Pergamon

0031-9422(95)00072-0

Phytochemistry, Vol. 39, No. 4, pp. 899–902, 1995

0031-9422/95 $9.50 + 0.00

LIGNANS FROM THE WOOD OF *ARALIA BIPINNATA*

JEH-JIAN HSIAO and HUNG-CHEH CHIANG*

Institute of Chemistry, National Taiwan Normal University, Taipei 117, Taiwan, R.O.C.

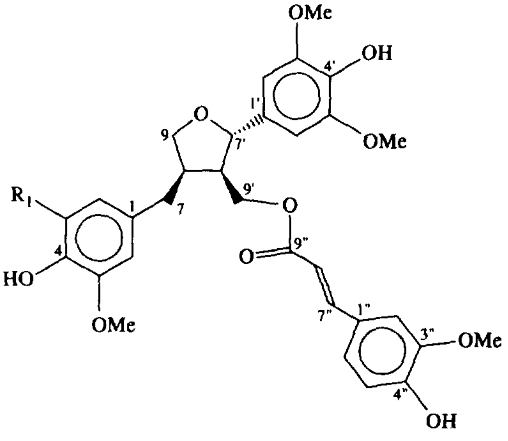
(*Received* 29 *November* 1994)

Key Word Index—*Aralia bipinnata*; Araliaceae; (−)-9′-*O*-*trans*-feruloyl-5,5′-dimethoxylariciresinol; (+)-9′-*O*-*trans*-feruloyl-5′-methoxylariciresinol; *threo*-2,3-bis-(4-hydroxy-3-methoxyphenyl)-3-methoxypropanol; lignans.

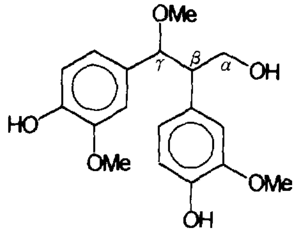
Abstract—Two new compounds (−)-9′-*O*-*trans*-feruloyl-5,5′-dimethoxylariciresinol and (+)-9′-*O*-*trans*-feruloyl-5′-methoxylariciresinol were isolated, together with *threo*-2,3-bis-(4-hydroxy-3-methoxyphenyl)-3-methoxypropanol, eight lignans, six alkaloids, stigmast-4-en-3-one, lupeol and eight aromatic compounds, from the wood of *Aralia bipinnata*. The structures of these compounds were elucidated by spectral methods. The hitherto unreported ^{1}H and ^{13}C NMR spectra of three of these compounds are also discussed.

INTRODUCTION

We have previously reported the isolation of three new phenylpropanoids from the woody part of *Aralia bipinnata* [1, 2]. In our continuing phytochemical investigations, we have isolated and identified twenty seven compounds, including eight lignans: (+)-syringaresinol [3], (−)-liriresinol-A [4], (+)-medioresinol [5], (+)-4-ketopinoresinol [6], (+)-pinoresinol [7], (±)-glaberide I [8], (+)-dihyrocubebin [9] and (+)-hinokinin [10]; six alkaloids: arnottianamide (**4**) [11], isoarnottianamide (**5**) [12], decarine [13], oxynitidine [14], 6-carboxymethyldihydrochelerythrine [15] and dihydroalatamide (**6**) [16]; stigmast-4-en-3-one [17]; lupeol [18]; *threo*-2,3-bis-(4-hydroxy-3-methoxyphenyl)-3-methoxypropanol (**3**); eight aromatic compounds: *p*-hydroxybenzaldehyde [19], vanillin [19], syringaldehyde [19], *trans*-*p*-coumaraldehyde [19], methyl *trans*-*p*-coumarate [19], *trans*-coniferyl aldehyde [20], *trans*-sinapaldehyde [19] and 5-(hydroxymethyl)furfural [21]. Two new lignan derivatives: (−)-9′-*O*-*trans*-feruloyl-5,5′-dimethoxylariciresinol (**1**) and (+)-9′-*O*-*trans*-feruloyl-5′-methoxylariciresinol (**2**) were also obtained. Compound **3** has previously been synthesized by chemical methods, but no data have been published [22]. It was isolated and identified for the first time from a natural source. This paper describes the isolation and characterization of **1**, **2** and **3**.



1 R_1 = OMe
2 R_1 = H



3

RESULTS AND DISCUSSION

Compound **1** was isolated as an amorphous powder and the molecular formula, $C_{32}H_{36}O_{11}$, determined by EI- ([M$^+$], *m/z* 596) and HR-mass spectrometry. In the ^{1}H NMR spectrum, the presence of the *trans*-feruloyl moiety was confirmed by the appearance of δ3.59 (3H, *s*), 6.22 (1H, *d*, J = 15.8 Hz) and 7.50 (1H, *d*, J = 15.8 Hz) in addition to a 3H multiplet at δ6.92–7.06. Comparison of the remaining signals in the ^{1}H NMR spectrum of **1** with the reported data of 5,5′-dimethoxylariciresinol [23, 24] revealed that the signals assignable to H-9′a and H-9′b

---

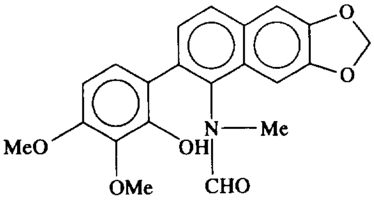
*Author to whom correspondence should be addressed.

were shifted by + 0.54 and + 0.59 ppm, suggesting the location of *trans*-feruloyl on the C-9′ hydroxy group of **1**. The structure of **1** is thus (−)-9′-*O*-*trans*-feruloyl-5,5′-dimethoxylariciresinol.

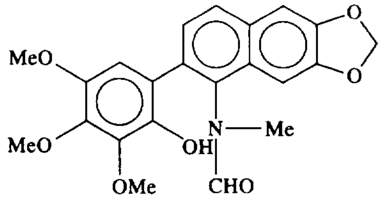
Compound **2** was isolated as an amorphous powder and the molecular formula, $C_{31}H_{34}O_{10}$, determined by EI- ([M$^+$], *m/z* 566) and HR-mass spectrometry. In the ^{1}H NMR spectrum, the presence of the *trans*-feruloyl moiety was also confirmed. A study of the ^{1}H NMR data of **2** in comparison with those of **1** revealed that **2** is a 5- or 5′-methoxylariciresinol-type lignan [25] containing a 9′-*O*-*trans*-feruloyl moiety. NOEs were observed between H7′/H2′ and H7′/H6′, and the structure of **2** was established as (+)-9′-*O*-*trans*-feruloyl-5′-methoxylariciresinol.

Compound **3** was isolated as an amorphous powder and the molecular formula, $C_{18}H_{22}O_6$, determined by EI- ([M$^+$], *m/z* 334) and HR-mass spectrometry. The UV and IR spectra of **3** indicated it to be an aromatic compound. Comparison of the ^{1}H NMR spectrum of **3** with that of 1,2-bis-(4-hydroxy-3-methoxyphenyl)-propane-1,3-diol revealed that **3** was a 1,2-bis-(4-hydroxy-3-methoxyphenyl)-1,3-propanediol-type [26] containing one methoxy group at δ3.26. NOE was observed between δ4.31/3.26. On the basis of these spectral data, the structure was assigned to 2,3-bis-(4-hydroxy-3-methoxyphenyl)-3-methoxypropanol and it was identified as the *threo* form [27].

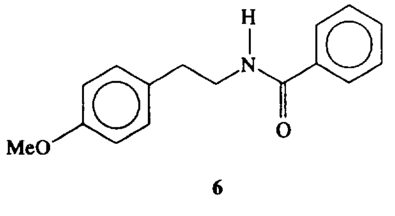
As far as we know, the ^{13}C NMR (DMSO-d_6) and ^{1}H NMR (DMSO-d_6) spectra of **4** and **5** and the ^{13}C NMR ($CDCl_3$) spectrum of **6** have not been described in the literature. Attribution of carbon and proton signals has been made according to the literature [11, 12, 18] and confirmed by examination of ^{13}C–^{1}H COSY and HMBC spectra.



4



5



6

EXPERIMENTAL

General. Mps: uncorr.; NMR: 400 MHz, $CDCl_3$, TMS as int. standard; MS, 70 eV; IR, KBr; HPLC was performed on Si60 (Waters, 6 μm, 7.8 × 300 nm) column using EtOAc–hexane and EtOAc–$CHCl_3$ as solvent systems and employing a refractive index detector.

Extraction and separation. The woody part of *Aralia bipinnata* (3 kg) was extracted with methanol (10 l × 3). These extracts were passed through a short column of activated charcoal. The filtrate was concd, the residue (31.5 g) was coated with silica gel (50 g) and subjected to chromatography on a silica gel (500 g) column by elution with gradients of ethyl acetate and hexane. The appropriate portions were combined to give six frs, A–F, in ascending order of polarity. Fr. A on HPLC (silica gel, EtOAc–hexane, 1:9) gave 25 mg of stigmast-4-en-3-one and 9 mg of lupeol. Fr. C on HPLC (silica gel, EtOAc–hexane, 3:7) gave 14 mg of (+)-hinokinin and 6 mg of methyl *trans*-*p*-coumarate. Fr. D on HPLC (silica gel, EtOAc–hexane, 7:13) gave 6 mg of (+)-dihydrocubebin, 11 mg of syringaldehyde, 4 mg of *trans*-sinapaldehyde and 82 mg of 5-(hydroxymethyl)-furfural. Fr. E on HPLC (silica gel, EtOAc–$CHCl_3$, 3:2) gave 15 mg of (+)-4-ketopinoresinol, 7 mg of (+)-pinoresinol, 14 mg of (±)-glaberide I, 52 mg of arnottianamide (**4**), 5 mg of oxynitidine, 4 mg of 6-carboxymethyldihydrochelerythrine and 3 mg of *threo*-2,3-bis-(4-hydroxy-3-methoxyphenyl)-3-methoxypropanol (**3**). Fr. F on HPLC (silica gel, EtOAc–$CHCl_3$, 4:1) gave 4.3 mg of (−)-9′-*O*-*trans*-feruloyl-5,5′-dimethoxylariciresinol (**1**), 2.8 mg of (+)-9′-*O*-*trans*-feruloyl-5′-methoxylariciresinol (**2**), 38 mg of (+)-syringaresinol, 10 mg of (−)-liriresinol-A, 4 mg of (+)-medioresinol, 42 mg of isoarnottianamide (**5**), 5 mg of decarine, 12 mg of dihydroalatamide (**6**), 87 mg of *p*-hydroxybenzaldehyde, 71 mg of vanillin, 42 mg of *trans*-*p*-coumaraldehyde and 17 mg of *trans*-coniferylaldehyde. The structures of these compounds were elucidated by comparison of spectral data with those of authentic samples.

(−)-9′-O-trans-*Feruloyl-5,5′-dimethoxylariciresinol* (**1**). HRMS *m/z* 596.2251 [M]$^+$ (calc. 596.2258, $C_{32}H_{36}O_{11}$) $[\alpha]_D^{25}$ − 27.7° (MeOH; *c* = 0.007); UV λ_{max}^{MeOH} nm (log ε): 324.5 (4.02), 299 (3.88), 286.5 (3.80); ^{1}H NMR data: Table 1; MS *m/z* (%): 596 [M]$^+$ (11), 402 (38), 235 (56), 194 (21), 181 (100), 167 (91).

(+)-9′-O-trans-*Feruloyl-5′-methoxylariciresinol* (**2**). HRMS *m/z* 566.2148 [M]$^+$ (calc. 566. 2152, $C_{31}H_{34}O_{10}$); $[\alpha]_D^{25}$ + 20.1° (MeOH; *c* = 0.005); UV λ_{max}^{MeOH} nm (log ε): 324.5 (4.03), 299 (3.90), 286.5 (3.96); ^{1}H NMR data: Table 1; MS *m/z* (%): 566 [M]$^+$ (7), 432 (8), 235 (26), 194 (57), 181 (88), 137 (100).

threo-2,3-*Bis-(4-hydroxy-3-methoxyphenyl)-3-methoxypropanol* (**3**). HRMS *m/z* 334.1412 [M$^+$] (calc. 334.1416, $C_{18}H_{22}O_6$); $[\alpha]_D^{24}$ 0° (MeOH); UV λ_{max}^{MeOH} nm (log ε): 280 (4.12); ^{1}H NMR ($CDCl_3$): δ3.87, 4.15 (each 1H, *m*, H-α), 3.03 (1H, *m*, H-β), 4.31 (1H, *d*, *J* = 9.3 Hz, H-γ), 6.32–6.74 (6H, *m*, ArH), 5.52, 5.54 (each 1H, *br s*, 2 × OH), 3.77 (3H, *s*, OMe), 3.72 (3H, *s*, OMe), 3.26 (3H, *s*, γ-OMe); ^{13}C NMR ($CDCl_3$): δ66.8 (C-α), 54.9 (C-β), 89.5 (C-γ),

Table 1. ^{1}H NMR data for **1** and **2** (400 MHz, CDCl$_3$, TMS as int. standard)

	(−)-9′-*O*-*trans*-Feruloyl-5,5′-dimethoxylariciresinol (**1**)	(+)-9′-*O*-*trans*-Feruloyl-5′-methoxylariciresinol (**2**)
H-2	6.41, *s*	6.70, *s*
H-5		6.86, *d*, *J* = 7.8 Hz
H-6	6.41, *s*	6.71, *d*, *J* = 7.8 Hz
H-7	2.56, *dd*, *J* = 13.1, 11.2 Hz	2.58, *dd*, *J* = 13.7, 10.7 Hz
	2.92, *dd*, *J* = 13.1, 10.7 Hz	2.90, *dd*, *J* = 13.7, 4.9 Hz
H-8	2.75, *m*	2.77, *m*
H-9	3.79, *dd*, *J* = 8.8, 7.4 Hz	3.79, *dd*, *J* = 8.8, 8.6 Hz
	4.12, *dd*, *J* = 8.8, 6.2 Hz	4.12, *dd*, *J* = 8.8, 6.3 Hz
H-2′, 6′	6.59, *s*	6.60, *s*
H-7′	4.82, *d*, *J* = 6.3 Hz	4.83, *d*, *J* = 6.3 Hz
H-8′	2.66, *m*	2.66, *m*
H-9′	4.33, *dd*, *J* = 11.2, 7.3 Hz	4.34, *dd*, *J* = 11.3, 7.3 Hz
	4.52, *dd*, *J* = 11.2, 7.2 Hz	4.52, *dd*, *J* = 11.3, 7.2 Hz
3,3′,5,5′-OMe	3.87, 3.88 (each 6H, *s*)	—
3,3′,5′-OMe		3.88 (9H, *s*)
4,4′-OH	5.40, 5.45 (each 1H, *br s*)	5.47, 5.51 (each 1H, *br s*)
H-2″	7.00, *s*	7.00, *s*
H-5″	6.92, *d*, *J* = 7.8 Hz	6.93, *d*, *J* = 7.8 Hz
H-6″	7.06, *d*, *J* = 7.8 Hz	7.06, *d*, *J* = 7.8 Hz
H-7″	6.22, *d*, *J* = 15.8 Hz	6.23, *d*, *J* = 15.8 Hz
H-8″	7.50, *d*, *J* = 15.8 Hz	7.51, *d*, *J* = 15.8 Hz
3″-OMe	3.95, *s*	3.96, *s*
4″-OH	5.88, *br s*	5.90, *br s*

131.2, 131.8 (C-1, C-1′), 109.4, 111.6, 113.8, 114.2 (C-2, C-2′, C-5, C-5′), 146.2, 146.3 (C-3, C-3′), 144.3, 145.0 (C-4, C-4′), 120.6, 120.7 (C-6, C-6′), 55.9 (3′-OMe), 56.6 (γ-OMe); MS *m*/*z* (%): 334 [M]$^+$ (4), 167 (100), 152 (41), 137 (10), 107 (20), 77 (9).

Arnottianamide (**4**). ^{1}H NMR (DMSO-d_6): δ7.23 (*d*, *J* = 8.3 Hz, H-3), 7.80 (*d*, *J* = 8.3 Hz, H-4), 7.45 (*s*, H-5), 7.01 (*s*, H-8), 6.56 (*d*, *J* = 8.8 Hz, H-5′), 6.73 (*d*, *J* = 8.8 Hz, H-6′), 6.18 (*s*,–OCH$_2$O–), 7.96 (*s*,–CHO), 8.90 (*br s*, OH), 2.89 (*s*, NMe), 3.35 (*s*, 3′-OMe), 3.69 (*s*, 4′-OMe); ^{13}C NMR (DMSO-d_6): δ135.3 (C-1), 134.3 (C-2), 127.6 (C-3), 126.9 (C-4), 104.1 (C-5), 147.8 (C-6), 148.9 (C-7), 98.6 (C-8), 128.0 (C-9), 130.6 (C-10), 119.8 (C-1′), 147.6 (C-2′), 136.2 (C-3′), 152.4 (C-4′), 103.1 (C-5′), 124.7 (C-6′), 101.6(–OCH$_2$O–), 163.2 (–CHO), 32.7 (NMe), 60.3 (3′-OMe), 55.6 (4′-OMe).

Isoarnottianamide (**5**). ^{1}H NMR (DMSO-d_6): δ7.26 (*d*, *J* = 8.3 Hz, H-3), 7.79 (*d*, *J* = 8.3 Hz, H-4), 7.44 (*s*, H-5), 7.01 (*s*, H-8), 6.55 (*s*, H-3′), 6.63 (*s*, H-6′), 6.17 (*s*,–OCH$_2$O–), 8.00 (*s*, CHO), 9.06 (*br s*, OH), 2.91 (*s*, NMe), 3.74 (*s*, 4′-OMe), 3.64 (*s*, 5′-OMe); ^{13}C NMR (DMSO-d_6): δ135.4 (C-1), 134.4 (C-2), 127.8 (C-3), 126.8 (C-4), 104.1 (C-5), 147.6 (C-6), 148.8 (C-7), 98.6 (C-8), 128.1 (C-9), 130.5 (C-10), 116.2 (C-1′), 149.0 (C-2′), 100.8 (C-3′), 148.4 (C-4′), 141.5 (C-5′), 114.8 (C-6′), 101.6 (–OCH$_2$O–), 163.4 (CHO), 32.7 (NMe), 55.3 (4′-OMe), 56.3 (5′-OMe).

Dihydroalatamide (**6**). ^{13}C NMR (CDCl$_3$): δ131.5 (C-1), 127.4 (C-2), 129.2 (C-3), 132.0 (C-4), 129.2 (C-5), 127.4 (C-6), 168.1 (C = O), 135.3 (C-1′), 130.4 (C-2′, C-6), 114.8 (C-3′, C-5′), 159.0 (C-4′), 35.4 (C-7′), 41.9 (C-8′), 55.9 (OMe).

REFERENCES

1. Hsiao, J.-J., Liu, H.-T. and Chiang, H.-C. (1994) *Chinese Pharmaceutical J.* **46**, 199.
2. Hsiao, J.-J. and Chiang, H.-C. (1994) *Phytochemistry* (in press).
3. Ratnayake, S., Fang, X.-P., Anderson, J. E. and McLaughlin, J. L. (1992) *J. Nat. Prod.* **55**, 1462.
4. Briggs, L. H., Cambie, R. C. and Cough, R. A. F. (1968) *J. Chem. Soc.* (*C*) 3024.
5. Deyama, T., Ikawa, T. and Nishibe, S. (1985) *Chem. Pharm. Bull.* **33**, 3651.
6. Cooper, R., Gottlieb, H. E., Lavie, D. and Levy, E. C. (1979) *Tetrahedron* **35**, 861.
7. Deyama, T., Ikawa, T., Kitagawa, S. and Nishibe, S. (1987) *Chem. Pharm. Bull.* **35**, 1785.
8. Chiji, H., Arakawa. Y., Ueda. S., Kuroda, M. and Izawa, M. (1986) *Phytochemistry* **25**, 281.
9. Koul, S. K., Taneja, S. C., Pushpangadan, P. and Dhar, K. L. (1988) *Phytochemistry* **27**, 1479.
10. Lopes, L. M. X., Yoshida, M. and Gottlieb, O. R. (1983) *Phytochemistry* **22**, 1516.
11. Ng, K. M., Gray, A. I. and Waterman, P. G. (1987) *J. Nat. Prod.* **50**, 1160.
12. Ishii, H., Ishikawa, T., Lu, S. T. and Chen, I. S. (1976) *Yakugaku Zasshi* **96**, 1458.
13. Boulware, R. T. and Stermitz, F. R. (1981) *J. Nat. Prod.* **44**, 200.
14. Ishii, H., Ohida, H. and Haginiwa, J. (1972) *Yakugaku Zasshi* **92**, 118.

15. Ng, K. M., Gray, A. I. and Waterman, P. G. (1987) *Phytochemistry* **26**, 3251.
16. Chatterjee, A., Chakrabarty, M. and Kundu, A. B. (1975) *Aust. J. Chem.* **28**, 457.
17. Chen, C. C., Yu, H. J., Ou, J. C. and Pan, T. M. (1994) *J. Chin. Chem. Soc.* **41**, 195.
18. Bhattacharyya, J. and Barros, C. B. (1986) *Phytochemistry* **25**, 274.
19. Gunhild, A. E. and Roland, S. (1968) *Acta Chem. Scand.* **22**, 1187.
20. Connors, W. J., Chen, C. L. and Pew, J. C. (1970) *J. Org. Chem.* **35**, 1920.
21. Hearn, T. W. (1976) *Aust. J. Chem.* **29**, 107.
22. Adler, E., Brunow, G. and Lundquist, K. (1987) *Holzforchung* **41**, 199.
23. Kinjo, J., Higuchi, H., Fukui, K. and Nohara, T. (1991) *Chem. Pharm. Bull.* **39**, 2952.
24. Achenbach, H., Stocker, M., and Constenla, M. A. (1988) *Phytochemistry* **27**, 1835.
25. Duh, C.-Y., Phoebe, C. H., Pezzuto, J. M., Kinghorn, A. D. and Farnsworth, N. R. (1986) *J. Nat. Prod.* **49**, 706.
26. Miki, K., Takehara, T., Sasaya, T. and Sakakibara, A. (1980) *Phytochemistry* **19**, 449.
27. Ferrand, G. and Huet, J. (1975) *Bull. Soc. Chim. Fr.* 1709.