Tannins and Related Compounds. LXXXVIII.[1] Isolation and Characterization of Hydrolyzable Tannins from *Mallotus japonicus* (THUNB.) MUELLER-ARG. and *M. philippinensis* (LAM.) MUELLER-ARG.

Reiko SAIJO,[a] Gen-ichiro NONAKA,[a] Itsuo NISHIOKA,*[,a] Ih-Sheng CHEN[b] and Tieh-Horng HWANG[c]

Faculty of Pharmaceutical Sciences, Kyushu University,[a] 62, 3-1-1 Maidashi, Higashi-ku, Fukuoka 812, Japan, School of Pharmacy, Kaohsiung Medical College,[b] Kaohsiung, Taiwan R.O.C. and Tajen Pharmaceutical College,[c] Ping-tung, Taiwan R.O.C. *Received April 12, 1989*

Further chemical examination of the bark and the leaves of *Mallotus japonicus* (THUNB.) MUELLER-ARG. (Euphorbiaceae) has led to the isolation of two new tannins [named mallotannins A (16) and B (18)]. Based on chemical and spectroscopic evidence, the structures of 16 and 18 were established to be dimeric hydrolyzable tannins in which the free carboxylic acid in mallotinic acid is connected to the C-6 position of bergenin and D-glucose, respectively. On the other hand, fifteen known tannins and related compounds have been isolated from the leaves of *M. philippinensis* (LAM.) MUELLER-ARG. and identified by comparisons of their physical and spectral data with those of authentic samples. In addition, a survey of tannin patterns in *Mallotus* species is presented.

Keywords Euphorbiaceae; *Mallotus japonicus*; *Mallotus philippinensis*; mallotannin A; mallotannin B; dimeric hydrolyzable tannin; mallotinic acid; bergenin; valoneayl group; *Mallotus repandus*

As part of our chemical studies on tannins and related compounds in the plants of the genus *Mallotus* (Euphorbiaceae), we previously reported the characterization of more than fifty compounds, including eighteen new tannins, from *Mallotus japonicus* (THUNB.) MUELLER-ARG. and *M. repandus* (WILLD.) MUELLER-ARG.[1,2] Further examination of the former species has now led to the isolation of two new hydrolyzable tannins designated as mallotannins A (**16**) and B (**18**). In addition, we have also examined the tannin components of *M. philippinensis* (LAM.) MUELLER-ARG.; this has resulted in the isolation and characterization of fifteen compounds. In this paper we wish to present a detailed account of the characterization of these compounds, and also to describe briefly the characteristics of tannins in the three *Mallotus* species so far examined.

A combination of Sephadex LH-20, MCI-gel CHP 20P and Bondapak C_{18}/Porasil B chromatographies of the aqueous acetone extract of the bark of *M. japonicus* afforded compound **16**, while on similar treatment, the leaf extract gave compound **18**. On the other hand, extraction of the leaves of *M. philippinensis* yielded fifteen compounds, which were found to be identical with bergenin (**1**),[2a] 6-*O*-galloylbergenin (**2**),[2a] norbergenin (**3**),[2a] 3-*O*-galloylnorbergenin (**4**),[2a] 6-*O*-galloylnorbergenin (**5**),[2a] 2,3-(*S*)-hexahydroxydiphenoyl-D-glucose (**6**),[3] corilagin (**7**),[4] geraniin (**8**),[5] furosin (**9**),[2c] mallotinic acid (**10**),[2c] mallotusinic acid (**11**),[2c] repandusinic acid A monopotassium salt (**12**),[1] brevifolin carboxylic acid (**13**),[1] tergallic acid dilactone (**14**)[6] and flavogallonic acid (**15**),[6] by comparisons of their physical and spectral data with those of authentic samples.

The new tannin, mallotannin A (**16**), isolated from *M. japonicus*, showed, in the proton-nuclear magnetic resonance (^{1}H-NMR) spectrum, four aromatic one-proton singlets (δ 6.51, 6.72, 7.10 and 7.16), together with signals of one galloyl group (δ 7.16, 2H, s) and one methoxyl group (δ 3.88, 3H, s). In addition, two anomeric signals were observed at δ 6.31 (1H, d, J=4 Hz) and 4.98 (1H, d, J=10 Hz), indicating the presence of two sugar moieties in the molecule. The appearance of the sugar C-1 signals at δ 93.7 and 74.0 in the carbon-13 nuclear magnetic resonance (^{13}C-NMR) spectrum clearly indicated that **16** possesses *O*- and *C*-glycosidic linkages.

Methylation of **16** with dimethyl sulfate and potassium carbonate in dry acetone yielded the tridecamethyl ether (**16a**) [field-desorption mass spectrum (FD-MS) *m/z*: 1294 (M^+)]. Subsequent methanolysis of **16a** with methanolic sodium methoxide cleaved the ester linkages to afford di-*O*-methylbergenin (**16b**), trimethyl octa-*O*-methylvaloneate (**16c**), methyl trimethoxybenzoate (**16d**) and glucose. The positive sign of the specific optical rotation [+14.0° ($CHCl_3$)] of **16c** indicated the atropisomerism of the biphenyl bond to be in the *R*-series.[7]

The ^{13}C-NMR spectrum of **16** showed twelve resonances in the sugar region, of which six (δ 62.8, 64.6, 70.3, 73.8, 76.1 and 93.7) were closely correlated with those found in mallotinic acid (**10**), whereas the chemical shifts of the remaining six signals (δ 64.9, 71.9, 74.0, 74.8, 79.8 and 80.5) were almost identical with those of 6-*O*-galloylbergenin (**2**). Similarly, the sugar signal patterns in the ^{1}H-NMR spectrum of **16** closely resemble those of **10** plus **2**. From these findings, **16** was considered to have mallotinic acid and bergenin moieties which are linked through the valoneayl group. This was consistent with the mass spectral data of **16** [negative fast atom bombardment mass spectrum (FAB-MS) *m/z*: 1111 $(M-H)^-$].

The orientation of the valoneayl group in **16** was determined on the basis of detailed ^{1}H–^{13}C long-range shift correlation spectral (COSY) examinations (Fig. 1) and by chemical means. Among four aromatic one-proton singlets (δ 6.51, 6.72, 7.10 and 7.16) arising from the valoneayl group and bergenin moiety, the signal at δ 7.10 was readily assignable to the aromatic proton in the bergenin moiety, based on the correlation between this proton signal and the methoxyl carbon (δ 60.8) through the aromatic carbon signal at δ 141.3. Next, since the signals at δ 146.8 and 143.3 could be assigned to the carbons (C-4‴ and C-1⁗) bearing an ether linkage by comparison of their chemical shifts with those of **10**, the observation of the corresponding cross peaks with the proton signals at δ 6.51 and 7.16 established the assignments of these signals to H-3‴ and

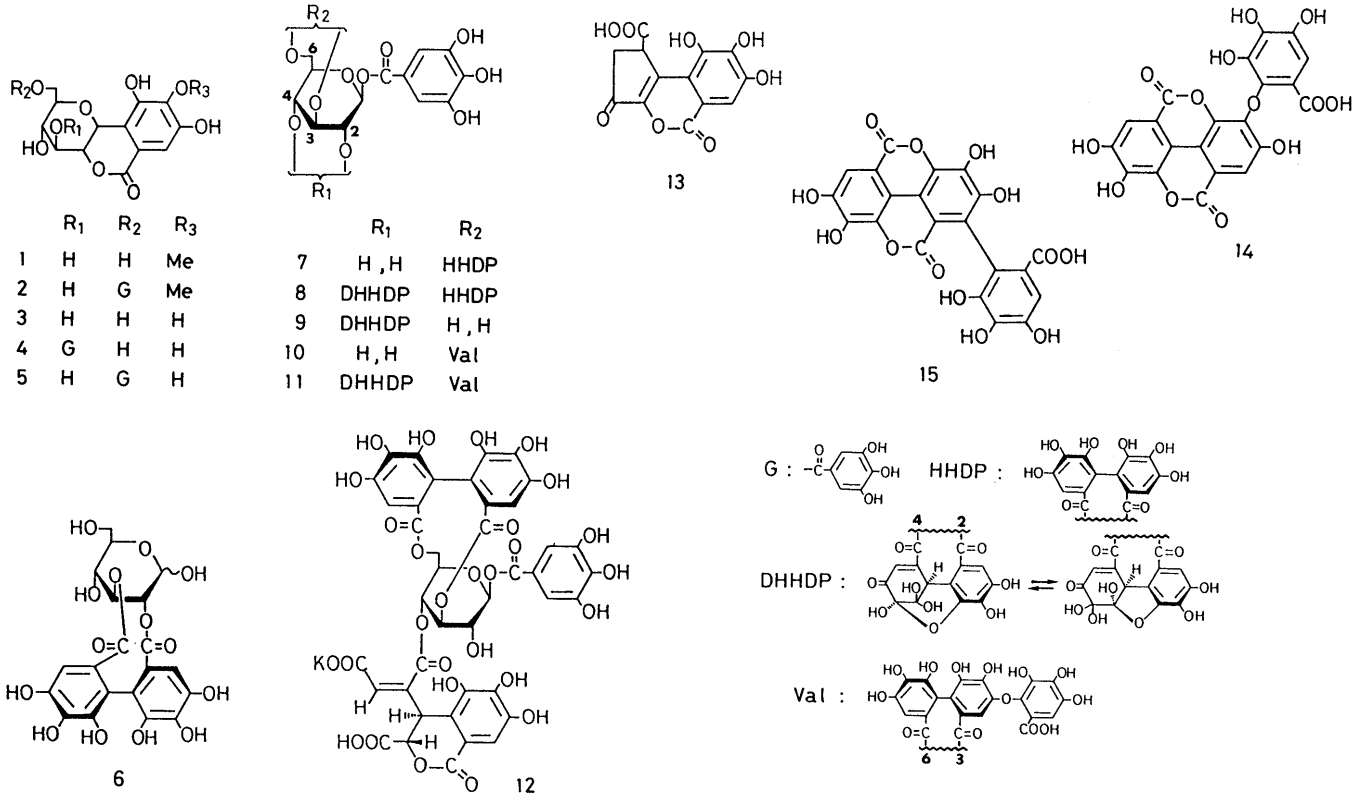

Chart 1

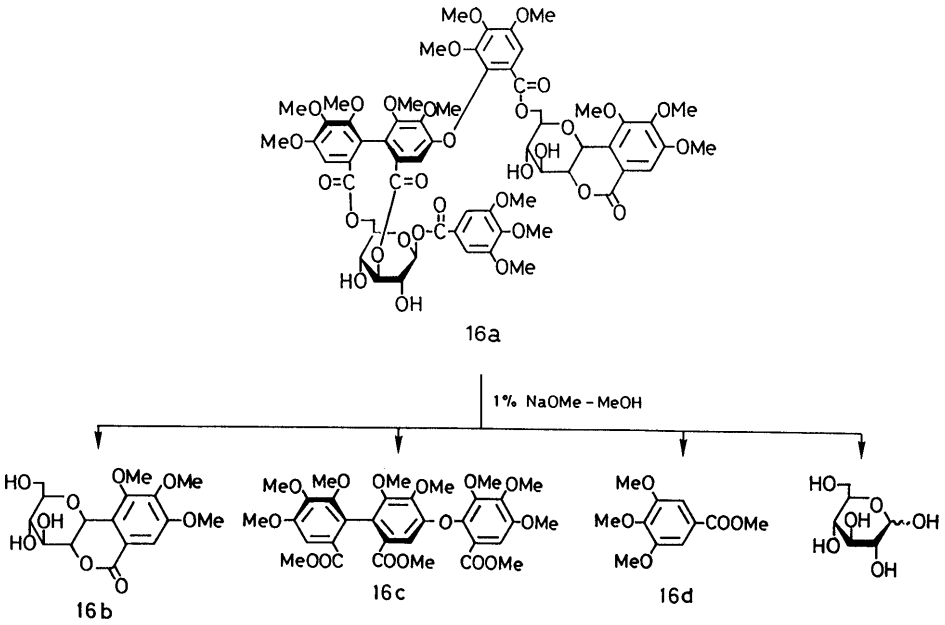

Chart 2

H-3''', respectively. The remaining proton signal at δ 6.72 was therefore attributable to H-3''. Furthermore, this H-3'' signal was found to be correlated with a carboxyl carbon signal at δ 168.4 through a three-bond coupling, and a similar long-range coupling was observed between the glucose H-6 signal and this carboxyl carbon signal. Thus, the orientation of the valoneayl group was considered to be as represented by the formula **16**. Further confirmation was obtained by hydrolytic studies; high-performance liquid chromatographic (HPLC) analysis of the partial hydrolysates obtained by treatment of **16** with weak alkali showed the presence of mallotinic acid (**10**), together with 1-desgalloylmallotinic acid (**17**), bergenin (**1**) and gallic acid. Based on the above-mentioned chemical and spectroscopic evidence, mallotannin A was assigned the structure **16**.

TABLE I. ^{13}C-NMR Spectral Data for Compounds **2**, **10**, **16**, **18** and **19**

			16[a]	**18**[b]	**10**[a]	**2**[a]	**19**[b]
Mallotinic acid moiety	Sugar	C-1	93.7	93.7	93.7		
		C-2	70.3	69.8	70.0		
		C-3	73.8	73.7	73.0		
		C-4	62.8	62.6	62.6		
		C-5	76.1	75.8	75.9		
		C-6	64.6	64.4	64.2		
	Valoneayl	C-1″	116.1	116.0	116.0		
		C-2″	125.7	125.3	125.8		
		C-3″	108.1	107.4	108.0		
		C-4″	144.9	145.4[c]	145.3		
		C-5″	136.8	136.9	136.7		
		C-6″	145.3	145.4[c]	145.4[c]		
		C-1‴	118.6	118.4	119.0		
		C-2‴	125.0	124.7	125.1		
		C-3‴	107.2	108.1	108.8		
		C-4‴	146.8	147.0	146.7		
		C-5‴	137.4	138.1[d]	138.8		
		C-6‴	145.3	144.8[c]	145.0[c]		
		C-1⁗	143.3	143.0	143.0		
		C-2⁗	114.4	114.6	114.6		
		C-3⁗	110.0	109.8	110.0		
		C-4⁗	140.3[c]	140.1[d]	139.8[d]		
		C-5⁗	139.6	138.1[d]	138.5		
		C-6⁗	137.7	139.9[d]	139.6[d]		
	Galloyl		120.9	120.4	120.8	121.2	121.0
			111.0 (2C)	110.0 (2C)	111.1 (2C)	109.9 (2C)	109.7 (2C)
			145.7 (2C)	145.7 (2C)[c]	145.7 (2C)	146.1 (2C)	145.6 (2C)
			140.1[c]	140.1[d]	140.3	139.1	138.7
	–COO–		165.3	165.9	165.3	166.8	167.1
			165.8	166.2	167.3		
			167.3	168.0	167.4		
			168.4	168.7	168.0		
Bergenin or glucose moiety	Sugar	C-1′	74.0	93.3 97.3		73.9	93.1 97.4
		C-2′	79.8	71.3 74.5		80.6	71.1 74.5
		C-3′	74.8	74.1 76.9		75.2	74.1 77.0
		C-4′	71.9	70.2 70.9		71.5	70.2 70.9
		C-5′	80.5	72.9 75.5		80.1	73.0 75.5
		C-6′	64.9	64.5 64.5		64.3	64.5 64.5
	Aromatic		117.0			116.6	
			119.3			119.3	
			110.5			110.4	
			151.5			151.8	
			141.3			141.3	
			148.7			148.9	
	–OMe–		60.8			60.7	
	–COO–		164.0			163.8	

a) Measured in acetone-d_6. *b*) Measured in acetone-d_6 + D_2O. *c*) and *d*) Assignments may be interchanged in each column.

The ^{1}H-NMR spectrum of mallotannin B (**18**) showed aromatic signals due to one galloyl group [δ 7.16 (2H, s)] and one valoneayl group [δ 6.53, 6.55, 6.73, 7.21 and 7.14 (3H in total, each s)]. The ^{13}C-NMR spectrum clearly showed the presence of two glucose moieties, one possessing no acyl group at the anomeric center [δ 93.3 (α), 97.3 (β)].

Prolonged heating of **18** in a mixture of dimethyl sulfate and potassium carbonate in dry acetone caused partial solvolysis to give methyl dodeca-*O*-methylmallotinate (**18a**).[1] The formation of **18a** confirmed the locations of the gallic acid ester group and two of the three ester groups in the valoneayl group, as well as the atropisomerism and the orientation of the valoneayl ester group.

In the ^{13}C-NMR spectrum of **18**, the chemical shifts of the sugar signals were almost identical with those of 6-*O*-galloyl-D-glucose (**19**) plus **10**. Methylation of **18** by the

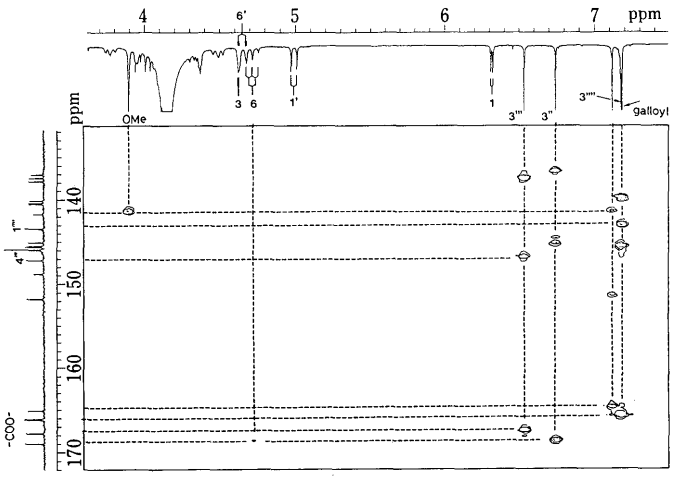

Fig. 1. ^{1}H–^{13}C Long-Range Shift Correlation Spectrum of **16** in Acetone-d_6 + D_2O (J_{CH} = 5 Hz)

Kuhn method, followed by alkaline methanolysis, yielded methyl 2,3,4-tri-*O*-methylglucopyranoside, thus establishing unequivocally the location of the 'branched' gallic acid moiety in the valoneayl group to be at the C-6 position of the glucose moiety. Accordingly, the structure of mallotannin B was represented by the formula **18**.

Mallotannins A (**16**) and B (**18**) are the first dimeric hydrolyzable tannins isolated from *Mallotus* species.

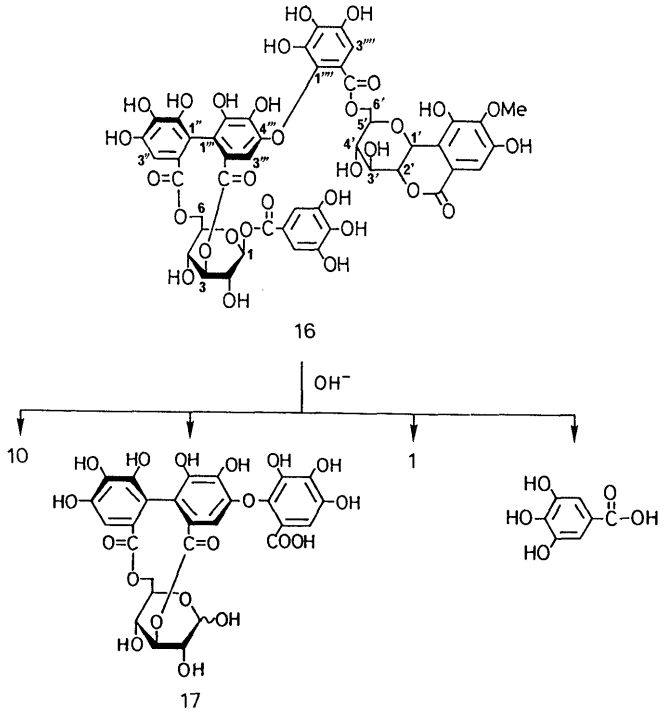

Chart 3

Considering the co-occurrence of corilagin (**7**)[2c] and 6-*O*-galloylbergenin (**2**)[2a] [6-*O*-galloylglucose (**19**)[2a]] in this plant material, mallotannins A and B are presumed to be biosynthetically produced by oxidative coupling of these compounds.

The phenolcarboxylic acids (such as hexahydroxydiphenic acid and valoneaic acid) in the hydrolyzable tannins were considered to be biosynthetically formed through oxidative carbon–carbon and/or carbon–oxygen coupling(s) of appropriately positioned gallic acid ester groups attached to the glucose moiety. Despite the fact that besides corilagin and geraniin, tannins (*e.g.*, mallotusinic acid and mallotinic acid) having the valoneayl group predominate in the extract, there was no biosynthetic evidence for the formation of this valoneayl group in the *Mallotus* species. The isolation of mallotannins A and B indicates that the valoneayl group is formed through an oxidative coupling of the hexahydroxydiphenoyl ester group and the galloyl group attached to the glucose moieties, and not produced from the hexahydroxydiphenoyl group and 'free' gallic acid. From this viewpoint, mallotannins A and B are regarded as precursors of mallotusinic acid and mallotinic acid.

Listed in Table II are tannins and related compounds isolated so far from *Mallotus* species. Based on their structural features, *Mallotus* tannins can be divided into four groups (I—IV). The first group is gallic acid esters with a variety of polyalcohols such as D-glucose, glycerol, shikimic acid and phenol glucosides. Among these compounds, a large accumulation of bergenin and its derivatives is one of the distinctive features in *Mallotus* plants. The ellagitannins (group II) were found to have two forms ($^4C_1$- and $^1C_4$-conformations) of glucose cores, although tannins (*e.g.*, corilagin, geraniin and punicafolin) having

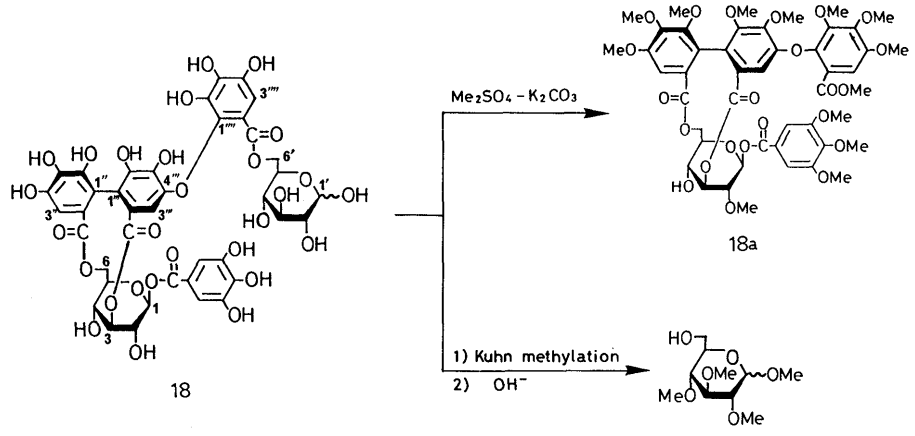

Chart 4

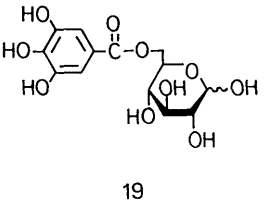

Chart 5

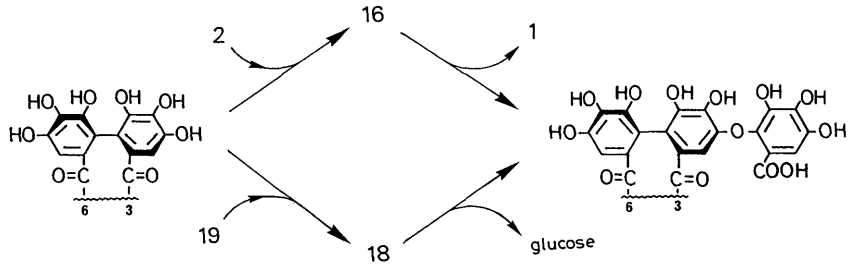

Chart 6. Possible Biosynthesis of the Valoneayl Group

TABLE II. Tannins and Related Compounds in the Plants of the Genus *Mallotus*

Group	Compounds	MJB[a]	MJL[b]	MRL[c]	MPL[d]
I	1-*O*-G-glucose (**20**)	+	+	+	−
	6-*O*-G-glucose (**19**)	+	+	−	−
	1,6-Di-*O*-G-glucose (**21**)	−	+	−	−
	1,2,3,6-Tetra-*O*-G-glucose (**22**)	+	−	−	−
	1,2,4,6-Tetra-*O*-G-glucose (**23**)	+	−	−	−
	1,2,3,4,6-Penta-*O*-G-glucose (**24**)	+	+	−	−
	1-*O*-G-glycerol (**25**)	−	+	−	−
	3-*O*-G-shikimic acid (**26**)	−	+	−	−
	4-OH-3-Me-phenol-1-*O*-(6′-*O*-G)-glucoside (**27**)	+	−	−	−
	4-OH-3-Me-phenol-1-*O*-(2′,6′-di-*O*-G)-glucoside (**28**)	+	−	−	−
	4-OH-3-Me-phenol-1-*O*-(2′,3′,6′-tri-*O*-G)-glucoside (**29**)	+	−	−	−
	4-OH-2-Me-phenol-1-*O*-(6′-*O*-G)-glucoside (**30**)	+	−	−	−
	4-OH-2,6-diMe-phenol-1-*O*-(6′-*O*-G)-glucoside (**31**)	+	−	−	−
	3,4,5-TriMe-phenol-1-*O*-(2′,6′-di-*O*-G)-glucoside (**32**)	+	−	−	−
	Bergenin (**1**)	+++	++	−	+++
	3-*O*-G-bergenin (**33**)	+++	−	−	−
	6-*O*-G-bergenin (**2**)	++	+	−	++
	3,4-Di-*O*-G-bergenin (**34**)	+	−	−	−
	3,6-Di-*O*-G-bergenin (**35**)	+	−	−	−
	3,4,6-Tri-*O*-G-bergenin (**36**)	+	−	−	−
	Norbergenin (**3**)	+	+	−	+++
	3-*O*-G-norbergenin (**4**)	+	+	−	++
	6-*O*-G-norbergenin (**5**)	+	+	−	++
II	2,3-(*S*)-HHDP-glucose (**6**)	++	−	−	+
	2,3-(*S*)-HHDP-4-*O*-G-glucose (**37**)	+	−	−	−
	2,3-(*S*)-HHDP-6-*O*-G-glucose (**38**)	+	−	−	−
	1,6-Di-*O*-G-2,3-(*S*)-HHDP-glucose (**39**)	+	−	−	−
	2,3-(*S*)-HHDP-4,6-di-*O*-G-glucose (**40**)	+	−	−	−
	1,4,6-Tri-*O*-G-2,3-(*S*)-HHDP-glucose (**41**)	+	−	−	−
	1-*O*-G-pedunculagin (**42**)	++	−	−	−
	Eugeniin (**43**)	−	−	+	−
	Corilagin (**7**)	+++	+++	++	++
	Punicafolin (**44**)	+	+	++	−
	1,2-Di-*O*-G-3,6-(*R*)-HHDP-glucose (**45**)	+	−	−	−
	1-*O*-DiG-3,6-(*R*)-HHDP-glucose (**46**)	+	−	−	−
	Geraniin (**8**)	+++	++	+++	+++
	Elaeocarpusin (**47**)	+	−	−	−
	Repandusinic acid A (**12**)	−	−	+	+
	Mallotinin (**48**)	+	−	+	−
	Mallotusinin (**49**)	+	−	−	−
III	Furosin (**9**)	++	+++	++	++
	Terchebin (**50**)	−	+	−	−
	Mallotinic acid (**10**)	+	++	++	+
	Mallotusinic acid (**11**)	+	+	++	+
	Repandusinin (**51**)	−	−	+	−
	Repandusinic acid B (**52**)	−	−	+	−
	Mallojaponin (**53**)	+	−	−	−
	Mallonin (**54**)	+	−	−	−
	Mallotannin A (**16**)	+	−	−	−
	Mallotannin B (**18**)	−	+	−	−
IV	Catechin (**55**)	+++	−	−	−
	Gallocatechin (**56**)	+++	−	−	−
	3-*O*-G-epicatechin (**57**)	++	−	−	−
	3-*O*-G-epigallocatechin (**58**)	+++	−	−	−
	Prodelphinidin B-3 (**59**)	+	−	−	−
	3′-*O*-G-prodelphinidin B-2 (**60**)	+	−	−	−
	3′-*O*-G-prodelphinidin B-4 (**61**)	++	−	−	−

G=galloyl; Me=methoxy; OH=hydroxy; HHDP=hexahydroxydiphenoyl. *a*) Fresh bark of *M. japonicus* (43.5 kg) collected at Fukuoka prefecture in Japan on May, 1987. −, not isolated; +, yield $<2\times10^{-5}$%; ++, yield $>2\times10^{-5}$%; +++, yield $>1\times10^{-4}$%. *b*) Fresh leaves of *M. japonicus* (32.3 kg) collected at Fukuoka prefecture in Japan on May, 1987. −, not isolated; +, yield $<2\times10^{-5}$%; ++, yield $>2\times10^{-5}$%; +++, yield $>1\times10^{-4}$%. *c*) Dried leaves of *M. repandus* (1.44 kg) collected at San-chi-Mon in Taiwan on May, 1987. −, not isolated; +, yield $<1\times10^{-4}$%; ++, yield $>1\times10^{-4}$%; +++, yield $>5\times10^{-4}$%. *d*) Dried leaves of *M. philippinensis* (1.80 kg) collected at San-chi-Mon in Taiwan on May, 1987. −, not isolated; +, yield $<1\times10^{-4}$%; yield $>1\times10^{-4}$%; +++, yield $>5\times10^{-4}$%.

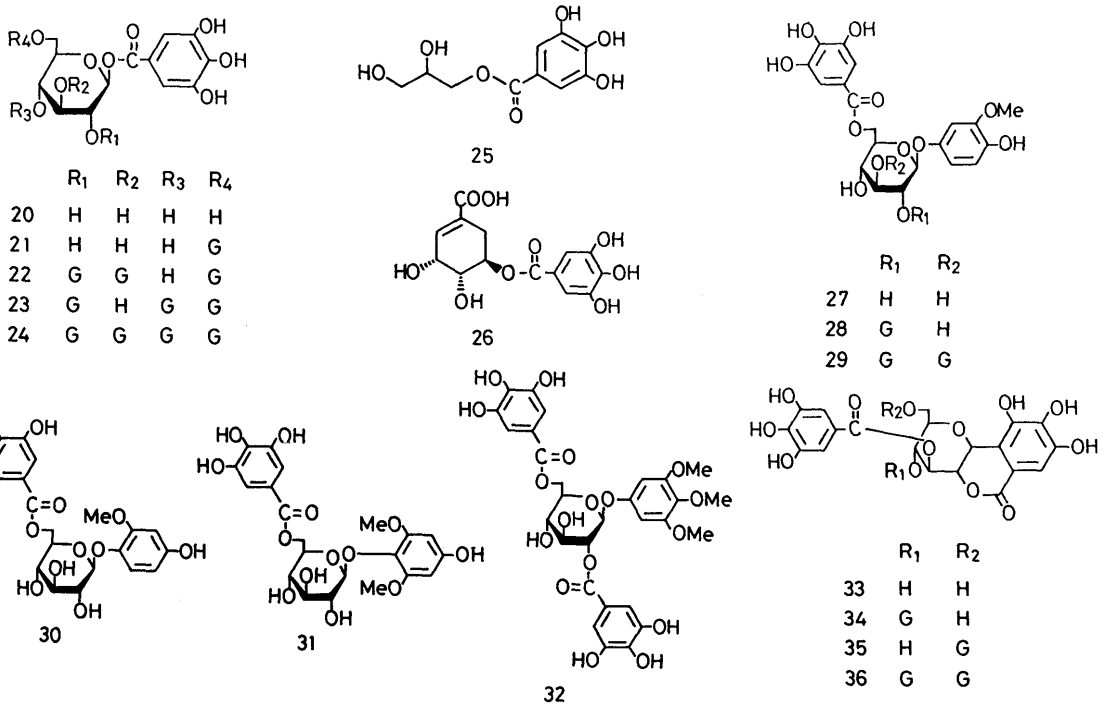

Chart 7

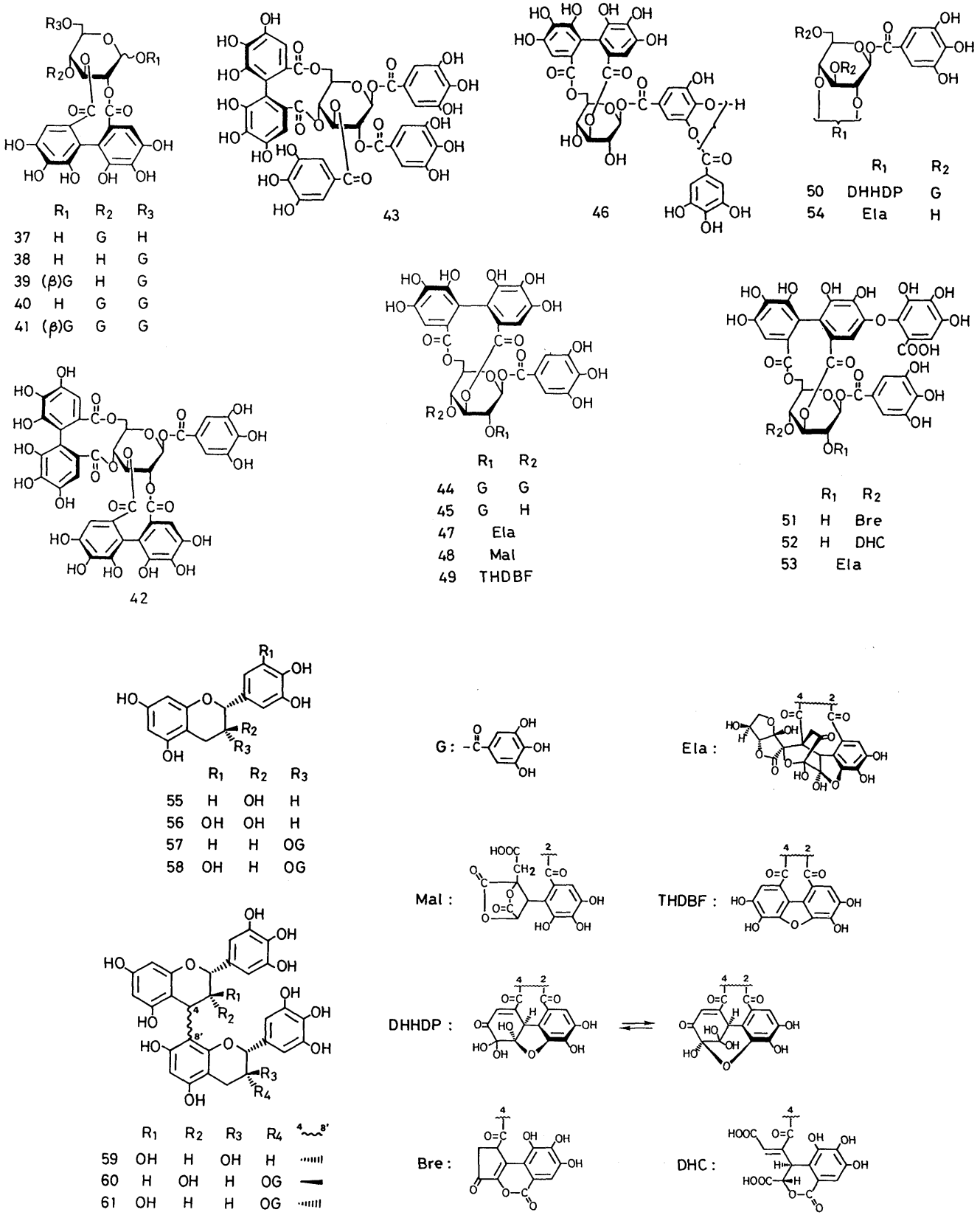

Chart 7

glucose with $^1C_4$-conformation predominate. One of the most distinctive features in *Mallotus* tannins is the presence of a variety of phenolcarboxylic acid moieties which seem to be derived biosynthetically from the dehydrohexahydroxydiphenoyl ester group (groups II, III) (Chart 8). Flavan-3-ols and prodelphinidins (group IV), which are units of condensed tannins, were found to occur only in the bark of *M. japonicus*.

Finally, it should be noted that the leaves of *M. paniculatus* (LAM.) MUELLER-ARG. and *M. moluccanus*

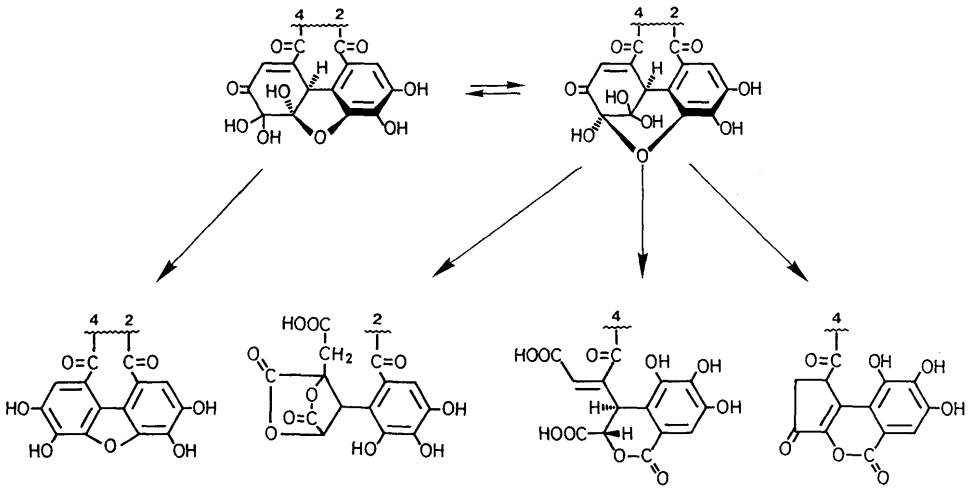

Chart 8

MUELLER-ARG. [= *Melanolepis multiglandulosa* (REINW.) REICH. f. & ZOLL.], collected in Taiwan, do not contain tannins.

Experimental

The instruments and chromatographic conditions used throughout this work are the same as described in the preceding paper.[1]

Isolation of Mallotannins A (16) and B (18) from *M. japonicus* Details of the fractionation of the 80% aqueous acetone extracts of the bark (43.5 kg) and the leaves (32.3 kg) were presented in the previous paper,[2] and the following fraction numbers correspond to those appearing in that paper.

Fraction II, obtained from the bark extract, was chromatographed over Sephadex LH-20 with EtOH to give five fractions (IIa—IIe). Fraction IIc was rechromatographed over MCI-gel CHP 20P with H_2O–MeOH (1 : 0—0 : 1), Sephadex LH-20 with 60% aqueous MeOH and Bondapak C_{18}/Porasil B with H_2O–MeOH (1 : 0—1 : 1) to give mallotannin A (**16**) (333 mg).

Fraction III from the leaf extract was divided by Sephadex LH-20 chromatography (EtOH) into two fractions (IIIa, IIIb). Fraction IIIb was rechromatographed over MCI-gel CHP 20P with H_2O–MeOH (1 : 0—3 : 7) and then over Bondapak C_{18}/Porasil B with H_2O–MeOH (1 : 0—2 : 3) to yield mallotannin B (**18**) (183 mg).

Mallotannin A (16) A tan amorphous powder, $[\alpha]_D^{26}$ −40.6° (c = 1.0, MeOH). *Anal.* Calcd for $C_{48}H_{40}O_{31}\cdot 2H_2O$: C, 50.17; H, 3.83. Found: C, 50.21; H, 3.95. Negative FAB-MS m/z: 1111 $(M-H)^-$. ^{1}H-NMR (acetone-d_6 + D_2O) ppm: 3.51 (1H, dd, J = 9, 10 Hz, H-4′), 3.88 (3H, s, OMe), 4.08 (1H, dd, J = 8, 10 Hz, H-6), 4.12 (1H, dd, J = 9, 10 Hz, H-2′), 4.29 (1H, dd, J = 8, 12 Hz, H-6′), 4.35 (1H, d, J = 3 Hz, H-4), 4.46 (1H, dd, J = 8, 10 Hz, H-5), 4.62 (1H, d, J = 3 Hz, H-3), 4.64 (1H, dd, J = 3, 12 Hz, H-6′), 4.68 (1H, t, J = 10 Hz, H-6), 4.98 (1H, d, J = 10 Hz, H-1′), 6.31 (1H, d, J = 4 Hz, H-1), 6.51, 6.72, 7.16 (each 1H, s, valoneayl H), 7.10 (1H, s, aromatic H), 7.16 (2H, s, galloyl H). ^{13}C-NMR: Table I.

Methylation of 16 A mixture of **16** (200 mg), dimethyl sulfate (1 ml) and anhydrous potassium carbonate (2 g) in dry acetone (20 ml) was refluxed for 1.5 h with stirring. After removal of inorganic salts by filtration, the filtrate was concentrated to a syrup, which was chromatographed over silica gel. Elution with benzene–acetone (3 : 1—2 : 1) furnished the tridecamethyl ether (**16a**) (117 mg) as a white amorphous powder, $[\alpha]_D^{26}$ −46.4° (c = 0.5, $CHCl_3$). *Anal.* Calcd for $C_{61}H_{66}O_{31}\cdot 2H_2O$: C, 55.04; H, 5.26. Found: C, 55.12; H, 5.20. FD-MS m/z: 1294 (M^+). ^{1}H-NMR ($CDCl_3$) ppm: 3.59—4.08 (42H in total, OMe), 5.12 (1H, br d, J = 10 Hz, H-6′), 5.22 (1H, d, J = 10 Hz, H-1′), 6.54 (1H, br s, H-1), 6.44, 6.78, 7.17, 7.41 (each 1H, s, aromatic H), 7.22 (2H, s, trimethoxybenzoyl H).

Methanolysis of 16a A solution of **16a** (40 mg) in 1% methanolic MeONa was stirred at room temperature for 1.5 h. The reaction mixture was neutralized with Amberlite IR-120B (H^+ form), and the solution was chromatographed over silica gel. Elution with hexane–acetone (4 : 1—1 : 3) afforded di-*O*-methylbergenin (**16b**) (8 mg), trimethyl (*R*)-octa-*O*-methylvaloneate (**16c**) (8 mg) and methyl trimethoxybenzoate (**16d**) (7 mg). **16b**: A white powder (MeOH), mp 196—198 °C, $[\alpha]_D^{18}$ −20.0° (c = 0.6, acetone). ^{1}H-NMR ($CDCl_3$) ppm: 3.86, 3.91, 3.96 (each 3H, s, OMe), 4.08 (1H, t, J = 10 Hz, H-2), 4.78 (1H, d, J = 10 Hz, H-1), 7.45 (1H, s, aromatic H). **16c**: A colorless syrup, $[\alpha]_D^{26}$ +14.0° (c = 0.4, $CHCl_3$). ^{1}H-NMR ($CDCl_3$) ppm: 3.48—4.07 (33H in total, OMe), 6.92, 7.30, 7.35 (each 1H, s, aromatic H). **16d**: Colorless prisms (MeOH), mp 81—82 °C. Successive elution of the above silica gel column with MeOH gave glucose, which was identified by co-chromatography on thin layer chromatography (TLC) (Avicel SF cellulose) [Rf 0.35; solvent: BuOH–pyridine–H_2O (6 : 4 : 3)].

Partial Hydrolysis of 16 A solution of **16** (20 mg) in 0.05% aqueous sodium hydroxide (3 ml) was heated at 60 °C for 48 h. The reaction mixture was directly analyzed by HPLC (column, Cosmosil 5Ph; solvent, 15% MeCN–50 mM H_3PO_4; flow rate, 1 ml/min) to detect mallotinic acid (**10**) (t_R 7.1 min), 1-desgalloylmallotinic acid (**17**) (t_R 3.7 min), bergenin (**1**) (t_R 5.7 min) and gallic acid (t_R 4.4 min).

Mallotannin B (18) A tan amorphous powder, $[\alpha]_D^{13}$ −73.1° (c = 1.1, MeOH). *Anal.* Calcd for $C_{40}H_{36}O_{28}\cdot 9/2\,H_2O$: C, 45.93; H, 4.31. Found: C, 46.01; H, 4.34. Negative FAB-MS m/z: 963 $(M-H)^-$. ^{1}H-NMR (acetone-d_6 + D_2O) ppm: 6.33 (1H, d, J = 4 Hz, H-1), 6.53, 6.55, 6.73, 7.12, 7.14 (3H, in total, each s, valoneayl H), 7.16 (2H, s, galloyl H). ^{13}C-NMR: Table I.

Methylation of 18 A mixture of **18** (40 mg), dimethyl sulfate (0.3 ml) and anhydrous potassium carbonate (400 mg) in dry acetone (7 ml) was refluxed for 6 h with stirring. The reaction mixture was worked up as described for **16** to furnish the tridecamethylate (**18a**) (17 mg) as a white amorphous powder, $[\alpha]_D^{13}$ −68.9° (c = 0.6, $CHCl_3$). ^{1}H-NMR ($CDCl_3$) ppm: 3.53—4.12 (39H in total, OMe), 6.25 (1H, br s, H-1), 6.40, 6.83, 7.21 (each 1H, s, aromatic H), 7.25 (2H, s, trimethoxybenzoyl H).

Methanolysis of 18a A solution of **18a** (10 mg) in 2% methanolic MeONa was stirred at room temperature for 8 h. The reaction mixture was worked up as described for **16a** to afford trimethyl (*R*)-octa-*O*-methylvaloneate (**16c**) (3 mg) and methyl trimethoxybenzoate (**16d**) (2 mg).

Permethylation of 18, Followed by Methanolysis A mixture of **18** (25 mg), methyl iodide (0.7 ml) and freshly prepared silver oxide (0.3 g) in dimethylformamide (1 ml) was stirred for 6 h with ice-cooling. After removal of the inorganics by filtration, the filtrate was concentrated, and extracted with ether. The organic layer was dried over Na_2SO_4 and concentrated to give a residue, which was passed through a silica gel column using benzene–acetone (1 : 1). A mixture of permethylates (α- and β-anomers) thus obtained was refluxed in 5% methanolic sodium hydroxide (1 ml) for 30 min. The mixture was neutralized with 3% methanolic hydrochloric acid, and the solution was concentrated to dryness under reduced pressure. The residue was passed through a silica gel column using hexane–ethyl acetate (1 : 2) to give a mixture of methyl sugars. Gas-liquid chromatographic analysis showed the presence of methyl 2,3,4-tri-*O*-methylglucopyranoside [t_R 4.05 min (α), 4.13 min (β); column, Neopentyl glycol succinate polyester 2%: N_2 flow rate, 60 ml/min; column temperature, 133 °C].

Isolation of Tannins from *M. philippinensis* The air-dried leaves (1.8 kg) of *M. philippinensis* (collected in Taiwan) were extracted with 80% aqueous acetone at room temperature. The acetone was removed by evaporation under reduced pressure (*ca.* 40 °C), and the resulting precipitates, consisting mainly of chlorophylls, 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 five fractions (I—V). Fraction I was rechromatographed over MCI-gel CHP 20P with H_2O–MeOH to afford norbergenin (**3**) (2.0 g) and brevifolin carboxylic acid (**13**) (267 mg). Fraction II was repeatedly chromatographed over MCI-gel CHP 20P with H_2O–MeOH, Sephadex LH-20 with EtOH and Bondapak C_{18}/Polasil B with H_2O–MeOH to give bergenin (**1**) (930 mg), 2,3-(*S*)-hexahydroxydiphenoyl-D-glucose (**6**) (81 mg) and repandusinic acid A monopotassium salt (**12**) (68 mg). On similar chromatographies, fraction III yielded corilagin (**7**) (356 mg) and flavogallonic acid (**15**) (531 mg), while fraction IV gave 6-*O*-galloylbergenin (**2**) (628 mg), 3-*O*-galloylnorbergenin (**4**) (193 mg), 6-*O*-galloylnorbergenin (**5**) (543 mg), furosin (**9**) (348 mg), mallotinic acid (**10**) (82 mg) and tergallic acid dilactone (**14**) (263 mg). Geraniin (**8**) (5.8 g) and mallotusinic acid (**11**) (134 mg) were obtained from fraction V by similar chromatographic separation. These compounds were identified by comparison of their physical and spectral data with those of authentic samples.

Acknowledgements The authors are grateful to Dr. T. Tanaka of Sankyo Co., Ltd. for provision of tannase, to Mr. Y. Tanaka, Miss Y. Soeda and Mr. R. Isobe for ^1H- and ^{13}C-NMR and MS measurements, and to the staff of the Central Analysis Room of this university for elemental analyses.

References

1) Part LXXXVII: R. Saijo, G. Nonaka and I. Nishioka, *Chem. Pharm. Bull.*, **37**, 2624 (1989).
2) *a*) R. Saijo, G. Nonaka and I. Nishioka, *Phytochemistry*, "in press"; *b*) *Idem, ibid.*, **28**, 2443 (1989), *c*) *Idem, Chem. Pharm. Bull.*, **37**, 2063 (1989).
3) T. Tanaka, G. Nonaka and I. Nishioka, *Chem. Pharm. Bull.*, **34**, 650 (1986).
4) T. Tanaka, G. Nonaka and I. Nishioka, *Phytochemistry*, **24**, 2075 (1985).
5) T. Tanaka, G. Nonaka, I. Nishioka, K. Miyahara and T. Kawasaki, *J. Chem. Soc., Perkin Trans. 1*, **1986**, 369.
6) T. Tanaka, G. Nonaka and I. Nishioka, *Chem. Pharm. Bull.*, **34**, 1039 (1986).
7) Y. Ikeya, H. Taguchi, I. Yosioka and H. Kobayashi, *Chem. Pharm. Bull.*, **27**, 1383 (1979).