The Amaranthaceae (a dicotyledon) comprises 71 genera and 800 species occurring in tropical, subtropical and temperate regions (Boulos, 1999). Some plants of the family are used because of their nutritive and medical value (Gu *et al*., 2008). Members of the family Amaranthaceae are mostly hardy, weedy, herbaceous and fast-growing cereal like plants that produce high protein grains in large terminal or axial sorghum-like inflorescences (Opute, 1979). They are noted for their tolerance to arid conditions and poor soils where cereals can not grow with ease (Pal and Khoshoo, 1974). Some occur naturally as weeds, but others are grown largely as ornamentals or as food. The protein-rich leaves and succulent stems are widely consumed in many parts of the tropics not only as delicates but also as condiments. Members of the Amaranthaceae are among the world's under-exploited plants which show promise for improving the quality of life in tropical regions (Opute, 1979; Rizk, 1986). The grain composition (starch, amino acids, proteins, lipids, vitamins and minerals) and nutritive value of grain proteins of several species of the Amaranthaceae have been reported (e.g. Carlsson, 1997; Zhu *et al*., 1998).

Chemical studies of the family revealed the presence of triterpenoids, steroids, flavonoids, chromones, alkaloids, pigments. and peptides (Gu *et al*., 2008).

Carbohydrates and Proteins

n-Butyl-β-D-fructoside and sucrose were isolated from the seeds of *Celosia argentea* (Fu *et al*., 1992). An antitumour fructan named CoPS3 was isolated from *Cyathula officinalis* Kuan. It is a graminans-type fructan that is composed of a β-D-fructofuranosyl backbone having residues on the nonreducing end of the fructan chain. Each branch is terminated by a β-D-frutofuranosyl residue (Chen and Tian, 2003a). The structural features of three fructans (CoPs1, CoPS2 and CoPS3) isolated from the roots of *Cyathula officinalis* showed that they are graminan type fructans, and comprised (2→1) and (2→6)-linked β-D-fructofuranosyl backbone residues containing high branches (Chen and Tian, 2003b).

Two fructo-polysaccharides FP-1 and FP-II were separated from tuberous roots of *Gomphrena macrocephala*. FP-I and FP-II were mixtures of saccharides with a wide-ranging degree of polymerization; their hydrolysis products were fructose and glucose. The ratios of fructose to glucose in the hydrolysates of FP-I and FP-II were 38 and 60, respectively. The FP-I and FP-II comprise fructose residues with β-2,6 linkages, and a terminal glucose bound with fructose residues at position C-1, although both polysaccharides possibly contained a non-terminal glucose residue in the molecule (Shiomi *et al*., 1996).

The soluble-protein in the underground part of *Gomphrena officinalis* amounted to 13% (Figueiredo-Ribeiro *et al*., 1986). Nine bicyclic peptides: celogentins A-C (Kobayashi *et al.*, 2001), celogentins D-H and J (Suzuki *et al*., 2003) have been isolated from the seeds of *Celosia argentea*. Other cyclic peptides *viz.* celogentin K (with a 3-hydroxyindole ring) and celogenamide A (Morita *et al*., 2004) were also idendentified from the seeds.

Lipids

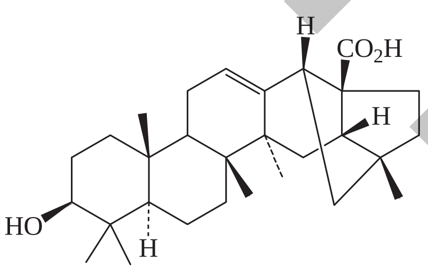
The seed oils of *Celosia argentea* L. var. *crispa* Kuntze (yellow flower) and *Celosia cristata* L. var. *spicata* (red flower) contain 10 fatty acids (FAs) including 4 trace FAs. Two FAs of of odd number of carbons in the seed oils, pentadecanoic acid ($C_{15:0}$) and heptadecenoic acid ($C_{17:1}$) were found. The compositions of main FAs in the seed oils were palmitic 20.61, 23.50; stearic 1.87, 2.39; oleic 20.77, 19.93, linoleic 51.39, 45.99; linolenic 1.54, 1.86 and arachidonic acid 3.20, 3.42% respectively (Weng and Wang, 2000). Analysis of the fatty acids (12.36%) in *Celosia argentea* L. seed oil showed that it comprises eight kinds of fatty acids, in which the content of oleic acid is the highest (about 37.45%), the second is linoleic acid (about 34.03), the third is palmitic acid (about 23.30%) (Zhu and Xu, 2002).

Terpenoids and Steroids

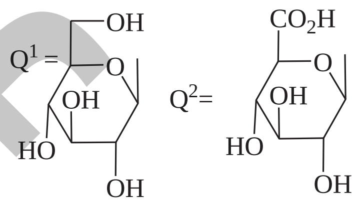
Several hexacyclic nortriterpenoids and their saponins (pfaffosides**)** have been isolated from *Pfaffia* species. Examples of these constituents are:

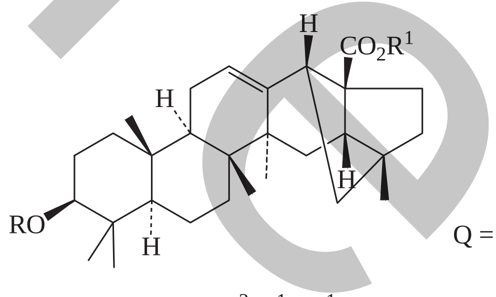
1. *Pfaffia glomerata*: Glomeric acid, and Pfameric acid (Shiobara *et al*., 1993a).
2. *Pfaffia paniculata* Kuntze: Pfaffic acid (**1**) (Takemoto *et al*., 1983), pfaffosides A (**2**), B (**3**), C (**4**) (Nishimoto *et al*., 1984), D, E (**5**), F (**6**), G (**7**) (Nakai *et al*.,1984) and I (Takemoto and Odajima, 1984).
3. *Pfaffia pulverulenta*: Pulveric acid (**8**), 11-deoxypulveric acid, 11-oxopfaffic acid, pfaffoside G (Shiobara *et al*., 1992a), 7-oxopulveric acid (**9**), 7-hydroxypulveric acid (**10**) and pulverulactone (**11**) (Shiobara *et al*., 1993b).

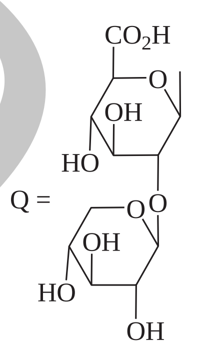
Oleanolic acid and β-glucosyl oleanolate were identified from *Pfaffia glomerata* (Shiobara *et al*., 1993a). Three stigmastane triterpenoids, and a sesquiterpenoid bearing an 11,12,13-trihydroxydrimene skeleton, were isolated from the aerial parts of *Tidestromia oblongifolia* (Chaudhary *et al*., 2008).



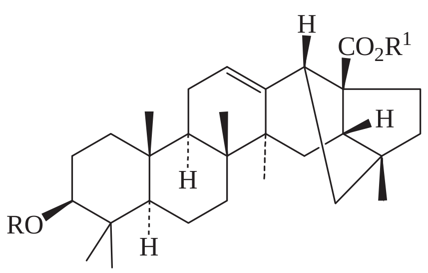
1 Pfaffic acid





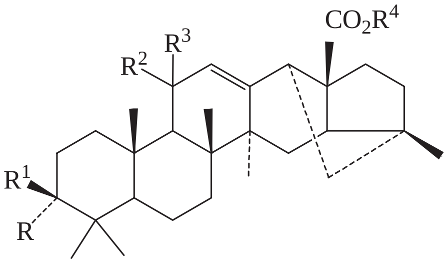


2 Pfaffoside A R= Q^2 ,R^1 =Q^1
3 Pfaffoside B R= Q ,R^1 =Q^1
4 Pfaffoside C R= Q^2 ,R^1 =Q^1

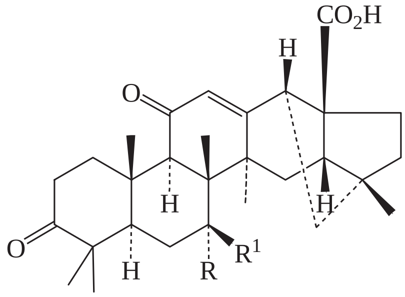


5 Pfaffosides E, R=β-D-xylopyranosyl-(1,2)β-D-(6-*O*-butyl-and-methyl) glucronopyranosyl, R^1 =1-β-D-glucronopyranosyl

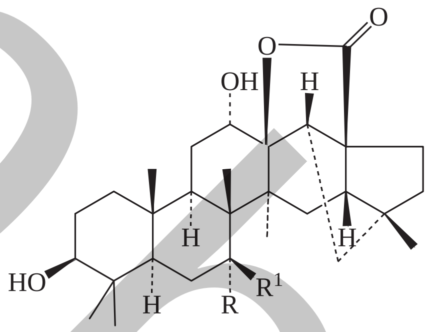
6 Pfaffosides F, R=β- D-glucronopyranosyl, R^1=H



7 Pfaffoside G R^1=OH, R=R^2 =R^3=H, R^4 =β-D-glucronopyranosyl
8 Pulveric acid, RR^1=R^2R^3=O, R^4 =H



9 7-Oxopulveric acid RR^1 =O
10 7-Hydroxypulveric acid R =OH, R^1 =H



(III)

11 Pulverulactone

Xu *et al*. (1986) investigated the sterol content of nineteen species and varieties of Amaranthaceae (*Amaranthus* and *Celosia*). They found that the desmethyl sterol content of these plants varied from 0.0084% to 0.034% of the total dry weight. Spinasterol and 7-stigmastrol were the dominant sterols in all species, although low levels of 5-unsaturated sterols were detected. Minor sterols identified in ≥ 1 species included cholesterol, campesterol, stigmasterol and sitosterol as well as 7,22-ergostadienol, 7,24(8)-ergostadienol, 7-ergostenol, 7,25-stigmastadienol, and 7,24(8)-stigmastadienol. Stigmastanol and 24-methylencycloartenol were also present (Xu *et al*., 1986). The major sterols of 14 genera of Amaranthaceae, examined by Patterson *et al*. (1991), were spinasterol, 7-stigmasterol, sitosterol and stigmasterol. Although the work of Xu *et al*. (1986) with 2 genera and 11 species of Amaranthaceae revealed only one species with dominant Δ-sterols, the work of Patterson *et al*. (1991) showed 19 species with dominant Δ^5-sterols, and 11 species had dominant Δ^7-sterols. Examples of desmethylsterol composition of some species of the family Amaranthaceae are shown in Tables 1 and 2. The sterol fraction isolated from *Celosia cristata* Linn. consists exclusively of Δ^7-sterols, rarely found in seed-bearing plants. GC analysis revealed the presence of 24-ethyl-22-dehydrolathosterol (24-ethyl-5'-cholesta-7-*trans*-22-dien-3β-ol; 69.6%) and 24-ethyllathosterol (17.5%) in major amounts, together with 24-methyl-22-dehydrolathosterol (3.8%,), 24-methylenelathosterol (1.9%), and 24-ethylidenelathosterol (Δ^7-avenasterol; 3.3%) (Behari and Shri, 1986). β-Sitosterol and cholesteryl palmitate were identified from the seeds of *Celosia argentea* (Fu *et al*., 1992). The aerial parts of *Blutaparon portulacoides* contain sitosterol, campesterol and stigmasterol, while the roots yielded sitosteryl-, stigmast-7-enyl- and spinasteryl β-D-glucopyranosides (Ferreira and Dias, 2000).

Table 1. Desmethylsterol composition of some species of the family Amaranthaceae*

Species	Sterols								
	A	B	C	D	E	F	G	H	I
1. *Aerva javanica*	11	21	20	7	13	16	2	3	4
2. *Aerva persica*	12	8	25	8	7	19	3	5	13
3. *Alternanthera brasiliana*	4	14	18	3	29	26		2	3
4. *Alternanthera canescens*	11	14	12	5	21	20	3	5	7
5. *Alternanthera caracasana*	5	11	24	4	24	20		6	5
6. *Alternanthera flavescens*	4	10	22	3	26	24		7	3
7. *Alternanthera halimifolia*	4	12	12	4	39	16		4	9
8. *Alternanthera maritima*[a]	2	8	14	4	26	34		7	5
9. *Alternanthera paronychioides*	7	24		3	42	3	2	2	13
10. *Amaranthus caudatus*[a]	1	3		9	62	24			
11. *Amaranthus cruentus*[b]	9	7		6	60	18			
12. *Amaranthus dubius*		13		16	52	19			
13. *Amaranthus gangeticus*	2	2		6	71	18			
14. *Amaranthus hybridus*		12		13	58	17			
15. *Amaranthus hypochondriacus*[a]	2	2		7	72	17			
16. *Amaranthus leucocarpus*[a]		2		5	77	15			
17. *Amaranthus retroflexus*[a]	1	6		4	69	20			
18. *Amaranthus tricolor*[a]	2	4		6	67	19			

*As % of total desmethyl sterols, totals may not equal 100% due to rounding or presence of sterols not listed in the Table (Patterson *et al.*, 1991).
A = campesterol, B = stigmasterol, C = sitosterol, D = 7-ergostenol, E = spinasterol, F = 7- stigmastenol, G = campestanol, H = stigmastanol, I = 22-stigmastenol.
a: (Xu *et al*., 1986); b: (Patterson *et al*., 1991)

α-Amyrin, β-amyrin, Δ^5-sterols, Δ^7-cholesterol, Δ^7-sitosterol and sitosterone were identified from whole plant of *Gomphrena boliviana* (Buschi and Pomilio, 1982a). Three triterpenes, olean-12-2n-3,11-dione, urs-12-2n-3,11-dione and 3-oxo-11α,12α-epoxy-D-friedoolean-14-one, were isolated from *Gomphrena clausenii* Moq. (Ferreira and Dias, 2004). Gomphosterol β-D-glucoside, (22*E*, 24*S*)-24-ethylcholesta-7,9(11),22-trien-3β-ol-3-*O*-β-D-glucopyranoside), β-sitosterol, stigmasterol β-D-glucoside, friedelin, and 3-epifridelinol were identified from the aerial parts of *Gomphrena globosa* (Dinda *et al*., 2006).

Iresin, a tricyclic sesquiterpene lactone (Djerassi *et al*., 1954) and three others related to iresin *viz.* dihydroiresin, dihydroiresone and 13-*nor*-3-dehydrodihydroiresin, were isolated from *Iresine celosioides* (Crabbé *et al*., 1958a).

Ecdysteroides have been identified in some genera of the family Amaranthaceae (Table 3). The biosynthesis of of isocyasterone was studied by Boid *et al*. (1974). 2,3-Isopropylidene cyasterone, 24-hydroxycyasterone and 2,3-isopropylidene iso-cyasterone have been isolated from the roots of *Cyathula officinalis* (Zhou *et al*., 2005a). Two cyasterone stereoisomers (28-*epi*-cyasterone and 25-*epi*-28-cyasterone) were identified from the roots and stems of *Cyathula officinalis* (Okuzumi *et al*., 2005).

Saponins

A triterpenoid saponin, chikusetsusaponin was isolated from the roots of *Pfaffia glomerata* (Nishimoto *et al*., 1987). Several oleanolic acid glucosides, in addition to a hederagenin glycoside were separated from the roots of *Cyathula officinalis* (Zhou, 2005b).

Table 2. Relative quantities of Δ^5, Δ^7 and Δ^0 sterols in some species of the family Amaranthaceae

Species	Sterols*		
	Δ^5	Δ^7	Δ^0
1- *Achyranthes bidentata*	34	56	8
2- *Aerva javanica*	52	36	9
3- *Aerva persica*	45	34	21
4- *Alternanthera brasiliana*	36	58	5
5- *Alternanthera canescens*	37	46	15
6- *Alternanthera caracasana*	40	48	11
7- *Alternanthera flavescens*	36	53	10
8- *Alternanthera halimifolia*	28	59	13
9- *Alternanthera maritima*	24	64	12
10- *Alternanthera paronychioides*	31	48	17
11- *Amaranthus caudatus*[a]	4	95	
12- *Amaranthus cruentus*[a]	16	84	
13- *Amaranthus dubius*[b]	13	87	
14- *Amaranthus gangeticus*[b]	4	95	
15- *Amaranthus hybridus*[b]	12	88	
16- *Amaranthus hypochondriacus*[a]	4	96	
17- *Amaranthus leucocarpus*[a]	2	97	
18- *Amaranthus retroflexus*[a]	7	93	
19- *Amaranthus tricolor*[a]	6	92	

*As % of desmethyl sterol, totals may not equal 100% due to rounding or presence of sterols not listed in the Table (Patterson *et al.* 1991)
a: (Xu *et al*., 1986); b: (Patterson *et al*., 1991)

Chikusetsusaponin was isolated from the tuberous roots of *Gomphrena officinalis* Mart. (Young *et al*., 1992). Monodesmosidic saponins e.g. 28-*O*-β-D-glucopyranosyl-ester-oleanolic acid and 28-*O*-β-D-glucopyranosyl-ester-olean-9(11),12-diene, 3-*O*-β-D-glucopyranosyl-erythrodiol and 3-*O*-β-D-glucopyranosyl-11,12-epoxy-olean-28-olide from *Gomphrena macrocephala* (Young *et al*., 1997). Several other oleanane and taraxerane glycosides have been isolated from the roots of *Gomphrena macrocephala* (Kuroda *et al*., 2006a,b).

Several glycosides have been isolated from the leaves of *Celosia argentea* L. *viz.* 1-(4-*O*-β-glucopyranosyl-3-methoxyphenyl) propane-2-ene (citrusin C, **15**), 3-*O*-β-D-glucopyranosyl-1*H*-indole (indican), (3*Z*)-hexenyl-1-*O*-(6-*O*-α-rhamnopyranosyl-β-D-glucopyranoside), (3*Z*)-hexenyl-1-*O*-β-glucopyranoside, (7*E*)-6,9-dihydromegastigma-7-ene-3-one-9-*O*-β-D-glucopyranoside (Sawabe *et al*., 1998, 1999a,b).

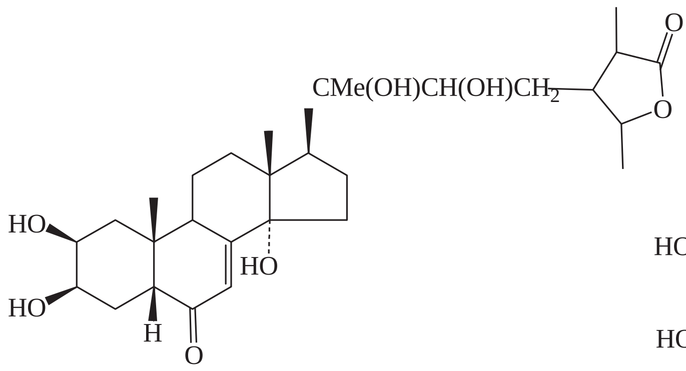
Betacyanins

Betacyanins, a class of water-soluble red-violet pigments, occur only in 10 families of the order Caryophyllales (old name for Centrospermae), including the family Amaranthaceae (Piattelli and Minale, 1964). The presence of betacyanins in plants is mutually exclusive of the occurrence of anthocyanins, which are more widely distributed in the plant kingdom. All betacyanins are glycosylated and derived mainly from their basic structural units, that is the aglycone betanidin and isobetanidin (the *C*-15 epimer). The hydroxyl groups of the latter enable the formation of glycosides that occur mostly as the 5-*O*-glucosides, for example, in

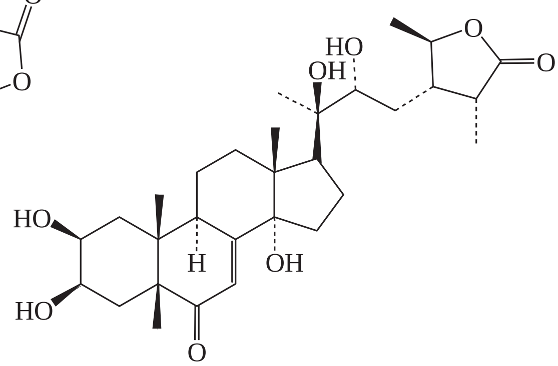
Table 3. Ecdysteroids of some species of the family *Amaranthaceae*

Species	Plant part	Ecdysteroids	References
1. *Cyathula capitata*		Cyasterone (**12**) and isocyasterone (**13**).	Hikino *et al.* (1971); Boid *et al.* (1974).
2. *Cyathula officinalis*	R	Cyasterone, 24-hydroxycyasterone and 2,3-isopropylidine cyasterone, 2,3-isopropylidene isocyasterone, amarasterone A, precyasterone and makisterone B	Zhou *et al.* (2005a)
	R, S	Two cyasterone stereoisomers (25-*epi*-cyastrone and 25-*epi*-28-*epi*-cyasterone	Okuzumi *et al*. (2005)
3. *Gomphrena affinis*	S	Ecdysone (**14**)	Savchenko *et al.* (1998)
4. *Gomphrena canescens*		Ecdysone	Savchenko *et al.* (1998)
5. *Gomphrena cellosioides*		Ecdysterone	Banerji *et al.* (1998)
6. *Gomphrena cunninghamii*		Ecdysone	Savchenko *et al.* (1998)
7. *Gomphrena depressa*	Ap	Ecdysone	Savchenko *et al.* (1998)
8. *Gomphrena haageana*	S	Ecydysone, 20-hydroxyecdysone and polypodine B	Sarker *et al*. (1996); Savchenko *et al.* (1998)
9. *Gomphrena haenkeana*		Ecdysterone	Buschi and Pomilio (1983)
10. *Gomphrena meyeniana*		Ecdysterone	Buschi and Pomilio (1983)
11. *Gomphrena officinalis*	R	Ecdysterone	Young et *al.* (1992)
12. *Gomphrena perennis*		Ecdysterone	Buschi and Pomilio (1983)
13. *Pfaffia glomerata*		Ecdysterone and rubrosterone	Shiobara *et al*. (1993a)
14. *Pfaffia iresinoides*	R	Ecdysterone, polypodine B and pterosterone	Nishimoto *et al*. (1987)

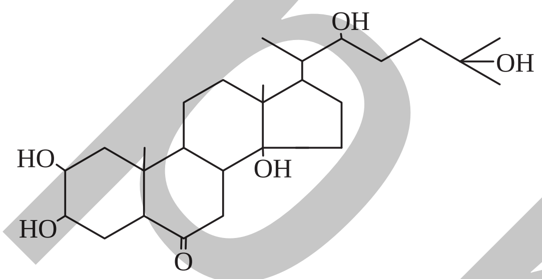
Ap: all parts, R: roots, S: seeds



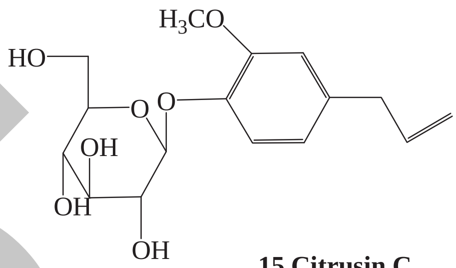
12 Cyasterone



13 Isocyasterone



14 Ecdysone



15 Citrusin C

betanin-type betacyanins that are a major or minor pigment component in many betacyanin-producing plants. Further glycosylation at the 5-*O*-glucosides is often found, for example, the glucuronosylglycosides in amaranthin-type betacyanins that are one of the most common pigments in the Amaranthaceae. Because the word "amaranthin" was also used for the name of a lectin or a globulin protein from *Amaranthus* (Rinderle *et al*., 1990; Chen and Paredez-López, 1997), the pigment was designed "amaranthine" rather than "amaranthin" to avoid confusion (Huang and von Elbe, 1986; Cai *et al*., 1998a, 2001).

The betacyanin pigments (well-known betalains) extracted from red beets (*Beta vulgaris*) are extensively used in the food industry (Freund *et al*., 1988). Piattelli and Minale (1964) investigated the betacyanin distribution in seven species of the genus *Amaranthus* and nine species of five other genera in the Amaranthaceae. The pigments from 21 genotypes of 7 *Amaranthus* species were identified as homogenous betacyanins (amaranthine and isoamaranthine) (Cai *et al*., 1998a,b; Cai and Corke, 1999). *Amaranthus* betacyanins have high potential for use as colourants in some food products. Red *Amaranthus* plants have attracted considerable interest as a potential alternative source of betacyanin pigments similar to those from red beet, because some *Amaranthus* genotypes produce higher biomass and contain more betacyanins than red beet. Furthermore, *Amaranthus* plants can grow in a wider ranger of environments than red beet (Cai *et al*., 2001).

The betacyanins gomphrenin I (betanidin 6-*O*-β-glucoside) and its acylated forms gomphrenin II (betanidin 6-*O*-[6'-*O*-(*E*-coumaroyl)-β-glucoside]) and gomphrenin III (betanidin-6-*O*-[6'-*O*-*E*-feruloyl-β-glucoside) were isolated from flowers of *Gomphrena globosa* (Heuer *et al*., 1992,1993). Red-coloured plants in the family Amaranthaceae are recognized as rich source of diverse unique betacyanins. The distribution of betacyanins in 37 species of 8 genera in the Amaranthaceae was investigated by Cai *et al*. (2001). A total of 16 kinds of betacyanins were characterized (Table 4). They consisted of 8 simple (nonacylated) betacyanins and 10 acylated betacyanins, including 8 amaranthine-type pigments, 6 gomphrenin - type pigments, and 2 betanin - type pigments. Acylated betacyanins were

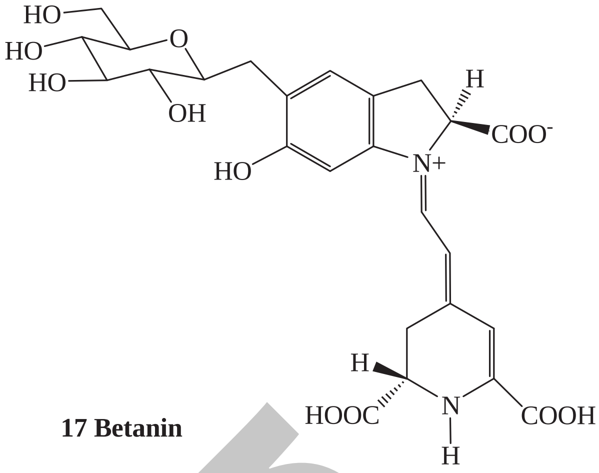
Table 4. Identification of betacyanins in the *Amaranthaceae**

Trivial name	Definitive name[a]
1- Amaranthine (**16**)	Betanidin 5-*O*-β-glucuronosylglucoside
2- Isoamaranthine	Isobetanidin 5-*O*-β-glucuronosylglucoside
3- Betanin (**17**)	Betanidin 5-*O*-β-glucoside
4- Isobetanin	Isobetanidin 5-*O*-β-glucoside
5- Iresinin I (**18**)	Betanidin 5-*O*-(6′-*O*-3-hydroxy-3-methyl-glutaryl)- β-glucuronosylglucoside
6- Isoiresinin I	Isobetanidin 5-*O*-(6′-*O*-3-hydroxy-3-methyl-glutaryl)-β-glucuronosylglucoside
7- Celosianin I (**19**)	Betanidin 5-*O*-(2''-O-*E*-4-coumaroyl)-β-glucuronosylglucoside
8- Isocelosianin I	Isobetanidin 5-*O*-(2''-*O*-*E*-4-coumaroyl)-β-glucuronosylglucoside
9- Celosianin II (**20**)	Betanidin 5-*O*-(2''-*O*-*E*-feruloyl)-β-glucuronosylglucoside
10- Isocelosianin II	Isobetanidin 5-*O*-(2''-*O*-*E*-feruloyl)-β glucuronosylglucoside
11- Gomphrenin I (**21**)	Betanidin 6-*O*-β-glucoside
12- Isogomphrenin I	Isobetanidin 6-*O*-β-glucoside
13- Gomphrenin II (**22**)	Betanidin 6-*O*-(6'-*O*-*E*-4-coumaroyl)-β-glucoside
14- Gomphrenin III (**23**)	Betanidin 6-*O*-(6'-*O*-*E*-feruloyl)-β-glucoside
15- Isogomphrenin II	Isobetanidin 6-*O*-(6'-*O*-*E*-4-coumaroyl)-β-glucoside
16- Isogomphrenin III	Isobetanidin,6-*O*-(6'-*O*-*E*-feruloyl)-β-glucoside

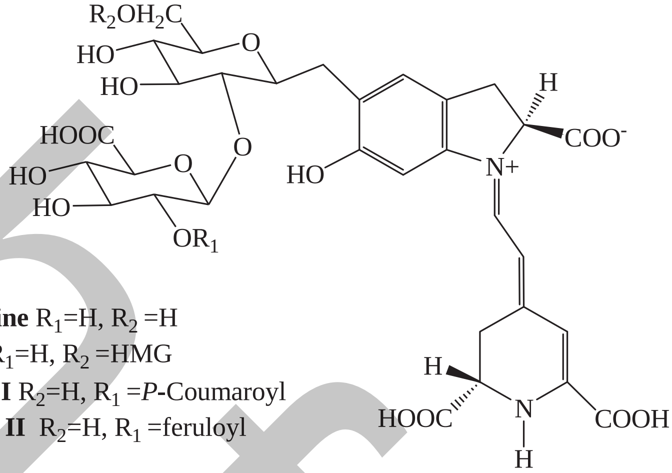
a:-β-glucuronsyl-glucoside = -β-(1″,2′)-glucuronysl-β-glucoside = (β-glucuronic acid)-β-glucoside = -(β-D-glucosyluronic acid)- β-glucoside = -(β-D-glucopyranosyluronic acid -β-D-glucopyranoside.

* Cai *et al.* (2001)

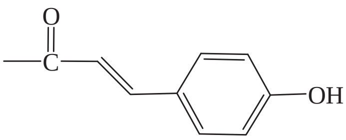
identified as betanidin 5-*O*-β-glucopyranosylglucoside or betanidin 6-*O*-β-glucoside acylated with ferulic, *p*-coumaric, or 3-hydroxy-3-methylglutaric acids. Total betacyanin content in the 37 species ranged from 0.08 to 1.36 mg/g of fresh weight. Simple betacyanins (such as amaranthine, which averaged 91.5% of total) were wide-spread among all species of 8 genera. Acylated betacyanins were distributed among 11 species of 6 genera, with the highest proportion occurring in *Iresine herbstii* (79.6%) and *Gomphrena globosa* (68.4%). Some cultivated species contained many more acylated betacyanins than wild species, representing a potential new source of these pigments as natural colourants (Cai *et al*, 2001). Cai *et al*. (2005) identified three betaxanthins from *Celosia* species as immonium conjugates of betalmic acid with dopamine, 3-methoxytyramine, and (*S*)-tryptophan. The betalines of yellow, orange, and red inflorescences of common cockscomb (*Celosia argentea* var. *cristata*) were compared and proved to be qualitatively identical to those of feathered amaranth (*Celosia argentea* var. *plumosa*). Among the betacyanins occurring in yellow inflorescenes in trace amounts, the presence of 2-decarboxy-betanidin, a dopamine-derived betacyanin, has been ascertained (**24**, **25**) (Schliemann *et al*., 2001). Studies on the synthesis of betalains in the inflorescenses of *Celosia cristata* (Sakata and Arismu, 1980) and betaxanthins in *Celosia plumosa* seedlings (De Nicola *et al*., 1973) have been reported.



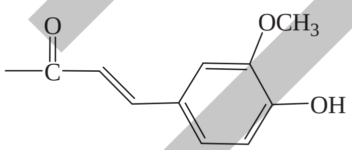
17 Betanin



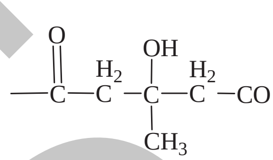
16 Amaranthine R_1=H, R_2 =H
18 Iresinin I R_1=H, R_2 =HMG
19 Celosianin I R_2=H, R_1 =*P*-Coumaroyl
20 Celosianin II R_2=H, R_1 =feruloyl



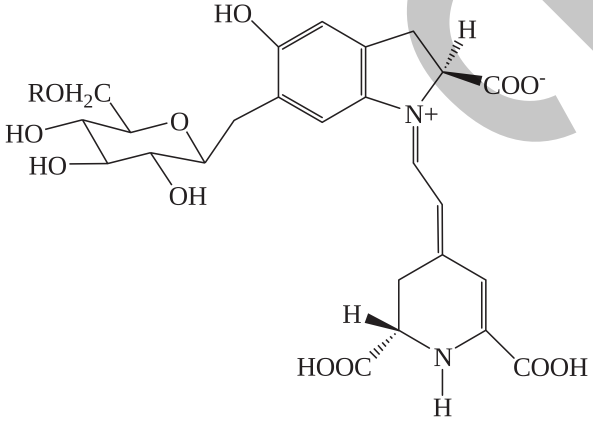
p-Coumaroyl



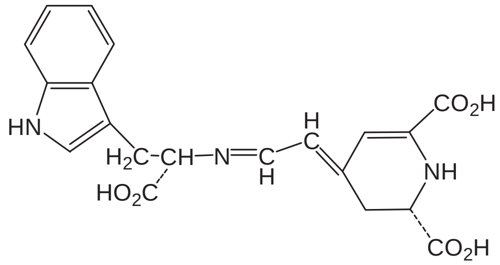
Feruloyl



3-Hydroxy-3-methyl glutaryl (HMG)



21 Gomphrenin I R =H
22 Gomphrenin II R = *p*-Coumaroyl
23 Gomphrenin III R =Feruloyl



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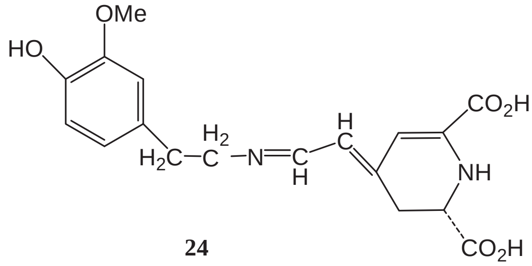


24

Betaines

Betaine distribution in several species of the family Amaranthaceae, has been studied by several investigators. Aerial parts of 23 species distributed in 10 genera of the Amaranthaceae have been examined for the presence of betaines. Glycinebetaine was isolated from all species studied and, in addition, trigonelline was detected in eight out of the nine species of *Amaranthus*, 1 of the two species of *Alternanthera* and in the species of the *Iresine* (3), *Celosia* (2), *Chamissoa* (1), *Aerva*, *Gomphrena* (1) and *Froelichia* (1). With the exception of *Iresine herbestii*, glycinebetaine was the predominant betaine. The highest yield of this compound was from *Cyathula geniculata* (2.11% dry weight), but, with the exception of *Iresine herbestii* (0.05%), the species tested had contents in the range 0.28-2.11% dry weight. Trigonelline yields varied from 0.004 to 0.15%, dry weight. These data justified the classification of Amaranthaceae as a betaine-accumulating family (Blunden *et al*., 1999). Choline and betaine have been also identified from *Gomphrena boliviana* (Buschi *et al*., 1982a). Diferuloylputrescine and feruloylputrescine have been detected in *Gomphrena globosa* and *Iresine herbestii* (Martin-Tanguy *et al*., 1978).

Flavonoids and Other Constituents

Several flavonoids (including a unique symmetrical glycosylated methylene bisflavonoid, methylenedioxy isoflavones and others) have been identified from species of the family Amaranthaceae (Table 5). A heptasubstituted (*E*)-aurone glucoside, *E*-3'-*O*-β-gluco-pyranosyl-4,5,6,4'-tetrahydroxy-7,2'-dimethoxyaurone), was isolated from *Gomphrena agrestis* (Ferreira *et al*., 2004).

Iresinoside, a yellow pigment has been isolated from the crude drug 'Brazil ginseng', the roots of *Pfaffia iresinoides*. Iresinoside which has an extended styryl-2-pyrone structure, was obtained in *ca* 2:1 ratio of two components (**26**) (Shiobara *et al*., 1992b).

Caffeic acid and catechol were reported as the main phenolic compounds of *Gomphrena holoserica* Mig. (Sant'ana *et al.*, 1977). 3,5-Dihydroxybenzaldehyde, 4-hydroxybenzoic acid and 3,4-dihydoxybenzoic acid were identified from the seeds of cockscomb (*Celosia argentea*) (Fu *et al*., 1992). Vanillic acid was detected in the roots of *Blutaparon portulacoides* (Ferreira and Dias, 2000).

Allantoin was identified in *Gomphrena globosa* (Dinda *et al*., 2006). 4-Methoxy-6-canthinone was isolated from stem and root bark of *Charpentiera obovata* (Scheuer and Pattabhiraman, 1965). Aurantiamide, a protoalkaloid, was isolated from *Gomphrena agrestis* (Ferreira *et al*., 2004). Both aurantiamide and aurantiamide acetate have been isolated from *Gomphrena clausenii* Moq. (Ferreira and Dias, 2004).

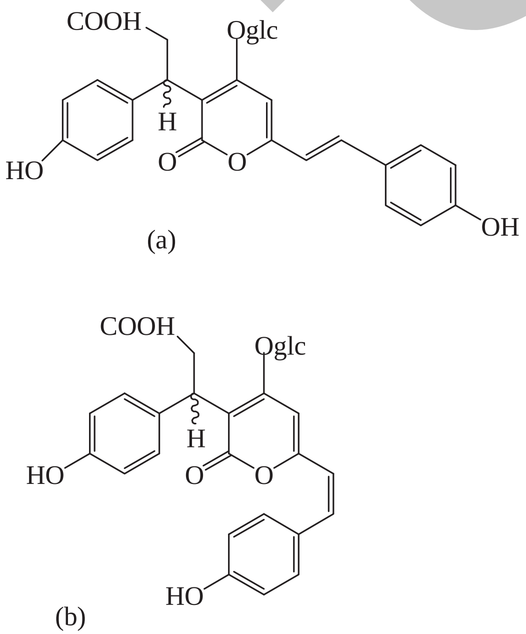
Table 5. Flavonoides of some species of the family *Amaranthaceae*

Species	Plant part	Flavonoides	References
1. *Blutaparon portulacoides* *(= Philoxerus portulacoides)*	Ap	Irisone B, 3,5,3′-trihydroxy- 4′-methoxy-6,7-methylene-dioxyflavone (**27**), spinacetin 3-*O*-robinobioside and 8,8´´´´-methylene bis (spinacetin 3-robinobioside)	Ferreira and Dias (2000); De Oliveira *et al.* (2003)
2. *Celosia argentea*	Ap	5-Methoxy-6,7-methylenedioxy-2′-hydroxyisoflavone and its 2′-methoxy derivative	Jong and Hwang, (1995)
3. *Celosia cristata*		Cristatin (5-hydroxy-6-hydroxymethyl-7,2´-dimethoxy-isoflavone), and cohliophilin A (5-hydroxy-6,7-methylenedioxyflavone)	Wen *et al*. (2006)
4. *Gomphrena boliviana*	Wp	5,7-Dihydroxy-3,6-dimethoxyflavone, 5,7-dihydroxy-6-methoxyflavone, 3,5,6,7-tetramethoxyflavone, 3,5-di-methoxy- 6,7-methylenedioxyflavone, 3,5,7-trimethoxy-flavone, 7-hydroxy-5,6-dimethoxyflavone and isorhamnetin-3-*O*-robinobioside	Buschi and Pomilio (1982a,b); Pomilio *et al.* (1992)
5. *Gomphrena clausenii*		Irisone B, patuletin, quercetin, kaempferol, isorhamnetin, patuletin 3-*O*-β-D-glucopyranoside, and kaempferol 3-*O*-β-D-glucopyranoside	Ferreiea and Dias (2004)
6. *Gomphrena globosa*	L	Gomphrenol*	Bouillant *et al.* (1978)
	Ap	Chrysoeriol 7-*O*-β- glucoside	Dinda *et al.* (2006)
7. *Gomphrena holosericea*	F	Polyhydroxyflavonoids	Sant'ana *et al.* (1977)
8. *Gomphrena maritiana*	Wp	3,5-Dimethoxy-6,7-methylenedioxyflavone, 3,5,6,7-tetramethoxyflavone, 3,6-dimethoxy-5,7-dihydroyflavone (**28**), 3,5,7-trimethoxyflavone, 7-hydroxy-5,6-dimethoxy-flavone, 5,7-dihydroxy6-methoxyflavone and isorhamnetin 3-*O*-robinobioside (**29**)	Buschi *et al*. (1979, 1980, 1981); Buschi and Pomilio (1982)

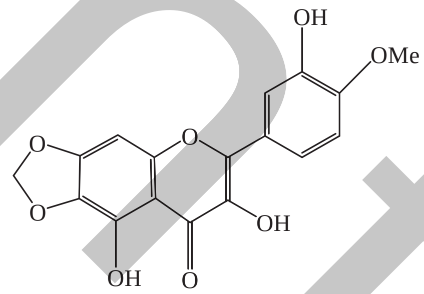
Table 5. Flavonoides of some species of the family *Amaranthaceae* (cont.)

Species	Plant part	Flavonoides	References
9. *Iresine celosioides*	Wp	Tlatlancuayin (2′,5-dimethoxy-6,7- methylene-dioxyisoflavone)	Crabbè *et al.* (1958b)
10. *Iresine herbstii*	Ap	3,4,7-Trihydroxy-6-methoxyflavone	Kubinova *et al.* (1998)

*Infected with bushy stunt virus
Ap: aerial parts, F: flowers, L: leaves, Wp: whole plant



26 Iresinoside



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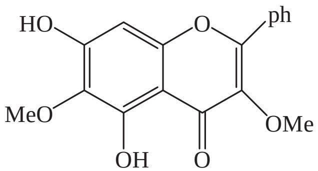

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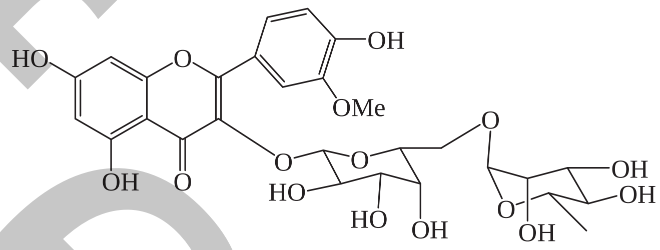

29 Isorhamenetin 3-*O*-robinobioside