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A Review

FLAVONOIDS IN THE SPECIES OF THE FAMILY ARACEAE: A REVIEW

Sebuah tinjauan: Senyawa-senyawa flavonoid pada suku Araceae

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Abstrak

Flavonoid merupakan salah satu metabolit sekunder dan terdiri dari dua cincin fenil (cincin A dan B) yang dihubungkan oleh jembatan tiga karbon. Lebih dari 8000 jenis flavonoid dilaporkan dari tumbuhan berpembuluh dan Bryophyta. Makalah ini mengulas karakter flavonoid dari suku Araceae *s.l.* (termasuk Lemnaceae). Sebagian besar flavonoid utama dari suku Araceae adalah C-glikosilflavon dengan pengecualian untuk anak suku Gymnostachydoideae dan Orontioideae. Jenis flavonoid lainnya, yaitu anthocyanin, flavon, flavonol, flavan, dan proanthocyanidins dilaporkan terdapat pada semua anak suku Araceae. Flavanon dan C-glikosil flavanon diisolasi masing-masing dari *Spirodela polyrhiza* dan *Anthurium binotii*. Namun demikian, dihydroflavonol, chalcone, dihydrochalcone, aurone, dan isoflavonoid tidak dilaporkan terdapat pada jenis-jenis dari suku Araceae yang telah diteliti. Meskipun Araceae *s.l.* merupakan suku tumbuhan besar yang terdiri atas sekitar 3645 jenis dan 144 marga, baru 146 jenis dari 48 marga yang diketahui kandungan flavonoidnya.

Kata kunci: Araceae, *C*-glycosylflavone, distribusi, flavonoid, Lemnaceae

Abstract

Flavonoids is one of the secondary metabolites and consists of two phenyl rings (A- and B-rings) connected by a three carbon bridge. Over 8000 kinds of flavonoids were reported from vascular plants and Bryophytes. This paper reviewed the flavonoid characters of the Araceae s.l. (including the Lemnaceae). Major flavonoids of the family were *C*-glycosylflavones with the exception for subfamilies Gymnostachydoideae and Orontioideae. Other flavonoid classes, i.e. anthocyanins, flavones, flavonols, flavan and proanthocyanidins, were reported in all subfamilies. Flavanone and *C*-glycosylflavanone were isolated from *Spirodela polyrhiza* and *Anthurium binotii*, respectively. However, dihydroflavonol, chalcone, dihydrochalcone, aurone, and isoflavonoids were not reported in the Araceae. Although Araceae s.l. is a large family consisting of ca. 3645 species and ca. 144 genera, flavonoids were surveyed only in 146 species of 48 genera, as far as known.

Keywords: Araceae, *C*-glycosylflavones, distribution, flavonoids, Lemnaceae

INTRODUCTION

Flavonoids is the general term for the compounds which have a fifteen carbon skeleton. At the simplest level, the skeleton consists of two phenyl rings (A- and B-rings) connected by a three carbon bridge (C-ring). In general, vascular plants and Bryophytes alone possess the biosynthetic ability of the flavonoids except for a few algae and fungi (List & Freud 1968, Zeng *et al*. 2001, Liu *et al.* 2009). Flavonoids can be divided into several classes, e.g. anthocyanins, aurones, biflavones, chalcones, dihydrochalcones, dihydroflavonols, flavan and proanthocyanidins, flavanones, flavones, flavonols, isoflavonoids, and so on. Anthocyanins are based on the flavilium salt structure (Figure 1). The common anthocyanidins are pelargonidin, cyanidin, peonidin, delphinidin, petunidin, and

malvidin. Flavones have substitutions on the A- and B-rings but lack oxygenation at the 3-position of the C-ring (Figure 2). Although flavones are generally present in vacuoles of cells as *O*- and/or *C*-glycosides (*C*-glycosylflavones), some compounds particularly the simple and polymethoxylated flavones, occur in heart woods and as farinose exudates, bud wax, and so on. Flavonols are flavones that are attached to a hydroxyl group at 3-position (Figure 3).

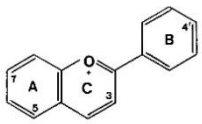

Figure 1. Anthocyanin

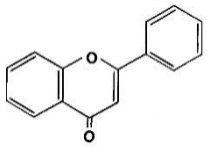

Figure 2. Flavone

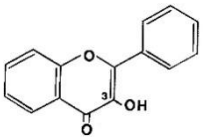

Figure 3. Flavonol

Chalcones and dihydrochalcones lack a central heterocyclic ring (C-ring). Positions on these compounds are identified using a numbering system unique to these groups. Chalcones were apparently recognized as being structurally related to acetophenones whose ring carbons were identified by primed numbers. Hence, chalcones and dihydrochalcones A-ring carbons are also identified with primed numbers and the B-ring carbon is identified with unprimed numbers. Chalcones are double bonding between the α- and β-positions, but not in dihydrochalcones. So that the color of many chalcones turns yellow (Figure 4). Aurones are based on the 2-benzylidene-coumaranone or 2-benzylidene-3(2H)-benzo-furanone system, and characterized by the presence of a five-membered heterocyclic ring. Aurone glycosides act as water-soluble yellow pigments on the flowers (Figure 5). Two structural features, i.e. the absence of the double bond between the 2- and 3-positions, and the presence of a chiral center at the 2-position, characterize flavanone. Dihydroflavonols, i.e. 3-hydroxy-flavanones are requisite intermediates on the pathway to flavonols by one route and to anthocyanins via flavan 3,4-diols by another (Figure 6).

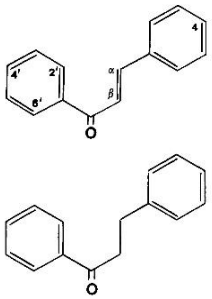

Figure 4. Chalcone (upper) and Dihydrochalcone (lower)

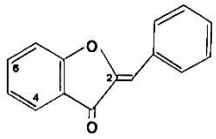

Figure 5. Aurone

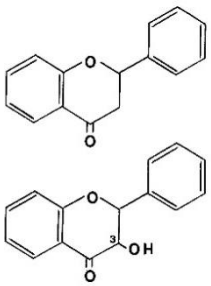

Figure 6. Flavanone (upper) and Dihydroflavonol (lower)

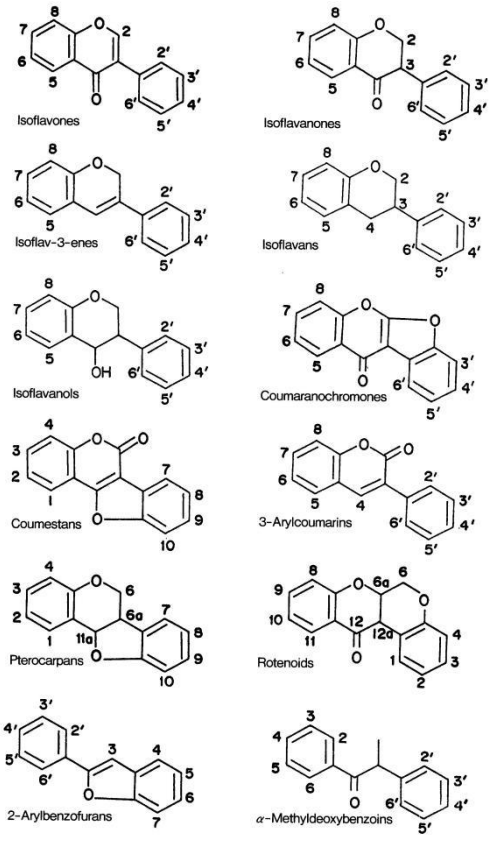

Figure 7. Basic chemical structures of isoflavonoids

Isoflavonoids differ from other flavonoid classes in having as a basic structural feature that B-ring attaches to C-3 but not C-2, and subdivided into several classes, e.g. isoflavones, coumestans, coumaronochromones, pterocarpans, rotenoids, and so on (Figure 7). Flavan and proanthocyanidins which lack a 4-carbonyl group are noteworthy for their activities on human health. Moreover, numerous sorts of flavonoids occur in plants with additional hydroxyl, methoxyl, methyl and/or glycosyl substitution patterns. Additionally, aromatic and aliphatic acids, sulfate, prenyl and/or methylenedioxyl groups also attach to flavonoids and their glycosides. Thus, more than 8000 kinds of flavonoids have been reported as naturally occurring compounds. The isolation and identification, structures, distribution and biosynthesis of flavonoids in plants have been reviewed by many authors e.g. Harborne *et al*. (1975), Harborne & Mabry (1982), Harborne (1988, 1994), Iwashina (2000), Andersen & Markham (2006).

The flavonoids as medicinal resources were also reviewed by several researchers such as Cody *et al*. (1986, 1988), Rice-Evans & Packer (1998). Anthocyanins in particular were recently noticed as antioxidants, antitumor, astringents as well as other medicinal properties (Ohba *et al*. 2000). However, secondary metabolites such as flavonoids were considered to be a waste products of plant metabolism in early days of the 20th century. One of the most important functions of flavonoids may be to serve as an ultraviolet filter in land plants. It was shown by the survey of some plant species that the flavonoids act as UV shield.

The occurrence of anthocyanins as pollinator attractants is well-known as a function of flavonoids in plants. Additionally, it is known that flavones and flavonols, which can hardly be seen by human eyes, also act as pollinator attractants in addition to visible anthocyanins. Moreover, other functions, e.g. oviposition stimulants, feeding attractants, feeding deterrents, allelopathy and phytoalexins of naturally occurring flavonoids, were reported by many authors e.g. Iwashina (2003).

The Araceae is a large family of mostly herbaceous species, with great diverse in appearance. They are herbaceous with aerial stems or underground tubers or rhizomes, but there are a few woody species. The family included several climbers and epiphytes as well as a floating water plant, and consists of ca. 3645 species of ca. 144 genera (Boyce & Croat 2011 onwards). APG III (2009) excluded the genus *Acorus* from Araceae, erected it in its own family, Acoraceae, and included Lemnaceae (genera *Landoltia*, *Lemna*, *Spirodela*, *Wolffia, Wolffiella*) into the Araceae. Araceae is divided into eight subfamilies, i.e. Aroideae, Gymnostachydoideae, Lasioideae, Lemnoideae, Monsteroideae, Orontioideae, Pothoideae, and Zamioculcadoideae. Of the araceous species, flavonoids were reported from 146 taxa of 48 genera. However, flavonoids were not reported from three genera of the Zamioculcadoideae growing in Africa. This review paper presents and describes the characters and distribution of flavonoids in the Araceae. The abbreviations used in Tables 1 – 8 are as follows: ap = aerial part, cr = corm, ep = epidermis, fl = flower, fr = fruit, if = inflorescence, lf = leaf, pt = petiole, rz = rhizome, sp = spathe, st = stem, sx = spadix, tb = tuber, wp = whole plant.

FLAVONOIDS IN THE SUBFAMILY GYMNOSTACHYDOIDEAE

Gymnostachys anceps alone belongs to this subfamily and was surveyed for flavonoids (Table 1). A flavonol glycoside, kaempferol 3-sophoroside-7-rhamnoside (Figure 8) was isolated from the leaves of this species (Williams *et al*. 1971). Other flavonoids were not reported. Williams *et al*. (1971) surveyed the *C*-glycosylflavones which were common flavonoids in the Araceae including Lemnaceae, however they were not present in this species.

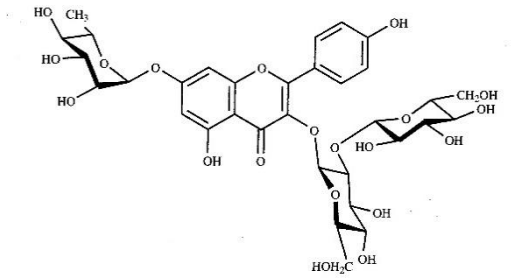

Figure 8. Kaempferol 3-sophoroside-7-rhamnoside

Table 1. Reports on the flavonoids from the species of subfamily Gymnostachydoideae

Gymnostachys anceps R.Br.
Flavonol: kaempferol 3-sophoroside-7-rhamnoside (lf) (Williams *et al*. 1971)

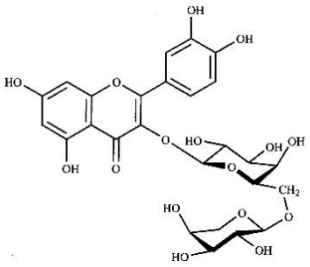

Figure 9. Quercetin 3-arabinosyl-(1→6)- galactoside

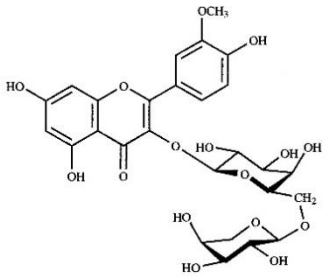

Figure 10. Isorhamnetin 3-arabinosyl-(1→6)-galactoside

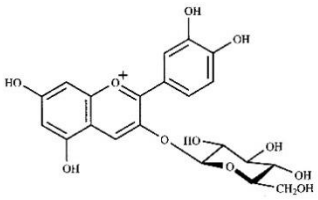

Figure 11. Cyanidin 3-glucoside

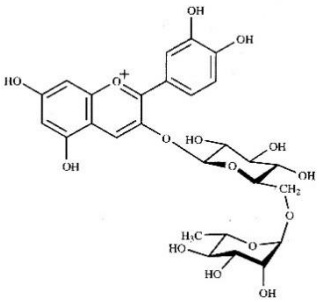

Figure 12. Cyanidin 3-rutinoside

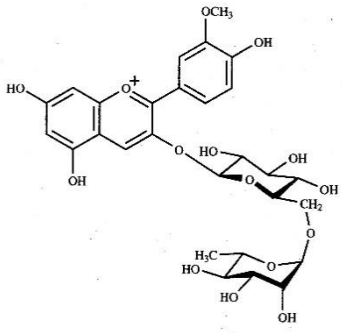

Figure 13. Peonidin 3-rutinoside

FLAVONOIDS IN THE SUBFAMILY ORONTIOIDEAE

Four species of subfamily Orontioideae, i.e. *Lysichiton camtschatcensis*, *Orontium aquaticum*, *Symplocarpus foetidus,* and *S. renifolius*, were surveyed for flavonoids (Table 2). Williams *et al*. (1981) and Whang & Lee (1999) reported that major flavonoids of this subfamily were flavonols, namely, kaempferol 3-arabinosyl-(1→6)-galactoside, 3-xylosylgalactoside and 3-sophoroside-7-glucoside, quercetin 3-arabinosyl-(1→6)-galactoside (Figure 9), 3-galactoside, 3-sophoroside and 3-sophoroside-7-glucoside, and isorhamnetin 3-arabinosyl-(1→6)-galactoside (Figure 10).

A quercetin glycoside which was acylated with caffeic acid, quercetin 3-sophoroside-7-(6”-*E*-caffeoylglucoside), was isolated from the leaves of *Symplocarpus renifolius* (Whang & Lee 1999). Three anthocyanins, namely cyanidin 3-glucoside (Figure 11), 3-rutinoside (Figure 12) and peonidin 3-rutinoside (Figure 13), were detected in the flowers of *Symplocarpus foetidus* (Chang *et al*. 1970).

Table 2. Reports on the flavonoids from the species of subfamily Orontioideae

Lysichiton camtschatcensis (L.) Schott
Flavonol: isorhamnetin 3-arabinosyl-(1→6)-galactoside, kaempferol 3-arabinosyl-(1→6)-galactoside, kaempferol 3-xylosylgalactoside, quercetin 3-arabinosyl-(1→6)-galactoside (lf) (Williams *et al*. 1981)

Orontium aquaticum L.
Flavonol: isorhamnetin 3-galactoside, isorhamnetin 3-rhamnosylgalactoside, kaempferol 3-galactosylglucoside, quercetin 3-galactoside (lf) (Williams *et al*. 1981)

Symplocarpus foetidus (L.) Salisb. ex W.P.C.Barton
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-rutinoside, peonidin 3-rutinoside (fl) (Chang *et al*. 1970),
Flavonol: kaempferol 3-diglucoside, kaempferol galactosylglucoside, quercetin galactosyl-glucoside (lf) (Williams *et al*. 1981)

Symplocarpus renifolius Schott ex Tzvelev
Flavonol: isorhamnetin 3-sophoroside-7-glucoside, kaempferol 3-sophoroside-7-glucoside, quercetin 3-sophoroside, quercetin 3-sophoroside-7-(6´´-*E*-caffeoylglucoside), quercetin 3-sophoroside-7-glucoside (lf) (Whang & Lee 1999)

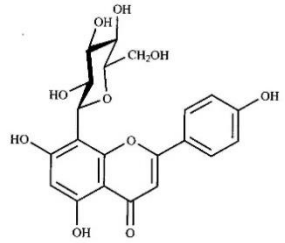

Figure 14. Vitexin

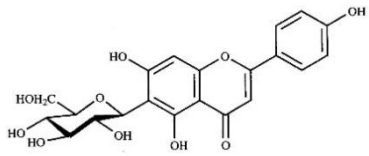

Figure 15. Isovitexin

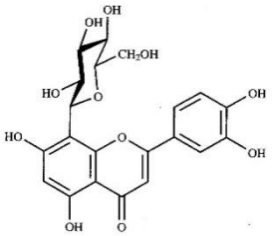

Figure 16. Orientin

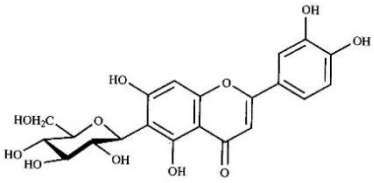

Figure 17. Isoorientin

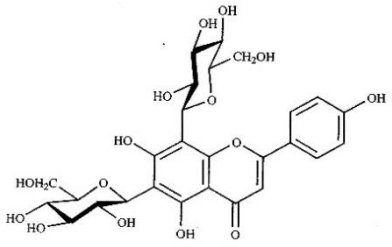

Figure 18. Vicenin-2

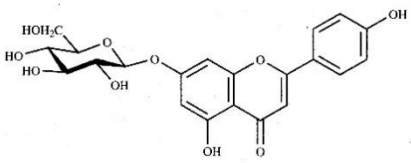

Figure 19. Apigenin 7-glucoside

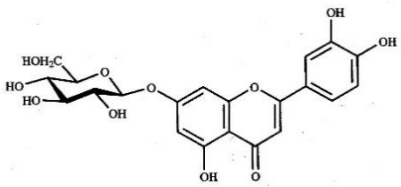

Figure 20. Luteolin 7-glucoside

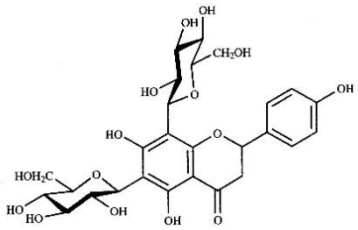

Figure 21. Naringenin 6,8-di-*C*-glucoside

FLAVONOIDS IN THE SUBFAMILY LEMNOIDEAE

Nineteen species of four genera of the Lemnoideae were surveyed for flavonoids (Table 3). The major flavonoid class of the subfamily is *C*-glycosylflavone. *C*-glycosylflavones such as vitexin (Figure 14), isovitexin (Figure 15), orientin (Figure 16), isoorientin (Figure 17), vicenin-2 (Figure 18) and their *O*-glycosides were found in all species surveyed, except for two *Wolffia* and three *Wolffiella* species. Major flavonoids in *Wolffia microscopica* and *W. brasiliensis* were flavonols, and kaempferol, quercetin and their 3-glycosides and 3,7-diglycoside were characterized (McClure & Alston 1966). Major flavonoids in other *Wolffia* species, *W. arrhiza*, *W. columbiana, W. globosa* were flavones and *C*-glycosylflavones such as apigenin 7-glucoside (Figure 19), luteolin 7-glucoside (Figure 20) (flavones), and vitexin, isovitexin, orientin, isoorientin (*C*-glycosylflavones) (McClure & Alston 1966, Wang *et al*. 2014b).

Quercetin 3- and 3,7-diglycosides were found in three *Wolffiella* species (McClure & Alston 1966). Various *C*-glycosylflavones, e.g. isovitexin, vitexin, orientin, isoorientin, vicenin-2, and their *O*-glycosides and acylated glycosides, were isolated from *Lemna* species, together with anthocyanin (cyanidin 3-glucoside) and flavones (McClure & Alston 1966, Wallace & Alston 1966, Veen 1975, Akhtar *et al*. 2010).

C-glycosylflavones frequently occured in *Spirodela* species with minor anthocyanins and flavonols. Another anthocyanin, petunidin 3,5-diglucoside, was found in *S. oligorrhiza* (McClure & Alston 1966). Rare *C*-glycosylflavanone, naringenin 6,8-di-*C*-glucoside (Figure 21), and *C*-glycosylflavone, 5,7-dihydroxy-3′,4′-methylenedioxyflavone 8-*C*-glucoside, were isolated from *S. polyrrhiza*, together with two acylated *C*-glycosylflavones, apigenin 8-*C*-(2′′-feruloylglucoside) and luteolin 8-*C*-(2′′-feruloylglucoside) (Quiao *et al*. 2011). Two rare flavans, 3,5,4′-trihydroxy-7,3′-dimethoxyflavan 5-glucoside and 3,5,4′-trihydroxy-4,7,3′-trimethoxyflavan 5-glucoside, were isolated from *S. punctata* (as *Landoltia punctata*), together with some common flavones and *C*-glycosylflavones (Wang *et al*. 2014a).

Table 3. Reports on the flavonoids from the species of subfamily Lemnoideae

Lemna aequinoctialis Welw. (as *Lemna trinervis* (Austin) Small) (McClure & Alston 1966)
Flavone: luteolin, luteolin 7-glycoside (wp),
***C*-Glycosylflavone**: apigenin 6,8-di-*C*-glycoside, apigenin 6,8-di-*C*-glycoside (acylated), luteolin 6,8-di-*C*-glycoside (wp) (McClure & Alston 1966)

Lemna gibba L.
Anthocyanin: cyanidin 3-glucoside (wp) (McClure & Alston 1966),
Flavone: luteolin malonylglucosyl-malyl-glucoside (wp) (Akhtar *et al*. 2010),
***C*-Glycosylflavone**: isoorientin, isoorientin 7-glucoside, isovitexin, isovitexin 4′-glucoside, apigenin 6-*C*-(malonylglucoside)-glucosyl-malyl-glucoside, luteolin 6-*C*-(malonylglucoside)-glucosyl-malylglucoside, orientin, vitexin (wp) (McClure & Alston 1966, Veen 1975, Akhtar *et al*. 2010)

Lemna japonica Landolt
Flavone: chrysoeriol, luteolin 7-glucoside (wp),
***C*-Glycosylflavone**: isoorientin, isoorientin 2′′-(*E*-caffeoyl-malate), isoorientin 2′′-(*E*-*p*-coumaroyl-malate), isoscoparin, isovitexin, isovitexin 2′′-(*E*-caffeoyl-malate), lucenin-2, vicenin-2 (wp) (Bai *et al*. 2018)

Lemna minor L.
Flavone: apigenin 7-glycoside, chrysoeriol glucoside, isoscoparin, luteolin 7-glucoside (wp) (Wallace & Alston 1966, Wallace *et al*. 1969, Vladimirova & Georgiyants 2013),
***C*-Glycosylflavone**: apigenin 6,8-di-*C*-glycoside, isoorientin, isoorientin 7-glucoside, isovitexin, isovitexin 4′-glucoside, luteolin 6,8-di-*C*-glycoside, orientin, vitexin (wp) (McClure & Alston 1966, Wallace & Alston 1966, Veen 1975)

Lemna minor (as *Lemna minima* Thuill. ex P.Beauv.) (McClure & Alston 1966)
Flavone: apigenin 7-diglycoside, apigenin 7-glycoside (wp),
***C*-Glycosylflavone**: apigenin 6,8-di-*C*-glycoside, isoorientin, orientin (wp) (McClure & Alston 1966)

Lemna obscura (Austin) Daubs
Anthocyanin: cyanidin 3-glucoside (wp),
***C*-Glycosylflavone**: apigenin 6,8-di-*C*-glycoside, apigenin 6,8-di-*C*-glycoside (acylated), isoorientin, luteolin 6,8-di-*C*-glycoside (acylated) (wp) (McClure & Alston 1966)

Lemna perpusilla Torr.
Flavone: apigenin 7-glycoside (wp),
***C*-Glycosylflavone**: apigenin 6,8-di-*C*-glycoside, apigenin 6,8-di-*C*-glycoside (acylated) (wp) (McClure & Alston 1966)

Lemna trisulca L.
Anthocyanin: cyanidin 3-glucoside (wp),
***C*-Glycosylflavone**: apigenin 6,8-di-*C*-glycoside, apigenin 6,8-di-*C*-glycoside (acylated), isoorientin, luteolin 6,8-di-*C*-glycoside, luteolin 6,8-di-*C*-glycoside (acylated), orientin, vitexin (wp) (McClure & Alston 1966)

Lemna valdiviana Phil.
***C*-Glycosylflavone**: apigenin 6,8-di-*C*-glycoside, apigenin 6,8-di-*C*-glycoside (acylated), luteolin 6,8-di-*C*-glycoside, luteolin 6,8-di-*C*-glycoside (acylated) (wp) (McClure & Alston 1966)

Spirodela oligorrhiza (Kurz) Hegelm.
Anthocyanin: petunidin 3,5-diglucoside (wp),
Flavone: luteolin, luteolin 7-diglycoside (wp),
Flavonol: quercetin, quercetin 3,7-diglycoside (wp) (McClure & Alston 1966),
***C*-Glycosylflavone**: apigenin 6,8-di-*C*-glycoside, isoorientin, isoorientin 7-glucoside, isovitexin, isovitexin (acylated), isovitexin 7-glucoside, isovitexin 4′-glucoside, luteolin 6,8-di-*C*-glycoside, orientin (wp) (Jurd *et al*. 1957, McClure & Alston 1966)

Spirodela polyrrhiza (L.) Schleid.
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-malonylglucoside (wp) (McClure & Alston 1966, Reznik & Menschick 1969, Krause & Strack 1979),
Flavanone: eriodictyol 7-glucoside, hesperetin 7-glucoside (wp) (Quiao *et al*. 2011),
Flavone: apigenin, apigenin 7-glucoside, chrysoeriol, luteolin, luteolin diglucoside, luteolin 7-glucoside (wp) (McClure & Alston 1966, Wallace & Alston 1966, Reznik & Menschick 1969, Wallace *et al*. 1969, Wallace 1975, Kim *et al*. 2010, Quiao *et al*. 2011),
Flavonol: quercetin diglucoside, quercetin diglucosylxyloside (wp),
***C*-Glycosylflavanone**: naringenin 6,8-di-*C*-glucoside (wp) (Quiao *et al*. 2011),
***C*-Glycosylflavone**: apigenin 8-*C*-(2′′-feruloyl-glucoside), 5,7-Dihydroxy-3′,4′- methylene-dioxyflavone 8-*C*-glucoside, isoorientin, isoorientin 7-glucoside, isovitexin, luteolin 8-*C*-(2′′-feruloylglucoside), orientin, vitexin, vitexin 7-glucoside (wp) (McClure & Alston 1966, Wallace & Alston 1966, Reznik & Menschick 1969, Wallace *et al*. 1969, Saunders & McClure 1976,

Wallace 1975, Kim *et al*. 2010, Quiao *et al*. 2011)

Spirodela punctata (G.Mey.) C.H.Thomps. (as *Landoltia punctata* (G.Mey) Les & D.J.Crawford) (Wang *et al*. 2014a)
Flavan and Proanthocyanidin: 3,5,4´-trihydroxy-7,3´-dimethoxyflavan 5-glucoside, 3,5,4´-trihydroxy-4,7,3´-trimethoxyflavan 5-glucoside (wp),
Flavone: apigenin, apigenin 7-glucoside, luteolin, luteolin 7-glucoside (wp),
***C*-Glycosylflavone**: apigenin 6-*C*-glucoside-8-*C*-galactoside, isoorientin, isovitexin, orientin, vicenin-2, vitexin (wp) (Wang *et al*. 2014a)

Spirodela punctata (G.Mey.) C.H.Thomps. (as *Spirodela biperforata* W.Koch) (McClure & Alston 1966)
Flavone: apigenin 7-glycoside, luteolin, luteolin 7-glycoside (wp),
***C*-Glycosylflavone**: isoorientin, isoorientin 7-glucoside, orientin, vitexin (wp) (McClure & Alston 1966)

Spirodela punctata (as *Spirodela intermedia* W.Koch) (McClure & Alston 1966, McClure 1968, Saunders & McClure 1976)
Anthocyanin: cyanidin 3-glucoside (wp),
Flavonol: kaempferol, kaempferol 3-glycoside, quercetin, quercetin 3-glycoside (wp) (McClure & Alston 1966, McClure 1968),
***C*-Glycosylflavone**: isovitexin 4´-glucoside, orientin, vitexin (wp) (McClure & Alston 1966, McClure 1968, Saunders & McClure 1976)

Wolffia arrhiza (L.) Horkel ex Wimm.
Flavone: luteolin, luteolin 7-diglycoside (wp),
***C*-Glycosylflavone**: apigenin 6,8-di-*C*-glycoside, Isoorientin, Isovitexin, orientin (wp) (McClure & Alston 1966)

Wolffia brasiliensis Wedd. (as *Wolffia papulifera* C.H.Thomps.) (McClure & Alston 1966)
Flavonol: kaempferol, kaempferol 3,7-diglycoside, kaempferol 3-glycoside, quercetin, quercetin 3,7-diglycoside, quercetin 3-glycoside, quercetin 3,7-triglycoside (wp) (McClure & Alston 1966)

Wolffia brasiliensis (*Wolffia punctata* Griseb.) (McClure & Alston 1966)
Flavonol: kaempferol, kaempferol 3,7-diglycoside, kaempferol 3-glycoside, kaempferol 3,7-triglycoside, quercetin, quercetin 3-diglycoside, quercetin 3-glycoside, quercetin 3,7-triglycoside (wp) (McClure & Alston 1966)

Wolffia columbiana H.Karst.
Flavone: luteolin, luteolin 7-diglycoside (wp),
***C*-Glycosylflavone**: apigenin 6,8-di-*C*-glycoside, isoorientin, isovitexin, orientin, vitexin (wp) (McClure & Alston 1966)

Wolffia globosea (Roxb.) Hartog & Plas
Flavone: apigenin 7-glucoside, luteolin 7-glucoside (wp),
***C*-Glycosylflavone**: isoorientin, isoorientin 6´´-glucoside, isovitexin, orientin, vicenin-2, vitexin (wp) (Wang *et al*. 2014b)

Wolffia microscopica (Griff.) Kurz
Flavonol: kaempferol, kaempferol 3,7-diglycoside, kaempferol 3-glycoside, quercetin, quercetin 3,7-diglycoside, quercetin 3-glycoside, quercetin 3,7-triglycoside (wp) (McClure & Alston 1966)

Wolffiella gladiata (Hegelm.) Hegelm.
Flavonol: quercetin 3-glycoside, quercetin 3,7-triglycoside (wp) (McClure & Alston 1966)

Wolffiella gladiata (*Wolffiella floridana* (J.D.Sm.) C.H.Thomps.) (McClure & Alston 1966)
Flavonol: quercetin 3,7-triglycoside (wp) (McClure & Alston 1966)

Wolffiella lingulata (Hegelm.) Hegelm.
Flavonol: quercetin 3,7-diglycoside, quercetin 3-glycoside, quercetin 3,7-triglycoside (wp) (McClure & Alston 1966)

Wolffiella oblonga (Phil.) Hegelm.
Flavonol: quercetin 3,7-diglycoside, quercetin 3-glycoside, quercetin 3,7-triglycoside (wp) (McClure & Alston 1966)

FLAVONOIDS IN THE SUBFAMILY POTHOIDEAE

The subfamily Pothoideae consists of ca. 900 species of four genera. Twenty two species of two genera and *Anthurium* cultivars were surveyed for flavonoids (Table 4). Anthocyanins were found in the fruits, spathe and spadix of many *Anthurium* species and identified as cyanidin 3-glucoside, 3-rutinoside, pelargonidin 3-rutinoside (Figure 22) and peonidin 3-rutinoside. Proanthocyanidins, procyanidins were also detected in some *Anthurium* species (Williams *et al*. 1981).

C-glycosylflavones flavones were isolated from three *Anthurium* species. They were relatively rare compounds, except for vitexin in *A. versicolor*, i.e. three embigenin (Figure 23) *O*-glycosides, 2´´-

rhamnoside, 2′′-(4′′′-3,4-dimethoxycinnamoyl-rhamnoside) and 2′′-(4′′′-feruloylrhamnoside) from *A. andraeanum* (Clark *et al*. 2012), isoschaftoside (Figure 24) and schaftoside (Figure 25) from *A. bellum* (Williams *et al*. 1981), and cytisoside (Figure 26) 3′′-rhamnoside, and isocytisoside (Figure 27) 3′′-apiofuranoside, 3′′-rhamnoside and 6′′-xyloside from *A. versicolor* (Aquino *et al*. 2001). Crude extract of *A. versicolor* including their flavonoids was shown to have radical-scavenging activity (Aquino *et al*. 2001). Common flavonols, kaempferol and/or quercetin, were reported from four *Anthurium* species (Williams *et al*. 1981) and cultivars (Li *et al*. 2013).

Acacetin (Figure 28) was obtained from *A. polyschistum* (Williams *et al*. 1981), and rare methylated eucalyptin (Figure 29) and sideroxylin (Figure 30) glycosides were obtained from *Anthurium* cultivars (Li *et al*. 2013). A flavanone, hesperetin 7-rutinoside (Figure 31), was isolated from the epidermis of *A. binotii* (Brunswik 1921). From another Pothodeae species, *Pothos chinensis*, flavone glycoside, chrysoeriol (Figure 32) 7-rhamnosylglucoside, and seven *C*-glycosyflavones, vitexin, vitexin 7-glucoside, isoschaftoside, schaftoside, isovitexin 7-glucoside, isoscoparin 7-glucoside (Figure 33) and scoparin 7-glucoside (Figure 34), were isolated (Iwashina *et al*. 2010).

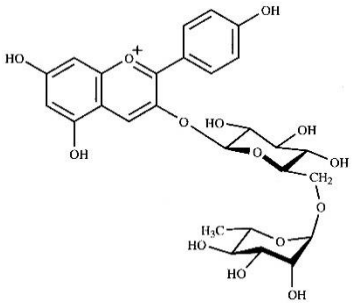

Figure 22. Pelargonidin 3-rutinoside

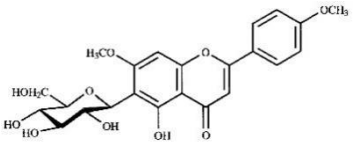

Figure 23. Embigenin

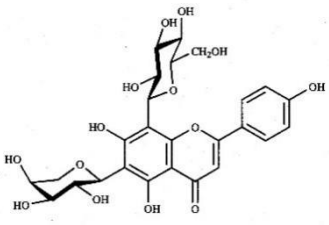

Figure 24. Isoschaftoside

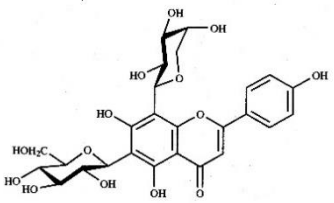

Figure 25. Schaftoside

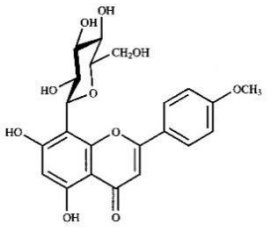

Figure 26. Cytisoside

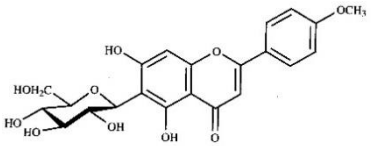

Figure 27. Isocytisoside

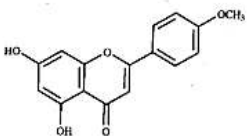

Figure 28. Acacetin

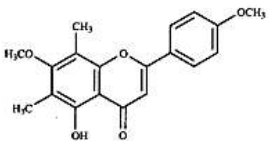

Figure 29. Eucalyptin

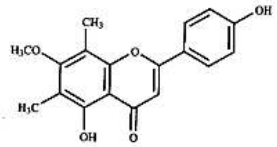

Figure 30. Sideroxylin

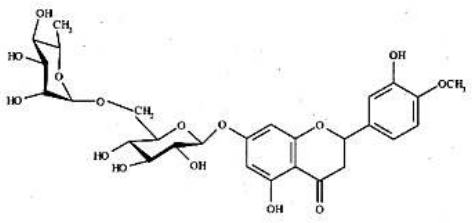

Figure 31. Hesperitin 7-rutinoside

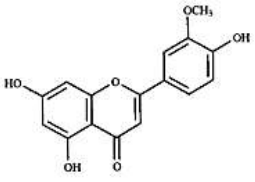

Figure 32. Chrysoeriol

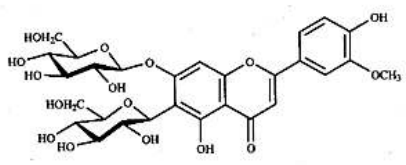

Figure 33. Isoscoparin 7-glucoside

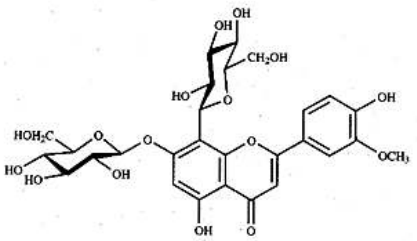

Figure 34. Scoparin 7-glucoside

Table 4. Reports on the flavonoids from the species of subfamily Pothoideae

Anthurium affine Schott
Anthocyanin: cyanidin 3-rutinoside, pelargonidin 3-rutinoside (fr) (Williams *et al*. 1981)

Anthurium andraeanum Linden ex André
Anthocyanin: cyanidin 3-rutinoside, pelargonidin 3-rutinoside (sp) (Iwata *et al*. 1979),
***C*-Glycosylflavone**: embigenin 2´´-rhamnoside, embigenin 2´´-(4´´´-3,4- dimethoxycinnamoyl-rhamnoside), embigenin 2´´-(4´´´-feruloyl-rhamnoside) (lf) (Clark *et al*. 2012)

Anthurium bakeri Hook.f.
Anthocyanin: cyanidin 3-rutinoside (fr) (Williams *et al*. 1981)

Anthurium bellum Schott
Anthocyanin: cyanidin 3-rutinoside, pelargonidin 3-rutinoside (sx),
Flavan and Proanthocyanidin: procyanidin (lf),
***C*-Glycosylflavone**: isoschaftoside, schaftoside (lf) (Williams *et al*. 1981)

Anthurium binotii Linden
Flavanone: hesperetin 7-rutinoside (ep) (Brunswik 1921)

Anthurium cultivars
Anthocyanin: cyanidin 3-rutinoside, pelargonidin 3-rutinoside, peonidin 3-rutinoside (sp),
Flavone: apigenin glucoside, chrysoeriol arabinosylglucoside, eucalyptin benzoylglucoside, luteolin glucoside, methylapigenin rhamnosyl-glucoside, methyleucalyptin benzoylglucoside, sideroxylin benzoylglucoside (sp),
Flavonol: kaempferol acetylmalonylglucoside, kaempferol 3-rhamnoside-7-(acetylarabinoside), kaempferol rhamnosylglucoside, quercetin rhamnoside (sp) (Li *et al*. 2013)

Anthurium erskinei Mayo
Anthocyanin: cyanidin 3-rutinoside (sp, sx) (Williams *et al*. 1981)

Anthurium galeottii K.Koch
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-rutinoside, pelargonidin 3-rutinoside (sp) (Williams *et al*. 1981)

Anthurium gladiifolium Schott
Anthocyanin: cyanidin 3-rutinoside (sx),
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: kaempferol, quercetin (lf) (Williams *et al*. 1981)

Anthurium gracile (Rudge) Lindl.
Anthocyanin: cyanidin 3-rutinoside, pelargonidin 3-rutinoside (fr),
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Anthurium hookeri Kunth
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Anthurium inconspicuum N.E.Br.
Anthocyanin: cyanidin 3-rutinoside, pelargonidin 3-rutinoside (sp, sx) (Williams *et al*. 1981)

Anthurium jilekii Schott
Anthocyanin: cyanidin 3-rutinoside (sx) (Williams *et al*. 1981)

Anthurium lindmanianum Engl.
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Anthurium longifolium (Hoffm.) G.Don
Anthocyanin: cyanidin 3-rutinoside (sp, sx) (Williams *et al*. 1981)

Anthurium parasiticum (Vell.) Stellfeld (as *Anthurium miquelianum* K.Koch & Augustin) (Williams *et al*. 1981)
Anthocyanin: cyanidin 3-rutinoside (pt, sx) (Williams *et al*. 1981)

Anthurium pentaphyllum (Aubl.) G.Don
Flavan and Proanthocyanidin: procyanidin (lf),

Flavonol: kaempferol, quercetin (lf) (Williams *et al*. 1981)

Anthurium polyschistum R.E.Schult. & Idrobo
Flavone: acacetin (lf) (Williams *et al*. 1981)

Anthurium radicans K.Koch & Haage
Anthocyanin: cyanidin 3-rutinoside (pt),
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: kaempferol, quercetin (lf) (Williams *et al*. 1981)

Anthurium regale Linden
Anthocyanin: cyanidin 3-rutinoside (sx),
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: quercetin (lf) (Williams *et al*. 1981)

Anthurium schlechtendalii Kunth
Anthocyanin: cyanidin 3-rutinoside (fr) (Williams *et al*. 1981)

Anthurium versicolor Sodiro
***C*-Glycosylflavone**: cytisoside 3´´-rhamnoside, isocytisoside 3´´-apiofuranoside, isocytisoside 3´´-rhamnoside, isocytisoside 6´´-xyloside, vitexin (lf) (Aquino *et al*. 2001)

Pothos chinensis (Raf.) Merr.
Flavone: chrysoeriol 7-rhamnosylglucoside (ap),
***C*-Glycosylflavone**: isoschaftoside, isoscoparin 7-glucoside, isovitexin 7-glucoside, schaftoside, scoparin 7-glucoside, vitexin, vitexin 7-glucoside (ap) (Iwashina *et al*. 2010)

FLAVONOIDS IN THE SUBFAMILY MONSTEROIDEAE

The Monsteroideae consists of ca. 360 species and 12 genera. Only one species, *Scindapsus pictus,* was surveyed for its flavonoids. Flavone (chrysoeriol) and flavonol (quercetin) were detected (Table 5) (Williams *et al*. 1981).

Table 5. Reports on the flavonoids from the species of subfamily Monsteroideae

Scindapsus pictus Hassk.
Flavone: chrysoeriol (lf),
Flavonol: quercetin (lf) (Williams *et al*. 1981)

FLAVONOIDS IN THE SUBFAMILY LASIOIDEAE

About 60 species of 10 genera belong to the Lasioideae. Two species, *Dracontium asperum* and *Lasia spinosa,* were surveyed for flavonoids (Table 6). Common anthocyanins, cyanidin and pelargonidin 3-rutinosides, were found in *Dracontium asperum* (Williams *et al*. 1981). *C*-Glycosylflavones were detected in *D. asperum* and *L. spinosa*, and characterized as isovitexin xyloside and vitexin glucoside (*D. asperum*) (Williams *et al*. 1981), and vitexin and its 2”-glucoside (*L. spinosa*) (Hong Van *et al*. 2006).

Table 6. Reports on the flavonoids from the species of subfamily Lasioideae

Dracontium asperum K.Koch
Anthocyanin: cyanidin 3-rutinoside, pelargonidin 3-rutinoside (pt),
***C*-Glycosylflavone**: isovitexin xyloside, vitexin glucoside (lf) (Williams *et al*. 1981)

Dracontium asperum (as *Dracontium foecundum* Hook.f.) (Williams *et al*. 1981)
Anthocyanin: cyanidin 3-rutinoside, pelargonidin 3-rutinoside (sp, sx) (Williams *et al*. 1981)

Lasia spinosa (L.) Thwaites
Flavonol: quercetin 3-rutinoside (wp),
***C*-Glycosylflavone**: vitexin, vitexin 2´´-glucoside (wp) (Hong Van *et al*. 2006)

FLAVONOIDS IN THE SUBFAMILY AROIDEAE

The Aroideae is the largest subfamily of Araceae and consists of 70 genera. Flavonoids from 94 species of 35 genera were surveyed (Table 7). Of seven surveyed *Alocasia* species, anthocyanin, cyanidin 3-rutinoside was found in five species. Procyanidins and common flavonols, kaempferol and/or quercetin, were accompanied by anthocyanin in almost species (Williams *et al*. 1981). An acylated anthocyanin was isolated from the tubers of *A. cucullata* and identified as cyanidin 3-(6´´-*E*-*p*-coumaroylglucoside)-5-(6´´-malonyl-glucoside) (Figure 35) (Lei *et al*. 2014).

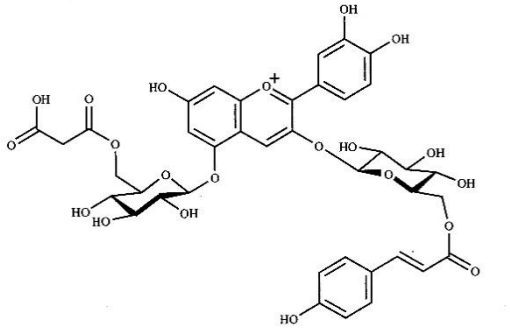

Figure 35. Cyanidin 3-(6´´-*E*-*p*-coumaroylglucoside)-5-(6´´-malonylglucoside)

Five *Amorphophallus* species were surveyed for their flavonoids. Of these species, *A. titanum* is the most well-known as the plant having the largest inflorescence among the plant kingdom, and the flavonoids of its spathe, and spadix and leaves were analyzed. The major flavonoids were anthocyanins and *C*-glycosylflavones, and identified as cyanidin 3-glucoside and 3-rutinoside, pelargonidin 3-coumaroylglucoside and 3-rhamnosylglucoside and peonidin 3-coumaroylglucoside, 3-glucoside and 3-rutinoside as anthocyanins, and isoorientin, orientin, schaftoside, isoschaftoside, vicenin-2, lucenin-2, vitexin and its 2′′-glucoside, and isovitexin and its 2′′-glucoside and X′′-rhamnoside (Gallori *et al*. 2004, Iwashina *et al*. 2015, 2020). Two flavones and five flavonols were accompanied by *C*-glycosylflavones and identified as chrysoeriol 7-glucoside and luteolin 7-glucoside, and kaempferol 3-robinobioside (Figure 36), 3-rhamno-sylarabinoside and 3-rutinoside, and quercetin 3-robinobioside and 3-rutinoside (Iwashina *et al*. 2015, 2020). Although similar anthocyanins, *C*-glycosylflavones and flavonols were obtained from the other two *Amorphophallus* species, i.e. *A. paeoniifolius* and *A. konjac* (Iwashina *et al*. 2015), a rare flavonol, 3,5-diacetyltambulin (7,8,4′-trimethoxy-3,5-diacetylflavone) was found in the former species (Khan *et al*. 2008). This flavonoid showed significant antibacterial activities against four Gram-positive bacteria (e.g. *Bacillis subtilis* and *Staphylococcus aureus*) and six Gram-negative bacteria (e.g. *Escheichia coli*, *Shigella sonnei*, *Pseudomonas aerginosa,* and *Salmonella typhi*) (Khan *et al*. 2008).

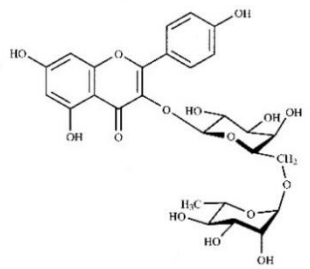

Figure 36. Kaempferol 3-robinobioside

Three *C*-glycosylflavones, apigenin 6,8-di-*C*-galactoside (Figure 37), isocorymboside (Figure 38) and neocorymboside (Figure 39), were isolated from the rhizomes and tubers of *Arisaema erubescens*, together with isoschaftoside, schaftoside and vicenin-2 (Du *et al*. 2005, 2011). Of their compounds, isoschaftoside and schaftoside showed the strong nematicidal activity against the root-knot nematode (*Meloidogyne incognita*) (Du *et al*. 2011).

Seven *Arum* taxa were surveyed for flavonoids. Although common *C*-glycosyflavones such as isovitexin, vitexin, isoorientin, orientin and rarely their *O*-glucosides were major flavonoids in *Arum* species, flavones e.g. apigenin, luteolin and chrysoeriol, flavonols e.g. quercetin and its 3-glycosides, and anthocyanins, cyanidin 3-glucoside and 3-rutinoside were scattered present (Phouphas 1956, Williams *et al*. 1981, Koleva 1982, 1984, Afifi *et al*. 2016). Polymethoxylated flavonol, quercetin 7,3′,4′-trimethyl ether (Figure 40), was isolated from the aerial parts of *Arum palaestinum* (Farid *et al*. 2015). Of the flavonoids from *A. palaestinum*, each two of flavones and *C*-glycosylflavones, i.e. luteolin and chrysoeriol, and isoorientin and isovitexin, showed a significant high antiproliferative activity (Farid *et al*. 2015).

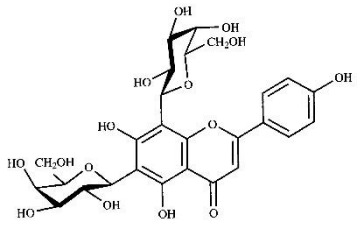

Figure 37. Apigenin 6,8-di-*C*-galactoside

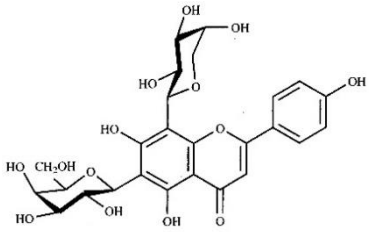

Figure 38. Isocorymboside

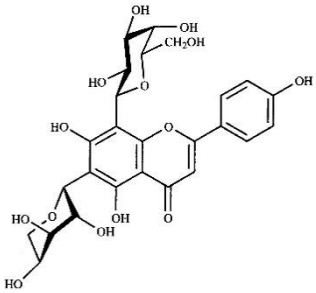

Figure 39. Neocorymboside

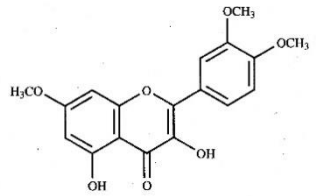

Figure 40. Quercetin 7,3′,4′-trimethyl ether

Six rare C-glycosylflavones were isolated from the leaves of *Asterostigma riedelianum*. They were characterized as apigenin 7,4′-dimethyl ether 6-*C*-arabinoside (Figure 41), 6,8-di-*C*-arabinoside (Figure 42), 6-*C*-arabinoside-2”-glucoside (Figure 43) and 6-*C*-arabinoside-2”-caffeoylglucoside, and isomolludistin 2”-glucoside (Figure 44) and 2”-caffeoylglucoside (Markham & Williams 1980).

Colocasia esculenta is widely cultivated in the world especially in tropical zone for its tubers (known as “taro”). The species was fully analyzed for flavonoids. Major flavonoids are *C*-glycosylflavones together with minor flavones, and many compounds were isolated, e.g. isoschaftoside, schaftoside, vicenin-2, isoorientin, orientin and its 7-glucoside, isovitexin and its 4′-glucoside, and apigenin, chrysoeriol, diosmetin, luteolin *O*-glycosides and so on (Iwashina *et al*. 1999, Leong *et al*. 2010, Ferreres *et al*. 2012, Li *et al*. 2014). Of their *C*-glycosylflavones, orientin and isoorientin significantly inhibited rat lens aldose reductase (Li *et al*. 2014). Anthocyanins, cyanidin 3-glucoside and 3-rhamnoside, and pelargonidin 3-glucoside, flavones, chrysoeriol and luteolin 7-glycosides, procyanidins and flavonol, quercetin, were accompanied by *C*-glycosylflavones, were also found in this species (Chan Jr. & Kao-Jao 1977, Williams *et al*. 1981, Iwashina *et al*. 1999).

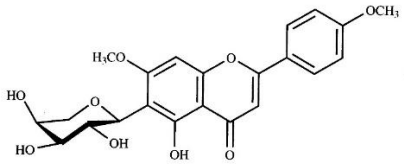

Figure 41. Apigenin 7,4′-dimethyl ether 6-*C*-arabinoside

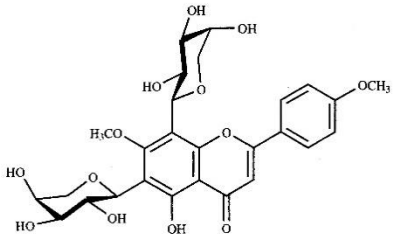

Figure 42. Apigenin 7,4′-dimethyl ether 6,8-di-*C*-arabinoside

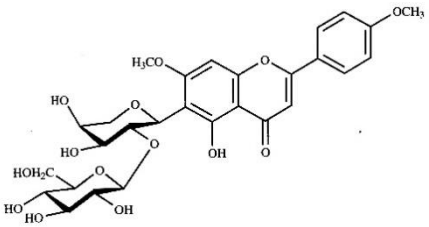

Figure 43. Apigenin 7,4′-dimethyl ether 6 -*C*-arabinoside-2′′-glucoside

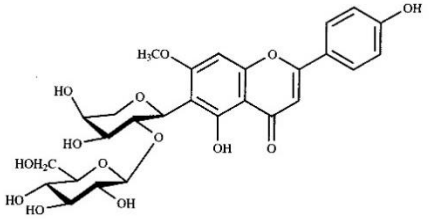

Figure 44. Isomolludistin 2′′-glucoside

Nine *Cryptocoryne* species were surveyed for flavonoids. Vitexin 2′′-glucoside (Figure 45) and sometimes 2′′-glucoside-6′′-*E*-sinapate were isolated from all species, except for *C. wendtii* (Franke *et al*. 2006). A rare sulfated *C*-glycosylflavone was isolated from *Culcasia saxatilis* and identified as vitexin 7-sulfate (Figure 46) (Williams *et al*. 1981). Two sulfated *C*-glycosylflavones were also isolated from *Philodendron ornatum* and identified as vitexin 7-sulfate and isovitexin 7-sulfate (Williams *et al*. 1981). Although 26 *Philodendron* species were surveyed for flavonoids and anthocyanins such as cyanidin 3-glycosides and rarely delphinidin, flavonols such as kaempferol, quercetin and isorhamnetin and procyanidins were found. They were roughly analyzed, except for *P. undulatum* containing four *C*-glycosylflavones (isoorientin, orientin, isoschaftoside and schaftosife) and *P. saxicola* containing four flavonols (isorhamnetin 3-glucoside, isorhamnetin 3-rutinoside, quercetin 3-glucoside and quercetin 3-rutinoside), and apigenin and luteolin *C*-glycosides (Williams *et al*. 1981).

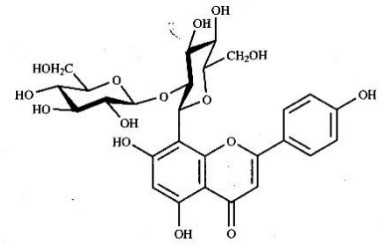

Figure 45. Vitexin 2´´-glucoside

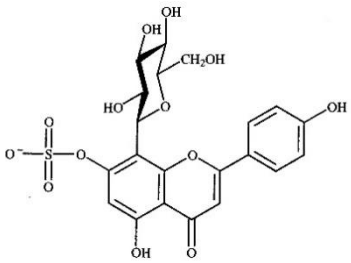

Figure 46. Vitexin 7-sulfate

Aquatic weed, *Pistia stratiotes*, contained flavones, chrysoeriol 4´-glucoside (Figure 47), luteolin and its 7-glycoside, and *C*-glycosylflavones, vitexin, orientin, and apigenin, luteolin 6,8-di-*C*-glycosides, and anthocyanin, cyanidin 3-glucoside (Zennie & McClure 1977, Liu *et al*. 2008, Tripathi *et al*. 2016). Six *C*-glycosylflavones, vitexin, vicenin-2, apigenin 6-*C*-glucoside-8-*C*-apiofuranoside, and isovitexin and its 6”-glucoside and 4´-rhamnoside, were isolated from the leaves of *Xanthosoma sagittifolium*, together with anthocyanin, cyanidin 3-rutinoside (Williams *et al*. 1981, Picerno *et al*. 2003). The fraction containing their *C*-glycosylflavones showed a significant antioxidant/ free-radical scavenging activity (Picerno *et al*. 2003). Six *C*-glycosylflavones were isolated from *Zantedeschia aethiopica*, together with other flavonoids, apigenin, luteolin, kaempferol and quercetin, and identified as isoorientin, isovitexin, orientin, swertiajaponin (Figure 48), swertisin (Figure 49) and vitexin (Martens *et al*. 2003, Luzzatto *et al*. 2007, Nakayama *et al*. 2015). Of their *C*-glycosylflavones, isoorientin and swertiajaponin responded to low temperature-induced yellow pigmentation of the bracts of this species (Nakayama *et al*. 2015). Moreover, swertisin and isovitexin showed the antimicrobial activity against *Pectobacterium carotovorum* (Luzzatto *et al*. 2007).

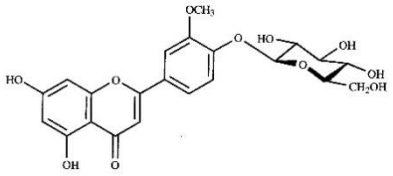

Figure 47. Chrysoeriol 4´-glucoside

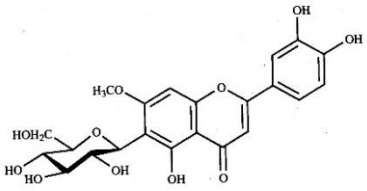

Figure 48. Swertiajaponin

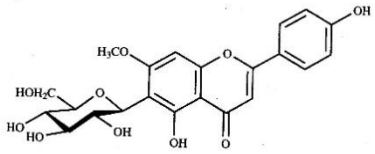

Figure 49. Swertisin

Williams *et al*. (1981) analyzed the flavonoids of many Aroideae species, e.g. *Aglaonema modestum*, *Alocasia* spp., *Anchomanes* spp. *Anubias varteri* var. *glabra*, *Apoballis acuminatissima*, *Arophyton crassifolium*, *Caladium bicolor*, *Calla palustris*, *Carlephyton* spp., *Cercestis* spp., *Dracunculus* spp., *Eminium* spp., *Helicodiceros muscivorus*, *Homalomena* spp., *Peltandra virginica*, *Pinellia tripartita*, *Stylochaeton* spp., *Synandrospadix vermitoxicus*, *Syngonium* spp., *Typhonium flagelliforme,* and *Typhonodorum lindleyanum*. Although anthocyanins, flavones, flavonols and proanthocyanidins were reported, they were insufficiently identified.

Table 7. Reports on the flavonoids from the species of subfamily Aroideae

Aglaonema modestum Schott ex Engl.
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)
Alocasia cucullata (Lour.) G.Don
Anthocyanin: cyanidin 3-(6´´-*E*-*p*-coumaroyl-glucoside)-5-(6´´-malonylglucoside) (tb) (Lei *et al*. 2014)
Alocasia cuprea K.Koch
Anthocyanin: cyanidin 3-rutinoside (lf), **Flavonol**: kaempferol, quercetin (lf) (Williams *et al*. 1981)

Alocasia lauterbachiana (Engl.) A.Hay (as *Xenophya lauterbachiana* (Engl.) Nicolson) (Williams *et al*. 1981)
Anthocyanin: cyanidin 3-rutinoside (lf),
Flavonol: quercetin (lf) (Williams *et al*. 1981)

Alocasia longiloba Miq. (as *Alocasia thibantiana* Mast.) (Williams *et al*. 1981)
Anthocyanin: cyanidin 3-rutinoside (lf),
Flavonol: kaempferol, quercetin (lf) (Williams *et al*. 1981)

Alocasia macrorrhizos (L.) G.Don (as *Alocasia macrorrhizos* var. *rubra* (Hassk.) Furtado) (Williams *et al*. 1981)
Anthocyanin: cyanidin 3-rutinoside (pt),
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: quercetin (lf) (Williams *et al*. 1981)

Alocasia macrorrhizos (as *Alocasia macrorrhizos* var. *variegata* (K.Koch & C.D.Bouché) Furtado) (Williams *et al*. 1981)
Anthocyanin: cyanidin 3-rutinoside (pt),
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: kaempferol, quercetin (lf) (Williams *et al*. 1981)

Alocasia macrorrhizos (as *Colocasia indica* (Lour.) Kunth) (Williams *et al*. 1981)
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Alocasia odora (Lindl.) K.Koch
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Alocasia portei Schott
Anthocyanin: cyanidin 3-rutinoside (pt) (Williams *et al*. 1981)

Amorphophallus abyssinicus (A.Rich.) N.E.Br.
Anthocyanin: cyanidin 3-rutinoside (sp) (Williams *et al*. 1981)

Amorphophallus konjac K.Koch
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-rutinoside, peonidin 3-glucoside, peonidin 3-rutinoside, pelargonidin 3-rhamnosylglucoside (if),
Flavonol: quercetin 3-glucoside (if),
***C*-Glycosylflavone**: isoorientin, isovitexin, orientin, vitexin 2´´-xyloside (if) (Iwashina *et al*. 2015)

Amorphophallus paeoniifolius (Dennst.) Nicolson (*Amorphophallus campanulatus* Decne)
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-diglucoside, pelargonidin 3-glucoside (if) (Iwashina *et al*. 2015),
Flavonol: 3,5-diacetytambulin, kaempferol 3-glucoside, quercetin, quercetin 3-glucoside (cr, if, tb) (Khan *et al*. 2008, Sharstry *et al*. 2010, Iwashina *et al*. 2015),
***C*-Glycosylflavone**: isovitexin, orientin, schaftoside, vicenin-2, vitexin (if) (Iwashina *et al*. 2015)

Amorphophallus stuhlmannii (Engl.) Engl. & Gehrm.
Anthocyanin: cyanidin 3-rutinoside (sp) (Williams *et al*. 1981)

Amorphophallus titanum (Becc.) Becc.
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-rutinoside, pelargonidin 3-coumaroylglucoside, pelargonidin 3-rhamnosylglucoside, peonidin 3-coumaroylglucoside, peonidin 3-glucoside, peonidin 3-rutinoside (sp, sx) (Gallori *et al*. 2004, Iwashina *et al*. 2015),
Flavone: chrysoeriol 7-glucoside (sp, sx) (Iwashina *et al*. 2015), luteolin 7-glucoside (lf) (Iwashina *et al*. 2020),
Flavonol: kaempferol 3-robinobioside, kaemopferol 3-rhamnosylarabinoside, kaempferol 3-rutinoside, quercetin 3-robinobioside, quercetin 3-rutinoside (lf) (Iwashina *et al*. 2020),
***C*-Glycosylflavone**: isoscoparin X´´-glucoside, isovitexin 2´´-glucoside, isovitexin X´´-rhamnoside, vitexin 2´´-glucoside (sp, sx) (Iwashina *et al*. 2015), isoorientin, isoschaftoside, isovitexin, lucenin-2, orientin, schaftoside, vicenin-2, vitexin (sp, sx, lf) (Iwashina *et al*. 2015, 2020)

Anchomanes abbreviatus Engl.
Anthocyanin: cyanidin 3-gentiobioside, pelargonidin 3-gentiobioside, pelargonidin 3-glucoside (fr) (Williams *et al*. 1981)

Anchomanes difformis (Blume) Engl.
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Anubias barteri Schott var. *glabra* N.E.Br. (*Anubias lanceolata* N.E.Br.) (Williams *et al*. 1981)
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Apoballis acuminatissima (Schott) S.Y.Wong & P.C.Boyce (as *Schismatoglottis concinna* Schott var. *immaculata* N.E.Br.) (Williams *et al*. 1981)
Anthocyanin: delphinidin 3-rutinoside (lf, pt),
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: isorhamnetin, quercetin (lf) (Williams *et al*. 1981)

Arisaema erubescens (Wall.) Schott
***C*-Glycosylflavone**: apigenin 6,8-di-*C*-galactoside, isocorymboside, isoschaftoside, neocorymboside, schaftoside, vicenin-2 (rz, tb) (Du *et al*. 2005, 2011)

Arisaema serratum (Thunb.) Schott
Anthocyanin: cyanidin 3,5-diglycoside (sp) (Ueno *et al*. 1969)

Arisarum vulgare O.Targ.Tozz.
***C*-Glycosylflavone**: orientin, vitexin (lf) (Pagani 1982)

Arophyton crassifolium (Buchet) Bogner
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Arum dioscoridis Sm.
Flavone: apigenin, luteolin (fl, lf),
Flavonol: quercetin, quercetin 3-glucoside (fl, lf),
***C*-Glycosylflavone**: isoorientin, vitexin (fl, lf) (Afifi *et al*. 2016)

Arum italicum Mill. subsp. *italicum*
Flavone: chrysoeriol, luteolin (lf) (Williams *et al*. 1981),
***C*-Glycosylflavone**: isovitexin 7-glucoside (rz) (Phouphas 1956)

Arum italicum subsp. *neglectum* (F.Towns.) Prime
Flavone: chrysoeriol (lf) (Williams *et al*. 1981)

Arum maculatum L.
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-rutinoside (sp, sx),
Flavone: chrysoeriol 7-glucoside, luteolin 7-glucoside (lf),
***C*-Glycosylflavone**: apigenin di-*C*-glycoside, isoorientin, isovitexin, luteolin di-*C*-glycoside, orientin (lf) (Williams *et al*. 1981)

Arum orientale M.Bieb.
Flavone: apigenin (lf),
Flavonol: quercetin, quercetin 3-rhamnoside, quercetin 3-rutinoside (lf) (Koleva 1984),
***C*-Glycosylflavone**: isoorientin, isovitexin, isovitexin 7-glucoside, orientin, vitexin (lf) (Koleva 1982, 1984)

Arum palaestinum Boiss.
Flavone: apigenin, chrysoeriol, luteolin (ap, fl, lf),
Flavonol: quercetin, quercetin 7,3′,4′-trimethyl ether (ap, fl, lf) (Farid *et al*. 2015, Afifi *et al*. 2016),
***C*-Glycosylflavone**: isoorientin, isovitexin, vitexin (ap, fl, lf) (Afifi *et al*. 1999, 2016, Farid *et al*. 2015)

Asterostigma riedelianum (Schott) Kuntze
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-rutinoside (st) (Williams *et al*. 1981),
***C*-Glycosylflavone**: apigenin 7,4′-dimetyl ether 6-*c*-arabinoside, apigenin 7,4′-dimethyl ether 6,8-di-*C*-arabinoside, apigenin 7,4′-dimethyl ether 6-*C*-arabinoside-2′′-glucoside, apigenin 7,4′-dimethyl ether 6-*C*-arabinoside-2′′-(caffeoyl-glucoside), isomolludistin 2′′-(caffeoylglucoside), isomolludistin 2′′-glucoside (lf) (Markham & Williams 1980, Williams *et al*. 1981)

Biarum tenuifolium (L.) Schott
Flavone: chrysoeriol, luteolin (lf) (Williams *et al*. 1981),
***C*-Glycosylflavone**: isovitexin 7-glucoside (rz) (Phouphas 1956)

Caladium bicolor (Aiton) Vent.
Anthocyanin: cyanidin 3-rutinoside (lf),
Flavonol: quercetin (lf) (Williams *et al*. 1981)

Calla palustris L.
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Carlephyton glaucophyllum Bogner
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Carlephyton madagascariense Jum.
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Cercestis afzelii Schott
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Cercestis congoensis Engl.
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Cercestis mirabilis (N.E.Br.) Bogner (as *Rhektophyllum mirabile* N.E.Br.) (Williams *et al*. 1981)
Anthocyanin: cyanidin 3-gentiobioside (pt),
Flavan and Proanthocyanidin: propelargonidin (lf) (Williams *et al*. 1981)

Colocasia esculenta (L.) Schott
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-rhamnoside, pelargonidin 3-glucoside (cr) (Chan Jr. & Kao-Jao 1977),
Flavone: chrysoeriol 7-hexoside, chrysoeriol 7-rhamnosyl-(1→6)-hexoside, luteolin 7-glucoside, luteolin 7-rutinoside, luteolin 7-sophoroside (lf, st) (Iwashina *et al*. 1999, Leong *et al*. 2010, Ferreres *et al*. 2012, Li *et al*. 2014),
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: quercetin (lf) (Williams *et al*. 1981),
***C*-Glycosylflavone**: apigenin 6-*C*-hexoside-6′′-hexoside, apigenin 8-*C*-pentoside-2′′-hexoside, apigenin 6-*C*-hexoside-2′′-hexoside-8-*C*-pentoside, apigenin 6-*C*-pentoside-8-*C*-hexoside-7-hexoside, apigenin 6-*C*-pentoside-8-*C*-hexoside-2′′-hexoside, chrysoeriol 6-*C*-hexoside, chrysoeriol 8-*C*-hexoside, chrysoeriol 6-*C*-hexoside-8-*C*-pentoside, diosmetin 6-*C*-hexoside-8-*C*-pentoside, isoschaftoside, isovitexin, isovitexin 4′-glucoside, isoorientin, luteolin 6-*C*-hexoside-6′′-hexoside, luteolin 6-*C*-hexoside-3′′-hexoside-8-*C*-pentoside, luteolin 6,8-di-*C*-hexoside, luteolin 6-*C*-hexoside-2′′-pentoside, luteolin 6-*C*-hexoside-8-*C*-pentoside, luteolin 6-*C*-pentoside-8-*C*-hexoside, orientin, orientin 7-glucoside, schaftoside, vicenin-2, vitexin, vitexin X′′-glucoside (lf, st) (Iwashina *et al*. 1999, Leong *et al*. 2010, Ferreres *et al*. 2012, Li *et al*. 2014)

Cryptocoryne albida R.Parker
***C*-Glycosylflavone**: vitexin 2′′-glucoside-6′′-*E*-sinapate, vitexin 2′′-glucoside (lf) (Franke *et al*. 2006)

Cryptocoryne crispatula Engl.
***C*-Glycosylflavone**: vitexin 2′′-glucoside (lf) (Franke *et al*. 2006)

Cryptocoryne pontederiifolia Schott
***C*-Glycosylflavone**: vitexin 2′′-glucoside-6′′-*E*-sinapate, vitexin 2′′-glucoside (lf) (Franke *et al*. 2006)

Cryptocoryne retrospiralis (Roxb.) Kunth
***C*-Glycosylflavone**: vitexin 2′′-glucoside (lf) (Franke *et al*. 2006)

Cryptocoryne spiralis (Retz.) Fisch. ex Wydler
***C*-Glycosylflavone**: vitexin 2′′-glucoside (lf) (Franke *et al*. 2006)

Cryptocoryne usteriana Engl.
***C*-Glycosylflavone**: vitexin 2′′-glucoside-6′′-*E*-sinapate, vitexin 2′′-glucoside (lf) (Franke *et al*. 2006)

Cryptocoryne vietnamensis I.hertel & H.Mühlberg
***C*-Glycosylflavone**: vitexin 2′′-glucoside (lf) (Franke *et al*. 2006)

Cryptocoryne wendtii de Wit
Flavone: chrysoeriol, luteolin (lf) (Williams *et al*. 1981)

Cryptocoryne ×*willisii* Reitz
***C*-Glycosylflavone**: vitexin 2′′-glucoside (lf) (Franke *et al*. 2006)

Culcasia scandens P.Beauv. (as *Culcasia saxatilis* A.Chev.) (Williams *et al*. 1981)
***C*-Glycosylflavone**: vitexin 7-sulfate (lf) (Williams *et al*. 1981)

Dracunculus canariensis Kunth
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-rutinoside (sp),
Flavone: chrysoeriol, luteolin (lf) (Williams *et al*. 1981)

Dracunculus vulgaris Schott (as *Arum dracunculus* L.) (Proliac *et al*. 1992)
***C*-Glycosylflavone**: isoorientin, orientin, vitexin (lf) (Proliac *et al*. 1992)

Eminium regelii Vved.
Flavone: luteolin (lf),
Flavonol: quercetin (lf) (Silybayeva *et al*. 2014)

Eminium spiculatum (Blume) Schott
Flavone: chrysoeriol 7-glucoside, luteolin, luteolin 7-glucoside (lf),
***C*-Glycosylflavone**: isoorientin, vitexin (lf) (Afifi & Abu-Dahab 2012)

Helicodiceros muscivorus (L.f.) Engl.
Anthocyanin: cyanidin 3-rutinoside (sp) (Williams *et al*. 1981)

Homalomena pendulata (Blume) Bakh.f. (as *Homalomena coerulescens* Jungh. ex Miq.) (Williams *et al*. 1981)
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Homalomena rubescens (Roxb.) Kunth
Anthocyanin: cyanidin 3-glucoside (lf, pt),
Flavonol: quercetin (lf) (Williams *et al*. 1981)

Peltandra virginica (L.) Schott
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: quercetin (lf) (Williams *et al*. 1981)

Philodendron auriculatum Standl. & L.O.Williams
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Philodendron crassinervium Lindl.
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: isorhamnetin, kaempferol, quercetin (lf) (Williams *et al*. 1981)

Philodendron erubescens K.Koch & Augustin
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-rutinoside (pt, sp, sx),
Flavonol: quercetin (lf) (Williams *et al*. 1981)

Philodendron fendleri K.Krause
Anthocyanin: cyanidin, delphinidin (sp) (Forsyth & Simmonds 1954)

Philodendron giganteum Schott
Anthocyanin: cyanidin (sp) (Forsyth & Simmonds 1954)

Philodendron goeldii G.M.Barroso
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Philodendron hastatum K.Koch & Sello
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-rutinoside (sp),
Flavonol: quercetin 3-glucoside (sp) (Alfa *et al*. 1987)

Philodendron hederaceum (Jacq.) Schott (as *Philodendron scandens* K.Koch & F.Sello subsp. *prieurianum* (Schott) G.S.Bunting) (Williams *et al*. 1981)
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Philodendron hederaceum as *Philodendron scandens* subsp. *scandens* in Williams *et al*. (1981)
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Philodendron imbe Schott & Kunth
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Philodendron insigne Schott
Anthocyanin: cyanidin 3-rutinoside (lf),
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: kaempferol, quercetin (lf) (Williams *et al*. 1981)

Philodendron latifolium K.Koch
Anthocyanin: cyanidin, delphinidin (sp) (Forsyth & Simmonds 1954)

Philodendron leal-costae Mayo & G.M.Barroso
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: kaempferol, quercetin (lf) (Williams *et al*. 1981)

Philodendron linnaei Kunth
Anthocyanin: cyanidin 3-rutinoside (lf),
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: kaempferol, quercetin (lf) (Williams *et al*. 1981)

Philodendron longilaminatum Schott
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: kaempferol, quercetin (lf) (Williams *et al*. 1981)

Philodendron melanochrysum Linden & André
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Philodendron melinonii Brongn. & Regel
Anthocyanin: cyanidin 3-glucoside (lf),
Flavonol: isorhamnetin, quercetin (lf) (Williams *et al*. 1981)

Philodendron ornatum Schott
Anthocyanin: cyanidin 3-glucoside (lf),
***C*-Glycosylflavone**: isovitexin 7-sulfate, vitexin 7-sulfate (lf) (Williams *et al*. 1981)

Philodendron pachyphyllum K.Krause
Flavonol: quercetin (lf) (Williams *et al*. 1981)

Philodendron pedatum (Hook.) Kunth
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: quercetin (lf) (Williams *et al*. 1981)

Philodendron radiatum Schott
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Philodendron saxicola K.Krause
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: isorhamnetin 3-glucoside, isorhamnetin 3-rutinoside, quercetin 3-glucoside, quercetin 3-rutinoside (lf),
***C*-Glycosylflavone**: apigenin di-*C*-glycoside, luteolin di-*C*-glycoside, luteolin *C*-glycoside (lf) (Williams *et al*. 1981)

Philodendron simsii (Hook.) Sweet ex Kunth
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Philodendron smithii Engl.
Flavan and Proanthocyanidin: procyanidin (lf),

***C*-Glycosylflavone**: isoschaftoside, schaftoside (lf) (Williams *et al*. 1981)

Philodendron squamiferum Poepp.
Anthocyanin: cyanidin 3-rutinoside (pt) (Williams *et al*. 1981)

Philodendron undulatum Engl. (as *Philodendron eichleri* Engl.) (Williams *et al*. (1981)
Flavan and Proanthocyanidin: procyanidin (lf),
***C*-Glycosylflavone**: isoorientin, isoschaftoside, orientin, schaftoside (lf) (Williams *et al*. 1981)

Philodendron verrucosum L.Mathieu ex Schott
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-rutinoside (lf, pt) (Williams *et al*. 1981)

Pinellia tripartita (Blume) Schott
Anthocyanin: cyanidin 3-rutinoside (st) (Williams *et al*. 1981)

Pistia stratiotes L.
Anthocyanin: cyanidin 3-glucoside (wp) (Zennie & McClure 1977, Tripathi *et al*. 2016),
Flavone: chrysoeriol 4´-glucoside, luteolin, luteolin 7-glycoside (wp) (Zennie & McClure 1977, Liu *et al*. 2008, Tripathi *et al*. 2016),
***C*-Glycosylflavone**: apigenin 6,8-di-*C*-glycoside, luteolin 6,8-di-*C*-glycoside, orientin, vitexin (wp) (Zennie & McClure 1977, Tripathi *et al*. 2016)

Sauromatum giganteum (Engl.) Cusimano & Hett. (as *Typhonium giraldii* (Baroni) Engl.) (Williams *et al*. 1981)
Anthocyanin: cyanidin 3-rutinoside (st),
Flavone: chrysoeriol, luteolin (lf) (Williams *et al*. 1981)

Stylochaeton borumensis N.E.Br.
Flavonol: quercetin (lf) (Williams *et al*. 1981)

Stylochaeton lancifolius Kotschy & Peyr.
Anthocyanin: cyanidin 3-rutinoside (st),
Flavan and Proanthocyanidin: procyanidin (lf),
Flavonol: kaempferol, quercetin (lf) (Williams *et al*. 1981)

Synandrospadix vermitoxicus (Griseb.) Engl.
***C*-Glycosylflavone**: isoorientin, isovitexin, isovitexin 7-glucoside, orientin, vitexin (lf) (Sosa *et al*. 1978)

Syngonium auritum (L.) Schott
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et* al. 1981)

Syngonium podophyllum Schott
***C*-Glycosylflavone**: isoschaftoside (lf) (Gomes *et al*. 2014)

Typhonium flagelliforme (Lodd.) Blume
***C*-Glycosylflavone**: isovitexin (lf) (Farida *et al*. 2012)

Typhonodorum lindleyanum Schott
Anthocyanin: cyanidin 3-glucoside, cyanidin 3-rutinoside (lf),
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Xanthosoma brasiliense (Desf.) Engl.
Flavonol: quercetin (lf) (Williams *et al*. 1981)

Xanthosoma helleborifolium (Jacq.) Schott
Anthocyanin: cyanidin 3-rutinoside, pelargonidin 3-rutinoside (st) (Williams *et al*. 1981)

Xanthosoma sagittifolium (L.) Schott
Flavan and Proanthocyanidin: procyanidin (lf) (Williams *et al*. 1981)

Xanthosoma sagittifolium (as *Xanthosoma violaceum Schott*) (Williams *et al*. 1981, Picerno *et al*. 2003)
Anthocyanin: cyanidin 3-rutinoside (lf) (Williams *et al*. 1981),
***C*-Glycosylflavone**: apigenin 6-*C*-glucoside-8-*C*-apiofuranoside, isovitexin, isovitexin 6´´-glucoside, isovitexin 4´-rhamnoside, vitexin, vicenin-2 (lf) (Picerno *et al*. 2003)

Zantedeschia aethiopica (L.) Spreng.
Flavan and Proanthocyanidin: procyanidin (fl),
Flavone: apigenin, luteolin (fl),
Flavonol: kaempferol, quercetin (fl) (Martens *et al*., 2003),
***C*-Glycosylflavone**: isoorientin, isovitexin, orientin, swertiajaponin, swertisin, vitexin (fl, lf, sp) (Martens *et al*. 2003, Luzzatto *et al*. 2007, Nakayama *et al*. 2015)

FLAVONOIDS IN THE FAMILY ACORACEAE

Although the genus *Acorus* is now erected to its own family, it used to be a member of the Araceae. Of two *Acorus* species, *A. calamus* was surveyed for flavonoids and a *C*-glycosylflavone, lucenin-2 (Figure 50), was found (Él'yashevich *et al*. 1974).

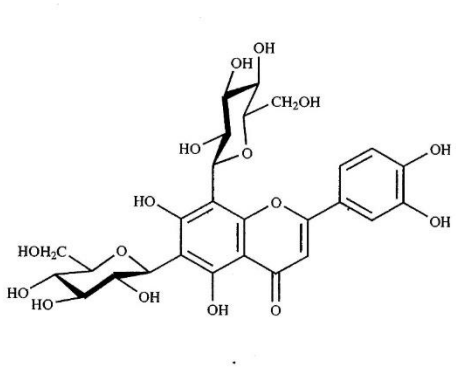

Figure 50. Lucenin-2

Table 8. Reports on the flavonoids from the species of the family Acoraceae

Acorus calamus L.
C-Glycosylflavone: Lucenin-2 (ap) (Él'yashevich et al. 1974)

The occurrence of flavonoid classes among the genera of Araceae and the related Acoraceae was shown in Table 9. The presence of anthocyanins, flavones, *C*-glycosylflavones, flavonols, flavan and proanthocyanidins, flavanones and *C*-glycosylflavanone were recognized. However, dihydroflavonol, chalcone, dihydrochalcone, aurone, isoflavonoid, and so on were not reported as far as I know. *C*-Glycosylflavones seem to be major flavonoids in the Araceae. Although Williams *et al*. (1981) showed the presence of *C*-glycosylflavones in almost species, they were not isolated and characterized. Of six subfamilies of the Araceae, *C*-glycosylflavones were not found in Gymnostachydoideae and Orontioideae. Instead, flavonols were major flavonoids in both subfamilies. In subfamily Lemnoideae, flavones and flavonols occurred in the genera *Lemna*, *Spirodela* and *Wolffia*. On the other hand, flavonols was absent in *Wolffillea*. Flavan and proanthocyanidins were also major flavonoids and present in 46 species. They were procyanidins except for propelargonidin in *Cercestis mirabilis* (as *Rhektophyllum mirabile*), but insufficiently identified (Williams *et al*. 1981). Subfamily Lemnoideae was not surveyed for flavan and proanthocyanidins except for *Spirodela punctata*. Flavanones were isolated from *Spirodela polyrrhyza* in subfamily Lemnoideae and *Anthurium binotii* in subfamily Pothodeae, and identified as eriodictyol and hesperetin 7-glucosides (Quiao *et al*. 2011), and hensperetin 7-rutinoside (Brunswik 1921), respectively. *C*-Glycosylflavanone was isolated from *Spirodela polyrrhyza* and identified as naringenin 6,8-di-*C*-glucoside (Quiao *et al*. 2011). The family Araceae s.l. (including Lemnaceae) consists of more than 3645 species of ca. 144 genera (Boyce & Croat 2011 onwards). However, flavonoids were surveyed in 146 species of 48 genera only. Further flavonoid survey must be performed in the Araceae.

Table 9. The occurrence of flavonoid classes among the genera of Araceae

	No.	An	Fv	Fn	CG	FP	Fa	Cf
Subfamily Gymnostachydoideae								
Gymnostachys	1			1				
Subfamily Orontioideae								
Lysichiton	1			1				
Orontium	1			1				
Symplocarpus	2	1		2				
Subfamily Lemnoideae								
Lemna	8	3	4		8			
Spirodela	3	3	3	3	3	1	1	1
Wolffia	5		3	2	3			
Wolffiella	3			3				
Subfamily Pothoideae								
Anthurium	22	16	2	5	3	8	1	
Pothos	1		1		1			
Subfamily Monsteroideae								
Scindapsus	1		1	1				
Subfamily Lasioideae								
Dracontium	1	1			1			
Lasia	1			1	1			
Subfamily Aroideae								
Aglaonema	1					1		
Alocasia	7	6		4		2		
Amorphophallus	5	5	1	3	3			
Anchomanes	2	1				1		
Anubias	1					1		
Apobalis	1	1		1		1		
Arisaema	2	1			1			
Arisarum	1				1			
Arophyton	1					1		
Arum	6	1	6	3	5			
Asterostigma	1	1			1			
Biarum	1		1		1			
Caladium	1	1		1				
Calla	1					1		
Carlephyton	2					2		
Cercestis	3	1				3		
Colocasia	1	1	1	1	1	1		
Cryptocoryne	9		1		8			
Culcasia	1				1			
Dracunculus	2	1	1		1			
Eminium	2		2	1	1			
Helicodiceros	1	1						
Homalomena	2	1		1		1		
Peltandra	1			1		1		
Philodendron	26	11		11	4	16		
Pinellia	1	1						
Pistia	1	1	1		1			
Sauromatum	1	1	1					
Stylochaeton	2	1		2		1		
Synandrospadix	1				1			
Syngonium	2				1	1		
Typhonium	1				1			
Typhonodorum	1	1				1		
Xanthosoma	3	2		1	1	1		
Zanthodeschia	1		1	1	1	1		
Family Acoraceae								
Acorus	1				1			
Total	146	64	30	51	55	46	2	1

No. = number of the species from which flavonoids were reported. An = anthocyanins, Fv = flavones, Fn = flavonols, CG = *C*-glycosylfavones, FP = flavan and proanthocyanidins, Fa = flavanones and Cf = *C*-glycosylflavanone.

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