Phytochemistry, Vol. 22, No. 10, pp. 2281–2286, 1983.
Printed in Great Britain.

0031–9422/83 $3.00 + 0.00

TOCOTRIENOLS FROM *IRYANTHERA GRANDIS**

PAULO C. VIEIRA, OTTO R. GOTTLIEB† and HUGO E. GOTTLIEB‡

Departamento de Química, Universidade Federal de São Carlos, 13560 São Carlos, SP; †Instituto de Química, Universidade de São Paulo, 05508 São Paulo, SP, Brazil; ‡Isotope Department, The Weizmann Institute of Science, Rehovot, Israel

(*Received* 6 *January* 1983)

Key Word Index—*Iryanthera grandis*; Myristicaceae; tocotrienols; tetralin neolignan; dihydrochalcone.

Abstract—The fruits of *Iryanthera grandis* contain the four compounds related with the tocotrienol group: 2,8-dimethyl-2-(4,8,12-trimethyl-3,7,11-tridecatrienyl)-6-chromanol; 2,8-dimethyl-2-(4,8,12-trimethyl-3,7,11-tridecatrienyl-5-*O*-[2′,8′-dimethyl-2′-(4′,8′,12′-trimethyl-3′,7′,11′-tridecatrienyl)-6′-chromanyl])-6-chromanol; 2,8-dimethyl-2-(4,12-dimethyl-8-carboxyl-3,7,11-tridecatrienyl)-6-chromanol and 5-hydroxy-7-(3,7,11,15-tetramethyl-2,6,10,11-hexadecatetraenyl-2(3*H*)-benzofuranone; the neolignan (2*R*,3*R*,4*S*)-2,3-dimethyl-4-(4′-hydroxyphenyl)-6-hydroxytetralin; and the flavonoid 2′,4′-dihydroxy-4,6′-dimethoxydihydrochalcone.

INTRODUCTION

Iryanthera grandis Ducke, known as ucu-úba vermelha, occurs in the central region of the Amazon, in the Madeira and Tapajóz basins [2]. The epithet of the latin name refers to the size of the fruits, larger than usual for other Myristicaceae. The present paper discloses the presence in these fruits, besides triglycerides (**1**), of seven compounds, **2a**, **2d**, **3a** and **4a**, related with the tocotrienol group of compounds, **5a**, a neolignan, **6**, a dihydrochalcone, and **7**, grandinolide. The last named compound has been described in a previous paper [3]. An additional isolate **8**, ethyl oleate, should be an artifact produced during the fractionation of the extract.

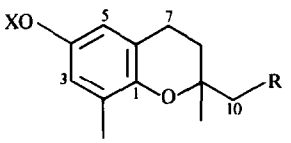
RESULTS

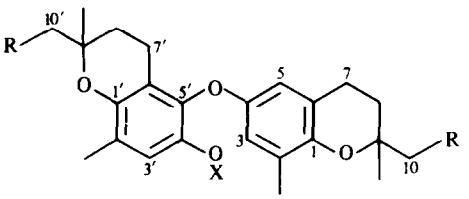
Compound **2a** was identified with δ-tocotrienol [4] by spectral means (Table 1), as well as transformation into the monoacetate (**2b**) and the hexahydro-derivative (**2c**, Tables 2 and 3). All ^{13}C NMR peaks (Table 3) were assignable either to the farnesyl moiety (R^1) (for data on model **9** see [5]) or to the benzopyran moiety (for data on model **2c** see [6]). The relative positions of the substituents on the aromatic ring were confirmed by ^{1}H NMR double resonance experiments and by a negative Gibbs test [7].

The mass spectrum of **2a** (M^+ 396, rel. int. 50%) showed peaks suggesting two series of fragments, one involving farnesyl (*m/z* 205, 6%), geranyl (*m/z* 137, 74%) and prenyl (*m/z* 69, 100%) cations, and the other involving **10** as parent cation. The structural proposal for **3a** (M^+ 790, rel. int. 90%) relied initially on the fact that this compound also generated the indicated series of fragments, together with additional ions of putative structures **11** (*m/z* 410, 5%) and **12** (*m/z* 191, 8%). Thus compound **3a** was an oxidative dimer of **2a**. Indeed the IR spectra of both substances were very similar, the hydroxyl band of **3a**, however, being less intense. As was to be expected, the latter compound also gave only a monoacetate (**3b**), besides a dodecahydro-derivative (**3c**, Table 2). The aromatic region of the ^{1}H NMR spectrum of **3a** (Table 1) showed a singlet (δ6.69) due to an isolated proton, besides two doublets (δ6.53 and 6.37, both J = 3.0 Hz) due to two *meta* related protons. The connection of the two units thus involved the oxygen of the hydroxyl of one monomer and an aromatic carbon of the other monomer. *A priori* both unsubstituted aromatic carbons of **2a** may function as bridgeheads in **3a**. No protective γ-effect, however, was exerted on the relevant aromatic methyl carbon of **3a**. The ^{13}C NMR chemical shifts (Table 3) of both aromatic methyls were closely comparable (δ15.9 and 16.2; cf. also δ16.0 for **2a**). Substitution thus could not occur also at the *ortho*-position of the methyl situated on the penta-substituted aromatic ring of **3a**.

The mass spectrum of **2d** (M^+ 426, rel. int. 22%) again showed the characteristic series of peaks involving **10** as parent cation. Although the isoprenoidal sequence was restricted to the prenyl (*m/z* 69, 60%) fragment, the presence of an isoprenyl side chain, even if in modified form, seemed certain. Thus compounds **2a** and **2d** appeared to have identical skeletons. Comparison of the MWs of both (396 vs. 426) revealed the existence of two hydrogens in the former as against two oxygens in the latter. Indeed, **2d** was an α,β-unsaturated carboxylic acid (IR ν_{max} 1690 cm^{-1}) which was transformed by diazomethane into a methyl ester (**2e**) and by acetic anhydride into a monoacetate (**2f**). Catalytic hydrogenation of this acetate led to a hexahydro-derivative (**2g**, Table 2), in complete agreement with the presence of an isoprenoidal side chain. Prominent mass spectrum fragments of this compound (M^+ 474, 60%) were **10** (*m/z* 177, 29%) and **13** (*m/z* 144, 50%). The latter, a McLafferty rearrangement product of **2g**, justified the placement of the carboxyl as shown in **2d**. All possible ^{1}H NMR double irradiation experiments, as well as spectral comparisons of **2d** with **2a** and **14** [8] as model compounds (Table 1), consubstantiated the validity of the proposed structure **2d**.

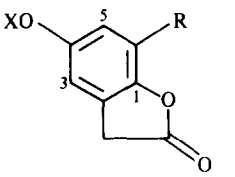
*Part 20 in the series "The Chemistry of Brazilian Myristicaceae". For Part 19 see ref. [1]. Taken from the Doctorate thesis presented by P. C. V. to Universidade de São Paulo (1982).



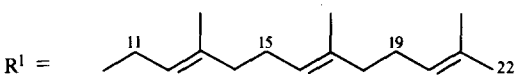


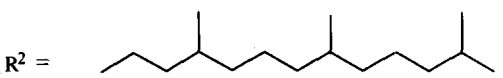
2a R = R^1, X = H
2b R = R^1, X = Ac
2c R = R^2, X = H
2d R = R^3, X = Y = H
2e R = R^3, X = H, Y = Me
2f R = R^3, X = Ac, Y = H
2g R = R^4, X = Ac

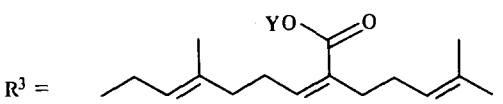
3a R = R^1, X = H
3b R = R^1, X = Ac
3c R = R^2, X = H

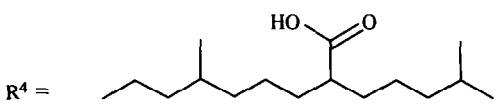


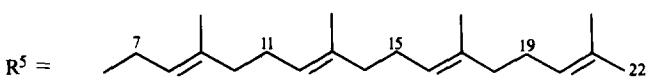
4a R = R^5, X = H
4b R = R^6, X = H
4c R = R^5, X = Ac

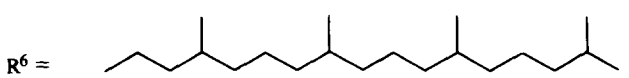












As in the preceding compounds **2a**, **2d** and **3a**, also in **4a** (M^+ 422, rel. int. 8%) the aromatic ring was substituted by an isoprenoidal side chain. Peaks due to prenyl (*m/z* 69, 100%) and geranyl (*m/z* 137, 25%) appeared in the mass spectrum. In this case, however, the four C_5-units formed a geranylgeranyl group, as indicated by ^{1}H NMR signals (Table 1) assignable to four olefinic protons (δ4.9–5.4), five vinylic methyls [δ1.60 (3), 1.66 (1), 1.74 (1)], twelve allylic protons (δ1.9–2.2) and two allylic/benzylic protons (δ3.27, *d*, *J* = 7.0 Hz). Indeed, catalytic hydrogenation led to an octahydro-derivative (**4b**, Table 2) with only one pair of benzylic protons (δ2.56, *t*, *J* = 6.0 Hz). The aromatic ring of **4a** contained an additional benzyl group, represented by a two proton signal at relatively low field (δ3.60, *br s*), and hence linked also to the butanolide carboxyl (IR ν_{max} 1770 cm^{-1}). Finally a phenolic hydroxyl, demonstrated by the formation of a monoacetate (**4c**), must be flanked by two aromatic protons (for the NMR

Table 1. ^{1}H NMR data of tocotrienols [270 and 60 (**2d** and **4a**) MHz, $CDCl_3$]

		3a				
	2a	n	n′	**2d**	**14** [8]	**4a**
H-3	6.36 *d*(3)*	6.37 *d*(3)	6.69 *s*	6.34 *d*(3)	—	6.51 *s*
H-5	6.46 *d*(3)	6.53 *d*(3)	—	6.43 *d*(3)	—	6.51 *s*
2H-7	2.66 *t*(6.5)	2.65 *t*(6.5)	2.50 *t*(6.5)	2.67 *t*(6.5)	—	3.27 *d*(7)
2H-11	1.95–2 *m*	1.9–2 *m*	1.9–2 *m*	2–2.3 *m*	—	1.9–2.2 *m*
2H-14	1.95–2 *m*	1.9–2 *m*	1.9–2 *m*	2–2.3 *m*	2.14 *t*	1.9–2.2 *m*
2H-18	1.95–2 *m*	1.9–2 *m*	1.9–2 *m*	2–2.3 *m*	2.28 *m*	1.9–2.2 *m*
2H-19	1.95–2 *m*	1.9–2 *m*	1.9–2 *m*	2–2.3 *m*	2.14 *dt*	1.9–2.2 *m*
2H-15	1.95–2 *m*	1.9–2 *m*	1.9–2 *m*	2.6 *m*	2.64 *dt*	1.9–2.2 *m*
2H-10	1.72 *m*	1.72 *m*	1.72 *m*	1.72 *m*	—	1.9–2.2 *m*
H-8	1.72 *m*	1.72 *m*	1.72 *m*	1.72 *m*	—	—
H-8	1.72 *m*	1.72 *m*	1.72 *m*	1.72 *m*	—	4.9–5.4
H-12	5.05–5.15 *m*	5.05–5.15 *m*	5.05–5.15 *m*	5–5.3 *m*	5.20 *tq*	4.9–5.4
H-20	5.05–5.15 *m*	5.05–5.15 *m*	5.05–5.15 *m*	5–5.3 *m*	5.10 *tqq*	4.9–5.4
H-16	5.05–5.15 *m*	5.05–5.15 *m*	5.05–5.15 *m*	5.94 *t* (6.5)	6.00 *t*	4.9–5.4
Me-2	2.11 *s*	2.11 *s*	2.16 *s*	2.10 *s*	—	—
Me-9	1.25 *s*	1.25 *s*	1.23 *s*	1.24 *s*	—	1.74 *s*
Me-13	1.59 *s*	1.59 *s*	1.59 *s*	1.60 *s*	1.60 *s*	1.60 *s*
Me-17	1.59 *s*	1.59 *s*	1.59 *s*	—	—	1.60 *s*
Me-21	1.59 *s*	1.59 *s*	1.59 *s*	1.60 *s*	1.60 *s*	1.60 *s*
3H-22	1.67 *s*	1.67 *s*	1.67 *s*	1.66 *s*	1.69 *s*	1.66 *s*
H_2C-2	—	—	—	—	—	3.60 *s*

*J (Hz) in parentheses.

Table 2. ^{1}H NMR data of hydrogenated derivatives of the natural tocotrienols (60 MHz, CCl_4)

		3c			
	2c	n	n′	**2g**	**4b**
H-3	6.25 *d*(3)*	6.21 *d*(3)	6.59 *s*	6.5 *s*	6.43 *s*
H-5	6.40 *d*(3)	6.40 *d*(3)		6.5 *s*	—
2H-7	2.66 *t*(6.5)	2.4–2.8		2.72 *t*(6.5)	2.5 *t*(6)
Me-2	2.07 *s*	2.08 *s*	2.10 *s*	2.10 *s*	—
CH	1.3–1.9 *m*	1.3–2 *m*		1.3–2 *m*	1.3–1.7 *m*
CH_2	1.25	1.25		1.25	1.25
Me-9	1.25	1.25		1.25	0.88 *d*(7)
Me-13	0.9 *d*(6)	0.9 *d*(6)		0.9 *d*(6)	0.88 *d*(7)
2Me-21	0.9 *d*(6)	0.9 *d*(6)		0.9 *d*(6)	0.88 *d*(7)
Me-17	0.9 *d*(6)	0.9 *d*(6)		—	0.88 *d*(7)
H_2C-2	—	—		—	3.6 *s*
AcO	—	—		2.18 *s*	—

*J (Hz) in parentheses.

signal of both $\Delta\delta$ $C_5D_5N/CDCl_3$ 0.50 [9]). Since these protons were practically equivalent (for both δ6.51, *s*), they were symmetrically situated also with respect to the other oxy-function and the compound possessed structure **4a**.

The dihydroxy-4-aryltetralin structure proposed for compound **5a** was shown by the formation of a diacetate (**5b**), as well as on mass, ^{1}H and ^{13}C NMR spectral comparison with known representatives of this series [10]. The major mass spectrum fragment (*m/z* 212, 69%) was formed by the retro Diels–Alder splitting of the elements of but-2-ene. It had to have the two hydroxyls on separate rings on account of the conspicuous hydroxytropylium ion (*m/z* 107, 18%). The localization of one hydroxyl on the aromatic part of the tetralin system was ascertained through the existence of a *meta*-split doublet at relatively very high field (δ6.2, J = 2.0 Hz) in the ^{1}H NMR spectrum, which could only belong to a *peri*-hydrogen protected by a nearby aryl group [11]. It was to be expected that this aryl would have two protons at C-2′,

Table 3. ^{13}C NMR data of tocotrienols and of model compounds (22.6 MHz, $CDCl_3$)

				3a	
C	2a	2c [6]	9 [5]	n	n'
1	146.0	145.8	—	145.6	147.2
2	127.4	127.1	—	127.7	123.4
3	115.7	115.8	—	115.4	115.1
4	147.8	147.5	—	149.8	141.3
5	112.7	112.7	—	111.9	137.1
6	121.3	121.1	—	121.4	115.3
7	22.5	22.7	—	22.6	15.9
8	31.4	31.4	—	31.4	30.6
9	75.4	75.5	—	75.7	75.1
10	39.7	—	—	39.8	
11	22.2	—	—	22.2	
12	124.2	—	—	124.2	
13	135.0	—	—	135.0	
14	39.7	—	—	39.8	
15	26.6	—	—	26.7	
16	124.3	—	124.5	124.2	
17	135.2	—	137.2	135.3	
18	39.7	—	39.7	39.8	
19	26.8	—	26.6	26.8	
20	124.5	—	124.9	124.5	
21	131.3	—	131.2	131.3	
22	25.7	—	25.5	25.7	
Me-2	16.0	16.0	—	15.9	16.2
Me-9	24.0	24.0	—	24.1	23.8
Me-13	16.0	—	—	16.0	
Me-17	15.9	—	—	15.9	
Me-21	17.7	—	17.4	17.7	

C-6′ protected by a reciprocal effect, and two protons at C-3′, C-5′ protected by a vicinal 4′-hydroxyl in the proposed structure **5a**. Indeed, all four protons were represented by a multiplet centered at *ca* 6.8. The C-4 aryl not only protected H-5, but also Me-3 (δ0.85). This fact required the 4-aryl and 3-methyl to possess equatorial conformations, inclusively because H-3 and H-4 had to be *trans*-diaxially related on the evidence of their coupling constant (J = 9.0 Hz). The novel (**5a**) and known (**15a**, **b**) *trans*, *trans*-tetralin neolignans [12, 13] showed comparable chemical shifts for Me-3/Me-2 (δ0.85/1.05 **5a**, 0.85/1.04 **15a**, 0.83/1.05 **15b**). Formula **5a** also represents the absolute configuration of the compound in view of a negative Cotton effect at 285 nm considered characteristic of 4β-aryls in tetralin neolignans [14]. The dihydrochalcone **6** had been found previously in *I. laevis* [15] and, as ethyl oleate (**8**), was identified by direct comparison with an authentic sample.

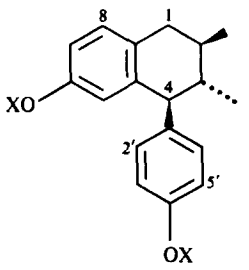
DISCUSSION

Work with ^{14}C-labelled precursors established homogentisic acid (**16**) as a probable intermediate in the biosynthesis of tocotrienols, tocopherols and plastoquinones [16]. Formation of the nuclear C-methyl groups of these end products should involve decarboxylation. Exceptionally, the entire 2,5-dihydroxyphenylacetic acid moiety is retained in **4a**, consubstantiating the intermediary existence of **16**.

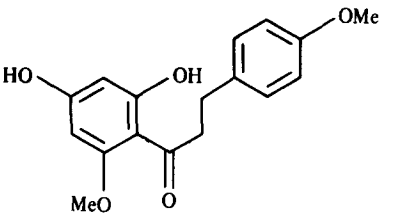
EXPERIMENTAL

Isolation of the constituents. Fruits of *I. grandis* were collected in the Municipality of Itaituba, Pará State, by Dr. Hipólito Paulino Ferreira Filho and identified by Dr. William Rodrigues, INPA, Manaus. Dry fruits were reduced to powder (130 g). This was percolated with C_6H_6. The soln was evaporated and the residue (90 g) was treated with EtOH. The EtOH insoluble portion was separated by filtration and recrystallized from EtOH to give **1** (50 g). The EtOH soln was evaporated and the residue (27 g) submitted to CC (400 g silica gel). The following fractions (250 ml each) were obtained with the indicated eluants: Fractions 1–6 (C_6H_{14}–C_6H_6, 9:1), 7–13 (C_6H_{14}–C_6H_6, 4:1), 14 (C_6H_{14}–C_6H_6, 7:3), 15–21 (C_6H_{14}–C_6H_6, 1:1), 22–27 (C_6H_6), 28–29 (C_6H_6–EtOAc, 49:1), 30–32 (C_6H_6–EtOAc, 19:1), 33–34 (C_6H_6–EtOAc, 9:1), 35 (EtOAc). Fraction 9 gave **8** (200 mg). Fraction 17 was purified by prep. TLC (silica gel, C_6H_6) to **3a** (200 mg). Fraction 22 contained **1** and **2a**. Fraction 23 gave **2a** (2 g). Fraction 26 was separated by prep. TLC (silica gel, C_6H_6–EtOAc, 19:1) into two portions. The more polar one was purified by prep. TLC (silica gel, C_6H_6–EtOAc, 49:1) to give **4a** (15 mg). Fractions 32 and 33 were recrystallized from C_6H_6 to give **6** (120 mg). Fraction 34 was crystallized from MeOH to give **5** (70 mg). The mother liquor was purified by prep. TLC to **7** (100 mg). Fraction 35, filtered through active charcoal, was submitted to CC (silica gel deactivated by 10% H_2O). A fraction, eluted with C_6H_6–MeOH (19:1) was purified by prep. TLC to give **2d** (80 mg).

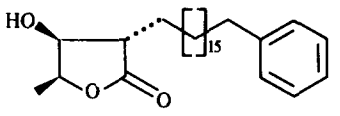
2,8-*Dimethyl*-2-(4,8,12-*trimethyl*-3,7,11-*tridecatrienyl*)-6-



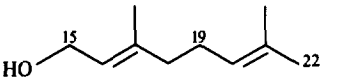
5a X = H
5b X = Ac



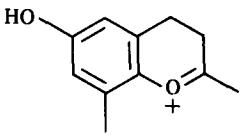
6



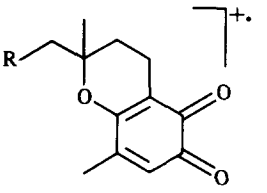
7



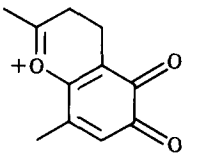
9



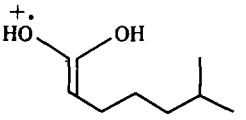
10



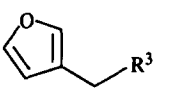
11



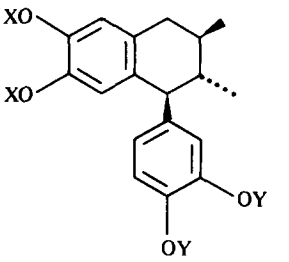
12



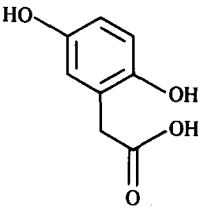
13



14



15a X = Me, Y − Y = CH_2
15b X − X = CH_2, Y = Me



16

chromanol (**2a**). Oil. IR ν_{max}^{film} cm^{-1}: 3350, 1601, 1460, 1370, 1215, 1140, 1100, 995, 935, 855; UV λ_{max}^{MeOH} nm: 296 (ε 3800); + NaOH 305 (ε 3200); MS *m/z* (rel. int.): 396 $[M]^+$ (50), 270 (4), 217 (6), 192 (16), 177 (40), 137 (74), 121 (16), 109 (16), 107 (14), 95 (13), 93 (14), 69 (100), 55 (27), 41 (70). *Acetate* (**2a**, Ac_2O, C_5H_5N, 4 hr, room temp.) (**2b**). IR ν_{max}^{film} cm^{-1}: 1765, 1470, 1445, 1370, 1205, 1100, 1020, 935, 900; ^1H NMR (60 MHz, CCl_4): δ practically superimposable on spectrum of **2a** (Table 1) except for 6.6 (*s* (*br*), 2 ArH), 2.17 (*s*, AcO); MS *m/z* (rel. int.): 438 $[M]^+$ (39), 396 (28), 219 (12), 217 (12), 191 (12), 177 (21), 137 (39), 121 (16), 109 (13), 107

(13), 95 (16), 93 (16), 69 (100), 55 (50), 41 (93). *Hexahydro-derivative* (**2a**, H_2, EtOH, 5% Pd–C) (**2c**). IR ν_{max}^{film} cm^{-1}: 3400, 1610, 1470, 1220, 1150, 1050, 1000, 940; MS *m/z* (rel. int.): 402 $[M]^+$ (100), 285 (5), 191 (4), 177 (29), 137 (61), 69 (19), 57 (32), 55 (28), 43 (53).

2,8-*Dimethyl*-2-(4,8,12-*trimethyl*-3,7,11-*tridecatrienyl*-5-O-[2′,8′-*dimethyl*-2′-(4′,8′,12′-*trimethyl*-3′,7′,11′-*tridecatrienyl*)-6′-*chromanyl*])-6-*chromanol* (**3a**). Oil. IR ν_{max}^{film} cm^{-1}: 3500, 1602, 1480, 1380, 1340, 1250, 1220, 1170, 1135, 1105, 995, 950; UV λ_{max}^{MeOH} nm: 250, 290 (ε 8350, 4000); + NaOH 250, 300 (ε 8350, 4100); MS *m/z* (rel. int.): 790 $[M]^+$ (90), 724 (4), 658 (8), 577 (3), 394 (8), 311 (6), 271 (15), 257 (6), 191 (8), 177 (15), 137 (29), 121 (27), 107 (18), 69 (100), 41 (74). *Acetate* (**3a**, Ac_2O, C_5H_5N, 4 hr, room temp.) (**3b**). IR ν_{max}^{film} cm^{-1}: 1770, 1480, 1380, 1205, 1105, 1020; ^1H NMR (60 MHz, CCl_4) δ 1.90 (*s*, AcO); MS *m/z* (rel. int.): 832 $[M]^+$ (5), 790 (5), 412 (6), 396 (6), 219 (15), 191 (16), 177 (50), 175 (30), 137 (30), 69 (40), 43 (100). *Dodecahydro-derivative* (**3a**, Ac_2O, C_5H_5N, 4 hr, room temp.) (**3c**), oil.

2,8-*Dimethyl*-2-(4,12-*dimethyl*-8-*carboxyl*-3,7,11-*tridecatrienyl*)-6-*chromanol* (**2d**). Oil. IR ν_{max}^{film} cm^{-1}: 3400 *br*, 1690, 1630, 1450, 1430, 1380, 1225, 1110, 1000, 940, 860; UV λ_{max}^{MeOH} nm: 240, 296 (ε 2800, 4000); + NaOH 240, 305 (ε 2790, 3600); MS *m/z* (rel. int.): 426 $[M]^+$ (22), 408 (2), 324 (18), 271 (4), 270 (5), 192 (11), 177 (27), 175 (19), 161 (18), 150 (27), 137 (54), 121 (27), 107 (68), 81 (32), 69 (80), 45 (100), 41 (66). *Methyl ester* (**2d**, Et_2O, CH_2N_2, 0°) (**2e**), IR ν_{max}^{film} cm^{-1}: 3430, 1705, 1470, 1440, 1375, 1220, 1000, 940, 860; ^1H NMR (60 MHz, CCl_4): δ 6.30 (*d*, *J* = 3.0 Hz, H-5), 6.20 (*d*, *J* = 3.0 Hz, H-7), 5.74 (*t*, *J* = 7.0 Hz, H-7′), 5.2–4.9 (*m*, H-3′, H-11′), 3.67 (*s*, CO_2Me-8′), 2.60 (*t*, *J* = 6.5 Hz, 2 H-4), 2.43 (*t*, *J* = 7.0 Hz, 2H-6′), 2.2–1.8 (*m*, 2H-2′, 2H-5′, 2H-9′, 2H-10′), 2.06 (*s*, Me-8), 1.65 (*s*, *cis*-Me-15′), 1.59 (*s*, *trans*-Me-15′, Me-4′), 1.23 (*s*, Me-2); MS *m/z* (rel. int.): 440 $[M]^+$ (100), 271 (8), 203 (19), 177 (54), 137 (61), 121 (21), 107 (25), 69 (58). *Acetate* (**2d**, Ac_2O, C_5H_5N, 4 hr; room temp.) (**2f**), oil. IR ν_{max}^{film} cm^{-1}: 3400 *br*, 1765, 1690, 1475, 1450, 1370, 1225, 1025, 950, 905; ^1H NMR (60 MHz, CCl_4): δ 6.5 (*s*, 2ArH), 2.18 (*s*, AcO); MS *m/z* (rel. int.): 468 $[M]^+$ (21), 426 (21), 408 (6), 281 (8), 271 (5), 219 (20), 217 (22), 192 (17), 179 (26), 177 (40), 175 (25), 137 (57), 122 (77), 105 (100), 69 (64), 43 (72). *Hexahydroacetate* (**2e**, H_2, EtOH, 5% Pd–C) (**2g**), oil. IR ν_{max}^{film} cm^{-1}: 3400 *br*, 1770, 1710, 1470, 1370, 1205, 1020; MS *m/z* (rel. int.): 474 $[M]^+$ (60), 432 (70), 191 (8), 177 (29), 144 (50), 137 (60), 107 (10), 45 (80), 43 (100).

5-*Hydroxy*-7-(3,7,11,15-*tetramethyl*-2,6,10,11-*hexadecatetraenyl*)-2(3H)-*benzofuranone* (**4a**). Mp 58–60° (MeOH). IR ν_{max}^{film} cm^{-1}: 3350, 1770, 1605, 1450, 1380, 1280, 1250, 1220, 1140, 995, 950, 925, 895, 805, 760, 735; UV λ_{max}^{MeOH} nm: 240 (ε 4700); MS *m/z* (rel. int.): 422 $[M]^+$ (8), 377 (4), 217 (8), 190 (33), 163 (29), 137 (25), 136 (29), 135 (38), 121 (28), 109 (23), 107 (23), 95 (26), 93 (24), 91 (22), 81 (64), 69 (100), 55 (29). *Octahydro-derivative* (**4a**, H_2, EtOH, 5% Pd–C) (**4b**), oil. IR ν_{max}^{film} cm^{-1}: 3350, 1770, 1605, 1450, 1370, 1250, 1200, 945, 890.

(2R,3R,4S)-2,3-*Dimethyl*-4-(p-*hydroxyphenyl*)-6-*hydroxytetralin* (**5a**). Mp 138–140° (C_6H_{14}–MeOH). IR ν_{max}^{KBr} cm^{-1}: 3400, 1600, 1500, 1450, 1375, 1280; UV λ_{max}^{MeOH} nm: 225, 290 (ε 18300, 4250); ^1H NMR (60 MHz, Ac_2O–d_6): δ 8.1 (*s*, OH), 7.7 (*s*, OH), 6.93 (*d*, *J* = 8.0 Hz, H-8), 6.8–6.6 (*m*, H-2′, H-6′, H-3′, H-5′), 6.47 (*dd*, *J* = 8.0, 2.0 Hz, H-7), 6.06 (*d*, *J* = 2.0 Hz, H-5), 3.40 (*d*, *J* = 9.0 Hz, H-4), 2.8–2.4 (*m*, 2H-1), 1.8–1.2 (*m*, H-2, H-3), 1.05 (*d*, *J* = 6.0 Hz, Me-2), 0.85 (*d*, *J* = 6.0 Hz, Me-3); MS *m/z* (rel. int.): 268 $[M]^+$ (58), 212 (69), 195 (31), 174 (27), 159 (21), 121 (6), 107 (18), 91 (6), 58 (36), 43 (100); CD (*c* 2 mg/20 ml, MeOH, 25°) $[\theta]_{267}^{pk}$ +7000, $[\theta]_{277}$ 0, $[\theta]_{287}^{tr}$ −13 000. *Diacetate* (**5a**, Ac_2O, C_5H_5N, 4 hr, room temp.) (**5b**), oil. IR ν_{max}^{film} cm^{-1}: 1770, 1605, 1500, 1370, 1190, 1020, 915; ^1H NMR (60 MHz, CCl_4) δ 7.2–6.8 (*m*, H-8, H-2′, H-3′, H-5′, H-6′), 6.66 (*dd*, *J* = 8.0, 2.0 Hz, H-7), 3.52 (*d*, *J* = 9.0 Hz, H-4), 2.9–2.5 (*m*, 2H-1), 2.20 (*s*, AcO), 2.06 (*s*, AcO), 1.7–1.3 (*m*, H-2, H-3), 1.06 (*d*, *J* = 6.0 Hz, Me-2), 0.86 (*d*, *J* = 6.0 Hz, Me-3); MS *m/z* (rel. int.): 352 $[M]^+$ (2%) 310 (85), 268 (100), 212 (86), 195 (23), 174 (45), 161 (24), 159 (18), 121 (10), 107 (33), 43 (84).

2′,4′-*Dihydroxy*-4,6′-*dimethoxydihydrochalcone* (**6**) [15] *and ethyl oleate* (**8**). These compounds were identified by direct comparison with authentic samples.

Acknowledgements—Fellowships were provided by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP).

REFERENCES

1. Lopes, L. M. X., Yoshida, M. and Gottlieb, O. R. (1983) *Phytochemistry* **22**, 1516.
2. Schultes, R. E. and Holmstedt, B. (1971) *Lloydia* **34**, 61.
3. Vieira, P. C., Yoshida, M., Gottlieb, O. R., Paulino Fo., H. F., Nagem, T. J. and Braz Fo., R. (1983) *Phytochemistry* **22**, 711.
4. Pennock, J. F., Hemming, F. W. and Kerr, J. D. (1964) *Biochem. Biophys. Res. Commun.* **17**, 542.
5. Bohlmann, F., Zeisberg, R. and Klein, E. (1975) *Org. Magn. Reson.* **7**, 426.
6. Matsuo, M. and Orano, S. (1976) *Tetrahedron* **32**, 229.
7. Mesquita, A. A. L., Corrêa, D. de B., Gottlieb, O. R. and Magalhães, M. T. (1968) *Anal. Chim. Acta* **42**, 311.
8. Bohlmann, F. and Mahanta, P. K. (1979) *Phytochemistry* **18**, 1067.
9. Demarco, P. V., Farkas, E., Doddrell, D., Mylari, B. L. and Wenkert, E. (1968) *J. Am. Chem. Soc.* **90**, 5480.
10. Gottlieb, O. R. (1978) *Progr. Chem. Org. Nat. Prod.* **35**, 1.
11. Gottlieb, O. R., Maia, J. G. S. and Ribeiro, M. N. de S. (1976) *Phytochemistry* **15**, 773.
12. Kohen, F., MacLean, J. and Stevenson, R. (1966) *J. Chem. Soc.* (C), 1775.
13. Adjangba, M. S. (1963) *Bull. Soc. Chim. Fr.* 1007.
14. Lopes, L. M. X., Yoshida, M. and Gottlieb, O. R. (1982) *Phytochemistry* **21**, 751.
15. Braz Fo., R., Silva, M. S. da and Gottlieb, O. R. (1980) *Phytochemistry* **19**, 1195.
16. Haslam, E. (1974) *The Shikimate Pathway*, p. 90. John Wiley, New York.