CHEMICAL CONSTITUENTS OF *Bacopa monnieri*

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Bacopa monnieri (L.) Wettst., a perennial creeping plant, is distributed in Fujian, Taiwan, Guangdong, Yunnan, and Sichuan Provinces in China. In the Ayurvedic system of medicine of India, this plant has been used as a brain tonic to enhance memory development, learning, and concentration for centuries [1]. Pharmacological studies showed that this plant can be used as a memory-enhancing, anti-inflammatory, analgesic, and antidepressant agent [2–4]. In our investigation on the chemical constituents of *B. monnieri*, 17 compounds were isolated from the whole plant of *B. monnieri* for the first time.

The whole plants of *B. monnieri* were collected in Zhang Zhou, Fujian Province, and authenticated by Prof. Han-Chen Zheng of the Dept. of Pharmacognosy, School of Pharmacy, Second Military Medical University, Shanghai, China. A voucher specimen (No. 0211-11) is deposited in the Herbarium of the School of Pharmacy, Second Military Medical University, Shanghai, China.

The whole plants of *B. monnieri* (8 kg) were extracted with methanol at room temperature. The methanol extract was partitioned with petroleum ether, $CHCl_3$, EtOAc, and *n*-BuOH. Each fraction was purified by column chromatography with silica gel, RP-18, and Sephadex LH-20 to yield compounds **1–17**.

All compounds were identified by spectroscopic methods, including NMR and mass spectrometry. The spectroscopic data of all compounds were in good agreement with the literature data.

***p*-Hydroxyl Benzenemethanol (1)**. Colorless needles. EIMS *m/z*: 124 (M^+, base peak), 123, 107, 95, 77. ^{1}H NMR (500 MHz, DMSO-d_6, δ, ppm, J/Hz): 4.36 (2H, d, J = 6.0, -C$\underline{H}_2$), 4.91 (1H, m, $CH_2O\underline{H}$), 6.70 (2H, d, J = 9.0, H-3, 5), 7.10 (2H, d, J = 9.0, H-2, 6), 9.18 (1H, s, ArOH). ^{13}C NMR (125 MHz, DMSO-d_6, δ, ppm): 62.8 (CH_2), 114.7 (C-3, 5), 128.0 (C-2,6), 132.7 (C-1), 156.1 (C-4) [5].

***p*-Hydroxyl Benzoic Acid (2)**. White powder. EIMS *m/z*: 137 $[M-1]^+$. ^{1}H NMR (500 MHz, DMSO-d_6, δ, ppm, J/Hz): 6.84 (2H, d, J = 9.0, H-3, 5), 7.81 (2H, d, J = 9.0, H-2, 6), 9.26 (1H, s, ArOH), 10.22 (1H, s, -COOH). ^{13}C NMR (125 MHz, DMSO-d_6, δ, ppm): 115.2 (C-3, 5), 131.4 (C-2, 6), 129.1 (C-1), 161.8 (C-4), 165.9 (-COOH) [6].

$\Delta^{5,24(28)}$-Ergostadien-3β-ol (3). Colorless needles. EIMS *m/z*: 398 $[M]^+$, 314, 299, 271, 255, 229, 213, 159. ^{1}H NMR [7].

Ursolic Acid (4). Colorless needles. EIMS *m/z*: 456 $[M]^+$, 248, 203, 189, 133. ^{1}H NMR [8].

Lupeol (5). Colorless needles. EIMS *m/z*: 426 $[M]^+$, 411, 393, 383, 218, 207, 203, 189. ^{1}H NMR [9].

28-Hydroxyllupeol (6). EIMS *m/z*: 442 $[M]^+$, 411, 233, 189, 135. ^{1}H NMR [10].

Stigmasterol-3-*O*-β-D-glucopyranoside (7). White powder. ESIMS *m/z*: 574 $[M]^+$. ^{1}H NMR [11].

β-Daucosterin (8). White powder. EIMS *m/z*: 576 $[M]^+$. ^{1}H NMR (500 MHz, $CDCl_3$, δ, ppm, J/Hz): 0.78 (3H, s, H-18), 0.89 (3H, d, J = 7.0, H-29), 0.93 (3H, t, J = 8.0, H-27), 0.97 (3H, d, J = 6.0, H-28), 1.23 (3H, s, H-19), 1.15 (3H, d, J = 7.0, H-21), 3.85 (1H, m, H-3), 5.44 (1H, t, J = 2.3, H-6), β-D-Glu: 5.12 (1H, d, J = 6.9, H-1), 3.54 (1H, m, H-2), 4.43 (1H, m, H-3), 4.44 (1H, m, H-4), 3.98 (1H, m, H-5), 4.90 (1H, dd, J = 3.0, 12.0, H-6a), 4.81 (1H, dd, J = 6.0, 12.0, H-6b). ^{13}C NMR (125 MHz, $CDCl_3$, δ, ppm): 37.5 (C-1), 31.8 (C-2), 72.0 (C-3), 42.3 (C-4), 141.1 (C-5), 121.9 (C-6), 32.1 (C-7), 31.0 (C-8), 50.5 (C-9), 36.8 (C-10), 21.7 (C-11), 40.2 (C-12), 42.5 (C-13), 56.8 (C-14), 24.7 (C-15), 29.3 (C-16), 56.1 (C-17), 12.3 (C-18), 19.6 (C-19), 40.7 (C-20), 21.5 (C-21), 138.6 (C-22), 129.7 (C-23), 51.4 (C-24), 32.0 (C-25), 19.4 (C-26), 12.7 (C-27), 21.3 (C-28), 19.5 (C-29), β-D-Glu: 103.1 (C-1), 75.1 (C-2), 78.3 (C-3), 71.4 (C-4), 77.9 (C-5), 62.5 (C-6) [12].

Ampelozigenin (9). Colorless flakes. EIMS *m/z*: 502 $[M]^+$. ^{1}H NMR (500 MHz, C_5D_5N, δ, ppm, J/Hz): 0.75 (3H, s, Me-18), 0.86 (3H, s, Me-19), 1.01 (3H, s, Me-21), 1.20 (3H, s, Me-28), 1.25 (3H, s, Me-29), 1.04 (3H, d, J = 3.0, Me-26), 1.06

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(3H, d, J = 3.0, Me-27), 3.15 (1H, dd, J = 4.0, 12, H-3), 3.83 (1H, s, H-15), 1.88 (1H, d, J = 4.0, H-17), 4.42 (1H, dd, J = 4.5, 7.5, H-22), 4.0 (1H, m, H-23), 4.88, 4.90 (2H, H_2-24′), 4.16 (1H, d, J = 7.0, H-30a), 4.29 (1H, d, J = 7.0, H-30b). ^{13}C NMR (125 MHz, C_5D_5N, δ, ppm): 38.0 (C-1), 28.4 (C-2), 78.3 (C-3), 39.5 (C-4), 56.0 (C-5), 18.7 (C-6), 36.8 (C-7), 38.4 (C-8), 53.9 (C-9), 38.0 (C-10), 21.9 (C-11), 29.9 (C-12), 40.1 (C-13), 57.2 (C-14), 70.3 (C-15), 116.7 (C-16), 61.0 (C-17), 18.5 (C-18), 16.7 (C-19), 76.9 (C-20), 32.8 (C-21), 93.1 (C-22), 39.5 (C-23), 153.7 (C-24), 24.2 (C-25), 21.6 (C-26), 21.7 (C-27), 29.9 (C-28), 16.7 (C-29), 65.5 (C-30), 108.6 (C-24′) [13].

3,4-Dimethoxycinnamic Acid (10). Pale yellow powder. EIMS *m/z*: 207 $[M-1]^+$. ^{1}H NMR [14].

Feruloyl Glucoside (11). Pale yellow needles. ESIMS *m/z*: 367 $[M+Na]^+$. ^{1}H NMR (500 MHz, C_5D_5N, δ, ppm, J/Hz): 7.30 (1H, d, J = 2.0, H-2′), 6.88 (1H, d, J = 8.0, H-5′), 7.24 (1H, dd, J = 8.0, 2.0, H-6′), 7.52 (1H, d, J = 16.0, H-7′), 6.45 (1H, d, J = 16.0, H-8′), 3.80 (3H, s, OCH_3), β-D-Glu: 5.02 (1H, d, J = 6.7, H-1), 3.33 (1H, m, H-2), 4.23 (1H, m, H-3), 4.21 (1H, m, H-4), 3.98 (1H, m, H-5), 4.96 (1H, dd, J = 3.0, 12.0, H-6a), 4.85 (1H, dd, J = 6.0, 12.0, H-6b). ^{13}C NMR (125 MHz, C_5D_5N, δ, ppm): 149.6 (C-1), 148.4 (C-2), 111.6 (C-3), 128.4 (C-4), 122.9 (C-5), 115.5 (C-6), 144.7 (C-7), 117.6 (C-8), 169.3 (C-9), β-D-Glu: 103.1 (C-1), 75.1 (C-2), 78.3 (C-3), 71.4 (C-4), 77.9 (C-5), 62.5 (C-6) [14].

Rosavin (12). White powder. ESIMS *m/z*: 451 $[M+Na]^+$. ^{1}H NMR (500MHz, C_5D_5N, δ, ppm, J/Hz): 6.80–7.49 (5H, m, H-2, H-3, H-4, H-5, H-6), 6.46 (1H, d, J = 16.0, H-7), 6.79 (1H, dt, J = 16.0, H-8), 4.44–4.47 (2H, m, H-9), β-D-Glu: 4.98 (1H, d, J = 7.0, H-1), 3.44 (1H, m, H-2), 4.26 (1H, m, H-3), 4.24 (1H, m, H-4), 3.95 (1H, m, H-5), 5.01 (1H, dd, J = 3.0, 12.0, H-6a), 4.92 (1H, dd, J = 6.0, 12.0, H-6b), α-L-Ara: 5.12 (1H, d, J = 6.8, H-1), 4.15 (1H, m, H-2), 3.78 (1H, d, J = 10.0, H-4a), 4.21 (1H, d, J = 10.0, H-4b), 4.30 (1H, d, J = 11.0, H-5a), 4.39 (1H, d, J = 11.0, H-6b). ^{13}C NMR (125 MHz, C_5D_5N, δ, ppm): 138.9 (C-1), 127.8 (C-2, 6), 129.8 (C-3, 5), 127.0 (C-4), 129.1 (C-7), 134.8 (C-8), 72.5 (C-9). β-D-Glu: 102.6 (C-1), 75.0 (C-2), 77.3 (C-3), 71.8 (C-4), 77.0 (C-5), 67.9 (C-6), α-L-Ara: 109.8 (C-1), 72.6 (C-2), 74.0 (C-3), 70.1 (C-4), 62.2 (C-5) [15].

Quercetin (13). Yellow powder. EIMS *m/z*: 302 $[M]^+$, 153, 137. ^{1}H NMR [16].

Apigenin (14). Pale yellow powder. EIMS *m/z*: 270 $[M]^+$, 242, 153, 121. ^{1}H NMR [17].

Luteolin (15). Yellow powder. EIMS *m/z*: 286 $[M]^+$, 270, 242, 153. ^{1}H NMR [18].

Zizyotin (16). Colorless needles. ESIMS *m/z*: 627 $[M+Na]^+$. ^{1}H NMR [19].

Loliolide (17). White powder. EIMS *m/z*: 196 $[M]^+$. ^{1}H NMR (500 MHz, C_5D_5N, δ, ppm, J/Hz): 5.68 (1H, s, H-3), 1.53 (1H, dd, J = 14.5, 3.78, H-6a), 1.98 (1H, dt, J = 14.5, 2.77, H-6b), 4.30 (1H, m, H-7), 1.78 (1H, dd, J = 13.3, 4.14, H-8a), 2.45 (1H, dt, J = 14.0, 2.85, H-8b), 1.77 (3H, s, H-10), 1.27 (3H, s, H-11), 1.46 (3H, s, H-12). ^{13}C NMR (125 MHz, DMSO-d_6, δ, ppm): 172.0 (C-2), 112.9 (C-3), 182.4 (C-4), 35.9 (C-5), 47.4 (C-6), 66.8 (C-7), 45.7 (C-8), 86.7 (C-9), 27.0 (C-10), 30.6 (C-11), 26.6 (C-12) [20].

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