase. The reaction mixture was analyzed by reversed-phase HPLC [Cosmosil 5C_{18}-AR II (4.6 mm×250 mm), 10 to 30% (20 min) CH_3CN in 50 mM H_3PO_4, flow rate: 0.8 ml/min, detection: UV 280 nm] to detect **2** (t_R=8.07 min) and gallic acid (t_R=4.92 min).

1-*O*-(*E*)-Caffeoyl-4,6-di-*O*-galloyl-*β*-D-glucopyranose (**17**): A yellow amorphous powder, $[\alpha]_D^{15}$ −177.8° (*c*=0.2, MeOH), FAB-MS (negative ion mode) *m/z*: 645 $(M-H)^-$, ^{1}H-NMR (300 MHz, acetone-d_6) *δ*: 7.66 (1H, d, *J*=16 Hz, caf-7), 7.20 (1H, d, *J*=2 Hz, caf-2), 7.15, 7.16 (each 2H, s, galloyl-2, 6), 7.08 (1H, dd, *J*=2, 8 Hz, caf-6), 6.88 (1H, d, *J*=8 Hz, caf-5), 6.31 (1H, d, *J*=16 Hz, caf-8), 5.79 (1H, d, *J*=8 Hz, glc-1), 5.25 (1H, t, *J*=9 Hz, glc-4), 4.91, 4.87 (each 1H, d, *J*=5 Hz, C-2-OH, C-3-OH), 4.46 (1H, br d, *J*=12 Hz, glc-6), 4.15 (2H, m, glc-5, 6), 3.96 (1H, dt, *J*=5, 9 Hz, glc-3), 3.65 (1H, dt, *J*=5, 8 Hz, glc-2). Assignments were achieved by a spin decoupling technique and D_2O exchange experiment. ^{13}C-NMR (75 MHz, acetone-d_6) *δ*: caffeoyl: 126.9 (C-1), 114.7, 115.3 (C-2, 8), 146.0, 146.3, 147.4 (C-3, 4, 7), 116.4 (C-5), 122.9 (C-6), 166.5 (C-9); galloyl: 120.4, 121.1 (C-1), 110.0 (4C) (C-2, 6), 146.0 (4C) (C-3, 5), 138.9, 139.0 (C-4), 166.0 (2C) (C-7); glucose: 95.1 (C-1), 75.5, 74.1, 73.9, 71.6 (C-2, 3, 4, 5), 63.3 (C-6). *Anal.* Calcd for $C_{29}H_{26}O_{17}\cdot 3H2O$: C, 49.72; H, 4.60. Found: C, 49.86; H, 4.80. Tannase hydrolysis of **17** was conducted in a manner similar to that described for **16**, and yielded gallic acid and **2**.

6-*O*-(*E*)-Caffeoyl-1,3,4-tri-*O*-galloyl-*β*-D-glucopyranose (**18**): A yellow amorphous powder, $[\alpha]_D^{15}$ 14.9° (*c*=0.6, MeOH), FAB-MS (negative mode) *m/z*: 797 $(M-H)^-$, ^{1}H-NMR (300 MHz, acetone-d_6) *δ*: 7.51 (1H, d, *J*=16 Hz, caf-7), 7.13 (1H, d, *J*=2 Hz, caf-2), 7.22, 7.08, 7.06 (each 2H, s, galloyl-2, 6), 7.00 (1H, dd, *J*=2, 8 Hz, caf-6), 6.86 (1H, d, *J*=8 Hz, caf-5), 6.18 (1H, d, *J*=16 Hz, caf-8), 6.02 (1H, d, *J*=8 Hz, glc-1), 5.67 (1H, t, *J*=9 Hz, glc-3), 5.43 (1H, t, *J*=9 Hz, glc-4), 4.32 (3H, m, glc-5, 6), 4.05 (1H, br t, *J*=8 Hz, glc-2). Assignments were achieved by a spin decoupling technique. ^{13}C-NMR (75 MHz, acetone-d_6) *δ*: caffeoyl: 127.5 (C-1), 115.0, 115.3 (C-2, 8), 146.0, 146.1, 148.8 (C-3, 4, 7), 116.4 (C-5), 122.6 (C-6), 166.9 (C-9); galloyl: 120.7, 120.8, 121.4 (C-1), 110.1, 110.2, 110.4 (C-2, 6), 145.8, 145.9, 146.2 (C-3, 5), 138.8, 139.1, 139.5 (C-4), 165.2, 165.8, 166.1 (C-7); glucose: 95.4 (C-1), 75.7, 73.5, 72.3, 70.0 (C-2, 3, 4, 5), 63.2 (C-6). *Anal.* Calcd for $C_{36}H_{30}O_{21}\cdot 5/2H_2O$: C, 51.25; H, 4.18. Found: C, 51.55; H, 4.52.

Tannase Hydrolysis of 18 A solution of **18** (17.4 mg) in water (1 ml) was hydrolyzed in a manner similar to that described for **12** to yield gallic acid (5.2 mg) and a hydrolysate **18a** (7 mg).

6-*O*-Galloyl-*β*-D-glucopyranose (**18a**): a yellow amorphous powder, ^{1}H-NMR (300 MHz, acetone-d_6+D_2O) *δ*: 7.58 (1H, d, *J*=16 Hz, caf-7), 7.19 (1H, br s, caf-2), 7.03 (1H, br d, *J*=8 Hz, caf-6), 6.89 (1H, d, *J*=8 Hz, caf-5), 6.35, 6.36 (each 1/2H, d, *J*=16 Hz, caf-8), 5.16 (1/2H, d, *J*=4 Hz, *α*-glc-1), 4.59 (1/2H, d, *J*=8 Hz, *β*-glc-1), 4.52, 4.46 (each 1/2H, dd, *J*=2, 12 Hz, *α*,*β*-glc-6), 4.31, 4.28 (each 1/2H, dd, *J*=5, 12 Hz, *α*,*β*-glc-6).

1,3-Di-*O*-galloyl-*β*-D-glucopyranose (**19**): A white amorphous powder, $[\alpha]_D^{15}$ 17.3° (*c*=0.7, MeOH), FAB-MS (negative ion mode) *m/z*: 483 $(M-H)^-$, ^{1}H-NMR (300 MHz, acetone-d_6+D_2O) *δ*: 7.19, 7.18 (each 2H, s, galloyl-2, 6), 5.82 (1H, d, *J*=8 Hz, glc-1), 5.30 (1H, t, *J*=9 Hz, glc-3), 3.89 (1H, dd, *J*=2, 12 Hz, glc-6), 3.67 (1H, ddd, *J*=2, 5, 9 Hz, glc-5). Assignments were achieved by ^{1}H–^{1}H COSY spectral analyses. ^{13}C-NMR (75 MHz, acetone-d_6+D_2O) *δ*: galloyl: 120.1, 120.2 (C-1), 109.9, 110.1, 110.4 (C-2, 6), 145.7, 145.9 (C-3, 5), 138.9, 139.5 (C-4), 165.9, 167.1 (C-7); glucose: 95.4 (C-1), 78.6, 78.0, 71.8, 68.9 (C-2, 3, 4, 5), 61.6 (C-6). *Anal.* Calcd for $C_{20}H_{20}O_{14}\cdot 3/2H_2O$: C, 46.97; H, 4.53. Found: C, 47.20; H, 4.50.

1-*O*-(*E*)-Caffeoyl-4,6-(*S*)-HHDP-*β*-D-glucopyranose (**28**): A yellow amorphous powder, $[\alpha]_D^{15}$ −19.0° (*c*=0.3, MeOH), FAB-MS (negative ion mode) *m/z*: 643 $(M-H)^-$, UV λ_{max} (EtOH) nm (log *ε*): 296 (4.26), 324 (4.21). CD (3.4×10^{-5} M, EtOH) $\Delta\varepsilon_{266}$ −7.2, $\Delta\varepsilon_{240}$ 31.5. ^{1}H-NMR (300 MHz, acetone-d_6) *δ*: 7.69 (1H, d, *J*=16 Hz, caf-7), 7.22 (1H, d, *J*=2 Hz, caf-2), 7.07 (1H, dd, *J*=2, 8 Hz, caf-6), 6.89 (1H, d, *J*=8 Hz, caf-5), 6.73, 6.61 (each 1H, s, HHDP-3, 3′), 6.34 (1H, d, *J*=16 Hz, caf-8), 5.68 (1H, d, *J*=8 Hz, glc-1), 5.21 (1H, dd, *J*=6, 13 Hz, glc-6), 4.89 (1H, t, *J*=10 Hz, glc-4), 4.10 (1H, br dd, *J*=6, 10 Hz, glc-5), 3.81 (1H, t, *J*=9 Hz, glc-3), 3.78 (1H, br d, *J*=13 Hz, glc-6), 3.64 (1H, dd, *J*=8, 9 Hz, glc-2). ^{1}H-NMR (300 MHz, CD_3OD) *δ*: 7.68 (1H, d, *J*=16 Hz, caf-7), 7.03 (1H, d, *J*=2 Hz, caf-2), 6.99 (1H, dd, *J*=2, 8 Hz, caf-6), 6.79 (1H, d, *J*=8 Hz, caf-5), 6.69, 6.56 (each 1H, s, HHDP-3, 3′), 6.29 (1H, d, *J*=16 Hz, caf-8), 5.59 (1H, d, *J*=8 Hz, glc-1), 5.23 (1H, dd, *J*=6, 13 Hz, glc-6), 4.84 (1H, t, *J*=10 Hz, glc-4), 4.03 (1H, br dd, *J*=6, 10 Hz, glc-5), 3.77 (1H, br d, *J*=13 Hz, glc-6), 3.71 (1H, t, *J*=10 Hz, glc-3), 3.57 (1H, dd, *J*=8, 10 Hz, glc-2). ^{13}C-NMR (75 MHz, CD_3OD) *δ*: caffeoyl: 127.5 (C-1), 115.3 (C-2), 146.8 (C-3), 149.9 (C-4), 116.5 (C-5), 123.3 (C-6), 148.6 (C-7), 114.0 (C-8), 167.5 (C-9); HHDP: 116.5, 116.8 (C-1, 1′), 126.3, 126.5 (C-2, 2′), 108.3, 108.6 (C-3, 3′), 144.7, 144.8, 145.7, 145.8 (C-4, 4′, 6, 6′), 137.3, 137.5 (C-5, 5′), 169.6, 169.8 (C-7, 7′); glucose: 96.0 (C-1), 73.6, 73.2 (C-2, 4), 74.6, 75.8 (C-3, 5), 64.3 (C-6). *Anal.* Calcd for $C_{29}H_{24}O_{17}\cdot 5/2H_2O$: C, 50.51; H, 4.24. Found: C, 50.75; H, 4.16.

Hydrolysis of 28 A solution of **28** (100 mg) in 2.5% HCl (10 ml) was heated at 90 °C for 30 min. The mixture was separated by MCI-gel CHP20P column chromatography (10—70% MeOH) to give caffeic acid (5 mg), **28a** (19.8 mg) and **28** (15 mg). The product **28a** was identified as 4,6-(*S*)-HHDP-D-glucopyranose by direct comparison with the authentic sample prepared by tannase hydrolysis of **32**.

1-*O*-*p*-(*E*)-Coumaroyl-4,6-(*S*)-HHDP-*β*-D-glucopyranose (**29**): A yellow amorphous powder, $[\alpha]_D^{15}$ −33.2° (*c*=0.3, MeOH), FAB-MS (negative ion mode) *m/z*: 627 $(M-H)^-$, ^{1}H-NMR (300 MHz, acetone-d_6) *δ*: 7.75 (1H, d, *J*=16 Hz, coum-7), 7.59 (2H, d, *J*=9 Hz, coum-2, 6), 6.92 (2H, d, *J*=9 Hz, coum-3, 5), 6.74, 6.62 (each 1H, s, HHDP-3, 3′), 6.41 (1H, d, *J*=16 Hz, coum-8), 5.68 (1H, d, *J*=8 Hz, glc-1), 5.21 (1H, dd, *J*=6, 13 Hz, glc-6), 4.88 (1H, t, *J*=10 Hz, glc-4), 4.20 (1H, br dd, *J*=6, 10 Hz, glc-5), 3.81 (1H, t, *J*=9 Hz, glc-3), 3.79 (1H, br d, *J*=13 Hz, glc-6), 3.64 (1H, dd, *J*=8, 9 Hz, glc-2). ^{13}C-NMR (75 MHz, acetone-d_6) *δ*: coumaroyl: 126.3 (C-1), 131.2 (C-2, 6), 116.6 (C-3, 5), 161.1 (C-4), 147.2 (C-7), 114.2 (C-8), 166.2 (C-9); HHDP: 115.8, 116.1 (C-1, 1′), 126.2, 126.6 (C-2, 2′), 107.7, 108.1 (C-3, 3′),

144.1, 144.4, 145.1 (2C) (C-4, 4′, 6, 6′), 136.1, 136.4 (C-5, 5′), 168.2, 168.5 (C-7, 7′); glucose: 95.5 (C-1), 72.5, 73.2 (C-2, 4), 74.3, 75.3 (C-3, 5), 63.6 (C-6). *Anal.* Calcd for $C_{29}H_{24}O_{16}\cdot 5/2H_2O$: C, 51.72; H, 4.34. Found: C, 51.62; H, 4.60.

1-*O*-(*E*)-Caffeoyl-3-*O*-galloyl-4,6-(*S*)-HHDP-*β*-D-glucopyranose (**30**): A yellow amorphous powder, $[\alpha]_D^{15}$ −5.5° (*c*=0.6, MeOH), FAB-MS (negative ion mode) *m/z*: 795 $(M-H)^-$-, ^{1}H-NMR (300 MHz, acetone-d_6) δ: 7.70 (1H, d, *J*=16 Hz, caf-7), 7.21 (1H, d, *J*=2 Hz, caf-2), 7.10 (1H, dd, *J*=2, 8 Hz, caf-6), 7.03 (2H, s, galloyl-H), 6.89 (1H, d, *J*=8 Hz, caf-5), 6.64, 6.44 (each 1H, s, HHDP-3, 3′), 6.33 (1H, d, *J*=16 Hz, caf-8), 5.85 (1H, d, *J*=8 Hz, glc-1), 5.48 (1H, t, *J*=9 Hz, glc-3), 5.33 (1H, dd, *J*=6, 13 Hz, glc-6), 5.20 (1H, d, *J*=5 Hz, C-2-OH), 5.04 (1H, t, *J*=10 Hz, glc-4), 4.34 (1H, br dd, *J*=6, 10 Hz, glc-5), 3.92 (1H, ddd, *J*=5, 8, 9 Hz, glc-2), 3.83 (1H, br d, *J*=13 Hz, glc-6). ^{13}C-NMR (75 MHz, acetone-d_6) δ: caffeoyl: 127.4 (C-1), 115.3 (C-2), 146.3 (C-3), 149.1 (C-4), 116.5 (C-5), 123.3 (C-6), 147.6 (C-7), 114.4 (C-8), 166.5 (C-9); galloyl: 121.4 (C-1), 110.2 (C-2, 6), 145.7 (C-3, 5), 138.8 (C-4), 165.7 (C-7); HHDP: 115.8, 115.3 (C-1, 1′), 126.1, 126.6 (C-2, 2′), 107.8, 108.1 (C-3, 3′), 144.3, 144.4, 145.1, 145.2 (C-4, 4′, 6, 6′), 136.4, 136.5 (C-5, 5′), 167.6, 168.0 (C-7, 7′); glucose: 95.5 (C-1), 75.6, 72.9, 72.5, 70.7 (C-2, 3, 4, 5), 63.3 (C-6). *Anal.* Calcd for $C_{36}H_{28}O_{21}\cdot 5/2H_2O$: C, 51.38; H, 3.95. Found: C, 51.47; H, 4.25.

Tannase Hydrolysis of 30 A solution of **30** (29.3 mg) in water (2 ml) was hydrolyzed in a manner similar to that described for **12** to yield gallic acid (4 mg) and **28** (19.7 mg).

1,3-Di-*O*-(*E*)-caffeoyl-4,6-(*S*)-HHDP-*β*-D-glucopyranose (**31**): A yellow amorphous powder, $[\alpha]_D^{15}$ −4.2° (*c*=0.6, MeOH), FAB-MS (negative ion mode) *m/z*: 805 $(M-H)^-$. ^{1}H-NMR (300 MHz, acetone-d_6) δ: 7.70, 7.51 (each 1H, d, *J*=16 Hz, caf-7), 7.21, 7.09 (each 1H, d, *J*=2 Hz, caf-2), 7.10, 6.98 (each 1H, dd, *J*=2, 8 Hz, caf-6), 6.90, 6.82 (each 1H, d, *J*=8 Hz, caf-5), 6.63, 6.52 (each 1H, s, HHDP-3, 3′), 6.33, 6.17 (each 1H, d, *J*=16 Hz, caf-8), 5.83 (1H, d, *J*=8 Hz, glc-1), 5.37 (1H, t, *J*=10 Hz, glc-3), 5.32 (1H, dd, *J*=6, 13 Hz, glc-6), 5.00 (1H, t, *J*=10 Hz, glc-4), 4.32 (1H, br dd, *J*=6, 10 Hz, glc-5), 3.90 (1H, dd, *J*=8, 10 Hz, glc-2), 3.81 (1H, br d, *J*=13 Hz, glc-6). ^{13}C-NMR (75 MHz, acetone-d_6) δ: caffeoyl: 127.2, 127.3 (C-1), 114.4, 114.9, 115.0, 115.2 (C-2, 8), 146.1 (2C), 146.3, 147.6, 148.7, 149.2 (C-3, 4, 7), 116.2, 116.3 (C-5), 122.6, 122.9 (C-6), 165.8, 167.1 (C-9); HHDP: 115.7, 116.7 (C-1, 1′), 126.3, 126.4 (C-2, 2′), 107.8, 108.1 (C-3, 3′), 144.3 (2C), 145.1 (2C) (C-4, 4′, 6, 6′), 136.3, 136.4 (C-5, 5′), 167.6, 168.0 (C-7, 7′); glucose: 95.4 (C-1), 75.5, 72.7, 72.2, 70.9 (C-2, 3, 4, 5), 63.2 (C-6). *Anal.* Calcd for $C_{38}H_{30}O_{20}\cdot 3H_2O$: C, 53.03; H, 4.22. Found: C, 53.13; H, 4.40.

References and Notes

1) Haruna M., Koube T., Ito K., Murata H., *Chem. Pharm. Bull.*, **30**, 1525—1527 (1982).
2) *a*) Birkofer L., Kaiser C., Nouvert W., Thomas U., *Naturforsch.*, **16b**, 249—251 (1961); *b*) Birkofer L., Kaiser C., Hillges B., Becker F., *Justus Liebigs Ann. Chem.*, **725**, 196—202 (1969).
3) Teng R., Wang D., Yang C., *Yunnan Zhiwu Yanjiu*, **22**, 225—233 (2000), CA **133**: 347159.
4) Lee M., Tanaka T., Nonaka G., Nishioka I., *Phytochemistry*, **31**, 2835—2839 (1992).
5) Hussein S. A. M., Barakat H. H., Merfort I., Nawwar M. A. M., *Phytochemistry*, **45**, 819—823 (1997).
6) Nonaka G., Nishioka I., Nagasawa T., Oura H., *Chem. Pharm. Bull.*, **29**, 2862—2870 (1981).
7) Lee M., Tanaka T., Nonaka G., Nishioka I., *Phytochemistry*, **31**, 967—970 (1992).
8) Amakura Y., Yoshida T., *Chem. Pharm. Bull.*, **44**, 1293—1297 (1996).
9) Nawwer M. A. M., Hussein S. A. M., *Phytochemistry*, **36**, 1035—1037 (1994).
10) Lee S., Tanaka T., Nonaka G., Nishioka I., Zhang B., *Phytochemistry*, **30**, 1251—1253 (1991).
11) Nonaka G., Sakai R., Nishioka I., *Phytochemistry*, **23**, 1753—1755 (1984).
12) El-Mousallamy, A. M. D., Barakat H. H., Soulememan A. M. A., Awadallah S., *Phytochemistry*, **30**, 3767—3768 (1991).
13) Weisler W. T., Vazquez J. T., Nakanishi K., *J. Am. Chem. Soc.*, **109**, 5586—5592 (1987).
14) Shimomura H., Sashida Y., Adachi T., *Phytochemistry*, **27**, 641—644 (1988).
15) Latza S., Gansser D., Berger R. G., *Phytochemistry*, **43**, 481—485 (1996).
16) Kashiwada Y., Nonaka G., Nishioka I., Yamagishi T., *Phytochemistry*, **27**, 1473—1477 (1988).
17) Okuda T., Yoshida T., Hatano T., *Progress in the Chemistry of Organic Natural Products*, **66**, 1—117 (1995).
18) Gupta R. K., Al-Shafi S. M. K., Layden K., Haslam E., *J. Chem. Soc., Perkin Trans. 1*, **1982**, 2525—2534.
19) Tanaka T., Nonaka G., Nishioka I., *J. Chem. Research* (*M*), **1985**, 2001—2029.
20) Okuda T., Yoshida T., Hatano T., Koga T., Toh N., Kuriyama K., *Tetrahedron Lett.*, **23**, 3937—940 (1982).
21) Yoshida T., Maruyama Y., Memon U. M., Shingu T., Okuda T., *Phytochemistry*, **24**, 1041—1046 (1985).