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Chemotaxonomical Studies of Some Important Monocotyledons

S. Ankanna, D. Suhrulatha and N. Savithramma

Department of Botany, Sri Venkateswara University, Tirupati, Andhra Pradesh, India

Abstract: Chemotaxonomy is concerned with the application of chemical characters to problems of classification and phylogeny the special value of the chemotaxonomic approaches can be seen when chemical characters correlate well with data obtained from preliminary screening of secondary metabolites. The present work is aimed to screen secondary metabolites from various Monocotyledonous plants by different chemical methods and to summarize new concepts of monocotyledonous taxonomic ranks. The results revealed that the selected species of monocotyledons responded positively for flavonoids, phenols, tannins and steroids. Whereas *Sorghum vulgare* and *Canna orientalis* showed synergistic chemical constituents and *Commelina benghalensis* proved two constituents only. *Sorghum vulgare* showed maximum number of secondary metabolites viz., flavonoids, glycosides, phenols, lignins, leucoanthocyanins, tannis, fats, coumarins, steroids, emodins and anthocyanins, followed by *Eragrostis tenella*, *Pothos scandens*, *Smilax zeylanica, Zingiber officinalis, Musa paradisiaca, Alliam cepa, Crinum asiaticum, Ravenala madagascarensis, Scilla hyacinthina*, *Cyperus rotundas, Dracaena fragrance, Gloriosa superba, Yucca gloriosa, Cymbopogan citratus, Acorus calamus, Typha angustata, Saccharum officinarum, Caryota urens, Cynodon dactylon, Kyllinga nemorates, Aloe vera, Allium sativum, Chloris barbata, Aristida hirtris, Eleusine coracana, Zea mays, Pandanus fascicularis, Borassus flabellifer, Bambusa arundinacea, Setcreasea purpurea, Commelina benghalensis. Amaryllis vittata, Curcuma longa, Sansevieria roxburghiana* and *Asparagus raccemosus.* Poaceae members are found to be rich in glycosides, phenols and flavonoids. These findings of the present study will be helpful to taxonomist, phytochemists and pharmacologists to solve taxonomical problems and for identification of new active compounds from monocotyledons.

Key words: Monocotyledons · Chemotaxonomy · Secondary metabolites

INTRODUCTION

Plant synthesizes a wide variety of chemical compounds, which can be stored by their chemical class, biosynthetic origin and functional groups in to primary and secondary metabolites. Secondary metabolites do not seem to be vital to the immediate survival of the organism that produces them and are not an essential part of the process of building and maintaining living cells. With the development of natural product chemistry, the potential of chemotaxonomy is now becoming increasing obviously. The application of chemical data to systematic has received serious attention of a large number of biochemists during the last three decades [1]. Phytochemical constituents are the basic source for the establishment of several pharmaceutical industries. The constituents present in the plant play a significant role in the identification of crude drug. Phytochemical screening is very important in identifying new sources of therapeutically and industrially important compounds like alkaloids, flavonoids, phenolic compounds, saponins, steroids, tannins, terpenoids etc [2]. Previously the drugs were identified by comparison only with the standard description available, but recently due to advancement in the field of pharmacognosy various techniques have been following for the standardization of crude drugs [3].

Chemotaxonomy of plants may be defined as a scientific investigation of the potentialities of chemical characters for the study of problems of plant taxonomy and plant physiology. The chemotaxonomic characters are better than the morphological characters, because the material to be analyzed must not be fresh or complete materials but it uses only dried and crushed material. A hundred years old herbaria specimen can also be

Corresponding Author: S. Ankanna, Department of Botany, Sri Venkateswara University, Tirupati, Andhra Pradesh, India-517 502.

examined for their secondary metabolites accurately [4]. The advent of chemotaxonomy is closely linked to the introduction of chemical analytical methods, especially chromatography [4]. There are four prominent groups of compounds that are phenolics, alkaloids, terpenoids and non protein amino acids, all of which exhibit a wide variation in chemical diversity, distribution and function [5]. Chemotaxonomic principles are considered and some examples are provided to show the importance of chemical evidence in taxonomic revision [6]. The system of chemotaxonomic classification relies on the chemical similarity of taxon, it is based on the existence of relationship between constituents and among the plants [7].

In traditional plant taxonomy the totality of morphological characters has always to be weighed and checked carefully when decisions with regard to delimitations and classification have to be made [6]. The role of chemistry in plant taxonomy has been explained by Heywood [8], Iwashiana *et al*. [9]. The position of many taxa in natural system of plant is still highly uncertain, this applies to all levels of taxonomic categories like species in genus, genera in a family, families in an order and even orders in a class. Varying interpretation and evaluation of morphological characters very often result in disagreement regarding classification. In such instances taxonomists as a rule look for characters other than morphological ones as described by Thorne [10]; Benson [11] and Davis and Heywood [12]. Generally anatomical, embryological, palynological and cytological characters are considered first. Sometimes they produce convincing evidence and sometimes fail to do so. In such situations chemical characters may become very useful guides to taxonomists. At present one important task of chemotaxonomy consists in procuring additional evidence in all cases of obscure relationships of plants. Hence an attempt has been made to assess the status of phytochemical properties in different plants of monocotyledons to solve some taxonomic problems and also to improve the health status of people and pharmaceutical products of commercial importance.

MATERIALS AND METHODS

Plant Materials: The fully matured healthy plants material of various monocotyledons like *Cyperus rotundas, Cymbopogan citratus, Aristida hirtris*, *Kyllinga nemorates* (Cyperaceae), *Eragrostis tenella, Sorghum vulgare, Chloris barbata, Saccharum officinarum, Cynodon dactylon, Bambusa arundinacea, Eleusine coracana, Zea mays* (Poaceae)*, Acorus calamus rhizome, Pothos scandens* (Aroidaceae)*, Typha angustata* (Typhaceae), *Pandanus fascicularis* (Pandanaceae), *Caryota urens, Borassus flabellifer* (Palmae)*, Commelina benghalensis, Setcreasea purpurea, Rhoeo discolor* (Commelinaceae)*, Allium cepa* and *Allium sativum* (Alliaceae)*, Amaryllis vittata, Crinum asiaticum* (Amaryllidaceae)*, Smilax zeylanica* (Smilacaceae), *Gloriosa superba, Aloe vera, Scilla indica* Var. *hyacinthina,* (Root tuber)*, Asparagus racemosus, Scilla indica* Var. *hyacinthina* (Leaves) (Liliaceae), *Curcuma domestica, Curcuma longa, Zingiber officinalis* (Zingibaraceae)*, Musa paradisiaca, Ravenala madagascarinsis* (Musaceae)*, Ananas cosmosus* (Bromeliaceae), *Sansevieria roxburghiana, Dracaena fragrance, Yucca gloriosa* (Agavaceae)*, Canna orientalis* (Cannaceae) were collected from Tirupati surrounding areas, Chittoor District of Andhra Pradesh, India during October 2012. The materials were washed thoroughly and shade dried.

Extraction of Plant Material

Aqueous Extraction: 10 g of air dried powder was added to 100 ml distilled water and boiled for 2 hrs. The supernatant was collected and this procedure was repeated twice. The collected supernatant at an interval of every 2 hrs were pooled together and concentrated to make the final volume into one-fourth of the original volume. It was then autoclaved at 121°C and at 15 lbs pressure and stored at 4°C.

Preliminary Phytochemical Screening: The condensed extracts were used for preliminary screening of phytochemicals such as flavonoids [13]; steroids, alkaloids and phenols [14]; terpenoids and glycosides [15]; tannins, anthroquinons, leucoanthocyanins and emodins [16]; saponins [17]; and anthocyanins [18].

RESULTS AND DISCUSSION

Most of the modern plant taxonomical systems are phylogenetic. Some of the phylogenetic systems of classifications are proposed by Engler and Prantl, Hutchinson, Bessy, Rendle, Takthajhan, Cronquist etc. Bentham and Hooker have proposed an efficient and practical system of classification of seed plants which is a natural system and based on an extensive comparative study of the plant characters indicating their natural affinities. Because of it is a byproduct of an extensive comparative study of vegetative and floral characters of

Table 1: Preliminary phytochemical screening of secondary metabolites from selected Monocotyledons.

S. No	Plant Name	Fla	Gly	Alk	Lig	Phe	Leu	Sap	Tan	Fat	Cou	Ste	Emo	Antho	Triterp	Anthraqu
1.	*Cyperus rotundas* (Cyperaceae)	-	-	+	+	+	-	-	-	-	-	+	-	-	+	+
2.	*Cymbopogan citratus* (Cyperaceae)	+	-	-	-	+	-	-	-	+	-	+	-	-	+	-
3.	*Aristida hirtris* (Cyperaceae)	+	+	-	-	+	-	-	+	-	-	+	-	-	+	-
4.	*Kyllinga nemorates* (Cyperaceae)	-	-	+	-	+	-	-	-	-	-	-	-	-	+	-
5.	*Eragrostis tenella* (Poaceae)	+	+	+	-	+	+	+	-	+	+	+	+	-	-	-
6.	*Sorghum vulgare* (Poaceae)	+	+	-	+	+	+	-	+	+	+	+	+	+	-	-
7.	*Chloris barbata* (Poaceae)	-	-	-	+	+	-	-	-	-	-	+	+	-	-	-
8.	*Saccharum officinarum* (Poaceae)	+	-	-	-	+	-	-	+	-	-	+	-	-	-	-
9.	*Cynodon dactylon* (Poaceae)	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-
10.	*Bambusa arundinacea* (Poaceae)	+	+	+	-	+	-	-	+	-	-	-	+	-	-	-
11.	*Eleusine coracana* (Poaceae)	+	++	+	-	++	-	-	-	-	-	-	-	-	-	-
12.	*Zea mays* (Poaceae)	+	-	-	-	+	-	-	+	-	-	-	-	-		+
13.	*Acorus calamus* (Aroidaceae)	+++	-	-	-	+	-	-	-	-	-	+++	+	-	++	-
14.	*Pothos scandens* (Aroidaceae)	+	-	-	-	+	-	-	+	-	-	+	-	-	+	-
15.	*Typha angustata* (Typhaceae)	+++	-	+	-	+++	-	-	+	-	-	-	-	-	+	-
16.	*Pandanus fascicularis* (Pandanaceae)	+	-	+	-	+	-	-	+	-	-	+	-	-	-	-
17.	*Caryota urens* (Palmae)	+	-	-	-	+	-	-	+	-	-	-	-	-	-	-
18.	*Borassus flabellifer* (Palmae)	+	-	-	-	+	-	-	+	-	+	+	-	-	-	-
19.	*Commelina benghalensis* (Commelinaceae)	+	+	-	-	+	-	-	+	-	-	-	-	-	-	-
20.	*Setcreasea purpurea* (Commelinaceae)	-	++	+	-	-	-	-	-	-	-	-	-	-	-	-
21.	*Rhoeo discolor* (Commelinaceae)	+	-	-	-	++	-	-	-	-	-	-	-	+++	-	-
22.	*Allium cepa* (Alliaceae)	-	+	-	-	-	-	-	+	+	-	+	-	-	-	-
23.	*Allium sativum* (Alliaceae)	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-
24.	*Amaryllis vittata* (Amaryllidaceae)	+	-	+	-	-	-	-	-	-	+	-	-	-	-	-
25.	*Crinum asiaticum* (Amaryllidaceae)	+	+	-	-	-	+	-	-	+	+	-	-	-	-	-
26.	*Smilax zeylanica* (Smilacaceae)	+	+	-	-	+	-	-	+	+	+	-	-	-	-	-
27.	*Gloriosa superba* (Liliaceae)	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-
28.	*Aloe vera* (Liliaceae)	-	+	-	-	-	-	-	-	-	+	+	-	-	-	-
29.	*Scilla hyacinthina, indica* (Liliaceae)	-	+	+	-	-	+	+	-	-	-	-	-	-	-	+
30.	*Asparagus racemosus* (Liliaceae)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31.	*Curcuma domestica* (Zingiberaceae)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
32.	*Curcuma longa* (Zingiberaceae)	+	+	+	-	+	-	-	+	-	-	-	+	-	-	-
33.	*Zingiber officinalis* (Zingibaraceae)	+	+	+	+	+	-	-	-	-	-	+	+	-	-	-
34.	*Musa paradisica* (Musaceae)	+	+	-	-	+	-	-	+	-	+	+	-	-	-	-
35.	*Ravenala madagascarinsis* (Musaceae)	+	+	-	-	+	-	-	+	-	-	-	-	+	-	-
36.	*Ananas cosmosus* (Bromeliaceae)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
37.	*Sansevieria roxburghiana* (Agavaceae)	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-
38.	*Dracaena fragrance* (Agavaceae)	+	+	-	-	-	+	-	+	-	+	-	-	-	-	-
39.	*Yucca gloriosa* (Agavaceae)	-	+	-	-	-	-	+	-	-	+	-	-	-	-	-
40.	*Canna orientalis (Cannaceae)*	+	+	+	+	+	+	+	+	+	+	-	-	+	-	-

Note: Fla – Flavonoids, Gly – Glycosides, Alk – Alkaloids, Lig – Lignins, Phe – Phenols, Leu – Leucoanthocyanins, Sap – Saponins, Tan – Tannins, Fat – Fatty acids, Cou – Coumarins, Ste – Steroids, Emo – Emodins, Antho – Anthocyanins, Triterp – Triterpenoids, Anthraqu – Anthraquinons,

plants indicating natural affinities. Taxonomic ranks are instituted by grouping of plants according to their similarity. The treatment of the monocotyledons by Bentham and Hooker is slightly different, they have not recognized cohorts within the series like dicotyledons the series of monocotyledons are followed directly by natural orders. In the present study 40 plants were screened among these 25 plant species has resulted positive reaction for flavonoids like, *Cymbopogon citratus, Eragrostis tenella, Sorghum vulgare, Acorus calamus, Typha angustata, Pothos scandens, Aristida hirtris, Saccharum officinarum, Pandanus fascicularis, Caryota urens, Curcuma longa, Kyllinga nemorates, Setcreasea purpurea, Rhoeo discolor, Elusine coracana, Zea mays, Crinum asiaticum, Smilax zeylanica, Musa paradisiaca, Ravenala madagascarinsis, Dracaena fragrance, Canna orientalis, Zingiber officinalis* and *Scilla indica* Var. *hyacinthina* (Table. 1 and Fig. 1). Flavonoids have been reported to possess many useful properties, including anti-inflammatory, oestrogenic, antimicrobial and enzyme inhibition [19]. Flavonoids are very large number of diverse compounds found throughout the vascular plants and in nearly, if not all angiosperms of great taxonomic value below the genus level and possible use in

Table 2: Family wise distribution of some important secondary metabolites

Family	Secondary metabolites Phenols	Flavonoids	Glycosides	Alkaloids	Tannins	Steroids	Triterpenoids
Cyperaceae	4	2	1	2	1	3	4
Poaceae	8	6	4	3	5	4	-
Commelinaceae	2	2	2	1	-	-	-
Alliaceae	2	-	2	-	1	1	-
Liliaceae	-	-	3	1	-	-	-
Zingiberaceae	2	2	3	3	1	-	-
Agavaceae	1	1	2	-	1	-	-
Aroidaceae	2	2	-	-	1	2	2
Arecaceae	2	2	-	-	2	-	-
Amaryllidaceae	-	2	-	-	-	-	-
Musaceae	2	2	2	-	2	-	-

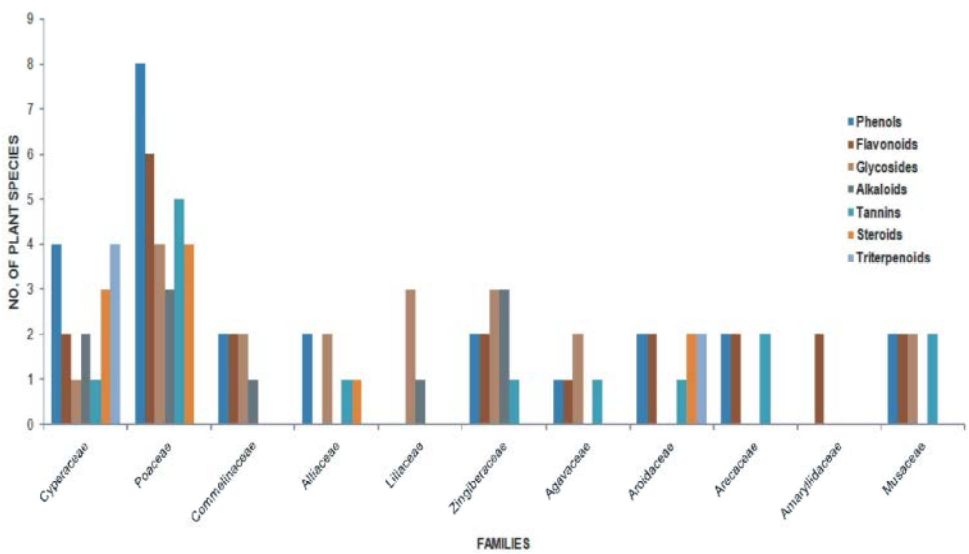

Fig. 1: Distribution of secondary metabolites in different families of Monocotyledons.

classification of higher categories [20] and antiallergic, antioxidant, cytotoxic antitumour and vascular activities [21]. Flavonoid pattern in the monocotyledons, flavonoids and flavones in some families associated with the poaceae has been described by Williams and Harborne [22]. Whereas *Eragrostis tenella, Sorghum vulgare, Pothos scandens, Curcuma longa, Kyllinga nemorates, Commelina benghalensis, Eleusine coracana, Alliam cepa, A. sativum, Crinum asiaticum, Smilax zeylanica, Gloriosa superb, Curcuma longa, Musa paradisiaca, Ravenala madagascarinsis, Dracaena fragrance, Aloe vera, Scilla indica* Var. *hyacinthina, Canna orientalis, Yucca gloriosa* and *Zingiber officinalis* positively responded for glycosides tests. Glycosides, flavonoids and alkaloids have hypoglycemic activities [23]. Glycosides are great chemical variation in the non-super position of the molecule varyingly of great usefulness in taxonomy [24].

Among selected plant species almost all species have given positive reaction for phenolic tests except *Commelina benghalensis, Allium cepa, Amaryllis vittata, Crinum asiaticum, Ananas cosmosus, Dracaena fragrance, Aloe vera, Asparagus racemosus and Yucca gloriosa.* Primarily phenolic compounds are of great importance as cellular support material because they form the integral part of cell wall structure by polymeric phenolics [25]. Bioactive polyphenols have attracted special attention because they can protect the human body from the oxidative stress which may cause many diseases, including cancer, cardiovascular problems and ageing [26]. 21 species have found to be rich in tannins and triterpenoids. The growth of many fungi, yeasts, bacteria and viruses was inhibited by tannins [27] and terpenoids have the property of astringent activity i.e. faster the healing of wounds and inflamed mucous membrane [28]. Triterpenoids have wide distribution in living organisms taxonomically useful in several angiosperm families such as cucurbitaceae and also found in fungi [29]. 15 species has been responded for steroids test like *Cyperus rotundas, Cymbopogan citratus, Eragrostis tenella, Sorghum vulgare, Chloris barbata, Acorus calamus, Typha angustata, Pothos scandens, Aristida hirtris, Saccharum officinarum, Caryota urens, Allium cepa, Musa paradisiaca and Zingiber officinalis.*

The groups of compounds mostly utilized for this purpose include alkaloids, phenols, glucosinolates, aminoacids, terpenoids, oils and waxes. Recent investigations and reports of the usefulness of these compounds either for medicinal/ therapeutic/ taxonomic elucidation of species include [30], Hassan *et al*. [31], Ibrahim *et al*. [32], Mallikarjuna *et al*. [33], Irshad *et al*. [34], Nyananyo *et al*. [35]; Rasool *et al*. [7] and Ganesh and Vennila [36]. It is noteworthy that all these phytochemicals are present in the different plant species connoting taxonomic affinity, these differences in their connections uniquely confers individualism on each species and thus support their being treated as taxonomic species. This agrees with Irshad *et al*. [34] where phytochemical results established closer relationship between *Lagenaria* and *Luffa cylindrica* then *Cucumis maxima.*

Among all tested plants Poaceae members are found to be rich in glycosides (Fig. 2), phenols (Fig. 3) and flavonoids (Fig. 4). The study of their chemical constituents may therefore bring to light new characteristics helpful in identification. A thorough study of chemistry of each member of aggregates and the elaboration of analytical methods which may be performed even with herbarium specimens can be in many instances useful to plant taxonomy. Chemotaxonomic studies on the *Amomum* genus based on chemical components of volatile oils have been employed [37]. Evolution of Angiosperms and their flavonoids reported by Harborne [38]. Chemotaxonomic approach on *Artimesia* and *Gentiana* was employed by Ling [39] and Omer [40]. Phytochemistry in relation to botanical classification is proved and solved similarity problems in the same genera

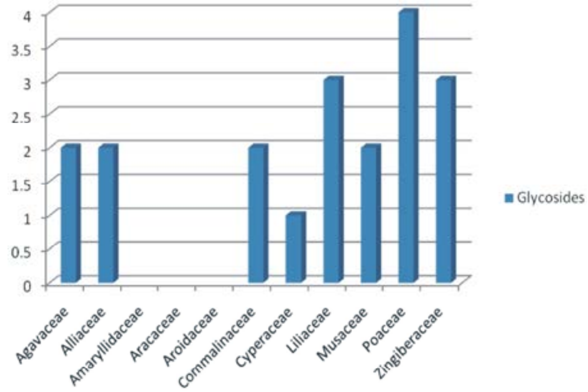

Fig. 2: Distribution of Glycosides in different families of Monocotyledons.

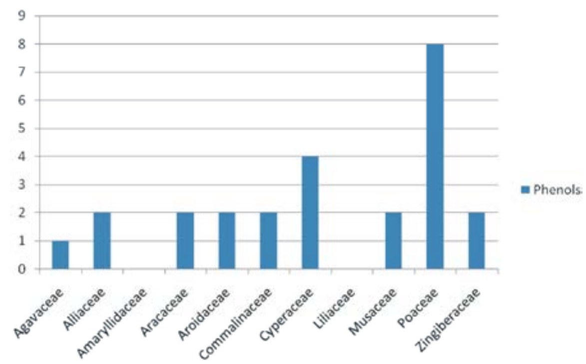

Fig. 3: Distribution of Phenols in different families of Monocotyledons.

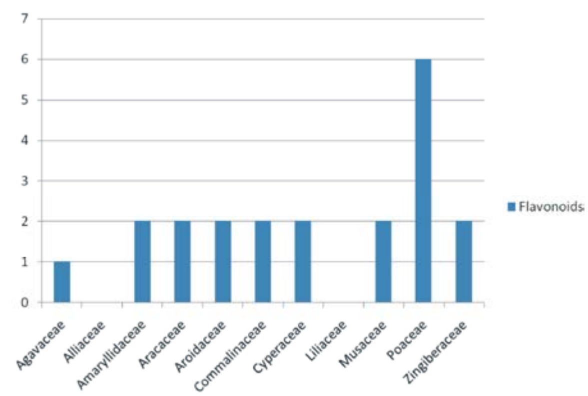

Fig. 4: Distribution of Flavonoids in different families of Monocotyledons.

[41]. Similar results pertaining to distribution of secondary metabolites are also obtained by Kayani *et al*. [42] and Achakzai *et al*. [43].

Traditionally Liliaceae are characterized by having hypogynous flowers with a showy perianth six stamina and pistillum composed of three carpels and Amaryllidaceae are separated from Liliaceae by their epigynous flowers. Hutchinson [44] believes that the most essential character of true Amaryllidaceous plants in their umbellate inflorescence subtended by involucres bracts. This results in transferring *Allium* and allied genera which all possess hypo-gynous flowers from Liliaceae and Amaryllidaceae. The delimitation of two families was rather profoundly altered by the new concept which has been accepted by several modern taxonomists and rejected by others. In such instances chemical characters may aid taxonomists. The present day chemical evidence favors the traditional delimitation of Liliaceae and Amaryllidaceae with respect to *Allium* and related genera because the highly characteristic alkaloids of all true amaryllidaceous plants are seemingly lacking in the *Allium* alliance and because steroids are wide spread in Liliaceae but apparently lacking in true Amaryllidaceae occur in *Allium* and allied genera.

Besides being helpful with the identification of plant specimens it forms us about patterns of chemical variation within genera and aggregate species and it may ultimately demonstrate how one pattern of plant constituents evolved from a preceding one. Moreover, joint botanical and phytochemical studies of monocotyledons may provide with a better understanding of biological and ecological meaning distinct spectra of primary and secondary plant metabolites. A thorough knowledge in this field is essential for a judgment of the overall taxonomic implications of the overwhelming multitude of phytochemical patterns.

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