GENERAL INTRODUCTION

If the diverse hues of the sky reach the climax in the colourful rainbow, the wonderful garment of the Mother Earth has the most captivating part - the green vegetable kingdom. The latter has so many bewitching names - woods, forests, jungles etc., which has plants of various sizes and varying utility. Many a factory has to be shuttered down if we miss plants. Let us think of the furniture, spices, perfumes, herbs, laurels, decorative flowers, paper, resin and the peak of its rewards - cotton which civilises man. The presence of one or more of the flavonoids graces the plants. About 2% of the total carbon photosynthesized by plants are converted to flavonoids.

Taxonomically the most valuable substances are those that are relatively stable as end products of metabolism. Of all secondary substances, by far the greatest diversity in structure is shown by those compounds that contain phenolic groups. Approximately 36% of the naturally occurring compounds of plants contain phenolic hydroxyls and of these about one-third are flavonoid types.
The term flavonoid (Lat, flavus=yellow) was coined by Geissman and Hinreiner. Kostanecki and Tambor suggested the name flavone first.

A number of monographs are available providing voluminous information on the isolation, synthesis, biochemistry, biogenesis, stereochemistry, biological activity and economic importance of flavonoids.

Flavonoids form the largest single family of naturally occurring oxygen containing heterocyclic compounds. Benzo-γ-pyrone(I) of various levels of saturation, oxidation and substitution constitutes the basic skeleton for these polyphenolics. 4-Chromanone(II) substituted by a phenyl ring at C-2 forms flavanones(IIIa) and flavanonols (dihydroflavonols)(IIIb). Flavones(IVa) and flavonols(IVb) which are the co-pigments in both cyanic and acyanic flowers are formed by substitution of a phenyl ring at C-2 position of the chromone nucleus. Also included in this category are the flavan-3,4-diols (proanthocyanidins) (V), anthocyanidins(VI) which occur as scarlet, red, mauve
Benzo-γ-pyrone  
(Chromone)

4-Chromanone

(a) R = H, Flavanone  
(b) R = OH, Flavanonol

(a) R = H, Flavone  
(b) R = OH, Flavonol

Flavan-3,4-diol

Anthocyanidin
and blue flower pigments, leucoanthocyanidins (VII) which are found in the heartwoods and in the leaves of woody plants, glycoflavones which contain C-C linked sugars as is exemplified by vitexin (VIIIa) and biflavonyls that are formed by carbon-carbon or carbon-oxygen coupling between two flavone units as in amentoflavone (IX) or hinokiflavone (X) and are confined to the gymnosperms. Chalcones (phenylstyrylketones) (XI), dihydrochalcones (3-phenylpropiophenones) (XII), isoflavones (3-phenylchromones) (XIII), neoflavones (4-phenylcoumarins) (XIVa) and aurones (Lat, aurum=gold) (2-benzilidine-3-coumarones) (XV) do not actually possess the basic 2-phenylchroman but are so closely related chemically and biosynthetically to the other flavonoid types.

All these heterocyclics are made up of two distinct units, the C₆-C₃ fragment that includes the B-ring and the C₆ fragment, A-ring. The flavonoids originate from a C₆-C₃-(C₂+C₂+C₂) precursor, the last six carbon atoms being found in the aromatic A-ring. The carbon atoms are referred to by a numbering
Leucoanthocyanidin

(a) $R^1 = \text{Glu}, R^2 = R^3 = H$, Vitexin
(b) $R^1, R^3 = H, R^2 = \text{Glu}$, Isovitexin (Saponaretin)
(c) $R^1 = H, R^2, R^3 = \text{Glu}$, Saponarin

Amentoflavone (Biflavone)
system which utilises ordinary numerals for the A- and C-rings and primed numbers for the B-ring. However, a modified numbering is adopted in the case of chalcones.

The various flavonoids differ from one another only in the state of oxidation of the central ring. The individual compounds within each class are distinguished mainly by the number and location of hydroxyl, methoxyl and other groups substituted on the two benzene rings. These groups are usually arranged in restricted patterns in the flavonoid molecules reflecting the different biosynthetic origin of the two aromatic rings. The hydroxylation pattern of the A-ring originates from the acetate or malonate unit while that of B-ring resembles that found in the commonly occurring cinnamic acids viz. p-coumaric acid(XVIa), caffeic acid (XVIb), ferulic acid(XVIc) and sinapic acid(XVIId) and coumarins(XIVb) and reflects their common biosynthetic origin from prephenic acid(XVII) and its congeners\textsuperscript{22}. In general, flavonoids are related biosynthetically to aromatic amino acids phenylalanine(XVIIIa) and
**Isoflavone**

(a) $R = \text{Phenyl, Neoflavone}$

(b) $R = \text{H, Coumarin}$

**Aurone**

(a) $R^1, R^2 = \text{H, p-Coumaric acid}$

(b) $R^1 = \text{OH, } R^2 = \text{H, Caffeic acid}$

(c) $R^1 = \text{OMe, } R^2 = \text{H, Ferulic acid}$

(d) $R^1, R^2 = \text{OMe, Sinapic acid}$
tyrosine(XVIIIb) through the corresponding cinnamic acids and the basic $C_{15}$ skeleton is probably derived in plants by the coupling of a $C_6-C_3$ unit produced by shikimic acid(XIX) pathway and three $C_2$ acetate units.$^{23}$

Flavonoids occur commonly as flavonoid 0-glycosides in which one or more of the flavonoid hydroxyls are involved in linkage with C-1 of a sugar through an acid-labile hemiacetal bond. In vivo the flavonoids largely exist as glycosides.$^{24}$ The sugar-free compounds are referred to as aglycones. Glycosylation not only confers sap solubility to the somewhat insoluble flavonoid aglycones but also confers stability especially for the highly hydroxylated compounds.

The ability of flavonoids to form glycosides with a number of rarer sugars viz. sugars that are not part of the common metabolism might be related to the transport of such saccharides in a non-reactive form to sites of synthesis of gums and mucilages in which they are found.$^{25}$ Glycosylation also serves to
(a) $R = H$, Phenylalanine
(b) $R = OH$, Tyrosine

Shikimic acid
protect the flavonoids themselves from attack by oxidising enzymes\textsuperscript{26} and also their translocation in plants\textsuperscript{27}.

There is a considerable range of flavonol glycosides present in plants. Over seventy different glycosides of quercetin alone have been described\textsuperscript{28}. By far the commonest is quercetin 3-0-rutinoside (rutin)(XXa). Flavones occur as glycosides but the range of different glycosides is less than those observed in the case of flavonols. Apigenin 7-0-\beta-glucopyranoside(XXIa) is a typical example of flavone glycoside.

Hydroxyls in certain sites have higher probability for glycosylation viz. C-7 hydroxyl in flavones and isoflavones, C-3 and C-7 hydroxyls in flavonols and dihydroflavonols and C-3 and C-5 hydroxyls in anthocyanidins. The sugars which have been found in flavonoid glycosides include simple hexoses and pentoses (monosides) or di- and tri-saccharides (biosides and triosides) always combined through the oxygen at the C-1 (anomeric centre)
(a) $R^1 = \text{Rut}, R^2, R^3, R^4, R^5 = H$, Quercetin 3-O-rutinoside (rutin)

(b) $R^1, R^2, R^3, R^4, R^5 = H$, Quercetin

(c) $R^1 = \text{Rha}, R^2, R^3, R^4, R^5 = H$, Quercetin 3-O-rhamnoside (quercitrin)

(d) $R^1, R^2, R^3, R^4, R^5 = \text{Me}$, Quercetin pentamethyl ether

(e) $R^1 = \text{Glu}, R^2, R^3, R^4, R^5 = H$, Quercetin 3-O-glucoside

(f) $R^1, R^3, R^5 = \text{Me}, R^2, R^4 = H$, Quercetin 3,4', 7-trimethyl ether (ayanin)

(g) $R^1 = \text{Gal}, R^2, R^3, R^4, R^5 = H$, Quercetin 3-O-galactoside (hyperoside)

(h) $R^1, R^2, R^4, R^5 = H, R^3 = \text{Glu}$, Quercetin 7-O-glucoside (quercimeritrin)

(i) $R^1 = \text{Xyl-Gal}, R^2, R^3, R^4, R^5 = H$, Quercetin 3-O-xylosylgalactoside

(j) $R^1 = \text{Xyl-Glu}, R^2, R^3, R^4, R^5 = H$, Quercetin 3-O-sambubioside

(k) $R^1, R^2 = H, R^3, R^4 = \text{Me}, R^5 = \text{Glu}$, Rhamnazin 4'-O-glucoside

(l) $R^1, R^2, R^4, R^5 = H, R^3 = \text{Xyl}$, Quercetin 7-O-xyloside

(m) $R^1 = \text{Glu-Ara}, R^2, R^3, R^4, R^5 = H$, Quercetin 3-O-glucoarabinoside

(n) $R^1 = \text{Me}, R^2, R^3, R^4, R^5 = H$, Quercetin 3-methyl ether

(o) $R^1 = \text{Me}, R^5 = \text{Glu}, R^2, R^3, R^4 = H$, Quercetin 3-methylether 4'-O-glucoside

(p) $R^1 = \text{Gal-Glu}, R^2, R^3, R^4, R^5 = H$, Quercetin 3-O-galactosylglucoside
(a) $R^1 = \beta$-Glu (pyranosyl), $R^2 = H$, Apigenin 7-0- $\beta$-glucopyranoside
(b) $R^1, R^2 = \text{Glu}$, Apigenin 4', 7-0- diglucoside
(c) $R^1 = \text{Rha - Glu}$, $R^2 = H$, Apigenin 7-0- rhamnoglucoside
(d) $R^1 = R^2 = H$, Apigenin
(e) $R^1 = \text{Glucur}$, $R^2 = H$, Apigenin 7-0- glucuronide
usually through a \( \beta \)-link; it is \( \alpha \)-only in the case of rhamnosides and arabinosides. Oligosaccharides of flavonoids are generally restricted to those with \( 1 \rightarrow 2 \) and \( 1 \rightarrow 6 \) linkages and they usually have glucose at the reducing end. A tetraglycoside viz. kaempferol 3-0-sophorotrioside-7-0-rhamnoside (XXIIa) is reported from the seeds of *Solanum tuberosum*\(^{29} \) and wild potato\(^{30} \).

Glucose (XXIIIa), galactose (XXIVa) rhamnose (XXV) xylose (XXVI), arabinose (XXVII), apiose (XXVIII) glucuronic acid (XXIIIb) and galacturonic acid (XXIVb) are the monosaccharides and rutinose (0-\( \alpha \)-L-rhamnosyl (1\( \rightarrow \)6) glucose) (XXIX), neohesperidose (0-\( \alpha \)-L-rhamnosyl (1\( \rightarrow \)2) glucose) (XXX) and sophorose (0-\( \beta \)-D-glucosyl (1\( \rightarrow \)2) glucose) (XXXI) are the disaccharides most commonly involved in glycosylation. Acylated glycosides have also been encountered where one or more sugar hydroxyls are derivatised with an acid such as acetic or ferulic acid. Within a plant it has been observed that the glycosidic pattern may be relatively constant\(^{31,32} \).
(a) $R^1 = (Sopho)_3, R^2 = R^4 = H, R^3 = \text{Rha}, \text{Kaempferol 3-O-sophorotrioside}$
$\quad - 7\text{-O-rhamnoside}$

(b) $R^1, R^2, R^3, R^4 = H$, Kaempferol

(c) $R^1 = \text{Ara}, R^2, R^3, R^4 = H$, Kaempferol 3-O-arabinoside

(d) $R^1 = \text{Glcur}, R^2, R^3 = H, R^4 = \text{Me}$, Kaempferide 3-O-glucuronide

(e) $R^1 = \text{Glu}, R^2, R^3, R^4 = H$, Kaempferol 3-O-glucoside

(f) $R^1 = \text{Rut}, R^2, R^3, R^4 = H$, Kaempferol 3-O-rutinoside

(g) $R^1 = (Sopho), R^2, R^3, R^4 = H$, Kaempferol 3-O-sophoroside

(h) $R^1 = \text{Neohesp}, R^2, R^3, R^4 = H$, Kaempferol 3-O-neohesperidoside

(i) $R^1, R^2 = \text{Gal}, R^3, R^4 = H$, Kaempferol 3,5-O-digalactoside

(j) $R^1, R^2, R^4 = H, R^3 = \text{Glu}$, Kaempferol 7-O-glucoside (populnin)

(k) $R^1 = \text{Gal}, R^2, R^3, R^4 = H$, Kaempferol 3-O-galactoside

(l) $R^1, R^3 = \text{Glu}, R^2, R^4 = H$, Kaempferol 3,7-di-O-glucoside

(m) $R^1 = \text{Me}, R^2, R^3, R^4 = H$, Isokaempferide
XXIII

(a) $R = \text{CHOH}$, $\beta$-D-Glucose

(b) $R = \text{COOH}$, D-Glucuronic acid

XXIV

(a) $R = \text{CH}_2\text{OH}$, $\beta$-D-Galactose

(b) $R = \text{COOH}$, D-Galacturonic acid

XXV

$\alpha$-L-Rhamnose
XXVI
\[ \beta - D - \text{Xylose} \]

XXVII
\[ \alpha - L - \text{Arabinose} \]

XXVIII
\[ D - \text{Apiose} \]
Rutinose \([\alpha - L - \text{Rhamnosyl} \ (1 \rightarrow 6) - \beta - \text{D-glucose}]\)

Neohesperidose \([\alpha - L - \text{Rhamnosyl} \ (1 \rightarrow 2) - \beta - \text{D-glucose}]\)
The enthralling colours of the plants, flowers and fruits are due to the presence of one or more of the flavonoids. The flavonoids are certainly one among the sundry floral pigments\textsuperscript{33}. The flavonoid colours in flower petals are the means of attracting insects and animals and ensure fertilisation\textsuperscript{34}. The coloured anthocyanins in flower petals are almost invariably accompanied by flavones and flavonols. Flavones are important co-pigments, being essential for the full expression of anthocyanin colour in floral tissues\textsuperscript{35}. Gossypetin(XXXIIa), quercetagetin(XXXIII), syringetin(XXXIVa) and isorhamnetin(XXXV\textsubscript{a}) are some of the few flavonols which are pigments in their own right providing yellow flower colours. Flavonols contribute to yellow colour particularly when they are methylated or when they are present in an unusual glycosidic form\textsuperscript{36}.

Flavonoids are widely distributed among the dicotyledonous angiosperms. Some classes are more widely distributed than others; while flavones and flavonols are universal, isoflavones and biflavonyls are found only in a few plant families. Although
XXXI

Sophorose \([\beta-D-\text{Glucosyl} (1 \rightarrow 2) - \beta-D-\text{glucose}]\)

XXXII

(a) \(R^1, R^2 = H\), Gossypetin
(b) \(R^1 = \text{Glu}, R^2 = H\), Gossypetin 3-\(\text{O}-\)glucoside
(c) \(R^1 = \text{SO}_3\ H, R^2 = \text{Glucur}, \text{Gossypetin 3-}\text{sulphate 8-} \text{O-}\text{glucuronide}\)
(d) \(R^1 = H, R^2 = \text{Rha}, \text{Gossypetin 8-} \text{O-}\text{rhamnoside}\)
(e) \(R^1 = H, R^2 = \text{Glucur}, \text{Gossypetin 8-} \text{O-}\text{glucuronide}\)
there are over a hundred flavonol aglycones known, only three are at all common; kaempferol(XXIIb), quercetin(XXb) and myricetin(XXXIVb). The other known flavonols are mostly structural variants of the common flavonols and are of limited occurrence. Flavonoids are present in plants as mixtures and it is very rare to find only a single flavonoid component in a plant tissue. There are often mixtures of flavonoid classes.37

The quantity of flavonoid formed varies in many plants from internal causes independent of external conditions. Flavonoids may originate at the point of vegetation but are more frequently formed in older tissues. Each organ and each tissue may carry a flavone. External factors such as starvation and special effect of potassium and magnesium ions may cause variation only in extreme cases. The greatest variations occur at the transition periods of three phases of growth. In the older woody tissue the change generally occurs at the time of death. Flavonols may be present as a precursor of flavone and anthocyanins may be formed from the latter.38
(a) $R^1, R^2 = H, R^3, R^4 = \text{Me}, \text{Syringetin}$

(b) $R^1, R^2, R^3, R^4 = H, \text{Myricetin}$

(c) $R^1 = \text{Glu-Rha}, R^2 = \text{Rha-Glu}, R^3, R^4 = H, 3-\text{O-Glucorhamnosyl} 7-\text{O-rhamnoglucosyl myricetin}$

(d) $R^1 = \text{Rha}, R^2, R^3, R^4 = H, \text{Myricetin 3-0-rhamnoside(myricitrin)}$

(e) $R^1 = \text{Me}, R^2, R^3, R^4 = H, \text{Annulatin}$
The flavonoid aglycones usually occur externally on the plant surface. Presently names of some twenty families are known which have accumulated flavonoid aglycones externally\(^39\). Their lipophilic nature excludes their accumulation in the aqueous environment of the cell sap and this leads to external accumulation as a consequence of glandulotrophic or epidermal secretion\(^40,41\). Flavonoid aglycones are hence encountered in oil cells or oil cavities, in and on glandular trichomes, in bud excretions, in thin epicuticular layers on leaves and in leaf wax and leaf resins. Glycosides are found in aqueous environment of cell sap. Dihydroquercetin(XXXVI) in the glycosidic form is a well-known heartwood constituent of many trees\(^42\).

In a recent report on flavonol glycoside production in callus cultures of *Epimedium diphyllum* it has been noted that effects of hormonal factors on cell growth and flavonol glycoside production indicated that 2,4-dichlorophenoxyacetic acid(XXXVII) was needed for the production of flavonol glycosides\(^43\).
(a) $R = H$, Isorhamnetin
(b) $R = \text{Neohesp}$, Isorhamnetin 3-0-neohesperidoside
(c) $R = \text{Glu}$, Isorhamnetin 3-0-glucoside
(d) $R = \text{Gal}$, Isorhamnetin 3-0-galactoside

Dihydroquercetin

2,4-Dichlorophenoxyacetic acid
Structural features of flavonoids known to be of importance in function are (1) presence of a resonating system often in extended conjugation with a carbonyl chromophore which is responsible for colour and the pigments in plants (2) presence of aromatic hydroxyls - depending on whether B-ring is monohydroxylated at C-4' or is of catechol type viz. carrying hydroxyls at C-3' and C-4' means that flavonoids are capable of alternately inhibiting or stimulating certain enzyme systems (3) molecular shape - their physiological activity can be accounted for by their similarity in structure to animal hormones.\textsuperscript{44}

Flavonoids, because of the presence of many hydroxyl groups, are easily attached to enzyme surfaces and are very potent inhibitors of some enzyme systems. Presence of flavonoids in plant extracts often makes isolation of enzymes very difficult. The possibility that flavonoids act as growth regulators in plants by their effect on indole acetic acid-indole acetic acid oxidase enzyme system has been extensively explored.\textsuperscript{45}
The presence of flavonoids in spinach chloroplasts\textsuperscript{46} and the isolation of kaempferol 3-0-arabinoside(XXIIC) from the chloroplasts of \textit{Impatiens balsamina}\textsuperscript{47} have suggested that the flavonoids may play a role in the photosynthesis of plants.

Some evidence has been presented for the flavonoid compounds having a function in the sexual process of the plant. The inability of two varieties of \textit{Forsythia} to cross-pollinate is associated with the presence of rutin in the pollen of one and quercitrin(XXIc) in the other\textsuperscript{48}.

Flavonoid compounds act as substrates for redox processes relating to the function of phenolase\textsuperscript{49}.

Flavonoids have been shown to be effective in preventing fungal attacks\textsuperscript{50}.

The remarkable efficacy of highly hydroxylated flavones in acting as antioxidants for fats has been established\textsuperscript{51}. 
Of all the natural pigments that can be used as dye-stuffs the flavones are by far the most widely distributed in nature. Luteolin (XXXVIIIa), the main colouring matter of the herbaceous plant weld Reseda luteola is the oldest European dye-stuff known. Dye-stuffs like weld, young and old fustic and quercitron bark are some of the flavone dye-stuffs which are still significant economically\(^5\). 

Most of the ultraviolet absorbance due to solar irradiation is attributable to flavonoids\(^5\). Flavonoids play subtle role as filters in plant growth.

Certain flavonoid glycosides like naringin (XXXIXa) and neohesperidin (XLa) are intensely bitter. The specific linkages in the sugars present are reported to be the determining factors for their bitterness\(^4\).

The pharmacological importance of flavonoids came to light when it was found that crude preparations of vitamin C (XLI) derived from natural sources were far more active than the pure vitamin C
(a) $R^1, R^2, R^3, R^4, R^5 = H$, Luteolin

(b) $R^1, R^3, R^4, R^5 = H, R^2 = \text{Glu}$, Luteolin 7-O-glucoside

(c) $R^1, R^3, R^5 = H, R^2 = \text{Rut}, R^4 = \text{Me}$, Chrysoeriol 7-O-rutinoside

(d) $R^1, R^3, R^5 = H, R^2 = \text{Glu-Apio}, R^4 = \text{Me}$, Chrysoeriol 7-O-glucoapioside

(e) $R^1, R^2, R^4, R^5 = H, R^3 = \text{Glu}$, Orientin

(f) $R^1 = \text{Glu}, R^2, R^3, R^4, R^5 = H$, Isoorientin

(g) $R^1, R^2, R^4 = H, R^3 = \text{0 Glu}, R^5 = \text{Me}$, Hypolaetin 4'-methylether - 8-O-glucoside

(h) $R^1, R^2, R^5 = H, R^3 = \text{0 Glu}, R^4 = \text{SO}_3 \text{H}$, Hypolaetin 8-O-glucoside - 3'-sulphate

(i) $R^1, R^3, R^4, R^5 = H, R^2 = \text{Glucur}$, Luteolin 7-O-glucuronide

(j) $R^1, R^3, R^5 = H, R^2 = \text{Glu-Apio}, R^4 = \text{Me}$, Chrysoeriol 7-O-glucoapioside
alone in curing capillary lesions\textsuperscript{55}.

Phenolic constituents usually improve the solubility characteristics of compounds and the phenols in general easily move across biological membranes\textsuperscript{56}. So, flavonoids have relatively weak influences on a broader range of biological phenomena since altered membrane characteristics appear to be a major means by which organisms control their biochemistry\textsuperscript{57}.

Highly hydroxylated flavones act as diuretics\textsuperscript{58,59}.

Flavones especially eupatorin(XLII) isolated from \textit{Eupatorium} spp. have been demonstrated to have cytotoxic and antineoplastic activities\textsuperscript{60,61}.

Quercitrin, kaempferol and naringenin(XXXIXb) isolated from \textit{Helichrysum angustifolium}(syn.\textit{H. italicum}) have been reported to increase bile secretion in experimental animals. Quercitrin also increased the detoxifying function of the liver and exhibited anti-inflammatory activity\textsuperscript{62}.
(a) $R^1, R^3 = H, R^2 = \text{Neohesp, Naringin}$
(b) $R^1, R^2, R^3 = H, \text{Naringenin}$
(c) $R^1, R^2 = H, R^3 = \text{Xyl-Glu, Naringenin 4'-O-xyloglucoside}$
(d) $R^1, R^2 = \text{Me}, R^3 = \text{Xyl-Ara, Flavanone 5,7-di-O-methylether 4'-O-xyloarabinoside}$

(a) $R = \text{Neohesp, Neohesperidin}$
(b) $R = H, \text{Hesperetin}$

$\text{Vitamin C}$
The flavonoids hesperetin(XLb) and rutin in peppermint leaves have choleretic activity in dogs\textsuperscript{63}.

The flavonoids present in \textit{Passiflora incarnata} reportedly have tranquilizing effects\textsuperscript{64}.

Isoflavones like genistein(XLIIIa) and daidzein(XLIIIb) have been found to be oestrogenic. The molecular shape of genistein is similar to that of oestradiol(XLIV)\textsuperscript{65,66}.

The role of flavonoids in such clinical conditions such as hypertension, rheumatism, arthritis and pregnancy as also their beneficial effects in frost-bite and cold injury have been studied\textsuperscript{67}.

\textit{Cassia alata} leaf extract which is known for its polyphenolic constituents has been recently studied for its wound-healing activity\textsuperscript{68} and mast cell stabilization\textsuperscript{69}.

Certain flavonoids like quercetin have been found to decrease capillary permeability induced by histamine(XLV)\textsuperscript{70}. By prior administration of
(a) $R^1, R^4 = \text{OH}, R^2, R^3 = \text{H}$, Genistein

(b) $R^1, R^2, R^3 = \text{H}, R^4 = \text{OH}$, Daidzein

(c) $R^1, R^3 = \text{H}, R^4 = \text{OH}, R^2 = \text{Glu}$, Daidzein 7-O-glucoside

(d) $R^1, R^4 = \text{H}, R^2 = \text{Me}, R^3 = \text{OH}$, 3'-Hydroxy-7-methoxyisoflavone

(e) $R^1 = \text{H}, R^3, R^4 = \text{OH}, R^2 = \text{Rha-Glu}$, 3'-Hydroxydaidzein 7-O-rhamnoglucoside

(f) $R^1 = \text{H}, R^3, R^4 = \text{OH}, R^2 = \text{Xyl-Glu}$, 3'-Hydroxydaidzein 7-O-xyloglucoside
flavonoids the increase in permeability produced by heat, X-ray and UV radiations could be reduced\textsuperscript{71,72}. Flavonoids have also been found to increase capillary resistance\textsuperscript{73}. The efficacy of the flavonoids in capillary fragility has been claimed\textsuperscript{74}. Small quantities of flavonoids act as cardiac stimulants but in larger doses systolic stoppage results\textsuperscript{75}. Some flavonoids appear to strengthen weak capillary blood vessels and hence are of interest in the search for means of counteracting the evils of exposure to radioactivity\textsuperscript{76}.

Several flavonoids are moderately effective against laboratory cultures of malignant cells. Quercetin pentamethylether(XXd) and rutin have been shown to be strongly and moderately effective in inhibiting respectively of benzopyrene induced pulmonary adenoma in mice. In these cases the flavonoids may induce benzopyrene hydroxylase which may detoxify carcinogen.

Antiulcer\textsuperscript{77} and antitumor\textsuperscript{78} activities of flavonoids have been observed.
Flavonoids and their related compounds synthesised in plants possessing antiviral, antifungal and bacteriostatic action are absorbed into the body and they attack reversibly the blood cells. In addition to any potential action against pathogens, certain of these compounds potentiate enzymes which detoxify carcinogenic hydrocarbons, exhibit anti-inflammatory activity, exert anti-adhesive action on blood cells and show anti-thrombogenic activity\textsuperscript{79}.

Studies on toxicity to fish of some chalcones, flavonols and flavones have been recently carried out and it has been reported that a concentration of 1\% (w/v) as dioxane solution is harmless to the fish over a period of 24 h and that halogenoflavonols are more toxic than their corresponding chalcones\textsuperscript{80}.

A rapid and detailed survey of the distribution of flavonoids has become possible, mainly because of the presently available techniques such as PC, TLC, GLC, HPLC and refined physical tools like UV, IR, NMR and GC-MS.

During the present work, a few plants belonging
to the Capparidaceae, Oleaceae, Mimosoideae, Nyctaginaceae, Malvaceae, Martyniaceae, Bombacaceae, Convolvulaceae and Cactaceae have been studied with a view to isolate and characterise their polyphenolics and also to study their biological activity.

Recent reports on the identification of known flavonoids in new plant sources as well as those on novel flavonoids have been summarised. General plant surveys for anthocyanins and flavonols have also been done.

General complexity in pattern increases with evolutionary advancement whereas morphologically primitive groups such as mosses, horsetails and ferns have simple flavonoids and the more highly specialised angiosperms have much more complex flavonoid constituents. So, monocotyledons and dicotyledons show significant differences in their flavonoid patterns.

Of the many and varied classes of secondary constituents, flavonoids have probably attracted the most attention as taxonomic markers in plant systematics.
The change over from woody to herbaceous habit in the angiosperms has caused a corresponding change in flavonoid pattern chiefly in the leaves. The woody pattern is characterised by high concentration of flavonol, presence of myricetin and leucoanthocyanidins and frequent occurrence of cyanidin(XLVIa). By contrast, the herbaceous pattern is shown by infrequency of flavonol, almost complete absence of myricetin and leucoanthocyanidins, presence of flavones and frequent occurrence of delphinidin(XLVIIa) and pelargonidin(XLVIIIa) as flower pigments.

The Capparidaceae containing about 42 genera and 450 species has not been much investigated for its polyphenolic content. Kaempferide 3-0-glucuronide(XXIIId) has been reported from the root of Cleome viscosa. A new glycoside of naringenin viz. naringenin 4'-0- β-D-xylopyranosyl-β-D-glucopyranoside(XXXIXc) has been characterised from the same plant. C. drosesifolia has been reported to contain kaempferol 3-0-glucoside(XXIIe), rutin, kaempferol and luteolin 7-0-glucoside(XXXVIIIb).
(a) $R^1, R^2 = H$, Cyanidin

(b) $R^1 = Rut, R^2 = H$, Cyanidin 3-O-rutinoside

(c) $R^1 = Glu, R^2 = H$, Cyanidin 3-O-glucoside

(d) $R^1 = Caffeylrha-glu, R^2 = H$, Cyanidin 3-O-caffeyl-rhamnosylglucoside

(e) $R^1 = Caffeylrha-glu-glu, R^2 = H$, Cyanidin 3-O-caffeyl-rhamnosyl-diglucoside

(f) $R^1 = Caffeylglu, R^2 = H$, Cyanidin 3-O-caffeyl-glucoside

(g) $R^1 = Caffeylrut, R^2 = H$, Cyanidin 3-O-caffeyl-rutinoside

(h) $R^1 = Gal, R^2 = H$, Cyanidin 3-O-galactoside

(i) $R^1, R^2 = Glu$, Cyanidin 3,5-O-diglucoside
(a) $R^1, R^2 = H$, Delphinidin
(b) $R^1 = \text{Rha–Glu}, R^2 = \text{Xyl}$, Delphinidin 3-0-rhamnosylglucoside-7-0-xyloside

(a) $R^1, R^2 = H$, Pelargonidin
(b) $R^1 = \text{p–Coumarylglu}, R^2 = H$, Pelargonidin 3-0-p-coumarylglucoside
(c) $R^1 = \text{Rha–Glu–Glu}, R^2 = H$, Pelargonidin 3-0-rhamnosylglucoside
(d) $R^1, R^2 = \text{Glu}$, Pelargonidin 3,5-0-diglucoside
Cleome genus is one among the natural sources of dihydroflavonols too. \((\text{-})-\text{Catechin}(XLIXa),\) \((\text{-})-\text{epiafzelechin}(XLIXb)\) and a new compound \((\text{-})-\text{epiafzelechin 5-0-glucoside}(XLIXc)\) have been isolated from \textit{Crataeva religiosa} \(^92\) (syn. \textit{C. nurvala}). Quercetin and rutin have been reported from the root bark of \textit{C. religiosa} \(^93\). Recently rutin and quercetin 3-0-glucoside(XXe) have been isolated from the flowers of the same plant \(^95,96\).

The Oleaceae contains about 25 genera and 120 species. This order is therapeutically inactive \(^97\). Isolation of delphinidin 3-0-rhamnosylglucoside \(-7-0-\text{xyloside}(XLVIIb)\) and cyanidin 3-0-rutinoside(XLVIIb) has been reported from the fruits of \textit{Olea europaea} cultivars \(^98,99\). Cyanidin 3-0-glucoside(XLVIc), 3-0-caffeylramnosylglucoside(XLVId), 3-0-caffeylramnosyldiglucoside(XLVId), pelargonidin 3-0-p-coumaryl-glucoside(XLVIIIb) and pelargonidin 3-0-rhamnosyldiglucoside(XLVIIIc) have also been reported from the fruits of the same plant \(^100-102\). \textit{Ligustrum sempervirens}, \textit{Olea europaea} and \textit{Phillyrea angustifolia} exist as natural sources of C-glycosyl flavonoids \(^103,104\). Fruits of \textit{L.amurense}, \textit{L.lucidum},
(a) \( R^1 = H, R^2 = OH \), Catechin
(b) \( R^1, R^2 = H \), Epiafzechin
(c) \( R^1 = \text{Glu}, R^2 = H \), Epiafzechin 5-O-glucoside

\[ R^1 = \text{Rut}, R^2 = \text{Glu}, \text{Malvidin 3-O-rutinoside 5-O-glucoside} \]

\[ R = \beta-D-\text{Api}-(1\rightarrow6)-\beta-D-\text{Glu}, \text{Methoxyhydroquinone-4-O-\beta-D-}
\text{apiosyl-(1\rightarrow6)-O-\beta-D-glucopyranoside} \]
L. sinense, L. vulgare have all been reported to contain cyanidin 3-0-glucoside, 3-0-rutinoside and malvidin 3-0-rutinoside-5-0-glucoside(L) whereas the fruits of L. ibota have been found to contain only cyanidin glycosides\textsuperscript{105}. From the fruits of L. ovalifolium and L. obtusifolium, cyanidin 3-0-caffeylglucoside(XLVI\textsubscript{f}) and 3-0-caffeylrutinoside(XLVI\textsubscript{g}) have been isolated\textsuperscript{106}. Isolation of cyanidin 3-0-rhamnoglucoside from the fruits of Osmanthus fragrans and cyanidin 3-0-glucorhamnioside from the fruits of O. ilicifolius has been reported\textsuperscript{107}.

Two new phenolic glycosides—methoxyhydroquinone-4-0-\textbeta-D-apiosyl-(1\rightarrow6)-0-\textbeta-D-glucopyranoside(LI) and 2-hydroxy-4-(2-hydroxyethyl)-phenyl-6-0-trans-feruloyl-\textbeta-D-glucopyranoside(LII) have been isolated from the leaves of Osmanthus asiaticus\textsuperscript{108}.

The Leguminosae is one of the three largest families of flowering plants exceeded only by the Asteraceae (\textequal;Compositae) and the Orchidaceae. Estimates of the number of genera and species vary
2-Hydroxy-4-(2-hydroxyethyl)-phenyl-6-trans-feruloyl glucoside

Rotenone

R\textsuperscript{1} = Glu, R\textsuperscript{2} = H, R\textsuperscript{3} = Me,
Texasin 7-O-glucoside

Bergenin
considerably-590-690 genera and 12000-17000 species. The Leguminosae, compared to most other plant families, is particularly rich in flavonoid content. A special feature of the Leguminosae is its ability to accumulate series of structurally and biosynthetically interrelated compounds at different levels of oxidation or substitution. The fact that a wide variety of flavonoids has been found in the Leguminosae is partly related to the sheer size of the family and partly to its considerable economic importance. Isolation of the isoflavone, genistein, from dyer's broom *Genista tinctoria* developed from the interest in identifying the dyeing principle of the crude plant extract. The early discovery of insecticidal properties of *Derris elliptica* root mainly due to the presence of a complex isoflavonoid, rotenone (LIII) has led to many subsequent investigations in related plants for similar substances.

Kaempferol and quercetin have been detected as the common flavonols in a leaf survey of over 50 species of the Leguminosae. Luteolin 7-O-glucoside has been isolated from *Cassia mimosa*.
A new flavonol tetracyglycoside viz. 3-O-(2-glucosylrhamnosyl)-7-O-β-(2-rhamnosylglucosyl)-myricetin(XXXIVc) along with tixasin-7-O-glucoside(LIV) and daidzein 7-O-glucoside(XLIIIc) has been reported from seeds/leaves of *Cyamopsis tetragonoloba*¹¹⁴,¹¹⁵. Pods of *Cassia roxburghii* have been found to contain (-)-epiafzelechin¹¹⁶. Bergenin(LV) has been isolated from *Peltophorum ferrugineum*¹¹⁷.

The occurrence of chrysin 7-O-glucoside(LVIa) in *Sarothamnus patens*¹¹⁸, chrysoeriol 7-O-rutinoside(XXXVIIIc) in the seeds of *Crotalaria saltiana*¹¹⁹ and chrysoeriol 7-O-glucoapioside (XXXVIIIId) in the leaves of *Dalbergia volubilis*¹²⁰ represents the isolation of some uncommon types of flavonoid glycosides in the Leguminoseae. In addition, glycoflavone derivatives of apigenin and luteolin have been reported from several *Crotalaria* spp.¹²¹ and *Rhynchosis minima*¹²².

The leaves of *Trifolium repens*¹²³ have been reported to contain quercetin 3-O-glucoside
(isoquercitrin). Methylated flavones have also been located in this family. Heartwood of *Distemonanthus benthamianus* \(^{124}\) contains quercetin \(^{3,4',7-}\)trimethylether (ayanin) (XXf). Quercetagetin itself has been detected in *Acacia catechu* wood \(^{125}\) and *Leucaena glauca* petals \(^{126}\), both of the Mimosoideae.

Vitexin and 3'-hydroxy-7-methoxyisoflavone (XLIIId) from the flowers of *Acacia leucophloea* \(^{127}\), quercitrin from the flowers of *Leucaena leucophloea* \(^{128}\), kaempferol 3-0-rutinoside (XXIIIf) from the flowers of *Glicicidia sepium* \(^{129}\), rutin from the flowers of *Samanea saman* \(^{130}\), myricetin 3-0-rhamnoside (XXXIVd) from the flowers of *Pithacollobium dulce* \(^{131}\) and quercetin 3-0-galactoside (hyperoside) (XXg) from *Delonix elata* \(^{132}\) have been recently isolated in this laboratory. The flowers of *Leucaena leucophloea* have been reported to contain kaempferol, and myricetin along with their corresponding 3-0-glucosides \(^{133}\). The flowers of *Delonix elata* have been reported \(^{134}\) to contain isoquercitrin also. There is a recent report on the isolation of quercetin 3-0 glucoside from the flowers of *Acacia leucophloea* \(^{135}\).
Flavonols lacking a 5-hydroxyl group such as robinetin (LVIIa) have been located in this family. The simple substances of this type are, 4',7-dihydroxy-(LVIIb) and 3',4',7-trihydroxyflavone (LVIIc) which have been isolated from the leaves of *Trifolium repens*\(^\text{136}\), the former having also been obtained from *Medicago sativa*\(^\text{137}\). A fisetin derivative viz. 3,7-dimethoxy-3',4'-methylenedioxyflavone (LVIII) has been found in the roots of *Pongamia glabra*\(^\text{138}\).

Phytochemical studies on *Pongamia pinnata* showed an abundance of flavonoid compounds such as flavones\(^\text{139,140}\), flavanones\(^\text{141}\), chalcones\(^\text{142}\), β-diketone and β-hydroxychalcone\(^\text{143,144}\). There is a report\(^\text{145}\) on the isolation and structural determination of nine flavonoid compounds including two new β-hydroxychalcones named ponganones from the root bark of *P. pinnata* and the same group has recently reported\(^\text{146}\) isolation of nine more new ponganones from the same part of the plant.

Two novel flavanones with a lavandulyl residue,
(a) $R^1 = \text{OH}, R^2, R^4, R^5, R^6 = \text{H}, R^3 = \text{Glu}, \text{Chrysin 7-O-glucoside}$

(b) $R^1, R^2, R^3, R^4, R^5 = \text{H}, R^6 = \text{OH}, 4',7'-\text{Dihydroxyflavone}$

(c) $R^1, R^2, R^3, R^4 = \text{H}, R^5, R^6 = \text{OH}, 3',4',7'-\text{Trihydroxyflavone}$

(d) $R^1 = \text{OH}, R^2, R^4 = \text{Me}, R^3 = \text{H}, R^5, R^6 = \text{OMe}, 5,7-\text{Dihydroxy-6,8-dimethylflavone-3',4'-di-O-methylether}$

(e) $R^1, R^5, R^6 = \text{OH}, R^2, R^3, R^4 = \text{H}, 3',4',5,7-\text{Tetrahydroxyflavone}$

(f) $R^1 = \text{OH}, R^2, R^3, R^4, R^5, R^6 = \text{H}, \text{Chrysin}$

(a) $R^1 = \text{H}, R^2 = \text{OH}, \text{Robinetin}$

(b) $R^1, R^2 = \text{H}, \text{Fisetin}$

(c) $R^1 = \text{Glu-Ara}, R^2 = \text{H}, \text{Fisetin 3-O-glucoarabinoside}$
exiguafavanones have been isolated from the roots of *Sophora exigua* in addition to a known flavanone viz. *sophorafavanone*(LIX). The structure of the new flavanones have been determined to be 2',5,6',7-tetrahydroxy-8-lavandulylflavanone(LXa) and 2',5,6'-trihydroxy-8-lavandulyl-7-methoxyflavanone (LXb) by 2D NMR spectral analysis.147

The flavanone naringenin has been reported from *Flemingia stricta*148 and *Monopteryx inpaef*149. Fleminone(LXI)- a new flavanone has been obtained from *F.monophylla*150.

Isolation of quercetin and kaempferol from the *in vivo* and *in vitro* tissue cultures of *Dolichos lablab* and their antifungal screening have been reported151. From the flowers of *Butea frondosa*, butrin(LXII) and isobutrin(LXIII) have been isolated and their oestrogenic activity has been studied152. Isolation of *orientin*(XXXVIIIe) and *isoorientin*(XXXVIIIIf) from the seeds of *Crotalaria laburnifolia*153, *isovitexin*(VIIIb) from the seeds of *C.anagyroides*154 and chrysoeriol 7-O-rutinosido.
LVIII

3,7-Dimethoxy-3',4'-methylenedioxyflavone

LIX

Sophoraflavanone
(a) \( R^1 = H, R^2 = \text{Lavandulyl}, 2',5,6',7\)-tetrahydroxy-8-lavandulyl flavanone

(b) \( R^1 = \text{Me}, R^2 = \text{Lavandulyl}, 2',5,6'\)-trihydroxy-8-lavandulyl-7-O-methoxyflavanone

Fleminone

Butrin
the seeds of \( C.saltiana \) has been reported.

Kaempferol, rhein(LXIVA) and aloe-emodin(LXIVb) have been reported from \( Cassia alata \). Recently, the analgesic effect of kaempferol 3-0-sophoroside (XXIIg) isolated from \( C.alata \) has been studied. There are also reports on the isolation of apigenin 4',7-0-diglucoside(XXIB), apigenin 7-0-rhamnoglucoside (XXIC) and kaempferol 3-0-neohesperidoside(XXIIh) from the leaves of \( Indigofera mysorensis \), kaempferol 3,5-0-digalactoside(XXIIIi) from the leaves of \( I.hirsuta \) and quercetin, kaempferol, fisetin(LVIIb), cyanidin and delphinidin from the leaves of \( I.heterantha \) and apigenin(XXId) and luteolin from \( Cassia glandulosa \). Kaempferol and its glycosides have been found in the flower parts of three plants of Leguminosae family- \( Cystisus monospessulanus, Ulex europaeus \) and \( Pongamia pinnata \).

The Nyctaginaceae comprises of about 20 genera and 160 species. The plants are used in herbal medicines and as ornamentals. There exists scanty
LXIII
Isobutrin

LXIV
(a) $R = \text{CO}_2\text{H}$, Rhein
(b) $R = \text{CH}_2\text{OH}$, Aloe- emodin

LXV
(a) $R = \text{H}$, Hibiscetin
(b) $R = \text{Glu}$, Hibiscetin 3-O-glucoside
reports on flavonoids in this order though it provides a natural source for C-glycosyl flavonoids. A new C-methyl flavone viz. 5,7-dihydroxyl-6,8-dimethyl flavone-3',4'-di-O-methylether (LVId) has been reported from the roots of Boerhaavia diffusa. Recently quercetin has been isolated from Pisonia grandis.

The Malvaceae is a very large cosmopolitan family of herbs, some shrubs and a few trees with a number of cultivated ornamentals and plants with edible seeds, stalks, leaves and berries. This order belongs to tropical and temperate regions. It accounts for about 35 genera and 700 species.

8-Hydroxyflavonol, viz. hibiscetin (LXVa) has been reported from Hibiscus sabdariffa, H. esculentus, H. vitifolius and H. cannabinus while its 3-O-glucoside (LXVb) has been isolated from H. cannabinus.

8-Hydroxyluteolin (hypolaetin) 4'-methylether-8-O-glucoside (XXXVIIIg) and its 8-O-glucoside-3' sulphate (XXXVIIIh) have been reported from the leaves
of *Althaea officinalis*\(^\text{172}\). The leaves of *Malva sylvestris* have also been found to contain 8-hydroxyxyluteolin 8-0-glucoside-3'-sulphate\(^\text{173}\).

Many a gossypetin glycoside has been located in the Malvaceae. There are reports of isolation of gossypetin 3-0-glucoside(XXXIIb) from the flowers of *H.tiliaceus*\(^\text{174}\) and *Gossypium indicum*\(^\text{171}\), gossypetin 8-0-glucuronide-3-sulphate(XXXIIc) from the leaves of *Malva sylvestris*\(^\text{175}\), gossypetin 8-0-rhamnosome(XXXIIId) from the flowers of *Gossypium arboreum*\(^\text{176}\) and gossypetin 8-0-glucuronide(XXXIIe) from the petals of *H.vitifolius*\(^\text{177}\).

Herbacetin 7-0-glucoside(LXVIa) from the flower — petals of *Gossypium herbaceum* and *G.indicum*\(^\text{171}\), herbacetin 8-0-glucoside(LXVIb) from the flowers of *Althaea rosea*\(^\text{178}\) and sexangularetin (herbacetin 8-0-methylether)(LXVlc) and herbacetin 3-0-glucoside-7-0-rhamnosome(LXVID) from the immature flower buds of *Gossypium hirsutum*\(^\text{179}\) have been isolated. Kaempferol 3-0-\(\alpha\)-D-glucofuranoside (isoastraagal) has also been found in the flowers of *G.hirsutum*\(^\text{180}\).
(a) $R^1, R^3 = H, R^2 = \text{Glu}$, Herbacetin $7\text{-O-glucoside}$
(b) $R^1, R^2 = H, R^3 = \text{Glu}$, Herbacetin $8\text{-O-glucoside}$
(c) $R^1, R^2 = H, R^3 = \text{Me}$, Sexangularetin
(d) $R^1 = \text{Glu}, R^2 = \text{Rha}, R^3 = H$, Herbacetin $3\text{-O-glucoside 7-O-rhamnoside}$

Heavenly blue anthocyanin

(a) $R^1, R^2 = \text{OH}, R^3, R^4, R^5 = H$, Baicalein
(b) $R^1 = H, R^2, R^4, R^5 = \text{OH}, R^3 = \text{O-Glu}$, Hypolaetin $8\text{-O-glucoside}$
(c) $R^1 = \text{OH}, R^2 = \text{O Glucur}, R^3, R^4, R^5 = H$, Baicalin
(d) $R^1, R^4, R^5 = H, R^2 = \text{OH}, R^3 = \text{OMe}$, Wogonin
Kaempferol and quercetin glycosides are common in the Malvaceae order. The petals of *Thespesia populnea* have been reported\(^1\) to contain kaempferol 7-0-glucoside (populnin) (XXIIj). Quercetin 3-0-glucopyranoside (isoquercitrin), quercetin 3-0-glucofuranoside (hirsutrin) and quercetin 7-0-glucoside (quercimeritrin) (XXh) have been reported from the flowers of *G. herbaceum*\(^1\). The flowers of *Hibiscus* spp. have been found to contain quercetin 3-0-\(\beta\)-D-xylosyl-\(\beta\)-D-galactoside (XXi)\(^1\). Reports of isolation of new flavonol glycosides viz. quercetin 3-0-sambubioside (XXj) from the flowers of *H. mutabilis*\(^1\) and rhamnazin 4'-0-glucoside (XXXk) from *H. furcatus*\(^1\) are also available.

The *Hibiscus* spp. have been reported to serve as natural sources of flavanones\(^1\) and C-glucosylflavonoids\(^1\). Flavanone 5,7-di-0-methylether 4'-0-xylosylarabinoside (XXXIxd) and saponarin (VIIIc) have been reported respectively from *H. mutabilis*\(^1\) and *H. syriacus*\(^1\).

The Martyniaceae is a relatively small family
of annual perennial herbs and shrubs. Reports of isolation of anthocyanins viz. cyanidin 3-0-galactoside (XLVIh) and pelargonidin 3,5-0-diglucoside (XLVIII Id), flavones-apigenin and luteolin and flavone glycosides apigenin 7-0-glucuronide (XXI e) and luteolin 7-0-glucuronide (XXXVIIIi) from the flowers of Martynia annua 190,191 are available. C-glycosylflavones have been reported in M. proboscidata 192.

The Bombacaceae is a widely distributed order in the tropics. It comprises of about 21 genera and about 150 species. Very few reports on flavonoid investigation of this order are available. The stem of Adansonia digitata has been reported to contain quercetin 7-0-xyloside (XXI) 193.

From the flowers of Chorisia speciosa, cyanidin 3-0-glucoside and 3,5-0-diglucoside (XLVIIi) have been reported 194.

The Convolvulaceae, comprising of 50 genera and 1000 species has been recorded to contain many common flavonoids. It is one of the 24 plant families from
which zwitter ionic anthocyanins have been recorded, structures of many of which remain to be elucidated.\(^\text{195}\)

Petals of *Ipomoea purpurea* \(^\text{196-199}\) have been recorded to contain pelargonidin 3,5-0-diglucoside and heavenly blue anthocyanin (LXVII). A new flavone viz. 3',4',5',7-tetrahydroxyflavone (LVIe) has been reported \(^\text{200}\) from the whole plant of *Evolvulus nummularius*. Kaempferol 3-0-galactoside (XXIIk), kaempferol 3-0-rutinoside, kaempferol 3-0-glucoside and quercetin 3-0-glucoside have been isolated from the leaves of *Calystegia hederacea*, leaves of *C. japonica* \(^\text{201}\), stem of *Cuscuta reflexa* \(^\text{202}\) and tubers of *Ipomoea* spp. \(^\text{203}\) 3-0-Glucoarabinosides of quercetin (XXm) and fisetin (LVIIc) \(^\text{204}\) and isorhamnetin 3-0-neohesperidoside (XXXVb) \(^\text{205}\) have also been reported from the flowers of *C. reflexa*. Kaempferol and its 3-0-glucoside (astragalin) have been isolated from the flowers of *Ipomoea aquatica* \(^\text{206}\) and *I. carnea* \(^\text{207}\). Kaempferol 3,7-0-diglucoside (XXIII) has also been reported from the petals of *I. carnea* \(^\text{208}\).

Kaempferol 3-0-glucoside occurs as a common constituent of plants belonging to this family.
Seed-coat of French bean viz. *Phaseolus vulgaris* 209, fronds of *Cyrtomium falcatum* 210, *C. fortunei* 211, flowers of *Astragalous sinicus* 212, flowers and leaves of *Thea sinensis* 213, 214, sepals of *Hydrangea macrophylla* 215, leaves of *Diospyros kaki* 216, flowers of *Aesculus hippocastanum* 217, leaves of *Humulus lupulus* 218, petals of *Anemone alpina* 219, petals of *Paeonia albiflora* 220, leaves of *Sinapis alba* 221 and *Phytolacca decandra* 222 have all been reported to contain kaempferol 3-0-glucoside.

There is a recent report on the isolation of 3'-hydroxydaidzein-7-0-α-L-rhamnopyranosyl(1→2)-0-β-D-glucopyranoside (XLIIIe), 3'-hydroxydaidzein-7-0-β-D-xylopyranosyl (1→6)-0-β-D-glucopyranoside (XLIIIf) and quercetin 3-0-β-D-xylopyranosyl (1→6)-0-β-D-glucopyranoside from the fruits of *Cressa cretica* 223.

The Cactaceae consisting of over 15 genera and 1500 species is rich in methylated flavonoids 224. *Isokaempferide* (XXIm) and quercetin 3-0-methylether (XXn) from the spines of *Opuntia* spp. 225, myricetin 3-0-methylether (annulatin) (XXXIVe) from *Cereus*...
jamacaru, Cleistocereus varispinus and Mammillaria elongata, quercetin 3-O-methylether-4'-glucoside (XXo) from the sepals of Neochilenia spp., isorhamnetin 3-O-glucoside(XXXVc) from the flowers of Cereus grandiflorus and isorhamnetin 3-O-galactoside(XXXVd) from the whole plant of Cactus grandiflora are the available reports of methylated flavonoids in this family. The flavone baicalein (LXVIIIa), a trioxygenated flavone has been isolated from Austrocylindropuntia subulata. There are many records of occurrence of apigenin in the Cactaceae. Similar glycosides of different flavonols in single species in the Cactaceae have been reported. 3-O-Galactoside of quercetin and isorhamnetin have been reported from Opuntia lindheimeri.