Identification of Six New Minor Diarylheptanoids from the Seeds of *Alpinia katsumadai*

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Phytochemical investigation of the seeds of *Alpinia katsumadai* (Zingiberaceae) led to the isolation and identification of six new diarylheptanoid derivatives, katsumains D–G (**1**–**4**), 3-(acetyloxy)-alpinikatin (**5**), and 5-(acetyloxy)alpinikatin (**6**). The structures of **1**–**6** were elucidated by spectroscopic data analysis including 1D- and 2D-NMR experiments.

Introduction. – *Alpinia katsumadai* HAYATA (Zingiberaceae) has been widely cultivated in South and Southeast Asia [1][2]. The seeds of *A. katsumadai* have been used as an oriental traditional medicine to treat emesis and gastric disorders [3][4]. Several secondary metabolites such as diarylheptanoids [1][4–8], flavonoids [2][4][6][9], stilbenes [2], and terpenoids [10] have been reported previously from this plant. Some of these isolates have diverse biological activities such as antioxidant [11], anti-emetic [12][13], antiviral [7], cytoprotective [14], and heat shock protein inducing [8] effects.

In the present study, compounds **1**–**6** were isolated and elucidated as the new diarylheptanoids, katsumains D–G (**1**–**4**), 3-(acetyloxy)alpinikatin (**5**), and 5-(acetyloxy)alpinikatin (**6**) from the seeds of *A. katsumadai* (*Fig. 1*).

Results and Discussion. – Compound **1** was obtained as a yellow powder. Its molecular formula was established as $C_{35}H_{34}O_7$ by HR-ESI-MS (*m*/*z* 567.2377 ($[M+H]^+$)). The ^{1}H- and ^{13}C-NMR spectra of **1** (*Tables 1* and *2*) exhibited signals for two sets of *para*-substituted benzene rings at δ(H) 7.30/δ(C) 128.3 and 6.88/116.0, δ(H) 7.63/δ(C) 131.4 and 6.93/116.8, and δ(C) 160.7, 158.1, 133.2, and 128.1, and a monosubstituted benzene ring at δ(H) 7.23/δ(C) 129.1, 7.19/129.2, and 7.10–7.14/126.3, and δ(C) 143.7. Four CH_2 groups were observed at δ(H) 2.70–2.78 and 2.58–2.65/δ(C) 32.9, 2.50 and 2.01–2.09/37.5, 1.64–1.77/41.5, and 2.45–2.51 and 1.29–1.32/42.0, and three CH groups appeared at δ(H) 3.39–3.46/δ(C) 28.6, 3.68–3.72/68.7, and 4.95/78.9. Resonances for an olefinic functionality appeared at δ(H) 7.93 (H–C(8‴))/δ(C) 125.3 (C(8‴)) and 7.79 (H–C(9‴))/143.5 (C(9‴)) with a large coupling constant (15.2 Hz), indicating *trans*-configuration. A *s* at δ(H) 15.19 (OH–C(2‴)) in the ^{1}H-NMR spectrum of **1** in (D_6)acetone, *i.e.*, a characteristic peak for a H-bonded OH group, seemed to arise from a H-bond system involving the C=O group at δ(C) 193.6 (C(7‴)).

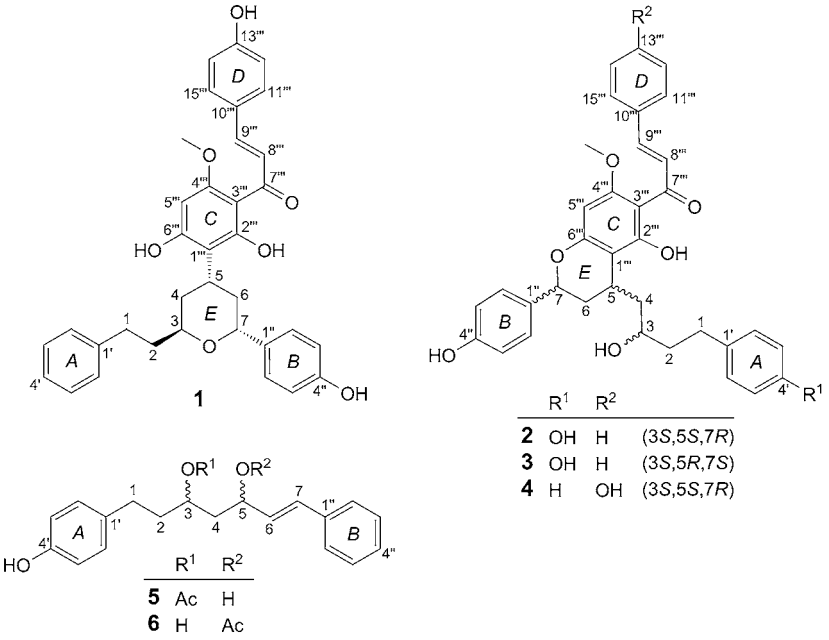

Fig. 1. *Compounds* **1**–**6** *isolated from the seeds of* Alpinia katsumadai. Trivial atom numbering.

The NMR resonances at δ(H) 3.98 (3 H, *s*)/δ(C) 56.4 indicated the presence of a MeO functionality attached to an aromatic group [15]. This MeO group was assigned to position C(4‴) by the three-bond HMBC MeO–C(4‴)/C(4‴). In addition, an isolated aromatic H-atom appeared at δ(H) 6.09 (*s*, H–C(5‴))(δ(C) 92.9). The relative position of substituents at ring *C* was deduced as shown in *Fig. 1* by the HMBC cross-peaks H–C(5‴)/C(1‴), C(3‴), C(4‴), and C(6‴), OH–C(2‴)/C(1‴), C(2‴), and C(3‴), CH_2(4)/C(1‴), H–C(5)/C(1‴), and CH_2(6)/C(1‴). These NMR data of **1** were very similar to those of the known compound calyxin L [16], except for the absence of a *para*-hydroxy group in ring *A* of **1**. The HMBCs H–C(2′,6′)/C(1), H–C(2″,6″)/C(7), and H–C(11‴,15‴)/C(9‴) suggested that rings *A*, *B*, and *D* could be assigned at C(1), C(7), and C(9‴), respectively. The linkage between C(5) and C(1‴) was determined by the HMBC cross-peaks CH_2(4), H–C(5), and CH_2(6)/C(1‴). In the ^{1}H-NMR spectrum, compound **1** showed H–C(7) at δ(H) 4.95, suggesting that **1** was an aliphatic ether *i.e.* had a tetrahydro-2*H*-pyran moiety [16]. Further detailed analysis of the ^{1}H,^{1}H-COSY, ^{1}H,^{1}H-NOESY, ^{1}H,^{13}C-HSQC, and ^{1}H,^{13}C-HMBC data (*Fig. 2*) allowed unambiguous assignments of all ^{1}H- and ^{13}C-NMR signals of **1**. The relative configurations at C(3), C(5), and C(7) were determined by the NOESY correlations as shown in *Fig. 3*, *i.e.*, H–C(5)/H–C(7), H–C(5)/H_{ax}–C(4), H–C(3)/H_{eq}–C(4), H–C(3)/H_{ax}–C(6), H–C(7)/H_{ax}–C(4), H_{eq}–C(4)/H_{ax}–C(6), and H_{eq}–C(6)/H_{ax}–C(4). These correlations indicated that H_{ax} –C(4), H–C(5), and H–C(7) were *cis* positioned to each other. The absolute configuration at C(3) could be assumed as (*S*) in view of the biogenesis [17–19]. Thus, the absolute configuration of **1** was supposed to be

Table 1. *^{1}H-NMR Data of Compounds* **1**–**6**[a]). Atom numbering as indicated in *Fig. 1*. δ in ppm, J in Hz.

H-Atom	**1**[b])	**2**[b])	**3**[c])	**4**[b])	**5**[d])	**6**[d])
CH_2(1)	2.70–2.78, 2.58–2.65 (2*m*)	2.70–2.78, 2.62–2.69 (2*m*)	2.65–2.77, 2.61–2.64 (2*m*)	2.81–2.88, 2.73–2.78 (2*m*)	2.51–2.56 (*m*)	2.62–2.69, 2.51–2.59 (2*m*)
CH_2(2)	1.64–1.77 (*m*)	1.77–1.83 (*m*)	1.72–1.83 (*m*)	1.84–1.88 (*m*)	1.87–1.91 (*m*)	1.64–1.78 (*m*)
H–C(3)	3.68–3.72 (*m*)	3.83–3.84 (*m*)	3.79–3.83 (*m*)	3.84–3.86 (*m*)	4.99–5.05 (*m*)	3.57–3.63 (*m*)
CH_2(4)	2.45–2.51, 1.29–1.32 (2*m*)	2.01–2.09, 1.76–1.82 (2*m*)	2.00–2.09, 1.72–1.79 (2*m*)	2.02–2.09, 1.76–1.84 (2*m*)	1.93–1.99, 1.78–1.85 (2*m*)	1.78–1.95 (*m*)
H–C(5)	3.39–3.46 (*m*)	3.42–3.45 (*m*)	3.19–3.21 (*m*)	3.41–3.44 (*m*)	4.27 (*q*, *J* = 6.8)	5.56 (*q*, *J* = 6.8)
CH_2(6) or H–C(6)	2.50 (*d*, *J* = 14.0), 2.01–2.09 (*m*)	2.26 (*d*, *J* = 13.6), 1.94 (*dt*, *J* = 13.6, 5.2)	2.38 (*d*, *J* = 13.7), 1.98 (*dt*, *J* = 13.7, 5.0)	2.25 (*d*, *J* = 14.0), 1.94 (*dt*, *J* = 14.0, 4.0)	6.17 (*dd*, *J* = 15.8, 6.8)	6.14 (*dd*, *J* = 15.6, 6.8)
H–C(7)	4.95 (*dd*, *J* = 10.2, 2.2)	5.17 (*dd*, *J* = 12.0, 2.0)	5.26 (*dd*, *J* = 11.9, 1.3)	5.17 (*dd*, *J* = 12.0, 1.4)	6.52 (*d*, *J* = 15.8)	6.62 (*d*, *J* = 15.6)
H–C(2′,6′)	7.23 (*d*, *J* = 7.2)	7.07 (*d*, *J* = 8.4)	7.06 (*d*, *J* = 8.4)	7.24–7.26 (*m*)	6.97 (*d*, *J* = 8.4)	6.99 (*d*, *J* = 8.4)
H–C(3′,5′)	7.19 (*d*, *J* = 7.2)	6.74 (*d*, *J* = 8.4)	6.74 (*d*, *J* = 8.4)	7.24–7.26 (*m*)	6.65 (*d*, *J* = 8.4)	6.65 (*d*, *J* = 8.4)
H–C(4″)	7.10–7.14 (*m*)			7.14–7.17 (*m*)		
H–C(2″,6″)	7.30 (*d*, *J* = 8.6)	7.30 (*d*, *J* = 8.6)	7.33 (*d*, *J* = 8.4)	7.30 (*d*, *J* = 8.4)	7.37 (*d*, *J* = 7.2)	7.39 (*d*, *J* = 7.2)
H–C(3″,5″)	6.88 (*d*, *J* = 8.6)	6.89 (*d*, *J* = 8.6)	6.89 (*d*, *J* = 8.4)	6.88 (*d*, *J* = 8.4)	7.30 (*t*, *J* = 7.2)	7.30 (*t*, *J* = 7.2)
H–C(4″)					7.19–7.23 (*m*)	7.21–7.25 (*m*)
OH–C(2‴)	15.19 (*s*)	14.90 (*s*)	15.09 (*s*)	15.14 (*s*)		
MeO–C(4‴)	3.98 (*s*)	3.98 (*s*)	3.99 (*s*)	3.97 (*s*)		
H–C(5‴)	6.09 (*s*)	6.06 (*s*)	6.07 (*s*)	6.04 (*s*)		
H–C(8‴)	7.93 (*d*, *J* = 15.2)	8.07 (*d*, *J* = 15.6)	8.08 (*d*, *J* = 15.6)	7.94 (*d*, *J* = 15.4)		
H–C(9‴)	7.79 (*d*, *J* = 15.2)	7.80 (*d*, *J* = 15.6)	7.81 (*d*, *J* = 15.6)	7.79 (*d*, *J* = 15.4)		
H–C(11‴,15‴)	7.63 (*d*, *J* = 8.8)	7.75 (*d*, *J* = 6.6)	7.76 (*d*, *J* = 6.6)	7.63 (*d*, *J* = 8.4)		
H–C(12‴,14‴)	6.93 (*d*, *J* = 8.8)	7.46 (*d*, *J* = 6.6)	7.48 (*d*, *J* = 6.6)	6.93 (*d*, *J* = 8.4)		
H–C(13‴)		7.38–7.48 (*m*)	7.37–7.48 (*m*)			
MeCO					1.99 (*s*)	2.01 (*s*)

[a]) $SiMe_4$ was used as an internal standard. [b]) In (D_6)acetone at 400 MHz. [c]) In (D_6)acetone at 600 MHz. [d]) In CD_3OD at 400 MHz.

Table 2. *^{13}C-NMR Data of Compounds* **1**–**6**[a]). Atom numbering as indicated in *Fig. 1.* δ in ppm.

C-Atom	**1**[b])	**2**[b])	**3**[c])	**4**[b])	**5**[d])	**6**[d])
C(1)	32.9	32.0	31.8	33.0	31.8	32.0
C(2)	41.5	41.0	41.1	40.8	37.6	40.7
C(3)	68.7	68.1	70.7	68.6	72.9	68.4
C(4)	42.0	41.8	43.5	42.1	42.7	43.1
C(5)	28.6	26.4	28.4	26.5	70.9	74.4
C(6)	37.5	33.5	34.9	33.7	133.1	128.5
C(7)	78.9	75.3	75.5	75.3	131.6	134.4
C(1′)	143.7	134.2	134.3	143.8	134.4	134.2
C(2′,6′)	129.1	130.1	130.2	129.2	130.3	130.4
C(3′,5′)	129.2	115.9	115.9	129.4	116.2	116.1
C(4′)	126.3	156.2	156.2	126.5	158.4	156.4
C(1″)	133.2	133.1	133.0	133.2	138.4	137.8
C(2″,6″)	128.3	128.7	128.7	128.8	127.5	127.7
C(3″,5″)	116.0	116.0	116.0	116.1	129.6	129.7
C(4″)	158.1	158.2	158.2	158.3	128.6	129.0
C(1‴)	108.6	108.3	108.1	108.3		
C(2‴)	167.3	166.0	166.5	166.5		
C(3‴)	106.9	106.4	106.3	106.5		
C(4‴)	161.6	161.9	162.0	161.9		
*Me*O-C(4‴)	56.4	56.4	56.4	56.4		
C(5‴)	92.9	92.6	92.7	92.5		
C(6‴)	164.2	162.9	162.9	162.7		
C(7‴)	193.6	193.5	193.4	193.5		
C(8‴)	125.3	128.4	128.5	125.3		
C(9‴)	143.5	142.7	142.9	143.6		
C(10‴)	128.1	136.5	136.5	128.2		
C(11‴,15‴)	131.4	129.3	129.3	131.4		
C(12‴,14‴)	116.8	129.9	129.9	116.9		
C(13‴)	160.7	131.0	131.1	160.8		
*Me*CO					21.2	21.3
Me*C*O					172.8	172.2

[a]) $SiMe_4$ was used as an internal standard. [b]) In (D_6)acetone at 100 MHz. [c]) In (D_6)acetone at 150 MHz. [d]) In CD_3OD at 100 MHz.

(3*S*,5*S*,7*R*). As a result, the structure of **1** was elucidated as (2*E*)-1-{2,4-dihydroxy-6-methoxy-3-[(2*R*,4*S*,6*S*)-tetrahydro-2-(4-hydroxyphenyl)-6-(2-phenylethyl)-2*H*-pyran-4-yl]phenyl}-3-(4-hydroxyphenyl)prop-2-en-1-one and named katsumain D.

Compound **2** was obtained as a yellow powder, and the molecular formula was determined to be $C_{35}H_{34}O_7$ by HR-ESI-MS (*m*/*z* 567.2367 ($[M+H]^+$)). The ^{1}H- and ^{13}C-NMR spectra of **2** (*Tables 1* and *2*) showed quite similar patterns to those of the reported compound, epicalyxin F [20], except for the absence of a *para*-OH group in ring *D* of **2**. Thus in the ^{1}H- and ^{13}C-NMR spectra of **2**, the resonances for a monosubstituted benzene ring at δ(H) 7.75/δ(C) 129.3, 7.46/129.9, and 7.38–7.48/131.0, and δ(C) 136.5 were the differences to those of epicalyxin F [20]. At a glance, the NMR spectra of **2** looked similar to those of **1**; however, **2** had a different skeleton from that of **1** as shown in *Fig. 1*. Further detailed analysis of the ^{1}H,^{1}H-COSY, ^{1}H,^{1}H-NOESY,

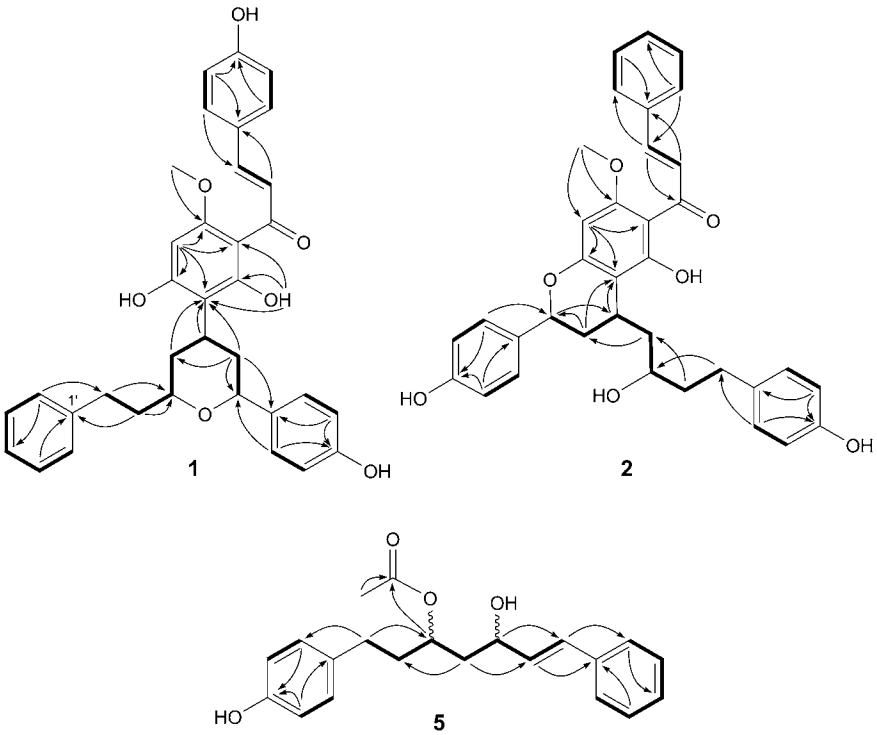

Fig. 2. *Important* $^1H,^1H$*-COSY* (—) *and HMB* (H → C) *correlations of* **1**, **2**, *and* **5**

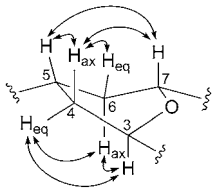

Fig. 3. *Key* $^1H,^1H$*-NOESY* (↔) *correlations of* **1**

$^1H,^{13}C$-HSQC, and $^1H,^{13}C$-HMBC data (*Fig. 2*) allowed unambiguous assignments of all ^1H- and ^{13}C-NMR signals of **2**. In the NOESY plot, the correlations H–C(5)/H_b–C(6) and H–C(7)/H_a–C(6) indicated that H–C(5) and H–C(7) had *trans* configuration. On the other hand, a molecular modeling program (MM3 of CAChe™ 5.0) was utilized to solve the relative configurations at C(3) and C(5). When an energy-minimized molecular model was built for compound **2** with the configurations (3*S**) and (5*S**), the calculated interatomic distance between H–C(3) and H–C(5) was 3.3 Å (> 3 Å) which could not be expected to give rise to an NOE correlation [21][22], as shown in *Fig. 4*; this was confirmed by the absence of a correlation between H–C(3)

and H–C(5) in the NOESY plot. The absolute configuration of **2** was determined as (3*S*,5*S*,7*R*), according to the method described in [17–20]. Thus, the structure of **2** was established as (2*E*)-1-{(2*R*,4*S*)-3,4-dihydro-5-hydroxy-4-[(2*S*)-2-hydroxy-4-(4-hydroxyphenyl)butyl]-2-(4-hydroxyphenyl)-7-methoxy-2*H*-1-benzopyran-6-yl}-3-phenylprop-2-en-1-one and named katsumain E.

Compound **3** was obtained as a yellow powder. The molecular formula was $C_{35}H_{34}O_7$, as established by HR-ESI-MS (*m*/*z* 567.2374 ($[M+H]^+$)). The ^{1}H- and ^{13}C-NMR spectra of **3** (*Tables 1* and *2*) were almost identical with those of **2**, except for the signals in the aliphatic region. Four CH_2 groups showed resonances at δ(H) 2.65–2.77 (H_a–C(1)) and 2.61–2.64 (H_b–C(1))/δ(C) 31.8 (C(1)), 1.72–1.83 (CH_2(2))/41.1 (C(2)), 2.00–2.09 (H_a–C(4)) and 1.72–1.79 (H_b–C(4))/43.5 (C(4)), and 2.38 (H_a–C(6)) and 1.98 (H_b–C(6))/34.9 (C(6)). Three CH groups appeared at δ(H) 3.79–3.83 (H–C(3))/δ(C) 70.7 (C(3)), 3.19–3.21 (H–C(5))/28.4 (C(5)), and 5.26 (H–C(7))/75.5 (C(7)). It was inferred that **2** and **3** were stereoisomers, according to the ^{1}H,^{1}H-COSY, ^{1}H,^{1}H-NOESY, ^{1}H,^{13}C-HSQC, and ^{1}H,^{13}C-HMBC data. On the other hand, the NMR data of **3** were also very similar to those of calyxin F [16], except for the absence of a *para*-OH group in ring *D* of **3**. In particular, compound **3** showed identical NMR data for the aliphatic region including C(1)–C(7); therefore, the relative configurations at C(3), C(5), and C(7) of **3** were assigned as (3*S**), (5*R**), and (7*S**), identical to those of calyxin F [16]. In the NOESY plot of **3**, the correlations H–C(5)/H_b–C(6) and H–C(7)/H_a–C(6), without a correlation H–C(5)/H–C(7), indicated that H–C(5) and H–C(7) were *trans* positioned to each other. To solve the relative configuration at C(3) and C(5), an energy minimized molecular model of compound **3** with (3*S**) and (5*R**) was constructed. The interatomic distance between H–C(3) and H–C(5) of **3** was calculated as 2.4 Å (< 3 Å; *Fig. 4*) which is expected to give rise to an NOE correlation [21][22]; this was confirmed by a correlation between H–C(3) and H–C(5) in the NOESY plot **3**. Thus, the absolute configurations at C(3), C(5), and C(7) of **3** were determined as (3*S*,5*R*,7*S*), respectively, according to the method described in [17–19]. As a result, the structure of **3** was established as (2*E*)-1-{(2*S*,4*R*)-3,4-dihydro-5-hydroxy-4-[(2*S*)-2-hydroxy-4-(4-hydroxyphenyl)butyl]-2-(4-hydroxyphenyl)-7-methoxy-2*H*-1-benzopyran-6-yl}-3-phenylprop-2-en-1-one and named, katsumain F.

Compound **4** was obtained as a yellow powder. Its molecular formula $C_{35}H_{34}O_7$ was determined on the basis of the HR-ESI-MS (*m*/*z* 567.2373 ($[M+H]^+$)). The ^{1}H- and ^{13}C-NMR spectra of **4** (*Tables 1* and *2*) showed similar patterns to those of **2**, except for the signals from rings *A* and *D*. The rings *A* (monosubstituted benzene ring) and *D* (*para*-substituted benzene ring) were assigned to C(1) and C(9‴), respectively, by the HMBCs H–C(2′,6′)/C(1) and H–C(11‴,15‴)/C(9‴) which were opposite to those of compound **2**. The NMR data of **4** were also identical to those of the reported compound epicalyxin F [20], except for the absence of a *para*-OH group in ring *A* of **4**. Further detailed analysis of the ^{1}H,^{1}H-COSY, ^{1}H,^{1}H-NOESY, ^{1}H,^{13}C-HSQC, and ^{1}H,^{13}C-HMBC data allowed unambiguous assignments of all ^{1}H- and ^{13}C-NMR signals of **4**. The relative configuration of C(3), C(5), and C(7) of **4** was determined by comparison of the ^{1}H- and ^{13}C-NMR chemical shifts with those of epicalyxin F [20] and by the NOESY correlations. The important NOEs H–C(5)/H_b–C(6) and H–C(7)/H_a–C(6) indicated that H–C(5) and H–C(7) were *trans* positioned to each other. The

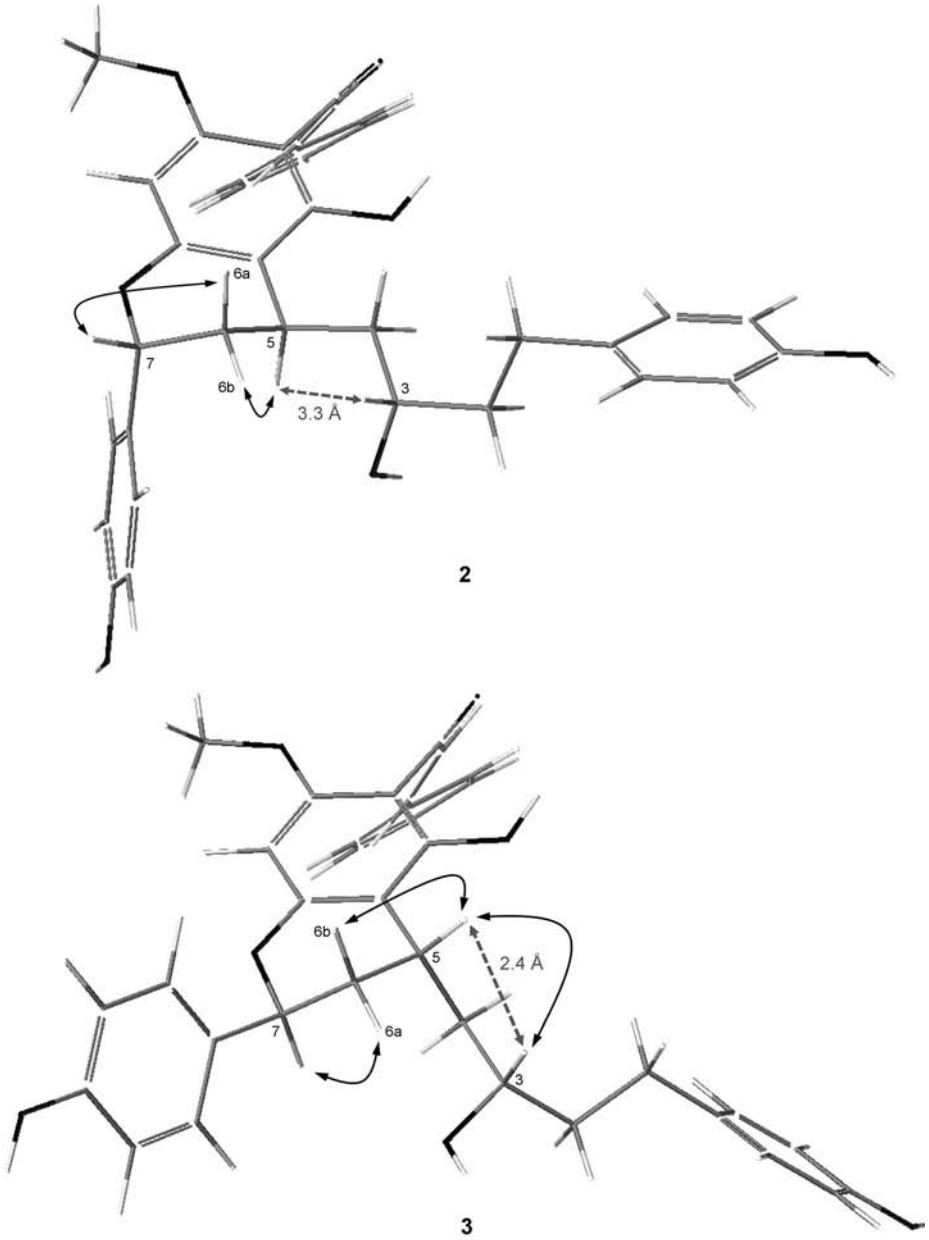

Fig. 4. *Key* $^1H,^1H$*-NOESY* (↔) *correlations of* **2** *and* **3**. Interatomic distances in Å.

relative configurations at C(3) and C(5) were deduced as (*S**,*S**) by the absence of an NOE correlation between H–C(3) and H–C(5), as described above for compound **2** (calculated interatomic distance of 3.8 Å in **3** (> 3 Å) [21][22]). Thus the absolute

configurations of **4** were determined as (3*S*,5*S*,7*R*), by comparison with the data of epicalyxin F [20]. As a result, the structure of **4** was elucidated as (2*E*)-1-{(2*R*,4*S*)-3,4-dihydro-5-hydroxy-2-(4-hydroxyphenyl)-4-[(2*S*)-2-hydroxy-4-phenylbutyl]-7-methoxy-2*H*-1-benzopyran-6-yl}-3-(4-hydroxyphenyl)prop-2-en-1-one and named, katsumain G.

Compound **5** was obtained as a colorless gum. The molecular formula of **5** was determined as $C_{21}H_{24}O_4$ on the basis of the HR-ESI-MS (*m*/*z* 341.1745 ($[M+H]^+$)). The DEPT 135 NMR spectrum of **5** showed three CH_2 groups (C(1), C(2), and C(4)), two CH groups (C(3) and C(5)), and one Me group(*Me*CO). The ^{1}H- and ^{13}C-NMR spectra of **5** (*Tables 1* and *2*) exhibited signals at δ(H) 6.97/δ(C) 130.3, 6.65/116.2, 7.37/127.5, 7.30/129.6, and 7.19–7.23/128.6, and δ(C) 134.4, 158.4, and 138.4 for two substituted benzene rings. In the ^{1}H-NMR spectrum of **5**, a *trans*-olefinic group appeared at δ(H) 6.17 (*dd*, $J=15.8$, 6.8 Hz, H–C(6)) and 6.52 (1 H, *d*, $J=15.8$, H–C(7)). A Me group appeared at δ(H) 1.99/δ(C) 21.2 which was connected to an ester CO at δ(C) 172.8 (Me*C*O) in the HMBC experiment of **5**. The position of the AcO group was assigned at C(3) by the HMBC δ(H) 4.99–5.05 (H–C(3))/δ(C) 172.8 (Me*C*O). The HMBCs CH_2(1)/C(2′,6′), H–C(7)/C(2″,6″), and H–C(6)/C(1″) provided the strong evidences for the positions of rings *A* and *B* at C(1) and C(7), respectively. These NMR data were similar to those of alpinikatin [8], except for the presence of an acetyloxy group at C(3) in **5** instead of an OH group in alpinikatin. Further detailed analysis of ^{1}H,^{1}H-COSY, ^{1}H,^{1}H-NOESY, ^{1}H,^{13}C-HSQC, and ^{1}H,^{13}C-HMBC data (*Fig. 2*) allowed unambiguous assignments of all ^{1}H- and ^{13}C-NMR signals of **5**. Compound **5** was optically inactive, an evidence for the presence of a racemic mixture. Thus, the structure of **5** was established as (1*E*)-7-(4-hydroxy-phenyl)-1-phenyl-hept-1-ene-3,5-diol 5-acetate and named, 3-(acetyloxy)alpinikatin.

Compound **6** was also obtained as a colorless gum, and the molecular formula was determined as $C_{21}H_{24}O_4$ by HR-ESI-MS (*m*/*z* 341.1749 ($[M+H]^+$)). The ^{1}H- and ^{13}C-NMR spectra of **6** (*Tables 1* and *2*)were very similar to those of compound **5**, except for the position of the AcO group at C(5) in **6**, instead of C(3) in **5**. Thus, it was inferred that **5** and **6** are regioisomers. The position of the AcO group of **6** was assigned at C(5) by the HMBC δ(H) 5.56 (H–C(5))/δ(C) 172.2 (Me*C*O). The rings *A* and *B* of **6** were assigned to C(1) and C(7), respectively, on the basis of the HMBCs of CH_2(1)/C(2′,6′) and H–C(2″,6″)/C(7). Compound **6** was also optically inactive; therefore, **6** was considered as a racemic mixture, and thus, the structure of **6** was determined as (1*E*)-7-(4-hydroxyphenyl)-1-phenylhept-1-ene-3,5-diol 3-acetate and named 5-(acetyloxy)alpinikatin.

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Experimental Part

General. Column chromatography (CC): silica gel (SiO_2; 230–400 mesh, *Merck*, Germany) and *YMC* gel *ODS-A* (S-150 μm, *YMC Co., Ltd.*, Japan). TLC: silica gel *60* F_{254} and *RP-18* F_{254s} silica gel

plates (*Merck*, Germany); spot observation under UV light and visualization by spraying with 10% aq. H_2SO_4 soln., followed by heating at 120° for 5 min. HPLC: prep. HPLC *Acme 9000* (*Young Lin*, Republic of Korea), equipped with a *J'sphere ODS-H80* column (S-4 μm, 250 mm × 20 mm; *YMC Co., Ltd.*, Japan); t_R in min. UV Spectra: *Hitachi U-3000* spectrophotometer; λ_{max} (log ε) in nm. Optical rotations: *Jasco P-1010* polarimeter. NMR spectra: *Varian Unity Inova 400* and *Bruker AVANCE 600* FT-NMR instruments, with Me_4Si as internal standard, chemical shift δ in ppm; *J* in Hz. MS: *Waters Acquity-UPLC* system coupled to a *Micromass-Q-Tof Micro* mass spectrometer and *Agilent-6220-Accurate-Mass* TOF LC/MS system; in *m*/*z*.

Plant Material. The seeds of *A. katsumadai* (Zingiberaceae) were purchased from the Kyungdong Oriental Herbal Market in Seoul, South Korea, in May 2010 and identified by Prof. *Je-Hyun Lee* (College of Oriental Medicine, Dongguk University, Korea). A voucher specimen (No. EA299) was deposited with the Natural Product Chemistry Laboratory, College of Pharmacy, Ewha Womans University, Korea.

Extraction and Isolation. The seeds of *A. katsumadai* (5.4 kg) were extracted with MeOH at r. t. (3 × 9 l, overnight). The extracts were concentrated *in vacuo* at 40° to afford a MeOH-soluble residue (788 g), which was then suspended in H_2O (4 l) and partitioned with hexane (1 × 4 l), AcOEt (6 × 4 l), and BuOH (4 × 4 l), sequentially. The AcOEt extract (150 g) was subjected to CC (SiO_2 (2 kg), 0.5 → 10% MeOH/CH_2Cl_2): *Frs. 1–16*. *Fr. 11* (6.150 g) was applied to CC (*ODS-A* (100 g), MeCN/H_2O 1:1): *Frs. 11.01–11.17*. *Fr. 11.08* (258 mg) was subjected to CC (SiO_2 (10 g), 5 → 50% acetone/hexane): *Frs. 11.08.01–11.08.12*. *Fr. 11.08.07* was purified by prep. HPLC (*ODS-H80*, MeOH/0.1% aq. formic acid 73:27, 2 ml/min): **5** (t_R 63.0; 1.2 mg) and **6** (t_R 68.5; 1.3 mg). *Fr. 11.14* (520 mg) was further separated by CC (SiO_2 (60 g), 10 → 30% AcOEt/hexane): *Frs. 11.14.01–11.14.07*. *Fr. 11.14.03* was purified by prep. HPLC (*ODS-H80*, MeOH/0.1% aq. formic acid 87:13, 2 ml/min): **1** (t_R 59.8; 3.6 mg), **4** (t_R 64.6; 12.3 mg), and **2** (t_R 79.8; 0.9 mg). *Fr. 11.14.04* was purified by prep. HPLC (*ODS-H80*, MeOH/0.1% aq. formic acid 87:13, 2 ml/min): **3** (t_R 75.5; 1.2 mg).

Katsumain D (=*(2*E*)-1-{2,4-Dihydroxy-6-methoxy-3-[(2*R*,4*S*,6*S*)-tetrahydro-2-(4-hydroxyphenyl)-6-(2-phenylethyl)-2*H*-pyran-4-yl]phenyl}-3-(4-hydroxyphenyl)prop-2-en-1-one*; **1**): Yellow amorphous powder. $[\alpha]_D^{25} = +12.33$ (*c* = 0.1, MeOH). UV (MeOH): 371 (4.7), 228 (4.6). ^{1}H- and ^{13}C-NMR: *Tables 1* and *2*. HMBC: *Fig. 2*. NOESY: H–C(5)/H–C(7), H–C(5)/H_{ax}–C(4), H–C(7)/H_{ax}–C(4), H–C(3)/H_{eq}–C(4), H–C(3)/H_{ax}–C(6), H_{eq}–C(4)/H_{ax}–C(6), H_{eq}–C(6)/H_{ax}–C(4), H–C(7)/H–C(2″,6″), MeO–C(4‴)/H–C(5‴), H–C(8‴)/H–C(11‴,15‴), H–C(9‴)/H–C(11‴15‴). HR-ESI-MS: 567.2377 ($[M+H]^+$, $C_{35}H_{35}O_7^+$; calc. 567.2377).

Katsumain E (=*(2*E*)-1-{(2*R*,4*S*)-3,4-Dihydro-5-hydroxy-4-[(2*S*)-2-hydroxy-4-(4-hydroxyphenyl)-butyl]-2-(4-hydroxyphenyl)-7-methoxy-2*H*-1-benzopyran-6-yl}-3-phenylprop-2-en-1-one*; **2**): Yellow amorphous powder. $[\alpha]_D^{25} = +21.43$ (*c* = 0.2, MeOH). UV (MeOH): 371 (4.7), 228 (4.6). ^{1}H- and ^{13}C-NMR: *Tables 1* and *2*. HMBC: *Fig. 2*. NOESY: H–C(3)/H_a–C(6), H–C(5)/H_b–C(6), H–C(7)/H_a–C(6), CH_2(2)/H–C(2′,6′), CH_2(6)/H–C(2″,6″), MeO–C(4‴)/H–C(5‴), H–C(8‴)/H–C(11‴,15‴), H–C(9‴)/H–C(11‴,15‴). HR-ESI-MS: 567.2367 ($[M+H]^+$, $C_{35}H_{35}O_7^+$; calc. 567.2377).

Katsumain F (=*(2*E*)-1-{(2*S*,4*R*)-3,4-Dihydro-5-hydroxy-4-[(2*S*)-2-hydroxy-4-(4-hydroxyphenyl)-butyl]-2-(4-hydroxyphenyl)-7-methoxy-2*H*-1-benzopyran-6-yl}-3-phenylprop-2-en-1-one*; **3**): Yellow amorphous powder. $[\alpha]_D^{25} = +15.91$ (*c* = 0.2, MeOH). UV (MeOH): 371 (4.8), 229 (4.7). ^{1}H- and ^{13}C-NMR: *Tables 1* and *2*. HMBC: H–C(3′,5′)/C(1′), C(4′); H–C(2′,6′)/C(3′), C(4′), C(5′), C(1); CH_2(1)/C(2), C(3), C(1′), C(2′), C(6′); CH_2(2)/C(1′), C(1), C(3); H–C(3)/C(5); CH_2(4)/C(2), C(6), C(1‴); H–C(5)/C(4), C(7), C(1‴); CH_2(6)/C(4), C(7), C(1‴); H–C(7)/C(5), C(1″), C(2″), C(6″); H–C(2″,6″)/C(7), C(3″), C(4″), C(5″); H–C(3″,5″)/C(1″), C(4″); H–C(5‴)/C(1‴), C(3‴), C(6‴), C(7‴); MeO–C(4‴)/C(4‴), C(5‴); H–C(8‴)/C(7‴), C(10‴); H–C(9‴)/C(7‴), C(10‴), C(11‴), C(15‴); H–C(11‴,15‴)/C(9‴), C(13‴); H–C(12‴,14‴)/C(10‴), C(13‴); H–C(13‴)/C(11‴), C(15‴). NOESY correlations: H–C(3)/H–C(5), H–C(5)/H_b–C(6), H–C(7)/H_a–C(6), CH_2(2)/H–C(2′(6′)), CH_2(6)/H–C(2″,6″), MeO–C(4‴)/H–C(5‴), H–C(8‴)/H–C(11‴,15‴). HR-ESI-MS: 567.2374 ($[M+H]^+$, $C_{35}H_{35}O_7^+$; calc. 567.2377).

Katsumain G (=*(2*E*)-1-{(2*R*,4*S*)-3,4-Dihydro-5-hydroxy-2-(4-hydroxyphenyl)-4-[(2*S*)-2-hydroxy-4-phenylbutyl]-7-methoxy-2*H*-1-benzopyran-6-yl}-3-(4-hydroxyphenyl)prop-2-en-1-one*; **4**): Yellow amorphous powder. $[\alpha]_D^{25} = +24.56$ (*c* = 0.06, MeOH). UV (MeOH): 372 (4.7), 229 (4.7). ^{1}H- and ^{13}C-NMR: *Tables 1* and *2*. HMBC: H–C(3′,5′)/C(1′), C(4′); H–C(2′,6′)/C(4′), C(1); CH_2(1)/C(2), C(3),

C(1′), C(2′), C(6′); CH_2(2)/C(1′), C(1), C(3), C(4); CH_2(4)/C(3), C(5), C(6); H-C(5)/C(7), C(1‴); CH_2(6)/C(4), C(5), C(7), C(1″), C(1‴); H–C(7)/C(5), C(6), C(1″), C(2″), C(6″); H–C(2″,6″)/C(3″), C(4″), C(5″); H–C(3″,5″)/C(1″), C(4″); H–C(5‴)/C(5), C(1‴), C(3‴), C(6‴), C(7‴); MeO–C(4‴)/C(4‴), C(5‴); OH–C(2‴)/C(1‴), C(2‴), C(3‴); H–C(8‴)/C(7‴), C(9‴), C(10‴); H–C(9‴)/C(7‴), C(8‴), C(10‴), C(11‴), C(15‴); H–C(11‴,15‴)/C(9‴), C(12‴), C(13‴), C(14‴); H–C(12‴,14‴)/C(10‴), C(13‴). NOESY: H–C(3)/H_a–C(6), H–C(5)/H_b–C(6), H–C(7)/H_a–C(6), CH_2(1)/H–C(2′,6′), CH_2(2)/H–C(2′,6′), CH_2(6)/H–C(2″,6″), H–C(7)/H–C(2″6″), MeO–C(4‴)/H–C(5‴), H–C(8‴)/H–C(11‴,15‴), H–C(9‴)/H–C(11‴,15‴). HR-ESI-MS: 567.2373 ($[M+H]^+$, $C_{35}H_{35}O_7^+$; calc. 567.2377).

3-(Acetyloxy)alpinikatin (=*(1*E*)-7-(4-Hydroxyphenyl)-1-phenylhept-1-ene-3,5-diol 5-Acetate*; **5**): Colorless gum. $[\alpha]_D^{25} = \pm 0$ ($c = 0.1$, MeOH). ^{1}H- and ^{13}C-NMR: *Tables 1* and *2*, HMBCs: *Fig.* 2. NOESY: H–C(2′,6′)/CH_2(1), CH_2(2)/H–C(2′,6′), CH_2(1)/H–C(3), H–C(3)/H–C(5), CH_2(4)/H–C(6), H–C(5)/H–C(7), H–C(6)/H–C(2″,6″), H–C(7)/H–C(2″,6″). HR-ESI-MS: 341.1745 ($[M+H]^+$, $C_{21}H_{25}O_4^+$; calc. 341.1747).

5-(Acetyloxy)alpinikatin (=*(1*E*)-7-(4-Hydroxyphenyl)-1-phenylhept-1-ene-3,5-diol 3-Acetate*; **6**): Colorless gum. $[\alpha]_D^{25} = \pm 0$ ($c = 0.1$, MeOH). ^{1}H- and ^{13}C-NMR: *Tables 1* and *2* HMBCs: H–C(3′,5′)/C(1′), C(4′); H–C(2′,6′)/C(4′); CH_2(1)/C(2′), C(6′), C(2), C(3); CH_2(4)/C(2), C(3), C(5); H–C(5)/Me*C*O; H–C(7)/C(5), C(1″), C(2″), C(6″); H–C(2″,6″)/C(7), C(4″); H–C(3″,5″)/C(1″), C(4″); MeCO)/Me*C*O. NOESY: H–C(2′,6′)/CH_2(1), CH_2(2)/H–C(2′,6′), CH_2(1)/H–C(3), H–C(3)/H–C(5), CH_2(4)/H–C(6), H–C(5)/H–C(7), H–C(6)/H–C(2″,6″), H–C(7)/H–C(2″,6″). HR-ESI-MS: 341.1749 ($[M+H]^+$, $C_{21}H_{25}O_4^+$; calc. 341.1747).

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