TAXONOMIC EVIDENCES FROM PHYTOCHEMISTRY

Plant produces many types of natural products and quite often the biosymthetic pathways producing these compounds differ from one taxon to another. These data sometimes have supported the existing classification or in some instances contradicted the existing classification. The use of chemical compounds in systematic and taxonomic study has created a new branches of biological science – Chemosystematics or Chemotaxonomy or Biochemical systematic.

The natural chemical compounds of taxonomic use can be divided as follows –

A. Micromolecules – Molecules having molecular weight 1000 or less. Micromolecules are divided into two major groups –

1. Primary metabolites- involved in vital metabolic pathway, usually of universal occurrence , e.g., Citric acid, Aconitic acid , amino acids, sugars etc.

2. Secondary metabolites – These are by-product of metabolism. They usually perform non-vital functions and not universal in occurrence therefore less widely spread among plants. It includes – non-protein amino acids, terpenoids, flavonoid compounds and other phenolic compounds, alkaloids, cyanogenic compounds, glucosinolates, fatty acids, oils, waxes etc.

B. Macromolecules- Molecules having molecular weight 1000 or more. Macromolecules are of two types –

1. Semantids – These are information carrying molecules and can be classified into 3 categories – Primary Semantids (DNA), secondary Semantids (RNA), and Tertiary Semantids ((Protein). The utilization of studies on DNA and RNA for understanding of Phylogeny has established a new field of study the molecular systematic. The results obtained from Protein taxonomy are largely divisable into four main headings – Serology, Electrophoresis, amino acid sequencing, and isoelectric focussing.

2. Non-Semantids macromolecules – compounds not involved in information transfer – Starch, Celluloses etc.

Apart from these there are some compounds that are directly visible such as crystals – Raphides etc. These are rather restricted in distribution and have been used in taxonomical studies by many earlier workers.

A. Primary metabolites

These substances are of universal occurrence and lack variation. As such they do not have much systematic value. In some cases quantitative differences of these metabolites are taxonomically significant. e.g., in *Aconitum* Aconitic acid, in *Citrus* Citric acid, in *Oxalis* Oxalic acid etc.

B. Secondar metabolites

1. Phenolic compounds: The phenolic compounds have provided more taxonomic data than all groups of secondary metabolites. These compounds are based upon phenol (C_6H_5OH) differing in position and number of OH group. Most of them are highly complicated, have several aromatic rings and side chains. Many of these compounds have no functions in plants but some are the most important flower pigment and others are involved in the inhibition of pathogenic fungi.

Taxonomically most important phenolics are the Flavonoids, because –

i. Their almost universal occurrence in nearly all plants.

ii. Their great structural variation – more than 2000 flavonoids have already been isolated from various plants. These variations have genetic basis.

iii. It is easy to isolate and identify these chemicals

iv. Chemical stability of flavonoids makes it possible to analyse the plant materials even from old dry Herbarium specimen.

v. Data on Flavonoids is valuable at all taxonomic ranks.

Although primarily useful inassessing relationship among closely related species, flavonoids are occasionally useful in assessing phylogenetic relationship at higher level.

Flavonoids chemistry also has been used to support a hypothesized relationship between Fabaceae and Sapindaceae. The Flavonoids are of two types-

a. Blue to purple to crimson, the Anthocyanins.

b. Yellow to orange to scarlet, the Anthoxanthins.

Anthocyanins and Anthoxanthins are important pigment in the cell sap of petals. The Anthocyanin pigments are widely distributed in flowering plants. They are absent in members of Caryophyllales (except in Caryophyllaceae and Molluginaceae).

Distribution of Anthocyanin along with distribution of Betalain pigment have been useful in solving taxonomic disputes. Betalains are nitrogenous red and yellow pigment, restricted to Caryophyllales except for the Caryophyllaceae and Molluginaceae. It has been observed that Anthocyanin and betalain never occur together. Mabry (1976) recognized two groups of families under Centrospermae of Engler and Prantl now recognized as Order Caryophyllales. Two groups are best treated as one Betalain suborder and another Anthocyanin suborder under one order Caryophyllales. Of the nine families which contain Betalain seven were included Centrospermae (Caryophyllales), Cactaceae was placed in Cactales and the ninth was placed in Sapindales. Traditional Centrospermae also included Gyrostemonaceae, Caryophyllaceae and Molluginaceae which lack Betalain but contain Anthocyanins instead. Mabry et al (1963) suggested the placement of only Betalain containing families in Centrospermae, thus advocating the inclusion of Cactaceae and Didiereaceae and exclusion of Gyrostemonaceae, Caryophyllaceae and Molluginaceae.

2. Terpenes

Terpenes include a large group of compounds derived from mevalonic acid precursor. Common examples are Camphor (*Cinnamomum*), Menthol (*Mentha*) Carotenoids. Terpenoids, the common group of Terpenes have been largely used in distinguishing specific and subspecific entities, geographic races and detection of hybrids. Many tribes within family Asteraceae are characterized by distinct types of Sesquiterpene lactones they produce. Triterpene saponins occur in Apiaceae and Pittosporaceae and support their close relationship. Iridoid compound constitute another important group of Terpenes, are mostly monoterpene lactone. Distribution of Iridoid compound is considered to be an evolutionary marker. They are present in over 50 families and their presence is correlated with sympetaly, unitegmic tenuinucellate ovule, cellular endosperm and endosperm haustoria. The occurrence of Iridoid compounds in several unrelated families e.g., Hamamelidaceae and Meliaceae suggest that Iridoids could have arisen independently several times in the evolution of Angiosperm.

3. Glucosinolates

Glucosinolates or Masterd oil glucosides are sulphur containing compound found in 15 families of Angiosperms. Originally Cruciferae, Capparaceae, Papavaraceae and Fumariaceae were placed in the same order Rhoeadales because of similar floral structure, parietal placentation, similar fruit type. Later chemical and other evidences supported the placement of Cruciferae and Capparaceae in the order Capparales on the basis of presence of Glucosinolates) and placement of Papavaraceae and Fumariaceae in the order Papavarales (on the basis of absence of Glucosinolate).

4. Alkaloids

Alkaloids are organic nitrogen containing waste product of plants resulting possibly from decomposition of proteins. Their distribution is often specific and thus taxonomically significant. Morphine is present only in Opium poppy (*Papaver somniferum*). Close relationship between Papaveraceae and Fumariaceae is supported by the occurrence of alkaloid Protopine. Tropane alkaloids of Solanaceae and Convolvulaceae are similar suggesting a close relationship. The families are placed in the same order in recent system (Gershenzon and Mabry, 1983). Gribbs (1974) grouped Rubiaceae, Apocynaceae, Asclepiadaceae, and Loganiaceae in the same order Gentianales based on Indole Alkaloids.

5. Tannin

Ellagitannins is a tannin derived from Ellagic acid. The systematic importance of Ellagic acid has been discussed by Bate-Smith and Metcalfe (1957). Extensive survey of flowering plants have revealed that this is exclusive to dicot indicating a fundamental cleavage between Magnoliidae and Hamamelidae, former lacking Ellagitannins while the later possessing them. This in turn probably points to the origin of monocot from a Magnolian stocksince monocots totally lack this compound.

6. Non-protein amino acid

A large number of amino acids not associated with protein are known. Their distribution is not universal but specific to certain groups and as such holds promise for taxonomic significance. Lathyrine is thus known only from *Lathyrus*. Canavanine occurs only in Fabaceae and is shown to be a protection against insect larvae.

7. Cyanogenic glycosides and Cyanogenesis

Cyanogenesis is the ability of certain plants to release Hydrocyanic acid (HCN) when injured. Cyanogenic compounds particularly Cyanogenic glycosides yield HCN on either enzymatic or non-enzymatic hydrolysis. The Cyanogenesis process has been proved adequate in solving taxonomic disputes. The presence of HCN can be detected easily by the smell of bitter almonds and using sodium picrate paper. The test may even be performed with the herbarium specimen. Cyanogenic compounds are characteristic of Rosaceae, Leguminosae,and Poaceae. Lindley (1830) and Endlicher (1836) had used the presence or absence of this compound to distinguish between the tribe Amygdaleae (with cyanogens) and Chrysobalaneae (without Cyanogen).