VIETNAM JOURNAL OF CHEMISTRY VOL. 53(2e) 77-81 APRIL 2015
DOI: 10.15625/0866-7144.2015-2e-018

FLAVONOIDS FROM THE ROOTS OF *Sophora flavescens*

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Received 23 January 2015; Accepted for Publication 18 March 2015

Abstract

Phytochemical study on the roots of *Sophora flavescens* resulted in the isolation of eight compounds. Their structures were identified as isoxanthohumol (**1**), norkurarinone (**2**), kurarinone (**3**), 2′-methoxykurarinone (**4**), kushenol T (**5**), norkurarinol (**6**), kuraridin (**7**), and formononetin (**8**) by detailed analyses of 1D and 2D NMR, and MS in comparison with the data reported in the literature.

Keywords. *Sophora flavescens*, Leguminosae, flavonoid.

1. INTRODUCTION

The dried roots of *S. flavescens* (Leguminosae) are commonly used as the traditional Chinese medicine and possess various physiological properties such as anti-bacterial, anti-inflammatory, antipyretic, anti-asthmatic, anti-ulcerative, and anti-neoplastic effects [1]. A series of isoprenylated or lavandulylated flavonoids have been isolated from this plant [2-7]. Some of these compounds exhibited significant antibacterial activity against Gram-positive bacteria [2], antiviral activity against herpes simplex virus types I and II [3], as well as cytotoxic activity against human myeloid leukemia HL-60 cells [5, 7], and potent inhibitory activity against cGMP phosphodiesterase 5 [6]. The present study describes the isolation and structural elucidation of eight known flavonoids (**2–9**) from the methanol extract of the roots of *S. flavescens*.

2. MATERIAL AND METHODS

2.1. Plant materials

The roots of *S. flavescens* were purchased from herbal market at Kumsan, Chungnam, Korea, in August 2010. The plant material was identified by one of us (Y. H. Kim). A voucher specimen (CNU10106) was deposited at herbarium, College of Pharmacy, Chungnam National University.

2.2. General experimental procedures

Optical rotation was determined using a Jasco P-2000 digital polarimeter. Electron-impact mass spectra (EIMS) were obtained using a Hewlett-Packard MS 5988 mass spectrometer. The NMR spectra were recorded on a Jeol ECA 600 spectrometer using TMS as an internal standard. CD spectra were recorded with a Jasco J-720 spectropolarimeter. TLC was performed on Kieselgel 60 F254 (1.05715; Merck, Darmstadt, Germany) or RP-18 F254s (Merck) plates. Spots were visualized by spraying with 10 % aqueous H_2SO_4 solution, followed by heating. Column chromatography (CC) was performed on silica gel (Kieselgel 60, 70-230 mesh and 230-400 mesh, Merck) and YMC RP-18 resins.

2.3. Extraction and Isolation

The dried stem bark of *S. flavescens* (3.0 kg) was extracted with hot MeOH. After concentration, the MeOH extract (250 g) was suspended in water and then partitioned successively with CH_2Cl_2 and EtOAc to give CH_2Cl_2 (A), EtOAc (B) and water (C) fractions, respectively. Fraction B was subjected to silica gel column chromatography, eluted with acetone in CH_2Cl_2 (0-100 %, stepwise) to yield five fractions (B1-5). Fraction B2 was then separated by column chromatography over C_{18} reverse-phase, using MeOH–H_2O (2:1) to afford **7** (30 mg) and **8**

(15 mg). Fraction B3 was separated by column chromatography over silica gel, using CH_2Cl_2–EtOAc (4:1) as eluent to give three subfractions (B3A–C). Fraction B3A was chromatographed over silica gel column, eluting with CH_2Cl_2–acetone (5:1) to provide **2** (50 mg). Subfraction B3B was then chromatographed over C_{18} reverse-phase, using MeOH–H_2O (3:1), and further purified by column chromatography over silica gel, eluting with CH_2Cl_2–MeOH (15:1) to obtain and **5** (7 mg). Subfraction B3C was separated by C_{18} reverse-phase chromatography, using MeOH–H_2O (2:1) as eluent, and further purified by column chromatography over silica gel, eluting with CH_2Cl_2–MeOH (12:1) to obtain **1** (10 mg) and **6** (45 mg). Fraction B4 was separated by column chromatography over silica gel, eluted with CH_2Cl_2–Acetone (4:1) to provide three subfractions (B4A-C). Fraction B4B was then purified by column chromatography over C_{18} reverse-phase, using MeOH–H_2O (2:1) to afford **3** (45 mg) and **4** (10 mg).

Isoxanthohumol (1): pale yellow, amorphous powder, $[\alpha]_D^{25}$ –25 (*c* = 0.5, MeOH). EIMS *m/z* 354 [M^+]. ^{1}H NMR (600 MHz, CD_3OD) δ: 5.23 (dd, *J* = 2.4, 13.2 Hz, H-2), 2.93 (dd, *J* = 13.2, 16.8 Hz, H-3a), 2.62 (dd, *J* = 3.6, 16.8 Hz, H-3b), 6.07 (br s, H-6), 7.27 (each d, *J* = 9.0 Hz, H-2′ and H-6′), 6.78 (each d, *J* = 9.0 Hz, H-3′ and H-5′), 3.16 (t, *J* = 6.0 Hz, H_2-1″), 5.10 (m, H-2″), 1.52 (s, H_3-4″), 1.58 (s, H_3-5″), 55.9 (5-OCH_3). ^{13}C NMR (150 MHz, CD_3OD) δ: 79.9 (C-2), 46.1 (C-3), 192.9 (C-4), 161.7 (C-5), 93.3 (C-6), 164.2 (C-7), 109.9 (C-8), 163.8 (C-9), 105.7 (C-10), 131.5 (C-1′), 128.8 (C-2′), 116.2 (C-3′), 158.7 (C-4′), 116.2 (C-5′), 128.8 (C-6′), 22.7 (C-1″), 123.9 (C-2″), 131.6 (C-3″), 17.9 (C-4″), 25.9 (C-5″), 55.9 (5-OCH_3).

Norkurarinone (2): yellow, amorphous powder, $[\alpha]_D^{25}$ +10.3 (*c* = 0.7, MeOH). EIMS *m/z* 424 [M^+]. ^{1}H NMR (600 MHz, CD_3OD) δ: 5.52 (dd, *J* = 3.0, 13.8 Hz, H-2), 2.90 (dd, *J* = 13.2, 16.8 Hz, H-3a), 2.70 (dd, *J* = 3.0, 17.4 Hz, H-3b), 5.87 (br s, H-6), 6.32 (d, *J* = 1.8 Hz, H-3′), 6.34 (dd, *J* = 1.8, 8.4 Hz, H-5′), 7.26 (d, *J* = 8.4 Hz, H-6′), 2.52 (m, H_2-1″), 2.41 (m, H-2″), 4.92 (t, *J* = 6.6 Hz, H-4″), 1.49 (s, H_3-6″), 1.41 (s, H_3-7″), 4.53 (d, *J* = 1.2 Hz, H-9″a), 4.47 (d, *J* = 1.2 Hz, H-9″b), 1.57 (s, H_3-10″). ^{13}C NMR (150 MHz, CD_3OD) δ: 74.9 (C-2), 42.3 (C-3), 198.2 (C-4), 162.1 (C-5), 95.5 (C-6), 165.6 (C-7), 107.9 (C-8), 161.7 (C-9), 102.5 (C-10), 117.6 (C-1′), 155.7 (C-2′), 102.6 (C-3′), 158.4 (C-4′), 106.9 (C-5′), 127.9 (C-6′), 27.1 (C-1″), 47.3 (C-2″), 31.5 (C-3″), 123.9 (C-4″), 131.2 (C-5″), 25.1 (C-6″), 17.1 (C-7″), 148.8 (C-8″), 110.4 (C-9″), 18.4 (C-10″).

Kurarinone (3): yellow, amorphous powder, $[\alpha]_D^{25}$ +13.5 (*c* = 0.2, MeOH). EIMS *m/z* 438 [M^+]. ^{1}H NMR (600 MHz, CD_3OD) δ: 5.52 (dd, *J* = 3.0, 13.8 Hz, H-2), 2.84 (dd, *J* = 13.2, 16.8 Hz, H-3a), 2.68 (dd, *J* = 2.4, 16.2 Hz, H-3b), 6.05 (br s, H-6), 6.33 (br s, H-3′), 6.34 (dd, *J* = 2.4, 8.4 Hz, H-5′), 7.28 (d, *J* = 8.4 Hz, H-6′), 2.58 (dd, *J* = 3.0, 7.2 Hz, H_2-1″), 2.45 (m, H-2″), 1.94 (m, H_2-3″), 4.91 (t, *J* = 6.6 Hz, H-4″), 1.51 (s, H_3-6″), 1.41 (s, H_3-7″), 4.52 (d, *J* = 1.8 Hz, H-9″a), 4.47 (d, *J* = 1.8 Hz, H-9″b), 1.57 (s, H_3-10″), 3.73 (5-OCH_3). ^{13}C NMR (150 MHz, CD_3OD) δ: 74.5 (C-2), 44.6 (C-3), 193.2 (C-4), 160.8 (C-5), 92.4 (C-6), 163.9 (C-7), 108.6 (C-8), 163.8 (C-9), 104.8 (C-10), 117.6 (C-1′), 155.6 (C-2′), 102.5 (C-3′), 158.4 (C-4′), 106.8 (C-5′), 127.6 (C-6′), 27.3 (C-1″), 47.2 (C-2″), 31.5 (C-3″), 123.9 (C-4″), 131.1 (C-5″), 25.0 (C-6″), 17.0 (C-7″), 148.8 (C-8″), 110.3 (C-9″), 18.3 (C-10″), 55.0 (5-OCH_3).

2′-Methoxykurarinone (4): pale yellow, amorphous powder, $[\alpha]_D^{25}$ –35.2 (*c* = 0.1, MeOH). EIMS *m/z* 452 [M^+]. ^{1}H NMR (600 MHz, CD_3OD) δ: 5.50 (dd, *J* = 2.4, 13.2 Hz, H-2), 2.83 (dd, *J* = 13.2, 16.8 Hz, H-3a), 2.59 (dd, *J* = 2.4, 16.8 Hz, H-3b), 6.06 (br s, H-6), 6.43 (d, *J* = 2.4 Hz, H-3′), 6.42 (dd, *J* = 2.4, 7.8 Hz, H-5′), 7.33 (d, *J* = 8.4 Hz, H-6′), 2.56 (m, H_2-1″), 2.45 (m, H-2″), 1.94 (m, H_2-3″), 4.90 (t, *J* = 6.6 Hz, H-4″), 1.51 (s, H_3-6″), 1.42 (s, H_3-7″), 4.53 (d, *J* = 1.8 Hz, H-9″a), 4.46 (d, *J* = 1.8 Hz, H-9″b), 1.59 (s, H_3-10″), 3.76 (5-OCH_3), 3.75 (2′-OCH_3). ^{13}C NMR (150 MHz, CD_3OD) δ: 74.1 (C-2), 44.5 (C-3), 192.7 (C-4), 160.9 (C-5), 92.6 (C-6), 164.5 (C-7), 108.7 (C-8), 163.8 (C-9), 104.6 (C-10), 118.7 (C-1′), 158.0 (C-2′), 98.8 (C-3′), 159.1 (C-4′), 107.2 (C-5′), 127.6 (C-6′), 27.3 (C-1″), 47.2 (C-2″), 31.4 (C-3″), 123.9 (C-4″), 131.1 (C-5″), 25.0 (C-6″), 16.9 (C-7″), 148.8 (C-8″), 110.3 (C-9″), 18.2 (C-10″), 54.9 (5-OCH_3), 55.0 (2′-OCH_3).

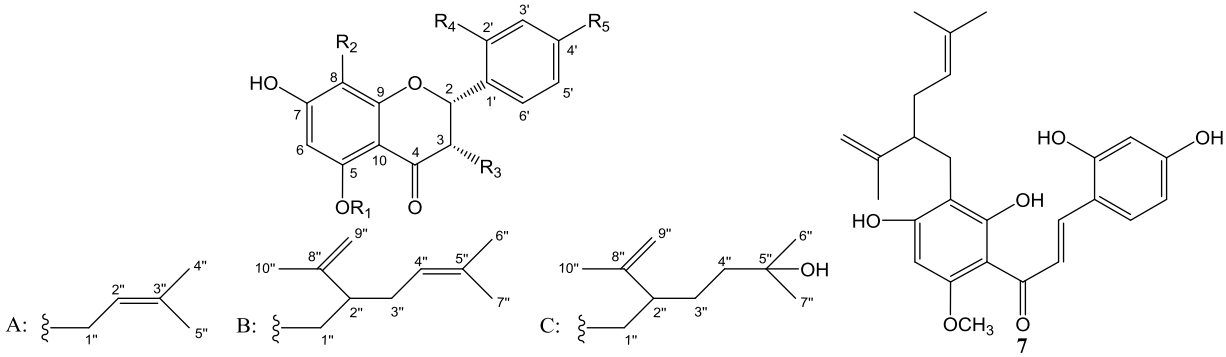
Kushenol T (5): yellow, amorphous powder, $[\alpha]_D^{25}$ –118.5 (*c* = 0.2, MeOH). EIMS *m/z* 426 [M^+]. ^{1}H NMR (600 MHz, CD_3OD) δ: 5.63 (dd, *J* = 2.4, 13.2 Hz, H-2), 3.28 (H-3a), 2.86 (H-3b), 5.91 (br s, H-6), 6.81 (d, *J* = 7.8 Hz, H-3′), 7.14 (t, *J* = 7.8 Hz, H-4′), 6.87 (t, *J* = 7.8 Hz, H-5′), 7.23 (d, *J* = 7.8 Hz, H-6′), 2.84 (m, H-1″a), 2.36 (m, H-1″b), 1.02 (s, H_3-6″), 1.01 (s, H_3-7″), 4.61 (s, H-9″a), 4.54 (s, H-9″b), 1.62 (s, H_3-10″). ^{13}C NMR (150 MHz, CD_3OD) δ: 75.0 (C-2), 42.2 (C-3), 197.7 (C-4), 161.4 (C-5), 95.5 (C-6), 162.3 (C-7), 107.7 (C-8), 165.6 (C-9),

102.4 (C-10), 126.1 (C-1′), 154.3 (C-2′), 115.2 (C-3′), 129.2 (C-4′), 119.7 (C-5′), 126.5 (C-6′), 27.6 (C-1″), 47.7 (C-2″), 27.0 (C-3″), 41.8 (C-4″), 70.6 (C-5″), 27.9 (C-6″), 28.3 (C-7″), 148.6 (C-8″), 110.7 (C-9″), 17.8 (C-10″).

Norkurarinol (6): yellow, amorphous powder, $[\alpha]_D^{25}$ –25.5 (*c* = 0.1, MeOH). EIMS *m/z* 442 [M^+]. ^{1}H NMR (600 MHz, CD_3OD) δ: 5.53 (dd, *J* = 2.4, 13.2 Hz, H-2), 2.92 (dd, *J* = 13.8, 17.4 Hz, H-3a), 2.70 (dd, *J* = 3.0, 17.4 Hz, H-3b), 5.88 (br s, H-6), 6.31 (d, *J* = 3.0 Hz, H-3′), 6.33 (dd, *J* = 3.0, 8.4 Hz, H-5′), 7.27 (d, *J* = 8.4 Hz, H-6′), 2.56 (m, H_2-1″), 2.34 (m, H-2″), 1.04 (s, H_3-6″), 1.03 (s, H_3-7″), 4.57 (br s, H-9″a), 4.51 (d, *J* = 1.8 Hz, H-9″b), 1.59 (s, H_3-10″). ^{13}C NMR (150 MHz, CD_3OD) δ: 74.8 (C-2), 42.3 (C-3), 198.1 (C-4), 162.2 (C-5), 95.4 (C-6), 165.5 (C-7), 107.7 (C-8), 161.0 (C-9), 102.4 (C-10), 117.4 (C-1′), 155.7 (C-2′), 102.5 (C-3′), 158.5 (C-4′), 106.8 (C-5′), 127.7 (C-6′), 27.5 (C-1″), 47.6 (C-2″), 27.1 (C-3″), 41.8 (C-4″), 70.7 (C-5″), 28.3 (C-6″), 27.9 (C-7″), 148.5 (C-8″), 110.7 (C-9″), 17.8 (C-10″).

Kuraridin (7): yellow, amorphous powder, $[\alpha]_D^{25}$ –25.5 (*c* = 0.1, MeOH). EIMS *m/z* 438 [M^+]. ^{1}H NMR (600 MHz, CD_3OD) δ: 7.98 (d, *J* = 15.6 Hz, H-2), 7.91 (d, *J* = 15.6 Hz, H-3), 5.95 (br s, H-6), 6.30 (br s, H-3′), 6.32 (dd, *J* = 2.4, 7.8 Hz, H-5′), 7.37 (d, *J* = 7.8 Hz, H-6′), 2.59 (m, H_2-1″), 2.51 (m, H-2″), 2.04 (m, H_2-3″), 5.00 (t, *J* = 6.6 Hz, H-4″), 1.58 (s, H_3-6″), 1.51 (s, H_3-7″), 4.55 (s, H-9″a), 4.50 (s, H-9″b), 1.66 (s, H_3-10″), 3.83 (s, 5-OCH_3). ^{13}C NMR (150 MHz, CD_3OD) δ: 138.6 (C-2), 124.3 (C-3), 193.6 (C-4), 165.5 (C-5), 90.4 (C-6), 162.9 (C-7), 107.7 (C-8), 161.3 (C-9), 105.4 (C-10), 115.2 (C-1′), 159.1 (C-2′), 102.5 (C-3′), 161.0 (C-4′), 107.8 (C-5′), 130.5 (C-6′), 27.0 (C-1″), 46.9 (C-2″), 31.3 (C-3″), 123.9 (C-4″), 130.7 (C-5″), 24.9 (C-6″), 16.8 (C-7″), 148.7 (C-8″), 110.1 (C-9″), 18.0 (C-10″), 54.9 (5-OCH_3).

Formononetin (8): pale yellow, amorphous powder. EIMS *m/z* 268 [M^+]. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 8.29 (d, *J* = 1.2 Hz, H-2), 7.94 (d, *J* = 9.0 Hz, H-5), 6.91 (dd, *J* = 1.2, 9.0 Hz, H-6), 6.83 (br s, H-8), 7.47 (each d, *J* = 8.4 Hz, H-2′ and H-6′), 6.95 (each d, *J* = 8.4 Hz, H-3′ and H-5′), 3.74 (s, 4′-OCH_3). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 154.0 (C-2), 124.0 (C-3), 175.5 (C-4), 117.5 (C-4a), 128.2 (C-5), 116.0 (C-6), 163.4 (C-7), 103.0 (C-8), 158.3 (C-8a), 125.1 (C-1′), 130.9 (C-2′), 114.5 (C-3′), 159.8 (C-4′), 114.5 (C-5′), 130.9 (C-6′), 56.0 (4′-OCH_3).



	R_1	R_2	R_3	R_4	R_5
1	-CH_3	-A	-H	-H	-OH
2	-H	-B	-H	-OH	-OH
3	-CH_3	-B	-H	-OH	-OH
4	-CH_3	-B	-H	-OCH_3	-OH
5	-H	-C	-H	-OH	-H
6	-H	-C	-H	-OH	-OH

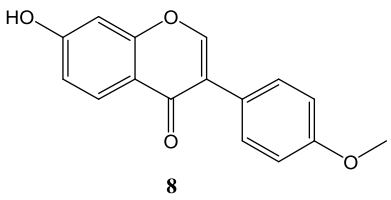


Figure 1: Chemical structures of compounds **1-8**

3. RESULTS AND DISCUSSION

Compound **1** was isolated as a pale yellow, amorphous powder and its molecular formula was established to be $C_{21}H_{22}O_5$ by ^{1}H and ^{13}C NMR spectroscopic analysis and EIMS at *m/z* 354 [M^+]. The ^{1}H NMR spectrum of **1** showed an aromatic proton singlet at δ_H 6.07 (H-6), and a typical A_2B_2 system at δ_H 7.27 (d, *J* = 9.0 Hz, H-2′ and H-6′) and 6.78 (d, *J* = 9.0 Hz, H-3′ and H-5′). The ^{1}H NMR of **1** further showed signals for a 3,3-dimethylallyl group at δ_H 3.16 (t, *J* = 6.0 Hz, H_2-1″), 5.10 (m, H-2″), 1.52 (s, H_3-4″), and 1.58 (s, H_3-5″). The

position of 3,3-dimethylallyl group was assigned to C-8 by the HMBC correlations from 3.16 (H_2-1″) to δ_C 164.2 (C-7), 109.9 (C-8), and 163.8 (C-9). The signals of a methoxyl group at 3.75 (s), an oxymethine group at 5.23 (dd, *J* = 2.4, 13.2 Hz, H-2), and a methylene group at 2.93 (dd, *J* = 13.2, 16.8 Hz, H-3a) and 2.62 (dd, *J* = 3.6, 16.8 Hz, H-3b) were also observed in the ^{1}H NMR spectrum of **1**. The ^{13}C NMR spectrum showed signals of a carbonyl carbon at 192.9 (C-4) and a methylene carbon at δ_C 46.1 (C-3) implying that **1** belongs to the flavanone skeleton. The methoxyl group was located at C-5 based on the HMBC correlation of δ_H 3.75 with δ_C 161.7 (C-5). Based on the above analysis and comparison of the NMR data of **1** with those of reported compound, the structure of **1** was identified as isoxanthohumol [8].

Compound **2** was obtained as yellow, amorphous powder. Its molecular formula was determined to be $C_{25}H_{28}O_6$ by an ion *m/z* 424 [M^+] in the EIMS. The ^{1}H NMR spectrum contained signals for an ABX aromatic ring system [δ_H 6.32 (d, *J* = 1.8 Hz, H-3′), 6.34 (dd, *J* = 1.8, 8.4 Hz, H-5′), and 7.26 (d, *J* = 8.4 Hz, H-6′)], a singlet at 5.87 (H-6), an oxymethine group at 5.52 (dd, *J* = 3.0, 13.8 Hz, H-2), and a methylene group at 2.90 (dd, *J* = 13.2, 16.8 Hz, H-3a) and 2.70 (dd, *J* = 3.0, 17.4 Hz, H-3b). The ^{1}H NMR spectrum further showed the signals of three olefinic prontons at δ_H 4.92 (1H, t, *J* = 6.6 Hz, H-4″), 4.53 (d, *J* = 1.2 Hz, H-9″a), 4.47 (d, *J* = 1.2 Hz, H-9″b), three tertiary methyl groups at δ_H 1.49 (s, H-6″), 1.41 (s, H-7″), and 1.57 (3H, s, H-10″), two methylene groups at δ_H 2.52 (m, H_2-1″) and 1.94 (m, H_2-3″), and one methine group at δ_H 2.41 (m, H-2″) suggesting the presence of a lavandulyl group. The ^{13}C NMR and DEPT spectra displayed 25 carbons, including signals for a flavanone and a lavandulyl group. The ^{13}C NMR signals at δ_C 117.6 (C-1′), 155.7 (C-2′), 102.6 (C-3′), 158.4 (C-4′), 106.9 (C-5′), and 127.9 (C-6′) characterized for a 1,2,4-trisubstituted aromatic ring of the flavanone. The lavandulyl group was located at C-8 by the HMBC correlations from δ_H 7.26 (H-1″) to 165.6 (C-7), 107.9 (C-8), and 161.7 (C-9). Finally, the structure of **2** was established as norkurarinone [9].

Compound **3**, a yellow, amorphous powder, had a molecular formula of $C_{26}H_{30}O_6$ as indicated by the ion *m/z* 438 [M^+] in the EIMS. The ^{1}H and ^{13}C NMR spectra of **3** were found nearly similar with those of **2**, except for the additional presence of a methoxyl group at δ_H 3.73/δ_C 55.0. By HMBC correlation of δ_H 3.73 with δ_C 160.8 (C-5), the methoxyl group was located at C-5. Thus, **3** was established as kurarinone [10].

Compound **4**, a pale yellow, amorphous powder, showed a molecular formula of $C_{27}H_{32}O_6$ as deduced by the ion *m/z* 452 [M^+] in the EIMS. Comparison of the ^{1}H and ^{13}C NMR spectra of **4** with those of **3** suggested the structures of these two compounds are nearly identical, except for the additional presence of a methoxyl signal at δ_H 3.75/δ_C 55.0. This methoxyl group was connected to C-2′ based on the HMBC correlation of δ_H 3.75 with δ_C 158.0 (C-2′). Therefore the structure of **4** was identified as 2′-methoxykurarinone [5].

Compound **5** was separated as a yellow, amorphous powder, with the molecular formula of $C_{25}H_{30}O_6$ as determined by ^{1}H and ^{13}C NMR spectroscopic analyses and EIMS. The ^{1}H NMR spectrum showed a singlet at δ_H 5.91 (H-6), an oxymethine group at δ_H 5.63 (dd, *J* = 2.4, 13.2, H-2), two olefinic protons [δ_H 4.61 (s, H-9″a) and 4.54 (s, H-9″b)], three tertiary methyl groups [δ_H 1.02 (C-6″), 1.01 (C-7″), and 1.62 (C-10″)], and signals characterized for a 1,2-disubstituted aromatic ring [δ_H 6.81 (d, *J* = 7.8 Hz, H-3′), 7.14 (t, *J* = 7.8 Hz, H-4′), 6.87 (t, *J* = 7.8 Hz, H-5′), and 7.23 (d, *J* = 7.8 Hz, H-6′)]. The ^{13}C NMR and DEPT spectra displayed 25 signals, including three tertiary methyl, five methylene, and seven methine groups, and 10 quaternary carbons. The ^{13}C NMR contained signals of one olefinic methylene group (δ_C 110.7, C-9″), one quaternary carbon (δ_C 70.6, C-5″), one methine group (δ_C 47.7, C-2″), three methylene groups [δ_C 27.6 (C-1″), 27.0 (C-3″), and 41.8 (C-4″)], and three tertiary methyl groups [δ_C 27.9 (C-6″), 28.3 (C-7″), and 17.8 (C-10″)] suggesting the presence of a 5-hydroxy-2-isopropenyl-5-methylhexyl group. The HMBC correlations of δ_H 2.84 and 2.36 (H_2-1″) with δ_C 162.3 (C-7), 107.7 (C-8), and 165.6 (C-9) indicated that the 5-hydroxy-2-isopropenyl-5-methylhexyl group was connected to C-8. Based on the aforementioned analysis, along with comparison of the NMR data of **5** with those of reported data, the structure of **5** was established as kushenol T [2].

Compound **6** was isolated as a yellow, amorphous powder and its molecular formula was identified as $C_{25}H_{30}O_7$ by EIMS. The ^{1}H and ^{13}C NMR spectra of **6** were found nearly identical with those of **2**, the difference is that the lavandulyl group in **2** was replaced by a 5-hydroxy-2-isopropenyl-5-methylhexyl group in **6**. Thus the structure of **6** was identified as norkurarinol [10].

Compound **7**, showed the molecular formula of $C_{26}H_{30}O_6$ by analysis of the ^{1}H and ^{13}C NMR data and EIMS. The ^{1}H NMR spectrum contained signals for an ABX aromatic ring system [δ_H 6.30 (br s, H-

3′), 6.32 (dd, *J* = 2.4, 7.8 Hz, H-5′), and 7.37 (d, *J* = 7.8 Hz, H-6′)], a singlet at 5.95 (H-6), a methoxyl group at δ_H 3.83 (s), and signals for a lavandulyl moiety [δ_H 5.00 (t, *J* = 6.6 Hz, H-4″), 4.55 (s, H-9″a), 4.50 (s, H-9″b), 2.59 (m, H_2-1″), 2.51 (m, H-2″), 2.04 (m, H_2-3″), 1.58 (s, H_3-6″), 1.51 (s, H-7″), and 1.66 (s, H_3-10″)]. The ^{1}H NMR spectrum further showed signals for two olefinic protons at δ_H 7.98 (d, *J* = 15.6 Hz, H-2) and 7.91 (d, *J* = 15.6 Hz, H-3). The large coupling constant (15.6 Hz) between these olefinic protons implied *trans*-configured double bond. The ^{13}C NMR and DEPT spectra exhibited one carbonyl carbon at δ_C 193.6 (C-4) and two olefinic methine carbon at δ_C 138.6 (C-2) and 124.3 (C-3) suggesting that the structure of **7** belongs to a chalcone skeleton. By HMBC correlation of δ_H 2.59 (H_2-1″) with δ_C 162.9 (C-7), 107.7 (C-8), and 161.3 (C-9), the lavandulyl moiety was located at C-8. The methoxyl group was connected to C-5 based on HMBC correlation from δ_H 3.83 to δ_C 165.5 (C-5). Based the above spectroscopy analysis and comparison with the reported data, the structure of **7** was established as kuraridin [10].

Compound **8** was given as a pale yellow, amorphous powder and its molecular formula was deduced from EIMS. The ^{1}H NMR spectrum exhibited signals for an ABX spin aromatic ring [δ_H 7.94 (d, *J* = 9.0 Hz, H-5), 6.91 (dd, *J* = 1.2, 9.0 Hz, H-6), and 6.83 (br s, H-8)] and an A_2B_2 system at δ_H 7.47 (d, *J* = 8.4 Hz, H-2′, 6′) and 6.95 (d, *J* = 8.4 Hz, H-3′, 5′). The ^{1}H NMR spectrum further showed signals of an olefinic proton at δ_H 8.29 (d, 1.2, H-2) and a methoxyl group at δ_H 3.74 (s). The ^{13}C NMR and DEPT presented 16 carbons, including one carbonyl carbon (δ_C 175.5, C-4), one olefin [δ_C 154.0 (C-2) and 124.0 (C-3)] suggesting that **8** belongs to the isoflavone skeleton. The methoxyl group was located at C-4′ based on the HMBC correlation of δ_H 3.74 with δ_C 159.8 (C-4′). Finally the structure of **8** was identified as formononetin [11].

Aknowledgements. *This work was financially supported by the Priority Research Center Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2009-0093815), Republic of Korea.*

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