CHAPTER 2

GENERAL CHEMICAL ASPECTS

2.1 Introduction

Annonaceous plants have been investigated long ago due to the chemotaxonomic and pharmacological interest of some chemical compounds in these species. Annonaceous comprising more than 2000 species classified in 120 genera[1]

Most of the Annonaceous species have been found to contain secondary metabolite compounds such as alkaloids, flavonoids and tannins. Due to the chemical interest, research has been done not only on alkaloid but also on non-alkaloid compounds belonging to various phytochemical groups.

2.2 Alkaloids In General

Alkaloids have been known because of their toxicity and medicinal properties[10]. More than 6000 alkaloids are known which are coloured or colourless solids and some are in liquids form.

There are more than one definition to define alkaloids specifically. Generally we can define the term alkaloids as a basic substances which contain one or more nitrogen atoms[11] or as N-heterocyclic basic metabolites[12].

The alkaloids enriched the maximum amount in the green part of the plant and minimum in the underground portion and in the bark13. Thus in the majority of the plants examined in detail, the production of the alkaloids has been found to be associated with living rather than dead cell tissue and in some cases the amount of alkaloids present seems to vary with time and degree of maturation of the plant[14].

Alkaloid can be classified according to their pharmacological action and structure especially in the basic C-skeleton and heterocyclic system. The classification methods of alkaloids have so far been subdivided into classes which involve intermediate cases. It is according to the nature of the classification for instance, biogenesis, structural relationships, botanical origin or spectroscopic criteria.

2.3 Alkaloids of Annonaceae

The Chemical Society of London[56] noted that phytochemical screening tests have revealed the presence of alkaloids in a number of Annonaceae.

Classification of alkaloids were developed base on the concept of biogenesis (see Scheme-2)[15].

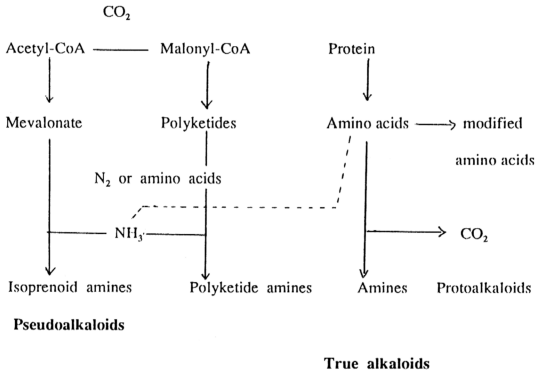(a) Protoalkaloids or biogenesis amines

These compounds are originated by N-methylation and decarboxylation of common amino acids and are heterocyclic only when derived from histidine and tryptophan.

(b) True alkaloids

N- containing heterocyclic system and derived from biogenetic amines, formed by decarboxylation of an amino acid.
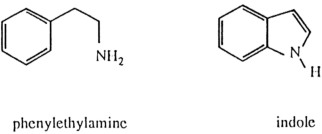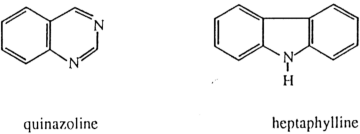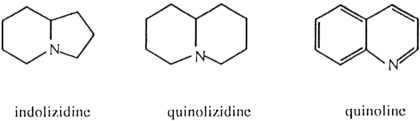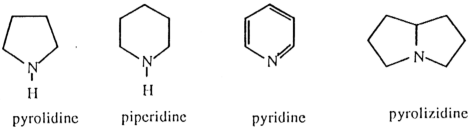
(c) Pseudoalkaloids

The compound have a C-skeleton derived from a polyketide, a shikimate derived metabolite or from terpenoids. Several examples of some common alkaloid ring system are illustrated in Scheme-3.

CO_2

Acetyl-CoA ——— Malonyl-CoA   Protein

Mevalonate   Polyketides   Amino acids ——→ modified

                                                                    amino acids

          N_2 or amino acids

———— NH_3 ————   ——————→ CO_2

Isoprenoid amines   Polyketide amines   Amines   Protoalkaloids

Pseudoalkaloids

                              True alkaloids

Scheme - 2 : Classification of alkaloids with the concept of biogenesis.

2.3.1 : The Isoquinoline Alkaloids

Most of the alkaloids of Annonaceae possess an isoquinoline derived structure. Alkaloids may thus subdivided into types with a distinct chromophore or fundamental skeleton such as indole, isoquinoline or quinoline alkaloids[16].


| pyrolidine | piperidine | pyridine | pyrolizidine |

| indolizidine | quinolizidine | quinoline |

| quinazoline | heptaphylline |

| phenylethylamine | indole |

Scheme 3 : Examples of Alkaloid Ring Skeleton

Isoquinoline alkaloids can be divided into several subgroups[1]. :

Simple isoquinolines -   these   alkaloids   are   derived   from tetrahydroisoquinoline
                          and for   the most part have a carbon chain attached to
                          C-1,   often   a   one-carbon   substituent.   Typical
   representative   is salsoline 1 from *Annona reticulata*.
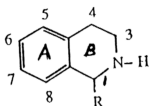
1-substituted tetrahydroisoquinoline

Benzyltetrahydroisoquinolines -   In some   alkaloids   of   this   class,   ring   B is
                                  aromatic but they are mostly   derivatives   of
                                  tetrahydroisoquinoline such as   reticuline 2   in
                                  Annona muricata.

Bisbenzylisoquinolines -   These   alkaloids   are structurally constructed of
                            two monomeric benzylisoquinoline units joined by
                            one or more etherbridges[17,18].   The alkaloids
                            that   belong to this class for example is phaentharina
                            3 in *Phaenthus ebracteolatus*.

<u>Bisbenzyltetrahydroisoquinolines -</u> These alkaloids also contain two diphenyl ether linkages such as phlebicine **4** in *Chrematosperma polyphlebum*.

<u>Protoberberines</u> - These quarternary alkaloids based on the tetracyclic structure as below,
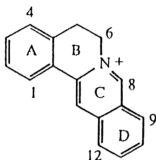
In addition, example such as berberine **5** which ring C has been dehydrogenated also occur naturally that have undergone oxidation, for example oxypalmatine **6** from *Enantia polycarpa*.

<u>Tetrahydroprotoberberines</u> - These also based on the tetracyclic structure by the hydrogenation process from protoberberine. One tetrahydroprotoberberine alkaloid was isolated from *Xylopia discreta* named as discretinine **7**.

Proaporphines - proaporphines are tetracyclic molecules incorporating a conjugated dienone system, and formed from intramolecular oxidative coupling of tetrahydrobenzylisoquinoline. Their acid catalyzed dienone phenol rearrangement would then lead to aporphines oxygenated at C-10. For an example see Scheme-4 [19]. One proaporphine isolated from annonaceae species was glaziovine **8** in *Uvaria* chamae.

Aporphines - All the aporphines alkaloids are based on the 4H-diben[de,g]quinoline structure or its N-methyl derivative commonly known as the aporphine nucleus. The aporphine alkaloids can be divided into three groups depending upon the degree of methylation at the nitrogen atom [20]. These groups are :

(a) the aporphines as such, which contain N-methyl function.

(b) the noraporphines, which possess a secondary nitrogen atom.

(c) the quarternary aporphine salts.

Oxoaporphine - t's naturally occuring with 7-keto-4H-dibenzo[de,g]quinoline skeleton. The oxoaporphines can be divided into two distinct subgroups :
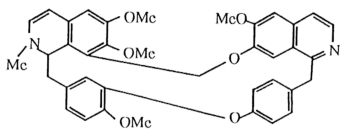
(a) the larger subgroup is made up of weakly basic, non-phenolic compounds which are bright yellow or orange - yellow in colour.
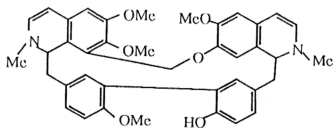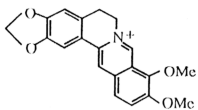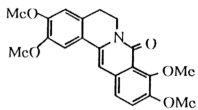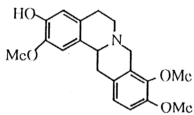
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MeO

HO

N—H

Me

1

MeO

HO

N—Me

MeO

OH

2

MeO

OMe

OMe

N

Me

OMe

O

N

MeO

O

3

OMe

OMe

MeO

O

N

Me

N—Me

OMe

HO

4

5

6

7

8

9

10

17
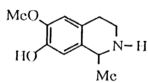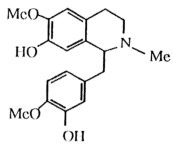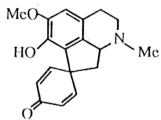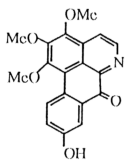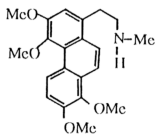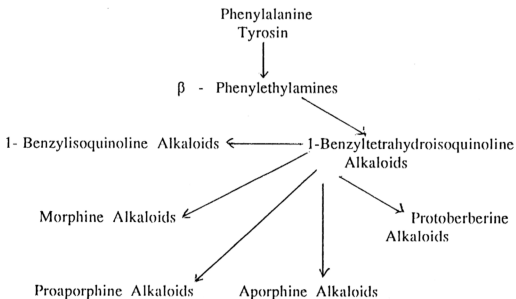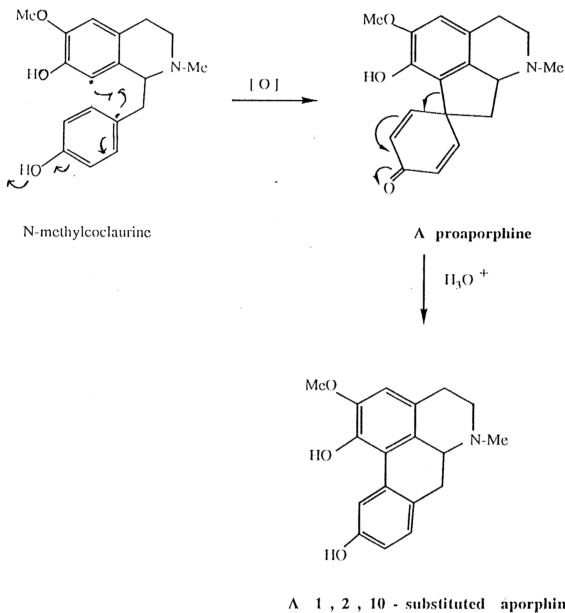
(b) the smaller one is non-phenolic, quarternary N-methyl salts which are green in neutral or basic solution and red in acid [21]. A typical example of this class is homoschatoline **9** in *Guatteria subsessilis* and *Triclisia gillettii* as the orange-yellow needles Crystal[22].
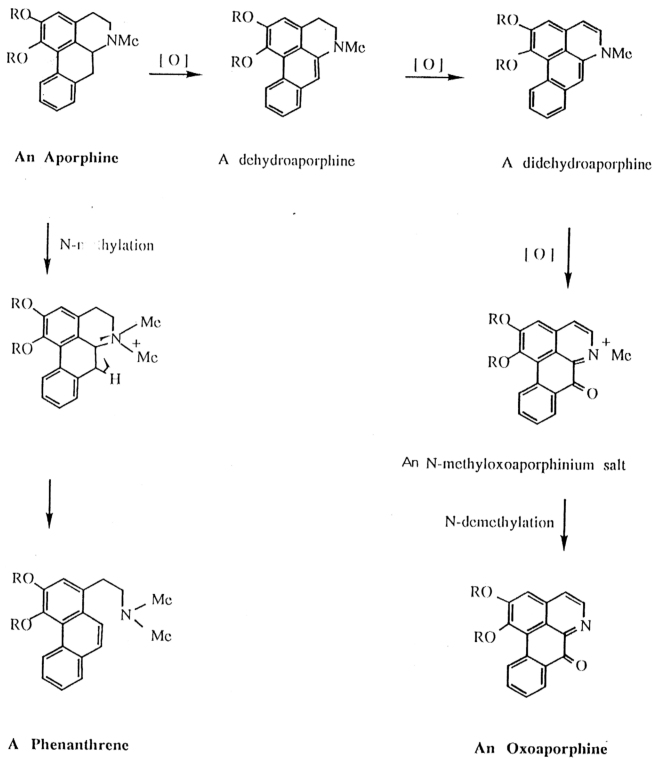
<u>Phenanthrenes</u> - Its having a slightly different skeleton with the ring B being opened like one example from *Uvariopsis species* called noruvariopsamine **10**.

<div align="center">

Phenylalanine
Tyrosin

↓

β - Phenylethylamines

1- Benzylisoquinoline Alkaloids ⟵————— 1-Benzyltetrahydroisoquinoline
Alkaloids

Morphine Alkaloids ↙   ↘ Protoberberine
                                           Alkaloids

Proaporphine Alkaloids   Aporphine Alkaloids

</div>

Scheme 6 : General biogenetic pathway of isoquinoline alkaloids.

N-methylcoclaurine

[O]

Λ proaporphine

H_3O^+

Λ 1 , 2 , 10 - substituted aporphine

Scheme 4 : The Biogenetic Pathway of Proaporphine and Aporphine

An Aporphine   [O]   A dehydroaporphine   [O]   A didehydroaporphine

N-methylation

[O]

An N-methyloxoaporphinium salt

N-demethylation

A Phenanthrene

An Oxoaporphine

Scheme 5 : The Biogenetic Pathway of Oxoaporphines and Phenanthrenes

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2.4 Structural Elucidation of Some Isoquinoline Alkaloids.

Structural elucidation of chemical compounds were carried out by using spectroscopic criteria. The common methods used are ^1H and ^{13}C nuclear magnetic resonance spectroscopy, ultra violet spectroscopy, infra-red spectroscopy and mass spectroscopy. Some authentic samples may .also be used to confirm the compounds by using T L C (Rf. value).

In the following sections, the general spectral behaviours of aporphine and oxoaporphine are discussed briefly.

2.4.1 : Aporphines and Oxoaporphines.
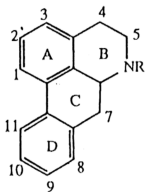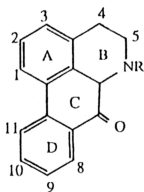
Aporphine   Oxoaporphine

UV Spectroscopy

In the ultra-violet absorption spectra of subtituted aporphine skeleton the substitution pattern around the aromatic area may be detected. The approximate absorption for various substitution patterns are listed below (**Table 2**).

Table 2 : The UV maximum absorption of aporphine.

Substitutions	λ max (nm)
1 , 2	234, 273, 312
1, 2, 9	233, 280, 305
1, 2, 10	226, 266, 275, 305
1, 2, 11	220, 265, 272, 300
1, 2, 9, 10	220, 282, 305
1, 2, 10, 11	220, 270, 305

Oxoaporphine showed three main absorption bands at 245 - 270, 309 and 413 nm [23] . Furthermore, the oxoaporphine reveals a bathochromic shift in acidic condition due to the formation of conjugated acids. The maximum absorptions are between 325 and 460 nm.

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Mass Spectrometry

In mass spectra, the fragmentation of the aporphines are mainly because of the loss of hydrogen beside nitrogen (6a - H). The $(M - 1)^+$ peak always serves as the base peak of the molecule.
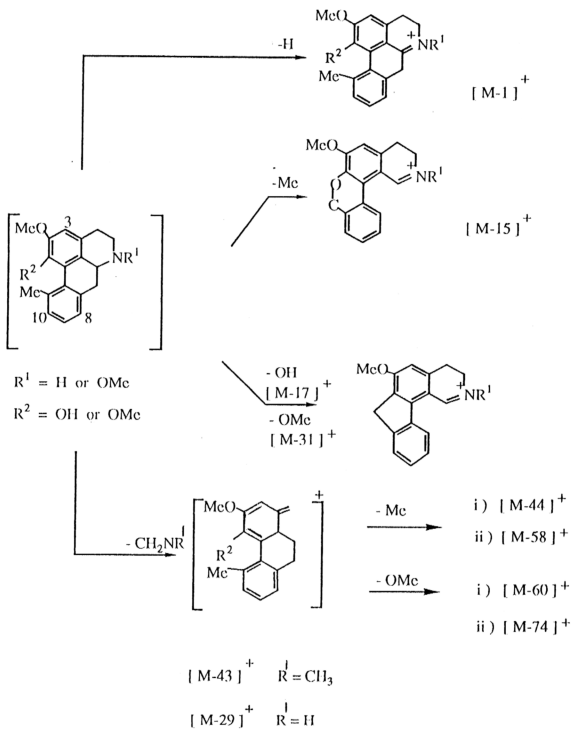
$(M - 15)^+$ and $(M - 31)^+$ peaks will be observed too due to the expulsion of a methyl and methoxyl respectively. If $(M - 17)^+$ peak occurred, it is hydroxyl substituted.

Aporphine with N - methyl or N - H functional groups will display peaks at $(M - 43)^+$ and $(M - 29)^+$ respectively due to the loss of the methylene imine group via a retro Diels - Alder mechanism. The ions formed can further loose another methoxyl or methyl group to give the $(M - 74)^+$, $(M - 58)^+$, $(M - 60)^+$ and $(M - 44)^+$ peaks. The fragmentation patterns are shown in Scheme 6[24].

The oxoaporphines invariably show a strong molecular ion peak. Other important fragmentations are $(M - 10)^+$, $(M - CH2O)^+$ and $(M - CHO)^+$ peaks.

^{1}II NMR Spectroscopy

The 1H NMR spectrum can yield important and valuable information leading to the structural elucidation of aporphines. Several general features have been observed in the proton shifts of these alkaloids. The following chemical shifts have been observed[25] :

-H

[M-1]$^+$

-Me

[M-15]$^+$

MeO
3
R^2
Me
10   8

NR^1

R^1 = H or OMe

R^2 = OH or OMe

- OH
[M-17]$^+$

- OMe
[M-31]$^+$

- CH$_2$NR

MeO
R^2
Me

- Me

i) [M-44]$^+$

ii) [M-58]$^+$

- OMe

i) [M-60]$^+$

ii) [M-74]$^+$

[M-43]$^+$ R = CH$_3$

[M-29]$^+$ R = H

Scheme 6 : The MS Fragmentation of Aporphines

<u>Methoxyl groups</u>:

The average shifts of methoxyl group at C-1 appear at higher fields 3.42-3.63 ppm, while substitution at position C-2, C-9, C-10 reveal peaks at 3.72-3.89 ppm. The methoxyl at position C-11 give resonance at 3.65-3.72 ppm.

<u>Methylenedioxy groups</u>.

The methylenedioxy group shows resonances at a region about 6 ppm. With good resolution the methylenedioxy function when at C-1 and C-2, C-2 and C-3, and C-10 and C-11 give rise to two doublets corresponding to a small difference in chemical shifts between the two nonequivalent protons due to the twisted biphenyl system. The two doublets are usually centered near 5.87-6.02 ppm. At position C-9 and C-10 it reveals a singlet.

<u>Aromatic hydrogens</u>.

The hydrogens at C-3, C-8 and C-9 are located upfield between 6.38-7.00 ppm and cannot be easily differentiated from one another while hydrogen at C-11 is found relatively downfield between 7.57-8.05 ppm.

<u>Aliphatic hydrogens</u>.

The aliphatic protons of C-4, C-5 and C-7 display a complex absorption pattern between 2.40-4.00 ppm. Proton at C-3 normally resonates at a higher field compared to the other aromatic protons when it is ortho to a hydroxyl or a methoxy. This is due to the induction effect.

^{13}C NMR Spectroscopy.

Structural studies of aporphine has general shift regions for the different type of carbons as summarized below [26,27,28].

(a) sp^2 carbon bearing a hydrogen : 105-112 ppm

(b) sp^2 carbon at position 1a , 1b , 3a , 7a and 11a : 119-130 ppm

(c) sp^3 carbon at position 4 (28-30 ppm) , 7 (about 35 ppm) , 5 and 6a (about 42 ppm and 53 ppm for noraporphine) and (about 53 ppm and 62 ppm for aporphine)

(d)   Carbon of the substituents : N-methyl (about 43 ppm) , methoxyl (about 56-62 ppm) and methylenedioxy (about 100 ppm).

Aporphines and oxoaporphines , are similar in characteristic and the shifts of the carbons . In addition , carbonyl group for oxoaporphine gives a downfield peak at about 185 ppm .

2.5 . Flavonoids In General.

Flavonoids occur in virtually all parts of the plant : the roots , stems , leaves , flowers , pollens , fruits , seeds , woods and barks[29]. The method of isolation depends to some extent both on the source material and the type of flavonoid being isolated .

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The carbon skeletons of the flavonoid compouds can be regarded as being made up of two distinct units **11** : the C_6 - C_3 fragment that contains the B ring and the C_6 fragment (A ring) .

A —C—C—C— B
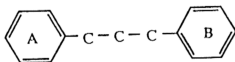
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These structural entities are of different biosynthetic origins . The wide occurence in nature of the large class of phenylpropane derivatives indicates that the synthesis , by the shikimic acid pathway . The combination of the C_6 - C_3 unit with additional carbon atoms derived from acetic acid in two-carbon units .

The different classes within the flavonoid group are distinguished by additional oxygen-heterocyclic rings and by hydroxyl groups distributed in different patterns . Flavonoids frequently occur as glycosides . The largest group of flavonoid is characterized by containing a pyran ring linking the three-carbon chain with one of the benzene rings . The numbering system for these flavonoid derivatives is given below .
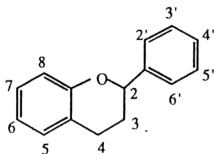
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The various types of flavonoids can be distinguished by the oxidation state of the C_3 chain. In each class of flavonoids, individual compounds differ in the number and distribution of -OH and -OCH$_3$ groups. Going from highly reduced to highly oxidized, the structures and their names are as follows[30] (Fig 1) .
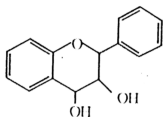
2.6 Flavonoids of Annonaceae

The flavonoids include many of the most common pigments and occur throughout the entire plant kingdom. They are found in the vegetative parts of the higher plant.

Flavonoids have been widely isolated from plant of Annonaceae. It occurs mostly in leaves, stems, barks and fruits. Some of the flavonoids are : -
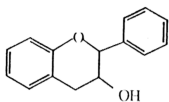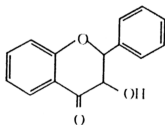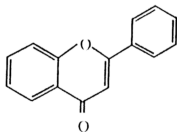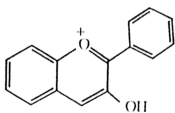
catechins

leucoanthocyanidins
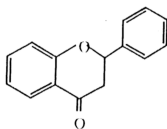
flavanones

flavanonols
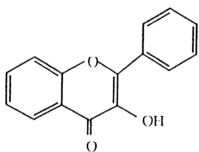

flavones
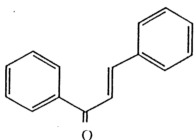

anthocyanidins

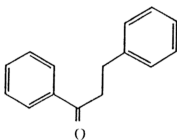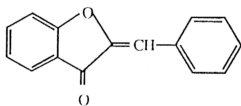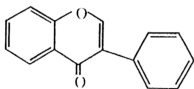Figure 1 : Classification of flavonoid

flavonols

chalcones

dihydrochalcones

aurones

isoflavones

Figure 1 : (continued)

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(a) Pachypodol 13 found in *Pachypodanthium confine* .

(b) 5 ,6 ,7 - trimethoxyflavone **14** , 5 - hydroxy -6 , 7 - dimethoxyflavone , 5 , 7 , 8 - trimethoxyflavone **15** , 2' - hydroxy -3' , 4' , 6' - trimethoxychalcone **16** , and 2' - hydroxy - 3' , 4' , 5' , 6' - tetramethoxychalcone **17** were isolated from the whole stem and ripe fruit of *Monanthotaxis cauliflora* and *Popowia cauliflora* .

(c) Pinocembrin **18** isolated from *Uvaria* species was one of the C- benzylated flavanones and C- benzylated dihydrochalcones skeleton which have demonstrated cytotoxic , antitumour and antimicrobial properties .

(d) Vafzeline **19** and uvafzeline **20** were isolated by Hufford[31] from *Uvaria afzelli* together with known syncarpic acid .

A common feature among the flavonoids isolated , except **13** , is the absence of B - ring substitution , a trait which may prove to have taxonomic significance .

.   In addition , the change from C - 8 to C - 6 substitution in the transition from chalcone or flavanone to flavone , C - 8 hydroxylation , is a characteristic of primitive Families and this is obviously the pattern that would be anticipated in the archaic Annonaceae[32] .

2.7 Structural Elucidation of Some Flavonoids.

Ultraviolet and visible absorption spectroscopy.

UV spectroscopy has become a major technique for the structure elucidation of flavonoids for two main reasons. The first is that only a small amount of pure material is required. Secondly, the amount of structural information gained from a UV spectrum is considerably enchanced by the use of specific reagents which react with one or more functional groups on the flavonoid nucleus.

The addition of each of these reagents separately to an alcoholic solution of the flavonoid induces structurally significant shifts in the UV spectrum.
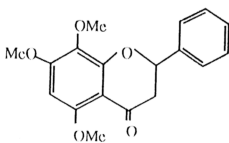
The UV spectra of most flavonoids consists of two major absorption maxima, one of which occurs in the range 240 - 285 nm (band II) and the other in the range 300 - 400 nm (band I) (See Fig. 2). In general terms the band II absorption may be considered as having originated from the A - ring benzoyl system and band I from the B - ring cinnamoyl system.
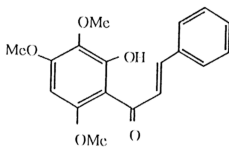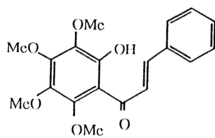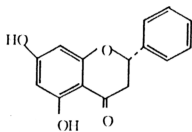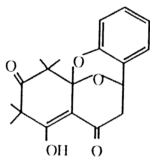
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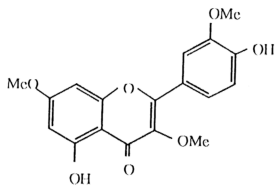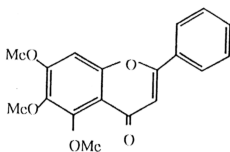
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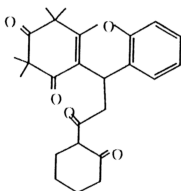
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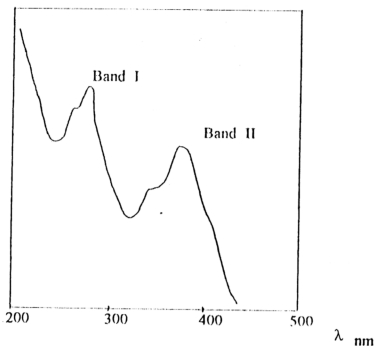
Figure 2: UV absorption of most flavonoid

Flavones absorb between 304 - 350 nm while flavonols absorb in the range 352 - 385 nm , so that the position of the band I absorption provides a guide to the type of flavonoid being examined . Futhermore , highly oxygenated flavones and flavonols tend to absorb at longer wavelenghs than those with fewer oxygen substituents .

Isoflavones, flavanones and dihydroflavonols are grouped together because all of them are lack of conjugation between the A- and B - rings. Their UV spectra are readily distinguished from those of flavones in that they normally exhibit a low intensity band I absorption which often appears as a shoulder to the band II peak. The spectra of these compounds are largely unaffected by changes in the oxygenation and substitution patterns in the B - ring . However , increased oxygenation in the A -

ring leads to a bathochromic shift in the band II absorption eg . 7 , 4' - dihydroxyisoflavone (249 nm), 5 , 7 , 4' - trihydroxyisoflavone (261 nm) and 5 , 6 , 7 , 4' - tetrahydroxyisoflavone (270 nm) .

The UV spectra of chalcones and aurones are characterized by the presence of a dominant band I absorption and a relatively minor band I I. In chalcones, band I I appears in the 220 - 270 nm region while band I is usually in the range 340 - 390 nm. As with other flavonoids, increasing oxygenation generally leads to bathochromic shifts, particularly in band I. Band I in aurones is generally found in the 370 - 430 nm region although it does appear at shorter wavelengh in aurones with simple oxygenation patterns.

Anthocyanidins have band I absorption maxima in the range 465 - 550 nm, band I I being represented by a less intense peak in the 270 - 280 nm region. Methylation and glycosylation of A - and B - ring hydroxyl groups in anthocyanidins generally produces small hypsochromic shifts.

Mass Spectrometry

Electron impact mass spectrometry of both flavonoid aglycones and glycosides serves as a valuable aid in determining their structures, especially when only very small quantities of the compounds are available .

Most flavonoids yield intense peaks for the molecular ion (M^+) and indeed this is often the base peak. Derivatization is thus unnecessary unless GLC - mass spectrometry is to be carried out, in which case trimethylsilylation provides adequate volatility. In addition to the molecular ion, flavonoids usually afford major peaks for $(M-H)^+$ and when methoxylated, $(M-CH_3)^+$. Perhaps the most useful fragmentations in terms of flavonoid identification are those which involve cleavage of intact A - and B - ring fragments. Some of these ions are derived by retro - Diels - Alder processes (see Scheme 7).
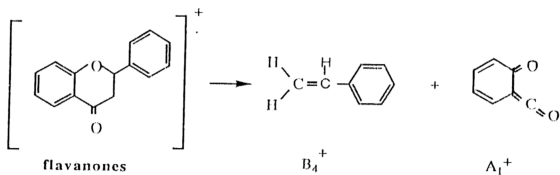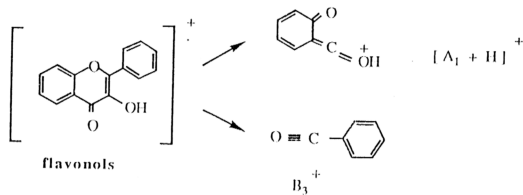
Flavones were among the first flavonoids to be analysed by mass spectrometry . Although the base peak for most flavones is the molecular ion, M^+, peaks are usually prominent in the spectra for $(M-CO)^+$. Flavone itself gives the molecular ion as the base peak with other major peaks corresponding to $(M-H)^+$ and $(M-CO)^+$. Flavones with four or more hydroxyl or methoxyl groups give only weak fragments derived via the primary retro - Diels - Alder reaction .

Flavonols have also been extensively investigated by mass spectrometry . More comprehensive investigations have confirmed that for most flavonols the molecular ion is indeed the base peak. However, other ions, including $(M-H)^+$, $(M-CH_3)^+$ and $(M-CH_3-CO)^+$ can provide considerable structural information . The $(M-1)^+$ ion which is usually prominent for flavonols may involve, the loss of an aromatic proton .

Table 3 : Ultraviolet absorption spectra of some flavonoids .

Flavonoid	(λ_{max} nm)
5 - hydroxyflavone	268 , 296 sh , 333 .
3' , 4' - dihydroxyflavone	242 , 308 sh , 340 .
3' , 4' , 7 - trihydroxyflavone	235 , 250 sh , 309 , 343 .
Apigenin	267 , 296 sh , 336 .
Saponarin	271 , 336 .
3' - hydroxy - 4' - methoxyflavone	232 , 252 , 318 sh , 355 .
Kaempferol	353 sh , 266 , 294 sh , 322 sh , 367 .
Qeurcetin	255 , 269 sh , 301 sh , 370 .
Fisetin	248 , 262 sh , 307 sh , 319 , 362 .
Rhamnetin	256 , 270 sh , 295 sh , 371 .
3 , 5 , 6 , 7 , 8 - Pentamethoxyflavone	268 , 309 , 338 sh .
Patuletin 3 - 0 - glucoside	261 , 270 sh , 355 .
Myricetin	254 , 272 sh , 301 sh , 374 .
Saptigenin	239 , 247 , 265 , 304 sh .
6 - hydroxygenistein	245 sh , 270 , 350 sh .
Irigenin	268 , 336 sh .
Irigenin 7 - glucoside	268 , 331 sh .

Solvent : MeOH

flavones

A_1^+

B_1^+

chalcones

$[M - CO]^{+\cdot}$

A_2^+

B_2^+

flavonols

$[A_1 + H]^+$

B_3^+

flavanones

B_4^+

A_1^+
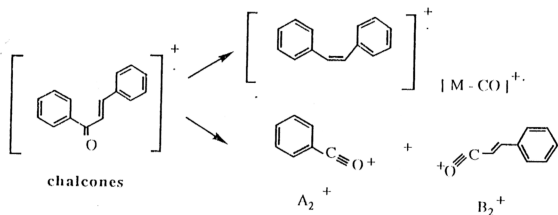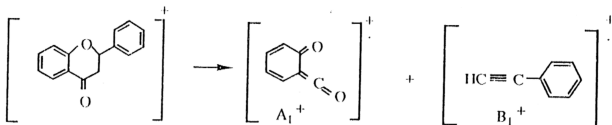
Scheme 7 : Diagnostic Mass Spectral Fragmentation Pathways for different classes of Flavonoids.

Flavanones typically fragmented by the retro - Diels - Alder reaction to yield ions which correspond to the A_1^+ and $(A_1 + H)^+$ (see Scheme 7) ions observed for flavones. As with all types of flavonoids, the intensities of the A - and B - ring fragment from flavanones depend upon the substitution patterns of the two rings.

Chalcones give strong ions for M^+, $(M - H)^+$ and $(M - CH_3)^+$ (for methoxychalcones) and structurally informative fragments derived by fission on either side of the carbonyl group. In some instances, cleavage of the chalcone adjacent to the carbonyl group is much faster than isomerization of the flavanone and thus the spectrum of the chalcone predominates. It should be emphasized that, in most cases, it is difficult to determine with certainty from mass spectral data which of the two tautomers, the chalcone or the flavanone, was originally present.

^1H NMR Spectroscopy.

Proton magnetic resonance spectroscopy is now well established as a method of flavonoid structure analysis. NMR studies were confined to the relatively non - polar flavonoids such as isoflavones and highly acetylated or methylated flavones, which are soluble in solvents such as deuteriochloroform ($CDCl_3$) or carbontetrachloride (CCl_4).

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Proton magnetic resonance in trimethylsilylated flavonoids normally occurs between 0 and 9 ppm, and within this range, signals may be assigned tentatively to structural features. Variations within each of the subgroups of flavonoids are stated in the tables [33].

Table 4 : Chemical shift data for C-6 and C-8 protons
(in 5,7 - dihydroxyflavonoids)

	H - 6 (ppm)	H - 8 (ppm)
Flavones, Flavonols, Isoflavones	6.0 - 2.0 d	6.3 - 6.5 d
Flavonones, Dihydroflavonols	5.7 - 5.9 d	5.9 - 6.1 d

Table 5 : Chemical shift data for C - 5, 6 and 8 protons
(in 5 - deoxyflavonoids)

	H - 5 (ppm)	H - 6 (ppm)	H - 8 (ppm)
Flavones, Flavonols, Isoflavones	7.9 - 8.2 d	6.7 - 7.1 q	6.7 - 7.0 d
Flavanones, Dihydroflavonols	7.7 - 7.9 d	6.4 - 6.5 q	6.3 - 6.4 d

Table 6 : Chemical shift data for C - 2', 3', 5', 6' protons

(in 4' - oxygenated flavonoids)

	H - 2', 6' (ppm)	H - 3', 5' (ppm)
Flavanones	7.1 - 7.3 d	6.5 - 7.1 d
Dihydroflavonols	7.2 - 7.4 d	6.5 - 7.1 d
Isoflavones	7.2 - 7.5 d	6.5 - 7.1 d
Chalcones (H-2,6 & H-3,5)	7.4 - 7.6 d	6.5 - 7.1 d
Aurones	7.6 - 7.8 d	6.5 - 7.1 d
Flavones	7.7 - 7.9 d	6.5 - 7.1 d
Flavonols	7.9 - 8.1 d	6.5 - 7.1 d

Table 7 : Chemical shift data for C - 2' and 6' protons

(in 3' , 4' - dioxygenated flavonoids)

	H - 2' (ppm)	H - 6' (ppm)
Flavones (3',4'-OH and 3'-OH, 4'-OMe)	7.2 - 7.3 d	7.3 - 7.5 q
Flavonols (3',4'-OH and 3'-OH, 4'-OMe)	7.5 - 7.7 d	7.6 - 7.9 q
Flavonols (3'- OMe, 4' - OH)	7.6 - 7.8 d	7.4 - 7.6 q
Flavonols (3',4' - OH, 3-0- glycosyl)	7.2 - 7.5 d	7.3 - 7.7 q