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Article

Prenylated Flavonoids from Roots of *Dahlstedtia glaziovii* (Fabaceae)

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O estudo fitoquímico das raízes de *Dahlstedtia glaziovii* (Fabaceae) forneceu um novo dibenzoilmetano (glaziovione), juntamente com dezoito compostos conhecidos. Suas estruturas foram determinadas através de métodos espectroscópicos de ressonância magnética nuclear (NMR) 1D e 2D (correlação heteronuclear única quântica, HSQC, e correlação heteronuclear de múltipla ligação, HMBC) e espectrometria de massas de alta resolução (HRMS). A atividade antiproliferativa foi investigada para os extratos, para os dibenzoilmetanos 2'-metóxi-8-(α-α-dimetilalil)-furano-[4",5":3',4']-dibenzoilmetano, 3,4-metilenodioxi-2'-metóxi-8-(α-α-dimetilalil)-furano-[4",5":3',4']-dibenzoilmetano e pongamol, e para as flavonas lanceolatina B, karanjina, pongapina e 3',4'-metilenodioxi-2'',2''-dimetilpirano-[5'',6'':8,7]-flavona. Os dibenzoilmetanos foram mais ativos do que as flavonas. A atividade antimicrobiana foi investigada para os extratos, sendo que estes não se apresentaram ativos.

A phytochemical study of roots of *Dahlstedtia glaziovii* (Fabaceae) furnished a new dibenzoylmethane (glaziovione), along with eighteen known compounds. Their structures were determined through 1D and 2D nuclear magnetic resonance (NMR) (heteronuclear single quantum coherence, HSQC, and heteronuclear multiple bond correlation, HMBC) and high-resolution mass spectrometry (HRMS) spectral analyses. The antiproliferative activity was investigated for the crude extracts, the dibenzoylmethanes 2'-methoxy-8-(α-α-dimethylallyl)-furano-[4",5":3',4']-dibenzoylmethane, 3,4-methylenedioxy-2'-methoxy-8-(α-α-dimethylallyl)-furano-[4",5":3',4']-dibenzoylmethane and pongamol, and the flavones lanceolatin B, karanjin, pongapin and 3',4'-methylenedioxy-2'',2''-dimethylpyrano-[5'',6'':8,7]-flavone. The dibenzoylmethanes were more active than the flavones.The extracts were evaluated for their antimicrobial effects, but none was shown to be active.

Keywords: *Lonchocarpus*, prenylated flavonoids, dibenzoylmethane, *Dahlstedtia glaziovii*, antiproliferative activity

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Introduction

The genera *Dahlstedtia* Malme and *Lonchocarpus* Kunth (Fabaceae) are very similar in terms of taxonomy as well as in the biosynthesis of secondary metabolites. A recent study investigated the relationships of *Lonchocarpus* and allied genera based on nuclear and plastid DNA markers.[1] This genus is native to the southern portion of South America, including southern and southeastern Brazil. *Dahlstedtia glaziovii* (Taub.) M.J. Silva & A.M.G. Azevedo (previously *Lonchocarpus glaziovii* Taub.) is restricted to Rio de Janeiro state, municipalities of Nova Friburgo and Alto Macaé, where it is popularly known as "Guaraná-timbó".[1]

Dahlstedtia has been characterized by producing prenylated flavonoids, usually containing furan and dimethylpyran moieties.[2]

Flavonoids are one of the largest groups of secondary metabolites, with a wide range of biological activities including antioxidant,[3] photoprotective,[4,5] antimicrobial,[6] anti-inflammatory,[7] anticancer,[8,9] memory effects and reduction of cardiovascular diseases,[10] antifungal,[9,11] and antiviral,[9] among others.[12]

In this context and continuing our research on native Fabaceae species, we conducted a phytochemical investigation of the roots of *D. glaziovii*, which led to the isolation and structural determination of a new dibenzoylmethane (**1**), in addition to eighteen known flavonoids (**2**-**19**) (Figure 1). Antibacterial and anti-*Candida* activities were assessed for the crude extracts. The antiproliferative *in vitro* activity of the extracts and some flavonoids was evaluated.

Experimental

General experimental procedures

Fourier transform infrared (FTIR) spectrum was acquired using a BIORAD FTS-3500 FTIR spectrometer, in $CHCl_3$ and as KBr discs. The UV-Vis spectra were obtained in $CHCl_3$ on a UV-2401PC (Shimadzu) spectrophotometer

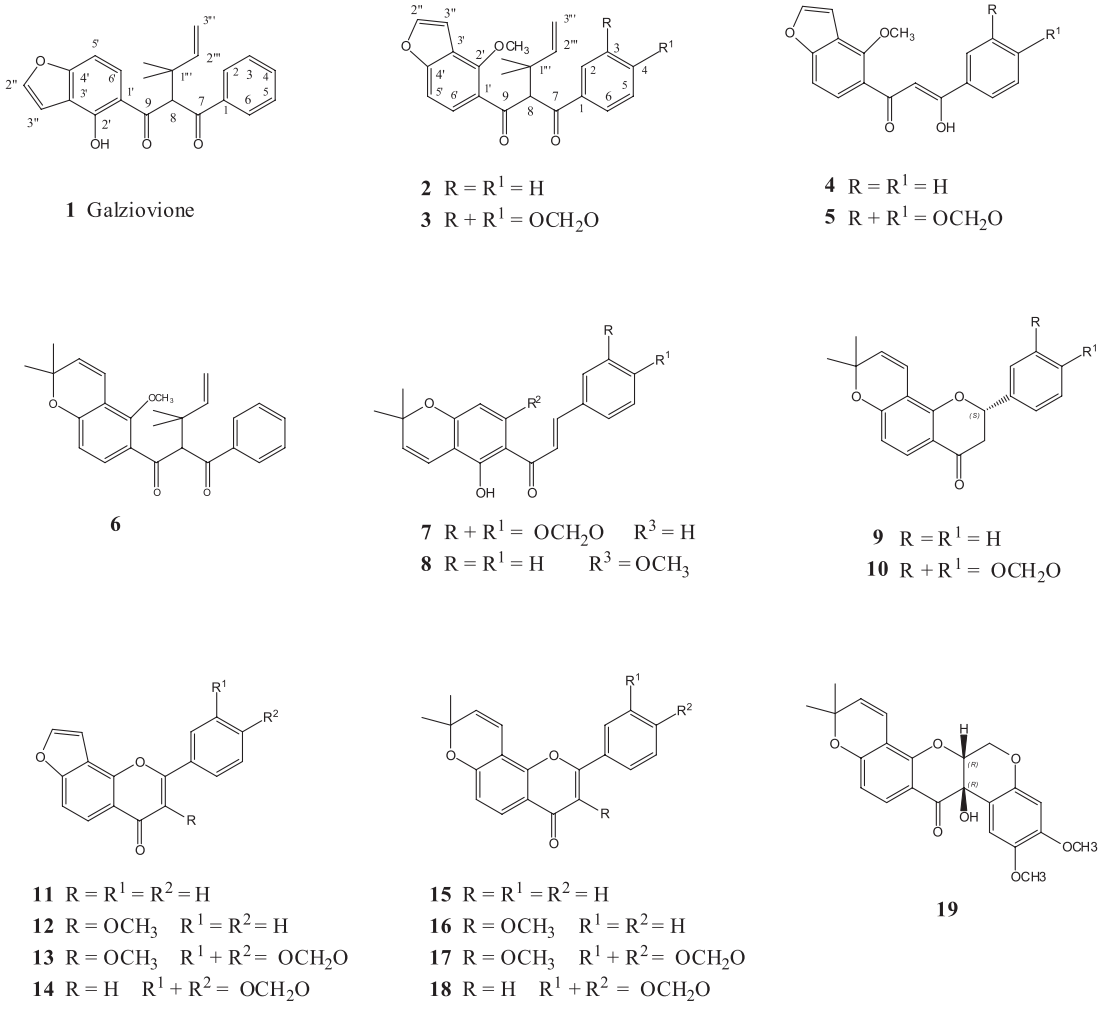

Figure 1. Prenylated flavonoids isolated from roots of *Dahlstedtia glaziovii*.

system. Optical rotations were measured in $CHCl_3$ solutions at room temperature on a Jasco polarimeter model P-2000. High-resolution mass spectra were run on a quadrupole LC-MS MicroQTOF II (Bruker) spectrometer equipped with an electrospray ionization source. Nuclear magnetic resonance (NMR) data were recorded at ambient temperature in $CDCl_3$ on a Bruker Avance 400, operating at 9.4 T, observing ^1H and ^{13}C at 400.1 and 100.6 MHz, respectively, and on a Bruker Avance III 600 MHz, operating at 14.1 T (^1H at 600 MHz; ^{13}C at 150 MHz) equipped with 5 mm cryo probe with automatic tuning matching (ATMA) and field gradient in z. The chemical shifts (δ) are given in ppm relative to tetramethylsilane (TMS, δ 0.00 ppm) as internal standard and coupling constants (*J*) in Hz. High-performance liquid chromatography (HPLC) analyses were performed on a Waters chromatograph consisting of quaternary pump, auto injector, 2998 PDA detector and coupled to an Empower software data acquisition system. The analyses were carried out using an analytic reversed phase column X-Terra C18, 5 µm, 250 × 4.6 mm and guard column at 20 ºC (Waters). The mobile phase consisted of an isocratic elution from acetonitrile:water (55:45, v/v), flow rate of 1 mL min^{-1}. The acetonitrile (ACN) was HPLC grade, filtered under vacuum through nylon membrane (0.45 µm) of Millipore® and degassed for 30 min in ultrasound bath. Ultrapure water was obtained by Milli-Q system. The samples were filtered through Millex® HV PVDF (0.45 µm) of Millipore® (Cork, Ireland). The separations of fractions by HPLC were carried out using a semi-preparative column X-Terra C18, 10 µm, 300 × 7.8 mm (Waters). For open column chromatography silica gel 60 (70-230 mesh) was used whereas in flash column chromatography silica gel (230-400 mesh, Merck) was used. Radial chromatography was performed on Chromatotron 7924T (Harrison Research Chromatotron, San Bruno, California, USA) using silica gel (60 GF_{254} Merck, 1 mm). Aluminum pre-coated silica-gel plates (60 F_{254} Merck, 0.25 mm) were used for thin layer chromatography (TLC) analyses and glass pre-coated silica-gel plates (60 PF_{254} Merck, 1 mm) were used for preparative TLC. The spots were detected by spraying with *p*-anisaldehyde reagent, followed by heating.

Plant material

The roots of *Dahlstedtia glaziovii* were collected in August 2009, in Nova Friburgo (Rio de Janeiro state, Brazil) at 22º20'2.2" S, 42º41'42.3" W and 1.221 m high, and identified by the taxonomists Prof Ana Maria Tozzi from Unicamp and Prof Marcos Silva from UFG. A voucher specimen (Marcos J. Silva 1077) was deposited at the Herbarium UEC, Institute of Biology, Unicamp.

Extraction and isolation

Dried root bark (315 g) of *D. glaziovii* was powdered and successively extracted at room temperature with petroleum ether (PE), dichloromethane (CH_2Cl_2) and methanol (MeOH). The solvents were removed under reduced pressure to afford the PE (1.1 g), CH_2Cl_2 (2.3 g) and MeOH (21.5 g) extracts. The dichloromethane extract (2.3 g) was subjected to silica gel flash column chromatography (diameter 3.5 cm), with gradient elution of PE/CH_2Cl_2 from 100:0 to 25:75, CH_2Cl_2/EtOAc from 100:0 to 25:75 and EtOAc/MeOH from 100:0 to 0:100, affording a total of 41 fractions (F1-F41) of 150 mL each. Fraction 16 (349 mg) was purified by radial chromatography with gradient elution of PE/CH_2Cl_2 from 70:30 to 0:100 yielding **12** (42 mg). Fraction 17 (500 mg) was subjected to a silica gel column chromatography eluted with PE/CH_2Cl_2 from 30:70 to 10:90, CH_2Cl_2/EtOAc from 100:0 to 20:80, EtOAc/MeOH from 100:0 to 50:50 and MeOH affording 31 fractions (F17-1 to F17-31) of 50 mL each. Fraction F17-6 (74 mg) was purified by preparative TLC, eluted with PE/acetone (75:25) (four times) yielding **13** (2.7 mg), **12** (3.0 mg) and **16** (1.0 mg). Fraction F17-9 (60 mg) was subjected to HPLC (H_2O/ACN (45:55), flow rate 1 mL min^{-1}) to give **19** (2.1 mg), **11** (2.5 mg), **13** (1.6 mg), **15** (3.0 mg) and **17** (2.1 mg). Fraction F17-14 was subjected to preparative TLC eluted with PE/acetone (80:20) (four times) yielding a mixture of **18** and **14** (8.2 mg). Fraction 14 (60.0 mg) was subjected to preparative TLC eluted with PE/EtOAc (80:20) yielding **2** (32.9 mg), **3** (12.5 mg), **5** (1.0 mg), **10** (2.6 mg) and **6** (2.9 mg). Fraction 12 (30.0 mg) was purified by preparative TLC eluted with PE/ethyl ether (7:3) (four times) yielding 6 fractions (F12-1 to F12-6). Fractions F12-2 (9.8 mg) and F12-4 (6.6 mg) were subjected to preparative TLC eluted with PE/ethyl ether (8:2) (twice) yielding **2** (2.2 mg) and **9** (1.7 mg), respectively. Fraction 8 (12.3 mg) was purified by preparative TLC with PE/ethyl ether (9.8:0.2) (three times) yielding **7** (1.4 mg), **4** (3.7 mg) and **1** (1.4 mg). Fraction 6 (5.8 mg) was subjected to preparative TLC with PE/ethyl ether (9:1) (twice) yielding **8** (2.1 mg).

Glaziovione (**1**): yellow oil; $[\alpha]_D^{20}$ –2.31 (*c* 0.0014, $CHCl_3$); λ_{max}/nm 249, 281, 336; IR (film) ν_{max}/cm^{-1} 3450, 2921, 2850, 1640, 1637, 1580, 1292; ^1H NMR ($CDCl_3$, 400.1 MHz) and ^{13}C NMR ($CDCl_3$, 100.6 MHz) data see Table 1; HRMS (pESI) calcd. for $C_{22}H_{20}O_4$ $[M+Na]^+$: 371.1255; found: 371.1255.

In vitro antimicrobial activity

The antimicrobial activity of the crude extracts was tested against eight microorganisms (*Escherichia coli*

ATCC 11775, *Pseudomonas aeruginosa* ATCC 13388, *Salmonella choleraesuis* ATCC 10708, *Staphylococcus aureus* ATCC 6538, *Streptococcus pneumonia* ATCC 11733, *Candida albicans* ATCC 10231, *Candida dubliniensis* CBS 7987 and *Candida krusei* CBS 573).

The microorganisms were subcultured overnight at 36 °C using nutrient agar (Merck) for bacteria, and Sabouraud dextrose agar for *Candida* spp. Inocula for the assays were prepared by diluting a scraped cell mass in 0.85% NaCl solution, adjusted to McFarland scale 0.5 and confirmed by spectrophotometer reading at 625 nm (bacteria) or 530 nm (yeasts). Cell suspensions were finally diluted to 10^4 colony forming units (CFU) mL^{-1} or 10^3 for use in the activity assays, respectively for bacteria and yeasts. Minimal inhibitory concentration (MIC) tests were carried out according to the Clinical and Laboratory Standards Institute (CLSI),[13,14] using Müller-Hinton broth on a tissue-culture test plate (96 wells) or Roswell Park Memorial Institute (RPMI)-1640 broth. The stock solution of crude extracts were diluted and transferred into the first well, and serial dilutions were made so that concentrations in the range of 1.0-0.015 mg mL^{-1} were obtained. Chloramphenicol and nistatin (Merck) were used as the reference antibiotic control in the range of 0.25-0.002 mg mL^{-1}. The inoculum was added to every well, and the plates were incubated at 36 °C for 48 h. Each concentration was screened in triplicate. Antibacterial activity was detected by adding 20 μL of 0.5% triphenyltetrazolium chloride (TTC, Merck) aqueous solution. MIC was defined as the lowest concentration of the sample that inhibited visible growth, as indicated by TTC staining (dead cells are not stained by TTC). In the case of *Candida* spp, after the incubation period the RPMI-1640 medium color changed from pink (original color) to yellow. The change indicates an acidification of the medium by the microorganism growth.

In vitro antiproliferative activity assay

Human tumor cell lines U251 (glioma), MCF-7 (breast), 786-0 (renal), and HT-29 (colon) were kindly provided by the Frederick Cancer Research & Development Center, National Cancer Institute, Frederick, MA, USA. Human keratinocyte (HaCaT) cell line was donated by Dr Ricardo Della Coletta (Piracicaba Dental School, University of Campinas). Stock cultures were grown in medium containing 5 mL RPMI-1640 (GIBCOR BRL) supplemented with 5% fetal bovine serum. Penicillin/streptomycin (1000 μg mL^{-1}:1000 UI mL^{-1}, 1 mL L^{-1}) was added to experimental cultures. Cells in 96 well plates (100.0 μL cells $well^{-1}$) were exposed to sample concentrations in dimethylsulfoxide (DMSO)/RPMI (0.25, 2.5, 25 and 250 μg mL^{-1}) at 37 °C, 5% of CO_2 in air for 48 h. Final DMSO concentration did not affect cell viability. Afterwards, cells were fixed with 50% trichloroacetic acid and cell proliferation determined by spectrophotometric quantification (540 nm) of cellular protein content using sulforhodamine B assay, by measuring absorbance at the beginning of incubation (time zero, T0) and 48 hours post-incubation for compound-free (T1) and tested (T) cells.[15] Cell proliferation was determined according to the equation $100 \times [(T - T0) / T1 - T0]$, for $T0 < T \leq T1$, and $100 \times [(T - T0) / T0]$, for $T \leq T0$. Using the concentration-response curve for each cell line, the concentration that elicits 50% growth inhibition (GI_{50}) was determined through non-linear regression analysis (Table 2) using ORIGIN 8.0 (OriginLab Corporation) software.

Results and Discussion

The dichloromethane extract afforded nineteen flavonoids, including one new (**1**) and five known dibenzoylmethanes (**2**-**6**), two chalcones (**7** and **8**), two flavanones (**9** and **10**), eight flavones (**11**-**18**) and one rotenoid (**19**) (Figure 1).

Glaziovione (**1**) was obtained as a yellow oil with the –2.31 (*c* 0.0014, $CHCl_3$). Its molecular formula $C_{22}H_{20}O_4$ was calculated by HRESIMS in positive mode, which revealed a peak at *m/z* 371.1255, relative to the pseudo-molecular ion $[M+Na]^+$. The ^1H NMR spectrum (Table 1) showed a singlet at δ 5.57 (*s*, 1H, H-8), which showed correlations with two carbonyl carbons at δ 193.9 (C-7) and δ 200.0 (C-9) in the heteronuclear multiple bond correlation (HMBC) spectrum, suggesting a dibenzoylmethane diketone skeleton.[16] Additionally, the ^1H NMR spectrum exhibited characteristic signals of a dimethylallyl group at δ 6.20 (dd, 1H, *J* 17.5, 10.7 Hz, H-2'''), 5.02 (dd, 1H, *J* 17.5, 0.9 Hz, H-3a''') and 4.98 (dd, 1H, *J* 10.7, 0.9 Hz, H-3b'''), as well as signals referring to methyl groups at δ 1.33 and 1.34 (s, 3H each). The location of the dimethylallyl group at C-8 (Figure 2) was determined from the HMBC spectrum. The presence of a monosubstituted aromatic ring was also corroborated by signals at δ 7.95 (m, 2H, H-2 and H-6), 7.42 (m, 2H, H-3 and H-5) and 7.53 (m, 1H, H-4). Two doublets were observed at δ 7.57 (d, 1H, *J* 2.2 Hz, H-2'') coupling with δ 6.99 (d, 1H, *J* 2.2, 0.9 Hz, H-3'') that were assigned to a furan ring; its angular position in the B ring was determined by the aromatic hydrogens at δ 7.07 (dd, 1H, *J* 9.0, 0.9 Hz, H-5') and δ 7.83 (d, 1H, *J* 9.0 Hz, H-6'), featuring *ortho* coupling between H-5' and H-6' (*J* 9.0 Hz), together with a long distance coupling (*J* 0.9 Hz) between H-5' and H-3'' from the furan ring.

Table 1. ^{1}H and ^{13}C NMR spectral data[a] for compounds **1** and **2**

Position	δ_C[b] 1	δ_H (J / Hz) 1	δ_H(J / Hz) 2
1	137.8	–	–
2,6	128.4	7.95 (m, 2H)	8.02 (m, 2H)
3,5	128.8	7.42 (m, 2H)	7,50 (m, 3H)
4	133.3	7.53 (m, 1H)	
7	193.9	–	–
8	62.0	5.57 (s, 1H)	5.74 (s, 1H)
9	200.0	–	–
1'	133.8	–	–
2'	160.0	–	–
3'	114.6	–	–
4'	159.9	–	–
5'	104.1	7.07 (dd, 1H, *J* 9.0 and 0.9 Hz)	7.18 (dd, 1H, *J* 8.6 and 0.8 Hz)
6'	126.7	7.83 (d, 1H, *J* 9.0 Hz)	7.44 (d, 1H, *J* 8.6 Hz)
2"	144.7	7.57 (d, 1H, *J* 2.2 Hz)	7.59 (d, 1H, *J* 2.3 Hz)
3"	105.2	6.99 (dd, 1H, *J* 2.2 and 0.9 Hz)	6.93 (dd, 1H, *J* 2.3 and 0.8 Hz)
1"'	41.6	–	–
2"'	145.7	6.20 (dd, 1H, *J* 17.5 and 10.7 Hz)	6.10 (dd, 1H, *J* 17.4 and 10.8 Hz)
3a"'	112.2	4.98 (dd, 1H, *J* 10.7 and 0.9 Hz)	4.90 (dd, 1H, *J* 17.4 and 1.0 Hz)
3b"'	112.2	5.02 (dd, 1H, *J* 17.5 and 0.9 Hz)	4.87 (dd, 1H, *J* 10.8 and 1.0 Hz)
CH_3	26.1	1.34 (s, 3H)	1.23 (s, 3H)
CH_3	26.3	1.33 (s, 3H)	1.21 (s, 3H)
OH	–	13.30 (s, 1H)	–
OCH_3	–	–	3.84 (s, 3H)

[a]The experiments were carried out at 400.1 MHz for ^{1}H of compounds **1** and **2**, and at 150 MHz for ^{13}C of compound **1** in $CDCl_3$ and TMS as the internal reference (δ 0.00 ppm); [b]assignments confirmed and complemented by HSQC and HMBC experiments (400.1 MHz).

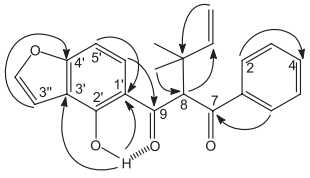

Figure 2. Relevant HMBC (H → C) correlations observed for glaziovione (**1**).

When comparing the ^{1}H NMR spectrum of **1** with that of 2'-methoxy-8-(α-α-dimethylallyl)-furano-[4",5":3',4']-dibenzoylmethane (**2**)[16] (Table 1), it was observed that **1** differed by the presence of a hydroxyl group characterized by the singlet at δ 13.30 (s, 1H, 2'-OH). This could be attributed to an internal hydrogen bond to a 4-oxo group, correlating to a carbonyl in C-9 (Table 1), in place of the methoxyl group observed for compound **2**.

The complete structure elucidation and unambiguous ^{1}H and ^{13}C NMR chemical shift assignments were supported by the heteronuclear single quantum coherence (HSQC) and HMBC experiments (Table 1, Figure 2) and by comparison with the spectral data of **2**.[16] Therefore, **1** was determined as 2'-hydroxy-8-(α,α-dimethylallyl)-furano-[4",5":3',4']-dibenzoylmethane and named glaziovione.

Compounds **2**-**19** (Figure 1) were identified by comparison of their spectral data with those described in the literature, as 2'-methoxy-8-(α-α-dimethylallyl)-furano-[4",5":3',4']-dibenzoylmethane (**2**),[16] 3,4-methylenedioxy-2'-methoxy-8-(α-α-dimethylallyl)-furano-[4",5":3',4']-dibenzoylmethane (**3**),[16] pongamol (**4**),[17] ovalitenone (**5**),[17] 2'-methoxy-8-(α,α-dimethylallyl)-2",2"-dimethylpyrano-(5",6":3',4')-dibenzoylmethane (**6**),[18] glabrachromene-II (**7**),[19] pongachalcone (**8**),[20] (–)-isolonchocarpin (**9**),[21] ovalichromene B (**10**),[22] lanceolatin B (**11**),[23] karanjin (**12**),[23] pongapin (**13**),[24] pongaglabrone (**14**),[25] 2",2"-dimethylpyrano-[5",6":8,7]-flavone (**15**),[2] karanjachromene (**16**),[2] pongachromene (**17**),[26] 3',4'-methylenedioxy-2",2"'-dimethylpyrano-[5",6":8,7]-flavone (**18**),[2] and tephrosin (**19**).[27]

The crude extracts were evaluated for antibacterial and anti-*Candida* activity. None of the extracts showed significant activity against any of the microorganisms tested.

Table 2. Antiproliferative activity for extracts and prenylated flavonoids from *D. glaziovii* roots

	GI_{50} / (μg mL^{-1})					
Extract	U251	MCF-7	786-0	HT29	Mean GI_{50}[a]	HaCat
PE	6.5	1.1	2.6	10.2	5.1	0.89
CH_2Cl_2	4.1	0.74	2.6	21.3	7.1	0.85
MeOH	104.0	34.0	55.8	35.9	57.4	27.4
Flavonoid	GI_{50} / (μmol L^{-1})					
2	29.3	19.6	21.3	30.9	25.1	14.6
3	13.5	18.7	30.0	66.0	32.0	21.9
4	11.9	34.3	33.3	55.8	33.7	11.6
11	76.7	105.7	151.9	248.8	145.8	93.9
12	> 856.2	> 856.2	856.2	> 856.2	> 856.2	> 856.2
13	139.6	89.9	229.7	> 401.8	> 215.2	148.5
18	56.6	134.5	171.8	160.0	130.7	111.5
Doxorubicin[b]	0.046	0.079	0.101	1.104	0.331	0.077

[a]Mean GI: arithmetic media of GI values; [b]reference drug (positive control). GI_{50}: concentration that elicits 50% growth inhibition. Extracts: PE (petroleum ether), CH_2Cl_2 (dichloromethane) and MeOH (methanol). Human tumoral cell lines: U251 (glioma CNS), MCF-7 (breast), 786-0 (renal), HT-29 (colon). Human non-tumoral cell line: HaCat (keratinocyte).

In vitro antiproliferative activity was evaluated for the three extracts, dibenzoylmethanes **2-4,** and flavones **11-13** and **18** (Table 2).

Considering the mean value of GI_{50}, the PE and CH_2Cl_2 extracts showed better antiproliferative activity, with mean GI_{50} of 5.1 and 7.1 μg mL^{-1}, respectively. The MeOH extract showed weak activity, with a mean GI_{50} of 57.4 μg mL^{-1}. Both PE and CH_2Cl_2 extracts showed a similar activity against the cell lines U251 (glioma), MCF7 (breast) and 786-0 (renal); the PE extract inhibited the HT29 (colon) cell line more strongly than the CH_2Cl_2 extract. Although they showed similar results for antiproliferative activity, the CH_2Cl_2 extract was obtained in a larger amount than the PE extract. Therefore, the CH_2Cl_2 extract was fractionated and some of the isolated flavonoids (**2-4**, **11-13** and **18**) were isolated in sufficient quantity to assay against tumor cell lines.

Considering all the flavonoids assayed and their mean GI_{50}, the members of the dibenzoylmethane series were more active than the flavones. Dibenzoylmethanes **2-4** exhibited the best antiproliferative activity, with mean GI_{50} of 25.1, 32.0 and 33.7 μmol L^{-1}, respectively. Flavones **11** and **18** showed similar activity (mean GI_{50} = 145.8 and 130.7 μmol L^{-1}, respectively). Flavone **13** was the least active of the series, with mean GI_{50} > 215.2 μmol L^{-1}. Flavone **12** showed no activity (mean GI_{50} > 856.2 μmol L^{-1}).

These results suggest that the cyclization to form the C ring decreased the antiproliferative activity, since the flavonoids with an open chain (the central part of the molecule) were more active (dibenzoylmethanes **2-4**) than those with a C ring (flavones **11-13** and **18**).

Comparison of dibenzoylmethanes **2** and **3** indicated that the presence of the methylenedioxy group in **3** decreased the mean GI_{50} activity (25.1 and 32.0 μmol L^{-1}, respectively). Comparing compounds **2** and **4**, the structural difference is the presence of the α,α-dimethylallyl group at C-8 in **2**, which leads to an increase of the mean GI_{50} activity (25.1 and 33.7 μmol L^{-1}, respectively).

Evaluating the antiproliferative activity on the non-tumor cell line HaCat (keratinocyte), the extracts and the prenylated flavonoids affected the proliferation of these cells within the same order of magnitude as their effect on tumor cells. The same trend was observed for the chemotherapeutic agent doxorubicin, while the prenylated flavonoids assayed showed less toxicity than doxorubicin. Thus, *in vivo* investigation is needed to determine the safety of using these flavonoids as potential chemotherapeutic agents.

Conclusions

The isolation of the prenylated flavonoids (**1-19**) from *D. glaziovii* roots concurs with the reclassification suggested by da Silva *et al.*.[1] Flavonoids with prenyl cyclized groups such as a furan ring and 2",2"-dimethylpyran, which have been used as indicators of the evolution of the genus *Dahlstedtia,* are found at the angular position in the main skeleton.[2]

Many compounds isolated from *D. glaziovii* have been found in other species, including *D. pinnata*[2] (Benth.) Malme and *D. penthaphylla*[2] (Taub.) Burkart. This indicates the chemical similarity between the species, in concordance with the morphological affinity cited by da Silva *et al.*.[1] In addition, other species reclassified as *Dahlstedtia*,[1] previously studied, have some chemical similarity to *D. glaziovii*, including *D. floribunda* (Vogel) M.L. Silva & A.M.G. Azevedo (*Lonchocarpus subglaucescens* Benth)[28]

and *D. muelbergiana* (Hassl.) M.J. Silva & A.M.G. Azevedo (*L. muehbergianus* Hassl.).[29]

Dibenzoylmethane **1** is a new metabolite, and flavonoids **6**, **7**, **13** and **19** are reported for the first time in the genus *Dahlstedtia*. This is the second report of dibenzoylmethane **6**, which was isolated for the first time in *Muellera montana* M.J. Silva & A.M.G. Azevedo (*Lonchocarpus montanus*).[20]

The antiproliferative assays showed that the members of the dibenzoylmethane series were more active than the flavones, and also showed that these flavonoids have promising activity.

Supplementary Information

Supplementary information (Figures S1-S26) is available free of charge at http://jbcs.sbq.org.br as a PDF file.

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