Asian Journal of Chemistry; Vol. 24, No. 1 (2012), 73-75

ASIAN JOURNAL OF CHEMISTRY

www.asianjournalofchemistry.co.in

Phenolic Compounds from the Fruits of *Ziziphus jujuba* Mill

XUE-SEN LI[1,2], HUAI-XUE MU[1,2], HAI-TAO HUANG[1], ZHONG LI[1,*] and QIU-FEN HU[2]

[1]Key Laboratory of Tobacco Chemistry of Yunnan Province, Yunnan Academy of Tobacco Science, Kunming 650106, P.R. China
[2]Key Laboratory of Ethnic Medicine Resource Chemistry (Yunnan University of Nationalities), State Ethnic Affairs Commission & Ministry of Education, Kunming 650031, P.R. China

*Corresponding author: E-mail: lizhong@cyats.com

(*Received*: 1 November 2010; *Accepted*: 9 September 2011) AJC-10373

A new phenolic compound [2-hydroxy-1-(3'-hydroxy,4'-methoxy)-pentane-1,4-dione] (**1**), together with five known compounds (**2-4**) *i.e.*, 4-hydroxy-3-methoxy-phenyl-1-O-(6'-O-galloyl)-β-D-glucopyranoside (**2**), batatasin(III) (**3**), D-glucopyranoside (**4**), glucopyranosylcaffeic acid (**5**) and vanillic acid (**6**) were isolated from the fruits of *Ziziphus jujuba* Mill. The structure of compound **1** was elucidated on the basis of extensive NMR and MS means. The antioxidant activity of (**1**) was evaluated and it showed antioxidant activity with an IC_{50} value of 2.92 μg/mL.

Key Words: Phenolic compounds, Fruit, *Ziziphus jujuba* Mill, Antioxidant activity.

INTRODUCTION

Ziziphus jujuba Mill belongs to the genus *Ziziphus* (Rhamnaceae) and originated in China and call as Da Zao which is cultivated for more than 4000 years and where there are over 400 cultivars[1-3]. The fruit of *Ziziphus jujuba* Mill is highly nutritional value and good tasting. In addition to fruit utilization, it has been used as a traditional Chinese medicine for a long time, which shows various beneficial activities including antioxidant, antihepatitis, anxiolytic, antitumor, *etc.*[4-6]. The extract of Da Zao has also been used as cigarette additives[7,8].

Previous phytochemical research on *Ziziphus jujuba* has revealed that flavones[9,10], triterpene acid[11,12], alkaloid[13,14] as well as polysaccharides[15] are major principles isolated from the plant of this plant. With the aim of continuing efforts to evaluate the quality of cigarette additives and to identify bioactive natural products from the plants, a chemical investigation on the fruits of *Ziziphus jujuba* Mill indigenous to the Hanzhong Prefecture of Shangxi Province of China was carried out. A new phenolic compound [2-hydroxy-1-(3'-hydroxy,4'-methoxy)-pentane-1,4-dione] (**1**), together with five known one *i.e.*, 4-hydroxy-3-methoxy-phenyl-1-O-(6'-O-galloyl)-β-D-glucopyranoside (**2**)[16], batatasin(III) (**3**)[17], D-glucopyranoside (**4**),[18] glucopyranosylcaffeic acid (**5**)[18] and vanillic acid (**6**)[19] (Fig. 1) were separated from this plant. In addition, the antioxidant activity of (**1**) were evaluated. Described in this paper are their structure elucidation and biological activities.

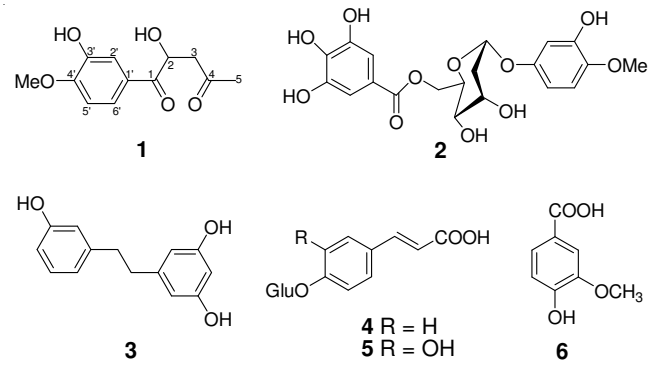

Fig. 1. Structure of phenolic compounds from the *Ziziphus jujube* Mill

EXPERIMENTAL

Optical rotation was measured in Horiba SEPA-300 high sensitive polarimeter. IR spectra were obtained in KBr disc on a Bio-Rad Wininfmred spectrophotometer. ESI-MS were measured on a VG Auto Spec-3000 MS spectrometer. ^{1}H, ^{13}C and 2D NMR spectra were recorded on Bruker DRX-500 instruments with TMS as internal standard. Column chromatography was performed on silica gel (200-300 mesh) or on silica gel H (10-40 mm, Qingdao Marine Chemical Inc., China). On second separate used Agilent 1100 HPLC equipped with ZORBAX-C_{18} (9.4 × 250 nm, 5.0 mm) column and DAD detector.

The fruit of *Ziziphus jujuba* Mill was collected in Hanzhong Prefecture, Shangxi Province, P.R. China, in

February 2009 and identified by Prof. N. Yuan. A voucher specimen (No. YNNi 09-2-02) was deposited in our laboratory.

Extraction and isolation: The air-dried and powdered fruit of *Ziziphus jujuba* Mill. (1.5 kg) were extracted with 70 % aqueous ethanol (3.0 L × 3, 24 h each) at room temperature and the extract was concentrated under vacuum. The dried extract (118 g) was applied to silica-gel (200-300 mesh) column chromatography eluting with a $CHCl_3$- Me_2CO gradient system (9:1, 8:2, 7:3, 6:4, 5:5, 2:1) to give six fractions A-F. The separation of fraction E ($CHCl_3$- Me_2CO 1:1, 18.6 g) by silica-gel column chromatography eluted with $CHCl_3$-Me_2OH (9:1-1:2) yielded mixtures A1-A5. Fraction A2 (2.6 g) was subjected to preparative HPLC (40 % MeOH-H_2O, flow rate 12 mL/min) to give **1** (19.2 mg) and **3** (45 mg). Fraction A3 (1.8 g) was subjected to preparative HPLC (25 % MeOH-H_2O, flow rate 12 mL/min) to give **2** (35.6 mg), **6** (29.8 mg). Fraction A4 (1.2 g) was subjected to preparative HPLC (15 % MeOH-H_2O, flow rate 12 mL/min) to give **4** (18.6 mg), **5** (23.5 mg).

Antioxidant activity assay: Antioxidant activity was determined by the detection of the oxidative products with the 2',7'-dichlorofluorescin diacetate (DCFH) method reported previously[20].

RESULTS AND DISCUSSION

Compound **1** was obtained as a white amorphous solid with m.f. $C_{12}H_{14}O_5$ from HRESIMS (m/z: 239.0914 $[M+H]^+$, calcd. 239.0919). IR absorptions at 3426, 1715 cm^{-1} indicated the presence of hydroxyl and carbonyl groups, respectively. The ^{13}C NMR spectrum of **1** (Table-1) along with analysis of the DEPT spectra displayed 12 carbon signals corresponding to 1-methyl (C, 31.2), 1-methylene (C, 48.4), 1-oxygenated methine (C, 71.2), 2-carbonyl carbons (C, 199.8, 207.6), 1-methoxyl carbon (C, 55.9) and 1-aromatic ring (C, 113.4, 115.9, 121.8, 125.2, 146.2, 152.8) with 3-aromatic protons (H, 6.84, 7.22, 7.46). The typical signals at (H, 6.84, d, *J* = 8.0), (H, 7.22, d, *J* = 8.0) and (H, 7.46, brs) observed in the ^1H NMR spectrum revealed the presence of 1, 2, 4-trisubstituted phenolic moiety, which was also supported by the HMBC correlations from H-2' (H, 7.46, brs) to C-3' (C, 146.2), C-4' (C, 152.8) and C-6' (C, 121.8), from H-5' (H, 6.84, d, *J* = 8.0) to C-1' (H, 125.2), C-3' (C, 146.2) and C-4' (C, 152.8) and from H-6' (7.22, d, *J* = 8.0) to C-2' (C, 115.9) and C-4' (C, 152.8). The side-chain of phenolic cycle was established by the HMBC correlations from H-2 (H, 5.82, dd, *J* = 4.6, 8.2) and H-3 (3.12, dd, *J* = 8.2, 15.8) to C-1 (C, 199.8), from H-2 (H, 5.82, dd, *J* = 4.6, 8.2), H-3 (H, 3.12, dd, *J* = 8.2, 15.8) and H-5 (H, 2.28 s) to C-4 (C, 207.6). The crosspeaks of H-2' (H, 7.46, brs) and H-6' (H, 7.22, d, *J* = 8.0) with C-1 (C, 199.8) (Fig. 2) helped in assigning the attachment of the side-chain to be at C-1'. The methoxyl groups located at C-4' was also supported by the HMBC of methoxyl proton (H, 3.79, s) to C-4' (C, 152.8). Thus, compound **1** was determined as 2-hydroxy-1-(3'-hydroxy, 4'-methoxy)-pentane-1, 4-dione.

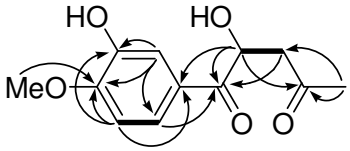

Fig. 2. Selected HBC ( ) and 1H-1H COSY (–)of (**1**)

The antioxidant activity of **1** was determined by the detection of the oxidative products with the 2',7'-dichlorofluorescin diacetate (DCFH) method reported previously[20]. It shows antioxidant activity with an IC_{50} value of 2.92 μg/mL. Compound **1** shows high antioxidant activity.

2-Hydroxy-1-(3'-hydroxy,4'-methoxy)-pentane-1,4-dione (**1**), $C_{12}H_{14}O_5$, white powder; $[a]_D^{25.8}$ + 88.6 (c 0.028, CH_3OH); UV (CH_3OH), λ_{max} (log e) 206 (4.66), 248 (3.26), 288 (2.37), 326 (1.84) nm; IR (KBr, ν_{max}, cm^{-1}) 3426, 3027, 2926, 2855, 1715, 1655, 1527, 1485, 1382, 1026, 874, 762; ^{13}C NMR and ^1H NMR data (CD_3OD, 500 MHz) see Table-1; positive ESIMS m/z 239 $[M+H]^+$; HRESIMS m/z 239.0914 $[M+H]^+$ (calcd. for $C_{12}H_{14}O_5$, 239.0919).

TABLE-1
^1H NMR AND ^{13}C NMR DATA OF COMPOUND (**1**) IN CD_3OD

No.	δ_C (mult.)	δ_H (mult., *J*, Hz)
1	199.8 s	
2	71.2 d	5.82, dd, *J* = 4.6, 8.2
3	48.4 t	3.12, dd, *J* = 8.2, 15.8
		3.33, dd, *J* = 5.2, 15.6
4	207.6 s	
5	31.2 s	2.28 s
1'	125.2 s	
2'	115.9 d	7.46, brs
3'	146.2 s	
4'	152.8 s	
5'	113.4 d	6.84, d, *J* = 8.0
6'	121.8 d	7.22, d, *J* = 8.0
OMe	55.9 q	3.79, s

ACKNOWLEDGEMENTS

This project was supported financially by the Excellent Scientific and Technological Team of Yunnan (2009CI014), the Yong Academic and Technical Leader Rising Foundation of Yunnan Province (2006PY01-47) and the Natural Science Foundation of Yunnan Province (2005XY04 and 2006B0042Q).

REFERENCES

1. H.B. Yang, S.Q. An, O.J. Sun and Z.M. Shi, *J. Integr. Plant. Biol.*, **50**, 210 (2008).
2. H. Zheng, H.F. Lu, Y.P. Zheng, H.Q. Lou and C.Q. Chen, *Int. J. Food. Eng.*, **101**, 402 (2010).
3. P. Tetali, C. Waghchaure, P.G. Daswani, N.H. Antia and T.J. Birdi, *J. Ethnopharmacol.*, **123**, 229 (2009).
4. H. Zhang, L. Jiang, S. Ye, Y.B. Ye and F.Z. Ren, *Food. Chem. Toxicol.*, **48**, 1461 (2010).
5. M.W. Saif, F. Lansigan, S. Ruta, L. Lamb, M. Mezes and K. Elligers, *Phytomedicine*, **17**, 161 (2010).
6. C.A. Wu, J.J. Wu, M.J. Tsai and R.Y. Chen, *J. Ethnopharmacol.*, **113**, 300 (2007).
7. Z.Y. Zhu, X.C. Liao, G.Z. Li amd P. Ji, *Chin. J. Agric. Sci. Bull.*, **12**, 1235 (2007).
8. J.S. Zhang, X.C. Jia, Y. Dai, D. Bi Mai and W.Y. Zhang, *Chin. J. Tob. Sci. Tech.*, **26**, 476 (2003).
9. Y. Tamaki, T. Konishi, M. Fukuta and M. Tako, *Food. Chem.*, **107**, 352 (2008).
10. J.G. Jiang, X.J. Huang, J. Chen and Q.S. Lin, *Nat. Prod. Res.*, **21**, 310 (2007).

11. S. Guo, Y.P. Tang, J.A. Duan, S.L. Su and A.W. Ding, *Chin. Chem. Lett.*, **20**, 197 (2009).
12. X.H. Fang, J.F. Hao, H.Y. Zhou, L.X. Zhu and J.H. Wang, *Phytomedicine*, **17**, 75 (2010).
13. Y. Ma, H.S. Han, S.Y. Nam, Y.B. Kim and J.T. Hong, *J. Ethnopharmacol.*, **117**, 318 (2008).
14. H.S. Han, Y. Ma, J.S. Eun, R.H. Li, J.T. Hong and M.K. Lee, *Pharm. Biochem. Behav*., **92**, 206 (2009).
15. Z.H. Zhao, J. Li, X.M. Wu, H. Dai, X.M. Gao and P.F. Tu, *Food. Res. Int.*, **39**, 917 (2006).
16. K. Ishi Maru, G.I. Nonaka and I. Nishioka, *Phytochemistry*, **26**, 1147 (1987).
17. X.Y. Guo, Y. Wang and N.L. Wang, *Chin. Trad. Herbal. Drugs*, **37**, 492 (2006).
18. C.B. Cui, Y. Tezuka and T. Kikuchi, *Chem. Pharm. Bull.*, **40**, 2035 (1992).
19. X.H. Pan, S. Li and Y. Li, *Nat. Prod. Res. Develop.*, **17**, 290 (2005).
20. S. Takamatsu, A.M. Galal, S.A. Ross, D. Ferreira, M.A. Elsohly, A.R. Ibrahim and F.S. El-Feraly, *Phytother. Res.*, **17**, 963 (2003).