Pergamon

PII: S0031-9422(97)00928-X

Phytochemistry, Vol. 48, No. 7, pp. 1245–1250, 1998

Printed in Great Britain
0031-9422/98 $19.00+0.00

GLYCOSIDES FROM *WAHLENBERGIA MARGINATA*

R. X. TAN,* W. G. MA,† H. X. WEI‡ and L. X. ZHANG

Institute of Biotechnology, Department of Biological Science & Technology, Nanjing University, Nanjing 210093, P. R. China

(*Received* 4 *April* 1997)

Key Word Index—*Wahlenbergia marginata*; Campanulaceae; glycosides; ionone analogs; nor-megastigmane glucoside; phenylpropanoid derivatives; demethyl syringin; wahlenoside A, B and C.

Abstract—Repeated fractionation of an aqueous ethanol extract of the whole herb of *Wahlenbergia marginata* afforded six ionone-related and five phenylpropanoid-derived glycosides. The structures of the five new compounds were established by spectroscopic and chemical methods as 3,5,5-trimethyl-4-(2′-β-D-glucopyranosyloxy)ethyl-cyclohexa-2-en-1-one, demethyl syringin, wahlenosides A, B and C, respectively. All constituents were not active against the human pathogenic fungi *Candida albican*, *Trichoderma viride* and *Aspergillus flavus*.

INTRODUCTION

In a preceding communication [1], we have described, in addition to the reisolation of lobetyolin, a known acetylene glucoside, the characterization of wahlenbergioside, a new 3-hydroxy-3-methylglutaroylphenyl propanoid glycoside from *Wahlenbergia marginata*, an important traditional Chinese medicine frequently utilized for many treatment purposes [1, 2]. In the present work, we have reinvestigated the chemical constituents of this species using more plant material and the results are presented in this paper.

RESULTS AND DISCUSSION

The powdered whole herb of *W. marginata* was extracted with aqueous ethanol at room temperature. The extract obtained after removal of solvents was partitioned between water and *n*-butanol. The butanol-soluble part was repeatedly fractionated by silica gel column chromatography, gel filtration on Sephadex LH-20 and reverse-phase HPLC to give five known (**1–5**) and one new (**6**) ionone-related glucosides, as well as a known (**8**) and four novel (**7, 9–11**) phenylpropanoid-derived glycosides.

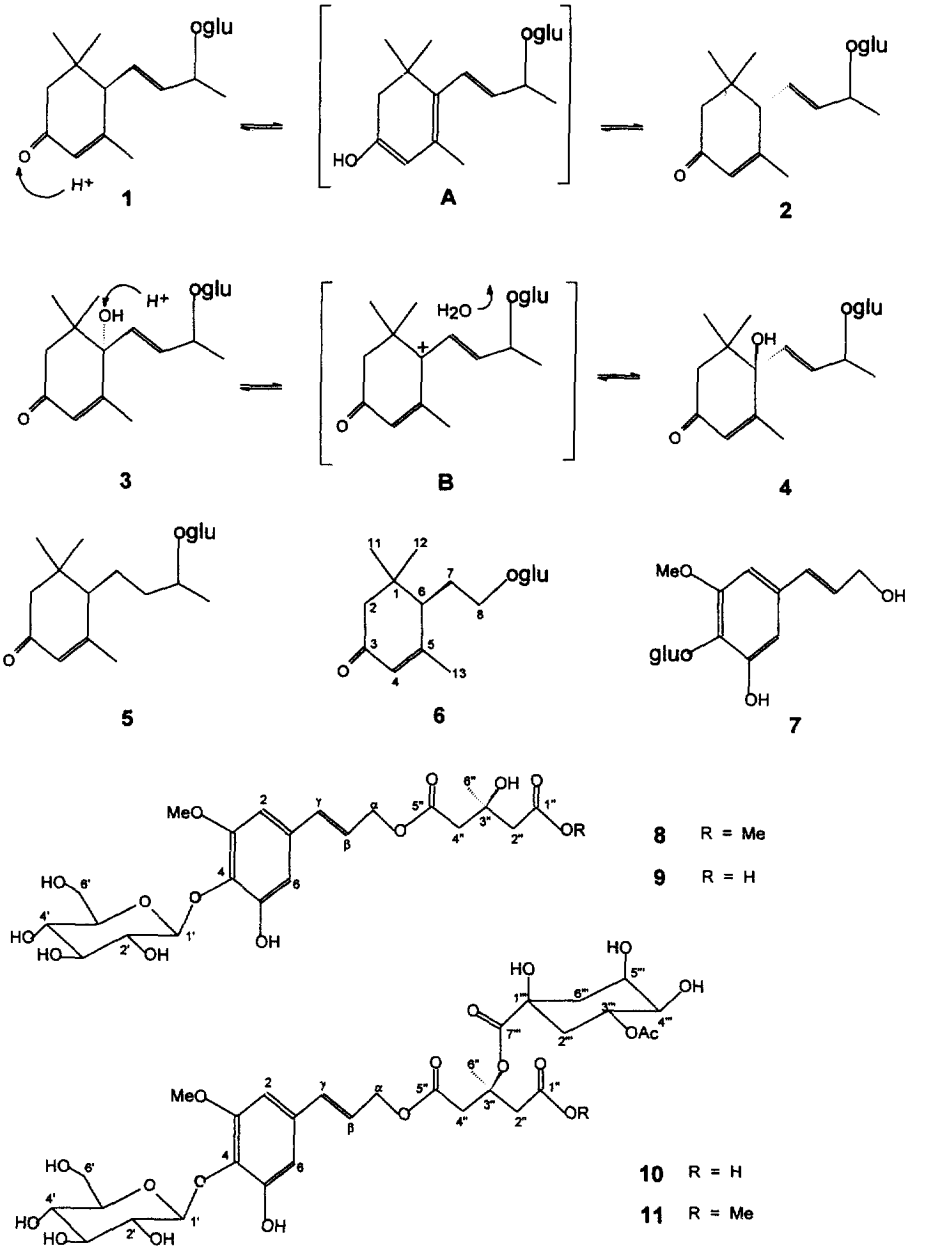
Glycosides **1** and **2** were eventually separated by HPLC. The FAB mass, ^{1}H and ^{13}C NMR spectral data, closely similar in both sets, established the identity of **1** and **2** as (+)-3-oxo-a-ionyl-*O*-β-D-glucopyranoside and (-)-3-oxo-a-ionyl-*O*-β-D-glucopyranoside, respectively [3–6]. The FAB mass, ^{1}H and ^{13}C NMR spectra of glycosides **3** and **4** showed that they were roseoside and 6-epimeric roseoside, respectively [7]. Since most of the megastigmane derivatives of plant origin characterized so far usually possess a 6β-side-chain, it was worth mentioning that glycosides **2** and **4** are possibly artifacts produced from compounds **1** and **3** through intermediates **A** and **B** (stabilized presumably by the lengthened conjugation systems), respectively.

The spectral data of glucoside **5** resembled those of compound **1**. But a pair of mutually coupled olefinic proton resonances present in the ^{1}H NMR of **1** was missing in that of **5**. This spectral feature, along with mass evidences, revealed that glycoside **5** was blumenol C-*O*-β-D-glucopyranoside [4]. The structure of the nor-megastigmane glycoside (**6**) was elucidated from its spectral data. In the positive FAB mass spectrum of **6**, a $[M+H]^+$ was observed at *m/z* 345, together with an intense peak at *m/z* 183 produced through elimination of a glucose moiety from the protonated parent ion. This mass spectral information, combined with its ^{1}H and ^{13}C NMR data, indicated that the molecular formula of **6** was $C_{17}H_{28}O_7$. The presence of a β-D-glucopyranosyloxy group ($C_6H_{11}O_6$) and a 3,5,5-trimethyl-cyclohexa-2-en-1-one

*Author to whom correspondence should be addressed.

† *Present address*: Department of Applied Bioscience, Faculty of Agriculture, Hokkaido University, Kita-ku, Sapporo 060, Japan.

‡ *Present address*: Department of Chemistry, University of Lausanne, BCH, CH-1015 Lausanne-Dorigny, Switzerland.



nucleus ($C_9H_{13}O_1$) was ascertained from the similar spectral characteristics as observed in the ^1H and ^{13}C NMR spectra of glycosides **1–5** (see Experimental) [3–7]. Subtraction of the elemental compositions of these two fragments from the molecular formula was equivalent to C_2H_4, which could be ascribed to either a $-CH_2CH_2-$ or a $CH_3CH=$ system. However, no methyl doublet could be found in the ^1H NMR spectrum of **6**. This observation, coupled with an oxygenated methylene carbon signal at δ 69.7 in its ^{13}C NMR spectrum, demonstrated that compound **6** was, as formulated, a nor-megastigmane glycoside (numbering deduced from megastigmane, *see* Formula). As evidenced from its ^1H and ^{13}C NMR spectral data, the stereochemistry of C-6 was found to be identical to that of **5** [3–7].

The structure of compound **7** is consistent with its spectral data. In the ^1H NMR spectrum, the presence of 1-(3′,4′,5′-trisubstituted)phenyl-3-hydroxypropene nucleus was indicated by a two-proton double doublet (J=6.5, 1.1 Hz) at δ 4.25, a double triplet (J=16.0, 6.5 Hz) at δ 6.23, a broadened doublet (J=16.0 Hz) at δ 6.56, as well as a pair of *meta*-coupled aromatic doublets (J=1.7 Hz) at δ 6.62 and 6.58 [8]. Furthermore, a methoxyl group and a glucopyranosyloxy residue, both situated on the benzene ring, was apparent from the typical ^1H NMR signals (see Experimental). In the NOE difference spectroscopy of **7**, irradiation of

Table 1. ^{1}H NMR spectral data of glycosides **9–11** (500 MHz, CD_3OD, J in Hz in parentheses)

H	9	10	11
2	6.61 *d* (1.7)	6.61 *d* (1.7)	6.63 *d* (1.8)
6	6.59 *d* (1.7)	6.59 *d* (1.7)	6.61 *d* (1.8)
α	4.69 *br d* (6.3)	4.69 *br d* (6.1)	4.72 *br d* (6.4)
β	6.22 *dt* (16.0, 6.3)	6.21 *dt* (15.8, 6.1)	6.25 *dt* (15.8, 6.4)
γ	6.55 *br d* (16.0)	6.55 *br d* (15.8)	6.58 *br d* (15.8)
OMe	3.83 *s*	3.82 *s*	3.85 *s*
1′	4.67 *d* (7.4)	4.66 *d* (7.5)	4.69 *d* (7.5)
2′	3.48 *dd* (7.5, 9.0)	3.47 *dd* (7.5, 9.0)	3.50 *dd* (7.5, 9.0)
3′	3.41 *dd* (9.0, 9.0)	3.44 *dd* (9.0, 9.0)	3.48 *dd* (9.0, 9.0)
4′	3.45 *dd* (9.0, 9.0)	3.40 *dd* (9.0, 9.0)	3.43 *dd* (9.0, 9.0)
5′	3.24 *m*	3.25 *m*	3.29 *m*
6′a	3.80 *dd* (11.9, 1.8)	3.78 *dd* (12.0, 2.4)	3.81 *dd* (12.1, 2.4)
6′b	3.71 *dd* (11.9, 4.3)	3.70 *dd* (12.0, 4.5)	3.73 *dd* (12.1, 4.5)
2″a	2.56 *d* (15.4)	3.12 *d* (14.9)	3.11 *d* (15.0)
2″b	2.44 *d* (15.4)	3.03 *d* (14.9)	3.07 *d* (15.0)
4″a	2.63 *s* (2H)	3.10 *d* (14.9)	3.13 *d* (15.0)
4″b	—	3.03 *d* (14.9)	3.02 *d* (15.0)
6″	1.33 *s*	1.62 *s*	1.65 *s*
COOMe	—	—	3.73 *s*
2‴a	—	2.18 *ddd* (13.5, 4.5, 1.8)	2.17 *ddd* (13.4, 4.4, 1.7)
2‴b	—	1.94 *dd* (13.5, 8.7)	1.96 *dd* (13.4, 9.0)
3‴	—	5.26 *ddd* (9.8, 9.0, 4.7)	5.25 *ddd* (9.0, 8.6, 4.4)
4‴	—	3.62 *dd* (9.8, 2.7)	3.61 *dd* (8.6, 3.3)
5‴	—	4.17 *ddd* (5.2, 3.6, 3.3)	4.06 *ddd* (5.3, 3.5, 3.2)
6‴a	—	2.05 *dd* (14.1, 3.6)	2.07 *dd* (14.2, 3.6)
6‴b	—	2.00 *ddd* (14.1, 5.1, 1.8)	2.03 *ddd* (14.2, 5.2, 1.7)
OAc	—	1.93 *s*	1.96 *s*

the methoxyl singlet at δ 3.84 produced a pronounced intensity enhancement (7%) of H-2 doublet at δ 6.62 and a weak effect (*ca* 0.4%) of the doublet of the anomeric proton at δ 4.65. Thus, compound **7** was most likely a demethylated analogue of syringin [9]. This assumption was confirmed by the conversion of **7** with pyridine-acetic anhydride to demethyl siringin peracetate [1].

The FAB mass, ^{1}H and ^{13}C NMR spectra of glycoside **8** established its identity as wahlenbergioside, characterized very recently from the title species [1]. The ^{1}H and ^{13}C NMR spectral data of compound **9** were closely similar to those of **8** (Tables 1 and 2) [1]. However, the three-proton singlet at δ 3.66 in the ^{1}H NMR spectrum of **8** was missing in that of glycoside **9**. Accordingly, compound **9** was a demethylated derivative of **8**. This conclusion was further reinforced by the negative and positive FAB mass spectra of **9** indicating that the Mr of **9** was 502, being 14 mu less than that of **8** (see Experimental) [1].

The negative and positive FAB mass spectra of **10** exhibited quasimolecular ions at *m/z* 717 $[M-H]^-$ and 741 $[M+Na]^+$, respectively. These findings, along with ^{1}H and ^{13}C NMR spectral data, including DEPT experiments, revealed that the molecular formula of **10** was $C_{31}H_{42}O_{19}$. In addition, the ^{1}H and ^{13}C NMR spectra of **10** indicated that it was also a 3-hydroxy-3-methylglutaroyl phenylpropanoid derivative. All ^{1}H and ^{13}C NMR signals of compound **10** were assigned by the sequential spin decoupling experiments, DEPT pulse sequences, 2D NMR techniques (COSY, HETCO and COLOC) and comparisons with those of analogues reported previously [1, 9, 10]. The ^{1}H and ^{13}C NMR signals due to (2-methoxy-3-β-D-glucopyranosyloxy-4-hydroxy)phenylpropene nucleus were identical to those of **8** and **9** (Tables 1 and 2) [1]. Besides signals assignable to a 3-hydroxy-3-methylglutaroyl phenylpropanoid glucoside moiety, the ^{13}C NMR spectrum of **10** gave nine additional resonances consisting of an oxygenated quaternary (δ 80.5), an ester carbonyl (δ 171.2), two magnetically similar methylenes (δ 38.4 and 37.9), three oxygen-bearing methines (δ 73.3, 72.3 and 70.8) and acetoxyl (δ 171.0 and 22.2) carbons. These observations and a set of ^{1}H NMR data ascribable to a quinoyl group (H-2‴ through H-6‴, Table 1), along with the downfield-shifted chemical shift, of the H-3‴ signal (δ 5.26), demonstrated the presence of a 3-acetylquinoyloxy

Table 2. ^{13}C NMR spectral data of glycosides **9–11** (500 MHz, CD_3OD)

C	9	10	11	DEPT
1	135.2	135.0	135.0	C
2	108.9	108.8	108.9	CH
3	154.2	154.3	154.3	C
4	135.1	135.0	135.0	C
5	151.9	151.9	151.9	C
6	106.7	106.7	106.7	CH
α	65.9	66.1	66.1	CH_2
β	124.3	124.1	124.1	CH
γ	134.7	135.2	135.1	CH
OMe	56.7	56.7	56.8	CH_3
1′	103.5	103.5	103.5	CH
2′	75.3	75.3	75.3	CH
3′	78.3	78.3	78.3	CH
4′	70.9	70.8	70.8	CH
5′	77.6	77.6	77.6	CH
6′	62.0	62.0	62.0	CH_2
1″	172.5	172.4	172.1	C
2″	45.3	43.5	43.5	CH_2
3″	70.8	76.4	76.2	C
4″	45.3	43.1	43.1	CH_2
5″	175.2	172.2	171.1	C
6″	27.8	25.2	25.1	CH_3
COOMe	—	—	53.1	CH_3
1‴	—	80.5	80.4	C
2‴	—	38.4	38.5	CH_2
3‴	—	73.3	73.1	CH
4‴	—	72.3	72.1	CH
5‴	—	70.8	71.0	CH
6‴	—	37.9	38.0	CH_2
7‴	—	171.2	171.0	C
OAc	—	171.0	170.7	C
	—	22.2	22.2	CH_3

* A few signals within the same column may be interchangeable although the given assignment was more preferable.

residue, which was also reinforced by the absence of a carbon signal around δ 180 (typical of the carboxylic group of quinic acid [11]) in the ^{13}C NMR spectrum of **10**. Moreover, the ^1H NMR signals arising from 3-oxygenated-3-methylglutaroyl moiety of **10** were shifted downfield by 0.3–0.6 ppm in comparison with those of **8** and **9** (Table 1) [1], suggesting acylation of the 3″-hydroxyl. This could only be explained by assuming the attachment of the 3-acetylquinoyloxy group to C-3″. The formulated stereochemistry of C-3″ followed from biogenetic considerations, because all constituents with a 3-oxygenated-3-methylglutaroyl moiety found so far in the members of the Campanulaceae possess a 3*S*-configuration [9, 10].

The negative and positive FAB mass spectra of **11** gave quasimolecular ions at *m/z* 731 $[M-H]^-$ and 755 $[M+Na]^+$. This observation, coupled with the ^1H and ^{13}C NMR data, suggested that the Mr of **11** was 732, being 14 mu higher than that of **10** (*see* above). Furthermore, the ^1H and ^{13}C NMR spectra, closely similar to those of **10**, indicated that it was also wahlenberioside analogue possessing a 3-acetylquinoyloxy residue. In the ^1H NMR spectrum of **11**, a three-proton singlet at δ 3.73, not present in that of **10**, was attributed to a COOMe group. Thus, glycoside **11** was the methyl ester of compound **10**. We have named compounds **9, 10** and **11**, wahlenosides A, B and C, respectively.

All isolates were subjected to antifungal bioassays utilizing the human pathogenetic fungi, *Candida albican*, *Trichoderma viride* and *Aspergillus flavus* following procedures described previously [12, 13]. None showed any discernable activity.

The present phytochemical reinvestigation gives more information on the constituents of *W. marginata*. Furthermore, the chemistry of this species indicates its relationship to other members of the Campanulaceae. However the presence of the nor-megastigmane glycoside (**6**) and phenylpropanoid glucosides (like **10** and **11**) with a quinoyloxyglutaroyl group seems to be quite unusual and probably characteristic of *W. marginata*.

EXPERIMENTAL

All NMR experiments were performed in CD_3OD on a Bruker AM 500 FT-NMR spectrometer using TMS as int. standard. Silica gel (200–300 mesh) for CC and silica GF_{254} (10–20 μ) for TLC were products of the Qingdao Marine Chemical Factory, China.

Plant material

Whole herb of *W. marginata* was purchased from the Jingsu Pharmaceutical Material Company. The plant, collected in June 1995 in Yunnan Province, P. R. China, was identified by Dr L. X. Zhang and a voucher specimen (ZL 96-b04) is deposited in the Herbarium of the Department of Biological Sciences & Technology, Nanjing University.

Extraction and isolation

Pulverized air-dried plant material (10 kg) was extracted ×2 with EtOH-H_2O (4 : 1) at room temp Evapn of solvent *in vacuo* from the extract afforded a brown gum (1096 g) which was dissolved in H_2O with occasional agitation. The soln was then extracted with *n*-BuOH. The *n*-BuoH soln was concd to dryness (56 g) under vacuum and subjected to CC (silica gel, 1200 g) eluting with $CHCl_3$ containing gradually increased amounts of MeOH-H_2O (9:2). According to TLC monitoring, 6 frs were collected (F-1: 11 g, F-2: 3.1 g, F-3: 2.9 g, F-4: 2.4 g, F-5: 2 g and F-6: 15 g). F-1 contained nothing of interest. CC of F-2 with a $CHCl_3$-MeOH gradient gave a fatty gum and a mixt. which was repeatedly chromatographed over Sephadex LH-20 utilizing MeOH-$CHCl_3$ (9 : 1). The UV-active fr. was further separated by prep. HPLC (RP-18, *ca* 95 bar, flow rate 2.6 ml min^{-1}, MeOH-

H_2O, 1:1) to yield **1** (4 mg) and **2** (3 mg). F-3 was fractionated into three parts (F-3-1, F-3-2 and F-3-3) by CC over silica gel with $CHCl_3$-MeOH mixts of increasing polarity. HPLC comparisons showed that F-3-1 contained mainly **1** and **2**. Gel filtration of F-3-2 with MeOH gave again a mixt. of **1** and **2**, as well as a gum which afforded **5** (5 mg) by HPLC purification as described above. Repetitive gel filtration of F-3-3 with MeOH-H_2O (9:1) afforded 7 mg of **6**. CC of F-4 over silica gel using $CHCl_3$-MeOH gave 3 mixts (F-4-1, F-4-2 and F-4-3). Repeated gel filtration of F-4-1 with MeOH gave a gum of **5** and **6**. Gel chromatography of F-4-2 with MeOH afforded an UV-active mixt. which, by HPLC separation, yielded **3** (6 mg) and **4** (4 mg). F-4-3 was combined with F-5 and the mixt. fractionated into four parts (F-5-1, F-5-2, F-5-3, and F-5-4) by CC over silica column utilizing a $CHCl_3$-MeOH-H_2O gradient. Repetitive gel chromatography of F-5-1 with MeOH afforded **8** (15 mg). Gel filtration of F-5-2 using MeOH yielded compound **7** (13 mg). Gel chromatography of F-5-3 using MeOH-H_2O (7:1) gave a mixt., which yielded **9** (5 mg) by HPLC purification (MeOH-H_2O, 2:3). F-6, combined with F-5-4, was further separated into 3 frs (F-6-1, F-6-2 and F-6-3) over silica gel with $CHCl_3$-MeOH-H_2O mixts. Repetitive gel filtration of F-6-1 with MeOH gave again glycoside **9** (6 mg). F-6-2 was fractionated by gel chromatography with MeOH to yield an UV-active gum which afforded **10** (9 mg) and **11** (12 mg) by HPLC separation (MeOH-H_2O,2:3). F-6-3 contained mainly saccharides.

3,5,5-*Trimethyl*-4-(2′-β-D-*glucopyranosyloxy*)*ethyl-cyclohexa*-2-*en*-1-*one* (**6**)

Colourless gum. $[\alpha]_D$+9.6° (MeOH; *c* 0.021). UV λ_{max} (MeOH) (log ϵ): 251 (4.11). IR ν_{max} (KBr) cm^{-1}: 3500–3200, 2940, 1685, 1420, 1335, 1010. FABMS (positive ion mode) *m/z*: 345 $[M+H]^+$, 183 $[M+H$-glucosyl$]^+$. ^1H NMR (CD_3OD) δ: 2.47 (1H, *d*, *J*=17.4 Hz, H-2a), 1.97 (1H, *d*, *J*=17.4 Hz, H-2b), 5.79 (1H, *br s*, H-4), 2.18 (1H, *br t*, *J*=5.5 Hz, H-6), 2.11 (1H, *m*, H-7a), 1.67 (1H, *m*, H-7b), 3.97 (1H, *ddd*, *J*=9.7, 7.0, 6.7 Hz, H-8a), 3.63 (1H, *ddd*, *J*=9.7, 6.8, 6.5 Hz, H-8b), 1.07 (3H, *s*, H-11), 1.01 (3H, *s*, H-12), 2.05 (3H, *br s*, H-13), 4.26 (1H, *d*, *J*=7.8 Hz, H-1′), 3.17 (1H, *dd*, *J*=7.8, 9.0 Hz, H-2′), 3.24-3.32 (3H, *m*, H-3′, H-4′ and H-5′), 3.85 (1H, *dd*, *J*=12.1, 1.9 Hz, H-6′a), 3.65 (1H, *dd*, *J*=12.1, 5.4 Hz, H-6′b). ^{13}C NMR (CD_3OD, multiplicities by DEPT pulse sequences) δ: 37.3 (*s*, C-1), 47.8 (*t*, C-2), 202.3 (*s*, C-3), 125.5 (*d*, C-4), 170.1 (*s*, C-5), 50.0 (*d*, C-6), 31.1 (*t*, C-7), 69.7 (*t*, C-8), 27.2, (*q*, C-11), 28.6 (*q*, C-12), 24.8 (*q*, C-13), 104.3 (*d*, C-1′), 75.2 (*d*, C-2′), 78.2 (*d*, C-3′), 71.7 (*d*, C-4′), 78.0 (*d*, C-5′), 62.8 (*t*, C-6′).

Demethyl syringin (**7**)

Colourless gum. UV λ_{max} (MeOH) (log ϵ): 222 (3.31), 264 (3.81). IR ν_{max} (KBr) cm^{-1}: 3570–3280, 2940, 1605, 1490, 1340, 1050. FABMS (positive ion mode) *m/z*: 359 $[M+H]^+$, 197 $[M+H$-glucosyl$]^+$. ^1H NMR (CD_3OD) δ: 6.62 (1H, *d*, *J*=1.7 Hz, H-2), 6.58 (1H, *d*, *J*=1.7 Hz, H-6), 4.25 (2H, *dd*, *J*=6.5, 1.1 Hz, H-α), 6.23 (1H, *dt*, *J*=6.5, 16.0 Hz, H-β), 6.56 (1H, *br d*, *J*=16.0 Hz, H-γ), 3.84 (3H, *s*, OMe), 4.65 (1H, *d*, *J*=7.5 Hz, H-1′), 3.49 (1H, *dd*, *J*=7.5, 9.0 Hz, H-2′), 3.44 (2H, *m*, H-3′ and H-4′), 3.24 (1H, *m*, H-5′), 3.75 (1H, *dd*, *J*=11.9, 1.8 Hz, H-6′a), 3.70 (1H, *dd*, *J*=11.9, 4.5 Hz, H-6′b).

Wahlenoside A (**9**)

Colourless gum. $[\alpha]_D$-8.4° (MeOH; *c* 0.032). UV λ_{max} (MeOH) (log ϵ): 223 (3.41), 266 (3.92). IR ν_{max} (Kbr) cm^{-1}: 3520-2580, 2940, 1725, 1605, 1490, 1340, 1050. FABMS (positive ion mode) *m/z*: 525 $[M+Na]^+$ 503 $[M+H]^+$. FABMS (negative ion mode) *m/z*: 501 $[M-H]^-$, 339 [M-H-glucosyl]$^-$. ^1H and ^{13}C NMR: Tables 1 and 2.

Wahlenoside B (**10**)

Colourless gum. $[\alpha]_D$-21° (MeOH; *c* 0.113). UV λ_{max} (MeOH) (log ϵ): 220 (3.39), 264 (3.88). IR ν_{max} (KBr) cm^{-1}: 3520–2570, 2970, 1725, 1600, 1495, 1345, 1030. FABMS (positive ion mode) *m/z*: 541 $[M+Na]^+$; FABMS (negative ion mode) *m/z*: 717 $[M-H]^-$. ^1H and ^{13}C NMR: Tables 1 and 2.

Wahlenoside C (**11**)

Colourless gum. $[\alpha]_D$-17° (MeOH; *c* 0.141). UV λ_{max} (MeOH) (log ϵ): 221 (3.49), 267 (3.97). IR ν_{max} (KBr) cm^{-1}: 3520–3180, 2940, 1720, 1595, 1485, 1340, 1030. FABMS (positive ion mode) *m/z*: 755 $[M+Na]^+$; FABMS (negative ion mode) *m/z*: 731 $[M-H]^-$. ^1H and ^{13}C NMR: Tables 1 and 2.

Acknowledgements—This work was co-financed by grants (for RXT) from the National Natural Science Foundation (No: 39670873), the State Education Commission of China [*Category*: "Trans-Century Talents Programme" and "Doctoral Training Programme" (No: 9628418)]. The authors are greatly indebted to Dr J. Hu, Department of Chemistry, Nanjing University, for recording NMR spectra.

REFERENCES

1. Ma, W. G., Tan, R. X., Fuzzati, N., Li, Q. S., Wolfender, J.-L. and Hostettmann, K., *Phytochemistry*, 1997, **45**, 411.
2. Jiangsu College of New Medicine, in *A comprehensive dictionary of the traditional Chinese medicines*. Suzhou, China, 1977, pp. 774–774.
3. Jakupovic, J., Tan, R. X., Bohlmann, F., Jia, Z. J. and Huneck, S., *Planta Med.*, 1991, **57**, 450.

4. Tazaki, H., Ohta, N., Nabeta, K., Okuyama, H. and Okumura, M., *Phytochemistry*, 1993, **34**, 1067.
5. Cui, B.-L., Nakamura, M., Kinjo, J. and Nohara, T., *Chem. Pharm. Bull.*, 1993, **41**, 178.
6. Miyase, T., Veno, A., Takizawa, N., Kobayyashi, H. and Oguchi, H., *Chem. Pharm. Bull.*, 1988, **36**, 2475.
7. Otsuka, H., Yao, M., Kamada, K. and Takeda, Y., *Chem. Pharm. Bull.*, 1995, **43**, 754.
8. Tan, R. X., Jakupovic, J. and Jia, Z. J., *Planta Med.*, 1990, **56**, 475.
9. Mizutani, K., Yuda, M., Tanaka, O., Saruwatari, Y., Jia, M. R., Ling, Y. K. and Pu, X. F., *Chem. Pharm. Bull.*, 1988, **36**, 2726.
10. Yuda, M., Ohtani, K., Mizutani, K., Kasai, R., Tanaka, O., Jia, M. R., Ling, X. F., Pu, X. F. and Saruwatari, Y., *Phytochemistry*, 1990, **29**, 1989.
11. Foo, L. Y., *Phytochemistry*, 1995, **39**, 217.
12. Rahalison, L., Hamburger, M., Hostettmann, K. and Monod, M., Frenk, E., *Phytochemical Analysis*, 1991, **2**, 199.
13. Zheng, W. F., Tan, R. X., Yang, L. and Liu, Z. L., *Planta Med.*, 1996, **62**, 160.