APPENDIX : III

Research articles published

1. The identity and taxonomy of **Sapindus trifoliatus** L.
   Umadevi, I., Daniel, M. and S.D. Sabnis
   Curr. Sci. 46 (8) : 369-370 (1987)

2. Interrelationships among the families Aceraceae, Hippocastanaceae, Melianthaceae and Staphyleaceae.
   Umadevi, I., Daniel, M. and S.D. Sabnis.
   J. Pl. Ana. Morph. 3 (2) : 169 - 172 (1986)

3. Sapwood - Heartwood conversion in **Melia azedarach** L.
   - A Chemical study.
   Umadevi, I., Daniel, M. and S.D. Sabnis
   J.Econ. Tax. Bot. 10 (2) : 411 - 415 (1987)

4. Tannins and related bioflavonoids in certain cultivated forest crops.
   Umadevi, I. and M. Daniel.
   Adv. For Res. Ind. 1 : 217 - 220 (1988)

5. Comments on the phylogeny and taxonomy of the Oxalidaceae.
   Umadevi, I. and M. Daniel.
   Adv. Biosci. 7 (1) : 79 - 33 (1988)

6. Chemotaxonomy of the Anacardiaceae
   Umadevi, I., Daniel, M. and S.D. Sabnis
   Proc. Ind. Acad. Sci. (Pl. Sci.) 98 (3) : 205 - 208 (1988)

7. Observations on the chemotaxonomy of the Burseraceae
   Umadevi, I., Daniel, M. and S.D. Sabnis
   J. Phytol. Res. 1 (1) : 15 - 19 (1988)

8. Chemosystematics of some Indian members of the family Meliaceae.
   Umadevi, I., Daniel, M. and S.D. Sabnis.
   Fedd. Repertorium 99 (5-6) : 195 - 197 (1988).

9. Allelopathic effects of certain common weeds on Fenugreek (**Trigonella foenum-graecum** L.)
   Mercy, B.V., Umadevi, I., Daniel, M. and S.D. Sabnis
   Jour. M.S. Univ. 33+34 (3) : 39 - 44 (1989)

Papers Accepted for Publication

1. Cladistic analysis of some members of the Burseraceae
   Umadevi, I., Daniel, M. and S.D. Sabnis.
   Jour M.S. Univ. 35 (1990).

Reasearch Papers Presented in Symposia / Conferences

1. Cladistics of the Anacardiaceae

   National Seminar, **Applied aspects of Physiology, Taxonomy, and Ecology of Flowering plants,** Department of Botany, The M.S. University of Baroda, Feb. 16 - 17, 1987.

2. New sources of Vitamin P from angiosperms
   National symposium, **Biology and Utility of Wild Plants,** Department of Botany, South Gujarat University, Surat, March 14 - 16, 1987.

3. Cladistics of the Simaroubaceae
   All India Seminar, **Recent Advances in Plant Sciences.** Postgraduate Department of Botany, Nagpur University Campus, Nagpur, September 25 - 27, 1989.

4. Cladistic analysis of the family Rutaceae.
   National symposium, **Current Trends in Biological Research,** Department of Biosciences, Sardar Patel University, Vallabh Vidyanagar, December 1 - 3, 1989.

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IDENTITY AND TAXONOMY OF *SAPINDUS TRIFOLIATUS* LINN

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THE ambiguities existing in the names of certain economic crops often impede the proper utilization of the plants. *Sapindus trifoliatus* Linn, the source of soapnut, is such a plant, the identity and nomenclature of which are understood variously by taxonomists. It was Hiern[1] who recognized two different forms of *Sapindus trifoliatus* Linn, one with acuminate glabrous leaves and the other with emarginate leaves pubescent beneath. Vahl[2] raised these two forms to distinct species *S. laurifolius* Vahl and *S. emarginatus* Vahl. *S. laurifolius* has longer (up to 30 cm) obliquely ovate lanceolate leaves, petals softly woolly on the inner surface and velvetty round drupes combined almost completely, whereas *S. emarginatus* possesses shorter (up to 17 cm) broadly oblong leaves, petals glabrous on the inner surface but with two woolly scales and glabrous wrinkled drupes combined half way up. This concept was accepted by Trimen[3], Gamble[4], Haines[5], Santapau[6] and Abdulla[7]. Radlkofer[8] considered *S. laurifolius* as a synonym of *S. trifoliatus* and had reduced *S. emarginatus* to a variety of *S. trifoliatus* viz *S. trifoliatus* Linn var *emarginatus* (Vahl) Radlk. Cooke[9] treated *S. emarginatus* as a variety of *S. laurifolius*. Brandis[10], Prain[11], Duthie[12] and Saldanha and Nicolson[13] considered *S. trifoliatus*, *S. laurifolius* and *S. emarginatus* as synonyms. There is still another view that *S. trifoliatus* Linn is a *nomen ambiguum* and *S. laurifolius* Vahl is the correct name of the plant[3].

To evaluate the taxonomic status, the leaves of both *S. laurifolius* and *S. emarginatus* were subjected to a chemotaxonomic treatment involving chemical characters such as flavonoids, phenolic acids, alkaloids, saponins, tannins and iridoids using standard procedures[14,15], the results of which are tabulated in table 1. Both the plants contained flavones, glycoflavones, proanthocyanins and various phenolic acids in the leaves. The flavones encountered were apigenin and its 7,4'-dimethoxylated derivative in *S. emarginatus* and 4'-methoxy apigenin (acacetin) in *S. laurifolius*. 4'-Methoxy vitexin was the glycoflavone present in the former plant and 7,4'-dimethoxy vitexin in the latter. Proanthocyanidins like prodelphinidin, procyanidin and propelargonidin and phenolic acids such as vanillic, syringic, *p*-hydroxybenzoic, melilotic, protocatechuic and *cis*-ferulic acids were located in both the plants. In addition, *S. emarginatus* contained coumarin in the leaves. Saponins were present in the leaves of both the taxa whereas alkaloids were seen in *S. laurifolius* only. Tannins and iridoids were absent in both the plants.

Table 1 *The distribution of various phytochemicals in S. emarginatus Vahl and S. laurifolius Vahl*

	S. emarginatus Vahl	*S. laurifolius* Vahl
Apigenin	+	–
4'-Methoxy apigenin	–	+
7,4'-Dimethoxy apigenin	+	–
4'-Methoxy vitexin	+	–
7,4'-Dimethoxy vitexin	–	+
Propelargonidin	+	+
Procyanidin	+	+
Prodelphinidin	+	+
p-Hydroxy benzoic acid	+	+
Vanillic acid	+	+
Syringic acid	+	+
Melilotic acid	+	+
Protocatechuic acid	+	+
cis-Ferulic acid	+	+
Coumarin	+	–
Alkaloids	–	+
Saponins	+	+
Tannins	–	–
Iridoids	–	–

The distribution of various chemical compounds clearly establishes the distinct chemical identities of both *S. laurifolius* and *S. emarginatus*. The former plant possesses 4'-methoxy-apigenin, 7,4'-dimethoxy vitexin and alkaloids as against apigenin, 7,4'-dimethoxy apigenin, 4'-methoxy vitexin and coumarin of the latter. These differences in the flavones, glycoflavones, phenyl propanes and alkaloids evidently indicate that *S. laurifolius* and *S. emarginatus* are two chemical entities. These overwhelming chemical evidences corroborate the existing morphological differences and justify the specific status accorded to both the plants by Vahl and later workers.

The presence of apigenin and vitexin derivatives, the same proanthocyanidins, phenolic acids and saponins in both the plants is indicative of the close chemical relationships the two species enjoy. The name *S. laurifolius* should be retained over *S. trifoliatus* because the plant referred to as *S. trifoliatus* by Linnaeus in Species Plantarum is in fact *Schleichera trijuga* Willd[3].

22 August 1986

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INTER-RELATIONSHIPS AMONG THE FAMILIES ACERACEAE, HIPPOCASTANACEAE, MELIANTHACEAE AND STAPHYLEACEAE

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ASTRACT

Chemical data on the analysis of the leaves of 8 members belonging to the Aceraceae, Hippocastanaceae, Melianthaceae and Staphyleaceae showed the Aceraceae to be the closest family to the Sapindaceae in containing proanthocyanins, flavones and gallic acid. The Hippocastanaceae with their saponins and flavonols also enjoy a close relationship with the Sapindaceae. The absence of these compounds relates the Staphyleaceae and Melianthaceae to a peripheral position. The inclusion of the Aceraceae and Hippocastanaceae among the core families of the Sapindales is thereby supported. The retention of *Acer negundo* within generic limits of *Acer* is suggested.

INTRODUCTION

The Sapindaceae of Bentham and Hooker (1862) contained five suborders; (1) Sapindeae (including *Aesculus*), (2) Acerineae, (3) Dodonaceae, (4) Meliantheae and (5) Staphyleae. Engler and Prantl (1895) treated the suborders Acerineae, Meliantheae and Staphyleae as separate families Aceraceae, Melianthaceae and Staphyleaceae while keeping Dodonaceae in the Sapindaceae itself. In addition, they elevated the genera *Aesculus* and *Billia* to a new family, the Hippocastanaceae. Such a treatment was accepted by almost all taxonomists (Hutchinson, 1973; Takhtajan, 1980; Cronquist, 1968; Dahlgren *et al.* 1981) except Brandis (1906), who retained *Aeculus* and *Billia* in the Sapindaceae. The Aceraceae, Hippocastanaceae and Sapindaceae are considered among the core families of the Sapindales while the Melianthaceae and Staphyleaceae occupy a peripheral position (Cronquist, 1981). Narayana (1963) supports this idea based on his observation on wood anatomy.

Among the various speceies of *Acer*, *A. negundo* Linn. differs from other species in having compound leaves, laterally placed inflorescence and dioecious flowers. These characters tempted many authors (Bentham and Hooker, 1862; Airy Shaw, 1973) to confer it a new generic statusas *Negundo acreoides* Moech. Pax (1885) and Cronquist (1981) opposed this idea and kept this species in a separate section of the genus *Acer*.

Earlier chemical reports of the family include quercetin and kaempferol (Timberlake & Bridle, 1975), cyanidin, luteolin 4'-glucoside, vitexin, isovitexin and isoorientin (Harborne, 1967), hydrolysable and condensed tannins (Batesmith, 1977) from leaves of *Acer* species; kaempferol, rhamnocitrin, quercetin

TABLE 1

The distribution of various flavonoids, phenolic acids, tannins, saponins and alkaloids in the members of Families Aceraceae, Hippocastanaceae, Melianthaceae and Staphyleaceae.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Family Aceraceae																										
Acer acuminatum Wall.			+				+	+				+		+	+	+			+	+	+	+		+		
A. caesium Wall.	+	+		+					+			+		+	+	+			+	+				+		
A. negundo Linn.			+	+		+	+			+		+	+	+	+	+					+	+	+	+		+
A. oblongum Wall.		+						+			+		+	+	+	+		+	+	+				+		
Family Hippocastanaceae																										
Aesculus indica Colebr.														+	+	+	+				+			+	+	
A. pandoricum Linn.			+				+					+		+	+	+	+	+						+	+	
Family Melianthaceae																										
Melianthus major Linn.			+				+								+	+	+		+		+					
Family Staphyleaceae																										
Staphylea emodi Wall.			+		+										+	+										

1) Apigenin, 2) Acacetin, 3) Kaempferol, 4) 3-OMe Kaempferol, 5) 4'-OMe Kaempferol, 6) 6-OMe Kaempferol, 7) Quercetin 8) 3-OMe quercetin, 9) 3'-OMe quercetin, 10) 7-OMe quercetin, 11) 3, 3'-diOMe quercetin, 12) 3', 4'-diOMe quercetin, 13) 7, 3', 4'-triOMe quercetin, 14) Proanthocyanidins, 15) p-Hydroxybenzoic, 16) Vanillic. 17) Syringic. 18) Protocatechuic, 19) Gallic, 20) Melilotic, 21) p-Coumaric, 22) Gentisic, 23) Ferulic, 24) Tannins, 25) Saponins. 26) Alkaloids.

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and myricetin derivatives from the oil of the buds (Wollenweber and Egger. 1970) and amino acids ftom leaves of *Aesculus* (Fowden *et al*, 1970).

In the present work, leaves of eight plants belonging to the Aceraceae, Hippocastanaceae, Melianthaceae and Staphyleaceae are analysed for their flavonoids, phenolic acids, tannins, saponins, alkaloids and iridoids. The chemical characters thus obtained are utilised in the assessment of the interrelationships existing among the varionus taxa.

MATERIAL AND METHODS

Mature leaves were collected from plants growing in various parts of Kashmir and Ooty. Voucher specimens were deposited in the Herbarium of the M.S. University of Baroda, Baroda. Standard methods (Mabry *et al*, 1970; Markham, 1982; Harborne, 1984) were follwerd for the isolation and characterisation of various compounds.

Distribution of various flavonoids, Phenolic acids, tannins, saponins and alkaloids in the member of families Aceraceae, Hippocastanaceae Melianthaceae and Staphyleacea were given in Table I.

RESULTS

Flavonols predominated the plants screened in the present work. In the Aceraceae they were accompanied by flavones and proanthocyanidins, though the latter group of compounds were seen in the Hippocastanaceae also. The various flavonols encountered were kaempferol, 3—OMe kaempferol, quercetin, 3OMe quercetin, 3 3'-diOMe quercetin, 3',4'-diOMe quercetin and 7,3',4'- triOMe quercetin. Of these compounds, 3-OMe quercetin and 3-OMe kaempfereol were confined to the family Aceraceae. The family Melianthaceae is devoid of any methoxylated flavonole. The various flavones spotted in *Acer caesium* and *A. oblongum* were apigenin and acacetin. Glycoflavones were not located in any of the plants screened.

Of the eleven phenolic acids identified, p-hydroxybenzoic and vanillic acids were ubiquitous. Syringic acid was confined to *Aesculus* and *Melianthus* while gallic acid was restricted to the latter genus and all the speices of *Acer* except *A. negundo*. All the plants screened except *Staphylea* showed the presence of tannins. Alkaloids were located only in *Acer negundo*. Saponins were restricted to the members of the Hippocastanaceae.

DISCUSSION

The families screened here can be classified into two groups. The Aceraceae and Hippocastanaceae forming the first group possess proanthocyanidins in their leaves and the second group inclusive of the Melianthaceae and Staphyleaceae, is devoid of these compounds. The Aceraceae is distinct in having 3-OMe quercetin and flavones. The presence of flavones, gallic acid and proanthocyanidins which are common in members of the Sapindaceae (Umadevi *et al*., unpublished), is indicative of the close relationship existing between the Aceraceae and the Sapindaceae. The Hippocastanaceae also are similar to Sapindaceae in containing saponins and flavonols. These evidence corraborate the assumption that these families, forming a closely knit group, are the core families of the Sapindales. The Melianthaceae and Staphyleaceae do not possess proanthocyanidins and flavones and have very

less incidence of methoxylated flavonols. In these respects they appear to be only distantly related to the core families and therefore occupy a peripheral position within the order Sapindales. Though these two families are similar in flavonoid chemistry, the occurrence of syringic and gallic acids in the Melianthaceae distinguishes them from the Sataphyleaceae.

The presence of a number of cinnamic acids and alkaloids and the absence of gallic acid keep *Acer negundo* distinct from other species of *Acer*. It also dose not contain flavones isolated/reported from various species of *Acer*. Though these features are not sufficient enough to warrant a generic status to this species, they entail them a special status away from the other species of *Acer*. It will be more appropriate to keep this species in a separate section within the genus *Acer*.

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SAPWOOD-HEARTWOOD CONVERSION IN *MELIA AZEDARACH* LINN. —A CHEMICAL STUDY

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ABSTRACT

The analysis of sapwood, heartwood and transition zone of *Melia azedarach* Linn. revealed a number of qualitative and quantitative differences in the chemical composition of these three zones. The oil content, tannins, ethanol solubles and lignin content increased with transition from sapwood to heartwood. These changes indicate the increased hydrophobic nature of the heartwood. Though the tannin content increased in both transition zone and heartwood, the higher tannin-non tannin ratio in sapwood is significant. Along with the increase in lignin content, the principal monomer gets changed from 3-methoxy, 4-hydroxy phenylpropane in transition zone to 4-hydroxy, phenylpropane in heartwood.

Thr hemicelluloses decreased with transition. The glucan of sapwood hemicellulose gets replaced by araban in transition zone, which in turn is changed to xylan in heartwood. The increase in water-solubles in transition zone is because of the higher rate of metabolic activity associated with this region. It is suggested that sapwood with higher hemicellulose content be used profitably for paper manufacture and the heartwood may be used for structural purpo ses.

INTRODUCTION

Wood, mostly consisting of secondary xylem, forms the bulk of a living tree. The wood of older stems can be distinguished clearly into two zones, the sapwood and the heartwood. Sapwood is the immediate xylem tissue cut out by cambium and consisted of actively transporting living cells. Heartwood is present in the center and consists of dead xylem elements. The region between these two is the transition zone. Many chemical and anatomical changes take place in this zone, with the result of which, the heartwood is formed. All these zones are indistinguishable in many plants but they can be clearly marked out in trees like *Melia azedarach* Linn.

Uses of wood are legion. Besides its utility in construction, the bulk of wood is used in paper and rayon industries. There are a number of sylvichemicals which are extracted and are effectively utilized in various ways. In spite of the myriads of uses, the chemistry of the wood is very poorly understood. This leads to a lot of waste in all the industries dealing with wood. A

knowledge or the components would immensely help in the complete exploitation of any wood. It will also help in proper selection of wood for a particular purpose and reduce waste.

Melia azedarach Linn. yields a valuable timber having a straight grain and coarse texture. The wood, which is tough. durable and resistant to white ants, is used for toys, furniture, musical instruments, cigar and museum cases. It is used as fuel wood also. Various parts of plant are reported to possess high therapeutic value. The aqueous extract of heartwood is used in asthma. It also yields a crystalline lactone, bacalactone, a resinous material and tannins.

MATERIALS AND METHODS

The wood material was taken from the branch of a large tree growing in the university campus. The bark was removed and the three regions, sapwood, heartwood and transition zone, were separated as thin flakes. Transition zone contained a part of heartwood and sapwood (about 1 mm thick) on either side. The flakes were dried at 60°C., powdered and the fine powder was used for the estimation and characterisation of various wood components using standard procedures (Whistler, 1965, Daniel and Sabnis, 1977).

RESULTS

The amount and the constituents of various micro and macromolecular components of the wood of *Melia azedarach* is presented in Tables I & II.

It was found that the oil contents of sapwood, transition and heartwood were 0.57%, 0.59% and 1.12% respectively. The saponification value of oils in both sapwood and heartwood were the same i.e. 112 while that of heartwood was 156. Non-saponifiable fraction of the wood oil contained steroids. Sapwood contained two steroids of high Rf values and transition zone contained two steroids of low Rf values. Heartwood contained all the four steroids.

The ethanol solubles increased with the transition. It was 2.06% in sapwood. 2 24% in transition zone and 3.9% in heartwood. The sugars of sapwood region were glucose, arabinose and xylose of which glucose formed the major component. The sugars of transition zone and heartwood were the same i.e. rhamnose, arabinose and xylose. Xylose formed the major sugar of transition zone while arabinose in heartwood. The phenolic acid fraction of all the three regions contained vanillic and syringic acids. Melilotic and sinapic acids common to both sapwood and transition zone were absent in heartwood region. Sapwood contained syringic acid as the major constituent, transition zone had vanillic acid in larger quantities and heartwood had vanillic and syringic acids in equal quantities.

The water soluble polysaccharides were maximum in transition zone and least in heartwood. Sugars present in this fraction of sapwood were rhamnose, glucose, xylose and arabinose. Transition zone contained glucose, arabinose and rhamnose. Heartwood had rhamnose, xylose and arabinose. Both transition zone and heartwood contained β-linked polymers. In transition zone it was a glucan and in heartwood it was a xyloglucan. All the three regions of the wood contained protocatechuic and vanillic acids

TABLE—1

% Amounts of different components of wood of *Melia azedarach*

Regions of wood	oil		Ethanol solubles	Water solubles	Lignin		Hemicelluloses	Cellulose	Astringency	
	Amount	Saponification value			Braun's	Sodium chlorite			Tannins	Non-tannins.
Sapwood	0 57	112	2.06	3.16	49	10	31	14	1.2	—
Transition zone	0.59	112	2.24	4.7	55	13	27	14	4.27	—
Heartwood	1.12	156	3.90	2.5	58	21	15	15	2.64	2.64

Components* of various fractions of *Melia Azedarach* wood

	LIPIDS		ETHANOL SOLUBLES		WATER SOLUBLES		HEMICELLULOSES	LIGNIN	ALKALOIDS	ORGANIC ACIDS
	Steroids	Fatty acids	Sugars	Phenolic acids	Sugars	Phenolic acids	Sugars	Phenolic acids		
SAPWOOD	Two in no.	Three	*Glucose* Arbinose Xylose	*Syringic* Vanillic Melilotic Sinapic	Glucose Arbinose Xylose Rkamnose	Vanillic Protocatechuic	Glucose Arabinose Xylose Rhamhose	*Syringic* Vanillic gallic	Three	Two
TRANSITION ZONE	Two in no.	Three	*Xylose* Arabinose Rhamnose	*Vanillic* Syringic Melilotic Rhamnose	Glucose Arabinose Sinapic	Vanillic *Syringic* Protocatechuic	*Arabinose* Xylose	*Vanillic* Syringic p-hydroxybenzoic Gentisic	Three	Two
HEART WOOD	Four in no.	Three	*Arabinose* Xylose Rhamnose	Vanillic — Syringic	Arabinose Xylose Rhamnose	Vanillic Protocatechuic	*Xylose* Arabinose	*P-hydroxybenzoic* Vanillic Syringic	Three	Two

* The major components are in *italics*

while transition zone contained syringic acid also which formed the major phenolic acid. Transition zone and heartwood contained a number of lipids probably in glycosidic form, liberated during hydrolysis. Amount of water solubles present in sapwood was 3.1%, in transition zone 4.7% and in heartwood 2.5%.

Hemicelluloses decreased with differentiation. The amount of hemicelluloses was maximum in sapwood (31%), decreased in transition zone (27%) and least in heartwood (15%). The sugars which were the components of the hemisellulosic fractions were glucose, arabinose, xylose and rhamnose in sapwood, xylose and arabinose in transition zone and heartwood. The sugars were in equal quantities in sapwood while in transition zone arabinose formed the major sugar and in heartwood, xylose.

Braun's lignin increased with transition. It was 49% in sapwood, 55% in transition zone and 58% in heartwood. The sodium chlorite extractable lignin also increased similarly from 10% in sapwood to 13% transition zone and 21% in heartwood. Phenolic acids associated with lignin were vanillic, syringic (major), and gallic acid in sapwood, vanillic (major), syringic p-hydroxybenzoic and gentisic acids in transition zone and vanillic syringic and p-hydroxybenzoic (major) in heartwood.

Cellulose content in sapwood and transition zone remained 14% while it increased to 22% in heartwood.

Tannins increased with the differentiation of sapwood to heartwood. Sapwood contained minimum amount of tannins i.e. 1.2%. The total astringency was equal to the amount of the tannins, there were no non-tannin astringent compounds. In transition zone there was maximum amount of tannins i.e. 4.2%. Here also there was no non-tannin astringent compounds. In heartwood half of the total astringent compounds were tannins. The tannin percentage amounted to 2.64%. It also contained equal amounts of non-tannin astringent principles.

All the three portions contained three alkaloids evidenced by 3 clear spots.

All the 3 regions contained 2 organic acids. One with high Rf value to oxalic acid and other with low Rf value.

DISCUSSION

There is a series of events when one proceeds from sapwood to heartwood through transition zone. The oil content is almost doubling in heartwood with a slight increase in transition zone. The saponification value of heartwood also is more than that of sapwood indicating that the oil of heartwood contained shorter fatty acids than that of sapwood and transition zone. Steroids are also changing from sapwood to heartwood. The similarities in steroids between transition zone and heartwood indicate the formation of new steroidal compounds which may have some role in biosynthesis of compounds of heartwood. The trend to make the heartwood more hydrophobic is evident by the increase of the oil content. The increase in ethanol solubles also is interesting which indicate that along with free neutral polysaccharides a number of aglycones, mostly phenolics are also increasing in heartwood. The polysaccharides are also mostly glucans

in sapwood. replaced by xylans in transition zone and arabinose in heartwood. The phenolics associated with this are, more of syringic acid in sapwood, more of vanillic in transition zone and both of them in equal quantities in heartwood. The water soluble polysaccharides are more in transition zone and least in heartwood. Transition zone being a turning point, production of more water soluble compounds will invariably help in chemical conversion of the constituents. There is a major change in the phenolics of water soluble fraction. Protocatechuic acid forms the major acid in sapwood, while syringic acid is the major one in transition zone and vanillic and syringic acids in heartwood. Transition zone and heartwood also contain a number of glycolipids evidenced by hydrophobic compounds in the hydrolysed aglycone fraction. The hemicelluloses are maximum in sapwood and least in heartwood with an intermediate concentration in transition zone. Here also glucose in sapwood is replaced by arabinose and xylose is transition zone and heartwood. The principal phenolic acid associated with lignin is syringic acid in sapwood, vanillic acid in transition and p-hydroxybenzoic in heartwood. Lignin content also gradually increased with the transition. The cellulose content is constant in sapwood and transition zone but increased in heartwood.

CONCLUSIONS

The sapwood due to higher hemicellulose content may be profitably used in pulping whereas the heartwood due to the high lignin and low hemicellulose content may not be useful for this purpose. The heartwood may be utilised for structural purposes.

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A CENSUS OF EDIBLE SPECIES OF *DIOSPYROS* L. IN INDIA

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ABSTRACT

The present paper deals with 15 species of the genus *Diospyros* L. (Ebenaceae) yielding edible fruits in India. Their distribution, fruit morphology, quality of fruits and way of utilization have been discussed in a short and lucid manner along with important local names.

INTRODUCTION

The Greek word Diospyros connotes 'celestial pear' bearing reference on those species of the genus which provide edible fruits. In India out of 56 species, 15 species of *Diospyros* L. viz. *D. chloroxylon* Roxb., *D. discolor* Willd., *D. ebenum* Koenig, *D. ferrea* (Willd.) Bakh., *D. kaki* L., *D. lancifolia* Roxb., *D. lotus* L., *D. malabarica* (Desr.) Costal, *D. melanoxylon* Roxb., *D. philippensis* (Desr.) Gurke, *D. pyrrhocarpa* Miq., *D. ramiflora* Roxb., *D. sylvatica* Roxb., *D. tomentosa* Roxb. and *D. toposia* Buch.-Ham. have been found to yield edible fruits. Among these, the fruits of some species viz. *D. kaki* L. are relished on large scale resulting in the cultivation, while some viz. *D. lotus* L., *D. philippensis* (Desr.) Gurke and *D. discolor* Willd. have been recently introduced from China, Philippines and Japan for this purpose. Our knowledge and literature regarding the economic utility of *Diospyros* species, particularly of food value, is very inadequate, scattered and sometimes restricted only to particular region or community.

The edible fruits of *Diospyros* L. have high percentage of sugar (usually more than 15%), low acidity and considerable percentage of tannin contents. As a whole, they have been found to be quite nutritious as well as of medicinal value. The authors, therefore, feel it worth to pool information on edible species of *Diospyros* L. which is diffused in a score of publications (Aitchison, 1880; Anonymous, 1952; Bennet, 1977; Dalzell & Gibs., 1861; Deb, 1983; Guhabakshi, 1984; Kanjilal *et al.*, 1939; Maheshwari *et al.*, 1965; Parker, 1918; Prain, 1903; Roxburgh 1832; Singh and Arora, 1978; Sunderarajan *et al*, 1959; Varma, 1981; Watt, 1890, Williams, 1943 etc.), herbaria, museums and rural communities, with a view to increase our knowledge regarding wild foods and to popularise the edible species of celestial pear among the people.

Diospyros chloroxylon Roxb.

Local name : Nallawoolymera, Andoli, Bun Gaub.

The species is widely distributed in peninsular India, Gujarat plains and from

TANNINS AND RELATED BIOFLAVONOIDS IN CERTAIN CULTIVATED/FOREST CROPS

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ABSTRACT

Tannins and bioflavonoids were estimated/analysed in 18 plants which gave a positive test for these compounds. Ten plants were found to be rich sources of leaf tannins of which *Melianthus major* and *Filicium decipiens* contained the maximum amounts (13-14%). Almost all the plants contained both hydrolysable and condensed tannins. Bioflavonoids are located in all plants except *Filicium* and *Quassia*.

INTRODUCTION

A majority of the commercial tanning materials are obtained from either bark or wood. Leaves, roots and sometimes galls are also used commercially. Sillician sumac (*Rhus coriaria*) sumac(*R.glabra*, *R. typhina*, *R. copallina*) and gambier (*Uncaria gambier*) are the principal sources of leaf tannins. Sources of leaf tannins are fewer when compared to the bark and wood tannins.

The extraction of leaf tannins is much easier, since the leaves do not need any laborious processing required for some of the wood or bark tanning materials. Leaf tannins are seldom used alone. They are preferred always in combination with bark/wood materials because of their higher tannin/non-tannin ratio.

The leaves also contain many other polyphenols like flavonoids and anthocyanins which impart a distinctive colour to the tanning liquor. 3', 4' - Dihydroxylated flavonoids are well known as "Vitamin-p" or "Bioflavonoids", which are responsible for the strengthening of the blood capillaries. They also play an important role in improving the circulation of blood by preventing the aggregation of erythrocytes. The presence of these compounds add to the medicinal value of the astringent tannins.

In the present work a survey for alternative sources of leaf

tannins is made on more than fifty plants belonging to the families Aceraceae, Anacardiaceae, Leeaceae, Meliaceae, Melianthaceae, Sapindaceae and Simaroubaceae. The plants which gave a positive indication were estimated for their tannin content. These plants were also analysed for their bioflavonoids in the leaves.

MATERIALS AND METHODS

All the plants were collected from the forests of Kerala, Kashmir, Madhya Pradesh and Gujarat. The voucher specimens are deposited in the Herbarium, M.S. University of Baroda, India. The leaf extracts were tested for tannins using 2% gelatin solution. The plants which gave a positive test for tannins were selected and their tannin content was estimated using standard procedures (Anon, 1957; Bate-Smith, 1977). The tannin extracts were hydrolysed using 2N HCl and the hydrolysates were analysed for gallic/ellagic acids as well as for anthocyanidins following Harborne (1984). The presence of gallic/ellagic acids indicated gallo/ellagitannins while the presence of anthocyanidins indicated condensed tannins. These plants were also analysed for their bioflavonoids in the leaves using standard procedures (Mabry et al, 1970; Daniel and Sabnis, 1977).

RESULTS AND DISCUSSION

Tannins were estimated in 18 plants which gave a positive test for tannins. The type of tannins, the percentage of total tannins and the various bioflavonoids located are presented in Table - I. *Melianthus major* recorded the maximum amount of tannins (approx. 14%) closely followed by *Filicium decipiens* (approx. 13%). *Anacardium occidentale, Lannea coromandelica, Rhus parviflora, R. succedanea, Dodonea viscosa, Schinus terebinthifolius, Schleichera trijuga and Acer acuminatum* are the other rich sources of tannins with 8-10% tannins in them. The remaining plants contained less than 5% tannins.

The families Anacardiaceae and Melianthaceae, evidently, are rich in tannins. The Aceraceae, Leeaceae and Sapindaceae have very low tannin content (exception being *Filicium)* while the Meliaceae and Simaroubaceae are almost devoid of tannins.

The analysis of the hydrosylates showed that atleast 13 plants had both hydrolysable and condensed tannins. *Lannea, Rhus parviflora* and *Mangifera* contained only condensed tannins and no plant contained hydrolysable tannins alone.

All the plants except *Filicium and Quassia* contained various bioflavonoids in the leaves. Quercetin was present in *Anacardium, Lannea, Mangifera, Rhus, Sapindus, Melianthus, Dodonea, Allophylus, Acer* and *Sandoricum* and myricetin in *Lannea, Rhus, Schinus and Leea.* The remaining plants contained only methoxylated quercetins.

Table - 1

The type and percentage tannins is and the distribution of bioflavonoids in the leaves of the members studied

	Name of the plant	Family	% Tannins	Type of tannins		Bioflavonoids		
				Hydro-lysable	Con densed	Quer-cetin	Methoxy Quercetin	Myrice-cetin
1.	*Anacardium occidentale* L.	Anacardiaceae	8.5	+	+	+	+	
2.	*Lannea coromandelica* Merr.	"	8.74	-	+	+		+
3.	*Mangifera indica* L.	"	2.26	-	+	+		
4.	*Rhus parviflora* Roxb.	"	8.97	-	+	+		+
5.	*R. succedanea*	"	9.3	+	+	+		+
6.	*Schinus terebinthifolius* Raddi	"	8.88	+	+	+		+
7.	*Allophylus serratus* DC	Sapindaceae	4.63	-	+	+		+
8.	*Filicium decipiens* Thw	"	12.75	+	+			
9.	*Sapindus mukrossi* Gaertn.	"	4.31	+	+	+	+	
10.	*Schleichera oleosa* Merr.	"	10.25	+	+		+	
11.	*Dodonea viscosa* L.	"	8.75	-	+	+	+	
12.	*Melianthus major* L.	Melianthaceae	13.73	+	+	+		
13.	*Acer caesium* Wall.	Aceraceae	4.1	+	+		+	
14.	*A. acuminatum* Wall.	"	9.02	+	+	+	+	
15.	*A. oblongum* Wall.	"	4.68	+	+	+		
16.	*Quassia amara* L.	Simaroubaceae	2.23	+	+			
17.	*Sandoricum indicum* Cav.	Meliaceae	1.97	+	+	+		
18.	*Leea sambucina* Willd.	Leeaceae	5.11	+	+	+	+	+

All the ten plants, which contained more than 8% tannins in their leaves, are cultivated for fruits and/or wood or are common in forests. The leaves of these plants can be commercially exploited as sources of tannins. The gallo/ellagitannins can be used in the manufacture of inks and the condensed tannins for the production of good quality leather. All these plants except *Filicium* and *Quassia* can be utilised commercially as the sources of bioflavonoids also.

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Comments on the Phylogeny and Taxonomy of the Oxalidaceae

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To findout the interrelationship and phylogeny of the Oxalidaceae, the distribution of flavonoids, phenolic acids and other chemical markers in nine members of this family, is analysed and compared with that of five members of Geraniaceae. The Oxalidaceae is characterised by flavones and glycoflavones. Absence of flavones and the predominance of flavonols and gallic acid keep the Geraniaceae distinct and chemically primitive to the Oxalidaceae. Though *Averrhoa* contains proanthocyanins and tannins, it possesses flavones and glycoflavones as a dominent phenolic pigments like the rest of the Oxalidaceae and therefore its retention in the Oxalidaceae is advocated.

KEY WORDS : Phylogeny, taxonomy, Oxalidaceae.

INTRODUCTION

The Oxalidaceae, a small predominantly herbaceous family, are accepted as a natural taxon. This family was kept as a tribe in Geraniaceae by many authors (Bentham and Hooker, 1862; Prain, 1963; Brandis, 1906). Knuth (1931) recognised it as a separate family and this concept was followed in almost all the recent taxonomic treatments. Oxalidaceae are customarily placed in the order geraniales alongwith closely related families Geraniaceae, Tropeolaceae and

Limnanthaceae. The Oxalidaceae differ from the Geraniaceae *(Sensu stricto)* by their monadelphous stamens and in their carpels not splitting apart. Though the typical members of Oxalidaceae and Geraniaceae are distinctive enough, these two groups are connected by a series of smaller genera, that are variously apportioned between the two families by different authors. Some of these smaller genera such as *Averrhoa, Lepidobotrys* and *Hypseocharis,* included within Oxalidaceae, were seggregated and treated as unigeneric families by Airy Shaw (1973). Takhtajan (1980) gives all these three genera a subfamilial status while Cronquist (1981) merges all of them in Oxalidaceae.

Due to the large amount of ascorbic acid present in some species of *Oxalis,* they are used as antiscorbutic principles and also as vegetables. Some other species of *Oxalis* are cultivated for their edible tubers. Carambola is the edible fruit of *Averrhoa carambola.* The fruits of a related species *A. bilimbi,* are also eaten raw or pickled.

Oxalis is known to accumulate calcium oxalate, anthocyanins and a number of organic acids. Aurones and a glycoflavone (orientin) have been reported from the petals of *O crenua* Thunb. (Shimokoriyana and Geissman, 1962; Bohm, 1975).

In the present work, leaves of nine species of Oxalidaceae and five species of Geraniaceae have been analysed for phenolics, tannis, saponins, alkaloids and iridoids. The data thus obtained were used in assessing the interrelationships within and in between the two families.

MATERIAL AND METHODS

Only mature leaves were used for the analysis. All the *Geranium* species, *Erodium cicutarium* and *Oxalis acetosella* were collected from Kashmir. *Biophytum sensitivum, O. rubra* and *Averrhoa bilimbi* were obtained from Kerala *O. pubescens* from Ooty. *O. trifoliata* and *O. latifolia* were available from Mahabaleswar and *A. carambola* and *O. corniculata* from Baroda. Voucher specimens were deposited in the Herbarium, Dept. of Botany, The M. S. Univ. of Baroda, Baroda. Standard procedures (Mabry *et al.,* 1970; Markham, 1982; Harborne, 1984) were followed for extraction, isolation and identification of various compounds.

RESULTS

The distribution of various chemical markers among fourteen members belonging to Oxalidaceae and Geraniaceae is presented in Table-I.

All the 14 plants screened, contained flavonoids in the leaves. The various

Table 1. The distribution of flavonoids, phenolic acids, tannis and alkaloids in some members of the Oxalidaceae and the Geraniaceae.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Oxalidaceae																										
1. *Averrhoa bilimbi* L.			–													–	–	–				–	–		–	–
2. *A. carambola* L.		–	–								–				–		–	–						–	–	
3. *Biophytum sensitivum* DC.	–	–		–									–	–			–	–	–							
4. *Oxalis acetosella* L.										–						–	–	–			–		–			
5. *O. corniculata* L		–	–						–		–	–	–			–	–	–			–		–			
6. *O. latifolia* H B. & K.	–	–									–					–	–	–			–	–				
7. *O. pubescens* H.B. & K.									–							–	–	–			–					
8. *O rubra* A.		–	–				–		–							–	–	–			–	–	–			
9. *O. trifoliata*																										
Geraniaceae	–	–								–							–	–								
10. *Erodium cicutarium* L'Herit									–								–		–	–		–	–			
11. *Geranium nepalense* Sweet								–	–								–			–						
12. *G. pratense* L:							–		–								–		–							
13. *G. robertianum* L.					–		–									–	–			–						
14. *G. sibericum* L.					–	–										–	–			–		–	–			

1- Apigenin, 2- Acacetin, 3- 7,4'-diOMe Apigenin, 4- Luteolin, 5- Kaempferol, 6- 4'-OMe Kaempferol, 7- 7-OMe Kaempferol, 8- Quercetin, 9- 3', 4'-diOME Quercetin, 10- Vitexin, 11- 4'-OMe Vitexin, 12- 4'OMe Isovitexin, 13- 3',4'-diOMe Orientin, 14- 3', 4'-diOMe Isoorientin, 15- Proanthocyanins, 16- p-Hydroxybenzoic acid, 17- Vanillic acid, 18- Syringic acid, 19- Protocatechuic acid, 20- Gallic acid, 21- Gentisic acid, 22- Melilotic acid, 23- p-Coumaric acid, 24- Ferulic acid, 25- Tannis, 26- Alkaloids.

flavonoids encountered were flavones, glycoflavones, flavonols and proanthocyanins. Flavones, glycoflavones and proanthocyanins were restricted to the members of Oxalidaceae, except *O. pubescens* contained flavones in their leaves. The flavones identified were apigenin, acacetin, 7, 4' -diOMe apigenin and luteolin. While apigenin and its methylethers were widely distributed, luteolin occured only in *Biophytum*. Glycoflavones were seen in all the members of Oxalidaceae except *O. pubescens* and *A. bilimbi*. In all the 7 plants where they were located the glycoflavones were found accompained by flavones. The various glycoflavones located were vitexin, 4' -OMe vitexin, 4' -OMe isovitexin and 3', 4' -diOMe of orientin and isoorientin. Flavonols were located in all the five members of Geraniaceae and three plants of Oxalidaceae. In members of Geraniaceae, flavonols predominated. Of the three species of *Oxalis* i.e. *O. pubescens, O. corniculata* and *O. rubra,* both the latter species contained flavonols in traces. Out of the ten phenolic acids isolated, p-hydroxy benzoic, vanillic, and p-coumaric acids were widely distributed in both the families. Gallic acid was confined to Geraniaceae and syringic and gentisic acids to Oxalidaceae. Proanthocyanins were seen in both the species of *Averrhoa*. Tannis were also found confined to these two taxa. Only *A. bilimbi* gave a positive test for alkaloids.

DISCUSSION

The two families Oxalidaceae and Geraniaceae are found to be chemically distinct. The former is characterised by flavones, glycoflavones, proanthocyanins, gentisic and syringic acids which are not located in any member of the latter family. In addition, Geraniaceae have gallic acid confined to them and flavonols widely distributed. The rarity of flavonols in Oxalidaceae is another feature in support of its chemical identity. The volatile oils uniformally present in Geraniaceae are absent in the other family. In possessing flavones and glycoflavones, which are advanced chemical characters, Oxalidaceae are chemically more evolved than the flavonol-rich Geraniaceae. The presence of advanced morphological characters such as compound leaves, paracytic stomata, cymose inflorescences many times reduced to single flower, monadelphous stamens and tenuinucellate ovules, corraborate the chemical advancement achieved by this family.

Within the Oxalidaceae, *Averrhoa* is different from *Oxalis* and *Biophytum* in producing proanthocyanins and tannins. The presence of alkaloids in *A bilimbi* also is significant. The predominance of flavones and glycoflavones in *Averrhoa*, which are the characteristic phenolic pigments of Oxalidaceae, illustrates very well that the affinities of the former lay with the latter. Therefore, this restrains us from making any comment on the separate identity of *Averrhoa* as a family

Averrhoaceae. The retention of proanthocyanins and tannins in *Averrhoa* may be associated with the woody habit of this genus. *Averrhoa* and *O. pubescens* remain the primitive members of this family while the rest of *Oxalis* species and *Biophytum* with their flavones from advanced group.

The ocurrence of flavonols in a few members of *Oxalis* and especially their trace amounts in two species, indicate that the herbaceous members of the family Oxalidaceae derive their origin from the flavonol-rich Geraniaceae. *Averrhoa* with their proanthocyanins and tannins might have evolved directly from the woody sapindales. The predominance of flavonols and gallic acid indicates that the ancestry of the Geraniaceae must be sought among the sapindalean families such as Meliaceae and Anacardiaceae.

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Chemotaxonomic studies on some members of Anacardiaceae

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Abstract. Nineteen taxa belonging to 13 genera of the Anacardiaceae have been screened for leaf flavonoids, phenolic acids, saponins, tannins, alkaloids and iridoids. The family characteristically contains highly hydroxylated compounds like myricetin and gallic acid. It is also rich in proanthocyanidins and flavonols such as quercetin, kaempferol and their methoxylated derivatives. Tannins are common, saponins rare and alkaloids and iridoids are absent. The chemical differences among the various tribes are not very pronounced. However, the tribe Mangiferae does not contain any flavone whereas the tribe Spondieae is comparatively rich in these compounds. The tribes Rhoideae and Semecarpeae are similar in many chemical features. The separate identity of *Chaerospondias* away from *Spondias* is also established in the light of chemical evidences.

Keywords. Anacardiaceae; chemotaxonomy; flavonols.

1. Introduction

The family Anacardiaceae is distinguished from the related families by the presence of intrastaminal disc, resin ducts, unilocular ovary and drupaceous fruits. This family includes a number of economically important plants which yield edible fruits, gums, resins, tan-dyes and wood. It is also known for their toxic long chain aliphatic phenolic compounds such as anacardol, anacardic acid, urushol and hydrourushol; which possess irritant and allergenic properties.

Anacardiaceae are customarily placed in Sapindales alongwith the closely related families such as Sapindaceae, Aceraceae, Hippocastanaceae, Julianaceae and Sabiaceae (Bentham and Hooker 1862; Benson 1970; Hutchinson 1973). Cronquist's (1981) Sapindales include, in addition to the above mentioned families, Burseraceae, Simaroubaceae, Meliaceae and Rutaceae. Almost all these families were grouped by Takhtajan (1980) in his Rutales. The family Anacardiaceae is divided into two tribes namely Anacardieae and Spondieae by Hooker (1872) based on the number of locules in the ovary. The tribe Spondieae was accepted by Engler and Prantl (1895) but they redistributed the taxa belonging to the tribe Anacardieae into 4 smaller tribes (i) Mangifereae (Anacardicae), (ii) Rhoideae, (iii) Semecarpeae and (iv) Dobineae.

The various taxa included in this family show a considerable variation and reduction especially in the number of stamens and carpels. According to Hallier (1905), Anacardiaceae have been evolved from Rutaceae and form the basic stock from which the families of Amentiferae and Aceraceae have been originated. Due to the tendency of the taxa to evolve unisexual flowers and compound leaved members, Hutchinson (1973) recognised Anacardiaceae as one of the advanced families of Sapindales. Within the family, the genus *Buchanania* is the most primitive genus in

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having pentamerous flowers with apocarpus pistil, 10 fertile stamens and simple alternate thickly coriaceous leaves. Between the monocarpellate members, *Anacardium* and *Mangifera*, the latter, due to the higher degree of sterility, is considered more advanced. Among the syncarpus group, *Semecarpus*, having 5 pistils (indicating the number of carpels) is primitive to *Schinus* and *Choerospondias*. Due to derived tetramerous conditions, *Lannea* is also considered one of the most advanced taxa.

Earlier chemical reports from the family are: mangiferin from the root bark of *Mangifera*; quercetin, myricetin and apigenin glycosides from the leaves of *Rhus* spp., robustoflavone from seed kernal of *Rhus* (Yuh-Meei and Fa Ching 1974), biflavones of *Rhus* (Fa-Ching and Yue-Meei 1975) and *Semecarpus* (Rao *et al* 1973) and fustin and fisetin from heartwood of *Rhus* (Fa-Ching *et al* 1974).

In the present work, 19 members belonging to Anacardiaceae have been analysed for phenolic compounds such as flavonoids, coumarins and phenolic acids. These plants have also been screened for tannins, saponins, alkaloids and iridoids.

2. Materials and methods

The plants were collected from various localities of India, such as Baroda, Panchamarhi, Kashmir, Kerala and Calcutta. Voucher specimens are deposited in the Herbarium of the University. Mature leaves were selected for the studies and standard procedures (Mabry *et al* 1970; Harborne 1984) were followed for the isolation and identification of various compounds.

3. Results

The distribution of various flavonoids, phenolic acids, saponins and tannins in 19 members of the Anacardiaceae is presented in table 1.

All the 19 taxa screened contained flavonoids in the leaves. Flavonols form the major pigments in the family. The various flavonols encountered are kaempferol, fisetin, quercetin, myricetin and their methoxylated derivatives. Quercetin and its derivatives are located in most of the taxa studied. Myricetin is fairly common and fisetin, kaempferol and its derivatives are less frequent. Flavones such as apigenin and its 7- and 4′-methoxylated derivatives are obtained from *Rhus paniculata*, *Dracontomelum mangiferum* and *Pleiogynium timoriense*. Glycoflavones are located in *Rhus paniculata*, *Semecarpus subpanduriformis*, *Dracontomelum mangiferum* and *Chaerospondias axillaris*. The glycoflavones identified are 4′-OCH_3 vitexin and its isomer 4′-OCH_3 isovitexin. Mangiferin- the C-glyosyl xanthone is present in both the species of *Mangifera*. Except *Pleiogynium* all the taxa contain proanthocyanidins. Tannins are common, saponins rare, alkaloids and iridoids are absent.

4. Discussion

The common constituents of the Anacardiaceae are the highly hydroxylated phenolic compounds such as quercetin, myricetin and gallic acid. The most obvious feature which the members of this family have in common is the presence of proanthocyanidins and flavonols. Though the number of plants screened is not quite large, the

Table 1. The distribution of various plant products in some members of Anacardiaceae.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Tribe Mangiferae																												
Anacardium occidentale Linn									+		+					+	+		+	+			+		+		+	+
Buchananai lanzan Spreng.						+	+		+		+			+		+			+	+	+				+			+
Lannea coromandelica Merr.									+					+		+			+	+		+			+			+
Mangifera caloneura Kurz								+	+						+	+			+	+		+						+
M. indica Linn.						+		+	+		+	+	+		+	+			+	+								
Tribe Rhoideae																												
Rhus mysorensis Heyne									+			+	+			+			+	+		+						+
R. paniculata Wall.	+	+		+				+								+			+	+		+						+
R. parviflora Roxb.									+		+			+		+			+	+	+				+	+		+
R. succedenea Linn.							+		+		+			+		+	+			+			+					+
Schinus molle Hort.									+					+		+			+	+	+		+					+
S. terebinthifolius Raddi							+		+					+		+				+	+		+					+
Tribe Semecarpeae																												
Semecarpus anacardium Linn.						+	+							+		+			+	+	+	+	+					
S. subpanduriformis Wall.				+	+	+		+						+		+		+	+	+			+					+
Holigarna arnottiana Hook.									+				+	+		+			+	+	+		+	+				+
Tribe Spondieae																												
Dracontomelum mangiferum Blume			+		+	+		+			+	+				+			+	+								+
Chaerospondias axillaris (Roxb) Burtt. and Hill.					+			+	+				+	+		+	+		+	+	+							
Pleiogynium timoriense Lee	+																+	+	+	+						+		
Sclerocarya caffara Sond.						+										+				+			+					
Spondias pinnata (Linn.f.) Kurz.									+		+	+	+			+	+	+	+						+			+

1. Apigenin; 2. 7-OCH_3 apigenin; 3. acacetin; 4. 4'-OCH_3 vitexin; 5. 4'-OCH_3 isovitexin; 6. kaempferol; 7. 4'-OCH_3 kaempferol; 8. fisetin; 9. quercetin; 10. 3-OCH_3 quercetin; 11. 3'-OCH_3 quercetin; 12. 7-OCH_3 quercetin; 13. 3', 4'-DiOCH_3 quercetin; 14. myricetin; 15. mangiferin; 16. pronathocyanidins; 17. *p*-hydroxy benzoic acid; 18. protocatechuic; 19. vanillic; 20. syringic; 21. melilotic; 22. gentisic; 23. gallic; 24. *β*-resorcyclic; 25. *p*-coumaric; 26. *o*-coumaric; 27. saponins; 28. tannins.

observations might prove, in the future, to have special taxonomic significance. The chemical differences among the tribes are not very pronounced, however none of the taxa of the tribe Mangiferae contains flavones, either as O-glycosides or C-glycosides. Mangiferin, a C-glycosidic xanthone, also is restricted to the two species of *Mangifera* within the tribe. On the other hand, flavones are more frequent in the tribe Spondieae. Both these tribes have lesser frequency of myricetin and gallic acid and higher incidence of fisetin. The common occurrence of flavonols with a trihydroxy substituted B-ring, namely myricetin, and gallic acid in the tribes Rhoideae and Semecarpeae is noteworthy.

Within the tribe Mangiferae, the genus *Mangifera* appears to be the most advanced member in the absence of both myricetin and gallic acid and in the presence of methoxylated derivatives of quercetin. In containing the former compounds, *Buchanania* can be considered the most primitive taxon.

Spondias axillaris Roxb., which is separated and elevated to a new genus *Chaerospondias* (*C. axillaris* (Roxb.) Burtt. and Hill.), is chemically different from *Spondias pinnata*, with which it was associated earlier. The former taxon contained fisetin, myricetin syringic acid and melilotic acid as against, 4'- and 3',4'-dimethoxy quercetin, protocatechuic and *p*-coumaric acids of the latter species. These differences corroborate the morphological differences existing between the two taxa and the concept of *Chaerospondias* away from *Spondias* (Mukherjee and Chandra 1983) gains more support.

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OBSERVATIONS ON THE CHEMOTAXONOMY OF THE BURSERACEAE

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A study of ten members of the Burseraceae reveals that the family is morphologically and chemically homogenous. It contains quercetin and its methoxylaed derivatives, myricetin and gallic acid. The three tribes are not chemically identifiable. The genus *Commiphora* is the most advanced taxon of the family in containing flavones and absence of pyrogallol systems, proanthocyanidins and tannins. The placement of *Protium caudatum* W. & A. in *Protium* rather than in *Commiphora* (*C. caudata* Engl.) is supported. *Filicium decipiens* Thw. which is included in the Burseraceae is chemically more closer to the Sapindaceae and therefore its placement in the latter family is supported, Chemically the family is closely related to the Anacardiaceae. The presence of primitive flavonoids such as biflavones, myricetin, proanthocyanidins and tannins keep this as one of the primitive families of the Rutales.

Keywords : Burseraceae; Chemotaxonomy; Flavonoids; *Protium caudatum* W. & A.; *Filicium decipiens* Thw.

Introduction

The family Burseraceae with 20 genera and 600 species is widely distributed in tropics and the subtropics. This family characteristically shows the presence of alternate compound leaves, stamens twice the number of petals, a single style, two ovules per locule and intercellular canals or ducts in all parts of the plant body. Many species are economically valuable on account of their resins. The resins of *Commiphora*, are medicinally important while that of *Canarium* species (elemi) are used for varnish, printer's ink and for the preparation of ointments. Frankincense is obtained from the various species of *Bursera*. The seeds and fruits of *Canarium* and *Garuga* are edible. The family is a source of softwoods also.

Most of the systematists (Dahlgren *et al.*, 1981; Hutchinson, 1969; Takhtajan, 1980 and Thorne, 1976) placed the Burseraceae in the order Rutales alongwith the Rutaceae, Meliaceae, Anacardiaceae and Simaroubaceae, which are considered to be very closely related. Cronquist (1981) inclu-

ded this family in his Sapindales (which include most of the families of the Rutales) while Bentham and Hooker (1862) kept them in the Gereniales.

Hallier (1912) kept both Burseraceae and Anacardiaceae in the same family Terebinthiaceae. The Burseraceae are very closely related to the family Anacardiaceae and they differ mainly in the orientation of the ovules. In Burseraceae the ovules are epitropous while in Anacardiaceae they are apotropous. On the basis of the nature of the fruit Engler (1931) subdivided the family Burseraceae into 3 tribes, Protieae *(Garuga* and *Protium)*, Boswellieae *(Boswellia, Bursera* and *Commiphora)* and Canarieae *(Canarium)*. The position of *Filicium decipiens* Thw. is controversial. Though it was placed in the Burseraceae, it is shifted to Sapindaceae by Radlkofer (1897).

Chemically this family is a rich storehouse of terpenes. The volatile oils of the resins are predominantly monoterpenoid and/or sesquiterpenoid. While monoterpenes are omnipresent, sesquiterpenes are reported from *Canarium, Boswellia* and *Commiphora* only. Diterpenes also are located from the latter two genera. The Burseraceae accumulate both tetracyclic and pentacyclic triterpenes. Of these, one triterpene, sapelin, is considered to be precursor of quassinoids and limonoids (Khalid, 1983). Among the flavonoids, biflavones (Amentoflavone) are reported from *Garuga pinnata* (Ansari *et al*, 1978); quercetin and kaempferol glycosides from *Protium* (Pernett, 1972) and *Commiphora* (Kakrani, 1982).

In the present work ten members belonging to the Burseraceae have been analysed for pnenolic compounds such as flavonoids and phenolic acids. These plants are also screened for tannins, soponins, alkaloids and iridoids.

Materials and Methods

The plants were collected from various localities of Panchamarhi, Kashmir, Kerala and Calcutta. Voucher specimens are deposited in the Herbarium of the M. S. University of Baroda. Mature leaves were used for the studies and the standard procedures (Daniel and Sabnis, 1977; Harborne, 1984)were followed for isolation and identification of various compounds.

Result

The distribution of various flavonoids, phenolic acids, saponins and tannins in ten members of the Burseraceae is presented in Table-1.

Flavonols are widespread in the Burseraceae. The various flavonols encountered were kaempferol, quercetin and their methoxylated derivatives and myricetin. All the ten plants screened contained quercetin and/or its

Table 1. Showing the distribution of various flavonoids, phenolic acids, tannins and saponins in 10 members of the family Burseraceae.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Tribe Protieae																					
1. *Garugu pinnata* Roxb.		+			+		+		+	+	+		+	+	+	+	+	+	+	+	
2. *Protium caudatum* W. & A.		+	+		+		+			+	+		+			+				+	
3. *P. serratum* Engl.		+	+		+	+	+			+	+		+	+		+				+	
Tribe Boswellieae																					
4. *Boswellia serrata* Roxb.						+	+		+	+				+		+	+			+	
5. *Bursera citronella* Linn.		+	+			+	+			+	+		+	+		+		+	+	+	
6. *B. delpechiana* Poiss.		+	+	+	+	+				+	+		+	+						+	
7. *Commiphora wightii* Bhandari	+					+					+	+	+								
Tribe Canarieae																					
8. *Canarium commune* Linn.		+			+	+		+	+	+	+		+	+			+	+	+	+	
9. *C. strictum* Roxb.		+				+		+		+	+		+	+			+	+	+	+	
10. *Fiticium decipiens* Thw.							+			+	+		+		+					+	+

1. Acacetin 2. Biflavones 3. Kaempferol 4. 4 '-OMe Kaempferol 5. Quercetin 6. 3'-OMe Quercetin 7. 3',4'-DiOMe Quercetin 8. 3, 3', 4'-TriOMe Quercetin 9. Myricetin 10. Proanthocyanidins 11. p-Hydroxybenzoic acid 12. Protocatechuic acid 13. Vanillic acid 14. Syringic acid 15. Melilotic acid 16. Gentisic acid 17. Gallic acid 18. *cis* p-Coumaric acid 19. *trans*. p-Coumaric acid 20. Tannins 21. Saponins.

methoxylated derivatives. Kaempferol is less frequent, present in five plants. The only flavone located, acacetin, is restricted to *Commiphora*. Biflavones are located in *Garuga*, *Protium* *Bursera* and *Canarium*. Except *Commiphora* all the taxa possessed proanthocyanidins. Altogether nine phenolic acids were located, of which 7 were benzoic acids and two, cinnamic acids. Tannins were present in all the plants except *Commiphora*. Saponins were located only in *Filicium*. Alkaloids and iridoids are absent in the family.

Discussion

The family Burseraceae is chemically homogenous and is characterised by presense of highly hydroxylated phenolics such asquercetin, myricetin and gallic acid. All the plants screened contained quercetin and/or its methoxylated derivatives. The three tribes Protieae, Bosweilleae and Canarieae are not chemically identifiable and therefore the subdivision of the family does not get any support form the chemical evidences.

The genus *Commiphora* is distinct from the other taxa of the family in the presence of flavones and in the absence of proanthocyanidins and tannins. The absence of primitive proanthocyanidins and the presence of advanced flavones as will as the unisexual flowers (in polygamous conditions) keep this taxan a most advanced member of the family.

Gamble (1967) treated *Protium caudatum* W. & A. in the genus *Commiphora* (*C. caudata* Engl.). *P. caudatum* is strikingly different from the *Commiphora* (*C. wightii*), which is screened in the present work. *P. caudatum* contains kaempferol, quercetin, 3'-OMe quercetin and proanthocyanidins which are not located in *Commiphora wightii* and also flavones isolated from *Commiphora* were absent from *P. caudatum*. Therefore, the placement of *P. caudatum* in *Protium* seems to be chemically valid.

Eventhough *Filicium decipiens* is similar to the members of the Burseraceae in flavonoid chemistry it does not contain the di/triterpenes prevalent in in the family . Moreover the presence of saponins provides another feature of dissimilarily with the Burseraceae. In containing the saponins and in the absence of typical terpenes of the Burseraceae, *Filicium* is similar to the members of Sapindaceae and therefore its inclusion in this family seems justified.

The two families Anacardiaceae and Burseraceae are closely reiated in morphological as well as chemical grounds. The chemical characters which they share are the presence of biflavones, similar types of flavonols, proanthocyanidins and tannins, But the Burseraceae is distinct from Anacardiaceae in containing wide range of terpenes.

The Burseraceae possess a number of primitive chemical characters such

as biflavones, myricetin, gallic acid, proanthocyanidins and tannins. The family shows a strong ability for oxidative modification of a number of triterpenes which may reflect the early stages of the limonoids of Rutaceae and Meliaceae and quassinoids of Simaroubaceae (Khalid, 1983). With all these primitive chemical characters and morphological characters such as numerous stamens; bi—or pentacarpellary ovary and more than one ovule in single locule, the Burseraceae are considered as one of the primitive families of the Rutales. This view gains support also from wood anatomy (Metcalfe and Chalk, 1950).

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Chemosystematics of some Indian members of the family Meliaceae

With one Table

Summary

Fifteen members belonging to the family Meliaceae have been analysed for their flavonoids, phenolic acids, saponins, tannins and alkaloids. It is found that most of the plants contained flavonols and proanthocyanins. Flavones were present in *Walsura* and Glycoflavones in *Chloroxylon*. Leaves of *Aglaia*, *Dysoxylum* and *Naregamia* were devoid of any flavonoid. *Chloroxylon* is the only taxon containing coumarins. Gallic acid is confined to the tribes Trichilieae and Swietenieae. *Chloroxylon* is found to be different from all other members of Meliaceae in chemical composition and therefore its inclusion in Rutaceae, with which it shares a number of characters, is justified. Trichilieae is the most advanced tribe of the family.

Zusammenfassung

Fünfzehn Gattungen der Familie Meliaceae wurden auf ihren Gehalt an Flavoniden, Phenolen, Saponin, Tannin und Alkaloiden untersucht. Dabei wurde festgestellt, daß die meisten dieser Pflanzen Flavonide und Pro-Anthocyanide enthalten. Flavonide waren in *Walsura*, Glycoflavonide in *Chloroxylon*. In den Blättern von *Aglaia*, *Dysoxylum* und *Naregamia* wurden keinerlei Spuren von Flavenoiden gefunden. *Chloroxylon* enthält als einziges Taxon Coumarin. Gerbsäure wurden in den Tribus Trichilieae und Swietenieae nachgewiesen. Es konnte nachgewiesen werden, daß sich *Chloroxylon* von allen anderen Gliedern der Meliaceae in seiner chemischen Zusammensetzung unterscheidet, weshalb seine Zuordnung zu den Rutaceae, mit denen es etliche Eigenschaften gemeinsam hat, gerechtfertigt ist. Trichilieae ist der fortgeschrittenste Tribus der Familie.

Introduction

Meliaceae, a small pantropical family, are economically important as the source of valuable timber, (mahogany, cedar etc.), seed oils and medicinal plants. This family is classified into four tribes, Melieae, Trichilieae, Swietenieae and Cedreleae by HIERN (1872). ENGLER (1897), divided the family into three subfamilies Melioideae (inclusive of the tribes Melieae and Trichilieae), Swietenioideae and Cedreloideae. The family, grouped in Sapindales, is related to the Rutaceae and Simaroubaceae and is believed to be derived from the former family. HUTCHINSON (1973) seggregates this family and keeps it in his unifamilial order Meliales stating that it differs from Rutales primarily in the "leaves usually not gland-dotted and the stamens connate into a tube". *Flindersia* and *Chloroxylon*, two genera included in this family, are of controversial position. Both these genera are placed in Rutaceae (HUTCHINSON, 1973; WATERMAN 1983) or in a separate family Flindersiaceae (AIRY SHAW 1973).

The family is known to produce a wide range of substituted limonoids (CONNOLLY 1983). The flavonoids, such as quercetin and kaempferol derivatives are reported from leaves of *Melia* and *Soymida* (HARBORNE 1983). Alkaloids of quinolinones and furoquinolines as well as a variety of furo- and pyranocoumarins are reported from *Chloroxylon* (MESTER 1983; GRAY 1983).

In the present work, leaf flavonoids, phenolic acids, coumarins, saponins, tannins and alkaloids of fifteen members belonging to this family have been analysed and the data on the distribution of these compounds are used in finding out the interrelationships existing within the family.

Materials and methods

All the plants have been collected from the forests of Gujarat, Madhya Pradesh, and Kerala. Voucher specimens of the plants are deposited in the Herbarium, Dept. of Botany, The M. S. University of Baroda, Baroda, India. Standard procedures (DANIEL & SABNIS 1977; HARBORNE 1984) were used for the analysis of various plant products from the leaves.

Results

The distribution of various flavonoids, phenolic acids, coumarins, tannins, saponins and alkaloids in fifteen members of Meliaceae is presented in Table 1.

It is found that all the plants screened, except *Dysoxylum*, *Naregamia* and *Aglaia*, contained flavonoids in the leaves. The various flavonoids present were flavones, flavonols, glycoflavones and proanthocyanins. Quercetin, kaempferol and their various mono- and dimethoxylated derivatives formed the major flavonols located in these plants. Quercetin was almost omnipresent whereas kaempferol was infrequent. Myricetin was located in *Walsura* and gossypetin along with its isomer quercetagetin was present in *Chloroxylon*. Apigenin and 4′ OMe luteolin were the two flavones identified in *Walsura*. A single glycoflavone, 4′ OMe vitexin was located in *Chloroxylon*. Proanthocyanins were seen in all the plants except *Melia azedarach*, *Naregamia* and *Aglaia*.

Among the various phenolic acids identified, vanillic and syringic acids were most common. Gallic and p-Coumaric acids were seen in tribes Trichilieae and Swietenieae whereas protocatechuic acid was confined to the former tribe. All the other phenolic acids were having a sporadic distribution. Coumarins were located

Table 1
The distribution of Flavonoids, Phenolic acids, Coumarins, Tannis, Saponins and Alkaloids in 15 members of Family Meliaceae

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Tribe Melieae																										
1. *Azadirachta indica* JUSS.				+	+			+	+					+	+	+								+	·	
2. *Cipadessa fruticosa* BL.			+			+			+					+		+	+		+					+	·	
3. *Melia azedarach* L.			+	+				+							+	+		+	+							+
4. *M. composita* WILLD.			+	+	+			+	+					+		+	+							+	·	
5. *Naregamia alata* W. & A.																+	+			+						
Tribe Trichilieae																										
6. *Aglaia roxburghiana* MIQ.																+	+									
7. *Amoora rohituka* W. & A.					+		+		+					+		+	+		+		+	+				
8. *Dysoxylum binecteriferum* H.f.															+	+	+		+		+					
9. *Walsura piscida* ROXB.	+	+			+		+		+			+		+			+	+							·	
Tribe Swietenieae																										
10. *Chickrasia tabularis* JUSS.				+					+					+				+				+			·	
11. *Soymida febrifuga* JUSS.					+		+		+					+		+	+	+		+		+		+		
12. *Swietenia macrophylla* KING.			+	+	+		+	+	+					+	+	+	+							+		
13. *S. mahogani* JACQ.					+				+						+			+								
Tribe Cedreleae																										
14. *Cedrela toona* ROXB.			+	+	+				+					+		+	+		+					+		
15. *Chloroxylon swietenia* DC.					+	+	+	+	+	+	+		+	+	+	+			+			+	–	+		+

1. Apigenin, 2. 4′OMe Luteolin, 3. Kaempferol, 4. 4′-OMe Kaempferol, 5. Quervetin, 6. 7-OMe Quercetin 7. 3′-OMe Quercetin, 8. 4′-OMe Quercetin, 9. 3′,4′-DiOMe Quercetin, 10. Gossypetin 11. Quercetagetin, 12. Myricetin, 13. 4′-OMe Vitexin, 14. Proanthocyanins, 15. p-Hydroxybenzoic acid, 16. Vanillic acid, 17. Syringic acid, 18. Gallic acid, 19. Gentisic acid, 20. Melilotic acid, 21. Protocatechuic acid, 22. p-Coumaric acid, 23. Coumarin, 24. Tannins, 25. Saponins, 26. Alkaloids

in *Chloroxylon* only. Tannins and saponins were present in about 50% of the plants screened. Only two plants, *Melia azedarach* and *Chloroxylon*, contained alkaloids in the leaves.

Discussion

Among the plants screened, *Chloroxylon* is strikingly different from the rest of the Meliaceae in containing unique flavonols such as gossypetin and quercetagetin. It also contains glycoflavones and coumarins which are otherwise not seen in any other member of Meliaceae. Syringic acid, uniformly distributed in all other members, is conspicuously absent in this plant. Due to these overwhelming dissimilarities, *Chloroxylon* does not find a proper place in any of the tribe: of Meliaceae since all the members tribes of Meliaceae since all the members screened have a different chemical constitution. Coumarins and glycoflavones being common in the family Rutaceae (HARBORNE 1983; GRAY 1983), *Chloroxylon* finds a better place in this family than in Meliaceae. The presence of alkaloids in this genus is another feature supporting its inclusion in the alkaloid-rich Rutaceae.

With the exclusion of *Chloroxylon*, the family Meliaceae, can be visualized as a chemically homogeneous assemblage of plants. The predominance of quercetin and its methoxylated derivatives in the family indicates the chemical closeness the members enjoy. Proanthocyanins, another group of compounds commonly associated with flavonols, also are frequent here. The near absence of flavones, both as o-glycosides and c-glycosides (glycoflavones) is another feature binding all the plants. The lesser frequency of Myricetin derivatives and the prevalence of methoxylated flavonols keep Meliaceae slightly advanced over other families of Sapindales.

Among the various tribes of Meliaceae, Trichilieae and Swietenieae are similar in containing p-coumaric and gallic acids in their leaves. In both tribes vanillic acid is less frequent. Between them, the tribe Trichilieae is peculiar in having two plants, *Aglaia*, and *Dysoxylum* where the entire flavonoid system is lost and also in the introduction of flavones (as o-glycosides) in *Walsura*. These features which are evolved late in a phylogenetic sequence keep this tribe as the most advanced taxon in the family. The absence of gallic and p-coumaric acids are the characters common between the tribes Melieae and Cedreleae. In Melieae, *Naregamia* which does not contain flavoneols or proanthocyanins in the leaves is chemically different from the rest of the tribe. The subfamilies Melioideae, Swietenioideae and Cedreloideae do not get any chemical support in the present work.

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Buchbesprechung

MICHAEL, E.; HENNIG, B.; KREISEL, H., Handbuch für Pilzfreunde. 3. Bd. Blätterpilze – Hellblättler und Leistlinge. 4. erw. Auflage. Herausgegeben und bearb. von H. KREISEL. Mit Beiträgen von P. HÜBSCH, K. MÜLLER und S. RAUSCHERT. 484 S. Mit farb. Abb. von rund 300 Pilzarten auf 147 Taf. sowie 23 einfarb. Abb. im Text. VEB Gustav Fischer Verlag, Jena, 1987. Preis: M 38,10.

Der Band 3 des Handbuchs für Pilzfreunde war 10 Jahre zuvor der erste Band des seinerzeit noch fünfbändigen Werkes, der unter der Herausgeberschaft von HANNS KREISEL ein neues Gesicht erhielt. Inzwischen liegen alle nunmehr 6 Bände in überarbeiteten Form vor, zumeist schon in mehreren Auflagen. Mit Band 3 in bereits 4. Auflage sind damit seit 1983 alle Bände „neu unter einheitlichen Gesichtspunkten herausgegeben" worden, wie es der Herausgeber selbst formuliert. Dabei sind in jedem Band etwa 15–20% der Farbbilder ausgewechselt worden und neue hinzugekommen.

Band 3 des Handbuchs behandelt im Allgemeinen Teil die Themenkomplexe „Namen der Pilze" sowie „Pilzausstellungen und Pilzsammlungen", die allen Pilzfreunden wichtige Informationen über diese sehr wichtigen Spezialgebiete der Mykologie vermitteln. Wesentlich überarbeitet wurden vor allem die Abschnitte über die „Nomenklaturregeln" und das „Zitieren der Autorennamen", von kompetenten Mitarbeitern des Handbuchs völlig neu geschrieben die Abschnitte über die „Betonung der wissenschaftlichen Pilznamen" (S. RAUSCHERT †) und die „Herkunft und Ableitung der deutschen Pilznamen" (K. MÜLLER). Im Systematischen Teil wurden neue taxonomische Erkenntnisse umfassend berücksichtigt, in größerem Umfange z. B. bei den Gattungen *Clitocybe*, *Entoloma*, *Hygrocybe*, *Macrolepiota* und *Melanoleuca* (letztere Gattung unter Mitwirkung von F. GRÖGER). Die Arten der Gattung *Leptoglossum* erscheinen jetzt in den Gattungen *Arrhenia* FR. und *Phaeotelhus* KÜHNER & LAMOURE. Neu ist die Familie Armillariaceae, zu der die Gattungen *Armillaria*, *Cystoderma*, *Melanophyllum*, *Phaeolepiota* und *Squamanita* gestellt werden.

Der Spezielle Teil enthält 45 neue Bilder von RICEK, die zumeist die bisherigen Abbildungen ersetzen. Neu aufgenommen wurden *Lepiota ventriosospora*, *Leucocoprinus birnbaumii*, *Clitocybula lacerata* und *Armillaria bulbosa*. Das bisher als *Tricholoma album* bezeichnete Bild wird jetzt zu *T. lascivum* gestellt, Bild 16 als *Macrolepiota venenata* gedeutet. Die Abb. 143 und 144 sind vertauscht worden.

Kein anspruchsvollerer Pilzfreund sollte es versäumen, sich die meist schnell vergriffenen Bände des Handbuchs für Pilzfreunde zu beschaffen, findet er doch darin einen in der deutschsprachigen Literatur einmaligen Überblick über den aktuellen Stand aller Teilgebiete der Mykologie, die für den Amateurmykologen von Bedeutung sind.

D. BENKERT, Berlin

ALLELOPATHIC EFFECTS OF CERTAIN COMMON WEEDS ON FENUGREEK (*TRIGONELLA FOENUM-GRAECUM LINN.*)

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Abstract

The allelopathic potential of *Trianthema portulacastrum*, *Portulaca quadrifida* and *Convolvulus microphyllus* on *Trigonella foenum-graecum* is assessed in the laboratory and in the field. Both *Trianthema* and *Portulaca* inhibited the germination of fenugreek seeds and also effected adverse changes in the root and shoot systems of the seedlings. In the field, *Portulaca* and *Convolvulus* reduced the crop yield to half. This is accompanied by the changes in the lipid and carbohydrate content. The weeds did not effect any qualitative changes on the chemical composition of the crop.

Introduction

Weeds are known to compete with crops for light, water and minerals. But the allelopathic influence of weeds on crops is very poorly understood. It is now precisely known that the chemicals exuded from a plant interfere with the metabolism and the growth processes of a neighbouring plant positively or negatively. These compounds, known as allelochemics, are liberated by leaching, weathering, exudation and volatilisation. They may be primary or secondary metabolites of the plant. Some of the plant products which are found to exert an inhibitory effect on other plants are alkaloids (strychnine, emetine and morphine), phenols (plastoquinones and other benzoquinones), and terpenoids (limonene, cineole, gitogenin and diosgenin) [1].

Lovett and Lewitt[2] reviewed the role of allelopathy in agriculture. Though India is an agricultural country, proper attention has not been given to the studies on allelopathy. Stevenson[3] opined that the soils of rice fields in Japan and India have been found to contain high enough concentrations of aliphatic acids to inhibit root growth of rice. Merlyn and co-workers[4] observed that the lipidic and phenolic fractions of *Euphorbia hirta*, a succulent weed, inhibited the root and shoot elongation in rice seedlings.

In the present work, fenugreek (*Trigonella foenum graecum* Linn.), a vegetable crop of Gujarat, has been selected for the study. The allelopathic effects of three weeds commonly occurring in and around fenugreek crops, i.e.

Trianthema portulacastrum Linn. *Portulaca quadrifida* Linn. and *Convolvulus microphyllus* Sieb., on seed germination and on growth of seedling have been assessed by treating the seeds and the seedlings (7 days old) with aqueous extracts of weeds.

2. Materials and Methods

Two sets of experiments were conducted: (1) germination studies and (2) field trials. The germination studies were conducted in laboratory conditions where the fenugreek seeds were allowed to germinate in petridishes containing weed extracts. The weed extract is prepared by boiling 10 gms of plant material (whole plant) in 100 ml water. This is considered as 100% solution and the different concentrations are prepared by diluting this solution. 10 ml of the stock solution in a petridish containing 25 fenugreek seeds is equivalent to one gram of weed material for 25 crop plants. The number of seeds germinated and the root and shoot length were noted after seven days.

For field trials, plots of 1 × 1m. size were selected for different treatments. Seeds were sown (approx. 600 per plot) and the weed extracts (prepared by boiling 24 gms of weed material in 500 ml water which provides the ratio of 1gm weed material for 25 plants) were sprayed on seven day old seedlings. A second spraying was done after seven days (i.e. on 14 days old seedlings). The changes in the size of the plant were noted every week by comparing with plants grown in the control plot. After two months, the plants were harvested (by pulling out the entire plants), dried and the dry weights were recorded. These plants were subjected to (1) quantitative analysis for total lipids and polysaccharides and (2) qualitative analysis for steroids, flavonoids, phenolic acids and sugar derivatives using standard procedures [5,6].

3. Results

The percentage of germination and the changes that took place in the root and shoot of the germinated seedlings are presented in Tables I to III.

The extracts of all the three weeds inhibited germination of fenugreek. But the maximum inhibition was seen with *Trianthema* extracts. With this weed, germination of fenugreek seeds took place only in very low concentrations. At slightly higher concentrations the germination was drastically reduced and the root that emerged became coiled and fleshy. At higher concentrations of weed extract, the seeds became swollen and decaying processes set in. Seeds treated with lower concentrations of *Portulaca* showed higher percentage of germination, but at slightly higher concentrations the taproot and stem became fragile. In all the higher concentrations there was observed a delayed germination; seedlings were also not healthy. In all these trials, root and shoot elongation was inhibited. *Convolvulus* exhibited less inhibition. Only at higher concentrations there was a marked retardation in germination and root/shoot elongation.

The changes in dry weight and lipid and carbohydrate content, which occurred in field-grown fenugreek plants treated with various weed extracts, are presented in Table IV. The dry weight, total lipids and the carbohydrate content decreased significantly in plants treated with weed extracts. Root and shoots showed only marginal reduction in length. Maximum decrease in dry weight (approx. 50%) occurred in plants treated with *Portulaca* and *Convolvulus* while the maximum decrease in storage polysaccharides (about 50%) took place in plants treated with the latter weed. The lipid content was reduced to half in plants treated with *Trianthema*.

The chemical composition of the crop in terms of their flavonoids, phenolic acids, sugars and steroids remain unchanged in all these treatments.

4. Discussion

The harmful allelopathic effects of the weeds on the *fenugreek* crop are clearly evident from the present work. All the three weeds studied not only compete with the crop for sunlight, space and nutrients but also contain certain chemicals which retard the germination and reduce the productivity of the crop. The water extracts, in which the allelochemicals are present, produce maximum inhibition at the germination phase of the life cycle of the fenugreek. Since water forms the prime requirement for the germination, the water soluble allelochemicals enter into the seed along with the imbibed water and bring about the harmful effects.

Of the three weeds studied, *Trianthema* and *Portulaca*, the most common weeds of the garden and the fields, showed maximum allelopathic effects. The inhibition on the germination is highly significant because often in the field these weeds are tilled and are allowed to remain in the soil to die and dry off. But when the field is irrigated at the time of sowing practices, the dried plant material remaining in the soil forms the source of allelochemics which get dissolved in water, leach out and bring about the inhibition of germination. The soil water with the leached out chemicals may prove similar to the aqueous extracts used for the experiments conducted during the present investigation. Both the weeds, being succulents, are not easily destroyed by the sun and often have enough vitality to produce mature seed. Even bits of branches can strike roots and proliferate very fast. To reduce the allelochemic potential of these weeds, it is suggested that the removed weeds be burnt to destroy the allelochemics.

In the field trials also similar harmful effects of varying degrees were observed. The decrease in the biomass was high *i.e.* about 50%. The reduction in the total lipids and polysaccharides is also noteworthy. This reduction in the vegetative growth will adversely affect the flowering as well as the fruiting potential of the plant.

This study also proves that the weeds interact with the crop in different ways and at different periods of growth. Both *Trianthema* and *Portulaca* affect the germination processes and the growth of the seedlings, while *Convolvulus*, which does not exert much inhibitory effect on germination reduces the dry weight and the carbohydrate content.

TABLE 1

Trigonella seeds treated with *Trianthema portulcastrum*

S. No.	% Con. of weed extract	% germination of crop seeds	Trigonella seedlings				Remarks
			Root		Shoot		
			Length in cm.	% decrease	Length in cm.	% decrease	
Control							
	0	100	6.7	—	4.1	—	Seedlings healthy and roots show root hairs
Treated							
1	6	13.3	0.2	97	—	—	Tip of root became coiled and after 1 week became fleshy
2	12	6.6	0.1	98	—	—	Delayed germination, Roots turned yellow
3	25	—	—	—	—	—	Seeds turned brown and later became swollen
4	100	—	—	—	—	—	Seeds became swollen and after 3 days decayed

TABLE 2

Fenugreek seeds treated with *Portulaca quadrifida*

Sr. No.	% Con. of weed extract	% germination of Trigonella seed	Trigonella seedlings				Remarks
			Root		Shoot		
			Length in cm.	% decrease	Length in cm.	% decrease	
Control							
	0	100	3.9	—	4.1	—	Seedlings healthy
Treated							
1	12	46.6	2.2	43.5	2.8	31.4	Radicle, shoot fleshy and fragile
2	25	26.6	0.5	87.1	1.5	63 4	Delayed germination, cotyledonary leaves did not open.
3	50	13.3	0.3	92	0.7	84.9	Delayed germination, seeds swollen on 3rd day
4	100	—	—	—	—	—	Seeds got swollen and decayed.

TABLE 3

Trigonella seeds treated with *Convolvulus microphyllus*

Sr. No.	% Con. of weed extract	% Germination of *Trigonella* seeds	Trigonella seedlings					Remarks
			Root		Shoot			
			Length in cms	% decrease	Length in cms	% increase	% decrease	
Control								
	0	100	6	—	5.6	—	—	Seedlings healthy
Treated								
1	6	76.6	4.9	18.3	6.8	21.4	—	—
2	12	65	4.8	20	5.2	—	7.1	—
3	25	46	4.0	33.3	4.4	—.	21	Roots/short and points of attachment of leaves fragile
4	50	25	2.9	51.6	6.3	12.5	—	Seeds turned brown.

TABLE 4

The dry weight, percentage of total lipids and water solubles and the root/shoot length of *Trigonella* plants (two months old) treated with the various weed extracts

Plot	Dry weight		Lipids		Carbohydrates		Root Length in cms.	Shoot Length in cms.
	in gm.	decrease in gm.	%	% decrease	%	% decrease		
Control	6.2	—	20	—	30	—	16	2.5
Trianthema	6	3.2	9.9	50.5	21.8	27.3	15	2.4
Portulaca	3.2	48.5	8.94	58	21.8	27.3	13.2	2.1
Convolvulus	3.4	48	17.6	12	16.6	47	15	1.6

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