Pergamon

PII: S0031-9422(97)00340-3

Phytochemistry, Vol. 46, No. 6, pp. 1029–1033, 1997

Printed in Great Britain
0031-9422/97 $17.00+0.00

THREE DIBENZOYLMETHANE DERIVATIVES FROM *LONCHOCARPUS* SPECIES

ADERBAL F. MAGALHÃES* ANA MARIA A. TOZZI†, EVA G. MAGALHÃES,* IVANI S. BLANCO* and MARISA A. NOGUEIRA*

* Instituto de Química, UNICAMP, P.O. Box 6154 CEP., 13081-970-Campinas-São Paulo-Brazil;
† Instituto de Biologia-UNICAMP

(*Received in revised form* 14 *March* 1997)

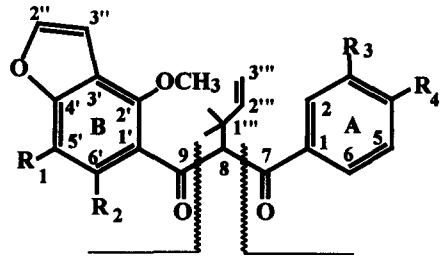
Key Word Index—*Lonchocarpus latifolius*; *L. muehlbergianus*; roots; Leguminosae; dibenzoylmenthanes.

Abstract—Three new dibenzoylmethane derivatives were isolated from petrol extracts of the roots of *Lonchocarpus latifolius* and *L. muehlbergianus*. Molecular structures were determined from spectroscopic data, especially NMR techniques. An alkyl group bonded to the central carbon (C-8) of a natural dibenzoylmethane, had not been found before. Spectral data analysis suggested a preponderance of the respective diketotautomers.

INTRODUCTION

Twenty four Brazilian species of *Lonchocarpus* are recognized from their morphological criteria. Inflorescence structure appeared as an outstanding character. According to this classification *L. muehlbergianus* belongs to the subgenus *Punctati* while *L. latifolius* is placed in the *Densiflori* section of the subgenus *Lonchocarpus*. Both species occur in southern Brazil.

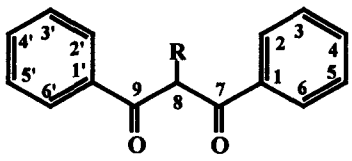
Dibenzoylmethane are rarely found in nature [1]. Among 32 *Lonchocarpus* species previously investigated, only *L. costaricensis* [2] and *L. subglaucescens* [3] furnished such compounds, which were described as β-hydroxychalcone derivatives, because of their high degree of enolization. None of them, possessed a substituent on C-8, although dibenzoylmethane itself (**4**) has been reacted with allyl halide in the presence of lithium hydroxide monohydrate, furnishing the corresponding C-8 allyl derivative **5** in 92% yield [4]. Some dibenzoylmethane derivatives were synthesized in order to assay their mutagenic activities against *Salmonella tiphymurium* [5].



1 $R_1 = R_2 = R_3 = R_4 = H$

2 $R_1 = R_2 = H$ $R_3 = R_4 = -O-CH_2-O-$

3 $R_1 = R_2 = OCH_3$ $R_3 = R_4 = H$



4 R = H

5 R = allyl

RESULTS AND DISCUSSION

The roots of each species were extracted with petrol, followed by chromatography on silica gel, allowing the isolation of several flavonoids. Compound **1** was isolated as a yellowish oil. The ^1H NMR spectrum (Table 1) showed absorptions corresponding to one free aromatic ring, an uncoupled methynic hydrogen, two *ortho*-coupled hydrogens, one furan ring, one 3,3-dimethylallyl group and one aromatic methoxyl group. The ^{13}C NMR spectrum (Table 2) indicated the presence of eight C_0, eleven CH, one CH_2 and three CH_3, which were confirmed by DEPT 90 and

* Author to whom correspondence should be addressed.

Table 1. ^{1}H NMR spectra (300 MHz, $CDCl_3$) of compounds **1–3**

	1	**2**	**3**
H-2	8.02 (2H, *m*)	7.50 (1H, *d*, *J* = 2)**	7.93–7.90 (2H, *m*)
H-3	7.45 (3H, *m*)	—	7.52–7.36 (3H, *m*)
H-4	7.53 (1H, *m*)	—	7.52–7.36 (3H, *m*)
H-5	7.45 (1H, *m*)	6.84 (1H, *d*, *J* = 8)††	7.52–7.36 (3H, *m*)
H-6	8.02 (2H, *m*)	7.66 (1H, *dd*, *J* = 8; 2)‡‡	7.93–7.90 (2H, *m*)
H-8	5.74 (1H, *s*)	5.64 (1H, *s*)	5.40 (1H, *s*)
H-5′	7.17 (1H, *dd*, *J* = 9; 1)*	7.19 (1H, *d*, *J* = 8; 1)*	—
H-6′	7.45 (3H, *m*)	7.42 (1H, *d*, *J* = 8)	—
H-2″	7.58 (1H, *d*, *J* = 2)†	7.60 (1H, *d*, *J* = 2)†	7.54 (1H, *d*, *J* = 2)†
H-3″	6.93 (1H, *dd*, *J* = 2; 1)‡	6.95 (1H, *dd*, *J* = 2; 1)‡	6.80 (1H, *d*, *J* = 2)†
H-2‴	6.10 (1H, *dd*, *J* = 17; 11)§	6.10 (1H, *dd*, *J* = 17; 11)§	6.14 (1H, *dd*, *J* = 17; 10)§
H-3‴a	4.88 (1H, *dd*, *J* = 11; 1)‖	4.88 (1H, *dd*, *J* = 11; 1)‖	4.90 (1H, *dd*, *J* = 10; 1)‖
H-3‴b	4.92 (1H, *dd*, *J* = 17; 1)¶	4.92 (1H, *dd*, *J* = 17; 1)¶	4.95 (1H, *dd*, *J* = 17; 1)¶
—OCH_3	3.84 (3H, *s*)	3.94 (3H, *s*)	3.78 (3H, *s*)
			3.79 (3H, *s*)
			4.02 (3H, *s*)
—CH_3	1.21 (CH_3)	1.21 (CH_3)	1.26 (CH_3)
	1.23 (CH_3)	1.23 (CH_3)	1.28 (CH_3)
—O—CH_2—O—	—	6.04 (2H, *s*)	

* $J_{5',6'}$; $J_{5',3''}$; † $J_{2'',3''}$; ‡ $J_{3'',2''}$; $J_{3'',5'}$.
§ $J_{2'''}$,3‴b; $J_{2'''}$;3‴a; ‖ $J_{3'''}$a;2‴; $J_{3'''}$a,b; ¶ $J_{3'''}$b,2‴; $J_{3'''}$a,b.
** $J_{2,5}$; †† $J_{5,6}$; ‡‡ $J_{6,5}$; $J_{6,2}$.

Table 2. ^{13}C NMR spectra (75 MHz, $CDCl_3$) of compounds **1–3**. DEPT data (90 and 135°) in parenthesis

C DEPT	**1***	**2**	**3**
1	138.7 (C_0)	133.5 (C_0)	135.0 (C_0)
2	128.9 (CH)	107.7 (CH)	128.6 (CH)
3	128.4 (CH)	148.0 (C_0)	128.3 (CH)
4	132.7 (CH)	151.5 (C_0)	132.5 (CH)
5	128.4 (CH)	108.7 (CH)	128.3 (CH)
6	128.9 (CH)	125.2 (CH)	128.6 (CH)
7	195.4 (C=O)	193.3 (C=O)	194.5 (C=O)
8	66.8 (CH)	66.6 (CH)	68.1 (CH)
9	197.6 (C=O)	197.6 (C=O)	196.4 (C=O)
1′	127.2 (C_0)	126.7 (C_0)	128.2 (C_0)
2′	152.3 (C_0)	152.2 (C_0)	138.6 (C_0)
3′	117.4 (C_0)	118.0 (C_0)	117.4 (C_0)
4′	158.8 (C_0)	158.7 (C_0)	148.9 (C_0)
5′	106.6 (CH)	106.7 (CH)	134.5 (C_0)
6′	126.7 (CH)	126.8 (CH)	144.7 (C_0)
2″	144.7 (CH)	144.7 (CH)	144.5 (CH)
3″	105.5 (CH)	105.5 (CH)	105.2 (CH)
1‴	41.7 (C_0)	41.5 (C_0)	41.6 (C_0)
2‴	146.1 (CH)	146.1 (CH)	146.0 (CH)
3‴a	111.7 (CH_2)	111.5 (CH_2)	111.4 (CH_2)
3‴b	111.7 (CH_2)	111.5 (CH_2)	111.4 (CH_2)
O—CH_3	60.0 (CH_3)	60.4 (CH_3)	61.0 (CH_3)
			61.1 (CH_3)
			62.4 (CH_3)
—CH_3	26.41 (CH_3)	25.8 (CH_3)	25.5 (CH_3)
	26.82 (CH_3)	26.4 (CH_3)	25.7 (CH_3)
—OCH_2—O	—	101.8 (CH_2)	—

* Assignments confirmed by HETCOR (Table 3) and COLOC (Table 4) spectra.

Table 3. Observed correlation in COSY (H–H) and HETCOR (vicinal C–H) spectra of compound **1**

δ ^{1}H (position)	HETCOR (attached carbon)	COSY (coupled hydrogen)
8.02 (H-2; H-6)	128.9 (C2-C6)	7.45 (H-3; H-5)
7.59 (H-2″)	144.7 (C2″)	6.87 (H-3″)
7.45 (H-6′)	126.7 (C6′)	7.18 (H-5′)
7.45 (H-3; H-5)	128.4 (C3; C5)	very near
7.53 (H-4)	132.7 (C4)	very near
7.18 (H-5′)	106.6 (C5′)	7.26–7.54 (H-6′)
6.93 (H-3″)	105.5 (C3″)	7.59 (H-2″)
		7.18 (H-5′)
6.10 (H-2‴)	146.1 (C2‴)	4.87–4.99 (H-3‴a; H-3‴b)
5.74 (H-8)	66.8 (C8)	—
4.88 (H-3‴a)	111.6 (C3‴)	6.10 (H-2‴)
4.92 (H-3‴b)	111.6 (C3‴)	6.10 (H-2‴)
3.84 (—OCH_3)	60.0 (—OCH_3)	—
1.21	26.4 (C—CH_3)	—
1.23	26.8 (—CH_3)	—

135°. Signals at δ 197.6 (C_0) and δ 195.4 (C_0) were assigned to dibenzoylmethane carbonyls [6, 7]. Two-dimensional spectra, such as COSY (Table 3), HETCOR (Table 3) and COLOC (Table 4), were also compatible with this assignment. The most prominent peaks in the mass spectrum could be rationalized as arising from the cleavage of α-carbonyl bonds (Table 5). These findings lead us to conclude that the 3,3-dimethylallyl group must be on C-8, in the middle of the molecule. The lack of a sharp singlet around δ 12–18 (1H) in the ^{1}H NMR spectrum, together with the UV spectrum typical of a benzoyl-type chromophore [λ_{max}^{MeOH}(log ε) nm: 239 (3.44)] could also be taken as an evidence that the tautomeric equilibrium is highly shifted to the diketo form. In fact, much less steric hindrance is evident from the corresponding diketo molecular model.

Table 4. Observed long-range C_0-H correlations (J^3) in the COLOC spectrum of compound **1** (See also fig. 2)

δ $^{13}C_0$	δ ^{1}H (ppm)	Carbon assigned
197.57	7.45 (H-6′)	C-9
195.41	8.20 (H-2; H-6)	C-7
158.75	7.45 (H-6′)	C-4′
152.34	3.84 (—OCH_3)	C-2′
	7.45 (H-6′)	
138.73	8.20 (H-2; H-6)	C-1
127.15	7.18 (H-5′)	C-1′
117.43	7.59 (H-2″)	C-3′
41.65	5.74 (H-8)	C-1‴
	4.92 (H-3‴)	
	4.87 (H-3‴)	
	1.23 (CH_3)	
	1.21 (CH_3)	

Table 5. Main fragments (a and b) in the mass spectra of compound **1–3**

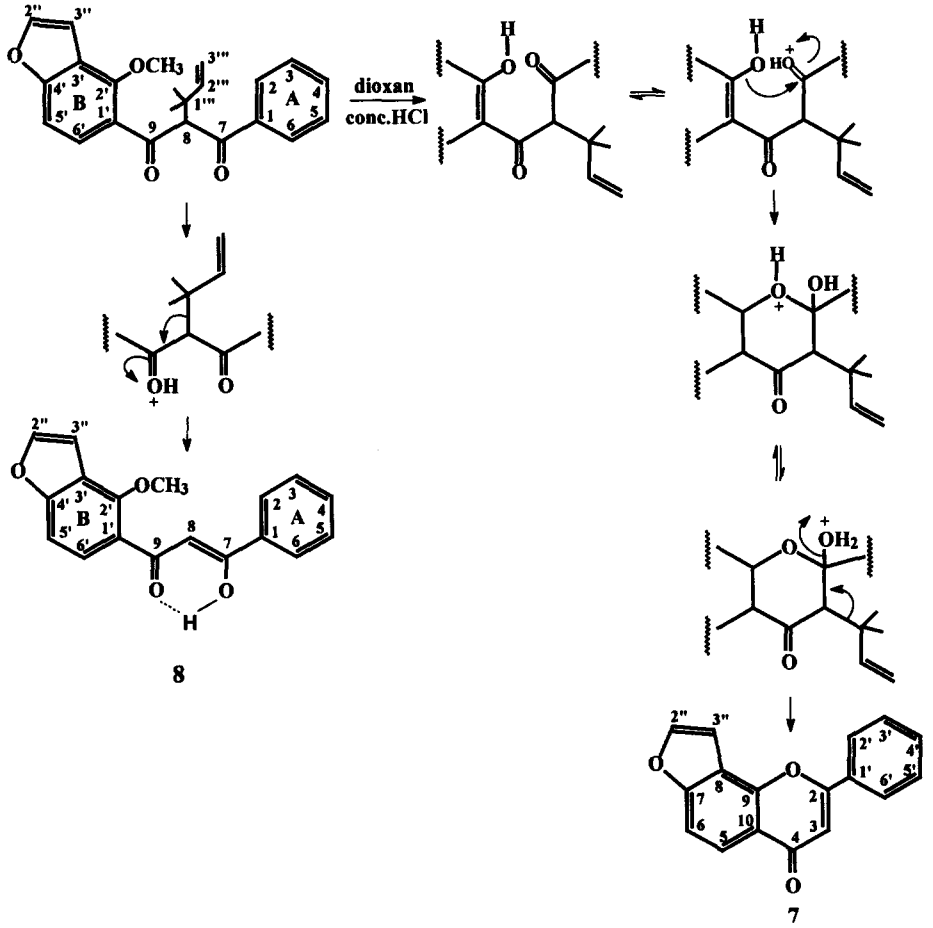
Compound	*m/z* (rel. int.) a	b
1	175 (100)	105 (23)
2	175 (100)	149 (17)
3	235 (100)	105 (23)

In addition, compound **1** was recovered after being left in the presence of CH_2N_2 for 40 hr at room temperature; highly enolized dibenzoylmethanes are rapidly transformed into their methyl-enol derivatives under similar conditions [3, 8]. However, when **1** was refluxed under acidic conditions [HCl, dioxan, 40 hr), several products were detected by TLC. Preparative TLC of the crude reaction product furnished lanceolatin B (**7**) and pongamol (**8**), which could have been formed through the reaction pathway shown on Scheme 1.

Compounds **2** and **3** had ^{1}H NMR (Table 1) and ^{13}C NMR (Table 2) spectra very similar to those of **1**, except for a methylenedioxy group on A ring of **2** and two additional methoxyl groups on B ring of **3**, confirmed by the most prominent peaks in their mass spectra (Table 5). In the NOE differential spectra of **1** and **2**, irradiation of H-8 caused a pronounced enhancement of the H-2 and H-6 signals, but those corresponding to the hydrogens of B ring were little affected (Fig. 1). We suggest the preferential conformation where the A ring benzoyl moiety and the C-8/H-8 bond lie in the same plane, while the B ring benzoyl moiety (R_1) and 3,3-dimethylallyl group (R_2) project out of it, sustaining once more the idea that diketotautomers are the preponderant form of these compounds.

EXPERIMENTAL

Plant material. Roots of *L. muehlbergianus* (Hassler) were collected at the Ecological Park belong-



Scheme 1. Possible reaction pathway of compound **1** in an acidic medium under reflux.

ing to the Campinas State University (UNICAMP) in the summer of 1992. Those of *L. latifolius* (Wild.) DC were collected at the Instituto Agronômico de Campinas during the winter of 1994. Voucher samples are deposited in the University Herbarium.

Extraction and separation. Dry roots of *L. latifolius* (714 g) and *L. muehlbergianus* (932 g) were separately powdered and extracted for 60 hr in a Sohxlet apparatus with petrol. After solvent evapn, *L. latifolius* gave a viscous yellow oil (12.5 g) and *L. muehlbergianus*, a viscous brownish oil (9.4 g). Each extract was chromatographed on silica gel, eluting first with petrol. Eluent polarity was gradually increased by addition of CH_2Cl_2, EtOAc and MeOH to EtOAc–MeOH (1:1). By taking only part of the *L. latifolius* extract (6 g), elution with CH_2Cl_2 followed by prep. TLC in petrol–EtOAc (4:1) gave **1** (200 mg) and **2** (3.0 mg). From the *L. muehlbergianus* extract (9.9 g), elution with petrol–EtOAc (3:2) gave a complex fr. (85.5 mg) which was further submitted to prep. TLC in petrol–EtOAc (9:1), furnishing a less complex fr. (44.7 mg).

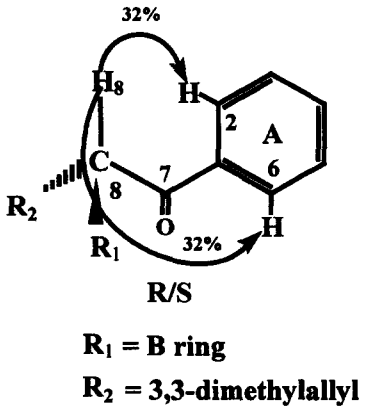


Fig. 1. Preferential conformation of compounds **1–3** based on NOE differential spectra.

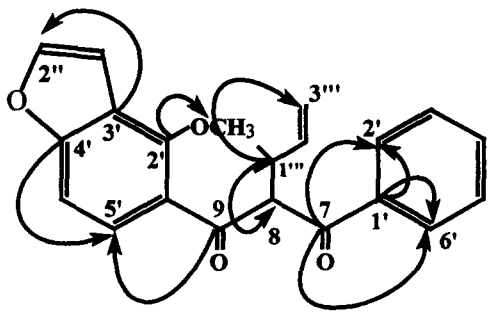


Fig. 2. Long-range C_0-H correlations in the COLOC spectrum of compound **1**.

After two prep. TLC separations in petrol–EtOAc (190:1) compound **3** (11 mg) was isolated.

2′-Methoxy-[2″,3″,4′,3′]-furanodibenzoylmethane (**1**). Viscous yellowish oil. $[\alpha]_{20}^{D} = +28.31$ (c 0.84, CH_2Cl_2). UV λ_{max} nm ($\log\varepsilon$) 239 (3.44). IR ν_{max} cm^{-1} (film CH_2Cl_2): 3055, 2956, 2925, 1698, 1597, 1468, 1355, 1266, 1074, 738. HR-EIMS, *m/z*: Found 362.14418 $[M]^+$ ($C_{23}H_{22}O_4$ requires 362.15180). GC-MS 70 eV, *m/z* (rel. int): 362 $[M]^+$ (2), 334 (6), 319 (10), 263 (20), 175 (100), 160 (20), 105 (25), 77 (27).

3,4-Methylenedioxy-2′-methoxy-[2″,3″:4′4′]-furanodibenzoylmethane (**2**). Viscous yellowish oil. UV λ_{max} nm ($\log\varepsilon$) 236 (3.47), 266 (3.05), 310 (2.89). IR ν_{max} cm^{-1} (film CH_2Cl_2): 3055, 2987, 1723, 1700, 1507, 1157. EIMS 70 eV, *m/z* (rel. int): 406 $[M]^+$ (0.4); 307 (5); 263 (10); 175 (100); 160 (17); 149 (17).

2′,5′,6′-Trimethoxy-[2″,3″:4′,3′]-furanodibenzoylmethane (**3**). Viscous yellowish oil. UV λ_{max} nm ($\log\varepsilon$) 247 (3.87). IR ν_{max} cm^{-1} (film CH_2Cl_2): 3386, 2936, 1709, 1594, 1478, 1423, 1347, 1265, 1133, 1108, 1067, 736, 701. EIMS 70 eV, *m/z* (rel. int.): 422 $[M]^+$ (7); 235 (100); 220 (11); 175 (4); 105 (11); 77 (10); 69 (5).

Transformation of **1**. Compound **1** (60 mg) was refluxed in dioxane (3 ml) and conc. HCl (3 ml) under reflux for 40 hr. After usual work-up, the reaction mixt. (53.2 mg) was submitted to prep. TLC in hexane–EtOAc (17:3), furnishing the flavone **7** (15.5 mg) and the β-hydroxychalcone **8** (3.5 mg), which were identified as lanceolatin B [9] and pongamol [10], respectively, from their ^{1}H NMR.

Acknowledgements—The authors are grateful to CAPES and FAPESP for financial support and the scholarships awarded to I.S.B. and M.A.N.

REFERENCES

1. Demizu, S., Kajiyama, K., Hiraga, D., Kinoshida, K., Koyama, K., Takahashi, K., Tamura, D., Okada, K. and Kinoshida, T., *Chemical and Pharmaceutical Bulletin*, 1992, **40**, 392.
2. Waterman, G. P. and Mahmoud, E. N., *Phytochemistry*, 1985, **24**, 571.
3. Magalhães, A. F., Tozzi, A. M. A. G., Salles, B. H. L. N. and Magalhães, E. G., *Phytochemistry*, 1996, **42**, 1459.
4. Antonioletti, R., Bonadies, F., Orelli, L. R. and Scettri, A., *Gazzeta Chimica Italiana*, 1992, **122**, 237.
5. Choshi, T., Horimoto, S., Wang, C. Y., Nagase, H., Ichikawa, M., Sugino, E. and Hibino, S., *Chemical and Pharmaceutical Bulletin*, 1992, **40**, 1047.
6. Zeng, L., Fukai, T., Kanesi, T., Nomura, T., Zhang, R. Y. and Lou, Z. C., *Heterocycles*, 1994, **34**, 85.
7. Fukai, T., Nishizaka, J. and Nomura, T., *Phytochemistry*, 1994, **35**, 515.
8. Kiuchi, F., Chen, Y. and Tsuda, Y., *Chemical and Pharmaceutical Bulletin*, 1990, **38**, 1862.
9. Tanaka, T., Iinuma, M., Yuki, K., Fujii, Y. and Mizuno, M., *Phytochemistry*, 1992, **31**, 534.
10. Parnar, V. S., Ratthore, J. S., Jain, R., Henderson, D. A. and Malone, J. F., *Phytochemistry*, 1989, **28**, 591.