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Pharmacognostic studies on ginger and related drugs—part 1: five sulfonated compounds from Zingiberis rhizome (Shokyo)

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Abstract

Five sulfonated compounds, namely 4-gingesulfonic acid and shogasulfonic acids A, B, C and D, were isolated together with seven known compounds including 6-gingesulfonic acid from Zingiberis rhizome (Japanese name: Shokyo) made out of ginger. Their structures were characterized by means of spectroscopic analysis.

Keywords: Ginger; Shokyo; Zingiberis rhizome; Zingiberaceae; *Zingiber officinale*; Gingerol; Gingesulfonic acid; Sulfonated diarylheptanoid; Shogaol; Shogasulfonic acid

1. Introduction

Shokyo and Kankyo (Japanese names for Zingiberis rhizome and Zingiberis siccatum rhizome, respectively) are important traditional Kampo medicines made via different processes from the rhizomes of *Zingiber officinale* ROSCOE (Zingiberaceae) (Egawa, 1987; Nishimoto, 1987; Yuta, 1987; Itokawa, 1993). Shokyo is dried ginger, and has been used as a component of some Kampo formulae in expectation of its anti-emetic and anti-pyretic effects. Kankyo is prepared also from ginger by steaming and then drying, and has been used as a component of another Kampo formulae in anticipation of its cough-suppressing, phlegm-dissolving and body-warming properties.

With regard to their constituents, volatile oil and diarylheptanoids were shown to be the pungent principle from fresh ginger (Kano, 1987; Yamagishi et al., 1972; Kikuzaki et al., 1991; Afzal et al., 2001), in addition to sesquiterpenes, gingerols and shogaols from Shokyo (Kano, 1987; Yamahara et al., 1992), and gingerols and shogaols from Kankyo (Kano, 1987), found so far. However, these constituents do not explain the choice of either Shokyo or Kankyo in Kampo medication. Thus, the chemical constituents of fresh ginger, Shokyo and Kankyo must be compared in order to make the difference between Shokyo and Kankyo clear. Together with seven known compounds including 6-gingesulfonic acid (**1**) (Hori et al., 2002), this paper reports the isolation and characterization of five sulfonated compounds, 4-gingesulfonic acid (**2**), shogasulfonic acids A (**3**), B (**4**), C (**5**) and D (**6**) obtained from Shokyo.

2. Results and discussion

The methanol–H_2O (4:1) extract of commercial Shokyo (5.0 kg) was divided into the ether and water soluble portions. The six known compounds, 6-, 8-, 10-gingerols, 6-shogaol, 6-paradol and 6-gingeacetate (Kano, 1987; Yamagishi et al., 1972; Kikuzaki et al., 1991; Afzal et al., 2001) were isolated from the former, and the five new sulfonated compounds **2** (53 mg), **3** (265 mg), **4** (24 mg), **5** (4 mg) and **6** (14 mg) were isolated from the latter, together with 6-gingesulfonic acid (**1**, 98 mg) (Yoshikawa et al., 1992; Fig. 1).

Compound **1** was isolated as a white amorphous powder and its HR-FAB-MS exhibited a pseudomolecular ($[M+H]^+$) ion peak at m/z 359.1457 ascribable to its molecular formula of $C_{17}H_{26}O_6S$. The NMR spectral data were coincident with those reported for 6-gingesulfonic acid, and **1** was identified as 6-gingesulfonic acid (Yoshikawa et al., 1992; Yoshikawa et al., 1994).

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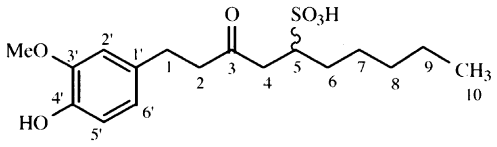
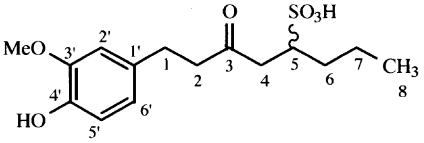
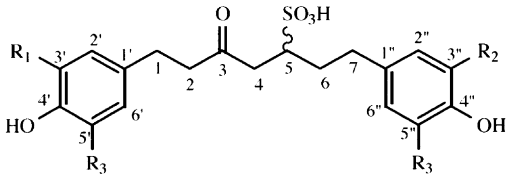


6-gingesulfonic acid (**1**)



4-gingesulfonic acid (**2**)



	R_1	R_2	R_3
shogasulfonic acid A (**3**)	OMe	OMe	H
shogasulfonic acid B (**4**)	OMe	OH	H
shogasulfonic acid C (**5**)	OH	OH	H
shogasulfonic acid D (**6**)	OMe	OMe	OH

Fig. 1. Structures of **1**–**6**.

The NMR analysis of **1** revealed that the assignment of carbon signals for C-6 (δ 32.9) and C-8 (δ 31.9) in the previous report(Yoshikawa et al., 1992; Yoshikawa et al., 1994) must be interchanged as shown in Table 1, since these carbon signals showed cross peaks with the H-10, H-4a and H-4b signals at δ 0.88, 2.50 and 3.03, respectively, in the HMBC spectrum.

Compound **2**, isolated as a pale brownish amorphous powder, showed an $[M+H]^+$ ion peak at m/z 331.1173 ($C_{15}H_{23}O_6S$), 28 mass units (C_2H_4) less than that of **1**, in the HR-FAB-MS. The IR spectrum showed absorption bands due to hydroxyl, carbonyl, benzene ring and sulfonic acid functionalities as shown in that of **1**. The ^1H and ^{13}C NMR spectroscopic features were similar to those of **1**, except for absence of signals due to two methylene groups present in the alkyl chain of **1** (Table 1). In addition, the signals at δ_H 3.31/δ_C 56.8 due to H-5/C-5 resembled those of **1**. Hence, **2** was characterized as a 5-dehydroxy-5-sulfonated derivative of 4-gingerol, and named 4-gingesulfonic acid.

Table 1
^{13}C NMR spectral data for **1, 2, 3, 3a, 4, 5, 6** and **8** (CD_3OD, 125 MHz)

	1	**2**	**3**	**3a**	**4**	**5**	**6**	**8**[a]
C-1	30.4	30.4	30.4	30.3	30.3	30.2	30.7	29.8
C-2	46.0	46.0	45.8	46.3	45.8	45.8	45.7	42.1
C-3	210.7	210.7	210.6	212.0	210.4	210.7	210.7	199.6
C-4	44.8	44.8	44.8	51.2	44.7	44.9	44.8	130.7
C-5	57.1	56.8	56.6	68.3	56.8	56.8	56.7	146.4
C-6	32.0	34.2	34.0	40.4	34.0	34.1	33.9	34.1
C-7	27.9	21.4	33.9	32.4	33.7	33.8	34.2	34.4
C-8	33.0	14.4	–	–	–	–	–	–
C-9	23.5	–	–	–	–	–	–	–
C-10	14.4	–	–	–	–	–	–	–
C-1′	134.1	134.1	134.0	134.1	134.0	134.1	133.4	132.5a
C-2′	113.1	113.1	113.1a	113.2	113.1	116.4	104.7	110.9b
C-3′	148.9	148.8	148.76b	148.8	148.8	146.05a	149.5a	146.4c
C-4′	145.7	145.6	145.5c	145.7	145.6	144.3b	146.3b	146.37d
C-5′	116.1	116.1	116.0d	116.1	116.1	116.4	133.1c	143.9e
C-6′	121.7	121.7	121.7	121.7	121.7	120.8	109.7	120.8f
C-1″	–	–	134.7	134.9	134.7	134.9	134.1	133.1a
C-2″	–	–	113.2a	113.1	116.6	116.6	105.0	111.1b
C-3″	–	–	148.82b	148.8	146.1	146.13a	149.6a	145.4c
C-4″	–	–	145.6c	145.5	144.3	144.4b	146.4b	146.40d
C-5″	–	–	116.1d	116.2	116.3	116.3	133.2c	144.0e
C-6″	–	–	121.9	121.8	120.7	120.6	109.9	120.9f
O-CH_3	56.4	56.3	56.30 56.33	56.4 56.4	56.4	–	56.55 56.58	55.9

[a] Run in $CDCl_3$. The assignments (a–f) may be interchangeable within the same column.

Compound **3**, obtained as a pale yellowish amorphous powder, showed an $[M+H]^+$ ion peak at m/z 439.1417 ($C_{21}H_{27}O_8S$) in the HR-FAB-MS, which was 64 mass units larger than hexahydrocurcumin (**3a**) corresponding to the presence of the sulphonic acid group, whereas the EI-MS shows a $[M–H_2SO_3]^+$ ion peak at m/z 356. The IR spectrum exhibited absorption bands due to the same functional groups as observed in that of **2**. The ^{13}C NMR spectroscopic data were similar to those of **3a**, except for carbon signals due to C-3–C-7, suggesting **3** to be a 5-sulfonyl derivative of gingerenone A (**8**) (Table 1). The structure of **3** was proved by synthesis from curcumin (**7**) by catalytic hydrogenation followed successively by dehydration and sulfonation as described in the Experimental (Fig. 2). Hence, **3** was formulated as 5-sulfonyl-1,7-bis(4-hydroxy-3-methoxyphenyl)-heptan-3-one, and named shogasulfonic acid A.

Compound **4**, a pale green oil, exhibited an $[M+H]^+$ ion peak at m/z 425.1247 ($C_{20}H_{25}O_8S$) in the HR-FAB-MS, 14 mass units (CH_2) less than that of **3**. The ^{13}C NMR spectroscopic data were similar to that of **3**, although it lacked a methoxyl group signal as in **3** (Table 1). In addition, the C-3″ signal appeared at higher field (δ 146.1) than that in **3** (δ 148.82). Therefore, **4** was characterized as 5-sulfonyl-1-(4-hydroxy-3-methoxyphenyl)-7-(3,4-dihydroxyphenyl)-heptan-3-one, and named shogasulfonic acid B.

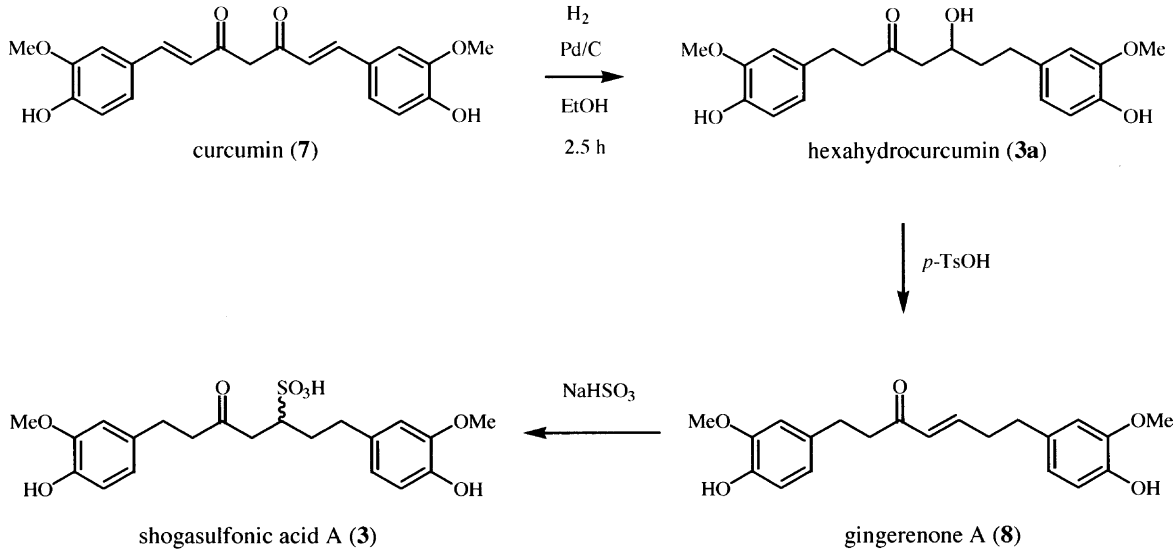


Fig. 2. Synthesis of shogasulfonic acid A.

Compound **5**, a pale yellowish oily substance, showed an $[M+H]^+$ ion peak at m/z 411.1084 ($C_{19}H_{23}O_8S$) in the HR-FAB-MS, 14 mass units (CH_2) less than that of **4**. The ^{13}C NMR spectrum was also similar to that of **3**, except the absence of two methoxyl groups in **3**, and the C-3′ and C-3″ signals appearing at higher field (δ 146.05 and 146.13) than those of **3** (Table 1). Hence, **5** was established as 5-sulfonyl-1,7-bis(3,4-dihydroxyphenyl)-heptan-3-one, and **5** was named shogasulfonic acid C.

Compound **6**, a pale yellowish crystalline powder, showed an $[M+H]^+$ ion peak at m/z 471.1370 ($C_{21}H_{27}O_{10}S$) in the HR-FAB-MS, 32 mass units ($O \times 2$) larger than that of **3**. The ^{13}C NMR spectrum of **6** was similar to that of **3**, except for the C-5′ and C-5″ signals appearing at lower field (δ 133.1, 133.2) than those of **3** (Table 1). The ^1H NMR spectrum revealed the presence of two 3,4,5-trisubstituted phenyl groups (δ 6.30, 6.31, 6.32, 6.33, 2H each, *d*) having two methoxyl and one hydroxyl groups. In addition, the signals due to C-2′, C-6′, C-2″ and C-6″ of **6** were observed at higher field than those of **3** (Table 1), suggesting that both C-5′ and C-5″ positions were occupied by hydroxyl groups. Accordingly, the structure of **6** was determined as 5-sulfonyl-1,7-bis(4,5-dihydroxy-3-methoxyphenyl)-heptan-3-one, and **6** was named shogasulfonic acid D.

As mentioned above, five sulfonated derivatives of gingerol and diarylheptanoid, namely 4-gingesulfonic acid (**2**), shogasulfonic acid A (**3**), B (**4**), C (**5**) and D (**6**), were isolated from Shokyo (Zingiberis rhizome), and their structures were established, though the stereochemistry at C-5 of **2**–**6** is still under investigation. Of them, 6-gingesulfonic acid (**1**) and shogasulfonic acid A (**3**) were reported to have anti-ulcer activity (Yoshikawa et al., 1992; Yoshikawa et al., 1994) and stimulating activity of gastric emptying (Hashimoto et al., 2002), respectively, suggesting that the other sulfonated derivatives could be also expected to have similar activities.

On the other hand, these sulfonated derivatives are thought to be artifacts formed as a consequence of processing, in which additional treatment such as bleaching with sulfur may be included besides only drying. Nevertheless, it is very interesting that the preparation process of ginger to Shokyo produces new active principles. Further investigations on the constituents of fresh ginger, Shokyo and Kankyo are now in progress.

3. Experimental

3.1. General

All melting points were determined on a Yanaco micro-melting point apparatus (hot stage type) and were uncorrected. Optical rotations were obtained on a JASCO DIP 140 digital polarimeter, whereas IR spectra were measured on a JASCO FT/IR-410 spectrometer. NMR spectra were recorded on a JEOL JNM LA-500 spectrometer (500 MHz for ^1H, 125 MHz for ^{13}C), with chemical shifts given in δ ppm scale from TMS as an internal standard, and signals assigned by means of DEPT and 2D NMR spectroscope techniques (^1H–^1H COSY, HMQC and HMBC). MS spectra were obtained on a JEOL JMS SX-120A or JMS-700 spectrometer, with the matrix used for FAB-MS shown in parenthesis. TLC was performed on precoated silica gel 60 F_{254} or RP-18W F_{254} plates (Merck) with detection achieved by spraying with 10% H_2SO_4 followed by heating. CC was performed on silica gel 60 (<45 μm, Merck), Sephadex LH-20 (Pharmacia), or ODS (Chromatorex DM-1020T, Fuji-Silysia Co.). Curcumin (**7**) was obtained from Wako Pure Chemical Ind. Ltd.

3.2. Extraction and isolation

Commercial Shokyo (Zingiberis rhizome) powder (5.0 kg, Uchida Wakanyaku Co., imported from China; Lot. No. 193012) was percolated with MeOH–H_2O (4:1, 28 l) at rt for 3 days; with the resulting for 80% MeOH extract concentrated in vacuo at 40 °C. The residual syrup was suspended in H_2O (1 l) and successfully extracted with diethyl ether (3 × 500 ml) to afford an ether extract (155 g) after concentration. The ether extract was repeatedly subjected to silica gel chromatography to give six known compounds, 6-, 8-, 10-gingerols, 6-shogaol, 6-paradol and 6-gingeacetate, identification of which was performed by comparison of spectral data with those reported. The aqueous layer (546 g) was, after concentration, subjected to an ODS column with a gradient mixture of H_2O and MeOH providing the following six fractions: Frs. A (H_2O, 498 g), B (H_2O, 12.2 g), C (50% MeOH, 1.2 g), D (50% MeOH, 19.0 g), E (50% MeOH, 8.2 g) and F (MeOH, 7.2 g). Fr. E was separated into three fractions by Sephadex LH-20 CC (MeOH): Frs. E-1 (0.09 g), E-2 (7.86 g), and E-3 (0.33 g). Fr. E-2 (1.0 g) was purified by silica gel CC [$CHCl_3$–MeOH–AcOEt–H_2O (2:2:4:1), lower phase] and then Sephadex LH-20 CC (MeOH) to give **1** (98 mg). Fr. D was applied to a silica gel column eluted with $CHCl_3$–MeOH–H_2O (7:3:0.4) to give six fractions: Frs. D-1 (0.8 g), D-2 (2.3 g), D-3 (5.8 g), D-4 (2.9 g), D-5 (0.9 g), and D-6 (4.2 g). Fr. D-2 was successively applied to ODS (10% MeOH), silica gel [$CHCl_3$–MeOH–AcOEt–H_2O (2:2:4:1), lower phase], and Sephadex LH-20 (MeOH) columns to afford **2** (31 mg) and **3** (62 mg). A similar separation protocol was applied for frs. D-3 and D-4, giving five compounds: **2** (22 mg) and **3** (203 mg) from the former and **4** (24 mg), **5** (4 mg) and **6** (14 mg) from the latter, respectively.

*6-Gingesulfonic acid (**1**)* White amorphous powder, mp. 177–181 °C (dec.). $[\alpha]_D^{21}$ +0.7° (MeOH, *c* 1.00). Positive FAB-MS (NBA), *m/z*: 359.1457 ($[M+H]^+$, $C_{17}H_{27}O_6S$: 359.1528). IR ν_{max}^{KBr} cm^{-1}: 3182 (OH), 1711 (C=O), 1525 (benzene ring), 1219, 1175, 1056 (SO_3H). ^1H NMR (CD_3OD) δ: 0.88 (3H, *t*, *J* = 7.3 Hz, H_3-10), 1.30- 1.35 (6H, *m*, H_2-7, H_2-8 and H_2-9), 1.42 (1H, *m*, H-6), 1.90 (1H, *m*, H-6), 2.80 (4H,*m*, H_2-1 and H_2-2), 2.50 (1H, *dd*, *J* = 17.4, 6.4 Hz, H-4a), 3.03 (1H, *dd*, *J* = 17.4, 6.4 Hz, H-4b), 3.30 (1H, *m*, H-5), 3.82 (3H,*s*, O-CH_3), 6.60 (1H, *dd*, *J* = 8.0, 1.9 Hz, H-6′), 6.67 (1H, *d*, *J* = 8.0 Hz, H-5′), 6.77 (1H, *d*, *J* = 1.9 Hz, H-2′). ^{13}C NMR: Table 1. HMBC correlations were observed between H-10/C-8, H-4a/C-6 and H-4b/C-6. The spectral data of **1** were coincident with those reported for 6-gingesulfonic acid (Yoshikawa et al., 1992; Yoshikawa et al., 1994)

*4-Gingesulfonic acid (**2**)* Pale brownish amorphous powder, mp. 180–190 °C (dec.), $[\alpha]_D^{21}$ +1.0° (MeOH, *c* 2.00). Positive FAB-MS (NBA), *m/z*: 331.1173 ($[M+H]^+$, $C_{15}H_{23}O_6S$: 331.1215). IR ν_{max}^{KBr} cm^{-1}: 3447 (OH), 1714 (C=O), 1527 (benzene ring), 1194, 1177, 1050 (SO_3H). ^1H NMR (CD_3OD) δ: 0.88 (3H, *t*, *J* = 7.3 Hz, H_3-8), 1.36, 1.87 (1H each, *m*, H_2-6), 1.36 (2H, *m*, H-7), 2.79 (4H, *m*, H_2-1 and H_2-2), 2.50 (1H, *dd*, *J* = 17.4, 6.4 Hz, H-4), 3.03 (1H, *dd*, *J* = 17.4, 6.1 Hz, H-4), 3.31 (1H, *m*, H-5), 3.82 (3H, *s*, O-CH_3), 6.61 (1H, *dd*, *J* = 8.2, 1.8 Hz, H-6′), 6.68 (1H, *d*, *J* = 8.2 Hz, H-5′), 6.75 (1H, *d*, *J* = 1.8 Hz, H-2′). ^{13}C NMR: Table 1.

*Shogasulfonic acid A (**3**)* Pale yellowish amorphous powder, mp. 205 °C (dec.), $[\alpha]_D^{21}$ −0.5° (MeOH, *c* 2.00). Positive FAB-MS (NBA) *m/z*: 439.1417 ($[M+H]^+$, $C_{21}H_{27}O_8S$: 439.1427). EI-MS, *m/z*: 356 ($[M\text{-}H_2SO_3]^+$). IR ν_{max}^{KBr} cm^{-1}: 3379 (OH), 1698 (C=O), 1523 (benzene ring), 1222, 1179, 1154, 1054 (SO_3H). ^1H NMR (CD_3OD) δ: 1.71 (1H, *m*, H-6), 2.19 (1H, *m*, H-6), 2.61 (2H, *t*, *J* = 7.6 Hz, H_2-7), 2.76 (4H, *m*, H_2-1 and H_2-2), 2.57 (1H, *dd*, *J* = 17.4, 6.4 Hz, H-4), 3.05 (1H, *dd*, *J* = 17.4, 6.1 Hz, H-4), 3.34 (1H, *m*, H-5), 3.79, 3.81 (3H each, *s*, O-CH_3 × 2), 6.58, 6.60 (1H each, *dd*, *J* = 8.2, 2.4 Hz, H-6′ and H-6″), 6.67, 6.68 (1H each, *d*, *J* = 8.2 Hz, H-5′ and H-5″), 6.75, 6.76 (1H each, *d*, *J* = 2.4 Hz, H-2′ and H-2″). ^{13}C NMR: Table 1.

*Shogasulfonic acid B (**4**)* Pale green oil, $[\alpha]_D^{21}$ −1.0° (MeOH, *c* 1.60). Positive FAB-MS (NBA) *m/z*: 425.1247 ($[M+H]^+$, $C_{20}H_{25}O_8S$: 425.1270). IR ν_{max}^{KBr} cm^{-1}: 3421 (OH), 1708 (C=O), 1519 (benzene ring), 1196, 1153, 1039 (SO_3H). ^1H NMR (CD_3OD) δ: 1.70 (1H, *m*, H-6), 2.16 (1H, *m*, H-6), 2.55 (2H, *m*, H_2-7), 2.57 (1H, *m*, H-4), 2.74 (4H, *m*, H_2-1 and H_2-2), 3.04 (1H, *dd*, *J* = 17.4, 5.8 Hz, H-4), 3.36 (1H, *m*, H-5), 3.80 (3H, *s*, O-CH_3), 6.47 (1H, *dd*, *J* = 7.9, 1.8 Hz, H-6′), 6.60 (1H, *dd*, *J* = 7.9, 1.8 Hz, H-6″), 6.62 (1H, *d*, *J* = 1.8 Hz, H-2′), 6.64 (1H, *d*, *J* = 7.9 Hz, H-5′), 6.67 (1H, *d*, *J* = 7.9 Hz, H-5″), 6.75 (1H, *d*, *J* = 1.8 Hz, H-2″). ^{13}C NMR: Table 1.

*Shogasulfonic acid C (**5**)* Pale yellowish oily substance, $[\alpha]_D^{21}$ −5.6° (MeOH, *c* 0.25). Positive FAB-MS (NBA) *m/z*: 411.1084 ($[M+H]^+$, $C_{19}H_{23}O_8S$: 411.1114). IR ν_{max}^{KBr} cm^{-1}: 3445 (OH), 1707 (C=O), 1527 (benzene ring), 1198, 1042 (SO_3H) ^1H NMR (CD_3OD) δ: 2.70 (4H, *m*, H_2-1 and H_2-2), 2.54 (1H, *dd*, *J* = 17.1, 6.4 Hz, H-4), 3.04 (1H, *dd*, *J* = 17.1, 5.8 Hz, H-4), 3.33 (1H, *m*, H-5), 1.68 (1H, *m*, H-6), 2.16 (1H, *m*, H-6), 2.54 (2H, *m*, H_2-7), 6.48 (1H, *dd*, *J* = 8.0, 2.2 Hz, H-6′), 6.49 (1H, *dd*, *J* = 8.2, 2.2 Hz, H-6″), 6.615, 6.619 (1H each, *d*, *J* = 2.2 Hz, H-2′ and H-2″), 6.638 (1H, *d*, *J* = 8.0 Hz, H-5′), 6.641 (1H, *d*, *J* = 8.2 Hz, H-5″). ^{13}C NMR: Table 1.

*Shogasulfonic acid D (**6**)* Pale yellowish crystaline powder, mp. 154–158 °C, $[\alpha]_D^{21}$ −0.3° (MeOH, *c* 1.00). Positive FAB-MS (NBA), *m/z*: 471.1370 ($[M+H]^+$, $C_{21}H_{27}O_{10}S$: 471.1325). IR ν_{max}^{KBr} cm^{-1}: 3421 (OH), 1714 (C=O), 1527 (benzene ring), 1194, 1177, 1050 (SO_3H). ^1H NMR (CD_3OD) δ: 1.72 (1H, *m*, H-6), 2.17 (1H, *m*, H-6), 2.56 (2H, *m*, H_2-7), 2.71 (4H, *m*, H_2-1 and H_2-2), 2.55 (1H, *dd*, *J* = 17.4, 6.4 Hz, H-4), 3.05 (1H, *dd*, *J* = 17.4, 6.1 Hz, H-4), 3.34 (1H, *m*, H-5), 3.78, 3.79 (3H each, *s*, O-CH_3 × 2), 6.30, 6.31 (1H each, *d*, *J* = 1.8 Hz,

H-2′ and H-6′), 6.32, 6.33 (1H each, *d*, $J = 1.8$ Hz, H-2″ and H-6″). ^{13}C NMR: Table 1.

*Synthesis of **3** from **7*** (Yoshikawa et al., 1994). Curcumin (**7,** 840 mg, 2.27 mmol) was hydrogenated with Pd/C (50 mg) in EtOH (100 ml) to give **3a** (136 mg) after purification by silica gel CC with hexane–EtOAc (3:2). Dehydration of **3a** (124 mg, 0.33 mmol) by reflux with *p*-TsOH monohydrate (30 mg) in dry benzene (40 ml) followed by similar purification as above afforded **8** (89 mg, 75%). A solution of **8** (13 mg, 37 μmol) in MeOH (10 ml) containing sodium hydrogen sulfite (76 mg, 0.73 mmol) and *tert*-butyl perbenzoate (139 μl, 0.73 mmol) was refluxed for 25 h. The reaction mixture was evaporated in vacuo and the product was purified by silica gel chromatography with $CHCl_3$–MeOH–H_2O (7:3:0.4) providing the target compound (2.6 mg, 0.31% from **7**) (Fig. 2), which was identified as **3** obtained from Shokyo by comparison of their spectral data and R_f values on TLC. The NMR spectral data of **3a** and **8** were identical with those reported for hexahydrocurcumin (Yamagishi et al., 1972; Itokawa et al., 1985) and gingernone A (dehydro-hexahydrocurcumin) (Kikuzaki et al., 1990), respectively.

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