Pergamon

PII: S0031-9422(96)00526-2

Phytochemistry, Vol. 43, No. 6, pp. 1265–1269, 1996

0031-9422/96 $15.00 + 0.00

FIVE FLAVANS FROM *MARISCUS PSILOSTACHYS*

ELIANE GARO, MARC MAILLARD, SÁNDOR ANTUS,* STEVEN MAVI† and KURT HOSTETTMANN*‡

Institut de Pharmacognosie et Phytochimie, Université de Lausanne, BEP, CH-1015 Lausanne, Switzerland; *Lehrstuhl für Organische Chemie der Lajos Kossuth Universität, Postfach 20, H-4010 Debrecen, Hungary; †National Herbarium and Botanic Garden, P.O. Box 8100, Causeway, Harare, Zimbabwe

(*Received* 8 *May* 1996)

Key Word Index—*Mariscus psilostachys*; Cyperaceae; flavans; flavanones; fungicidal activity.

Abstract—Phytochemical investigation of two batches of *Mariscus psilostachys* led to the isolation and characterization of five flavans and three flavanones. Two flavans are new natural products and their structures have been established as (2*S*)-4′-hydroxy-5,7,3′-trimethoxyflavan and (±)-5,4′-dihydroxy-7-3′-dimethoxyflavan. Absolute configuration of the optically active compound isolated has been determined on the basis of its CD spectrum. Antimicrobial activity against *Candida albicans* and *Cladosporium cucumerinum* were determined for all compounds. The less polar flavans showed to be more active in both TLC assays and dilution assays. Copyright © 1996 Elsevier Science Ltd

INTRODUCTION

In the course of our systematic studies on Zimbabwean plants used in traditional medicine, we investigated the monocotyledon *Mariscus psilostachys* C. B. Clarke. This small herb belongs to the Cyperaceae and is distributed throughout tropical Africa [1]. Although no uses for *M. psilostachys* are directly reported in the traditional pharmacopoea of Zimbabwe, it is well known that other species of the same genus are commonly used by West African healers to treat different affections (gonorrhoea, infected wounds, etc.) [2].

Two specimens of *M. psilostachys* were collected in the Harare area on different dates (November 1994 and June 1995). The whole plants were dried and successively extracted with dichloromethane and methanol at room temperature. The dichloromethane extracts displayed activity in bioautographic TLC assays against the yeast *Candida albicans* [3] and the plant pathogenic fungus *Cladosporium cucumerinum* [4]. According to HPLC-UV analysis of the crude extracts, the amount of the secondary metabolites in the two batches was different. We report here on the isolation, structure elucidation and antifungal activity of some of these constituents.

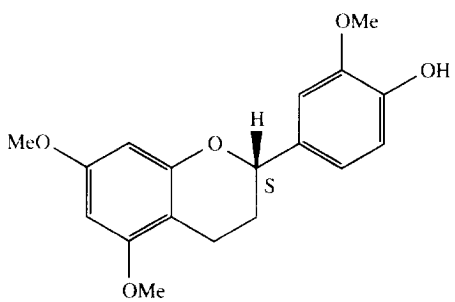
RESULTS AND DISCUSSION

The fractionation of the first dichloromethane extract (4.4 g) on silica gel, followed by gel filtration on Sephadex LH-20 ($CHCl_3$–MeOH) and Lobar on RP-18 column afforded compounds **1**–**3**. Spectrometric measurements including ^{1}H NMR, ^{13}C NMR, together with DEPT subspectra, suggested the presence of a flavan skeleton for all these three compounds. Indeed, in their ^{1}H NMR spectra, two multiplets (in the range δ 1.88–2.44 and δ 2.51–2.66) attributable to two pairs of aliphatic protons and signals characteristic for aromatic protons of rings A and B (in the range δ 5.95–6.14 and δ 6.81–6.99, respectively) were in good agreement with data reported for this type of compounds [5]. In addition, ^{1}H NMR spectrum recorded for **1** displayed resonances of three aromatic methoxyl (δ 3.75, 3.80 and 3.90) and one hydroxyl (δ 5.62) moieties. The EI-mass spectrum exhibited a $[M]^+$ ion peak at *m/z* 316 and a typical RDA-fragment ion at *m/z* 150 ($[B_1]^+$) indicating the presence of one methoxyl unit together with one hydroxyl group in ring B. Thus, ring A bears the two other methoxyl substituents and their exact positions were determined on the basis of NMR considerations. Indeed, two doublets (δ 6.08 and 6.13) associated to two *meta*-coupled protons (J = 2Hz) were observed in the ^{1}H NMR spectrum, while resonances of the oxygenated carbons at δ 156.3, 158.5 and 159.3 (C-5, C-7, C-9) confirmed that their relative positions were in *meta* [5]. Thus, ring A was 5,7-dimethoxysubstituted. The substitution pattern of ring B was less easy to determine. Acetyation of **1** in standard conditions clarified the ^{1}H NMR spectrum in the range of the aromatic protons and an ABX system was visible with three signals attributable to one *meta*-coupling proton (δ 7.05, *d*, J = 1.7 Hz, H-2′), one *ortho*-coupling (δ 7.04, *d*, J = 8.2 Hz, H-5′) and one *ortho-meta*-coupling (δ 6.98, *dd*, J = 1.7 and 8.2 Hz, H-6′). In addi-

‡Author to whom correspondence should be addressed.

tion, the chemical shifts of the oxygenated carbons observed in the ^{13}C NMR spectrum at δ 145.3 and δ 146.5 confirm their *ortho*-position. Thus, the 3′-4′-disubstitution was clearly established. At last, the positions of the hydroxyl on C-4′ and the methoxyl on C-3′ in **1** were established with a series of NOE difference experiments on the acetylated product **1a**. Presaturation of the methoxy resonance at δ 3.85 gave solely enhancement of the signals attributable to the *meta*-coupled proton (δ 7.05, H-2′) and proved the C-3′ position of the methoxyl substituent on ring B. As **1** showed a weak negative optical rotation [$\alpha_D = -4.15$], the absolute configuration at carbon C-2 has been determined by CD experiments.

Compound **1** possesses two chiral perturbed benzene chromophore systems, which contribute to the Cotton effect within any absorption band, but these contributions are not simply additive. Since the chiral sphere which is nearest to the chromophore determines in most cases the sign, and to a great extent, even the magnitude of the rotational strength [6], the chromane moiety of **1** containing a chiral second sphere determines therefore its chiroptical properties. Recently, we have found [7] that an opposite helicity rule is valid for the ^1L_b band of the chromane chromophore as compared to the homochirally analogous tetralins [8, 9]. Namely, the P/M helicity of the hetero-ring led to a negative/positive CD within the ^1L_b band. Two Cotton effects have been observed for **1** in acetonitrile, of which the band with a negative sign at the longest wavelength (282 nm) has been unequivocally assigned to the ^1L_b transition of the tetrasubstituted benzene chromophore in full agreement with predictions [10]. Taking into considerations the negative sign of the ^1L_b band, a P-conformation of the hetero-ring of **1** could be deduced on the basis of our helicity rule [7], if the direction of its spectroscopic moment ($\vec{q}$) [10] is approximately identical with that of (*S*)-(−)-flavan [7]. Since the electric transition-moment vector for these compounds lies in the same sector of the polarization diagrams in both cases, our helicity rule used for (*S*)-(−)-unsubstituted flavan must be valid for **1** as well. According to the P helicity of the hetero-ring of **1**, deduced from the negative sign of the ^1L_b band, **1** was identified as (2*S*)-4′-hydroxy-5,7,3′-trimethoxyflavan, a new natural product.



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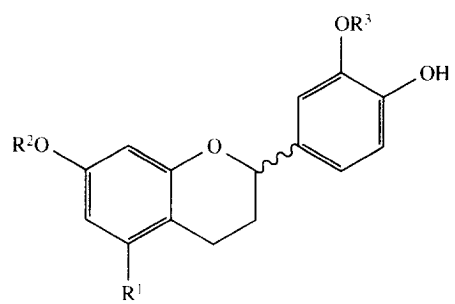


	R^1	R^2	R^3
2	OH	Me	Me
3	OMe	Me	H
4	H	Me	Me
5	H	H	Me

The EI-mass spectra of flavans **2** and **3** exhibited ion peaks $[M]^+$ at *m/z* 302. Thus, these two flavans bear two methoxyl and two hydroxyl substituents. EI-mass spectrum of **2** presented two principal ion fragments at *m/z* 150 and *m/z* 152, resulting from typical RDA cleavage [5]. On the basis of these data, we concluded that the former fragment ion corresponds to the B-ring with one methoxyl and one hydroxyl substituent, and the latter to the A-ring with also one methoxyl and one hydroxyl group. The NMR spectra of **2** were measured in CD_3OD, since the shifts of the aromatic protons were enough distinct in this solvent to show the presence of a 5,7,3′-4′-tetrasubstitution. The exact positions of the two methoxyl groups were established by a series of NOE difference experiments. Presaturation of the methoxy resonance at δ 3.68 gave enhancement of both signals at δ 5.98 (*d*, $J = 2.5$ Hz) and δ 5.95 (*d*, $J = 2.5$ Hz) attributable to the two *meta*-coupled protons of the A-ring (H-6, H-8). Consequently, the methoxyl unit was between these two protons and placed at C-7 position. Enhancement of H-2′ (δ 6.99, *d*, $J = 1.5$ Hz) was solely observed upon irradiation of the signal at δ 3.86 showing the C-3′ position of the methoxyl group. Thus, the structure of **2** was established as 5,4′-dihydroxy-7,3′-dimethoxyflavan, a new natural product. In a similar manner, the structure of **3** was established as 3′,4′-dihydroxy-5,7-dimethoxyflavan. This compound has previously been isolated from *Iryanthera coriaceae*, a Myristicaceae which grows in the Amazonian forest [11]. Compounds **2** and **3** were isolated as racemic mixtures.

Antifungal activity-guided fractionation of the methanolic extract yielded **6**. Its ^1H NMR spectrum showed signals characteristic for a flavanone. Observation of its ^{13}C NMR spectrum, together with UV spectroscopy with the use of shift reagents, allowed **6** to be identified as 5,7,3′-4′-tetrahydroxyflavanone, or eriodictyol, a widely distributed compound. Comparison of the NMR data recorded with those listed in reference [12] confirmed this conclusion.

The dichloromethane extract of the second batch

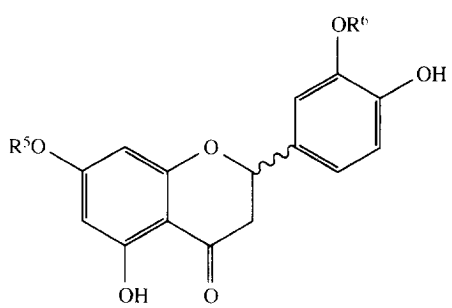
(collection June 1995) (20.8 g) was subjected to MPLC on silica gel, gel filtration on Sephadex LH-20 and to CC on silica gel to afford **4**, **5**, **7** and **8**. Pure **1** and **2** were also obtained from this second batch while **3** and **6** were in too small quantities to be isolated. The EI-mass spectrum of **4** exhibited an ion peak $[M]^+$ at *m/z* 286 together with typical fragmentation of a flavan [5] bearing one methoxyl and one hydroxyl substituent on ring B and only one methoxyl group on ring A. ^1H and ^{13}C NMR spectral data confirmed these conclusions. NOE difference experiments were used to determine ring B to be 4′-hydroxy-3′-methoxy substituted, but these kinds of experiments were insufficient to ascertain the exact position of the methoxyl group in ring A and an extensive 2D-NMR experiment (FLOCK) [6] had to be employed to reach this objective. In the ^1H NMR spectrum, an ABX system in ring A was visible with three signals attributable to one *ortho*-coupling (δ 6.96, J = 8.4 Hz), one *meta*-coupling (δ 6.37, J = 2.5 Hz), and one *ortho-meta*-coupling proton (δ 6.44, J = 2.5 and 8.4 Hz). Long range correlations between the *ortho*-coupled proton and a methylene carbon at δ 24.9 and also with an oxygenated carbon at δ 159.8 were visible. Since the same oxygenated carbon gave long-range coupling with H_3C-O- (δ 3.75), the position of the methoxy was confirmed to be at C-7. Thus, the structure of **4** was 7,3′-dimethoxy-4′-hydroxyflavan. This metabolite has been already isolated from *Virola calophylloidea*, a Colombian Myristicaceae [13], and from Panaman legume *Bauhinia manca* [14].

EI-mass spectrum, NMR data and NOE experiments showed **5** to be 7,4′-dihydroxy-3′-methoxyflavan, a compound previously isolated from *Bauhinia manca* (Leguminosae) [14] and from *Iryanthera elliptica* (Myristicaceae) [15]. Finally, the structure of the two flavanones **7** and **8** were established on the basis of NMR data, NOE difference experiments together with the use of shift reagents in UV spectroscopy. Thus, **7** and **8** were identified as the known compounds 5,4′-dihydroxy-7,3′-dimethoxyflavanone and 3′-methoxy-5,7,4′-trihydroxyflavanone, also known as homoeriodictyol [12].

Antifungal **1**–**4** showed activity against *Candida albicans* in the bioautographic bioassay. The minimum quantities spotted on TLC plates required to inhibit the growth of *Candida albicans* were 1 μg for compound **1**, and 5 μg for **2**, **3** and **4** [3]. Compounds **5**–**8** were inactive at the limit amount of 10 μg spotted on the plate. The growth of the phytopathogenic fungus *Cladosporium cucumerinum* [4] was inhibited by 5 μg of **1**, **2**, **3**, **5**, **7**, **8**, and flavan **4** was shown to be the most active product in the TLC bioassay with clear inhibition zones visible till 1 μg. Flavanone **6** was devoid of any antifungal activity against this fungus. Miconazole, used as positive control, was active against the two microorganisms, respectively, at 0.001 and 10 μg.

The toxicity of the compounds against these microorganisms has also been determined in a dilution assay using solid media [16]. In comparison with a blank, compound **1** inhibited growth of the yeast *Candida albicans* within 50 μg ml^{-1}, while compounds **3** and **4** had a MIC of 100 μg ml^{-1}. The two more polar flavans **2** and **5** and the flavanones **6**–**8** were devoid of any antifungal activity. As noticed in the TLC bioassay, **4** was the most active against the phytopathogenic fungus *Cladosporium cucumerinum* with a MIC of 50 μg ml^{-1}. Compounds **1** and **3** showed a MIC of 100 μg ml^{-1}. No activity was effectively observed for **2** and **5**, nor for **6**–**8** in this assay. In the determination of MIC values, miconazole was used as positive control and inhibit the growth of the two microorganisms respectively within 0.1 μg ml^{-1} and 1 μg ml^{-1}.

The presence of simple flavans in *Mariscus psilostachys* species, belonging to Cyperaceae should be of a great interest from a chemotaxonomic point of view. Indeed, up to now, simple flavans have been restricted to only seven families (Ericaceae, Gentianaceae, Leguminosae, Liliaceae, Myristicaceae, Santalaceae and Amaryllidaceae) [5].



	R^5	R^6
6	H	H
7	Me	Me
8	H	Me

EXPERIMENTAL

General. Mp: Mettler-FP-80/82 hot stage apparatus, uncorr. α_D: Perkin-Elmer-241 polarimeter. CD curve was measured on a Jobin-Yvon-Isa Dichrograph-6 in acetonitrile. UV: Varian DMS 100 spectrophotometer and UV spectra recorded in MeOH, shift reagents according to ref. [17]. IR: Philips PU 9716. CPC: Pharma-Tech Research Corp. CCC-1000 instrument; the total volume of the three coils was 660 ml, the rotation speed 1000 r.p.m., flow-rate 3 ml min^{-1}, detection was done at 254 nm, and the solvent system employed was $CHCl_3$–MeOH–H_2O (5:6:4), the lower phase used as mobile phase. TLC: Silica gel $60F_{254}$ Al sheets (Merck), detection with Godin reagent [18]. The solvent systems employed were petrol–EtOAc (1:1) (system A) and $CHCl_3$–MeOH (9:1) (system B). For open CC, silica gel 60 Merck (40–63 μm and 63–200 μm) was used. For MPLC, silica gel (63–200 μm)

and RP-18 (15–24 μm) were used. Analytical HPLC has been carried out on a HP-1090 instrument equipped with a photodiode array detector. Frs were analysed on Nova-pak C_{18} columns, (4 μm, 150 mm × 3.9 mm, i.d., Waters) with a gradient of CH_3CN 20%–70% in 20 min, at a flow rate of 1 ml min^{-1}. ^1H and ^{13}C NMR spectra were measured on a Varian VXR 200 at 200.06 MHz and 50.3 MHz, respectively; samples were dissolved in $CDCl_3$, CD_3OD, Acetone-d_6 or DMSO-d_6, and TMS was used as int. standard. Complete attribution has been performed on the basis of 2D-experiments (COSY, HETCOR, FLOCK). MS detection was achieved on a Finnigan-MAT-TSQ-700 triple stage quadrupole instrument: EI-MS (70 eV) and DCI-MS (NH_3, positive ion mode). Dilution assays were carried out in Malt agar for *Candida albicans*, and in LB (Luria–Bertani) for *Cladosporium cucumerinum*. The pure compounds were assayed at 1, 10, 50 and 100 μg ml^{-1}.

Plant material. Whole plants of *M. psilostachys* C. B. Clarke were collected in Christian Bank, Mazowe Road, near Harare (Zimbabwe) in November 1994 and June 1995. Voucher specimens have been deposited at the National Herbarium of Zimbabwe, Causeway, Harare.

Extraction and isolation. Dry plants were ground and extracted at room temp. successively with CH_2Cl_2 and MeOH (3 × 2.5 l each). The first CH_2Cl_2 extract (4.4 g) was factionated on Si 60 column into 13 frs (I–XIII) with a step-gradient elution (petrol-EtOAc, 8:1 → 1:2) and finally MeOH. Compound **1** (110 mg) was obtained from fr. VI by gel filtration on Sephadex LH-20 ($CHCl_3$–MeOH, 1:1). Further sepn of fr. VII on Sephadex LH-20 ($CHCl_3$–MeOH, 1:1) yielded 5 frs (A–E). From which, fr. E treated on Lobar RP-18 (MeOH–H_2O, 3:2) afforded **2** and **3**.

The CH_2Cl_2 extract (20.8 g) of the second batch was fractionated by MPLC on silica gel Si 60 into 10 frs (I–X) using gradient elution (petrol–EtOAc, 8:1 → 1:2, followed by MeOH). Fr. V was treated by gel filtration on Sephadex LH-20 ($CHCl_3$–MeOH; 1:1), by MPLC on RP-18 using MeOH (50 → 65%) as solvent, and afforded 3 frs (V.1–V.3); frs V.1 and V.2 consisted of pure **4** (150 mg) and **1** (140 mg). VII was separated on silica gel to afford 3 fractions (VII.1–VII.3). Compound **7** (19 mg) was obtained after purification of fr VII.2 by gel filtration on Sephadex LH-20. Gel filtration on Sephadex LH-20 ($CHCl_3$–MeOH, 1:1) of VIII yielded pure **2** (160 mg). IX was subjected to CC on silica gel using petrol–EtOAc (2:1) as eluent, 3 frs were collected, Compound **5** (10 mg) was isolated from fr. IX.2 and purified on silica gel CC with $CHCl_3$–MeOH (49:1). Finally, fr. X was fractionated by MPLC on RP-18 into 6 frs using MeOH 55% as solvent. Compound **8** was isolated from fr. X.2 after gel filtration on Sephadex LH-20 ($CHCl_3$–MeOH; 1:1).

The MeOH extract (7.0 g) was fractionated by CPC and afforded 4 frs. The second fraction was treated by gel filtration on Sephadex LH-20 (MeOH), Lobar RP-18 using MeOH 45% as solvent and afforded pure compound **6**.

(2S)-4′-*Hydroxy*-5,7,3′-*trimethoxyflavan* (**1**). Brownish solid, mp 71–73°. TLC (system A) R_f 0.50; (system B) R_f 0.67. UV λ_{max}^{MeOH} nm (log ε): 205 (5.12), 278 (3.93). $[\alpha]_D^{23} = -4.15$ ($CHCl_3$; *c* 0.25). EIMS *m/z* (rel. int.): 316 [M^+] (5), 191 (16), 150 [B_1]$^+$ (100), 135 (82), 107 (25). ^1H NMR ($CDCl_3$): δ 6.94 (1H, *dd*, J = 1.2 Hz, 8.0 Hz, H-6′), 6.93 (1H, *d*, J = 8.0 Hz, H-5′). 6.91 (1H, *d*, J = 1.2 Hz, H-2′), 6.13 (H, *d*, J = 2.4 Hz, H-8), 6.08 (H, *d*, J = 2.5 Hz, H-6), 5.67 (1H, *br s*, OH-4′), 4.88 (1H, *dd*, J = 2.4, 10.5 Hz, H-2), 3.90 (3H, *s*, MeO-3′), 3.80 (3H, *s*, MeO-5), 3.75 (3H, *s*, MeO-7), 2.65 (2H, *m*, H-4), 2.10 (2H, *m*, H-3). ^{13}C NMR ($CDCl_3$): δ 159.3, 158.5 (C-5 and C-7), 156.3 (C-9), 146.5 (C-3′), 145.3 (C-4′), 133.6 (C-1′), 119.3 (C-6′), 114.2 (C-5′), 108.7 (C-2), 103.3 (C-10), 93.3 (C-8), 91.3 (C-6), 77.9 (C-2), 55.9, 55.4, 55.3 (3 × MeO), 29.5 (C-3), 19.5 (C-4). CD data: $\Delta\varepsilon_{282}$ −0.79 (MeCN; *c* 0.022).

Acetylation of compound **1**. 10 mg of **1** were treated with pyridine: Ac_2O (1:1) at room temp. The solution was stirred during 24 hrs and extracted with EtOAc. The residue was purified on Sephadex affording the acetylated compound (6 mg). ^1H NMR ($CDCl_3$): δ 7.05 (1H, *d*, J = 1.7 Hz, H-2′), 7.04 (1H, *d*, J = 8.2 Hz, H-5′), 6.98 (1H, *dd*, J = 1.7, 8.2 Hz, H-6′), 6.14 (1H, *d*, H-8), 6.09 (1H, *d*, H-6), 4.95 (1H, *dd*, J = 2.3, 10.3 Hz, H-2), 3.85 (3H, *s*, MeO-3′), 3.80 (3H, *s*, MeO-5), 3.76 (3H, *s*, MeO-7), 2.66 (2H, *m*, H-4), 2.32 (3H, *s*, AcO-4′), 2.10 (2H, *m*, H-3).

(±) - 5,4′ - *Dihydroxy* - 7,3′ - *dimethoxyflavan* (**2**). Brownish powder, mp 158–159°. TLC (system A) R_f 0.42; (system B) R_f 0.60. UV λ_{max}^{MeOH} nm (log ε): 278 (3.65), 204 (4.83). EIMS *m/z* (rel. int.): 302 [M^+] (63), 272 (15), 166 (20), 152 [A_1]$^+$ (93), 150 [B_1]$^+$ (100), 135 (27). ^1H NMR (CD_3OD): δ 6.99 (1H, *d*, J = 1.5 Hz, H-2′), 6.85 (1H, *dd*, J = 1.4, 8.6 Hz, H-6′). 6.78 (1H, *d*, J = 8.0 Hz, H-5′), 5.98 (H, *d*, J = 2.5 Hz, H-8), 5.95 (H, *d*, J = 2.5 Hz, H-6), 4.89 (1H, *dd*, J = 2.4, 7.3 Hz, H-2), 3.86 (3H, *s*, MeO-3′), 3.68 (3H, *s*, MeO-7), 2.65 (2H, *m*, H-4), 2.04 (2H, *m*, H-3). ^{13}C NMR (CD_3OD): δ 160.5, (C-7), 157.9, 157.3 (C-5 and C-9), 148.9 (C-3′), 147.2 (C-4′), 134.8 (C-1′), 119.9 (C-6′), 115.9 (C-5′), 110.8 (C-2′), 103.5 (C-10), 95.0, 94.1 (C-6 and C-8), 79.0 (C-2), 56.3, 55.5 (2 × MeO), 30.9 (C-3), 20.4 (C-4).

(±)-3′,4′-*Dihydroxy*-5,7-*dimethoxyflavan* (**3**). Reddish powder. TLC: (system A) R_f 0.41, (system B) R_f 0.55. UV and EIMS as in ref. [11]. ^1H NMR (CD_3OD): δ 6.84 (1H, *d*, J = 1.7 Hz, H-2′), 6.76 (1H, *d*, J = 8.0 Hz, H-5′), 6.70 (1H, *dd*, J = 1.7, 8.3 Hz, H-6′), 6.08 (H, *d*, J = 2.2 Hz, H-8), 6.03 (H, *d*, J = 2.2 Hz, H-6), 4.79 (H, *dd*, J = 2.5, 10.5 Hz, H-2), 3.76, 3.72 (2 × 3H, *s*, 2 × MeO), 2.61 (2H, *m*, H-4), 1.99 (2H, *m*, H-3). ^{13}C NMR ($CDCl_3$): δ 159.2, 158.5 (C-5 and C-7), 156.2 (C-9), 143.9, 143.7 (C-3′ and C-4′), 134.3 (C-1′), 118.9 (C-6′), 115.6 (C-5′), 113.8 (C-2′), 103.4 (C-10), 93.4 (C-8), 91.3 (C-6), 77.6 (C-2), 55.4, 55.3 (2 × MeO), 29.1 (C-3), 19.3 (C-4).

(±)-7,3′-*Dimethoxy*-4′-*hydroxyflavan* (**4**). Powder, mp 107–108°; TLC: (system A) R_f 0.51; (system B) R_f 0.67. ^1H NMR in acetone as in ref. [14]. ^1H NMR in

$CDCl_3$ as in ref. [13]. ^{13}C NMR in acetone as in ref. [14].

(±)-*7,4′-Dihydroxy-3′-methoxyflavan* (**5**). Amorphous powder; TLC: (system A) R_f 0.44; (system B) R_f 0.58. UV, EIMS and ^1H NMR as in ref. [14]. ^{13}C NMR (acetone-d_6): δ 157.2 (C-7), 156.6 (C9), 147.9 (C-3′), 146.8 (C-4′), 134.2 (C-1′), 130.5 (C-5), 119.5 (C-6′), 115.2 (C-5′), 113.5 (C-10), 110.4 (C-2′), 108.5 (C-6), 103.7 (C-8), 78.2 (C-2), 56.0 (MeO-3′), 30.7 (C-4), 24.9 (C-3).

(±)-*5,7,3′,4′-Tetrahydroxyflavanone* (**6**). Amorphous powder; TLC: (system A) R_f 0; (system B) R_f 0.19. ^1H NMR (DMSO): δ 6.80 (3H, *m*, H-2′, H-5′ and H-6′), 5.79 (2H, *s*, H-6 and H-8), 5.33 (1H, *dd*, J = 3.1, 12.4 Hz, H-2), 3.11 (1H, *dd*, J = 11.9, 16.8 Hz, H-3 *trans*), 2.64 (1H, *dd*, J = 2.9, 16.8 Hz, H-3 *cis*). ^{13}C NMR as in ref. [12].

(±)-5,4′-Dihydroxy-7,3′-dimethoxyflavanone (**7**). Amorphous powder; TLC: (system A) R_f 0.13; system B R_f 0.47. ^1H NMR and ^{13}C NMR as ref. [19].

(±)-*5,7,4′-Trihydroxy-3′-methoxyflavanone* (**8**). Amorphous powder; TLC: (system A) R_f 0.03; (system B) R_f 0.39. ^1H NMR (acetone-d_6): δ 12.2 (1H, *s*, H-5), 7.20 (1H, *d*, J = 2.0 Hz, H-2′), 7.02 (1H, *dd*, J = 2.0, 8.1 Hz, H-6′), 6.88 (1H, *d*, J = 8.0 Hz, H-5), 5.97 (2H, *s*, H-6 and H-8), 5.45 (1H, *dd*, J = 3.1, 13.0 Hz, H-2), 3.89 (3H, *s*, MeO-3′), 3.23 (1H, *dd*, J = 13.0, 17.3 Hz, H-3 *trans*), 2.73 (1H, *dd*, J = 3.1, 17.3 Hz, H-3 *cis*). ^{13}C NMR (acetone-d_6): δ 197.2 (C-4), 167.4, 165.2, 164.3 (C-5, C-7 and C-9), 148.4 (C-3′), 147.9 (C-4′), 131.2 (C-1′), 120.5 (C-6′), 115.6 (C-5′), 111.1 (C-2′), 103.1 (C-10), 96.8 (C-8), 95.8 (C-6), 80.2 (C-2), 56.2 (MeO-3′), 43.6 (C-3).

Acknowledgements—Financial support was provided by the Swiss National Science Foundation, the Herbette Foundation of the University of Lausanne, and Hungarian National Science Foundation (Grant Nr OTKAT 14349).

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