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CHEMICAL CONSTITUENTS OF *Ainsliaea macrocephala*

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The characteristic components of the *Ainsliaea* (Compositae) genus are sesquiterpenes (especially eudesmanolide and guaianolide) [1–4]. *Ainsliaea macrocephala* Y.C. Tseng, a plant of *Ainsliaea*, is distributed mainly in the southwest of China. The whole plant of *A. macrocephala* has been used in Chinese folk medicine to treat rheumatism, lumbago, and gonitis [5]. Some chemical constituents of this plant have been reported previously [6–8]. In our continuing investigation of this plant, we now report 27 compounds isolated from the whole plant of *A. macrocephala.*

The whole plant of *A. macrocephala* were collected in Lijing, Yunnan province, China and authenticated as *A. macrocephala* by Prof. Li-Shang Xie of Kunming Institute of Botany, Chinese Academy of Sciences. A voucher specimen is deposited in the Herbarium of the School of Pharmacy, Second Military Medical University.

The whole air-dried plant of *A. macrocephala* (12 kg) was refluxed with alcohol for 3 × 2 h; then the alcohol extract was concentrated *in vacuo* to an aqueous residue, which was extracted successively with petroleum ether, EtOAc, and *n*-BuOH. Each fraction was purified by column chromatography with silica gel and Sephadex LH-20 or RP-18 to yield compounds **1–27**.

The compounds were analyzed by spectroscopic methods, including NMR and mass spectrometry. All 27 compounds were determined as 4-hydroxybenzaldehyde (**1**) [9], linoleic acid (**2**) [10], gochnatiolide A (**3**) [11], betulin (**4**) [12], cholest-4-en-3-one (**5**) [13], (20*Z*)-cholest-5,20(22)-dien-3β-ol (**6**) [14], 4-hydroxyacetophenone (**7**) [15], vanillin (**8**) [16], protocatechualdehyde (**9**) [17], dihydrodehydrodiconiferyl alcohol (**10**) [18], secoisolariciresinol (**11**) [19], caffeic acid (**12**) [20], tianshic acid (**13**) [21], methyl 3-*O*-caffeoylquinate (**14**) [22], methyl 3,4-*O*-dicaffeoylquinate (**15**) [23], picein (**16**) [24], 2-isopropyl-5-methylphenol-*O*-β-D-glucopyranoside (**17**) [25], zataroside-A (**18**) [26], 4-allyl-2,6-dimethoxyphenol-β-D-glucoside (**19**) [27], phenylethyl-*O*-β-D-glucopyranoside (**20**) [28], 2-*O*-methyl-α-D-fructofuranoside (**21**) [29], 6-*O*-methyl-α-D-fructofuranoside (**22**) [30], ethyl-α-D-fructofuranoside (**23**) [30], methyl-β-D-fructopyranoside (**24**) [30], adenosine (**25**) [31], daucosterol (**26**) [32], and 4-*O*-α-L-rhamnopyranosyl-(1→6)-β-D-glucopyranosyl acetophenone (**27**) [33]. All these compounds were isolated from *A. macrocephala* for the first time.

Gochnatiolide A (3). White powder. ESI-MS *m/z* 526 $[M + Na]^+$. ^{1}H NMR (400 MHz, $CDCl_3$, δ, ppm, J/Hz): 6.26 (1H, d, J = 3.2, H-13$_a$′), 6.17 (1H, br.s, H-15$_a$), 6.16 (1H, d, J = 3.2, H-13$_a$), 5.98 (1H, br.s, H-15$_b$), 5.63 (1H, d, J = 2.8, H-13$_b$′), 5.46 (1H, d, J = 3.2, H-13$_b$), 5.07 (1H, br.s, H-14$_a$′), 4.68 (1H, br.s, H-14$_b$′), 4.24 (1H, t, J = 9.6, H-6′), 3.89 (1H, br.s, H-5), 3.87 (1H, br.s, H-7), 3.72 (1H, t, J = 10.0, H-6), 3.35 (1H, m, H-2$_a$′), 3.32 (1H, m, H-5′), 3.24 (1H, m, H-1′), 3.05 (1H, m, H-7′), 2.63 (1H, m, H-2$_b$′), 2.42 (1H, m, H-9$_a$′), 2.21 (1H, m, H-15$_a$′), 2.14 (1H, m, H-9$_b$′), 2.04 (1H, m, H-8$_a$′), 1.92 (1H, m, H-8$_a$), 1.90 (1H, m, H-8$_b$), 1.88 (1H, m, H-15$_b$′), 1.85 (1H, m, H-9$_a$), 1.62 (1H, m, H-9$_b$), 1.54 (2H, m, H-14), 1.48 (1H, m, H-8$_b$′). ^{13}C NMR (100 MHz, $CDCl_3$, δ, ppm): 170.0 (C-1), 143.1 (C-2), 194.2 (C-3), 142.1 (C-4), 49.1 (C-5), 83.7 (C-6), 39.4 (C-7), 23.0 (C-8), 43.5 (C-9), 70.9 (C-10), 140.4 (C-11), 170.9 (C-12), 119.6 (C-13), 35.3 (C-14), 122.7 (C-15), 39.8 (C-1′), 44.9 (C-2′), 220.4 (C-3′), 50.1 (C-4′), 51.1 (C-5′), 84.5 (C-6′), 43.4 (C-7′), 31.9 (C-8′), 38.2 (C-9′), 150.1 (C-10′), 138.1 (C-11′), 170.9 (C-12′), 121.6 (C-13′), 114.2 (C-14′), 28.3 (C-15′).

Dihydrodehydrodiconiferyl Alcohol (10). Colorless oil. ESI-MS *m/z* 383 $[M + Na]^+$. ^{1}H NMR (400 MHz, CD_3OD, δ, ppm, J/Hz): 6.94 (1H, d, J = 1.8, H-2), 6.88 (1H, dd, J = 1.8, 8.2, H-6), 6.80 (1H, d, J = 7.8, H-5), 6.68 (2H, br.s, H-2′, 6′), 5.54 (1H, d, J = 7.2, H-7), 3.84 (3H, s, 3′-OCH_3), 3.82 (2H, m, H-9), 3.80 (3H, s, 3-OCH_3), 3.70 (2H, t, J = 6.3, H-9′), 3.60 (1H, m, H-8), 2.70 (2H, m, H-7′), 1.91 (2H, m, H-8′). ^{13}C NMR (100 MHz, CD_3OD, δ, ppm): 133.1 (C-1), 108.8 (C-2), 146.7 (C-3), 146.4 (C-4), 114.3 (C-5), 116.0 (C-6), 87.8 (C-7), 53.8 (C-8), 63.9 (C-9), 135.4 (C-1′), 114.3 (C-2′), 127.8 (C-3′), 146.7 (C-4′), 143.8 (C-5′), 121.7 (C-6′), 32.0 (C-7′), 35.9 (C-8′), 62.3 (C-9′), 55.8 (3-OCH_3), 56.0 (3′-OCH_3).

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Secoisolariciresinol (11). White powder. ESI-MS *m/z* 361 $[M - H]^-$. ^1H NMR (400 MHz, $CDCl_3$, δ, ppm, J/Hz): 6.81 (2H, d, J = 7.8, H-5, 5′), 6.64 (2H, dd, J = 1.8, 7.8, H-6, 6′), 6.59 (2H, d, J = 1.5, H-2, 2′), 3.82 (6H, 2 × OCH_3), 3.57 (4H, m, H-9, 9′), 2.68 (4H, m, H-7, 7′), 1.87 (2H, br.s, H-8, 8′). ^{13}C NMR (100 MHz, $CDCl_3$, δ, ppm): 132.4 (C-1, 1′), 111.4 (C-2, 2′), 146.5 (C-3, 3′), 143.8 (C-4, 4′), 114.1 (C-5, 5′), 121.7 (C-6, 6′), 35.9 (C-7, 7′), 43.8 (C-8, 8′), 61.0 (C-9, 9′), 55.8 (OCH_3).

Methyl 3,4-*O*-Dicaffeoylquinate (15). Yellow powder. ESI-MS *m/z* 529 $[M - H]^-$. ^1H NMR (400 MHz, CD_3OD, δ, ppm, J/Hz): 7.61, 7.50 (1H each, d, J = 15.9, H-7′, 7″), 7.04, 7.00 (1H each, d, J = 1.8, H-2′, 2″), 6.91 (2H, m, H-6′, 6″), 6.75 (1H each, d, J = 8.4, H-5′, 5″), 6.28, 6.16 (1H each , d, J = 15.9, H-8′, 8″), 5.55 (1H, m, H-3), 5.11 (1H, dd, J = 3.0, 8.1, H-4), 4.33 (1H, m, H-5), 3.71 (3H, s, OCH_3), 2.26 (4H, m, H-2, 6). ^{13}C NMR (100 MHz, CD_3OD, δ, ppm): 75.8 (C-1), 38.4 (C-2, 6), 69.1 (C-3), 74.9 (C-4), 68.6 (C-5), 175.2 (C-7), 127.6, 127.7 (C-1′, 1″), 115.2 (C-2′, 2″), 146.8 (C-3′, 3″), 149.7 (C-4′, 4″), 116.5 (C-5′, 5″), 123.1 (C-6′, 6″), 147.7 (C-7′, 7″), 114.6, 114.7 (C-8′, 8″), 167.9, 168.5 (C-9′, 9″), 53.1 (OCH_3).

Zataroside-A (18). White powder. ESI-MS *m/z* 351 $[M + Na]^+$. ^1H NMR (400 MHz, CD_3OD, δ, ppm, J/Hz): 6.91 (1H, s, H-6), 6.62 (1H, s, H-3), 4.71 (1H, d, J = 7.8, H-1′), 3.87 (1H, m, H-6_a′), 3.73 (1H, m, H-6_b′), 3.30–3.47 (5H, m, H-7 and H-2′, 3′, 4′, 5′), 2.17 (3H, s, H-10), 1.18 (6H, br.s, H-8, 9). ^{13}C NMR (100 MHz, CD_3OD, δ, ppm): 138.2 (C-1), 151.7 (C-2), 120.3 (C-3), 123.2 (C-4), 149.1 (C-5), 113.1 (C-6), 27.0 (C-7), 23.6, 23.7 (C-8, 9), 16.1 (C-10), 104.3 (C-1′), 75.1 (C-2′), 77.9 (C-3′), 71.5 (C-4′), 78.2 (C-5′), 62.6 (C-6′).

4-Allyl-2,6-dimethoxyphenol-β-D-glucopyranoside (19). White powder. ESI-MS *m/z* 379 $[M + Na]^+$. ^1H NMR (400 MHz, DMSO-d_6, δ, ppm, J/Hz): 6.48 (2H, s, H-3, 5), 5.98 (1H, m, H-8), 5.13 (2H, br.s, H-9), 4.88 (1H, d, J = 7.5, H-1′), 3.72 (6H, s, 2 × OCH_3), 2.98–3.70 (8H, m, H-7 and H-2′, 3′, 4′, 5′, 6′). ^{13}C NMR (100 MHz, DMSO-d_6, δ, ppm): 135.4 (C-1), 152.4 (C-2, 6), 106.5 (C-3, 5), 132.8 (C-4), 40.4 (C-7), 137.5 (C-8), 115.9 (C-9), 56.2 (2 × OCH_3), 102.7 (C-1′), 74.1 (C-2′), 76.5 (C-3′), 69.9 (C-4′), 77.1 (C-5′), 60.9 (C-6′).

Phenylethyl-*O*-β-D-glucopyranoside (20). White powder. ESI-MS *m/z* 307 $[M + Na]^+$. ^1H NMR (400 MHz, CD_3OD, δ, ppm, J/Hz): 7.25 (4H, br.s, H-2, 3, 5, 6), 7.16 (1H, m, H-4), 4.30 (1H, d, J = 7.8, H-1′), 3.72 (2H, m, H-7), 3.18 (2H, m, H-8). ^{13}C NMR (100 MHz, CD_3OD, δ, ppm): 140.4 (C-1), 130.0 (C-2, 6), 129.3 (C-3, 5), 127.2 (C-4), 37.2 (C-7), 71.7 (C-8), 104.4 (C-1′), 75.1 (C-2′), 78.1 (C-3′), 71.6 (C-4′), 77.9 (C-5′), 62.8 (C-6′).

4-*O*-α-L-Rhamnopyranosyl-(1→6)-β-D-glucopyranosyl Acetophenone (27). White powder. ESI-MS *m/z* 467 $[M + Na]^+$. ^1H NMR (400 MHz, CD_3OD, δ, ppm, J/Hz): 1.17 (3H, d, J = 6.6, H-6″), 2.55 (3H, s, H-8), 3.29 (1H, m, H-4′), 3.34 (1H, m, H-2″), 3.48 (1H, m, H-5′), 3.59–3.64 (4H, m, H-3′, 3″, 4″, 6′), 3.68 (1H, m, H-2′), 3.82 (1H, m, H-5″), 4.03 (1H, d, J = 9.0, H-6′), 4.68 (1H, d, J = 1.2, H-1″), 4.99 (1H, d, J = 7.2, H-1′), 7.14 (2H, d, J = 9.0, H-3, 5), 7.98 (2H, d, J = 9.0, H-2, 6). ^{13}C NMR (100 MHz, CD_3OD, δ, ppm): 132.7 (C-1), 131.7 (C-2, 6), 117.3 (C-3, 5), 163.0 (C-4), 199.6 (C-7), 26.5 (C-8), 102.2 (C-1′), 74.0 (C-2′), 77.1 (C-3′), 71.5 (C-4′), 78.0 (C-5′), 67.8 (C-6′), 101.5 (C-1″), 72.2 (C-2″), 72.4 (C-3″), 74.8 (C-4″), 69.9 (C-5″), 18.0 (C-6″).

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REFERENCES

1. F. Bohlmann and Z. L. Chen, *Phytochemisry*, **21**, 2120 (1982).
2. H. Jin, *Yakugaku Zasshi*, **102**, 911 (1982).
3. T. Miyase and S. Fukushima, *Chem. Pharm. Bull*., **32**, 3043 (1984).
4. J. X. Pu, J. F. Zhao, X. D. Yang, S. X. Mei, H. B. Zhang, and L. Li, *Chin. Chem. Lett.,*, **15**, 1454 (2004).
5. Editorial Committee, *Flora of China*, Science Press, **79**, 23 (1996).
6. Z. J. Wu, X. K. Xu, Y. H. Shen, J. M. Tian, S. Liang, H. L. Li, R. H. Liu, and W. D. Zhang, *Org. Lett.,* **10**, 2397 (2008).
7. X. K. Xu, R. H. Liu, L. Shan, J. Su, H. L. Li, and Y. H. Shen, *J. Phar. Pract.*, **28**, 50 (2010).
8. Z. J. Wu, X. K. Xu, H. W. Zeng, Y. H. Shen, J. M. Tian, J. Su, H. L. Li, S. Shan, R. H. Liu, and W. D. Zhang, *Planta Med.,* **77**, 1545 (2011).
9. Y. Q. Li, Y. L. Feng, S. L. Yang, and L. S. Xu, *Chin. Trad. Herb. Drugs*, **38**, 510 (2007).

10. D. Y. Liu, X. Y. Wang, Z. T. Xa, and X. Wang*, Acad. Period. Changchun Coll. Trad. Chin. Med.*, **19**, 71 (2003).
11. F. Bohlmann, M. Ahmed, J. Jakupovic, R. M. King, and H. Robinson, *Phytochemistry*, **22**, 191 (1983).
12. W. F. Tinto, L. C. Blair, A. Alli, W. F. Reynolds, and S. Mclean, *J. Nat. Prod.*, **55**, 395 (1992).
13. J. W. Blunt and J. B. Stothers, *Org. Magn. Reson.*, **439**, 9 (1977).
14. W. G. Anderson, C. Y. Byon, and M. Gut, *Tetrahedron Lett.*, **26**, 2193 (1976).
15. Y. S. Li, S. D. Luo, M. Zhang, J. J. Chen, and Z. T. Wang, *China J. Chin. Mater. Med.*, **26**, 835 (2001).
16. H. G. Xie, H. W. Zhang, J. Zhang, L. Z. Xu, and Z. M. Zou, *Chin. J. Nat. Med.*, **5**, 193 (2007).
17. D. C. Zhang, *Zhong Cheng Yao Yan Jiu*, **1**, 24 (1982).
18. F. Hanawa, M. Shiro, and Y. Hayashi, *Phytochemistry*, **45**, 589 (1997).
19. S. F. Fonseca, J. D. P. Campello, E. S. Lauro, and E. A. Ruveda, *Phytochemistry*, **17**, 499 (1978).
20. W. Zhang, K. P. Kang, Y. J. Zhou, and G. S. An, *Central South Pharmacy*, **5**, 446 (2007).
21. X. S. Chen, D. H. Chen, J. Y. Si, G. G. Tu, and L. B. Ma, *Acta Pharm. Sin.*, **35**, 198 (2000).
22. K. Machida and M. Kikuchi, *Phytochemistry*, **31**, 3654 (1992).
23. M. Chen, W. W. Wu, G. Q. Shen, S. O. Luo, and H. T. Li, *Acta Pharm. Sin.*, **29**, 617 (1994).
24. N. B. Perry, M. H. Benn, L. M. Foster, A. Routledge, and R. T. Weavers, *Phytochemistry*, **42**, 453 (1996).
25. K. Shimoda, Y. Kondo, T. Nishda, H. Hamada, N. Nakajima, and H. Hamada, *Phytochemisry*, **67**, 2256 (2006).
26. U. F. Castillo, A. L. Wilkins, and B. L. Smith, *J. Nat. Prod.*, **58**, 1889 (1995).
27. T. Miyase, M. Kuroyanagi, T. Noro, A. Ueno, and S. Fukushima, *Chem. Pharm. Bull*., **33**, 4445 (1985).
28. K. Umehara, I. Hattori, T. Miyase, A. Ueno, S. Hara, and C. Kageyama, *Chem. Pharm. Bull.*, **36**, 5004 (1988).
29. W. M. Zhu, C. F. Yin, S. Wang, G. Y. Zho, and X. J. Xiao, *Nat. Prod. Res. Dev.*, **13**, 1 (2001).
30. P. Page, C. Blonski, and J. Perie, *Tetrahedron*, **52**, 1557 (1996).
31. T. Ono, Y. Ito, T. Ishikawa, J. Kitajima, Y. Tanaka, and T. Nohara, *Chem. Pharm. Bull*., **44**, 337 (1996).
32. V. Laurence, L. Catherine, M. Georges, S. Thierry, and A. H. Hamid, *Phytochemistry*, **50**, 63 (1999).
33. Z. J. Wu, M. A. Ouyang, and S. B. Wang, *Nat. Prod. Res.*, **22**, 483 (2008).