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TWO NEW XANTHONE GLUCOSIDES FROM *SWERTIA MUSSOTII* FRANCH

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Abstract – Two new xanthone glucosides, 1-O-β-D-glucopyranosyl-3,5,6-trimethoxy-xanthone (**1**), 1-O-[β-D-xylopyranosyl-(1→6)-β-D-glucopyranosyl]-3,5,6-trimethoxy-xanthone (**2**), were isolated from a EtOH extract of the overground parts of *Swertia mussotii* Franch,which is a traditional Tibet medicine. Their structures were elucidated by spectroscopic methods as well as by chemical studies. Compound **1** showed α-glucosidase inhibitory activity, while compound **2** showed DPP-IV (Dipeptidyl Peptidase IV) inhibitory activity.

Plants of the genus *Swertia* have been used as traditional medicinal plants in various parts of the world. *Swertia mussotii* Franch, known as “Zangyingcheng” (Chinese), is mainly distributed in Qinghai, Xizang, Sichuan, and Yunnan of China. In traditional Chinese medicine, the plant is of cold property and its taste is bitter. It has been used as a traditional Tibetan remedy to treat acute epioephysitis, soprethroat, tonsillitis, icterichepatitis, cholecystitis, gastroenteritis bacillary dysentery and urinary tract infection.[1] Our previous studies have shown that xanthone, triterpenoid, iridoid, and steroid are main constituents of this plant.[2-4] As a continuation of our studies on chemical constituents of *Swertia* plant, from the overground parts of *Swertia mussotii* Franch, two new xanthone glucosides, 1-O-β-D-glucopyranosyl-3,5,6-trimethoxy-xanthone (**1**), 1-O-[β-D-xylopyranosyl-(1→6)-β-D-glucopyranosyl]-3,5,6-trimethoxy-xanthone (**2**), were isolated. Their structures were elucidated by spectroscopic methods as well as by chemical studies. In the *in vitro* assays, compound **1** showed weak α-glucosidase inhibitory activity compared with the positive control acarbose, while compound **2** showed weak DPP-IV

(Dipeptidyl Peptidase IV) inhibitory activity compared with the positive control INDPP-2.

Compound **1** was obtained as a colorless gum. Its molecular formula was deduced to be $C_{22}H_{24}O_{11}$ by ^{13}C NMR spectra (Table 1) and ESI-MS, with quasi-molecular ion peaks at *m/z* 465 ($[M+H]^+$) and 487 ($[M+Na]^+$). The IR spectrum showed the presence of hydroxyl group (3406 cm^{-1}), aromatic ring (1624, 1588, 1453 cm^{-1}), and C = O bond (1650 cm^{-1}). The UV spectrum exhibited absorption maxima at λ_{max} 357, 303, and 248 nm, characteristic of a 1,3,5,6-tetraoxygenated xanthone skeleton.[5]

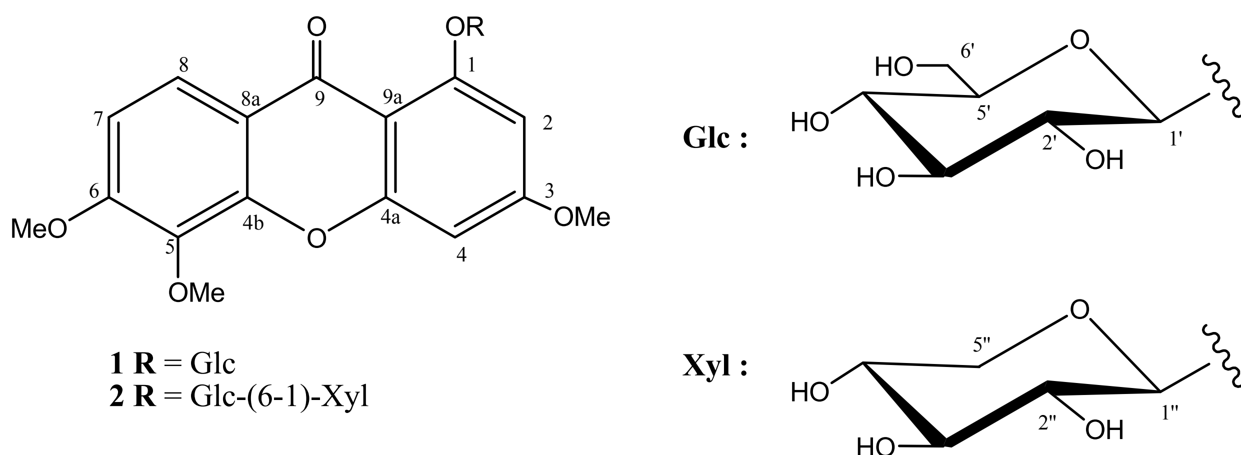

Figure 1. Structures of compounds **1** and **2**

The ^1H NMR spectrum of compound **1** showed two meta-coupled H-atoms at δ_H 7.26 (1H, d, J = 2.4 Hz) and 6.61 (1H, d, J = 2.4 Hz), assigned to H-2 and H-4, and a pair of ortho-coupled H-atoms at δ_H 7.33 (1H, d, J = 9.2 Hz) and 7.21 (1H, d, J = 9.2 Hz) attributed to H-7 and H-8, respectively. The three signals at δ_H 3.74 (s), 3.76 (s), and 4.08 (s) were determined to three MeO groups. The ^{13}C NMR (DEPT) spectroscopic data further showed the presence of three methyls, one methylenes, nine methines, and nine quaternary carbons, among which carbon signals at δ_C 105.3 (d), 75.1 (d), 79.6 (d), 71.2 (d), 77.8 (d), and 62.5 (t) suggested the presence of one glucose, which was confirmed by its MS fragmentation peak at *m/z* 303 $[M+1-glc]^+$. Acid hydrolysis of compound **1** also showed the presence of glucose.

In the HMBC spectrum of 1, H-2 (δ_H 7.26) exhibited cross-peaks with C-1, C-3, C-4, and C-9a at δ_C 160.6, 164.9, 95.4, and 108.8, respectively. Also, H-4 (δ_H 6.61) showed correlations with C-2, C-3, C-4a, and C-9a at δ_C 101.3, 164.9, 158.6, and 108.8, respectively. Further, H-7 (δ_H 7.33) exhibited cross-peaks with C-5, C-6, C-8, and C-8a at δ_C 148.8, 150.3, 112.6, and 118.7, and H-8 (δ_H 7.21) showed correlations with C-4b, C-6, C-7, C-8a, and C-9 at δ_C 149.9, 150.3, 119.5, 118.7, and 175.9, respectively, in agreement with the assignments for 1,3,5,6-tetraoxygenated xanthone skeleton. The linkage of sugar moiety to C-1 was determined by the HMBC correlations from H-1′ (δ_H 5.53) to C-1 (δ_C 160.6). The

configuration of anomeric proton of the glucose was determined as *β* based on *J* value ($J = 7.6$ Hz) in the ^{1}H NMR spectrum. The linkages of three OCH_3 to C-3, C-5, and C-6 were confirmed by the HMBC correlations from OCH_3 (δ_H 3.74) to C-3 (δ_C 164.9), OCH_3 (δ_H 4.08) to C-5 (δ_C 148.8), and OCH_3 (δ_H 3.76) to C-6 (δ_C 150.3). These assignments were supported by the presence of ROESY correlations of between 3-OCH_3 with H-2 and H-4, H-2 with H-1′, and 6-OCH_3 with H-7. Thus, the structure of **1** was determined as 1-O-*β*-D-glucopyranosyl-3,5,6-trimethoxy-xanthone.

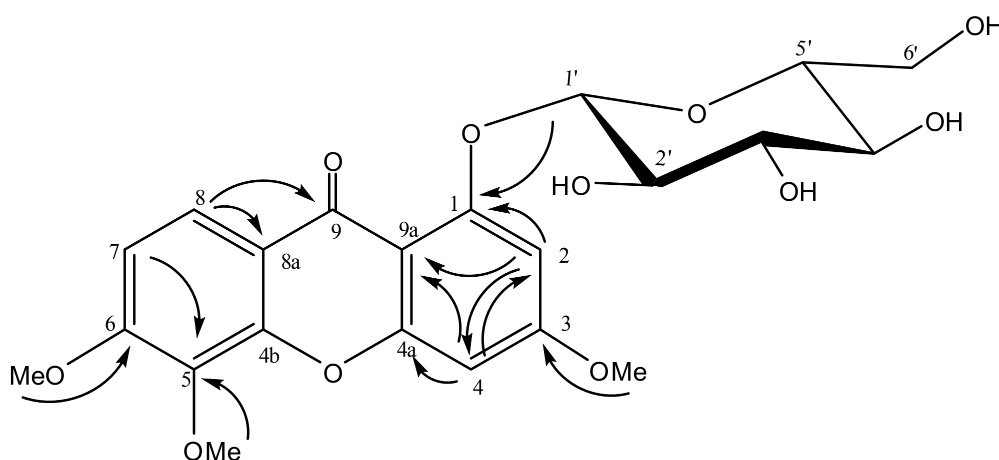

Figure 2. Key HMBC correlations of compound **1**

Compound **2** was deduced to have a molecular formula of $C_{27}H_{32}O_{15}$ from ^{13}C NMR spectra and HR-ESI-MS $[M+H]^+$ ion peak at *m/z* 597.1780, and $[M+Na]^+$ ion peak at *m/z* 619.1595. The IR spectrum showed the presence of hydroxyl group (3425 cm^{-1}), aromatic ring (1624, 1586, 1450 cm^{-1}), and C = O bond (1645 cm^{-1}). The UV spectrum exhibited absorption maxima at λ_{max} 356, 304, and 245 nm. The IR and UV spectra were similar to those of compound **1**.

The ^{1}H and ^{13}C NMR spectra of compound **2** closely resembled those of compound **1**, except for the appearance of one more pentosyl unit in **2**. The pentosyl was assigned to be a *β*-D-xylopyranosyl based on the characteristic ^{1}H and ^{13}C NMR spectrum signals [δ_H 4.95 (1H, d, $J = 7.6$ Hz, anomeric H); δ_C 106.1, 74.9, 78.2, 71.0, and 67.1].[6] Acid hydrolysis of **2** produced glucose and xylose identified on the basis of TLC by comparing with those authentic sugar sample. The obvious downfield shift of glucosyl C-6′ by +7.7 ppm suggested that the xylosyl unit was linked at C-6′ of glucosyl unit, which was confirmed by HMBC correction of anomeric proton (δ_H 4.95) of the xylosyl with the C-6′ (δ_C 70.2) of glucosyl. Therefore, the structure of compound **2** was established to be 1-O-[*β*-D-xylopyranosyl-(1→6)-*β*-D-glucopyranosyl]-3,5,6-trimethoxy-xanthone.

In the *in vitro* assays, the *α*-glucosidase and DPP-IV (Dipeptidyl Peptidase IV) inhibitory activities of compounds **1** and **2** were performed. Compound **1** showed weak *α*-glucosidase inhibitory activity with 5.4% inhibition at 40μM, while the positive control acarbose gave an inhibitory rate of 98.8% at the same concentration.[7] Compound **2** showed weak DPP-IV inhibitory activity with 2.1% inhibition at 10^{-5} M, while the positive control INDPP-2 gave an inhibitory rate of 96.6% at the same concentration [the negative control DMSO gave an inhibitory rate of 0%]. Compound **1** was inactive for DPP-IV inhibitory activity compared with compound **2**, and compound **2** was inactive for *α*-glucosidase inhibitory activity.

Table 1. ^{1}H and ^{13}C NMR spectral data of compounds **1** and **2**[a]

position	**1**		**2**	
	proton	carbon	proton	carbon
1		160.6		160.5
2	7.26 d (2.4)	101.3	7.36 d (2.4)	101.4
3		164.9		165.0
4	6.61 d (2.4)	95.4	6.60 d (2.4)	95.5
4a		158.6		158.4
4b		149.9		149.8
5		148.8		148.7
6		150.3		150.0
7	7.33 d (9.2)	119.5	7.33 d (9.2)	119.4
8	7.21 d (9.2)	112.6	7.20 d (9.2)	112.6
8a		118.7		118.6
9		175.9		175.8
9a		108.8		108.7
1′	5.53 d (7.6)	105.3	5.49 d (7.2)	105.2
2′	4.47 t (8.4)	75.1	4.41 dd (7.2, 8.8)	74.8
3′	4.18 m	79.6	4.36 m	77.7
4′	4.29 t (8.8)	71.2	4.25 m	71.2
5′	4.40 t (8.4)	77.8	4.36 m	77.7
6′	4.62 d (10.8)	62.5	4.37 m	70.2
	4.37 m		4.84 dd (9.2, 5.2)	
1″			4.95 d (7.6)	106.1
2″			4.05 dd (7.6, 8.8)	74.9
3″			4.15 t (8.4)	78.2
4″			4.25 m	71.0
5″			3.66 dd (10.0, 10.8)	67.1
			4.35 m	
3-OCH_3	3.74 s	55.9	3.77 s	55.9
5-OCH_3	4.08 s	61.4	4.09 s	61.4
6-OCH_3	3.76 s	56.7	3.79 s	56.6

[a] ^{1}H NMR spectral data measured at 400 MHz; ^{13}C NMR spectral data measured at 100 MHz; Proton coupling constants (*J*) in Hz given in parentheses. Pyridine-d_5 as solvent.

EXPERIMENTAL

General experimental procedures. Optical rotations and UV data were measured on a JASCO-20 polarimeter and UV-2401PC spectrometer. MS were measured on a VG Auto Spec-3000 spectrometer. HR-ESI-MS data were measured using a JMS-T100CS AccuTOF LC/MS spectrometer. ^{1}H-NMR and ^{13}C-NMR spectra were recorded on Bruker AM-400 instruments with TMS as internal standard. IR spectra were measured on a Bruker Tensor 27 spectrometer with KBr pellets. Column chromatography was performed with silica gel (200-300 mesh; Qingdao Marine Chemical Inc. Qingdao, People's Republic of China) and Lichroprep RP-18 gel (40-63 μm; Merk, Darmstadt, Germany) and Sephadex LH-20 (Pharmacia Fine Chemical Co., Ltd. Uppsala, Sweden).

Plant material. Whole herb of *Swertia mussotii* Franch was collected from Xianggelila, Yunnan Province, People's Republic of China, in July 2006. The plant was identified by Physician Zhaxiduoze (Diqing Tibetan Medicine Hospital). A voucher specimen (NO. 0601005) is deposited at the Herbarium of Key Laboratory of Ethnic Medicine Resource Chemistry, Yunnan University of Nationalities.

Extraction and Isolation. The air-dried leaves and stem of *Swertia mussotii* Franch (9.5 kg) were extracted with EtOH (70%) under reflux at room temperature (3 h each time, total 4 times), After filtering and evaporating the solvents in vacuo a residue was obtained (980 g). Then the residue was extracted successively with petroleum ether, EtOAc, and BuOH. The BuOH extract (250 g) was chromatographed on a silica gel (200-300 mesh) column and eluted with gradient mixtures of EtOAc-MeOH from 50:1 (V/V) to 1:5 (V/V) to afford four fractions. Fraction 3 was purified with silica gel CC (EtOAc-MeOH, 10:1) and then Sephadex LH-20 (MeOH) CC and semipreparative HPLC (MeOH–H_2O, 55:45 and 65:35) afforded **1** (12 mg) and **2** (28 mg).

Compound 1: $C_{22}H_{24}O_{11}$, colorless gum; $[\alpha]^{19.1}_D$ −165.1 (*c* 0.087, MeOH+$CHCl_3$); UV (MeOH) λ_{max} (log ε) 214 (3.85), 248 (4.09), 303 (3.74) , 357 (3.30) nm; IR (KBr): ν_{max} 3406, 2924, 2853, 1650, 1624, 1588, 1481, 1453, 1430, 1288, 1201, 1148, 1103, 1074, 978 cm^{-1}; ^{1}H NMR (C_5D_5N, 400 MHz) and ^{13}C NMR (C_5D_5N, 100 MHz) spectral data see Table 1; positive-mode ESI-MS *m/z* 487 $[M+Na]^+$ and 503 $[M+K]^+$; HR-ESI-MS *m/z* 487.1169 $[M+Na]^+$ (calcd for $C_{22}H_{24}O_{11}Na$, 487.1216).

Compound 2: $C_{27}H_{32}O_{15}$, light yellow powder; $[\alpha]^{16.5}_D$ −116.0 (*c* 0.037, MeOH+$CHCl_3$); UV (MeOH) λ_{max} (log ε) 215 (3.96), 245 (4.16), 304 (3.82), 356 (3.33) nm; IR (KBr): ν_{max} 3425, 2923, 2853, 1645, 1624, 1586, 1480, 1450, 1429, 1283, 1204, 1170, 1065, 1044, 979 cm^{-1}; ^{1}H NMR (C_5D_5N, 400 MHz) and ^{13}C NMR (C_5D_5N, 100 MHz) spectral data see Table 1; positive-mode ESI-MS *m/z* 619 $[M+Na]^+$; HR-ESI-MS *m/z* 597.1780 $[M+H]^+$ (calcd for $C_{27}H_{33}O_{15}$, 597.1819), 619.1595 $[M+Na]^+$ (calcd for $C_{27}H_{32}O_{15}Na$, 619.1633).

Acid hydrolysis of compounds 1 and 2. Compounds **1** (3 mg) and **2** (3 mg) in 2N HCl (3 mL) were each

heated at 80 °C for 1 h, then cooled for 30 min. The mixture was extracted with EtOAc (5 mL×3). The residue and authentic sugars were dotted to the plated developed with $CHCl_3$-CH_3OH-H_2O (5:3:0.5), and phenylene diamine-aniline-phosphoric acid used as spray reagent, followed by heating at 80 °C. From compound **1** gulcose was detected; R_f glucose 0.45. From compound **2** gulcose and xylose were detected; R_f glucose 0.45, xylose 0.58.

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