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PISCIDIC ACID AND FUKIIC ACID ESTERS FROM *CIMICIFUGA SIMPLEX**

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Key Word Index—*Cimicifuga simplex*; Ranunculaceae; piscidic acid; piscidic acid esters; fukiic acid esters.

Abstract—Investigation of the underground parts of *Cimicifuga simplex* afforded five new piscidic acid esters and two new fukiic acid esters: 2-caffeoyl piscidic acid, 2-feruloyl piscidic acid, 2-isoferuloyl piscidic acid, 2-feruloyl piscidic acid-1-methyl ester, 2-isoferuloyl piscidic acid-1-methyl ester, 2-feruloyl fukiic acid-1-methyl ester, and 2-isoferuloyl fukiic acid-1-methyl ester. © 1998 Elsevier Science Ltd. All rights reserved

INTRODUCTION

The genus *Cimicifuga* has been studied by our group for more than twenty years. Triterpenic glycosides, caffeic acid derivatives, chromones and a carbazole alkaloid appear to be characteristic of this genus [1–4]. Phenolic constituents of *C. simplex*, grown in Japan, which is prescribed as one of source plants of Cimicifugae Rhizoma in Japanese and Chinese Pharmacopoeias [5, 6], are described in the present paper.

RESULTS AND DISCUSSION

Eight phenolic compounds were isolated by repeated column chromatography and reversed-phase HPLC from the methanol–water (1:1) extract of *Cimicifuga simplex*. They were identified as piscidic acid (**1**) [(2*S*,3*R*)-2,3-dihydroxy-4-(4-hydroxyphenyl)-3-carboxybutyric acid] [7–12], as well as five new piscidic acid esters (**2**–**6**) and two new fukiic acid esters (**7**, **8**).

Compound **2**, $[\alpha]_D + 67.3°$ was obtained as a pale yellow powder. The positive high resolution secondary ion mass spectrum (HR-SI-MS) showed the $[M + H]^+$ ion peak at *m*/*z* 419.0973, revealing its molecular formula as $C_{20}H_{18}O_{10}$, which was confirmed by ^1H and ^{13}C NMR spectra (Tables 1 and 2). The ^1H NMR spectrum of **2** showed signals for a caffeic acid and a piscidic acid moiety. A singlet (^1H, δ 5.62) was assigned to an ester carbinyl hydrogen (H-2) in the latter moiety. The positive SI-MS exhibited a significant base peak at *m*/*z* 163 due to a caffeoyl fragment and a peak at *m*/*z* 107 due to a *p*-hydroxybenzyl moiety of piscidic acid.

The heteronuclear multiple bond connectivity (HMBC) spectrum of **2** showed the cross peaks between H-2 and C-1″ (δ 168.31), and H-2 and C-3 (δ 79.90), suggesting that the caffeic acid moiety was linked to C-2 of the piscidic acid. A difference of the chemical shifts (Δ 1.07 ppm) between H-2 (δ 5.62) in the ^1H NMR spectrum of **2** and H-2 (δ 4.55) in that of **1** again supported the above assignment. Hydrolysis of **2** with 2 N NaOH gave **1** and caffeic acid (**9**), with a molar ratio (1:1). Thus, compound **2** was formulated as 2-caffeoyl piscidic acid.

Compound **3**, $[\alpha]_D + 50.3°$, $C_{21}H_{20}O_{10}$ and compound **4**, $[\alpha]_D + 37.6°$, $C_{21}H_{20}O_{10}$ were obtained as pale yellow powders. Similarly on the basis of the spectroscopic and chemical data, the structures of **3** and **4** were established as 2-feruloyl piscidic acid and 2-isoferuloyl piscidic acid, respectively. The ferulic acid moiety of **3** and the isoferulic acid moiety of **4** were confirmed by NOE between the methoxy group and the *ortho*-hydrogen.

Compound **5**, $[\alpha]_D + 32.8°$, was obtained as a pale yellow powder. The $[M + H]^+$ ion peak at *m*/*z* 447.1299 in HR-SI-MS revealed its molecular formula as $C_{22}H_{22}O_{10}$, which was confirmed by ^1H

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*Part 24 in the series "Constituents of *Cimicifuga* spp.", and Part 2 in the series "Phenolics of *Cimicifuga* spp." For part 23 see Ref. [1].

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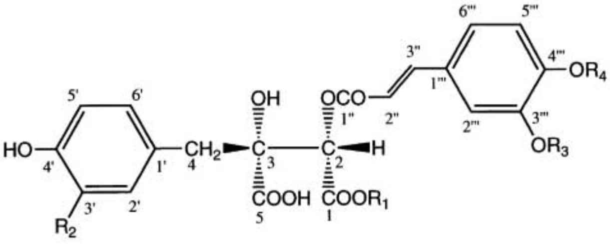
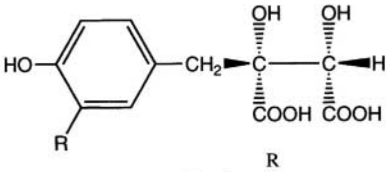
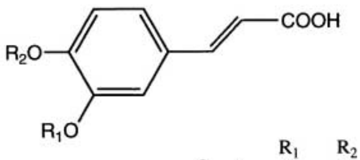


		R_1	R_2	R_3	R_4
2	:	H	H	H	H
3	:	H	H	Me	H
4	:	H	H	H	Me
5	:	Me	H	Me	H
6	:	Me	H	H	Me
7	:	Me	OH	Me	H
8	:	Me	OH	H	Me
12	:	H	OH	Me	H
13	:	H	OH	H	Me



		R
1	:	H
14	:	OH



		R_1	R_2
9	:	H	H
10	:	Me	H
11	:	H	Me

Table 1. ^{1}H NMR spectral data for **2**–**8**

H	**2**	**3**	**4**	**5**	**6**	**7**	**8**
2	5.62 *br s*	5.57 *br s*	5.63 *br s*	5.63 *br s*	5.63 *br s*	5.62 *br s*	5.63 *br s*
4	2.98 *d* (13.5)	2.97 *d* (13.6)	2.98 *d* (13.6)	2.95 *d* (13.5)	2.94 *d* (13.6)	2.92 *d* (13.6)	2.91 *d* (13.7)
	3.05 *d* (13.5)	3.03 *d* (13.6)	3.06 *d* (13.6)	3.09 *d* (13.5)	3.07 *d* (13.6)	3.05 *d* (13.6)	3.03 *d* (13.7)
$COOCH_3$	–	–	–	3.70 *s*	3.70 *s*	3.69 *s*	3.70 *s*
2′	7.08 d (8.5)	7.10 *d* (8.4)	7.09 *d* (8.6)	7.08 *d* (8.4)	7.08 *d* (8.5)	6.75 *d* (2.2)	6.74 *d* (2.3)
3′	6.65 *d* (8.5)	6.64 *d* (8.4)	6.66 *d* (8.6)	6.65 *d* (8.4)	6.64 *d* (8.5)	–	–
5′	6.65 *d* (8.5)	6.64 *d* (8.4)	6.66 *d* (8.6)	6.65 *d* (8.4)	6.64 *d* (8.5)	6.64 *d* (8.2)	6.64 *d* (8.3)
6′	7.08 *d* (8.5)	7.10 *d* (8.4)	7.09 *d* (8.6)	7.08 *d* (8.4)	7.08 *d* (8.5)	6.60 *dd* (8.2, 2.2)	6.60 *dd* (8.3, 2.3)
2″	6.39 *d* (16.0)	6.46 *d* (16.1)	6.46 *d* (15.9)	6.51 *d* (16.1)	6.46 *d* (16.0)	6.50 *d* (16.1)	6.46 *d* (16.0)
3″	7.70 *d* (16.0)	7.72 *d* (16.1)	7.73 *d* (15.9)	7.78 *d* (16.1)	7.74 *d* (16.0)	7.78 *d* (16.1)	7.74 *d* (16.0)
2‴	7.09 *d* (2.2)	7.23 *d* (2.3)	7.12 *d* (2.3)	7.22 *d* (2.3)	7.13 *d* (2.3)	7.24 *d* (2.3)	7.14 *d* (2.3)
5‴	6.80 *d* (8.5)	6.82 *d* (8.5)	6.96 *d* (8.3)	6.82 *d* (8.4)	6.96 *d* (8.4)	6.83 *d* (8.5)	6.96 *d* (8.3)
6‴	7.00 *dd* (8.5, 2.2)	7.10 *dd* (8.5, 2.3)	7.11 *dd* (8.3, 2.3)	7.12 *dd* (8.4, 2.3)	7.11 *dd* (8.4, 2.3)	7.12 *dd* (8.5, 2.3)	7.11 *dd* (8.3, 2.3)
OCH_3	–	3.90 *s*	3.89 *s*	3.90 *s*	3.89 *s*	3.89 *s*	3.89 *s*

Chemical shifts are in δ values and are followed by multiplicities and *J* values (in Hz), and obtained on a JEOL ALPHA-400 in CD_3OD soln.

Table 2. ^{13}C NMR spectral data for **2**–**8**

C	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	170.58	170.44	170.28	169.16	169.02	169.17	169.95
2	79.61	78.16	78.08	77.67	77.83	77.71	78.08
3	79.90	80.02	80.09	79.50	80.63	79.57	80.07
4	41.93	41.88	41.92	41.75	42.35	42.00	41.85
5	174.85	174.96	174.43	174.23	174.40	174.65	174.69
$COOCH_3$	–	–	–	52.78	52.67	52.71	51.98
1′	127.66	127.96	127.57	127.38	127.32	127.77	127.47
2′	132.64	132.69	132.59	132.39	132.37	118.66	118.67
3′	115.78	115.68	115.77	115.64	115.53	145.47	145.37
4′	157.32	157.27	157.30	157.07	157.77	145.07	145.19
5′	115.78	115.68	115.77	115.64	115.53	115.74	115.67
6′	132.64	132.69	132.59	132.39	132.37	122.91	122.95
1″	168.31	168.38	168.09	167.90	167.76	167.90	167.81
2″	114.50	114.59	115.47	114.12	114.71	114.14	114.90
3″	148.08	148.03	147.68	148.17	147.63	148.15	147.72
1‴	127.85	128.18	128.96	127.31	128.68	127.43	128.59
2‴	115.31	111.94	114.96	111.62	114.44	111.66	115.26
3‴	146.89	149.43	148.09	149.16	147.81	149.19	148.01
4‴	149.82	150.82	151.72	150.65	151.50	150.69	151.75
5‴	116.60	116.52	112.65	116.35	112.48	116.36	112.31
6‴	123.20	124.26	122.99	123.01	122.96	124.31	122.95
OCH_3	–	56.55	56.44	56.47	56.36	56.44	56.40

Chemical shifts are in δ values and measured at 100.4 MHz in CD_3OD soln.

and ^{13}C NMR spectra (Tables 1 and 2). Comparison between the ^{1}H NMR spectrum of **5** and that of **3** showed that they were similar, only different in an additional methoxy signal (δ 3.69), suggesting the presence of a carbomethoxy group, instead of one of two carboxyl groups of **3**. A cross-peak between the methoxy group and C-1 (δ 169.17) in the HMBC spectrum confirmed the esterification site at C-1 not C-5 (δ 174.65). Hydrolysis of **5** with 2 N NaOH yielded **1** and **10** with a molar ratio (1:1). Thus, compound **5** was 2-feruloyl piscidic acid-1-methyl ester, which was confirmed as a natural product not as an artifact by HPLC analysis of the acetone–water (1:1) extract.

Compound **6**, $[\alpha]_D + 33.6°$, $C_{22}H_{22}O_{10}$, compound **7**, $[\alpha]_D + 41.3°$, $C_{22}H_{22}O_{11}$, and compound **8**, $[\alpha]_D + 36.4°$, $C_{22}H_{22}O_{11}$ were obtained as pale yellow powders. Similarly, they were formulated as 2-isoferuloyl piscidic acid-1-methyl ester (**6**), 2-feruloyl fukiic acid (= cimicifugic acid A (**12**) [1])-1-methyl ester (**7**), and 2-isoferuloyl fukiic acid (= cimicifugic acid B (**13**) [1])-1-methyl ester (**8**), which were confirmed as natural products as **5**.

EXPERIMENTAL

General

^{1}H (400 MHz) and ^{13}C (100 MHz) NMR: JEOL α-400, and chemical shifts are given in δ values (ppm); SI-MS: Hitachi M-80 mass spectrometer using glycerol as the matrix agent; $[\alpha]_D$: JASCO digital polarimeter measured in MeOH at 25°C; UV spectra: Shimadzu UV-2100 measured in MeOH at 25°C. IR spectra: Perkin-Elmer 1720X-FT IR spectrometer; mp: Yamagimoto micromelting apparatus (uncorr.). Chromatography was carried out on a Diaion HP-20 (NIPPON RENSUI CO.), a silica gel (Wakogel C-200) and an ODS-A YMC. The HPLC procedure used a JASCO PU-980 pump equipped with a JASCO 875-UV detector, 254 and 280 nm, and a JASCO Model 807-IT Integrator. TLC was carried out on precoated Kieselgel $60F_{254}$ (Merck) or RP-$8F_{254}$ (Merck) reversed-phase plates with $CHCl_3$–MeOH (1:99) and MeOH–H_2O (1:1), and spots were detected by 40% H_2SO_4 spray followed by heating on a hot plate, or exposure under a National UV (6 W) lamp.

Isolation of compounds **1-8**

The dried rhizomes (1.1 kg) of *Cimicifuga simplex*, which was transplanted from Ibuki mountainous area of Shiga Prefecture in Japan and has been cultivated in the research station of Osaka University of Pharmaceutical Sciences for several years, were extracted with MeOH (5 l × 3) at room temp. overnight. The MeOH soln was concentrated *in vacuo* to yield a viscous extract (*ca.* 300 ml). The concentrated extract was suspended in H_2O (100 ml) and the mixture was shaken with *n*-BuOH-EtOAc (1:1) (200 ml) three times.

The water soluble layer was chromatographed on a Diaion HP-20 column (500 ml, i.d. 5.5 × 70 cm). After elution with H_2O (3 l), the adsorbed fraction was eluted with MeOH (500 ml). The MeOH eluate was concentrated *in vacuo* to gummy extracts (3.5 g) and these were rechromatographed on an ODS column (80 g, i.d. 3.0 × 20 cm) and eluted with MeOH–H_2O (2:1 to 1:0). Fractions eluted with MeOH–H_2O (2:1) (2.5 g) was chromatographed on a silica gel column (90 g, i.d. 4.0 × 20 cm) and eluted with $CHCl_3$–MeOH (10:1 to 1:5).

Elution with $CHCl_3$–MeOH (1:2) provided gummy eluates (1.0 g), 1% HCl solution of which was stirred at room temp. for 1 h. The acidic solution was rechromatographed on a Diaion HP-20 (i.d. 3 × 20 cm). Elution with H_2O provided arginine (main) and histidine (minor), which were identified by TLC, ^{1}H NMR spectra, and amino acid analysis. Eluates (300 mg) with MeOH–H_2O (5:1 to 1:0) were subjected repeatedly to preparative HPLC [column: Cosmosil 5C_{18}-AR-II (5 μm, i.d. 10.0 × 250 mm) and Cosmosil 10 Ph (10 μm, i.d. 8.0 × 250 mm); solvent: MeCN-1% AcOH (5:95 to 15:85); column temperature: 40°C; effluent rate: 2 ml/min]. Elution with MeCN-1% AcOH (5:95) afforded, in order of their t_R, piscidic acid (**1**, 6 mg), and compound **2** (20 mg). Eluates with MeCN-1% AcOH (15:85) afforded, in order of their t_R, compounds **3** (12 mg), **4** (10 mg), **5** (6 mg), **6** (4 mg), **7** (10 mg), and **8** (8 mg), respectively.

Piscidic acid (**1**)

A white powder from $CHCl_3$–MeOH, $[\alpha]_D + 42.8°$ (MeOH; *c* 0.80). The reported $[\alpha]_D + 41.0°$(H_2O; *c* 2.65 at 20°C) [10]. UV λ_{max}^{MeOH} nm (log ε): 277.5 (3.17), 255 (3.88). $C_{11}H_{12}O_7$. HR-SI-MS *m/z*: 257.0667 [(M + H)$^+$, error: 0.7 mmu], SI-MS *m/z* (rel. int.): 257 (M + H)$^+$ (13.5), 231 (100), 107 (17.8), 86 (75.9), 72 (62.5), 45 (18.3), 30 (10.5). IR ν_{max}^{KBr} cm^{-1}: 3450 (OH), 3400–2450 (OH, COOH), 1729 (bicarboxylic), 1615, 1595, 1515 (aromatic ring), 1447. ^{1}H NMR (CD_3OD) δ: 2.97 (2H, *m*, H-4), 4.55 (1H, *s*, H-2), 6.72 (2H, *d*, *J* = 7.9 Hz, H-3′, 5′), 7.04 (2H, *d*, *J* = 7.9 Hz, H-2′, 6′). ^{13}C NMR (CD_3OD) δ: 174.88 (C-1), 76.57 (C-2), 81.44 (C-3), 41.98 (C-4), 176.18 (C-5), 128.10 (C-1′), 132.16 (C-2′), 116.24 (C-3′), 156.53 (C-4′), 116.24 (C-5′), 132.16 (C-6′). Compound **1** was identified as piscidic acid by comparison of these data with the reported data [10].

Compound **2**

A pale yellow powder, $[\alpha]_D + 67.3°$ (MeOH; *c* 0.34), UV λ_{max}^{MeOH} nm (log ε): 332 (4.25), 291 (4.07), 248 *sh* (4.02). $C_{20}H_{18}O_{10}$. HR-SI-MS *m/z*: 419.0973 ([M + H]$^+$, error: −0.4 mmu), SI-MS *m/z* (rel. int.): 419 [M + 1]$^+$ (2.1), 163 (100), 107 (5.4), 86

(15.9), 44 (4.4), 30 (3.3). IR ν_{max}^{KBr} cm^{-1}: 3416 (OH), 1698, 1658 (bicarboxylic, conjugated carboxyl), 1601, 1516 (aromatic ring). ^{1}H NMR and ^{13}C NMR δ: Tables 1 and 2.

Compound **3**

A pale yellow powder, $[\alpha]_D + 50.3°$ (MeOH; *c* 0.21), UV λ_{max}^{MeOH} nm (log ε): 325 (4.16), 291 (3.98). $C_{21}H_{20}O_{10}$. HR-SI-MS *m/z*: 433.1132 ([M + H]$^+$, error: −0.2 mmu), SI-MS *m/z* (rel. int.): 433 [M + 1]$^+$ (12.9), 194 (13.8), 177 (100), 110 (18.5), 107 (19.7), 86 (71.8), 70 (85.1), 45 (18.4), 30 (10.0). IR ν_{max}^{KBr} cm^{-1}: 3430 (OH), 1717 (bicarboxylic, conjugated carboxyl), 1596, 1559 (aromatic ring). ^{1}H and ^{13}C NMR δ: Tables 1 and 2. NOE: Me (δ 3.90) and H-2‴ (δ 7.23). HMBC: cross peaks between H-2 (δ 5.57) and C-1″ (δ 168.38), H-2 and C-3 (δ 80.02). Acylation shift of H-2 between **1** and **3**: Δ 1.02 ppm. Hydrolysis of **3** with 2 N NaOH yielded **1** and **10** (1:1).

Compound **4**

A pale yellow powder, $[\alpha]_D + 37.6°$ (MeOH; *c* 0.52), UV λ_{max}^{MeOH} nm (log ε): 326 (4.25), 297 (4.19), 245 *sh* (4.10). $C_{21}H_{20}O_{10}$. HR-SI-MS *m/z*: 433.1138 ([M + H]$^+$, error: 0.5 mmu), SI-MS *m/z* (rel. int.): 433 [M + 1]$^+$ (4.6), 194 (6.2), 177 (100), 107 (7.3), 86 (74.4), 70 (80.2). IR ν_{max}^{KBr} cm^{-1}: 3429 (OH), 1715 (bicarboxylic, conjugated carboxyl), 1614, 1515 (aromatic ring). ^{1}H and ^{13}C NMR δ: Tables 1 and 2. HMBC: cross peaks between H-2 (δ 5.63) and C-1″ (δ 168.09), H-2 and C-3 (δ 80.09). Acylation shift of H-2 between **1** and **4**: Δ 1.08 ppm. Hydrolysis of **3** with 2 N NaOH yielded **1** and **11** (1:1).

Compound **5**

A pale yellow powder, $[\alpha]_D + 32.8°$ (MeOH; *c* 0.33), UV λ_{max}^{MeOH} nm (log ε): 326.5 (4.24), 292.5 *sh* (4.07), 246 *sh* (4.03). $C_{22}H_{22}O_{10}$. HR-SI-MS *m/z*: 447.1299 ([M + H]$^+$, error: 1.0 mmu), SI-MS *m/z* (rel. int.): 447 [M + 1]$^+$ (2.3), 319 (7.6), 182 (24.8), 177 (100), 107 (20.0), 81 (20.2), 69 (29.0), 56 (25.2), 42 (23.8). IR ν_{max}^{KBr} cm^{-1}: 3424 (OH), 1720 (ester C=O, carbonate), 1596, 1516 (aromatic ring), 1439. ^{1}H and ^{13}C NMR δ: Tables 1 and 2. HMBC: cross peaks between OMe (δ 3.70) and C-1 (δ 169.17).

Compound **6**

A pale yellow powder, $[\alpha]_D + 33.6°$ (MeOH; *c* 0.20), UV λ_{max}^{MeOH} nm (log ε): 325 (3.97), 295.5 (3.93), 245 *sh* (3.92). $C_{22}H_{22}O_{10}$. HR-SI-MS *m/z*: 447.1289 ([M + H] + , error: 0.0 mmu), SI-MS *m/z* (rel. int.): 447 [M + 1]$^+$ (3.5), 319 (12.8), 201 (18.2), 177 (100), 115 (22.4), 107 (20.3), 81 (13.0), 69 (20.2), 56 (20.0), 44 (40.0). IR ν_{max}^{KBr} cm^{-1}: 3455 (OH), 1721 (ester C=O, carbonate), 1611, 1515 (aromatic ring), 1440. ^{1}H and ^{13}C NMR δ: Tables 1 and 2. HMBC: cross peaks between OMe (δ 3.70) and C-1 (δ 169.95).

Compound **7**

A pale yellow powder, $[\alpha]_D + 41.3°$ (MeOH; *c* 0.42), UV λ_{max}^{MeOH} nm (log ε): 327.5 (4.36), 291.5 (4.25), 235.5 *sh* (4.36). $C_{22}H_{22}O_{11}$. HR-SI-MS *m/z*: 463.1248 ([M + H]$^+$, error: 0.9 mmu), SI-MS *m/z*: 463 [M + 1]$^+$ (5.3), 177 (100), 163 (16.9), 123 (14.2), 86 (5.0), 44 (9.0). IR ν_{max}^{KBr} cm^{-1}: 3425 (OH), 1722 (ester C=O, carbonate), 1601, 1516 (aromatic ring), 1448. ^{1}H and ^{13}C NMR δ: Tables 1 and 2. HMBC: cross peaks between OMe (δ 3.69) and C-1 (δ 169.16).

Compound **8**

A pale yellow powder, $[\alpha]_D + 36.4°$ (MeOH; *c* 0.37), UV λ_{max}^{MeOH} nm (log ε): 325.5 (4.22), 290 (4.19), 235 sh (4.30). $C_{22}H_{22}O_{11}$. HR-SI-MS *m/z*: 463.1234 ([M + H]$^+$, error: −0.5 mmu), SI-MS *m/z*: 463 [M + 1]$^+$ (4.7), 177 (100), 163 (22.1), 123 (16.1), 86 (12.0), 44 (34.4). IR ν_{max}^{KBr} cm^{-1}: 3413 (OH), 1723 (ester C=O, carbonate), 1606, 1516 (aromatic ring), 1444. ^{1}H and ^{13}C NMR δ: Tables 1 and 2. HMBC: cross peaks between OMe (δ 3.70) and C-1 (δ 169.02).

Hydrolysis of **2**–**8**

2 (15 mg) was dissolved in 2N NaOH (2 ml) under a nitrogen atmosphere, and stirred for 5 h at 25°C. After the solution was adjusted to pH 2.5 by 2 N HCl, the acidic solution was shaken with EtOAc (30 ml × 3), and after washing the joined EtOAc layer with water, the organic layer was concentrated *in vacuo*. The residues were recrystallized from MeOH–H_2O and caffeic acid (**9**, 4 mg) was obtained as yellowish crystals of mp 213°C, and identified by comparison of ^{1}H and ^{13}C NMR and IR spectra, t_R of HPLC with an authentic sample. The above aqueous layer was subjected to chromatography on a Diaion HP-20 (i.d. 1.0 × 10 cm). After elution with H_2O (300 ml), the adsorbed fraction was eluted with H_2O–MeOH (1:4 to 0:1). The eluates with H_2O–MeOH (1:4) were subjected repeatedly to preparative HPLC [column: Cosmosil 5C$_{18}$-AR-II (5 μm, i.d. 10.0 × 250 mm); solvent: MeCN-1% AcOH (10:90); column temperature: 40°C; effluent rate: 2 ml/min] to yield **1** (6 mg), which was identified with piscidic acid by comparison of ^{1}H and ^{13}C NMR and IR spectra, and t_R of HPLC with an authentic specimen. The molar ratio (1:1) of **1** and **9** was confirmed by HPLC of the hydrolysis products just after the adjustment to *p*H 2.5, using the calibration curves of the authentic specimens.

By the same treatments as in **2**, 2 N NaOH hydrolysis of **3** (10 mg) yielded **10** (2 mg) and **1** (3 mg), and that of **4** (9 mg) yielded **11** (2 mg) and **1** (3 mg), respectively. The similar HPLC analysis confirmed the molar ratio (1:1) of the products as follows: **1** and **10** from **5**, **1** and **11** from **6**, fukiic acid (**14**) [8] and **10** from **7**, **14** and **11** from **8**.

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