PERGAMON

Phytochemistry 55 (2000) 505–511

PHYTOCHEMISTRY

www.elsevier.com/locate/phytochem

Review

Distribution of flavonoids in the Myristicaceae

Juan C. Martínez Valderrama *

Departamento de Química, Universidad Nacional de Colombia, A.A. 14490, Santafé de Bogotá, Colombia

Received 29 December 1999; received in revised form 17 February 2000

Dedicated to Professor Dr. Otto Richard Gottlieb for his 80th birthday

Abstract

During the past two decades the study of the Myristicaceae species has increased, and many flavonoids of different types have been isolated. This review discusses the flavonoids presently known in the Myristicaceae. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Myristicaceae; *Compsoneura*; *Dialyanthera*; *Iryanthera*; *Knema*; *Myristica*; *Osteophloeum*; *Otoba*; *Pycnanthus*; *Virola*; Flavonoids

Contents

1. Introduction 505

2. Results 506
   2.1. Chalcones (**1**) 506
   2.2. Flavanones (**2**), flavones (**3**), dihydroflavonols (**4**) and flavonols (**5**) 506
   2.3. Flavans (**6**) and flavan-3-ol (**7**) 507
   2.4. 1,3-Diarylpropanes (**8**) and 1,3-diaryl-2-propanols (**9**) 507
   2.5. Dihydrochalcones (**10**) 508
   2.6. Isoflavones (**11**) 508
   2.7. Pterocarpans (**12**) 509

3. Conclusion 510

References 510

1. Introduction

Interest in the Myristicaceae family was inspired by their ethnopharmacology, and a review describing the research on these plants (Gottlieb, 1979) clearly indicated the need for phytochemical and pharmacological studies of this family. The Myristicaceae family belongs to the Magnonliflorae super-order, morphologically considered one of the most primitive of the Angiosperms, and comprises nineteen genera of trees and shrubs distributed in Asia (four genera), Africa and Madagascar (nine genera) and America (six genera). Fifty samples from among the six genera native to the American continent are housed in the Colombian National Herbarium, including five *Compsoneura*, five *Dialyanthera*, eleven *Iryanthera*, two *Osteophloeum*, three *Otoba* and twenty-four *Virola*. We have collected material (fruit, leaves, bark and wood) from fifteen of these species in the Amazonian region, the Eastern Plains, the Middle Magdalena Antioqueño and the Chocó, and have isolated and identified flavonoids from eight of them. The presence of flavonoids in species of the Myristicaceae family is less common than in other families of Angiosperms, but the occurrence of certain classes of flavonoids is

* Fax: +57-1-3165220.

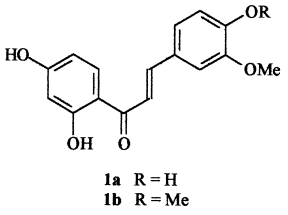
E-mail address: jumarva@ciencias.unal.edu.co (J.C. Martínez Valderrama).

PII: S0031-9422(00)00114-X

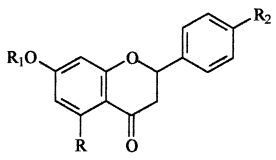
typical of some genera, and can be used to establish chemotaxonomic relationships.

2. Results

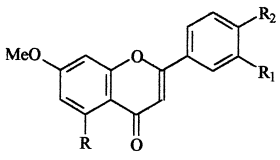
The flavonoids are compounds made up of two phenolic nuclei connected by three carbon units regarded as C_6–C_3–C_6. The different types of flavonoids vary in the oxidation state of the connecting C_3 moiety, which also determines the properties of the flavanoid. Types of flavonoids that have been found in the Myristicaceae species include chalcones, flavanones, flavones, dihydroflavonols, flavonols, flavans, flavan-3-ols, 1,3-diarylpropanes (virolanes), 1,3-diaryl-2-propanols (virolanols), dihydrochalcones, isoflavones and pterocarpans. A biogenetic correlation among the Myristicaceae for all these types of flavonoids is shown in Chart 1.



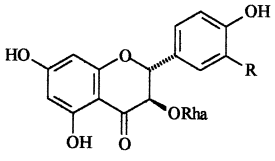
1a R = H
1b R = Me



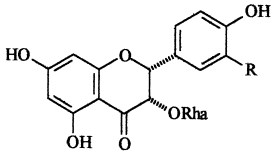
	R	R_1	R_2
2a	OH	H	H
2b	H	Me	OMe



	R	R_1	R_2
3a	H	H	OMe
3b	H	OH	OMe
3c	H	OMe	OMe
3d	H	-OCH_2O-	
3e	OH	H	OMe



4a R = H Rha = Rhamnose
4b R = OH Rha = Rhamnose



4c R = H Rha = Rhamnose
4d R = OH Rha = Rhamnose

2.1. Chalcones (*1*)

Two chalcones, differentiated only by the hydroxyl or methyl groups at C-4, have been isolated and identified solely from *Iryanthera polyneura* (Almeida et al., 1979), and correspond to **1a** and **1b**.

2.2. Flavanones (*2*), flavones (*3*), dihydroflavonols (*4*) and flavonols (*5*)

Only two flavanones have been isolated from Myristicaceae species. One of them, **2a** (pinocembrin), with a phloroglucinol-type A ring, was isolated from *Iryanthera polyneura* wood (Almeida et. al. 1979), and from *Virola surinamensis* twigs (Lopes et al., 1998) and roots (Lopes et al., 1999). The other, **2b**, with a resorcinol-type A ring, was isolated from *Virola carinata* wood (Gottlieb et al., 1976). The absolute configuration at C-2 of these compounds is not known. Of the 315 flavones reported by Wollenweber (1993) which exhibited simple substitutions by hydroxyl, methoxyl and/or methylenedioxy groups, only five have been isolated, from four Myristicaceae species: **3a** from fruit (Cavalcante et al., 1985) and leaves (Daza, 1999) of *Virola flexuosa*; **3a**, **3b**, **3c** and **3d** from the leaves, flowers and fruit (seeds) of *Virola venosa* (Kato, et al., 1992); **3b** (tithonine) from *Virola surinamensis* seeds

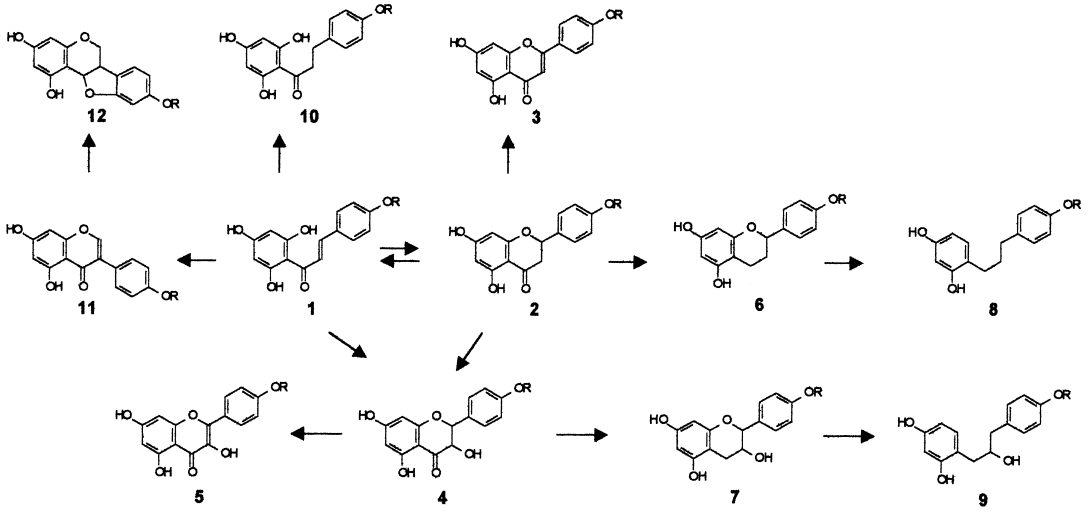
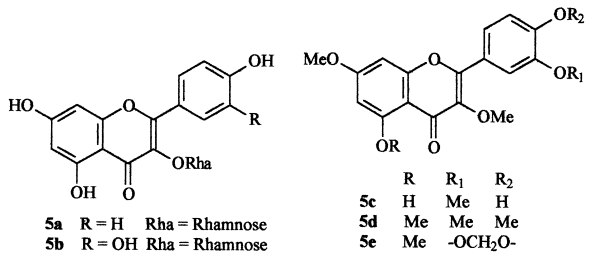
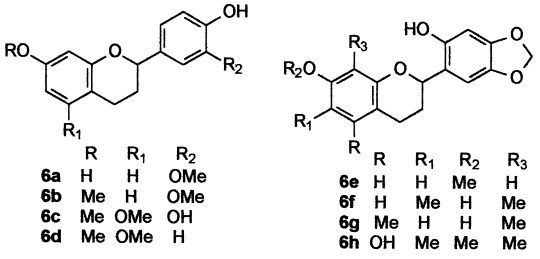


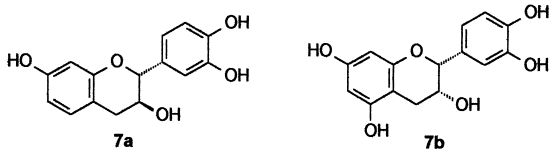
Chart 1. Biogenetic correlation of flavonoids isolated from Myristicaceae. Adapted from Gottlieb (1979).

(Blumental et al., 1997); and **3a**, **3b**, **3c** and **3e** from the leaves of *Virola michelii* (Santos et al., 1996).

Four 3-*O*-α-L-rhamnosyldihydroflavonols were identified from the inflorescences of *Iryanthera sagotiana* (Silva et al., 1997): **4a** (engeletin), **4b** (astilbin), **4c** (isoengeletin) and **4d** (isoastilbin), and two 3-*O*-rhamnosylflavonols **5a** (afzelin) and **5b** (quercitrin). **4a**, **4b**, **5a**, **5b** were isolated from the leaves of *I. sagotiana* (Silva et al., 1997). From the leaves of the *Otoba parvifolia*, three flavonols with C3-*O*-methyl groups (**5c**, **5d** and **5e**) were reported (Devia and Martínez, 1999).







2.3. Flavans (*6*) and flavan-3-ol (*7*)

The flavans and flavan-3-ols, though not very abundant in nature, serve as monomer units of proanthocyanidins; in the case of the Myristicaceae, they seem to be the precursors of virolanes and virolanols.

Eight flavans have been identified in Myristicaceae species (**6a**–**6h**), and all have been isolated from wood: **6a** from *Iryanthera elliptica* (Braz Filho et al., 1980b) and *Knema austrosiamensis* (Gonzales et al., 1993); **6b** from *Virola calophylloidea* (Martínez and Cuca, 1987); **6c** from *Iryanthera coriacea* (Franca et al., 1974; de Lima et al., 1975); **6a**, **6d** from *Iryanthera grandis* (Díaz and de Díaz, 1986); **6e** from *Iryanthera juruensis* (Franca et al., 1974); and **6f**, **6g** and **6h** from *Iryanthera laevis* (Braz Filho et al., 1980a). Compounds **6a**–**6d** are indicated to exist as racemates; the stereochemistry of **6f**, **6g** and **6h** is not known.

Only two flavan-3-ols have been reported, corresponding to **7a** ((−)fisetinidol) isolated from *Virola elongata* wood (Kijjoa et al., 1981), and **7b** ((−)epicatechin) from *Myristica fragrans* seeds (Gopalarkishnan and Mathew, 1983).

2.4. 1,3-Diarylpropanes (*8*) and 1,3-diaryl-2-propanols (*9*)

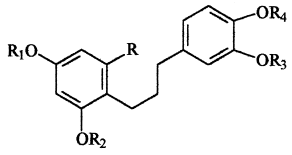
The presence of these classes of compounds is limited, with very few exceptions, to species of the Myristicaceae; since the first analogues were found in species of the *Virola* genus, they were named virolanes and virolanols (Braz Filho et al., 1973). Fifteen virolanes (**8a**–**8o**) and three virolanols (**9a**–**9c**) in the genera *Virola*, *Iryanthera* and *Knema* (Table 1) have been reported. All have been isolated from wood, as is common with the flavans and flavan-3-ols that are considered to be their biogenetics precursors. The stereochemistry of virolanols has been variously assigned as 2R (Kijjoa et al., 1981) and 2S (Fernandez et al., 1980).

The 1,3-diarylpropanes are used to prevent the growth of malaria mosquito larvae (Jurd, 1977) and the 1,3-diaryl-2-propanols inhibit electrically-induced contractions in smooth muscle (Hagos et al., 1987). Two structurally modified compounds of the 1,3-diarylpro-

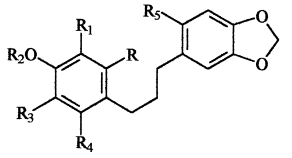
Table 1
Distribution of 1,3-diarylpropanes and 1,3-diaryl-2-propanols in the Myristicaceae

Source	Compounds	References
V. caducifolia	**8g**, **9a**	Braz Filho et al., 1976b
V. calophylloidea	**8c**	Martínez and Cuca, 1987
V. divergens	**8g**, **9a**	Gottlieb et al., 1973; Fernandez et al., 1980
V. elongata	**8g**, **9a**, **9b**, **9c**	Kijjoa et al., 1981
V. flexuosa	**8g**, **9a**	Braz Filho et al., 1977
V. guggenheimii	**8g**, **9a**	Fernandez et al., 1980
V. melinonii	**8g**, **9a**	Gottlieb et al., 1973
V. minutiflora	**8g**	Kijjoa et al., 1981
V. multinervia	**8a**	Braz Filho et al., 1976a
	8g, **9a**	Braz Filho et al., 1973
V. pavonis	**8g**, **9a**	Gottlieb et al., 1973
V. sebifera	**8a**, **9b**, **9c**	Von Rotz et al., 1990
V. surinamensis	**8g**, **9a**	Gottlieb et al., 1973
V. venosa	**8g**, **9a**	Gottlieb et al., 1973
I. coriacea	**8b**, **8f**, **8g**, **8h**, **8i**, **8m**	de Lima et al., 1975
I. elliptica	**8b**	Braz Filho et al., 1980a
I. grandis	**8e**, **8f**, **8h**, **8j**, **8o**	Díaz and de Díaz, 1986
I. laevis	**8h**, **8j**, **8k**, **8m**	Braz Filho et al., 1980
I. paraensi	**8b**, **8f**, **8g**, **8h**, **8j**	Da Silva et al., 1984
I. polyneura	**8f**, **8j**	Almeida et al., 1979
I. tricornis	**8b**, **8f**, **8h**	Da Silva et al., 1984; Salazar et al., 1988
I. ulei	**8h**, **8j**, **8l**, **8m**, **8n**	Conserva et al., 1990a
Knema austrosiamensis	**8d**	Gonzales et al., 1993

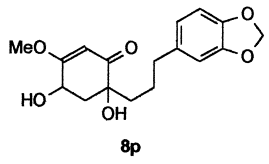
pane-type have been isolated: virolaflorin (**8p**) isolated from *Virola minutiflora* wood (Kijjoa et al., 1981) and spiroelliptin (**8q**) isolated from *Iryanthera elliptica* wood (Braz Filho et al., 1980b).



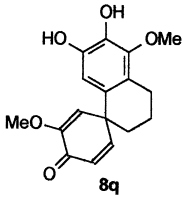
	R	R_1	R_2	R_3	R_4
8a	H	H	Me	H	Me
8b	H	H	Me	Me	H
8c	H	Me	H	Me	H
8d	H	Me	H	H	Me
8e	OMe	Me	H	Me	H



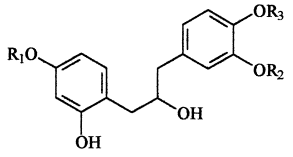
	R	R_1	R_2	R_3	R_4	R_5
8f	H	H	H	H	OH	H
8g	H	H	Me	H	OH	H
8h	H	H	H	H	OH	OMe
8i	H	H	Me	H	H	OH
8j	H	H	H	Me	OH	OMe
8k	H	Me	Me	H	OH	OH
8l	H	Me	H	H	OMe	OH
8m	H	Me	H	Me	OH	OH
8n	OMe	Me	H	Me	OH	OH
8o	OMe	H	Me	H	OH	H



8p



8q



	R_1	R_2 R_3
9a	H	-CH2-
9b	H	Me H
9c	Me	Me H

2.5. Dihydrochalcones (*10*)

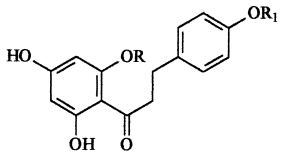
Seven simple dihydrochalcones (**10a**–**10g**) from different parts of the plant (bark, inflorescences, fruit, leaves and wood) have been reported; they are very common in species of the *Iryanthera* genus (Table 2). The genus *Virola* has thus far yielded only the (±)-α-hydroxydihydrochalcone **10h**.

The first biflavonoid (**10i**) reported from the Myristicaceae family was isolated from the leaves of *Iryanthera sagotiana* (Silva et al., 1997), and is the second dimer of dihydrochalcone isolated as a natural product.

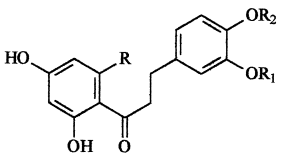
A complex group of dihydrochalcones, designated Iryantherins, has thus far been isolated exclusively from *Iryanthera* species: **10j**, **10k**, **10l**, **10m** and **10n** from *I. laevis* (Garzón et al., 1987; Martínez and Cuca, 1989; Conserva et al., 1990b); **10k**, **10m**, **10n** and **10o** from *I. ulei* (Conserva et al., 1990b); **10o** from *I. paraensis* (Conserva et al., 1990b); and **10p**, **10q**, **10r** and **10s** from *I. grandis* (Silva et al., 1995). Only relative configurations are known for Iryantherins **10p** to **10s**, as indicated in the structures.

Table 2
Distribution of dihydrochalcones in the Myristicaceae

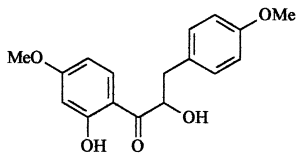
Source	Compounds	References
I. grandis, fruits	**10c**	Vieira et al., 1983; Silva et al., 1995
I. laevis, bark	**10c**, **10f**, **10g**	Martínez and Cuca, 1989
fruits	**10a**, **10c**	Garzón et al., 1987
wood	**10c**	Braz Filho et al., 1980
I. paraensis, bark	**10c**	Conserva et al., 1990b
I. polyneura, wood	**10e**	Almeida et al., 1979
I. sagotiana, bark	**10c**, **10g**	Kawanishi et al., 1990
inflorescence	**10a**, **10b**, **10c**, **10d**	Silva et al., 1997
leaves	**10b**, **10c**	Silva et al., 1997
I. ulei, bark	**10f**	Conserva et al., 1990a
wood	**10c**	Conserva et al., 1990a
V. Calophylloidea, wood	**10h**	Martínez and Cuca, 1987
V. surinmensis, twigs	**10h**	Lopes et al., 1998
roots	**10h**	Lopes et al., 1999
V. carinata, bark	**10h**	Benavides, 1999



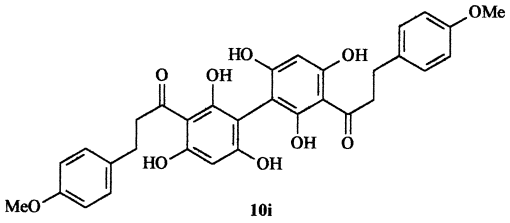
	R	R_1
10a	H	Me
10b	Me	H
10c	Me	Me
10d	Glu	Me



	R	R_1	R_2
10e	H	Me	H
10f	OMe	Me	Me
10g	OMe	-OCH_2O-	



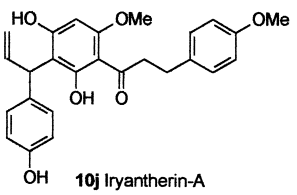
10h



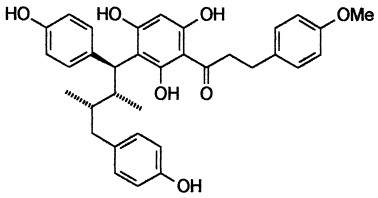
10i

2.6. Isoflavones (*11*)

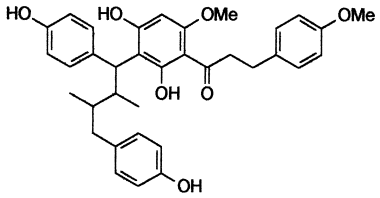
From the results of some of the first studies on Myristicaceae species (Braz Filho et al., 1976a, 1977) it was concluded that isoflavonoids were a characteristic of this family (Gottlieb, 1979), but further reports of this type of compound have only recently begun to appear (Devia and Martinez, 1999; Benavides, 1999). Ten isoflavonoids (**11a**–**11j**) have been isolated from seven species of Myristicaceae (Table 3).



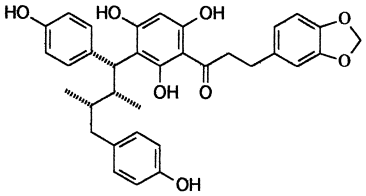
10j Iryantherin-A



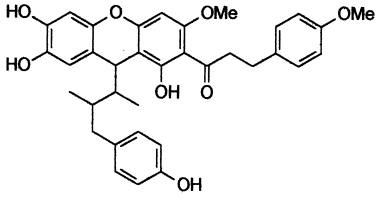
10q Iryantherin-H



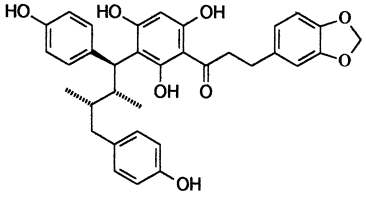
10k Iryantherin-B



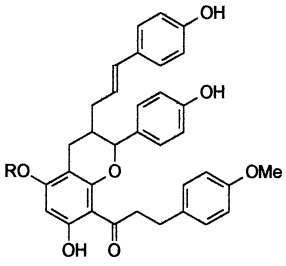
10r Iryantherin-I



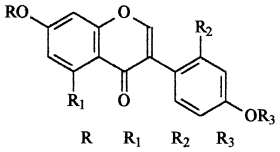
10l Iryantherin-C



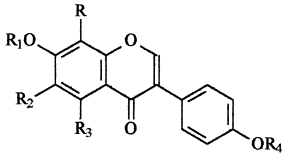
10s Iryantherin-J



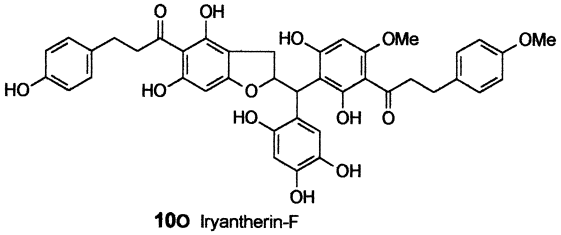
10m R = H Iryantherin-D
10n R = Me Iryantherin-E



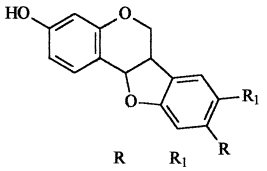
	R	R_1	R_2	R_3
11a	H	OH	H	Me
11b	H	OH	OH	Me
11c	H	OH	OMe	Me
11d	H	H	H	Me
11e	H	H	OH	Me
11f	H	OH	H	H
11g	Me	H	OH	Me



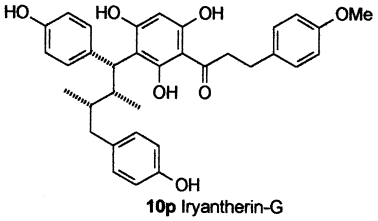
	R	R_1	R_2	R_3	R_4
11h	H	Me	H	OH	H
11i	H	H	OMe	OH	Me
11j	OMe	H	H	H	Me



10o Iryantherin-F



	R	R_1
12a	OMe	H
12b	$-OCH_2O-$	



10p Iryantherin-G

2.7. *Pterocarpans* (*12*)

Two pterocarpans, namely (±)-3-demethylhomopterocarpin (medicarpin, **12a**) and (±)-maackiain (**12b**) (Braz Filho et al., 1977), have been reported, both from the leaves of *Osteophloeum platyspermum*.

Table 3
Distribution of isoflavonoids in the Myristicaceae

Source	Compounds	References
V. caducifolia, wood	**11a**, **11b**, **11c**	Braz Filho et al., 1976b
	11a, **11b**, **11c**, **11d**, **11e**	Braz Filho et al., 1977
V. carinata, bark	**11a**, **11d**, **11e**, **11f**, **11h**	Benavides, 1999
V. multinervia, wood	**11b**, **11c**, **11d**, **11e**	Braz Filho et al., 1977
V. surinamensis, twigs	**11a**, **11b**, **11e**	Lopes et al., 1998
roots	**11a**, **11d**, **11g**	Lopes et al., 1999
seed	**11i**	Blumental et. al. 1997
Knema glomerata, bark	**11j**	Zeng et al., 1994
Otoba parvifolia, bark	**11a**, **11h**	Devia and Martínez, 1999
Pycnanthus angolensis, wood	**11e**, **11g**	Omobuwajo et al., 1992

3. Conclusion

The established occurrence of flavonoids in seven genera of Myristicaceae suggests that this class of metabolites is a general feature of this family. There are twelve types of flavonoids reported in Myristicaceae, among which the aromatic B ring (derivative from shikimic acid) is either oxygenated at C-4 or dioxygenated at C-3, C-4 but not trioxygenated at C-3, C-4, C-5 as expected according to the phenylpropanoids such as myristicin (Forrest et al., 1972) and elemicin (Barata et al., 1978) isolated from this family. Finally, it is of note that the presence of 1,3-diarylpropanes and 1,3-diaryl-2-propanols is restricted to the wood of *Virola*, *Iryanthera* and *Knema* genus; further, the occurrence of dihydrochalcones is a chemotaxonomic characteristic of the *Iryanthera* genus, and the Iryantherins are unique to this family.

References

Almeida, M.E.L. de, Braz Filho, R., von Bulow, M.V., Correa, J.J.L., Gottlieb, O.R., Maia, J.G.S., da Silva, M.S., 1979. Diarylpropanoids from *Iryanthera polyneura*. Phytochemistry 18, 1015–1016.

Barata, L.E.S., Baker, P.M., Gottlieb, O.R., Rúveda, E.A., 1978. Neolignans of *Virola surinamensis*. Phytochemistry 17, 783–786.

Benavides, E., 1999. Contribución al Estudio Químico de los extractos Etanólicos de las Hojas y Corteza de la Especie *Virola* sp., Trabajo de grado, Departamento de Química, Universidad Nacional de Colombia, Bogotá.

Blumental, E.E. de, A., Da Silva, M.S., Yoshida, M., 1997. Lignoids, Flavonoids and Polyketides of *Virola surinamensis*. Phytochemistry 46, 745–749.

Braz Filho, R., Da Silva, M.S., Gottlieb, O.R., 1980. Flavonoids from *Iryanthera laevis*. Phytochemistry 19, 1195–1197.

Braz Filho, R., Diaz, P.P., Gottlieb, O.R., 1980a. Tetronic acid and diarylpropanes from *Iryanthera elliptica*. Phytochemistry 19, 455–459.

Braz Filho, R., Frota Leite, M.F., Gottlieb, O.R., 1973. Constitution of diarylpropanoids from *Virola multinervia*. Phytochemistry 12, 417–419.

Braz Filho, R., Gottlieb, O.R., De Moraes, A.A., Pedreira, G., Pinho, S.L.V., Magalhaes, M.T., Ribeiro, M.N., 1977. Isoflavonoids from Amazonian species. Lloydia 40, 236–238.

Braz Filho, R., Gottlieb, O.R., Pinho, S.L.V., 1976a. Diarylpropanoids from *Virola multinervia*. Phytochemistry 15, 567–568.

Braz Filho, R., Pedreira, G., Gottlieb, O.R., Maia, J.G., 1976b. Isoflavones from *Virola caducifolia*. Phytochemistry 15, 1029–1030.

Cavalcante, S de H., Fernandes, D., Paulino Filho, H.F., Yoshida, M., Gottlieb, O.R., 1985. Lignoids from the fruit of three *Virola* species. Phytochemistry 24, 1865–1866.

Conserva, L.M., Yoshida, M., Gottlieb, O.R., 1990a. Diarylpropanes from *Iryanthera ulei*. Phytochemistry 29, 3986–3988.

Conserva, L.M., Yoshida, M., Gottlieb, O.R., Martínez, V.J.C., Gottlieb, H.E., 1990b. Iryantherins, lignoflavonoids of novel structural types from the Myristicaceae. Phytochemistry 29, 3911–3918.

Da Silva, J.J., Giesbrecht, A.M., Alvarenga, M.A., Gottlieb, O.R., 1984. 1,3-Diarilpropano de *Iryanthera paraensis* e *Iryanthera tricornis*. Acta Amazonica 14 (3–4), 455–457.

Daza, M.C., 1999. Estudio Químico de las Hojas de *Virola flexuosa*. Trabajo de Grado, Departamento de Química, Universidad Nacional de Colombia, Bogotá.

de Lima, R.A., Franca, N.C., Diaz, P.P., Gottlieb, O.R., 1975. Diarylpropanes from *Iryanthera coriaceae*. Phytochemistry 14, 1831–1833.

Devia, J., Martínez V.J.C., 1999. Flavonoides en Hojas y Corteza de *Otoba parvifolia*. Trabajo de Grado, Departamento de Química, Universidad Nacional de Colombia, Bogotá.

Díaz, P.P., de Díaz, A.M., 1986. Diarylpropanes from the wood of *Iryanthera grandis*. Phytochemistry 25, 2395–2397.

Fernandez, J.B., Ribeiro, M.N., Gottlieb, O.R., Gottlieb, H.E., 1980. Eusiderins and 1,3-diarylpropanes from *Virola* Species. Phytochemistry 19, 1523–1525.

Franca, N.C., Diaz, P.P., Gottlieb, O.R., de P., Rosa, B., 1974. Flavans from *Iryanthera* species. Phytochemistry 13, 1631–1632.

Forrest, J.E., Heacock, R.A., Forrest, T.P., 1972. Identification of the major components of the essential oil of mace. Journal of Chromatography 69, 115–121.

Garzón, L., Cuca, L.E., Martínez, V.J.C., Yoshida, M., Gottlieb, O.R., 1987. Flavonolignoids from the fruit of *Iryanthera laevis*. Phytochemistry 26, 2835–2837.

Gonzales, M.J., Pinto, M.M., Kijjoa, A., Anantachoke, C., Herz, W., 1993. Stilbenes and other constituents of *Knema austrosiamensis*. Phytochemistry 32, 433–438.

Gopalarkishnan, M., Mathews, A.G., 1983. Proanthocyanidins of nutmeg. Indian Cocoa Arecanut Species Journal 64, 105.

Gottlieb, O.R., 1979. Chemical studies on medicinal Myristicaceae from Amazonia. Journal of Ethnopharmacology 1, 309–323.

Gottlieb, O.R., Maia, J.G.S., Ribeiro, M.N., 1976. Neolignans from *Virola carinata*. Phytochemistry 15, 773–774.

Gottlieb, O.R., Loureiro, A.A., Dos Santos, C.M., Da Rocha, A.I., 1973. Distribution of diarylpropanoids in Amazonian *Virola* species. Phytochemistry 12, 1830.

Hagos, M., Samuelson, G., Kenne, L., Modawi, B., 1987. Isolation of smooth muscle relaxing 1,3-diarylpropane-2-ol derivatives from *Acacia tortilis*. Planta Medica 53, 27–31.

Jurd, L., 1977. Cinnamyl phenols as growth inhibitor for mosquito larvae. US patent 3, 973040. Chemical Abstract 83, 6410.

Kato, M.J., Yoshida, M., Gottlieb, O.R., 1992. Flavones and lignans in flowers, fruits and seedlings of *Virola venosa*. Phytochemistry 31, 283–287.

Kawanishi, K., Takagaki, T., Hashimoto, Y., 1990. Dihydrochalcones from *Iryanthera sagotiana*. Phytochemistry 29, 2735–2736.

Kijjoa, A., Giesbrecht, A.M., Gottlieb, O.R., Gottlieb, H.E., 1981. 1,3-Diaryl-propanes and propan-2-ols from *Virola* species. Phytochemistry 20, 1385–1388.

Lopes, N.P., Chicaro, P., Kato, M.J., Albuquerque, S., Yoshida, M., 1998. Flavonoids and lignans from *Virola surinamensis* twigs and

their in vitro activity against *Trypanosoma cruzi*. Planta Medica 64, 667–669.

Lopes, N.P., Kato, M.J., Yoshida, M., 1999. Antifungal constituents from roots of *Virola surinamensis*. Phytochemistry 51, 29–33.

Martínez, V.J.C., Cuca, L.E., 1987. Flavonoids from *Virola calophylloidea*. Journal of Natural Products 50, 1045–1047.

Martínez, V.J.C., Cuca, L.E., 1989. Dihidrochalcona en Corteza de *Iryanthera laevis*. Revista Colombiana de Química 18 (1–2), 37–46.

Omobuwajo, O.R., Adesanya, S.A., Babalola, G.O., 1992. Isoflavonoids from *Pycnanthus angolensis* and *Baphia nitida*. Phytochemistry 31, 1013–1014.

Salazar, L.M., Cuca, L.E., Martínez, V.J.C., 1988. 1,3-Diarilpropanos en Madera de *Iryanthera tricornis*. Revista Colombiana de Química 17 (1–2), 23–37.

Santos, L.S., Correa, M.J.C., Campos, L.M.O., Andrade, M.A., 1996. Constituents from the leaves of *Virola michelii*. Fitoterapia 67 (6), 555–556.

Silva, D.H.S., Cavalheiro, A.J., Yoshida, M., Gottlieb, O.R., 1995. Flavonolignoids from fruits of *Iryanthera grandis*. Phytochemistry 38, 1013–1016.

Silva, D.H.S., Yoshida, M., Kato, M.J., 1997. Flavonoids from *Iryanthera sagotiana*. Phytochemistry 46, 579–582.

Vieira, P.C., Gottlieb, O.R., Gottlieb, H.E., 1983. Tocotrienols from *Iryanthera grandis*. Phytochemistry 22, 2281–2286.

Von Rotz, R., Cuca, L.E., Martínez, V.J.C., 1990. Diarilpropanos y Derivado Indólico en Madera de *Virola sebifera* y *Virola calophylloidea*. Revista Colombiana de Química 17 (1–2), 23–37.

Wollenweber, E., 1993. Flavones and flavonols. In: Harborn, J. B., (Ed.), The Flavonoids: Advances in Research Since 1986. Chapman & Hall, London; Chapter 7.

Zeng, L., Gu, Z.-M., Fang, X.-P., McLaughlin, J.L., 1994. Kneglomeratanol, Kneglomeratanones A and B, and related bioactive compounds from *Knema glomerata*. Journal of Natural Products 57, 376–381.