CHEMOSYSTEMATICS OF THE CACTACEAE

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The Cactaceae are one of the few large families of dicotyledons with clear ecogeographic significance. Cacti are native to temperate and tropical regions of the new world, particularly in warm and dry places. The Cactaceae consists of 30 to 200 genera (depending on the author) and at least 1000, perhaps as many as 2000 species.

Lophora williamsii or 'Mescal button', the source of peyote, is a member of this family. Mescal buttons contain several alkaloids with narcotic properties. Peyote is extensively used by Indians for its medicinal value. It is considered to be a panacea for most body ills. Many Cacti are cultivated as pot plants.

The Cactaceae members are spiny succulents. Leaves are absent except in Pereskia and Pereskiopsis which possess woody stem and well developed succulent alternate simple leaves. Flowers are solitary large and showy, at the areolal or sometimes at the branch tips (Pereskia). Flowers are perfect or seldom unisexual, regular or sometimes irregular through curvature of the perianth tube or due to the unequal reflexion of the segments. Sepals are numerous, spirally arranged, showy and petaloid, united below to form a perianth tube or hypanthium. Stamens are numerous, initiated in centrifugal

sequence. Anthers are tetrasporangiate and dithecal, opening by longitudinal slits. Gynoecium of 3-many carpels united to form a compound inferior ovary (in Pereskia the flowers are perigynous and ovary is superior) with a single style and as many radiating stigmas as carpels (in Pereskia the carpels are slightly united). Ovules usually numerous with parietal placenta in unilocular ovary (in Pereskia basal and the ovary partly partitioned). Ovules are campylotropous to rarely anatropous, bitegmic and crassinucellar. Fruit is indehiscent fleshy baccate, rarely dry or dehiscent.

TAXONOMY

Briton and Rose (1873) classified the Cactaceae into three tribes viz the Pereskieae, Opuntieae and Cacteae (Cereae). The tribe Pereskieae is characterized by the presence of broad flat leaves and stalked, clustered flowers and is devoid of glochids. Small terete, early deciduous leaves, sessile flowers and glochids are the distinguishing characters of tribe opuntieaee whereas the tribe cacteae possesses rudimentary leaves, sessile flowers, perianth forming a tube and glochids.

Thorne (1968) elevated these three tribes to subfamilies, the Pereskioideae, Opuntioideae and Cactoideae.

Bentham and Hooker (1865) recognized only two tribes, the Echinocacteae and Opuntieae, the former contains 9 genera

and the latter with 4 genera. They included Pereskia in tribe Opuntieae.

EARLIER CHEMICAL WORK

The known chemical data of various Cactaceae taxa is presented in the table -II .

The Cactaceae are characterized by the presence of a peculiar type of alkaloid mescaline. Lophophorine, hordenine and anhalidine are the other alkaloids reported in this family. Apart from alkaloics, various type of flavonoids located in this family are quercetin, kaempferol, and their variously methoxylated derivatives. β -Sitosterol, deoxyviperidene, macdongathin, peniocrenol, cyclosterol, stenocerol and tuberol are the major steroids reported in the Cactaceae.

In the present study, 9 plants belonging to the 5 genera have been studied for their chemical markers. The data thus obtained, alongwith data from other disciplines, are used to understand the taxonomy and phylogeny of the family at various levels.

MATERIALS AND METHODS

Screening was done with plant materials collected from gardens in and around Baroda. The plant materials were properly identified and deposited in the Herbarium of the Botany Department, M.S. University of Baroda, India.

TABLE - II . SOME OF THE EARLIER CHEMICAL WORKS IN THE CACTACEAE

Sl.No.	Name of the plants	Organ	Compounds	Reference
			FLAVONOIDS	
1.	Echinocereus viridiflolius	Tepal	6-flavonol-o-glycosides	Leuck et al. (1982)
2.	E. chloranthum		2-dihydroflavonol 7-o-glycoside	
3.	E. russanthus			
4.	E. davissii			
5.	Echinocereus triglochidiatus var. gurneyi		Dihydroquercetin and its 7-o-glycoside Dihydrokaempferol, Dihydromyriectin and their 7-o-glucoside	Miller et al. (1982)
6.	Neochilenia acrocarpa N. glabrascens N. nepina	Whole plant	4'O-glucoside of 3-methyl ether of quercetin	Iwashina et al.(1980)
7.	Neoporteria chilensis N. litoralis N. rapifor N. microsperma N. polyraphis N. riohuascofecher N. serenana	Whole Plant	3-methyl ether of quercetin	Iswashina et al. (1984)

(Contd....)

TABLE 11 (Contd.)

Sl.No.	Name of the plants	Organ	Compounds	Reference
8.	Opuntia subgenus cylindropuntia		Quercetin 3-glucoside, quercetin 3-ratinoside and kaempferol 3-glucoside	Clark et al. (1980)
9.	Parodia sanguiniflora	Whole plant	7-O-glucosides of 3-methyl ether of quercetin	Iwashina et al.(1984)
10.		STEROIDS AND RELATED COMPOUNDS		
1.	Cereus peruviana	Epicuticular wax	Hydrocarbon (with C_{31} predominating) and ether	Hughes et al. (1980)
2.	Cereus forbesii C.pervianum C.pervianum c.v.montam		2-C-methylaldotetronic acid (probably the erythroform)	Kringstad et al.(1980)
3.	Hydrocerus undulatus		(A lactone forming acid)	
4.	Lophocerus Schttii L.Williamsii		β -sitosterol	Sen et al. (1968)
5.	Peniocereus greggii	root	β -sitosterol, deoxy viperidene Viperidene	Knight et al. (1969)
6.	Stenocerus thurbori (turberi)		Macdongalbin peniocrerol, Cydosterol, stenocerol and thurberol	Kircher et al.(1982)

(Contd...)

TABLE 11 (Contd.)

Sl.No.	Name of the plant	Organ	Compounds	Reference
7	Trichocereus santiagoensis T. spachianum T. strigosus T. pachonais T. schiekendantzii T. terschekii T. werdermanianus		2-C-Methoxyal dotetronic acid probably the erythroform (A loctone forming acid)	Kringstad et al. (1980)
			ALKALOIDS	
1.	Backebergia militaris		6,7-Dimethoxy-1,2,3,4-tetrahydroisoquinoline (Heliamine) 3,4,Dimethoxy β-phenethylamine hydrochloride	Mata Rachel et al. (1980)
2.	Coryphantha runyouii		β-phenethylene (Macromerene)	Below, et al. (1968)
3.	Coryphantha greenwoodii		Nor macromerine N-methyl 1-3,4-dimethoxy, β-Methoxy phenethylamine and N,N-dimethyl 1-3,4-dimethoxy β-Methoxy phenethylamine Hordeine, -C-methyl synephrine	Bruhn et al. (1975)

(Contd...)

TABLE-II (Contd)

Sl.No.	Name of the plant	Organ	Compounds	Reference
4.	Coryphantha bumania C.calipensis C.radion C.vivipara		Hordenine	Bruhn et al.(1975)
5.	Coryphantha calipensis	(-) Calipamine	(+)eCalipamine (N-Methyl 3,4,dimethoxy-methoxy phethylamine)	Woodard et al.(1978)
6.	Coryphantha greenwoodii		N,N,N-trimethyl-4-methoxy Penethylamine chloride (O-methyl candicine) + -N,N,N-trimethyl- β - Methoxy phenethylamine chloride (coryphanthaine)	Meyer, et al. (1983)
7.	Coryphantha bumamma		N-Methyl-4-Methoxy phenethylamine	Bruhn et al. (1975)
8.	Coryphantha calipensis		(-) Calipamine, N-methoyl 3,4-dimethoxymethyl phenathylamine	Woodard et al.(1978)
9.	Lophora Williamsii		Peyonine novel β- phenethylpyroite	Kapadia et al.(1968)
10.	Lopho cereus schotti		Pilocerenine, lophocerine trace of unidentified alkaloids	West et al. (1975)

(Contd....)

TABLE II (Contd.)

Sl.No.	Name of the plant	Organ	Compounds	Reference
11.	Pachycereus pringlei		Tehuamine N-oxide	Pummangura et al.(1982)
12.	Pachycereus gaumeri		Deglucopterocereine N-oxide	Pummangura et al.(1982)
13.	Pachycereus weberi		Weberine 2-methyl 5,6,7,8, tetramethoxy 1,2,3,4,tetra-hydroxy isoquinoline.	Takashashi et al.(1982)
14.	Peyote button		Methoderivatives of tetra-hydroxy isoquinoline, anha-line, lophopharine,pellotine, choline, lophorine,anhalonine and peillotine.	Kepadia et al (1968)
15.	Peyote aselliformis		Hordemine, anhalidine,pello-tine,3-dimethyltrichocerene, Mescaline,3,4,dimethoxy β - phenethylamine, N-monomethyl derivatives of Mescaline and 3,4-Dimethoxy β-phenethylamine.	Neal et al. (1972)
16.	Trichocereues cuzcoeusis T.fulvilanum T.taquembalensis T.validis		Mescaline	Verdejovivas et al.(1974)
17.	Trichocereus Spp.		Tyramine,N-Methyltyramine Hordene-3-methodytyramine 3,4-dimethoxyphenethylamine 3-hydroxy-4-5-dimethoxy phenethylamine and Mescaline.	Agrurell et al.(1971)

Whole plants (Phylloclades) were used for analysis except for Pereskia grandifolia where the leaves were studied. Procedures followed for the extraction, isolation, and identification of various chemical markers are the same as those described in Chapter 2.

RESULTS

The distribution of flavonoids, phenolic acids, alkaloids, Saponins and steroids from members of Cactaceae is presented in the table-12 .

All the members screened contained flavonols. Flavones, and glycoflavones were absent in the family.

Various type of flavonols located in this family include quercetin, kaempferol and their methoxylated derivatives. Kaempferol, as such, was detected in all members except Opuntia dellini. Quercetin was present in Mamillaria sps., Opuntia dellini, Opuntia sps. and Pereskia grandifolia. 4'-OMe kaempferol was present in Cereus pervianus, Cereus sps. and Pereskia grandifolia. Melocactus spp. and Opuntia dellini were the two species with 3'-OMe quercetin whereas Cereus forbesii was the only member with 4'-Ome quercetin. 3',4'-DiOMe quercetin was located in Opuntia dellini and Pereskia grandifolia.

Altogether 5 phenolic acids have been identified in this family. Vanillic, and Syringic acids were present in all the

TABLE - 12 . DISTRIBUTION OF PHENOLIC ACIDS, SAPONINS, STEROIDS, PROANTHOCYANILINS, ALKALOIDS, AND FLAVONOIDS IN THE CACTACEAE.

	TRIBE ECHINOCACTEAE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	Ceveus forbesii	+	+	+				+	+		+		+					+	
2.	Cereus peruvianus	+			+	+	+		+	+	+		+						
3.	Cereus pervianum	+	+	+				+	+		+		+	+					
4.	Cereus Sp .	+	+					+	+		+		+	+					
5.	Mamilaria Sp .	+	+					+	+		+		+		+				
6.	Melocactus Sp .	+	+	+				+	+		+		+				+		
	TRIBE II OPUNTIEAE																		
7.	Opuntia dillenii	+	+				+	+	+		+				+		+		+
8.	Opuntia Sp .	+	+					+	+		+		+		+				
9.	Pereskia grandifolia	+	+					+	+		+		+	+	+				+

PHENOLIC ACILS

1. Vanillic , 2. Syringic, 3. p-OH Benzoic 4. Melilotic, 5. Ferulic 6. Tannin
7. Saponin, 8. Steroids, 9. Proanthocyanidins, 10. Alkaloids, 11. Iridoids

FLAVONOILS

12. Kaempferol , 13. 4'-OMe Kaempferol , 14. Quercetin, 15. 3-OMe Quercetin, 16.3'-OMe Quercetin, 17. 4'-OMe Quercetin, 18. 3',4'-diOMe Quercetin.

members except Cereus peruvianus where the later compound was absent. p-OH Benzoic acid was present in 3 species, viz. Cerus forbessi, Cereus Peruvianus and Melocactus sps. Melilotic acid and ferulic acid were present in Cereus peruvianus.

Saponins and steroids were present in all the members screened. All the plants gave a positive test for alkaloids. None contained proanthocyanidins, tannins, iridoids and quinones.

DISCUSSION

Flavonols are found to be the only phenolic pigment of this family. The uniform distribution of flavonols establishes the homogeneity of the family and therefore the tribel and subfamilial classifications proposed by various workers do not get any chemical support. Moreover there is no chemical deleneation observed between leafy and leafless Cactaceae members. However, certain phenolic acids like, p-OH benzoic, melilotic and gentisic were found to confined to the tribe Echinocacteae.

Of the two tribes the tribe Opuntieae seems to be more primitive due to the presence of higher percentage of incidence of quercetin and more varieties of flavonols. The morphological characters like woody habit of some of the members of this tribe also support this contention. The tribe Echinocaceteae is a relatively advanced group in this family

with higher percentage of incidence of kaempferol (a less hydroxylated compound) and with fewer variety of flavonols.