Phytochemistry, Vol. 25, No. 6, pp. 1427–1430, 1986.
Printed in Great Britain.

0031-9422/86 \$3.00 + 0.00

PHENYLPROPENE, BENZOIC ACID AND FLAVONOID DERIVATIVES FROM FRUITS OF JAMAICAN *PIPER* SPECIES

B. BURKE* and M. NAIR*

Department of Chemistry, University of West Indies, Mona, Kingston-7, Jamaica, West Indies

(*Received* 12 *August* 1985)

Key Word Index—*Piper aduncum*; *P. hispidum*; Piperaceae; fruits; pseudo-dillapiole; 4-methoxy-3,5-bis(3′-methyl-2′-butenyl)-benzoic acid; flavonoids.

Abstract—1-Allyl-2,3-(methylenedioxy)-4,5-dimethoxybenzene, 4-methoxy-3,5-bis(3′-methyl-2′-butenyl)-benzoic acid, and the known compounds 5-hydroxy-7-methoxyflavanone and 2,6-dihydroxy-4-methoxydihydrochalcone have been isolated from the fruits of Jamaican *Piper aduncum* and *Piper hispidum*.

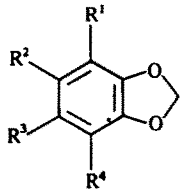
INTRODUCTION

The Piperaceae with its three genera *Piper*, *Pothomorphe* and *Peperomea* are found commonly in Jamaican thickets and limestone area, at an altitude of 17–670 m. The genus *Piper* is widely used in folklore medicine in Latin America and the West Indies [1–6]. In Jamaica, of the eleven *Piper* species known, *Piper aduncum* L. and *Piper hispidum* Sw. are listed as remedies for cold and stomach aches and as insect-repellents [1]. *Piper fadyenii* C.DC., endemic to Jamaica, though not noted for its biological activity, was previously investigated by Burke *et al.* [7] in an attempt to study the chemosystematics of new and old world *Piper*. They reported the isolation, characterization and synthesis of the *E*- and *Z*-isomers of a simple butenolide, fadyenolide. Prior to this, several other lactones isolated from *Piper* have been used as taxonomic indicators [8–11]. In addition to these lactones, terpenes [12, 13], alkaloids [14–18] and flavonoids [19, 20] have also been found in other medicinally important *Piper* species, especially in those native to the Middle and Far East. These discoveries, especially of fadyenolide, 5,6-*Z*- and *E*-butenolide in the endemic *P. fadyenii*, prompted the investigation of other Jamaican *Piper* species. We here report the results of our findings on the fruits of *P. aduncum* and *P. hispidum*.

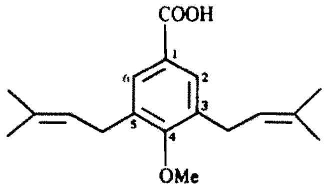
RESULTS AND DISCUSSION

Cold petrol extraction of the dried, milled fruits of *P. aduncum* and *P. hispidum* collected in the hills of St. Andrew, Jamaica, afforded a yellow viscous oil in each case upon removal of the solvent. Evaluation of each crude extract by TLC indicated a strikingly similar profile of compounds. The crude extracts were purified by silica column chromatography, followed by preparative TLC. This gave compounds **1a**, **2** and **4**. Methanol extraction of the defatted residue gave compound **3**. All four compounds were obtained from each plant extract.

Compound **1a**, $C_{12}H_{14}O_4$, a colourless and aromatic oil gave λ_{max}^{EtOH} at 208 and 285 nm and ν_{max}^{film} at 1625 cm^{-1}. The ^{1}H NMR spectrum showed signals for two methoxy, one methylenedioxy and one allyl group as well as single aromatic proton. Considering all the spectral evidence,



	R¹	R²	R³	R⁴
1a	OMe	OMe	H	CH₂CH═CH₂
1b	OMe	OMe	CH₂CH═CH₂	H
1c	H	OMe	OMe	CH₂CH═CH₂
1d	OMe	H	OMe	CH₂CH═CH₂
1e	OMe	CH₂CH═CH₂	OMe	H
1f	OMe	H	CH₂CH═CH₂	OMe
1g	OMe	OMe	H	CH═CHMe
1h	OMe	OMe	COOH	H
1i	OMe	OMe	H	COOH
1j	OMe	H	COOH	OMe



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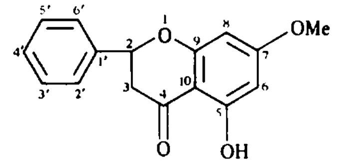
*Present address: ARCO Plant Cell Research Institute, 6560 Trinity Court, Dublin, CA 94568, U.S.A.



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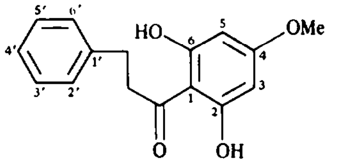

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including the ^{13}C NMR, six possible structural forms were evident for compound **1a**. The proposed structure (**1a**) was confirmed by chemical transformations.

The double bond of the allyl group was first isomerized into conjugation with the aryl ring using alcoholic potassium hydroxide. The resulting olefinic bond was then cleaved with osmium tetroxide–sodium periodate in aqueous THF to produce the corresponding carboxylic acid (**1i**). The melting point (68–69°) of this acid differed considerably from those of the two isomeric acids, dillapiolic acid (**1h**) (mp 150–151°) and apiolic acid (**1j**) (mp 175–176°) [14] which are derivatives of dillapiole (**1b**) and apiole (**1f**), respectively [21]. The synthesis of dillapiole and apiole have been reported by Dallacker [22] and the corresponding acids with *ortho* hydrogens fully characterized. This eliminated structures **1b** and **1f** from consideration. Thus, only four possible isomers, (**1a, c, d** and **e**), remained possible structures of this compound.

The structure of the acid was resolved primarily by NMR techniques since several efforts to decarboxylate the acid failed to afford a product with a tetrasubstituted aromatic ring. This latter compound with two aryl protons would have indicated the relative orientation of the proton and the carboxylate group in the acid. The differences in the chemical shifts of the aryl proton in the olefins (**1a** and **1g**) and the corresponding acid (**1i**) indicated that the aryl proton was in the position *ortho* to the alkenyl side chain. This was confirmed by observing the shift in the position of this aryl proton in the ^{1}H NMR spectrum of **1i** with the addition of a euroshift reagent, tris[3-(heptafluoropropylhydroxymethylene)-2-camphorato]europrium (III). A mole ratio of 0.77 mole shift reagent to 1.0 mole acid (**1i**) in $CDCl_3$ produced a downfield shift of 2.51 ppm in the position of the aryl proton. Other groups experienced shifts of 0.53, 0.73 (2 × methoxy), 0.31 (methylenedioxy) and 3.30 (acid proton) ppm to lower fields. When the euroshift reagent was checked against 4-(3′,3′-dimethyl allyl)-benzoic acid, the *ortho* protons (H-2, H-6) were similarly shifted, the magnitude being significantly larger than that of the *meta* protons (H-3, H-5). The shifts were 2.14 and 0.44 ppm, respectively. Signals for the methylene proton of the dimethyl allyl group showed a shift comparable to that shown by the methoxy and methylenedioxy groups of the acid **1i**. Hence, of the four possible structures remaining, only the acid derived from pseudodillapiole (**1a**) has a proton *ortho* to the carboxylate group. Our compound is therefore pseudo-dillapiole (**1a**), which to our knowledge is the first time it has been found as a natural product.

Compound **2**, $C_{18}H_{24}O_3$, mp 94–96° was obtained from petroleum. The IR ν_{max}^{KBr} at 2950, 1695 and 1600 cm^{-1}, UV λ_{max}^{EtOH} at 242 and 208 nm, ^{1}H NMR and ^{13}C NMR spectra confirmed that this compound was the substituted *p*-methoxybenzoic acid (**2**). The appearance of the two ring protons as a low field singlet at δ 7.79 established that they are *ortho* to the carboxylic acid. The number of signals in the ^{1}H and ^{13}C NMR spectra, in particular, highlighted the symmetrical substitution pattern on the benzene ring. The shift in the carbonyl absorption band in forming the methyl ester (1720 cm^{-1}) from the acid (1695 cm^{-1}) and the lack of base shift in the UV spectrum of the latter confirmed that **2** is the carboxylic acid and not the isomeric phenolic ester. Since the onset of our work, this compound was reported to be present in a Columbian *Piper* sp. [23].

The crystals obtained from the methanolic extract was shown to be the pinostrobin (**3**), $C_{16}H_{14}O_4$, mp 103–104°, by comparison of the spectral data [24–26], UV, IR, ^{1}H and ^{13}C NMR spectra and GC-MS of its silylated derivative. The values for the optical rotation, $[\alpha]_D^{25}$ $-8°$ (c 1.0; $CHCl_3$) and the mp of **3** compared with the range of literature values [24–26] and indicated that our isolate differ in enatiomeric purity. To evaluate the latter, the ^{1}H NMR spectrum of **3** was checked using a chiral shift reagent, (*S*)-(+)-2,2,2-trifluoro-1-(9-anthryl)ethanol [27–29]. The chiral shift reagent, 3.93 mole ratio, resolved the C-2 proton into two doublet of doublets for the *S* and *R* enantiomers, which had appeared previously as one doublet of doublets at δ 5.40. The integral ratio of these two doublet of doublets at 5.24 and 5.29 ppm, respectively, were 53:47. Since the measured molecular rotation represented by this molecular excess was $-8°$ it is clear that the molecular rotation of the 2*S*-anomer of **3** should be about $-130°$.

The biogenetically related dihydrochalcone (**4**), $C_{16}H_{16}O_4$, mp 164–165° was also obtained from ethyl acetate–petrol, and was characterized by UV, IR, NMR and by MS. In addition, **3** and **4** were correlated by conversion of **3** to **4** by reductive cleavage at C-2 with zinc in acetic acid.

Piper aduncum and *P. hispidum* are easily distinguished by their fruits [30]. Yet, despite the morphological differences, our results show a similar biochemistry. It is interesting that flavanones and chalcones, but no 5- or 6-membered ring lactones, nor piperamides [7–11, 19, 20, 25] found in fruits of several *Piper* species, were detected in the fruits of the two *Piper* species described.

EXPERIMENTAL

General methods. Elemental analysis were in agreement with molecular formulae. Mps are uncorr. ^{1}H NMR (60, 300 and 400 MHz) and ^{13}C NMR (75.45 MHz): $CDCl_3$. MS (70 eV, EI); $[\alpha]_D^{25}$: $CHCl_3$; UV: EtOH, KBr, $CHCl_3$ or as film. Prep. TLC, TLC and CC were carried out on silica gel using a petrol–Me_2CO solvent system.

Plant material. Fruits of *P. aduncum* and *P. hispidum* were collected in Newcastle, St. Andrew, Jamaica, and samples are identified and stored in the herbarium at the Institute of Jamaica, Kingston, Jamaica.

Extraction and isolation of compounds **1a**, **2**, **3** *and* **4**. Dried, milled fruits of *P. aduncum* and *P. hispidum* (150 g each) were separately extracted with cold petrol, affording 16 g each of an oily, yellow, fragrant gum. The crude extract was fractionated on a silica gel column with petrol–Me_2CO mixtures. Extended CC and TLC gave the pure compounds **1a**, **2** and **4**. The plant residue, after the petrol extraction, was air dried and extracted with cold MeOH. On concn of the extract, compound **3** was crystallized out. It was filtered off and recrystallized from MeOH. The percentage yield of compounds **1a**–**4**, with respect to the dried plant material, were 1.03, 0.70, 1.54 and 0.74 respectively.

Compound **1a**. Volatile, aromatic, colourless oil, $C_{12}H_{14}O_4$ (M_r 222); UV λ_{max}^{EtOH} nm (log ε): 208 (3337), 285 (295); IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1625 (olefin); ^1H NMR ($CDCl_3$, 300 MHz): δ3.19 (2H, *d*, $J = 9.0$ Hz, CH_2 benzylic), 3.76 (3H, *s*, OMe), 4.01 (3H, *s*, OMe), 5.05 (2H, *m*, vinylic CH_2), 5.87 (2H, *s*, methylenedioxy), 5.92 (1H, *m*, allylic), 6.30 (1H, *s*, H-6); ^{13}C NMR ($CDCl_3$, 75.45 MHz): δ58.08 and 56.33 (both *q*, OMe), 100.71 (*t*, OCH_2O), 32.97 (*t*, benzylic CH_2), 115.43 (*t*, $CH{=}\underline{C}H_2$), 135.0 (*d*, $\underline{C}H{=}CH_2$), 104.90 (*d*, C-6), 113.30 (*s*, C-1), 146.82 (*s*, C-2), 140.37 (*s*, C-5), 137.19 (*s*, C-3), 131.97 (*s*, C-4). MS *m/z* (rel. int.): 222.0891 $[M]^+$ (100), 207.0662 $[M - Me]^+$ (20.26), 195.0659 $[M - CH{=}CH_2]$ (5.57), 191.0712 $[M - OMe]^+$ (3.7), 179.0692 $[M - Me, CO]^+$ (4.74), 176.0468 $[M - OMe, Me]^+$ (3.05), 177.0556 $[M - Me, CH_2O]^+$ (34.94).

Double bond isomerization in **1a**. Compound **1a** (300 mg) refluxed with KOH in EtOH (25 %, 10 ml) for 24 hr. The reaction mixture was diluted with H_2O, extracted with EtOAc, dried over anhydrous $MgSO_4$ and evaporation of the solvent resulted in a viscous oil (**1g**), purified by TLC; UV λ_{max}^{EtOH} nm (log ε): 218 (2386), 264 (888), 305 (333); IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1618 (olefin) ^1H NMR ($CDCl_3$): δ1.97 (3H, *d*, $J = 6.0$ Hz, Me), 3.75 (3H, *s*, OMe), 4.00 (3H, *s*, OMe), 5.85 (2H, *s*, OCH_2O), 6.60 (1H, *s*, Ar–H), 6.00–6.80 (2H, *m*, Ar–CH=CH); MS *m/z* (rel. int.): 222 $[M]^+$ (100 %).

OsO_4–$NaIO_4$ *oxidation of* **1g**. The isomerized product (250 mg) was dissolved in THF–H_2O (10:1, 25 ml) and OsO_4 (20 mg) added and stirred for 10 min at room temp. Finely powdered $NaIO_4$ (600 mg) was added in portions into the stirred mixture (10 min intervals) and left to stir (24 hr). The ppt was filtered off and the filtrate diluted with H_2O (25 ml) and extracted with EtOAc (3 × 15 ml). The organic layer, on evaporation, gave a black residue which was purified by eluting through small column of silica with $CHCl_3$. The $CHCl_3$ portion yielded a colourless product (200 mg), recrystallized from petrol as colourless needles (**1i**), mp 68–69°; UV λ_{max}^{EtOH} nm (log ε): 220 (10272), 288 (7190), 322 (5157); IR ν_{max}^{KBr} cm^{-1}: 1610; ^1H NMR ($CDCl_3$): δ3.98 (3H, *s*, OMe), 4.01 (3H, *s*, OMe), 6.00 (2H, *s*, OCH_2O), 7.00 (1H, *s*, Ar–H), 10.30 (1H, *s*, exchanged with D_2O, acid); ($CDCl_3$ + Eu(hfc)$_3$, 0.77 mole): δ4.51 (3H, *s*, OMe), 4.74 (3H, *s*, OMe), 6.31 (2H, *s*, OCH_2O), 9.51 (1H, *s*, Ar–H), 13.60 (1H, *s*, acid).

Compound **2**. Recrystallized from petrol (0–5°), mp 94–94.5°; UV λ_{max}^{EtOH} nm (log ε): (6850), 242 (26363); no base shift with KOH–MeOH; IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1600, 1695 (aromatic acid), 2950 (OH); ^1H NMR ($CDCl_3$, 300 MHz): δ1.76 (12H, *s*, 4 × Me), 3.40 (4H, *d*, $J = 7.0$ Hz, 2 × CH_2, benzylic), 3.77 (3H, *s*, OMe), 5.30 (2H, *m*, olefinic), 7.79 (2H, *s*, C-2, C-6), 12.10 (1H, *s*, exchanged with D_2O, COOH); ^{13}C NMR ($CDCl_3$, 75.45 MHz): δ17.91 (*q*, 2 × Me), 25.78 (*q*, 2 × Me), 60.96 (*q*, OMe), 28.38 (*t*, 2 × CH_2), 122.34 (*d*, 2 × $\underline{C}H{=}C$), 130.27 (*d*, C-2, C-6), 125.04 (*s*, C-3, C-5), 135.24 (*s*, C-1), 133.25 (*s*, 2 × $C{=}\underline{C}Me_2$), 161.20 (*s*, C-4), 172.20 (*s*, COOH). MS *m/z* (rel. int.): 288.1719 $[M]^+$ (37.4), 273.1481 $[M - Me]^+$ (10.29), 257.1551 $[M - OMe]^+$ (15.36), 243.1743 $[M - COOH]^+$ (39), 217.0869 (100), 189.0561 (89), 187, 1121 (46.5); methylation of **2** with CH_2N_2 gave a gummy compound; IR $\nu_{max}^{CHCl_3}$ cm^{-1}: 1720 (ester), 1600; ^1H NMR ($CDCl_3$): δ1.74 (12H, *s*, 4 × Me), 3.40 (4H, *d*, $J = 7.0$ Hz, 2 × CH_2), 3.65 (3H, *s*, 2 × OMe), 7.80 (2H, *s*, Ar–H), 5.20–5.30 (2H, *m*, olefin); MS *m/z* (rel. int.): 302 $[M]^+$ (100).

Compound **3**. Plate like crystals from MeOH, mp 103–104°, $[\alpha]_D^{25}$ −8° (*c* 1.0, $CHCl_3$); UV λ_{max}^{EtOH} nm (log ε): 226 (17102), 287 (18182), 328 (3600); base shift with KOH–MeOH; IR ν_{max}^{KBr} cm^{-1}: 3350 (OH), 1660 (C=O), 1600; ^1H NMR ($CDCl_3$, 300 MHz); δ2.85 (1H, *dd*, $J = 13.00$, 3.30 Hz, C-3 *cis*), 3.10 (1H, *dd*, $J = 13.00$, 10.30 Hz, C-3 *trans*), 3.90 (3H, *s*, OMe), 5.40 (1H, *dd*, $J = 10.30$, 3.30 Hz, C-2), 6.03 (2H, *d*, $J = 2.0$ Hz, C-6, C-8), 7.40 (5H, *m*, C-2′–C-6′), 12.00 (1H, *s*, exchanged with D_2O, phenolic); ^{13}C NMR ($CDCl_3$, 75.45 MHz): δ55.36 (*q*, OMe), 43.05 (*t*, C-3), 78.89 (*d*, C-2), 162.43, 163.80 and 167.62 (each *s*, C-5, C-7, C-9), 102.80 (*s*, C-10), 138.02 (*s*, C-1′), 94.80 and 93.93 (both *d*, C-6, C-8), 128.54 and 125.81 (each overlapping *d*, C-2′, C-3′, C-4′, C-5′, C-6′) 197.25 (*s*, C=O); MS *m/z* (rel. int.): 270.0889 $[M]^+$ (100), 269.0828 $[M - H]^+$ (39.52), 252.0796 $[M - H_2O]^+$ (4.17), 193.0502 $[M - C_6H_5]^+$ (96.17), 166.0275 (59.5), 138.0310 (32); GC-MS on the silylated product of **3**, *m/z*: 342 $[M + TMS]^+$, 327 $[M + (TMS - Me)]^+$, 238 $[166 + TMS]$.

Compound **4**. Plate-like crystals from EtOAc–petrol, mp 164–165°; λ_{max}^{EtOH} nm (log ε): 285 (1758), 226 (1430), 208 (2016); bathochromic shift with KOH–MeOH; IR ν_{max}^{KBr} cm^{-1}: 3250 (OH), 1660 (C=O), 1600; ^1H NMR ($CDCl_3$, 300 MHz): δ3.02 (2H, *t*, $J = 3.0$ Hz, CH_2 benzylic), 3.40 (2H, *t*, $J = 3.0$ Hz, $COCH_2$), 3.73 (3H, *s*, OMe), 5.94 (2H, *s*, C-3, C-5), 7.26 (5H, *s*, C-2′–C-6′), 11.80 (1H, *s*, exchanged with D_2O, phenolic); ^{13}C NMR ($CDCl_3$, 75.45 MHz): δ54.35 (*q*, OMe), 45.56 (*t*, $CO\underline{C}H_2$), 30.58 (*t*, benzylic CH_2), 165.71, 163.68 and 157.83 (each *s*, C-2, C-6, C-4), 141.48 (*s*, C-1′), 104.95 (*s*, C-1), 93.29 (*d*, C-3, C-5), 128.34, 128.20 and 125.65 (each overlapping *d*, C-2′, C-3′, C-4′, C-5′, C-6′), 205.17 (*s*, C=O); MS *m/z* (rel. int.): 272.1050 $[M]^+$ (17.6), 167.0351 $[M - ArCH_2CH_2]^+$ (100), 255.1017 $[M - OH]^+$ (4.7), 254.0950 $[M - H_2O]^+$ (6.4).

Conversion of **3** *to* **4**. Compound **3** (100 mg) in HOAc (3 ml) was added dropwise to a stirred mixture of Zn dust (300 mg) in water (3 ml). After maintaining the temp. at 20° for 1 hr, the mixture was refluxed for 12 hr. Zinc dust was removed from the reaction mixture and the filtrate worked up in the usual manner to give a solid (60 mg), which upon recrystallization was identical to **4** in every respect.

REFERENCES

1. Asprey, G. F. and Thornton, P. (1954) *Medicinal Plants of Jamaica*, p. 17. West Indies Medicinal Journal, Kingston, Jamaica.
2. Morton, J. F. (1981) *Atlas of Medicinal Plants of Middle America—Bahamas to Yucatan*, p. 123. Charles C. Thomas.
3. Giron, A. (1966) *Relaciones de Unos Aspertose de la Flora Util de Guatemala*, p. 383. Amigos del Bosque, Guatemala.
4. Roig, Y. and Mesa, J. T. (1945) *Plantas Medicinales*, p. 872. Aromaticas O Veneuosas de Cuba, Cultural, S. A. Havana.
5. Oakes, A. J. and Morris, M. P. (1958) *The West Indian Weed Woman of U.S. Virgin Islands*, p. 164. Bull. of the History of Medicine.
6. Guzman, D. J. (1947) *Especies Utiles de la Flora Sulvadorena*, p. 691. Imprenta nacional, San Salvador, El Salvador.
7. Pelter, A., Bayat, R. A., Hansel, R., Dinter, H. and Burke, B. A. (1981) *Tetrahedron Letters* **22**, 1545.
8. Hansel, R. and Pelter, A. (1971) *Phytochemistry* **10**, 1627.
9. Pelter, A. and Hansel, R. (1972) *Z. Naturforsch.* **276**, 1186.
10. Hansel, R., Pelter, A., Schulz, J. and Hille, C. (1976) *Chem. Ber.* **109**, 161.

11. Snatzke, G. and Hansel, R. (1968) *Tetrahedron Letters* **15**, 1797.
12. Ohta, Y., Sakai, T. and Hirose, Y. (1966) *Tetrahedron Letters* 6365.
13. Chatterjee, A., Basa, S. C. and Roy, A. B. (1968) *J. Ind. Chem. Soc.* **45**, 723.
14. Atal, C. K., Moza, P. N. and Pelter, A. (1968) *Tetrahedron Letters* **11**, 1397.
15. Atal, C. K. and Banga, S. J. (1962) *J. Ind. Pharm.* **24**, 105.
16. Viswanathan, N., Balakrishnan, V., Joshi, B. S. and Vonphilipsborn, W. (1975) *Helv. Chim. Acta* **58**, 2026.
17. Joshi, B. S., Viswanathan, N., Gawad, D. H., Balakrishnan, V. and Vonphilipsborn, W. (1975) *Helv. Chim. Acta* **58**, 2295.
18. Loder, J. W., Moorhouse, A. and Russel, G. B. (1969) *Aust. J. Chem.* **22**, 1531.
19. Jossang, P. and Mocho, D. (1970) *Bull. Natl. Hist. Nat. (Paris)* **42**, 440.
20. Dhar, K. L., Atal, C. K. and Pelter, A. (1970) *Planta Med.* **18**, 332.
21. Guenther, E. (1952) *The Essential Oils*, p. 264. Van Nostrand, New York.
22. Dallacker, F. (1969) *Chem. Ber.* **102**, 2663.
23. Calle, A. and Jairo (1983) *Rev. Colomb. Cienc. Quim. Farm* **1**, 47.
24. Lasswell, W. L. Jr. and Hufford, C. D. (1977) *J. Org. Chem.* **42**, 1295.
25. Sauer, H. and Hansel, R. (1967) *Planta Med.* **15**, 443.
26. El-Sholy, H. N., Lasswell, W. L., Jr. and Hufford, C. D. (1979) *J. Nat. Prod.* **42**, 264.
27. Tal., B., Robeson, D. J., Burke, B. A. and Aasen, A. J. (1985) *Phytochemistry* **24**, 729.
28. Pirkle, W., Sikkenga, D. and Paulen, M. (1977) *J. Org. Chem.* **42**, 348.
29. Pirkle, W. and Boden, W. (1977) *J. Org. Chem.* **42**, 3697.
30. Adams, C. D., Proctor, G. R. and Reid, R. W. (1972) *Flowering Plants of Jamaica*, p. 212. University of the West Indies; The University Press, Glasgow.