Tannins and Related Compounds. CXXIV.[1] Five New Ellagitannins, Platycaryanins A, B, C, and D, and Platycariin, and a New Complex Tannin, Strobilanin, from the Fruits and Bark of *Platycarya strobilacea* SIEB *et* ZUCC., and Biomimetic Synthesis of *C*-Glycosidic Ellagitannins from Glucopyranose-Based Ellagitannins

Takashi TANAKA,*[,2] Shinji KIRIHARA, Gen-ichiro NONAKA, and Itsuo NISHIOKA

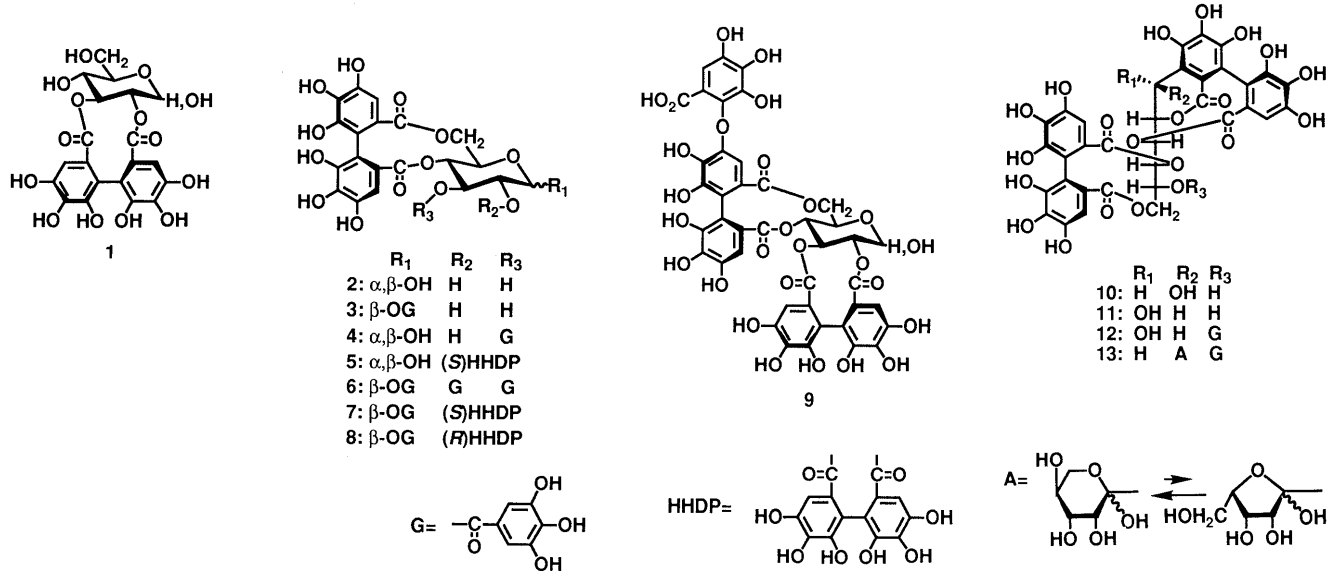
Faculty of Pharmaceutical Sciences, Kyushu University 62, 3–1–1 Maidashi, Higashi-ku, Fukuoka 812, Japan.
Received February 10, 1993

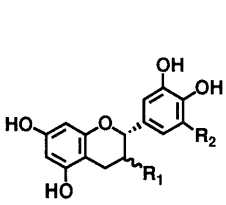
Five new ellagitannins, platycaryanins A (27), B (26), C (30), and D (25), and platycariin (31), and a new complex tannin, strobilanin (32), have been isolated from the fruits and bark of *Platycarya strobilacea* SIEB. *et* ZUCC. (Juglandaceae), together with twenty-six known compounds. On the basis of spectroscopic and chemical evidence, platycaryanins A, B and C, and platycariin have been characterized as the ellagitannins having a tergalloyl ester group, while platycaryanin D was found to be an unusual ellagitannin possessing (*R*)-hexahydroxydiphenoyl esters at the glucopyranose 2,3- and 4,6-positions. During these chemical studies, re-examination of the similar ellagitannins, alnusnins A and B, which were previously reported from *Alnus sieboldiana*, led us to revise their structures to 29 and 28, respectively, in which the tergalloyl group forms a lactone ring. Furthermore, biomimetic conversion of ellagitannins having a glucopyranose core into *C*-glycosidic ellagitannins was successfully achieved for the first time, and the reaction was applied to the structure elucidation of platycariin (31).

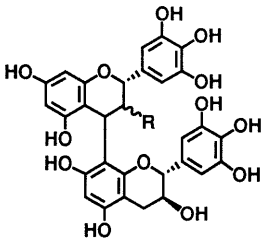
Keywords tannin; *Platycarya strobilacea*; Juglandaceae; ellagitannin; *C*-glycosidic ellagitannin; biomimetic synthesis

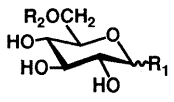
Previously, we have reported on the structures of *C*-glycosidic ellagitannins, pterocarinins A (**13**) and B, which were isolated from the bark of *Pterocarya stenoptera* C. DC. (Juglandaceae).[3] In continuing our chemical studies of the polyphenolic constituents in Juglandaceous plants, we have examined the fruits and bark of *Platycarya strobilacea* SIEB. *et* ZUCC., and isolated and structurally characterized six new tannins named platycaryanins A (**27**), B (**26**), C (**30**) and D (**25**), platycariin (**31**), and strobilanin (**32**), together with twenty-six known compounds. During the structure elucidation of these tannins, some doubt arose as to the structures of the similar known tannins, alnusnins A and B, which had been obtained from *Alnus sieboldiana*,[4] and re-examination has led to the revision of their structures to **29** and **28**, respectively. Furthermore, we have successfully achieved the biomimetic conversion of the ellagitannins having a glycopyranose core into the *C*-glycosidic ellagitannins, and this method was applied to the structural study of platycariin (**31**). We present here a detailed accout of the isolation and characterization of these compounds.

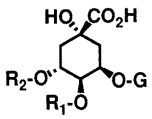
A combination of Sephadex LH-20 and various reversed-phase (MCI-gel CHP 20P, Cosmosil 75C_{18}OPN, Bondapak C_{18}/Porasil B and Toyopearl HW 40F) chromatographies of the aqueous acetone extract of the fruits afforded platycaryanins A (**27**), B (**26**), C (**30**) and D (**25**), together with fourteen known ellagitannins, which were identified as 2,3-(**1**)[5] and 4,6-(*S*)-hexahydroxydiphenoyl (HHDP)-D-glucoses (**2**),[6] strictinin (**3**),[6] pedunculagin (**5**),[5] eugeniin (**6**),[7] 1(*β*)-*O*-galloylpedunculagin (**7**),[8] cuspinin (**8**),[9] praecoxin A (**9**),[10] 5-desgalloylstachyurin (**10**),[11] casuariin (**11**),[6,12] casuarinin (**12**),[6,12] pterocarinin A (**13**),[3,12] and alunusnins A (**29**) and B (**28**).[4] On the other

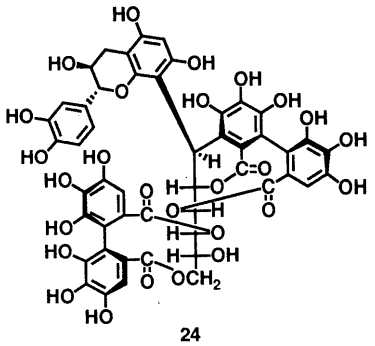










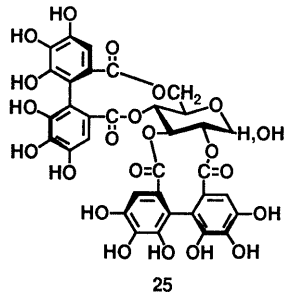


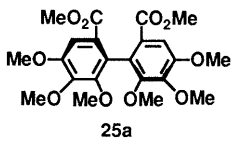
hand, similar extraction and chromatographic separation of the bark yielded platycariin (**31**) and strobilanin (**32**), together with (+)-catechin (**14**),[13] (+)-gallocatechin (**15**),[14] (−)-epigallocatechin (**16**),[13] (−)-epigallocatechin 3-*O*-gallate (**17**),[13] prodelphinidins B-1 (**18**),[14] and B-3 (**19**),[15] 6-*O*-galloyl-D-glucose (**20**),[16] 1,6-di-*O*-galloyl-*β*-D-glucose (**21**),[16] 3,4- (**22**) and 3,5-di-*O*-galloylquinic acids (**23**),[17] gemin D (**4**),[18] 2,3-(*S*)-HHDP-D-glucose (**1**), pedunculagin (**5**), casuariin (**11**), pterocarinin A (**13**) and stenophyllanin C (**24**).[19] Large amounts of a mixture of condensed tannins with higher molecular weights were also present in the bark. It should be noted here that the polyphenols present in the fruits were ellagitannins, whereas the phenolic ingredients of the bark were quite complex, consisting of gallo- and ellagitannins, condensed tannins and complex tannins.

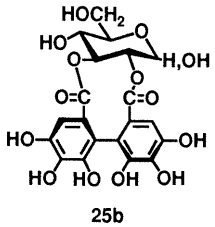
Platycaryanin D (**25**) was characterized as an ellagitannin by its color reactions with the ferric chloride (dark blue) and the sodium nitrite–acetic acid (reddish brown) reagents.[20] The ^{13}C-NMR spectrum of **25** showed twelve signals due to oxygen-bearing aliphatic carbons including two anomeric signals (δ 91.2 and 95.2), the chemical shifts of which were closely related to those of the glucose signals in pedunculagin (**5**), indicating that **25** is an equilibrium mixture of α- and β-glucopyranoses. The presence of two HHDP groups in the molecule was easily deduced from the aromatic acid ester carbon signals which were also analogous to those of **5** (see Experimental). Furthermore, the negative ion FAB-MS of **25** showed the same $[M-H]^-$ peak at *m/z* 783 as that of **5**. These spectroscopic observations indicated that **25** is a structural isomer of **5**.

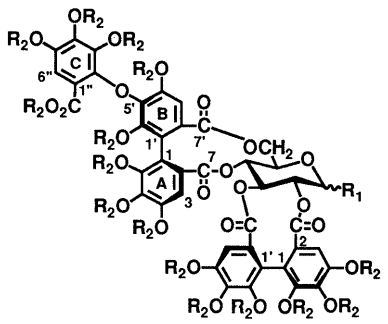
Methylation of **25** with dimethyl sulfate and anhydrous potassium carbonate in dry acetone, and subsequent alkaline methanolysis yielded dimethyl hexamethoxydiphenate (**25a**) as the component phenolcarboxylic acid. The atropisomerism of **25a** was confirmed to be in the *R*-series by the positive sign of its specific optical rotation $[[\alpha]_D +23.6^\circ (CHCl_3)]$.[21] Furthermore, partial hydrolysis of **25** with borate buffer (pH 7.5, 70 °C, 10 min)[22] yielded ellagic acid and **25b**, the ^{1}H-NMR spectrum of which was found to be identical with that of 2,3-(*R*)-HHDP-D-glucopyranose.[9] On the basis of these findings, the structure of platycaryanin D was determined to be 2,3; 4,6-bis-(*R*)-HHDP-D-glucopyranose (**25**). Among the ellagitannins isolated so far, the chirality of the HHDP group in the glucopyranose 2,3- and/or 4,6-positions was entirely in the *S*-series,[8] except for 2,3-(*R*)-HHDP-glucose isolated from *Cercidiphyllum japonicum* and *Castanopsis cuspidata* var. *sieboldii*.[9] Platycaryanin D therefore represents the first example of an ellagitannin having the (*R*)-HHDP group at the glucose 4,6-positions.

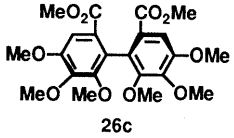
Platycaryanin B (**26**) showed, in the ^{1}H- and ^{13}C-NMR

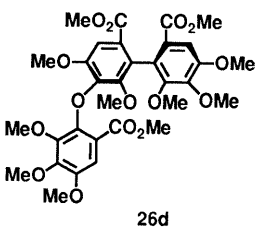


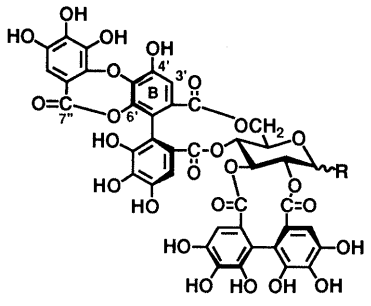












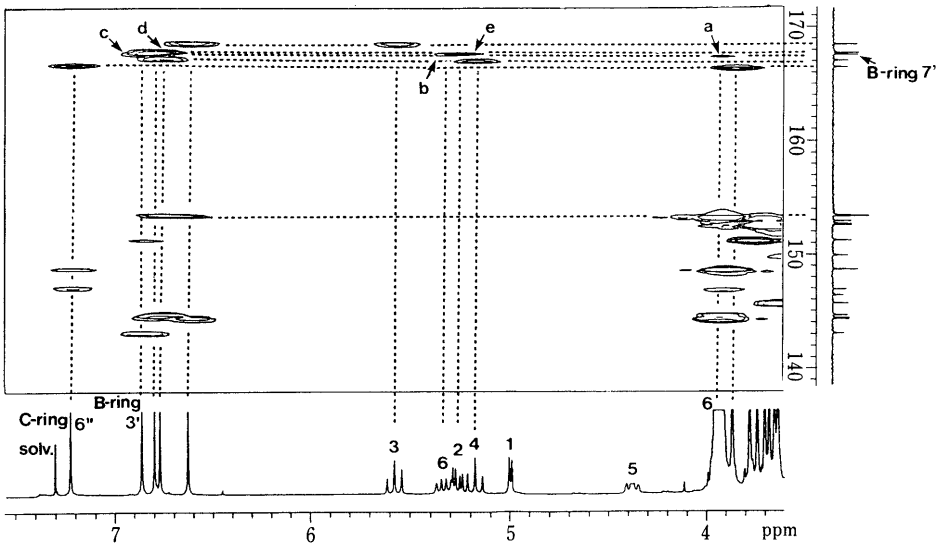


Fig. 1. ^{1}H–^{13}C Long-Range COSY Spectrum of the Hexadecamethyl Ether (**26a**) of Platycaryanin B (**26**) in $CDCl_3$ ($J=5$ Hz)

a—e, cross peaks between the signals due to the glucose H-6 and the B-ring C-7 (a and b), B-ring H-3 and C-7 (c), HHDP H-3 and C-7 (d) and glucose H-2 and HHDP C-7 (e).

spectra, carbohydrate resonances closely related to those found in **5**, but their spectra differed in the aromatic field. The appearance of aromatic singlets attributable to a total of five protons [δ 6.34 (1H), 6.54 (1/2H), 6.59 (1/2H), 6.61 (1H), 6.63 (1/2H), 6.65 (1/2H) and 7.00 (1H)] in the ^{1}H-NMR spectrum, and of the $[M-H]^-$ peak at m/z 951 in the negative ion FAB-MS suggested the presence of an additional gallic acid moiety in the molecule of **26**.

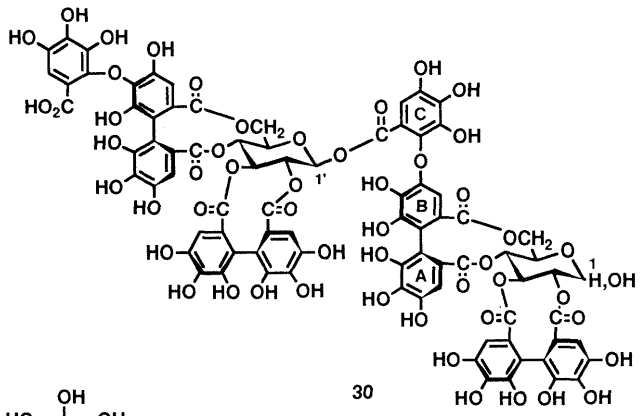
Methylation of **26** afforded two hexadecamethyl ethers (**26a** and **26b**) [FAB-MS m/z: 1176 (M^+)], which exhibited anomeric doublets in the ^{1}H-NMR spectra (**26a**: δ 4.97 ($J=4$ Hz), **26b**: δ 4.64 ($J=8$ Hz)], indicating that **26a** and **26b** correspond to α- and β-anomers, respectively. Subsequent alkaline methanolysis of these methyl ethers liberated dimethyl (*S*)-hexamethoxydiphenate (**26c**) [$[\alpha]_D$ $-27.2°$ ($CHCl_3$)][21] and trimethyl (*S*)-octamethyltergallate (**26d**) [$[\alpha]_D-18.2°$ ($CHCl_3$)],[4] thus confirming the structure of the component acyl groups in **26**.

Partial hydrolysis of **26** in borate buffer (pH 7.5) yielded 2,3-(*S*)-HHDP-D-glucose (**1**), indicating that the glucose 4,6-positions are occupied by the tergalloyl group. The orientation of the tergalloyl esters in **26** was determined by ^{1}H–^{13}C long-range shift correlation (COSY) spectral analysis using **26a** (Fig. 1). The correlations between five one-proton singlets and carboxyl signals through three-bond long-range coupling were seen from the spectrum. Among them, the signal at δ 7.20 was correlated with the carboxyl signal at δ 166.3, which was also coupled with the carbomethoxyl signal (δ 3.87), indicating that the signal at δ 7.20 is assignable to the proton of the tergalloyl C-ring (H-6″). Since the signals at δ 6.60, 6.75 and 6.77 were shown to be correlated with the aromatic carbon signals at δ 153.3 (3C), which were assignable to C-4 of the tergalloyl A-ring and C-4 and C-4′ of the hexamethoxydiphenoyl group based on the structural similarities of these aromatic rings, these proton signals could be assigned to H-3 of the tergalloyl A-ring and H-3 and H-3′ of the hexamethoxydiphenoyl group. The remaining aromatic singlet at δ 6.83 should therefore be assigned to the tergalloyl B-ring proton (H-3′). Furthermore, this proton signal was shown to be coupled with the ester carbon signal at δ 167.4, and this ester carbon signal was also correlated with the signals due to glucose H-6 [δ 3.97 (d, $J=12$ Hz) and 5.31 (dd, $J=12$, 6 Hz)]. From these findings, the structure of platycarynanin B was concluded to be as represented by the formula **26**.

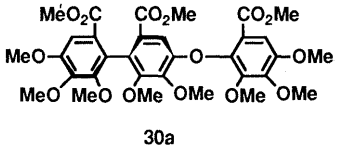
The ^{1}H-NMR spectrum of platycaryanin A (**27**) showed a two-proton singlet due to a galloyl group (δ 7.18) and five one-proton singlets (δ 6.38, 6.47, 6.58, 6.65 and 7.01), the chemical shifts being related to those of **26**. The negative ion FAB-MS of **27** exhibited the $[M-H]^-$ peak at m/z 1103, which was larger than that of **26** by 152 mass units, corresponding to a galloyl group. Furthermore, the lowfield shift and the large coupling constant of the anomeric proton doublet [δ 6.23 ($J=8$ Hz)] indicated that the anomeric position was acylated, having the β-configuration. The acyl group locations were determined by partial hydrolysis of **27** with tannase, which afforded gallic acid and **26**. Accordingly, platycaryanin A was assigned the structure **27**.

The structures of platycaryanins A and B proposed here were in conflict with those of alnusnins A and B, which were formerly characterized as **27** and **26**, respectively.[4] Re-examination of the negative ion FAB-MS of alnusnins A and B [alnusnin A, m/z: 933 $(M-H)^-$; B, m/z: 1085 $(M-H)^-$] revealed that the molecular weights of these tannins were 18 mass units smaller than those of platycaryanins A and B. These findings suggested that the free carboxylic acid in the tergalloyl moiety forms a lactone ring in both cases. To confirm this, an attempt was made to prepare alnusnin B from platycaryanin B by lactonization. Treatment of platycaryanin B with water soluble carbodiimide in 1 N HCl yielded a product, which was identical with alnusnin B by physical and ^{1}H-NMR comparisons.

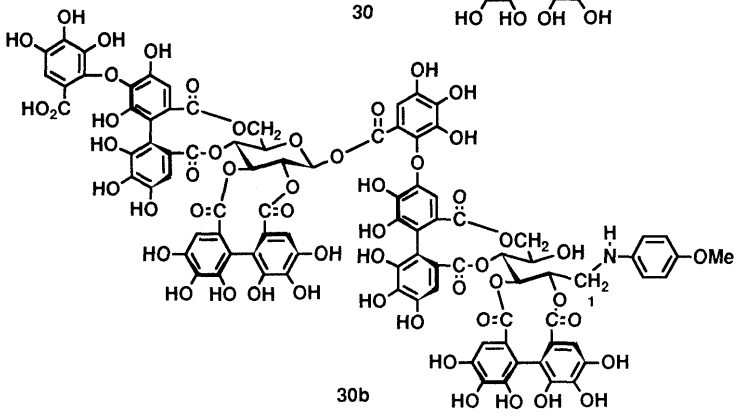
In the ^{13}C-NMR spectrum of platycaryanin B, two oxygen-bearing aromatic carbon signals were observed at lower field (δ 149.4 and 149.6), as compared with the chemical shifts of the HHDP C-4 and C-6 signals (*ca.* 145.0 ppm). These signals were assignable to C-4 and C-6



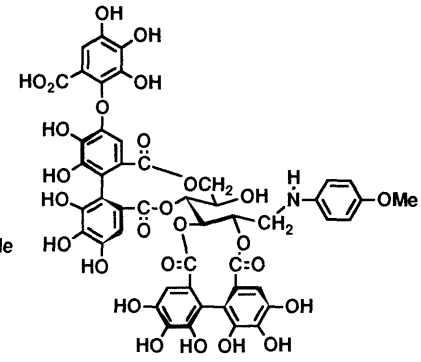
30



30a



30b



9a

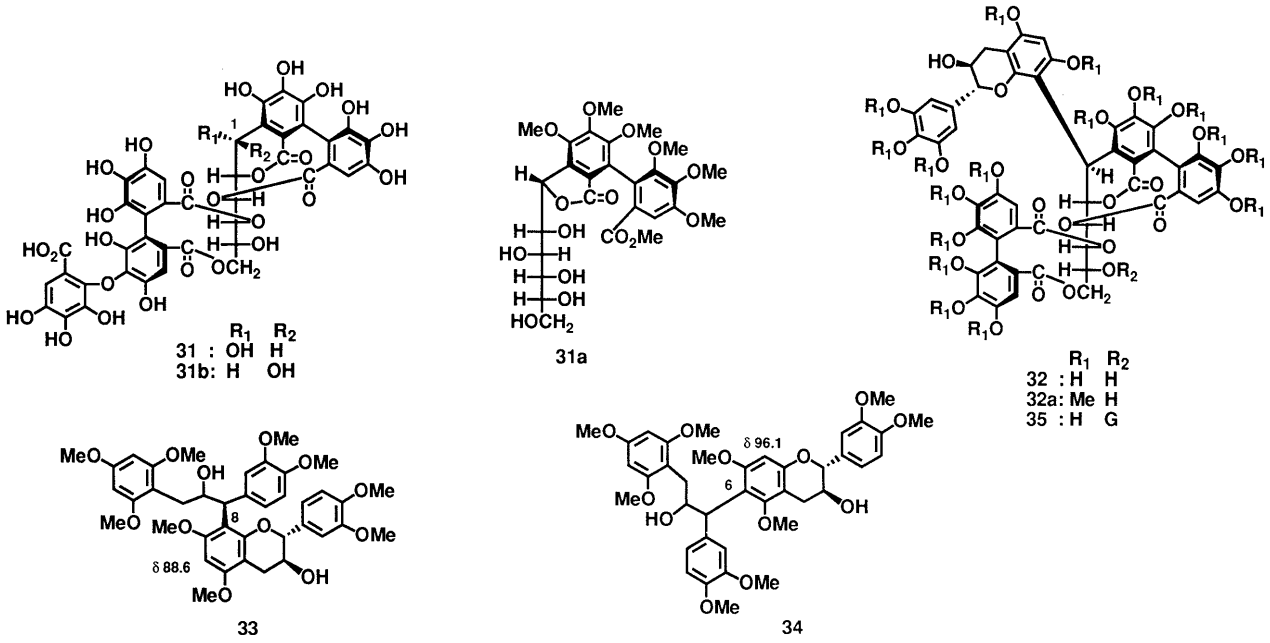
of the tergalloyl B-ring,[23] because the lowfield shifts were considered to be caused by arylation of the neighboring phenolic hydroxyl group (C-5′). On the other hand, in the spectrum of alnusnin B, one of the signals due to C-4 or C-6 of the tergalloyl B-ring was shifted to upper field (*ca.* −5 ppm)[23] owing to the formation of a lactone ring. The lowfield signal at δ 148.3 was therefore attributable to the carbon (C-4′ or C-6′) which does not participate in the formation of the lactone ring. In the ^{1}H–^{13}C long-range COSY spectrum, this signal (δ 148.3) was shown to be correlated with the aromatic proton signal (δ 6.99 and 7.01, 1H in total, H-3′) through a long-range coupling, indicating that this carbon signal is assignable to C-4 of the tergalloyl B-ring, and the lactone ring was therefore concluded to be formed at the C-6′ hydroxyl group. On the basis of these findings, the structure of alnusnin B was revised as shown by the formula **28**. Alnusnin A, which yielded alnusnin B upon partial hydrolysis with tannase, was hence assigned the structure **29**.

Platycaryanin C (**30**) was obtained as a white powder, mp 268 °C (dec.), and characterized as an ellagitannin on the basis of its reddish brown coloration with the sodium nitrite–acetic acid reagent. The ^{1}H-NMR spectrum showed signals due to two sugar moieties including two anomeric doublets at δ 6.14 (1H, J=9 Hz) and 5.40 (1H, d, J=4 Hz), the chemical shifts and coupling constants suggesting the presence of a fully acylated β-glucopyranose and a 1-desacylglucopyranose moiety. The nagative ion FAB-MS $[M-H]^-$ peak at m/z 1885 was consistent with the above ^{1}H-NMR observations.

Methylation of **31** and subsequent alkaline methanolysis afforded three phenolcarboxylic acid methylates. Among them, one was identical with **26c**, whereas the remaining two colud not be separated. The ^{1}H-NMR spectrum of the mixture, however, showed six aromatic singlets, among which the chemical shifts of three (δ 7.18, 7.34 and 7.39) were in good agreement with those of **26d**, and those of the remaining signals (δ 6.92, 7.30 and 7.35) were found to be identical with those of trimethyl octamethylvaloneate (**30a**).[24] Furthermore, the negative sign of the specific optical rotation of this mixture [$[\alpha]_D$ −16.6° ($CHCl_3$)] implied that the tergalloyl and valoneoyl esters are both in the *S*-series [**26d**, $[\alpha]_D$ −18.2°; **30a**, $[\alpha]_D$ −15.9°[23]].

The units constituting the dimeric molecule were determined by selective hydrolysis with hot water, yielding **26** and praecoxin A (**9**). These findings indicated that the free carboxyl group in either **9** or **26** is linked to another anomeric position in **30**. In the ^{1}H–^{13}C long-range COSY spectrum of **30**, the anomeric doublet at δ 6.14 was shown to be correlated with the carboxyl carbon signal at δ 163.0 which was also coupled with the aromatic singlet at δ 7.22. This aromatic singlet was considered to be assignable to the valoneoyl C-ring proton from comparisons of their chemical shifts [**9**, δ 7.13 (valoneoyl C-ring); **26**, δ 7.00 (tergalloyl C-ring)], suggesting that the valoneoyl group in **9** is attached to the anomeric center of **26**. This was further confirmed by partial hydrolysis of the aminoalditol derivative (**30b**), which was obtained by treatment of **30** with *p*-anisidine, followed by sodium cyanoborohydride reduction.[25] Heating (80 °C) of **30b** in water yielded **26** and the aminoalditol derivative (**9a**) of **9**. From these findings, the structure **30** was assigned to platycaryanin C.

Platycariin (**31**), isolated from the bark, exhibited, in the negative ion FAB-MS, the $[M-H]^-$ peak at m/z 951, which was in accord with that of **26**. The ^{1}H-NMR spectrum showed seven aliphatic proton signals [δ 5.62 (dd, J=5, 3 Hz, H-1, coupled with the hydroxyl group at δ 6.30), 5.43 (dd, J=3, 2 Hz, H-3), 5.06 (dd, J=8, 3 Hz, H-4), 4.76 (dd, J=5, 2 Hz, H-2), 4.62 (dd, J=12, 3 Hz, H-6), 4.13 (dd, J=8, 3 Hz, H-5), 3.88 (d, J=12 Hz, H-6)], the chemical shifts



and coupling constants of which were almost identical with those of casuariin (**11**). Furthermore, in the ^{13}C-NNR spectrum, the observation of the carbon signals at δ 132.6 (B-ring C-2) and 150.1 (2C, B-ring C-4 and C-6) suggested the pressence of a tergalloyl ester group in **31**. This was confirmed by methylation of **31** and subsequent alkaline methanolysis, yielding **26d** and **31a**.[12] From these findings, the structure of platycariin was considered to be as shown by the formula **31**.

To confirm the structure, we attempted to synthesize **31** by intramolecular *C*-glycosidation from **26**. Recently, one-step syntheses of the *C*-glycosides of barbituric acid[26] and 2,4,6-trihydroxyacetophenone[1] under neutral or weakly alkaline conditions have been reported. Thus, to apply these methods, we first attempted the conversion by employing readily available pedunculagin (**5**) as a model compound. Heating (70 °C, 2.5 h) of **5** in phosphate buffer (pH 7.5) successfully afforded the *C*-glycosidic ellagitannin, casuariin (**11**) (6%) and its C-1 epimer, 5-desgalloyl-stachyurin (**10**) (34%), together with a partial hydrolysate (**1**) (30%). Below pH 7.0, this *C*-glycosidation reaction did not proceed. The predominance of **10** was considered to be due to the nucleophilic attack of the pyrogallol ring on the glucose C-1 aldehyde from the lower side of the glucose molecule (Chart 1). Since epimerization at the C-1 position in *C*-glycosidic ellagitannins occurs readily in hot water,[6,27] **11** might be formed from **10**. Next, the application of this reaction to **26** afforded **31** (4%) and its epimer (**31b**) (18%), together with **1** (8%). These results unequivocally indicated the structure of platycariin to be as represented by the formula **31**, including the orientation of the tergalloyl ester.

Strobilanin (**32**) gave a reddish pink coloration on treatment with the anisaldehyde–sulfuric acid reagent,[28] suggesting the presence of a flavan-3-ol framework in the molecule, while brown coloration with the sodium nitrite–acetic acid reagent was characteristic of an ellagitannin. The ^{1}H-NMR spectrum measured at room temperature showed broadened signals, presumably due to dynamic rotational isomerism,[19] but the spectrum taken at 120 °C showed a first-order splitting pattern. The presence of a gallocatechin unit was readily deduced from this spectrum, which showed signals due to the flavan-3-ol

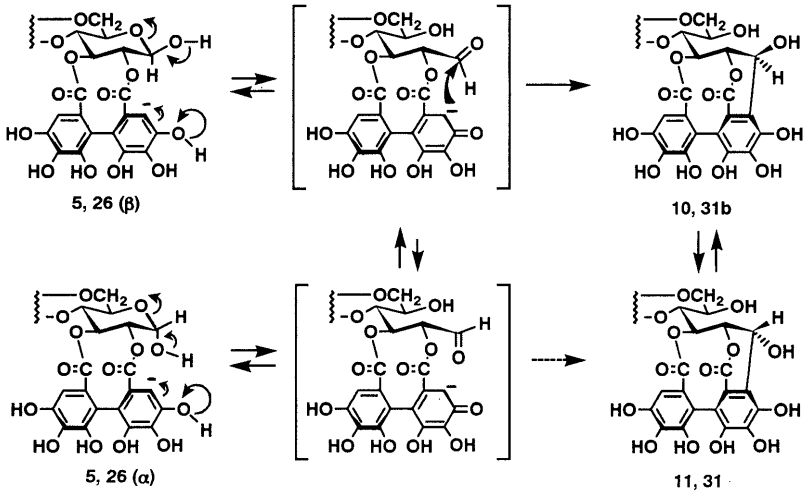


Chart 1. Possible Reaction Mechanism for the Intramolecular *C*-Glycosidation

A-ring [δ 5.85, (1H, s)], B-ring [δ 6.42, (2H, s)] and C-ring [δ 4.59 (1H, d, J=8 Hz, H-2)], 3.78 (1H, m, H-3), 2.75 (1H, dd, J=16, 5 Hz, H-4) and 2.44 (1H, dd, J=16, 8 Hz, H-4)]. The chemical shifts and coupling constants of the three aromatic singlets (δ 6.08, 6.37 and 6.45) and the aliphatic signals (see Experimental) were analogous to those of stenophyllanin C (**24**). The ^{13}C-NMR spectrum showed, in addition to flavan C-ring signals, aliphatic signals due to a C_6-polyalcohol unit [δ 38.3 (C-1), 67.8 (C-6), 69.1 (C-5), 75.9, 76.9 (C-3, 4) and 80.5 (C-2)], the chemical shifts of which were also closely related to those of **24**. Furthermore, the negative ion FAB-MS of **32** showed the $[M-H]^-$ peak at m/z 1071, which was 16 mass units larger than that of **24**. From these spectral observations, it was deduced that strobilanin is a flavano-ellagitannin[29] which possesses a gallocatechin unit in place of the catechin unit of **24**. Since the above-mentioned rotational isomerism was similarly observed in the cases of some complex tannins having the C-8 substitution of flavan-3-ol,[19] the casuariin moiety was considered to be linked to the C-8 position of the gallocatechin unit in **32**. In addition, the ^{13}C-NMR spectrum of the heptadecamethyl ether (**32a**) of **32** showed the unsubstituted A-ring carbon signal at δ 89.2, the chemical shifts being in good agreement with those of the C-8-substituted catechin derivatives[19] [*e.g.* gambiriin A_1 nonamethyl ether (**33**)[30]: δ 88.6] rather than those of the C-6-substituted alternatives [*e.g.* gambiriin A_3 nonamethyl ether (**34**)[30]: δ 96.1]. Final structural confirmation was obtained by partial hydrolysis of guajavin A (**35**)[31] with tannase, which afforded gallic acid and a hydrolysate, shown to be identical with strobilanin (**32**).

The present study has yielded the following results. 1) There are significant differences in the phenolic constituents between fruits and bark. The absence of condensed tannins in fruits is particularly noteworthy. 2) The co-existence of the atropisomeric ellagitannins (**5**, **8** and **25**) in fruits implies that biosynthetic conversion of a galloyl group to an HHDP group is not completely enantiospecific in this plant. 3) A successful biomimetic conversion of ellagitannins having a glucopyranose core into *C*-glycosidic ellagitannins by one-step intramolecular *C*-glycosidation supports the proposed route of biosynthesis of *C*-glycosidic ellagitannins.[32]

Experimental

Melting points were determined on a Yanagimoto micro-melting point apparatus and are uncorrected. Optical rotations were measured with a JASCO DIP-4 digital polarimeter. FAB-MS were taken with a JEOL JMS DX-300/JMA 3500 or JEOL JMS SX-102 instrument. ^{1}H- and ^{13}C-NMR spectra were recorded on JEOL FX-100 and JEOL GX-270 spectrometers, with tetramethylsilane as an internal standard, and chemical shifts are given in δ (ppm). Column chromatography was performed with Sephadex LH-20 (25—100 μ, Pharmacia Fine Chemical Co., Ltd.), MCI-gel CHP 20P (75—150 μ, Mitsubishi Chemical Industries, Ltd.), Cosmosil 75 C_{18}-OPN (75 μ, Nacalai Tesque Inc.), Bondapak C_{18}/Porasil B (37—75 μ, Waters Associates Inc.), and Toyopearl HW-40F (Tosoh Corp.). TLC was performed on precoated Kieselgel 60 F_{254} plates (0.2 mm thick, Merck) with benzene–ethyl formate–formic acid (1:7:1) and precoated cellulose F_{254} plates (0.1 mm thick, Merck) with 2% acetic acid, and spots were detected by ultraviolet (UV) illumination and by spraying 1% ethanolic ferric chloride, sodium nitrite–acetic acid or 5% sulfuric acid reagents. HPLC was performed on a Tosoh apparatus equipped with a CCPM solvent delivery system and a UV-8000 spectrometer.

Isolation of Tannins From Fruits: Fresh fruits (12 kg) of *Platycarya strobilacea*, which were collected near Fukuoka City in September, were extracted with 80% aqueous acetone three times at room temperature. Concentration of the extract under reduced pressure (*ca.* 40 °C) afforded brown precipitates, which were removed by filtration. The filtrate was further concentrated and applied to a column of Sephadex LH-20. Elution with H_2O containing increasing amounts of MeOH gave four fractions; I (120 g), II (340 g), III (540 g) and IV (115 g). Fraction I was rechromatographed over MCI-gel CHP 20P and then over Toyopearl HW-40F with H_2O–MeOH (1:0—0.1, v/v) to give 2,3- (**1**) (30 g) and 4,6-(*S*)-HHDP-D-glucoses (**2**) (12 g). Fraction II was repeatedly chromatographed over Sephadex LH-20 with EtOH and with 60% aqueous MeOH, and over MCI-gel CHP 20P, Cosmosil 75C_{18} OPN and Toyopearl HW-40F with H_2O–MeOH (1:0—4:1, v/v) to yield strictinin (**3**) (1.4 g), pedunculagin (**5**) (18 g), 5-desgalloylstachyurin (**10**) (400 mg), casuariin (**11**) (580 mg), pterocarinin A (**13**) (2.2 g) and platycaryanin D (**25**) (500 mg). Fraction III was chromatographed over MCI-gel CHP 20P and then Cosmosil 75C_{18} OPN with H_2O–MeOH (1:1—3:2, v/v) to afford praecoxin A (**9**) (2.9 g), platycaryanin B (**26**) (44 g) and alnusnin B (**28**) (33 g). Repeated chromatography of fraction IV over MCI-gel CHP 20P, Sephadex LH-20, Cosmosil 75C_{18}OPN, Toyopearl HW-40F and Bondapak C_{18}/Porasil B with H_2O–MeOH (1:0—4:1, v/v) yielded eugeniin (**6**) (930 mg), 1(β)-*O*-galloylpedunculagin (**7**) (1.8 g), cuspinin (**8**) (250 mg), casuarinin (**12**) (450 mg), platycaryanin A (**27**) (1.9 g), alnusnin A (**29**) (2.3 g) and platycaryanin C (**30**) (1.1 g).

From Bark: The fresh bark (17.5 kg), collected in Yamaguchi prefecture in August, was chopped into small pieces and extracted with 80% aqueous acetone at room temperature. The acetone was removed by evaporation under reduced pressure and the resulting precipitates were filtered off. The filtrate, after concentration, was subjected to Sephadex LH-20 chromatography. Elution with H_2O containing increasing amounts of MeOH and then H_2O–acetone (1:1, v/v) afforded three fractions; I (105 g), II (230 g) and III (210 g). Fraction I was repeatedly chromatographed over Sephadex LH-20, MCI-gel CHP 20P and Bondapak C_{18}/Porasil B with H_2O–MeOH (1:0—0:1, v/v) to afford **1** (300 mg), prodelphinidin B-1 (**18**) (1.3 g), 6-*O*-galloyl-D-glucose (**20**) (100 mg), and 3,4- (**22**) (500 mg) and 3,5-di-*O*-galloylquinic acids (**23**) (700 mg). On similar chromatographies, fraction II gave **4** (5.2 g), **10** (4.3 g), **12** (1.5 g), (+)-catechin (**14**) (3.7 g), (+)-gallocatechin (**15**) (5.4 g), (−)-epigallocatechin (**16**) (810 mg), (−)-epigallocatechin 3-*O*-gallate (**17**) (600 mg), prodelphinidin B-3 (**19**) (210 mg), 1,6-di-*O*-galloyl-β-D-glucose (**21**) (120 mg), gemin D (**4**) (100 mg), stenophyllain C (**24**), platycariin (**31**) (45 mg) and strobilanin (**32**) (1.3 g). Fraction III consisted largely of high-molecular-weight condensed tannins, which showed dark blue coloration with the ferric chloride reagent and reddish orange coloration with the *p*-anisaldehyde–sulfuric acid reagent.

Platycaryanin D (25) A tan amorphous powder, $[\alpha]_D^{22}$ +4.6° (c=1.0, acetone). *Anal.* Calcd for $C_{34}H_{24}O_{22}$: C, 52.05; H, 3.08. Found: C, 51.82; H, 3.11. Negative ion FAB-MS m/z: 783 $[M-H]^-$. ^{1}H-NMR (acetone-d_6+D_2O, 270 MHz): 3.72 (1/2H, d, J=13 Hz, α-H-6), 3.79 (1/2H, d, J=13 Hz, β-H-6), 4.13 (1/2H, dd, J=10, 6 Hz, β-H-5), 4.51 (1/2H, dd, J=10, 6 Hz, α-H-5), 4.56 (1/2H, dd, J=10, 8 Hz, β-H-2), 4.73 (1/2H, dd, J=10, 4 Hz, α-H-2), 4.79 (1/2H, t, J=10 Hz, β-H-4), 4.86 (1/2H, t, J=10 Hz, α-H-4), 4.98 (1/2H, d, J=8 Hz, β-H-1), 5.00 (1/2H, t, J=10 Hz, β-H-3), 5.10 (1/2H, dd, J=13, 6 Hz, α-H-6), 5.23 (1/2H, t, J=10 Hz, α-H-3), 5.25 (1/2H, dd, J=13, 6 Hz, β-H-6), 5.48 (1/2H, d, J=4 Hz, α-H-1), 6.59 (1H, s), 6.63, 6.71, 6.75, 6.83, 7.04, 7.19 (each 1/2H, s, HHDP-H). ^{13}C-NMR (acetone-d_6+D_2O, 25.05 MHz): 63.6 [2C, α-, β-glucose (Glc)-6], 67.1, 70.0, 70.3, 72.0, 76.8, 77.2 78.6, 79.8 (α-, β-Glc-2, 3, 4, 5, 6], 91.2 (α-Glc-1), 95.2 (β-Glc-1), 107.5, 108.1, 110.3, 111.8, 115.8, 117.4, 117.8, 118.0, 119.4, 120.6, 121.7, 122.6, 126.0, 126.2 (HHDP-1, 1′, 2, 2′, 3, 3′), 136.4, 136.5, 137.3, 138.2, 139.0 (HHDP-5, 5′), 143.7, 143.9, 144.0, 144.3, 144.4, 144.7, 144.9, 145.1, 145.5 (HHDP-4, 4′, 6, 6′), 167.5, 168.4, 168.5, 168.7, 169.0, 169.8 (COO).

Methylation of 25, Followed by Methanolysis A mixture of **25** (100 mg), dimethyl sulfate (2 ml) and anhydrous potassium carbonate (2 g) in dry acetone (15 ml) was heated under reflux for 1.5 h. The inorganic compound were removed by filtration, and the filtrate, after concentration, was applied to a silica gel column. Elution with benzene–acetone (1:0—9:1) yielded a mixture of the tridecamethyl ethers corresponding to the α- and β-anomers, FAB-MS m/z: 966 (M^+). Without further separation, the products were treated with 2% methanolic sodium methoxide (5 ml) at room temperature for 10 h. The reaction mixture was neutralized with Amberlite IR 120B (H^+ form) and subjected to silica gel chromatography. Elution with benzene–acetone (19:1) afforded dimethyl (*R*)-hexamethoxydiphenate (**25a**) (75 mg), a colorless syrup, $[\alpha]_D^{22}$ +23.6° (c=1.1, $CHCl_3$).

Partial Hydrolysis of 25 A solution of **25** (44 mg) in 0.2 M borate buffer (pH 7.5) (3 ml) was heated at 70 °C for 10 min. The reaction mixture was acidified with 1 N HCl and directly subjected to Sephadex LH-20 chromatography. Elution with H_2O containing increasing amounts of

MeOH afforded ellagic acid and 2,3-(*R*)-HHDP-D-glucopyranose (**25b**) (17 mg).

Platycaryanin B (26) A tan amorphous powder, $[\alpha]_D^{28}$ +10.3° (*c* = 1.0, acetone). *Anal.* Calcd for $C_{41}H_{28}O_{27}\cdot H_2O$: C, 50.73; H, 3.12. Found: C, 50.40; H, 3.51. Negative ion FAB-MS *m/z*: 951 $[M-H]^-$. ^{1}H-NMR (acetone-d_6 + D_2O, 100 MHz): 3.85, 3.90 (each 1/2H, d, *J* = 13 Hz, α-, β-H-6), 4.23, 4.67 (each 1/2H, dd, *J* = 10, 6 Hz, α-, β-H-5), 4.94—5.61 (5H in total, m, H-1, 2, 3, 4, 6), 6.34 (1H), 6.54, 6.59 (each 1/2H), 6.61 (1H), 6.63, 6.65 (each 1/2H), 7.00 (1H) [each s, HHDP-H, tergalloyl(ter)-H]. ^{13}C-NMR (acetone-d_6 + D_2O, 25.05 MHz): 64.0 (2C, α-, β-Glu-6), 67.3, 69.6, 70.0, 72.3, 75.6 (2C), 77.4, 78.3 (α-, β-Glc-2, 3, 4, 5), 91.7 (α-Glc-1), 95.4 (β-Glc-1), 107.4, 107.6, 107.7, 108.5, 108.6 (HHDP-3, 3′-ter-3, 3′, 6″), 114.4, 114.7, 115.8, 116.2 (HHDP-1, 1′, ter-1, 1′, 1″), 125.1, 126.4, 126.6 (HHDP-2, 2′, ter-2), 131.8 (ter-2′), 136.1, 136.4, 136.6, 137.0, 139.4, 140.1, 140.3, 142.3, 144.3, 144.6, 145.1, 145.4 (HHDP-4, 4′, 5, 5′, 6, 6′, ter-2″, 3″, 4, 4″, 5, 5′, 5″, 6), 149.4, 149.6 (ter-4′, 6′), 168.1, 169.6, 171.1 (COO).

Methylation of 26 A mixture of **26** (500 mg), dimethyl sulfate (3 ml) and anhydrous potassium carbonate (3 g) in dry acetone (25 ml) was heated reflux for 1.5 h. After removal of inorganic salts by filtration, the filtrate was concentrated to a syrup, which was chromatographed over silica gel, Elution with benzene–acetone (1 : 0—9 : 1) yielded **26a** (200 mg) and **26b** (185 mg). **26a**: a white amorphous powder, $[\alpha]_D^{22}$ +52.1° (*c* = 1.0, $CHCl_3$). *Anal.* Calcd for $C_{57}H_{60}O_{27}$: C, 58.16; H, 5.14. Found: C, 58.20; H, 5.41. FAB-MS *m/z*: 1176 (M^+). ^{1}H-NMR ($CDCl_3$, 100 MHz): 3.48—3.94 (m, OCH_3), 3.97 (1H, d, *J* = 12 Hz, H-6), 4.34 (1H, dd, *J* = 10, 6 Hz, H-5), 4.97 (1H, d, *J* = 4 Hz, H-1), 5.15 (1H, t, *J* = 10 Hz, H-4), 5.24 (1H, dd, *J* = 10, 4 Hz, H-2), 5.31 (1H, dd, *J* = 12, 6 Hz, H-6), 5.56 (1H, t, *J* = 10 Hz, H-3), 6.60 [1H, s, hexamethoxydiphenoyl (HMDP)-H-3′], 6.75 [1H, s, octamethyltergalloyl (OMT)-H-3], 6.77 (1H, s, HMDP-H-3), 6.83 (1H, s, OMT-H-3′), 7.20 (1H, s, OMT-H-6″). ^{13}C-NMR ($CDCl_3$, 25.05 MHz): 63.1 (Glc-6), 67.0, 69.7, 74.2, 74.8 (Glc-2, 3, 4, 5), 97.8 (Glc-1), 105.1, 105.2 (2C) (HMDP-3, 3′, OMT-3), 106.6 (OMT-3′), 108.3 (OMT-6″), 117.0 (OMT-1″), 120.5, 121.0 (HMDP-1, 1′), 122.3 (OMT-1), 123.1 (OMT-1′), 127.2 (OMT-2′), 128.3, 128.6 (2C) (HMDP-2, 2′, OMT-2), 142.8 (OMT-5′), 144.0, 144.1, 144.4 (HMDP-5, 5′, OMT-5), 145.4, 146.1, 146.7, 148.4 (OMT-2″, 3″, 4″, 5″), 149.7 (OMT-6′), 151.0 (OMT-4′), 152.5 (2C), 152.7 (HMDP-6, 6′, OMT-6), 153.3 (3C) (HMDP-4, 4′, OMT-4), 166.3 (OMT-7″), 166.9 (OMT-7), 167.4 (OMT-7′), 167.6 (HMDP-7), 168.4 (HMDP-7′). **26b**: a white amorphous powder, $[\alpha]_D^{22}$ +11.3° (*c* = 1.2, $CHCl_3$). *Anal.* Calcd for $C_{57}H_{60}O_{27}$: C, 58.16; H. 5.14. Found: C, 58.21; H, 5.41. FAB-MS *m/z*: 1176 (M^+). ^{1}H-NMR ($CDCl_3$, 100 MHz): 3.59—4.07 (m, OCH_3, H-5, 6), 4.64 (1H, d, *J* = 8 Hz, H-1), 5.08 (1H, t, *J* = 10 Hz, H-4), 5.15 (1H, dd, *J* = 10, 8 Hz, H-2), 5.23 (1H, t, *J* = 10 Hz, H-3), 5.37 (1H, dd, *J* = 13, 6 Hz, H-6), 6.61, 6.70, 6.78, 6.83, 7.20 (each 1H, s, aromatic H). ^{13}C-NMR ($CDCl_3$, 25.05 MHz): 62.9 (Glc-6), 69.3, 72.0, 75.5, 76.8 (Glc-2, 3, 4, 5), 100.9 (Glc-1), 166.3, 166.9, 167.4, 167.6, 168.4 (COO).

Methanolysis of 26a and 26b A mixture of **26a** and **26b** (100 mg) was treated with 2% methanolic sodium methoxide (5 ml) at room temperature for 10 h. The reaction mixture was neutralized with Amberlite IR 120B (H^+ form), and subjected to silica gel chromatography. Elution with benzene–acetone (19 : 1—9 : 1) afforded dimethyl (*S*)-hexamethoxydiphenate (**26c**) (28.5 mg), a colorless syrup, $[\alpha]_D^{22}$ −27.2° (*c* = 1.2, $CHCl_3$), and trimethyl (*S*)-octamethyltergallate (**26d**) (39.2 mg), a colorless syrup, $[\alpha]_D^{22}$ −18.2° (*c* = 1.4, $CHCl_3$). ^{1}H-NMR ($CDCl_3$, 100 MHz): 3.38, 3.60, 3.62, 3.63 (×2), 3.76, 3.81, 3.88 (×2), 3.92, 3.93 (each 3H, s, OCH_3), 7.18, 7.34, 7.39 (each 1H, s, aromatic H).

Partial Hydrolysis of 26 A solution of **26** (100 mg) in 0.2 M borate buffer (pH 7.5) (10 ml) was heated at 70 °C for 10 min. The products were separated in the same way as described for **25** to furnish ellagic acid and **1** (57 mg).

Platycaryanin A (27) A tan amorphous powder, $[\alpha]_D^{24}$ −45.1° (*c* = 0.8, acetone). Negative ion FAB-MS *m/z*: 1103 $[M-H]^-$. *Anal.* Calcd for $C_{48}H_{32}O_{31}$: C, 52.19; H, 2.92. Found: C, 51.71; H, 3.32. ^{1}H-NMR (acetone-d_6, 100 MHz): 3.92 (1H, d, *J* = 13 Hz, H-6), 4.54 (1H, dd, *J* = 10, 6 Hz, H-5), 5.20 (1H, dd, *J* = 10, 8 Hz, H-2), 5.22 (1H, t, *J* = 10 Hz, H-4), 5.50 (1H, dd, *J* = 13, 6 Hz, H-6), 5.60 (1H, t, *J* = 10 Hz, H-3), 6.23 (1H, d, *J* = 8 Hz, H-1), 6.38, 6.47, 6.58, 6.65, 7.01 (each 1H, d, HHDP-H), ter-H), 7.18 (2H, s, galloyl-H). ^{13}C-NMR (acetone-d_6 + D_2O, 25.05 MHz): 63.6 (Glc-6), 69.1 (Glc-4), 73.2 (Glc-5), 76.0 (Glc-2), 77.1 (Glc-3), 92.2 (Glc-1), 107.3, 107.6, 108.2, 108.5 (HHDP-3, 3′, ter-3, 6″), 110.3 (ter-3′, galloyl-2, 6), 114.4, 115.0, 115.8, 116.4 (HHDP-1, 1′, ter-1, 1′, 1″), 119.3 (galloyl-1), 124.7, 125.7, 126.0 (HHDP-2, 2′, ter-2), 131.4 (ter-2′), 136.3, 136.3, 137.0 (HHDP-5, 5′, ter-5), 139.2, 139.6, 140.1 (ter-3″, 4″, 5″, galloyl-4), 142.3 (ter-2″), 144.1, 144.4, 145.1, 145.3, 146.1 (galloyl-3, 5, HHDP-4, 4′, 6, 6′, ter-4, 6), 149.6 (ter-4′, 6′), 165.4, 168.2, 168.9, 169.4, 169.6, 170.0 (COO).

Tannase Hydrolysis of 27 A solution of **27** (100 mg) in water (5 ml) was treated with tannase for 2 h at room temperature. The reaction mixture was concentrated to dryness under reduced pressure. The EtOH-soluble portion was applied to a column of Sephadex LH-20 with EtOH to give gallic acid (15 mg) and **26** (77 mg).

Alnusnin B (28) An off-white amorphous powder, $[\alpha]_D^{24}$ −33.6° (*c* = 1.0, acetone). *Anal.* Calcd for $C_{41}H_{26}O_{26}\cdot H_2O$: C, 51.70; H, 3.30. Found: C, 51.69; H, 2.96. Negative ion FAB-MS *m/z*: 933 $[M-H]^-$. ^{1}H-NMR (acetone-d_6, 270 MHz); 3.86 (1/2H, d, *J* = 12 Hz, α-H-6), 3.94 (1/2H, d, *J* = 12 Hz, β-H-6), 4.27 (1/2H, dd, *J* = 10, 6 Hz, β-H-5), 4.65 (1/2H, dd, *J* = 10, 6 Hz, α-H-5), 4.88 (1/2H, t, *J* = 8 Hz, β-H-2), 5.07 (1/2H, d, *J* = 8 Hz β-H-1), 5.09 (1/2H, dd, *J* = 10, 4 Hz, α-H-2), 5.16 (1H, t, *J* = 10 Hz, α-, β-H-4), 5.21 (1H, dd, *J* = 12, 6 Hz, α-, β-H-6), 5.28 (1/2H, dd, *J* = 10, 8 Hz, β-H-3), 5.47 (1/2H, d, *J* = 4 Hz, α-H-1), 5.51 (1/2H, t, *J* = 10 Hz, α-H-3), 6.41 (1H, s, HHDP-H), 6.61, 6.64 (1H in total, each s, ter-H-3), 6.65, 6.66 (1H, in total, each s, HHDP-H), 6.95, 6.96 (1H, in total, each s, ter-H-6″), 6.99, 7.01 (1H in total, each s, ter-H-3′). ^{13}C-NMR (acetone-d_6 + D_2O, 25.05 MHz): 64.4 (α-, β-Glc-6), 67.2, 69.6, 69.9, 72.3, 75.5 (×2), 77.2, 78.3 (α- β-Glc-2, 3, 4, 5), 91.8 (α-Glc-1), 95.5 (β-Glc-1), 106.6, 107.2, 107.4, 107.8 (HHDP-3, 3′, ter-3, 6″), 109.9 (ter-3′), 112.6, 112.7 (ter-1″), 114.1, 115.0 (HHDP-1, 1′, ter-1), 120.9 (ter-1′), 125.1, 126.5, 126.7 (HHDP-2, 2′, ter-2), 132.4 (ter-2′), 136.0, 136.3, 136.5 (HHDP-5, 5′, ter-5), 140.5 (ter-4″), 142.9 (ter-5′), 144.1 (ter-2″), 143.6, 144.3, 145.0, 145.4, 145.8, 146.1 (HHDP-4, 4′, 6, 6′, ter-4, 6, 6′, 3″, 5″), 148.3 (ter-4′), 163.2 (ter-7″), 167.3 (ter-7′), 168.0 (ter-7), 168.8 (HHDP-7), 169.4 (HHDP-7′).

Preparation of 28 from 26 A mixture of **26** (1.0 g) and 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (1.0 g) in 1 N HCl (30 ml) was stirred for 30 min at room temperature. The reaction mixture was extracted with ethyl acetate five times, concentrated under reduced pressure, and subjected to Sephadex LH-20 chromatography. Elution with 60—80% aqueous MeOH yielded **28** (210 mg) and the unchanged starting material (135 mg).

Alnusnin A (29) An off-white amorphous powder, $[\alpha]_D^{24}$ −165.1° (*c* = 0.9, acetone). *Anal.* Calcd for $C_{48}H_{30}O_{30}\cdot 5H_2O$: C, 48.99; H, 3.43. Found: C, 48.92; H, 3.48. Negative ion FAB-MS *m/z*: 1085 $[M-H]^-$. ^{1}H-NMR (acetone-d_6 + D_2O, 100 MHz): 3.93 (1H, d, *J* = 13 Hz, H-6), 4.52 (1H, dd, *J* = 9, 6 Hz, H-5), 5.19 (2H, t, *J* = 9 Hz, H-2, 4), 5.28 (1H, dd, *J* = 13, 6 Hz, H-6), 5.50 (1H, t, *J* = 9 Hz, H-3), 6.24 (1H, d, *J* = 8 Hz, H-1), 6.43, 6.47, 6.60, 6.93, 6.98 (each 1H, s, HHDP-H, ter-H), 7.10 (2H, s, galloyl-H).

Platycaryanin C (30) A white powder (H_2O), mp 268 °C (dec.), $[\alpha]_D^{24}$ +64.2° (*c* = 0.8, acetone). *Anal.* Calcd for $C_{82}H_{54}H_{53}\cdot 3/2H_2O$: C, 51.45; H, 3.00. Found: C, 51.32; H, 3.02. Negative ion FAB-MS *m/z*: 1885 $[M-H]^-$. ^{1}H-NMR (acetone-d_6 + D_2O, 270 MHz): 4.46 (1H, dd, *J* = 10, 6 Hz, H-5′), 4.54 (1H, dd, *J* = 10, 6 Hz, H-5), 5.00 (2H, t, *J* = 10 Hz, H-4, 4′), 5.05 (1H, dd, *J* = 10, 4 Hz, H-2), 5.10—5.22 (3H, m, H-2′, 6, 6′), 5.40 (1H, d, *J* = 4 Hz, H-1), 5.43 (1H, t, *J* = 10 Hz, H-3), 5.44 (1H, t, *J* = 10 Hz, H-3′), 6.14 (1H, d, *J* = 9 Hz, H-1′), 6.23 [valoneoyl (val)-H-3′] 6.40, 6.42, 6.46, 6.56, 6.60, 6.65, 6.66 (each 1H, s, HHDP-H, val-H-3, ter-H-3, 3′), 6.98 (1H, s, ter-H-6″), 7.22 (1H, s, val-H-6″). ^{13}C-NMR (acetone-d_6 + D_2O, 67.80 MHz): 63.1 (β-Glc-6), 63.5 (α-Glc-6), 63.7 (α-, β-Glc-6′), 67.1 (β-Glc-5), 69.1 (α-, β-Glc-4′), 69.7 (β-Glc-4), 70.0 (α-Glc-4), 72.1 (β-Glc-5), 73.2 (α-Glc-5′), 73.3 (β-Glc-5′), 75.5 (α-Glc-2), 75.8, 75.9 (α-Glc-3, α-, β-Glc-2′), 77.1 (α-Glc-3′), 77.3 (β-Glc-3′), 77.6 (β-Glc-3), 78.1 (β-Glc-2), 91.4 (β-Glc-1), 91.9 (α-, β-Glc-1′), 95.0 (β-Glc-1), 104.8 (val-3′), 107.3, 107.4, 107.6, 108.2, 108.3, 108.6 (HHDP-3, 3′, ter-3, 3′, 6″, val-3), 109.8 (val-6″), 113.0, 114.5, 114.6, 114.8, 115.0, 115.4, 115.7, 115.9, 116.1, 116.2, 117.5 (HHDP-1, 1′, ter-1, 1′, 1″, val-1, 1′, 1″), 124.7, 125.3, 125.4, 125.5, 125.9, 126.0, 126.3 (HHDP-2, 2′, ter-2, val-2, 2′), 131.4 (ter-2′), 136.2, 136.4, 136.5, 136.6, 136.7, 137.0, 137.8, 139.2, 140.0, 140.4, 141.6, 142.3, 143.4, 144.3, 144.4, 144.5, 144.6, 144.7, 145.1, 145.3, 145.4 (HHDP-4, 4′, 5, 5′, 6, 6′, ter-2″, 3″, 4, 4″, 5, 5′, 5″, 6, val-2″, 3″, 4, 4″, 5, 5′, 5″, 6, 6′), 147.0 (val-4′), 149.4, 149.5 (ter-4′, 6′), 163.0 (val-7″), 168.2, 168.3, 168.4, 169.3, 169.4, 169.6, 169.7, 169.8 (HHDP-7, 7′, ter-7, 7′, val-7, 7′), 171.1 (ter-7″).

Methylation of 30, Followed by Methanolysis A mixture of **30** (100 mg), dimethyl sulfate (2 ml) and anhydrous potassium carbonate (2 g) in dry acetone (15 ml) was heated under reflux for 1.5 h. The inorganic compounds were removed by filtration, and the filtrate, after concentration, was passed through a silica gel column [benzene–acetone (1 : 0—9 : 1)] to yield a mixture of the triacontamethyl ethers corresponding to the α- and β-anomers. Without further separation, the products were treated with 2% methanolic sodium methoxide (5 ml) at room temperature for 10 h. The reaction mixture was neutralized with Amberlite IR 120B (H^+ form) and subjected to silica gel chromatography. Elution with benzene–acetone

(19 : 1—9 : 1) afforded dimethyl (*S*)-hexamethoxydiphenate (**26c**) (11 mg), $[[\alpha]_D^{22}$ −25.2° (*c* = 1.1, $CHCl_3$)], and a mixture (12 mg) of trimethyl octamethyltergallate (**26d**) and trimethyl octamethylvaloneate (**30a**), $[[\alpha]_D^{22}$ −16.6° (*c* = 1.2, $CHCl_3$)]. ^{1}H-NMR ($CDCl_3$, 270 MHz): 3.48, 3.57, 3.60, 3.67, 3.78 (×2), 3.93, 3.94 (×2), 3.98, 4.08 (each 3H, s, OCH_3), 6.92, 7.30, 7.35 (each 1H, s, aromatic H) (trimethyl octamethylvalonate), 3.38, 3.60, 3.62, 3.63 (×2), 3.76, 3.81, 3.88 (×2), 3.92, 3.93 (each 3H, s, OCH_3), 7.18, 7.34, 7.39 (each 1H, s, aromatic H) (trimethyl octamethyltergallate).

Partial Hydrolysis of 30 A solution of **30** (50 mg) in H_2O (2 ml) was heated at 90 °C for 3 h. The reaction mixture was separated by Sephadex LH-20 chromatography with 60% aqueous MeOH to give **9** (10.6 mg) and **26** (9.8 mg).

Aminoalditol Derivative of 30 A mixture of **30** (50 mg) and *p*-anisidine (10 mg) in 20% ethanolic acetic acid was stirred at room temperature for 2 h, and the mixture was treated with sodium cyanoborohydride (10 mg) at room temperature for 1 h. After addition of 1 N HCl, the product was purified by chromatographies over Sephadex LH-20 with H_2O–MeOH (1 : 0—0 : 1) and then Bondapak C_{18}/Porasil B with H_2O–MeOH (1 : 0—1 : 1) to afford **30b** (14 mg) as a white amorphous powder, $[\alpha]_D^{22}$ +37.3° (*c* = 0.7, acetone). Negative ion FAB-MS *m/z*: 1992 $[M-H]^-$. ^{1}H-NMR (acetone-d_6 + D_2O, 270 MHz): 3.47 (1H, dd, *J* = 14, 8 Hz, H-1), 3.67 (3H, s, OCH_3), 3.72—3.92 (m, H-1, 6, 6′), 4.26 (1H, dd, *J* = 8, 2 Hz, H-5), 4.40 (1H, dd, *J* = 10, 6 Hz, H-5′), 4.60 (1H, dd, *J* = 13, 3 Hz, H-6), 5.13 (1H, t, *J* = 10 Hz, H-4′), 5.17 (1H, dd, *J* = 10, 9 Hz, H-2′), 5.25—5.33 (3H, m, H-2, 4, 6′), 5.41 (1H, t, *J* = 10 Hz, H-3′), 5.52 (1H, dd, *J* = 8, 2 Hz, H-3), 6.12 (1H, d, *J* = 9 Hz, H-1′), 6.15, 6.40, 6.50, 6.58, 6.64, 6.66, 6.69, 6.70, 6.71, 7.22 (each 1H, s, HHDP-H, val-H, ter-H), 6.70 (4H, s, aromatic H).

Partial Hydrolysis of 30b A solution of **30b** (5 mg) in H_2O (1 ml) was heated at 80 °C for 1 h. A portion of the reaction mixture was diluted with H_2O and analyzed by HPLC to detect **9a** and **26**. HPLC: column, Cosmosil 5C_{18}-AR (4.6 mm i.d. × 250 mm); solvent, 15% acetonitrile–50 mM H_3PO_4; flow rate, 0.8 ml/min; t_R 4.62 min for **9a**, and 8.25 and 12.16 min for α- and β-anomers of **26**. (*cf.* t_R 5.75 and 6.21 for **9**, and 7.07 for aminoalditol derivative of **26**).

Platycariin (31) A tan amorphous powder, $[\alpha]_D^{25}$ +18.5° (*c* = 1.0, acetone). *Anal.* Calcd for $C_{41}H_{28}O_{27}$: C, 51.69; H, 2.96. Found: C, 51.82; H, 3.11. Negative ion FAB-MS *m/z*: 951 $[M-H]^-$. ^{1}H-NMR (acetone-d_6, 100 MHz): 3.88 (1H, d, *J* = 12 Hz, H-6), 4.13 (1H, dd, *J* = 8, 3 Hz, H-5), 4.62 (1H, dd, *J* = 12, 3 Hz, H-6), 4.76 (1H, dd, *J* = 5, 2 Hz, H-2), 5.06 (1H, dd, *J* = 8, 3 Hz, H-4), 5.43 (1H, dd, *J* = 3, 2 Hz, H-3), 5.62 (1H, dd, *J* = 5, 3 Hz, H-1), 6.30 (1H, d, *J* = 3 Hz, C-1-OH), 6.42, 6.48, 6.78, 6.90 [each 1H, s, ter-H, C-substituted HHDP (BPH)-H]. ^{13}C-NMR (acetone-d_6 + D_2O, 25.05 MHz): 67.3 (C-1), 68.4 (C-5, 6), 70.8 (C-3), 76.9 (C-2, 4), 105.4, 107.4, 108.3, 109.0 (BPH-3′, ter-3, 3′, 6″), 115.4, 116.2, 116.5, 117.1 (BPH-1, 1′, ter-1, 1″), 119.7, 120.2 (BPH-2, ter-1′), 124.6, 127.6 (BPH-2′, ter-2), 132.6 (ter-2′), 135.0, 136.7, 137.5, 138.3, 138.8, 139.0 (×2), 142.3 (×2), 143.8, 144.6, 145.1, 146.0, 146.2 (BPH-4, 4′, 5, 5′, 6, 6′, ter-2″, 3″, 4, 4″, 5, 5′, 5″, 6), 150.1 (×2) (ter-4′, 6′), 165.6 (BPH-7), 168.9, 169.5, 170.4 (BPH-7′, ter-7, 7′), 173.4 (ter-7″).

Methylation of 31, Followed by Methanolysis A solution of **31** (7 mg) in MeOH (1 ml) was treated with ethereal diazomethane at 5 °C for 14 h. The reaction mixture was concentrated to dryness, and the residue was passed through a silica gel column with benzene–acetone (9 : 1). The methyl ether thus obtained was methanolyzed with 2% methanolic sodium methoxide (2 ml) at room temperature for 24 h. After neutralization with Amberlite IR 120B (H^+ form), the products were separated by silica gel chromatography with benzene–acetone (46 : 4) and then benzene–EtOH (19 : 1) to yield **26d** (1 mg), $[[\alpha]_D^{27}$ −17.5° (*c* = 0.1, $CHCl_3$)], and **31a** (1 mg), respectively. **31a**: a colorless syrup, $[\alpha]_D^{27}$ −48.2° (*c* = 0.1, $CHCl_3$). ^{1}H-NMR ($CDCl_3$, 100 MHz): 5.64 (1H, br s, H-1), 7.38 (1H, s, aromatic H).

Intramolecular *C*-Glycosidation of Pedunculagin (5) A solution of **5** (1.5 g) in 0.2 M potassium phosphate buffer (pH 7.5) (50 ml) was heated at 70 °C for 2.5 h. The reaction mixture was acidified (to pH 3) with 1 N HCl and applied to a column of MCI-gel CHP 20P with H_2O–MeOH (1 : 0—1 : 1, v/v) to yield **1** (278 mg, 30%), **10** (514 mg, 34%) and **11** (92 mg, 6%), together with the unchanged starting material (268 mg, 18%).

Preparation of 31 A solution of **26** (500 mg) in 0.2 M potassium phosphate buffer (pH 7.5) (10 ml) was heated at 70 °C for 50 min. The reaction mixture was worked up as described for **5** to furnish **1** (20 mg, 8%), **31** (20 mg, 4%) and **31b** (90 mg, 18%), together with the unchanged starting material (140 mg, 28%). **31b**: a tan amorphous powder, $[\alpha]_D^{22}$ +16.8° (*c* = 1.0, acetone). *Anal.* Calcd for $C_{41}H_{28}O_{27}\cdot H_2O$: C, 50.73; H, 3.12. Found: C, 51.07; H, 3.57. Negative ion FAB-MS *m/z*: 951 $[M-H]^-$. ^{1}H-NMR (acetone-d_6 + D_2O, 100 MHz): 3.88 (1H, d, *J* = 12 Hz, H-6), 4.11 (1H, dd, *J* = 5, 2 Hz, H-5), 4.69 (1H, dd, *J* = 12, 2 Hz, H-6), 4.82—4.93 (3H, m, H-1, 2, 3), 5.26 (1H, dd, *J* = 8, 2 Hz, H-4), 6.45, 6.52, 6.80, 6.97 (each 1H, s, ter-H, BPH-H).

Strobilanin (32) A tan amorphous powder, $[\alpha]_D^{22}$ +39.4° (*c* = 0.8, acetone). *Anal.* Calcd for $C_{49}H_{36}O_{28}\cdot 2H_2O$: C, 53.08; H, 3.64. Found: C, 53.26; H, 3.85. Negative ion FAB-MS *m/z*: 1071 $[M-H]^-$. ^{1}H-NMR (DMSO-d_6, at 120 °C, 270 MHz): 2.44 [1H, dd, *J* = 16, 8 Hz, gallocatechin unit (GC)-4], 2.75 (1H, dd, *J* = 16, 5 Hz, GC-4), 3.59 (1H, d, *J* = 12 Hz, H-6), 3.65 (1H, br d, *J* = 7 Hz, H-5), 3.78 (1H, m, GC-3), 4.22 (1H, dd, *J* = 12, 2 Hz, H-6), 4.47 (1H, s, H-1), 4.59 (1H, d, *J* = 8 Hz, GC-2), 4.67 (1H, dd, *J* = 7, 2 Hz, H-3), 4.90 (1H, br s, H-2), 4.90 (1H, t, *J* = 7 Hz, H-4), 5.85 (1H, s, GC-6), 6.08, 6.37, 6.45 (each 1H, s, HHDP-H, BPH-H), 6.42 (2H, s, GC-2′, 6′). ^{13}C-NMR (acetone-d_6 + D_2O, 25.05 MHz): 38.3 (C-1), 67.8 (C-6, GC-3), 69.1 (C-5), 75.9, 76.9 (C-3, 4), 80.5 (C-2), 82.0 (GC-2), 96.5 (GC-6), 100.3 (GC-4a), 105.5 (×2), 107.4 (×3), 108.8 (HHDP-3, 3′, BPH-3′, GC-2′, 6′, 8), 115.4 (×2), 115.9, 117.0 (HHDP-1, 1′, BPH-1, 1′), 123.0, 125.7, 127.3, 128.1 (HHDP-2, 2′, BPH-2, 2′), 131.3 (GC-1′), 133.3 (GC-4′), 135.1, 135.9, 136.5, 137.5, 143.1, 144.2 (×2), 145.2 (×2), 145.6 (×2), 146.0 (HHDP-4, 4′, 5, 5′, 6, 6′, BPH-4, 4′, 5, 5′, 6, 6′, GC-3, 5), 153.3, 155.4, 156.4 (GC-5, 7, 8a), 168.1, 169.5, 170.5 (COO).

Methylation of 32 A mixture of **32** (100 mg), dimethyl sulfate (1 ml) and anhydrous potassium carbonate (1 g) in dry acetone (15 ml) was heated under reflux for 3 h. The reaction mixture was worked up as described for **25** to give the heptadecamethyl ether (**32a**) (12.5 mg) as a white amorphous powder, $[\alpha]_D^{22}$ +72.4° (*c* = 1.2, $CHCl_3$). *Anal.* Calcd for $C_{66}H_{70}O_{28}$: C, 60.46; H, 5.38. Found: C, 60.70; H, 5.60. FAB-MS *m/z*: 1351 $[M+K+2H]^+$, 1335 $[M+Na+2H]^+$. ^{1}H-NMR ($CDCl_3$, 100 MHz): 2.51 (1H, dd, *J* = 16, 10 Hz, GC-4), 3.09 (1H, dd, *J* = 16, 6 Hz, GC-4), 3.41, 3.50, 3.55, 3.64, 3.66 (×2), 3.76, 3.77, 3.85, 3.87, 3.88, 3.90, 3.93, 3.95, 4.02 (×2), 4.12 (each 3H, s, OCH_3), 4.54—4.93 (5H, m, H-1, 2, 3, 6, GC-2), 5.38 (1H, dd, *J* = 8, 2 Hz, H-4), 6.01 (1H, s, GC-6), 6.56, 6.64, 6.95 (each 1H, s, aromatic H), 6.90 (2H, s, GC-2′, 6′). ^{13}C-NMR ($CDCl_3$, 67.8 MHz): 29.5 (GC-4), 36.9 (C-1), 53.8, 55.5 (×2), 55.9, 56.2, 56.7, 57.5, 60.2, 60.3, 60.6, 60.7, 60.8 (×2), 61.0, 61.1, 61.2, 61.8 (OCH_3), 65.4, 67.6, 73.9, 75.5, 75.7, 76.1, 78.9 (C-2, 3, 4, 5, 6, GC-2, 3), 89.2 (GC-6), 103.1, 103.6, 104.3, 105.2, 106.6, 107.1, 121.3, 121.9, 123.2, 125.1, 127.0, 128.2, 128.9, 129.3, 129.8, 142.2, 143.3, 143.6, 145.1, 149.4, 149.9, 150.6, 151.8, 152.1, 152.2, 152.5, 153.0, 153.2, 153.5, 157.8, 158.6 (aromatic C), 165.2, 168.2, 168.3, 171.9 (COO).

Partial Hydrolysis of Guajavin A (35) A solution of **35** (20 mg) in H_2O (2 ml) was treated with tannase at room temperature for 3 h. Work-up as described for **27** gave gallic acid and **32** (6 mg).

Stenophyllanin C (24) A tan amorphous powder, $[\alpha]_D^{21}$ +80.1° (*c* = 1.0, MeOH). ^{1}H-NMR (DMSO-d_6, at 120 °C, 270 MHz): 2.44 [1H, dd, *J* = 16, 8 Hz, catechin (CT)-4], 2.75 (1H, dd, *J* = 16, 6 Hz, CT-4), 3.60 (1H, d, *J* = 12 Hz, H-6), 3.66 (1H, br d, *J* = 6 Hz, H-5), 3.82 (1H, m, CT-3), 4.23 (1H, dd, *J* = 12, 2 Hz, H-6), 4.44 (1H, s, H-1), 4.60 (1H, d, *J* = 7 Hz, CT-2), 4.68 (1H, dd, *J* = 6, 2 Hz, H-3), 4.84 (1H, s, H-2), 4.89 (1H, t, *J* = 6 Hz, H-4), 5.85 (1H, s, CT-6), 6.11, 6.38, 6.46 (each 1H, s, HHDP-H, BPH-H), 6.69 (1H, br d, *J* = 8 Hz, CT-6′), 6.74 (1H, d, *J* = 8 Hz, CT-5′), 6.83 (1H, br s, CT-2′).

Acknowledgements The authors thank Dr. M. Kanaoka (Sankyo Co., Ltd.) for the provision of tannase. They are also indebted to Mr. Y. Tanaka, Miss Y. Soeda and Dr. R. Isobe for ^{13}C-NMR, ^{1}H-NMR and MS measurements, respectively, and the staff of the Analysis Room of Kyushu University for elemental analyses.

References and Notes

1) T. Tanaka, Y. Orii, G. Nonaka, I. Nishioka, *Chem. Pharm. Bull.*, **41**, 1232 (1933).
2) Present address: *Faculty of Pharmaceutical Sciences, Nagasaki University, 1—14 Bunkyo-cho, Nagasaki 852, Japan.*
3) G. Nonaka, K. Ishimaru, Z. Azuma, M. Ishimatsu, I. Nishioka, *Chem. Pharm. Bull.*, **37**, 2071 (1989).
4) M. Ishimatsu, T. Tanaka, G. Nonaka, I. Nishioka, *Phytochemistry*, **28**, 3179 (1989).
5) O. T. Schmidt, L. Würtele, A. Harrèus, *Justus Liebigs Ann. Chem.*, **690**, 150 (1965).
6) T. Okuda, T. Yoshida, M. Ashida, K. Yazaki, *J. Chem. Soc., Perkin Trans. 1*, **1983**, 1765.
7) G. Nonaka, H. Harada, I. Nishioka, *Chem. Pharm. Bull.*, **28**, 685 (1980).
8) R. K. Gupta, S. M. K. Al-Shafi, K. Layden, E. Haslam, *J. Chem. Soc., Perkin Trans. 1*, **1982**, 2525.

9) G. Nonaka, M. Ishimatsu, M. Ageta, I. Nishioka, *Chem. Pharm. Bull.*, **37**, 50 (1989).
10) T. Hatano, K. Yazaki, A. Okonogi, T. Okuda, *Chem. Pharm. Bull.*, **39**, 1689 (1991).
11) S.-H. Lee, T. Tanaka, G. Nonaka, I. Nishioka, *Phytochemistry*, **29**, 3621 (1990).
12) G. Nonaka, T. Sakai, T. Tanaka, K. Mihashi, I. Nishioka, *Chem. Pharm. Bull.*, **38**, 2151 (1990).
13) G. Nonaka, O. Kawahara, I. Nishioka, *Chem. Pharm. Bull.*, **31**, 3906 (1983).
14) G. Nonaka, M. Muta, I. Nishioka, *Phytochemistry*, **22**, 237 (1983).
15) D. Sun, H. Wong, L. Y. Foo, *Phytochemistry*, **26**, 1825 (1987).
16) G. Nonaka, I. Nishioka, *Chem. Pharm. Bull.*, **31**, 1652 (1983).
17) H. Nishimura, G. Nonaka, I. Nishioka, *Phytochemistry*, **23**, 262 (1984).
18) T. Yoshida, Y. Maruyama, T. Okuda, M. Memon, T. Shingu, *Chem. Pharm. Bull.*, **30**, 4245 (1982).
19) G. Nonaka, H. Nishimura, I. Nishioka, *J. Chem. Soc., Perkin Trans. 1*, **1985**, 183.
20) E. C. Bate-Smith, *Phytochemistry*, **11**, 1153 (1972).
21) Y. Ikeya, H. Taguchi, I. Yoshioka, H. Kobayashi, *Chem. Pharm. Bull.*, **27**, 1383 (1979).
22) Preferential hydrolysis of the 4,6-bridged acyl group proceeded more rapidly under these conditions than in hot water. In the course of the reaction, a slight production of *C*-glycosidic ellagitannins was also observed.
23) J.-H. Lin, M. Ishimatsu, T. Tanaka, G. Nonaka, I. Nishioka, *Chem. Pharm. Bull.*, **38**, 1844 (1990).
24) G. Nonaka, S, Nakayama, I. Nishioka, *Chem. Pharm. Bull.*, **37**, 2030 (1989).
25) Y.-X. Xu, T. Sakai, T. Tanaka, G. Nonaka, I. Nishioka, *Chem. Pharm. Bull.*, **39**, 639 (1991).
26) M. A. Gonzalez, J. L. J. Requejo, J. C. P. Albarran, J. A. G. Perez, *Carbohydr. Res.*, **158**, 53 (1986).
27) W. Mayer, W. Gabler, A. Riester, H. Körger, *Justus Liebigs Ann. Chem.*, **707**, 117 (1967).
28) G. Nonaka, I. Nishioka, T. Nagasawa, H. Oura, *Chem. Pharm. Bull.*, **29**, 2862 (1981).
29) K. Ishimaru, M. Ishimatsu, G. Nonaka, K. Mihashi, Y. Iwase, I. Nishioka, *Chem. Pharm. Bull.*, **36**,3312 (1988).
30) G. Nonaka, I. Nishioka, *Chem. Pharm. Bull.*, **28**, 3145 (1980).
31) T. Tanaka, N. Ishida, M. Ishimatsu, G. Nonaka, I. Nishioka, *Chem. Pharm. Bull.*, **40**, 2092 (1992).
32) T. Okuda, T. Yoshida, T. Hatano, K. Yazaki, M. Ashida, *Phytochemistry*, **21**, 2871 (1982).