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BRIEF INVESTIGATIONS ON ISOLATED BIOACTIVE MOLECULES OF SOME CASSIA SPECIES

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Abstract:

Review of related literature is an important research effort as it provides comprehensive understanding of what is already known about the topic. Familiarity with research work of others provides up-to-date knowledge of the latest developments, findings, recommendations, tools and loop holes of researches. It helps to avoid duplication of what has already been done, and provides useful directions and helpful suggestions for research work. Cassia is the largest genus from family Caesalpiniaceae comprising about 550 to 600 species including herbs, shrubs and trees. Cassia species are widely distributed around the world in that only 50 species are investigated phytochemically. In India, the genus is represented by 20 species. A large number of bioactive molecules like anthraquinones, flavonoids, glycosides, tannins etc., are present. In that particularly anthraquinones namely emodin, chrysophanol, physcion and rhein are identified and widely distributed throughout this genus which suggests that these compounds may be chemotaxonomic markers of the genus Cassia. It is traditionally used as a medicine for ringworm infection. it is also used in folk medicine for their laxative and purgative property. Particularly for treating skin diseases such as scabies, eczema and wounds. Thus an attempt has been made to review some important cassia species as it contains high source of secondary metabolites that leads to wide medicinal applications .

Key Words: Cassia, Habitat & Bioactive Molecules

1. Introduction:

Today a variety of medicinal plants and bioactive phytocompounds are widely used and our scientific knowledge gave a pathway to the modern field of "phytosciences". Phytochemistry or plant chemistry; *"is concerned with the enormous variety of organic substances that are elaborated and accumulated by plants and deals with the chemical structures of these substances, their biosynthesis, turnover and metabolism, their natural distribution and their biological function*[1]." According to the World Health Organisation, in day to day life about 80% of the world's population follow nutritional diet including turmeric, cardamom, garlic, onion, ginger, tulsi, cloves, other species, fruits, vegetables, pulses, wheat and rice grains which act as natural medicine against various diseases and also helps for smooth functioning of our body. Phytochemical research gained more momentum in India due to the oldest system of medicines like ayurveda, siddha and unani.therefore,researchers are presently seeking out documented information on medicinal herbs and such documented information has formed the basis of several pharmacological and clinical investigations[2].

1.1 Natural Products Chemistry:

Long before mankind has used plants to treat common infectious diseases. For example, cranberry juice (*Vaccinium macrocarpon*) was used to treat urinary tract infections and is reported in different manuals of phytotherapy[3]. Even today some of these traditional medicines are included as part of the habitual treatment in various communities. In recent years, a development in the drug design based on the interaction between traditional medicine and modern biotechnological tools was well established. Medicinal plants produce safe byproducts and thereby play a vital role when compared to synthetic drugs which produce undesirable side effects. The variety of natural products present in different plant species have been isolated and the isolated bioactive molecules present in 1μg/ml a low concentration can also be separated by using various advanced sophisticated separation techniques like HPLC (High Performance Liquid Chromatography) and spectroscopic techniques – UV-VIS, FT-IR, Proton- NMR, Carbon-13 NMR, 2D-NMR (two dimensional Nuclear Magnetic Resonance) and Mass Spectrometry. thus natural products concentrating more on the chemistry of these compounds and becomes a major part of organic chemistry[4].The remarkable group of compounds present in natural products having wide applications in different fields like cosmetics, dyes, pharmaceutical industries, plant growth regulators, fungicides, insecticides, pest control agents and repellents of herbivores etc.,

1.2 Drug Discovery:

A number of plant based drugs included in the WHO's essential medicine list is due to metabolites especially secondary metabolic compounds produced by plant species. Metabolites of plants are grouped into two broad categories namely primary metabolites and secondary metabolites. Primary metabolites are the compounds that are necessary for cellular processes while Secondary metabolites are the substances that are produced by plants through secondary metabolism. if we consider the biological effect of these metabolites, the primary metabolites concentrates within the cell or organism while secondary metabolites concentrates on other organism this will be the base for drug discovery .From natural products, a number of herbal drugs have been developed in the form of food supplements, nutraceuticals, and complementary and alternative medicine.

Examples:

- ✓ Since 1775, the herbal preparation of Foxclove was used to cure various diseases, even today the powdered leaf of this plant is used for heart patients as cardiac stimulant digitalis [5]
- ✓ During Vietnam War an antimalarial drug namely Mefloquine (Lariam®),an alkaloid compound, was developed in the treatment of malaria[6]
- ✓ An isoquinoline alkaloid emetine obtained from *Cephaelis ipecacuanha* and related species was used for the treatment of abscesses due to the spread of *Escherichia histolytica* infections [7]

There are also some major plant drugs for which no synthetic one is currently available[8] and is represented in Table-1 and the structures are illustrated in Fig-1.

Table 1: Major plant drugs for which no synthetic one is currently available

S.No	Drug isolated	Plant species	Medicinal value of the drug
1.	*Vinblastine*	*Catharanthus roseus*	*Anticancer*
2.	*Podophyllin*	*Podophyllum emodi*	*Anticancer*
3.	*Rescinnamine,Reserpine*	*Rauvolfia serpentine*	*Tranquilizer*
4.	*Quinine*	*Cinchona sp.*	*Antimalarial, amoebic dysentery*
5.	*Pilocarpine*	*Pilocarpus jaborandi*	*Antiglucoma*
6.	*Cocaine*	*Erythroxylum coca*	*Topical anaesthetic*
7.	*Morphine,* *Codeine*	*Papaver somniferum*	*Painkiller* *Anticough*

8.	*Atropine*	*Atropa belladonna Hyoscyamus niger*	*Spasmolytic, cold*
9.	*Cardiac glycosides*	*Digitalis sp.*	*congestive heart failure*
10.	*Artemisinin*	*Artemesia annua*	*Antimalarial*

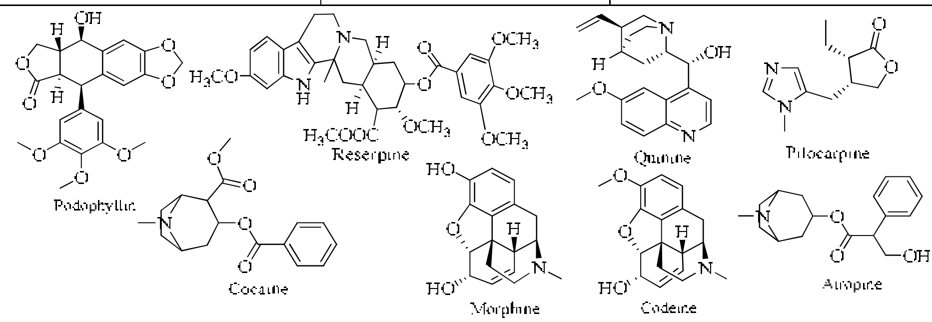


Figure 1: Some common examples of plant drugs

1.3 Bioactive Principles:

Historically, the compounds produced by plants have been categorized into primary and secondary metabolites. There are three broad categories of plant secondary metabolites as natural products; terpenes and terpenoids (~25,000 types), alkaloids (~12,000 types), and phenolic compounds (~8,000 types) [9]. Varieties of secondary metabolites are synthesized from the plant kingdom that can be utilized by mankind in different fields [10].

1.3.1 Primary Metabolites:

It is the necessary substance, required for the growth and survival of the producer plant. aminoacids, simple sugars, nucleic acids, and lipids are some examples of Primary metabolites[11].

1.3.1.1 Carbohydrates[12]:

Sugars or carbohydrates are the primary products of photosynthesis and are essential source of energy to plants. It is defined as a large group of organic compounds which are either themselves polyhydroxy aldehydes or ketones or closely related compounds an acid hydrolysis They have the general formula $C_n(H_2O)_n$ (where n can be in the range 3-1000). it is a white solid, sparingly soluble in organic liquids but soluble in water (except certain polysaccharides).many carbohydrates of low molecular weight are sweet to taste. The total energy requirement of man is provided by breaking down of carbohydrate. Sugars are classified into four types, on the basis of molecular size-monosaccharides, disaccharides, oligosaccharides and polysaccharides.

Common test for carbohydrates includes Molisch's test, Benedict's test, Iodine test, Osazone test, Iodometric, Colorimetric and titrimetric methods

Sugars, Starch,cellulose are some of the examples of carbohydrates and some of the carbohydrate structures are shown in Fig-1.1.

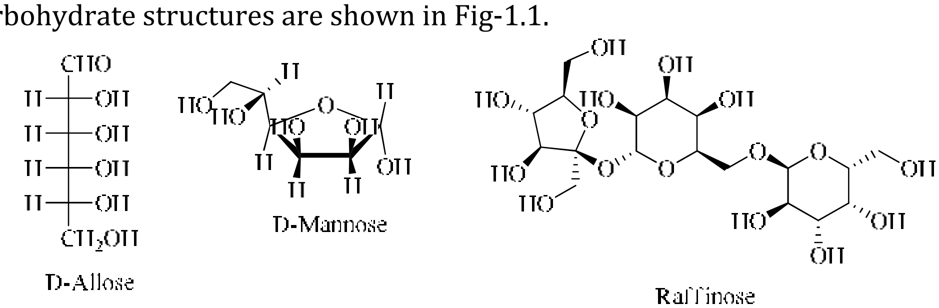


Figure 1.1: Structures of some Carbohydrates

1.3.1.2 Aminoacids[13]

These are the compounds with the properties of both acids and amines. There are 20 amino acids. The body synthesizes some of them from components within the body, but it cannot synthesize 9 of the amino acids—called essential amino acids. They must be consumed in the diet. Everyone needs 8 of these amino acids: isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. Infants also need a 9th one, histidine. The percentage of protein the body can use to synthesize essential amino acids varies from protein to protein. The body can use 100% of the protein in egg and a high percentage of the proteins in milk and meats. it is classified as aminoacids and non protein aminoacids. Some of the tests for Aminoacids are Ninhydrin reaction, Xanthoproteic reaction, Ehrlich's test etc.,

Examples: glycine, threonine, cystine, proline, glutamine etc., are shown in Fig-1.2.

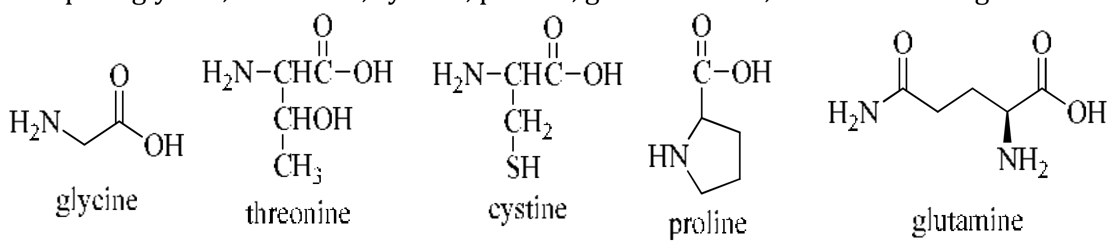
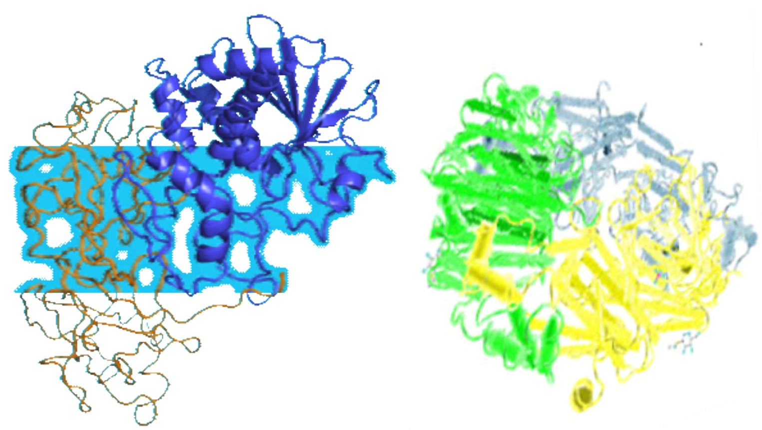


Figure 1.2: Structures of some Aminoacids

1.3.1.3 Proteins[14]

It is used to refer the complex organic nitrogenous substances found in the cells of all living organisms. Proteins are mostly amphoteric in nature, because they contain both basic (-NH_2) and acidic (-COOH) functionality. The proteins are high-molecular-weight polymers of amino acids present in plants. Simple proteins, Conjugated proteins and Derived proteins are some of the Classification of proteins.Test for proteins include Burette test, Millon's test.

Examples: Albumins (leucosin, Ricin), Globulins(legumin, tuberin), Prolamines (Zein,Giladin) shown in Fig-1.3 .



Ricin Legumin

Figure 1.3: Structures of some proteins

1.3.1.4 Lipids[15]

It is naturally occurring compound which are insoluble in water but soluble in fat solvents such as benzene, chloroform, ether and acetone. They are important dietary constituents. lipids are even superior to carbohydrate as they yield more energy than carbohydrates (for example, 1g of lipid yields 9.2calories of energy while 1g of carbohydrate yields 4calories).Simple lipids ,Compound lipids and Derived lipids are some of the types of lipids represented in **Fig-1.4** and test for lipids includes Solubility test, saponification test

Examples: Fats, oils, Sterols, Phospholipids etc.,

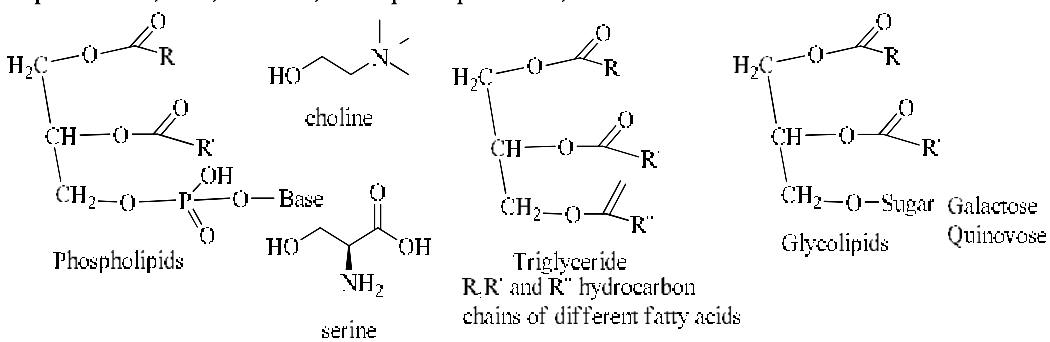


Figure 1.4: Structures of some Lipids

1.3.1.5 Minerals:

Minerals are the inorganic nutrients which plays various roles like builders, activators, regulators, transmitters and controllers. There are about 29 kinds of elements present in our body. They are characterized as Macro elements and Micro elements.

The macro elements refer to the main or principle elements that are required by the plants for their basic functions. These essential elements include Sodium (Na), Potassium (K), Phosphorus (P), Calcium (Ca) and Sulphur (S). Microelements are also known as trace elements [16] , some of the trace elements are Chromium (Cr), Copper (Cu), Cobalt (Co) and Zinc (Zn). Nutritionally important minerals or principle elements are daily required to about 100mg. Trace elements are essential and required less than 100mg per day. There are however, no standards for medicinal raw plant materials which establish a permissible level of metals in such materials. The World Health Organization mentions maximum permissible levels in raw plant materials only for arsenic, cadmium and lead, amounting to 1.0, 0.3, and 10 mg.kg-1, respectively [17].

1.3.1.6 Water[18]

About 70% of water is present in all living things. it plays a vital role and executes many functions which includes,

- ✓ water gives form and shape to the cells
- ✓ helps to regulate the electrolyte balance
- ✓ as a solvent for secretory and excretory processes
- ✓ maintains the body temperature
- ✓ as a chemical carrier to transport important chemical substances in and out of the cells or tissues.

1.3.1.7 Vitamins[19]

Nature manufactured an important organic dietary substance so called 'vitamins' was named by Funk in 1912.they are the utilizable precursors and less amount was required for the growth process. 'Fat-soluble Vitamins' and 'Water-soluble Vitamins'. Vitamins are the two types of vitamins classified based on their solubility. The fat-soluble vitamins are A, D, E and K and vitamins B-complex and C are the water-soluble vitamins shown in Fig-1.5.

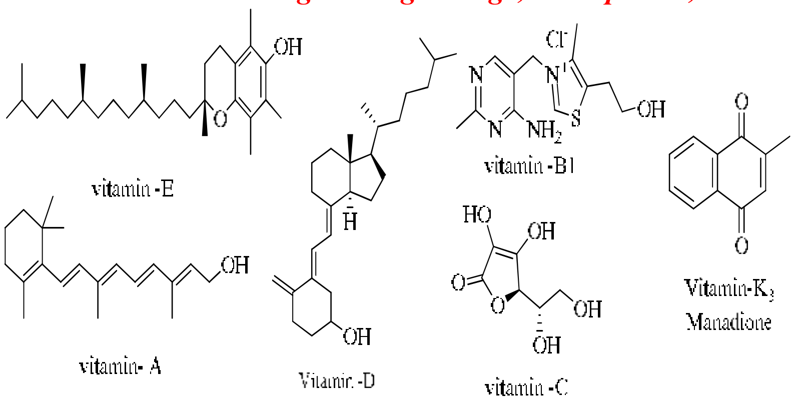


Figure 1.5: Structures of some Vitamins

1.3.2 Secondary Metabolites:

Secondary metabolites may be defined as plant substances which are derived biosynthetically from primary metabolic compounds. The plant produces numerous secondary substances such as alkaloids, terpenoids, phenols, resins, tannins etc., it plays a vital role in living plants such as the free radicals generated during photosynthesis are protected by Flavonoids, Terpenoids may attract pollinators or seed dispersers, or inhibit competing plants, Alkaloids usually ward off herbivore animals or insect attacks (phytoalexins) and Other secondary metabolites function as cellular signalling molecules or have other functions in the plants [20.]

1.3.2.1 Alkaloids:

In 1818 Messiner coined the 'alkali-like' compounds as "Alkaloids " while Hesse etal[21] described the nitrogen containing compounds obtained from plants or animals as alkaloids.there are about 6000 natural alkaloids are identified presently.they are classified as Heterocyclic alkaloids, Alkaloids with exocyclic atom, Polyamines, Peptide alkaloids and Terpene alkaloids shown in Fig-1.6 .

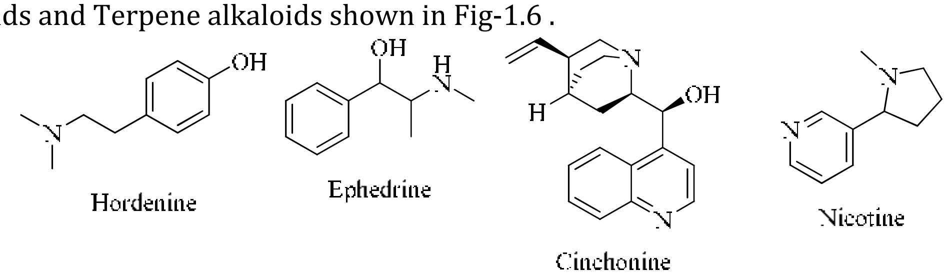


Figure 1.6: Structures of some Alkaloids

1.3.2.2 Terpenoids[22]

Terpenoids are the group of complex compounds having 5-carbon units called isoprene.these compounds are also together called as terpenes since it contains unsaturated hydrocarbons skeleton. Terpenes are further classified as Hemiterpenes, monoterpenes, sesquiterpenes , polyterpenes based on the number of isoprene units. Due to the similarity of some physical properties with alkaloids, More compounds derived from terpenes are often classified as alkaloids[23,24].

The monoterpenes and sesquiterpenes are combined together to form volatile oils which holds important functions like

- ✓ give protection from microbial attack
- ✓ help pollination by attracting insects or act as insect repellants
- ✓ Used in natural perfumes and flavorings in food industry.

Myrcene, linalool, santonin, juniperol are some of the examples of terpenoids shown in Fig-1.7.

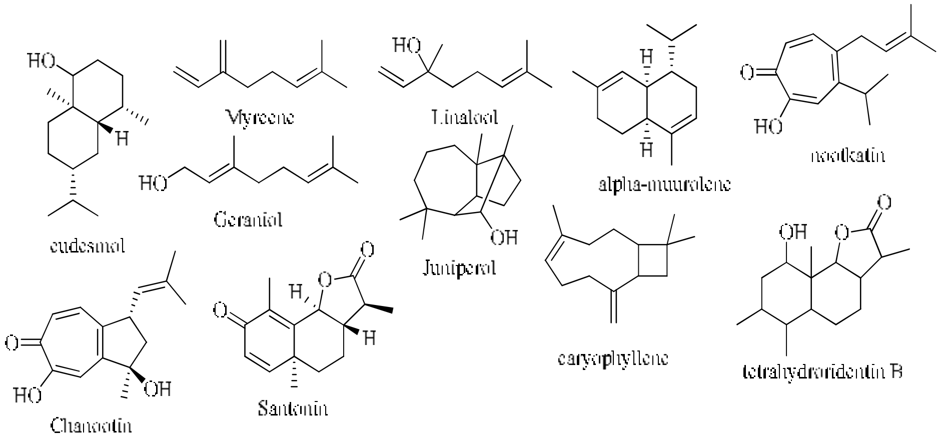


Figure 1.7: Structures of some Terpenoids

1.3.2.3 Steroids:

Based on cyclopentane perhydro phenanthrene ring system like triterpenes, Sterols are naturally occurring compounds[25]. The most common steroids in higher plants are sitosterol, Campesterol, Citrostadienol, Betulinol (betulin), Serratenediol shown in Fig-1.8.

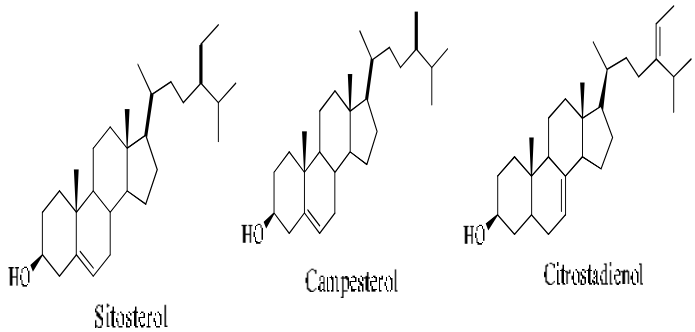


Figure 1.8: Structures of some Steroids

1.3.2.4 Carotenoids:

Carotenoids are the tetraterpenes, present in leaves together with chlorophyll and have lipochromic pigments and soluble in fats and they are located in chloroplast along with chlorophyll molecules. They are soluble in most of the organic solvents, since they are light and sensitive, their extraction procedure is to be carried out in diffused light.

There are two groups of carotenoids;

(i) Hydrocarbons, soluble in petroleum ether

(ii) Xanthophylls – oxygenated derivatives

The attractive colors of carrots, egg yolk, tomatoes, yellow autumn leaves and algae are due to the carotenoids. They are long conjugated systems. The most important substance retinol (vitamin A), is synthesized from β – Carotene in the human body especially in liver portion.

The most important Carotenoids in the diet are α – Carotene, β - Carotene, β - Cryptoxanthin, Lycopene Lutein , Zeaxanthin shown in Fig-1.9.

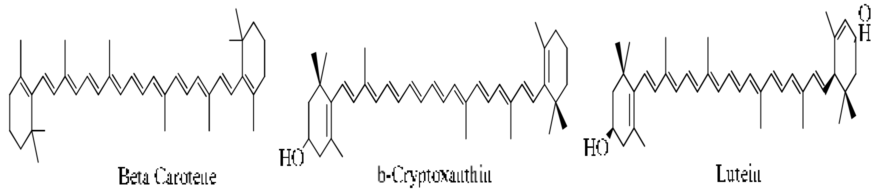


Figure 1.9: Structures of some Carotenoids

1.3.2.5 Phenols:

Phenols plays a significant role in plant kingdom due to the multiple functions like pigmentation, flavour, growth, reproduction and resistance to pathogens and predators. it contains atleast one aromatic ring attached with a hydroxyl group. Phenols are classified in to different groups of compounds like phenolic acids, flavonoids, stilbenes, and lignans based on the structural components[26-29] shown in Fig-1.10.

polyphenols contribute to the prevention of cardiovascular diseases, cancers, osteoporosis and antioxidant activity with potential health benefits[30].they are known to have beneficial effects on cardio vascular system[31] and have a role in the prevention of neurodegenerative diseases and diabetes mellitus[32-35]

Test for Phenols: Libermann's test, $FeCl_3$ test, etc.,

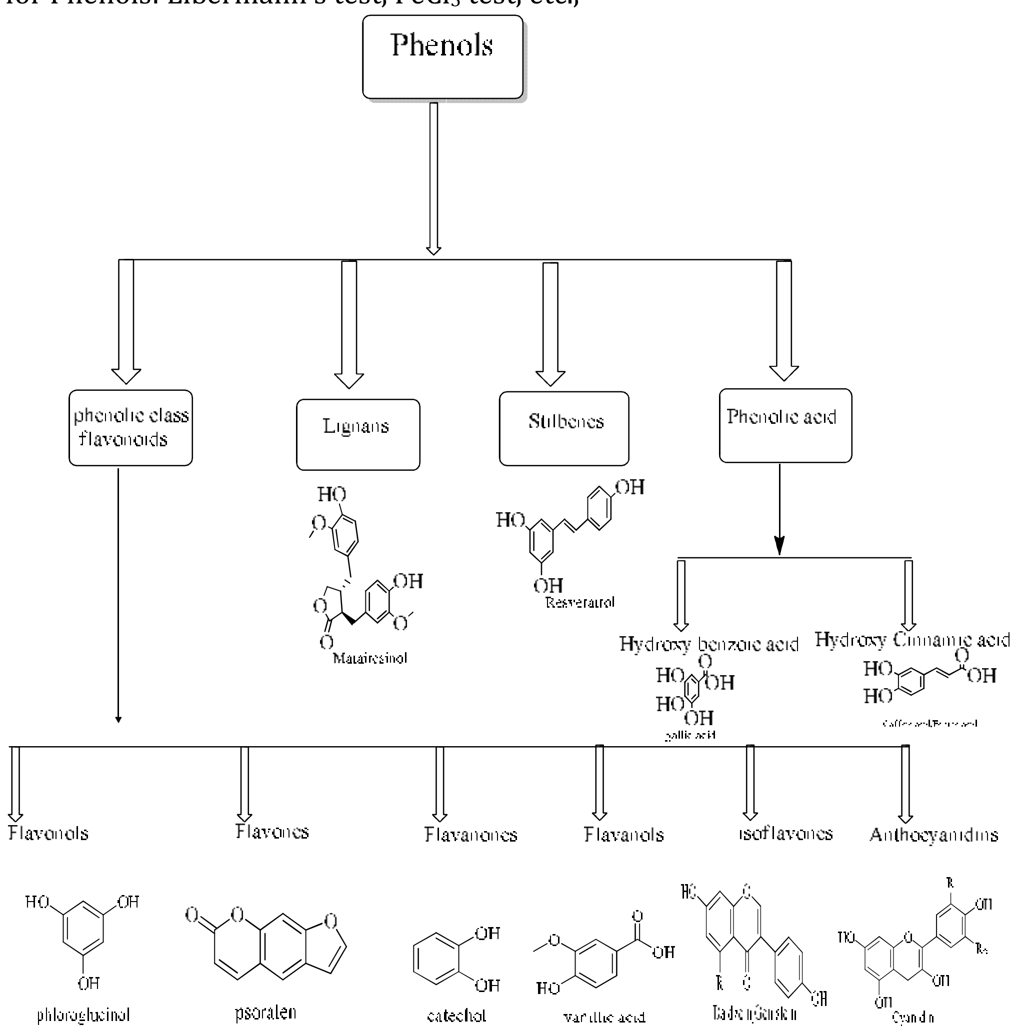


Figure 1.10: Classification and structures of phenols

1.3.2.6 Lignin:

It is widely distributed throughout the plant kingdom. it is an important constituent of the wood and other Woody plant tissues. Lignins are polymers of phenyl propane units which are composed of phenolic acids like p-Coumaric acids, Ferulic acids and Sinapic acids. This can be determined by gravimetric method. Lignins are insoluble in water, unhydrolysable by acids, soluble in hot alkali and bisulphate. They undergo condensation with phenols and thiols.

1.3.2.7 Tannins:

The Polyphenolic compounds present in all the plants are called Tannins. It is classified in to two types namely hydrolysable tannins and condensed tannins. a polyhydric alcohol with glucose esterified gallic acid or with hexa-hydroxydipheric acid will be present in Hydrolysable tannins and the polymers of flavan-3-ol (Catechin) are Condensed tannins, it cannot be hydrolysed easily. Proanthocyanidins, Quinic acid, gallic acid are some of the examples of tannins shown in Fig-1.11.

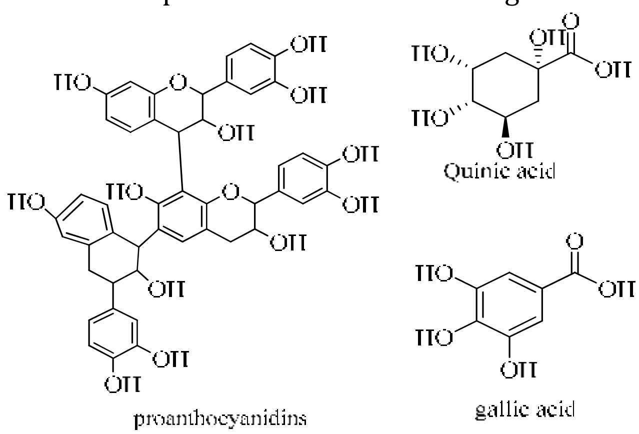


Figure 1.11: Structures of some Tannins

1.3.2.8 Saponins[36]

It contains triterpenoid, steroid or steroidal glycoalkaloids with one or more sugar chains.it is of two types Monodesmosidic saponins and Bisdesmosidic saponins. Bisdesmosidic saponins are converted to biologically active monodesmosidic form by removal of sugar at C-26 or C-28.example Solanine shown in Fig-1.12.

Saponins claimed more important pharmacological activity like

- ✓ lowering of serum cholesterol levels[37]
- ✓ stimulation of luteinizing hormone release leading to abortifacient properties, immunomodulatory potential via cytokine interplay[38]
- ✓ cytostatic and cytotoxic effects on malignant tumor cells[39]

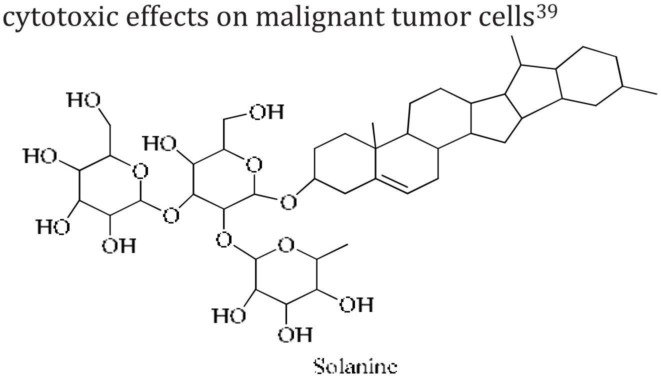


Figure 1.12: Structures of some Saponins

1.4 Characteristics Habitat of Some Cassia Species:

Cassia is the largest genus from family *Caesalpiniaceae* comprising about 550 to 600 species including herbs, shrubs and trees. *Cassia* species are widely distributed around the world in that only 50 species are investigated phytochemically. In India, the genus is represented by 20 species. There is very scanty and scattered work in the genus *Cassia* . All the species of *Cassia* have bright yellow flowers of characteristic shape. Some of the most important bioactive phytochemical constituents are the glycosides, alkaloids, flavonoids, tannins, steroids, terpenoids, essential oils and phenolic compounds[40]. Species of *Cassia* are rich sources of polyphenols, anthraquinone derivatives[41], flavonoids and polysaccharides. These biologically active chemical substances, known as secondary metabolites in medicinal plants, form the foundations of modern prescription drugs[42]. The most important species among them are *C.roxburghii, C.fistula, C.auriculata, C.hirsute, C. absus, C. occidentalis, C. angustifolia, C. acutifolia* and their characters are listed in Table 2.

Table 2: A brief comparative account of habitat in *Cassia* species

Name of the plant	Native	Soil type needed	Habitat	Leaves	Seed	Fruit
C.roxburghii[43]	South india and srilanka	well-drained soils	medium-sized tree	Leaves are clusters with three to eight pairs of leaflets	seeds are separated by papery partitions	Fruit is legume
C.fistula linn [44]	Maharashtra throughout Deccan and Konkan	well-drained soil	deciduous tree	greenish grey bark, compound leaves, leaf lets are each 5-12 cm long pairs.	Seeds broadly ovate, 8 mm. long and 5 mm thick.	The fruit is cylindrical pod.
C.auriculata[45]	hot deciduous forests of India and srilanka	well-drained soil	shrub	The leaves are alternate, stipulate, very numerous, closely placed, slender, pubescent.	12-20 seeds	The fruit is a short legume, pale brown.
C.hirsuta linn[46]	subtropical South America.	well-drained soil	perennial shrub with erect	The compound leaves are alternatively arranged	The seeds are ovoid in shape. it will be olive, brown, or black in colour.	The fruit are slightly sickle-shaped
C. absus[47]	distributed throughout India	well-drained soil	herb	Leaves are alternate and they are pinnate or bipinnate	Seeds are endospermic	The fruit is legume
C. occidentalis[48]	distributed throughout India	well-drained soil	offensively odorous under shrub	leaflets 3-5 pairs	20-30 seeds	fruits cylindrical
C. angustifolia vahl.[49]	Pakistan	Well drained soil	small under shrub	compound pinnate leaves	5- 10 seeded	Fruit 5-6 cm long, 17-23 mm broad,

						sparsely hairy, turning black at maturity
***C.acutifolia delile*[50]**	throughout the tropics	well-drained soil	perennial plant.	oval-elliptical leaflet	many-seeded.	The fruit is legume

1.5 Review of isolated bioactive molecules of *Cassia* species:

A large number of anthraquinones are identified from various parts of cassia species[51] and it was reported that Emodin , Chrysophanol , Physcion and rhein represented in Fig-1.13 are widely distributed throughout this genus which suggests that these compounds may be chemotaxonomic markers of the genus *Cassia*.

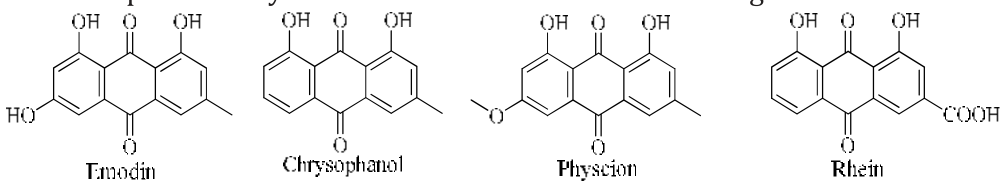


Figure 1.13: Chemical structures of some common compounds present in *Cassia* species

Reddy etal[52] documented the presence of Terephathalic acid and (-) epiafzelichin in leaf and stem and also Roxburghin in leaf of *Cassia roxburghii*. Ashok and his coworkers[53] observed Roxburghinol from the leaves of *C.roxburghii* along with that many anthroquinone derivatives such as 1,8–Dihydroxy–3-Carbo(ß-Dglucopyranosyloxy)- anthraquinone,), 1,3-dihydroxy-2-methyl anthraquinone 8-0-ά–arabinoside, 1,3–dihydroxy-6,8–dimethoxy–2-isoprenyl anthraquinone are also identified from different parts of the plant shown in Fig-1.14.

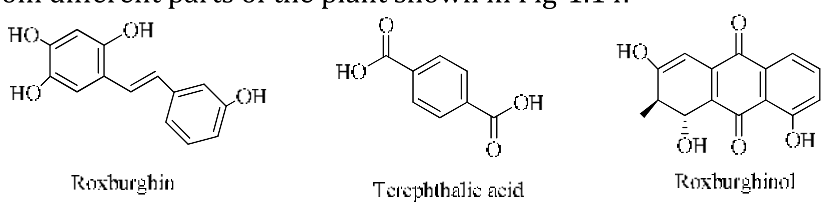


Figure 1.14: Chemical structures of some of the compounds present in *C.roxburghii*

Padmanabha etal[54] first extracted Fistucacidin, an optically inactive leucoanthocyanidin (3,4,7,8,4'-pentahydroxyflavan) from the heartwood of *C. fistula.*Narayanan etal[55] reported the presence of kaempferol and a proanthocyanidin in the acetone extract of the flower. And also Kumar etal[56] isolated a bianthraquinone glycoside, Fistulin from the flowers of *C. fistula*. besides other chemical constituents,Asseleih et al[57] also reported Certain amount of alkaloids in the flowers.Morimoto et al[58] isolated (-)-epiafzelechin 3-O-B-Dglucopyranoside,7 biflavonoids and two triflavonoids together with (-)-epiafzelechin , (-)-epicatechin and procyanidin B-2 from the leaves. Kaji et al[59] reported the presence of rhein glucoside and sennosides A and sennoside B in leaves and also Singh etal[60] isolated 2-new aliphatic compounds namely Cis-Heptacosanyl-5-hydroxypentadec-2-enoate ,Octacosan-5,8-diol from the leaves. common flavan-3-ols and proanthocyanidins like catechin , epicatechin, procyanidin B-2 and epiafzelichin was reported in pods by Kashiwada etal[61] and also isolated 1,8-dihydroxy-3-anthraquinone carboxylic acid from the pods. Agrawal etal[62] elucidated a new colouring matter, fistulic acid , an anthraquinone acid, from the pods. Rani etal[63] reported first time on the isolation and characterisation of 3-formyl-1hydroxy-8-methoxy anthraquinone in pods and also Misra etal [64] isolated a new diterpene, 3B-hydroxy-17-norpimar-8(9)-en-15-one from the pods of *C. fistula*. Gupta etal [65] reported the presence of 5, 7, 3', 4' - tetrahydroxy - 6, 8- dimethoxy flavone -3 -O - a arabinopyranoside while Vaishnav etal[66] showed the presence of rhamnetin 3-O-gentibioside in roots and also Biswak etal[67] documented Aurantiamide acetate from the roots. along with this chrysophanic acid, fistuacacidin barbaloin are also reported by various authors[68] in *C.fistula* and the structures are shown in Fig-1.15.

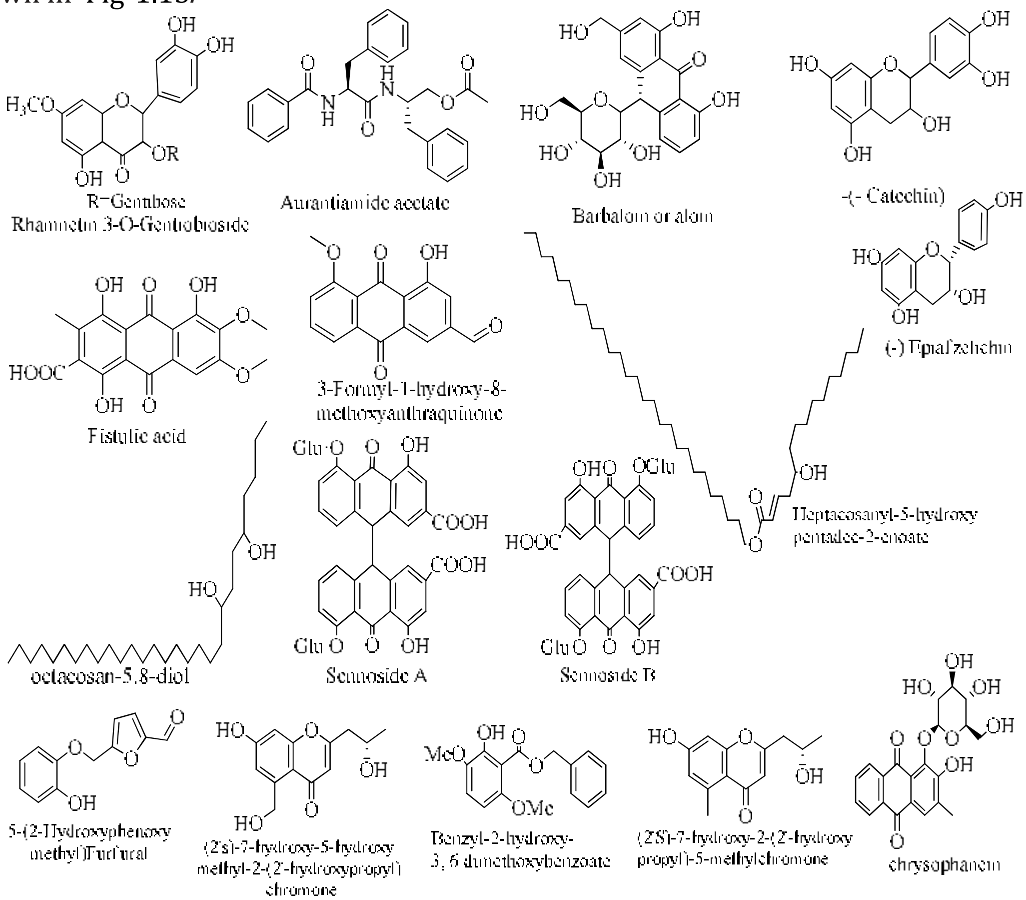


Figure 1.15: Chemical structures of some of the compounds present in *C. fistula*

Kuo etal[69] isolated 5-(2-hydroxyphenoxymethyl) Furfural , (2'*S*)-7-hydroxy-5-hydroxymethyl-2-(2'-hydroxypropyl) chromone , benzyl 2-hydroxy-3,6-dimethoxybenzoate, and benzyl 2β-*O*-D-gluco-pyranosyl-3,6-dimethoxybenzoate, together with known compounds, 5-hydroxymethylfurfural, (2'*S*)-7-hydroxy-2-(2'-hydroxypropyl)-5-methylchromone and chrysophanein from the seeds of *C.fistula*.

Senthilkumar etal[70] report on the isolation Oleanolic acid an antibacterial compound from the leaves of *C.auriculata*. Juvekar etal[71] documented the presence of anthroquinones, aloe emodin and sitosterols from the flowers.Rai etal[72] observed the presence of 1, 5, 8 - tri hydroxy -6 methoxy - 2 - methyl anthraquinone - 3 - O -ß- D - galactopyranosyl - (1→ 4) - O - ß - D- Manopyranoside ,7, 4'' - dihydroxy Flavone - 5 - O - ß -O -galactopyranoside from the seeds and also Nopi etal[73] indicated the presence of Fisetinidol - (4 a - 8'') Catechin ,Fisetinidol - (4 a - 8'') Epicatechin ,Fisetinidol - (4 a - 8'') Gallaocatechin ,Fisetinidol - (4 a - 8'') Epi gallocatechin in the seeds. Pod husk contains

Rubiadin along with usual anthraquinones[74] and Malindra etal[75] elucidated the presence of an antioxidant compound, luteolin from the aerial part of *C.auriculata* shown in Fig-1.16.

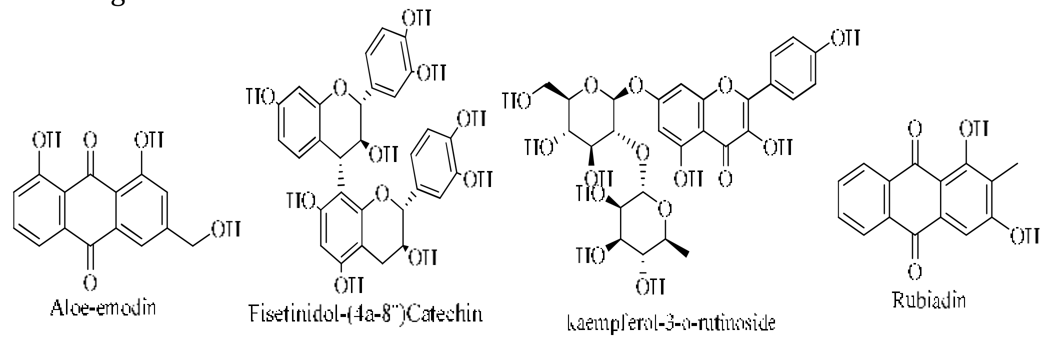


Figure 1.16: Chemical structures of some of the compounds present in *C.auriculata and hirsuta*

Singh etal[76] report on the isolation of a new bianthraquinone,4,4'-bis (1,3,8-trihydroxy-6- methoxy -2- methyl)anthraquinone and a triterpenoid 3β,16 β,22-trihydroxyisohopane from the seeds of *C.hirsuta* and also Rao etal[77] indicated the presence of Kaempferol- 3 O - a - L - rhamnopyranosyl (1 → 2)a -L rhamnopyranoside , Kaempferol - 3 - O – rutinoside and Rutin from the root of *C.hirsuta* are shown in Fig-1.16.

Krishna Rao etal[78] investigated the leaves of the plant *C. absus Linn* and revealed the presence of Chaksine , Isochaksine, Rutin and from the seeds Kostora etal [79] report on the isolation of Gentisic acid ,5-O-D-gluco pyranosyl gentisic acid , Ethyl-α -D-galacto pyranoside, Hydro carpin, Isohydrocarpin and also Kapadia etal [80] observed Raffinose from the seeds shown in Fig-1.17.

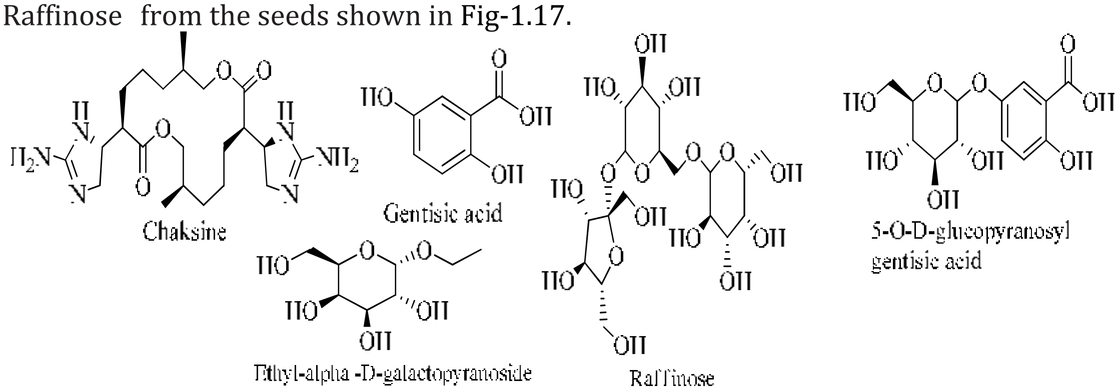


Figure 1.17: Chemical structures of some of the compounds present in *C. absus*

Kitanaka etal[81] elucidated the presence of Occidentalol – I ,Occidentalol – II ,Chrysophanol ,Emodin ,Germichrysone ,Methyl germitorosone,Singueanol from the root of *Cassia occidentalis Linn* and other anthraquinones like islandicin ,questin,Chrysophanol-10,10'-bianthrone,α-hydroxyanthraquinone are also reported in the root by various authors[82-84].Tiwari etal[85] report on the isolation of Matteucinol - 7 – rhamnoside ,Jaceidin - 7 – rhamnoside in the leaves of *C.occidentalis Linn* and also Lal etal [86] showed the presence of anthroquinones like 1, 8 - dihydroxy - 2 - methyl anthraquinone ,1, 4, 5 - trihydroxy - 7 - methoxy - 3 - methyl anthraquinone shown in Fig-1.18 .

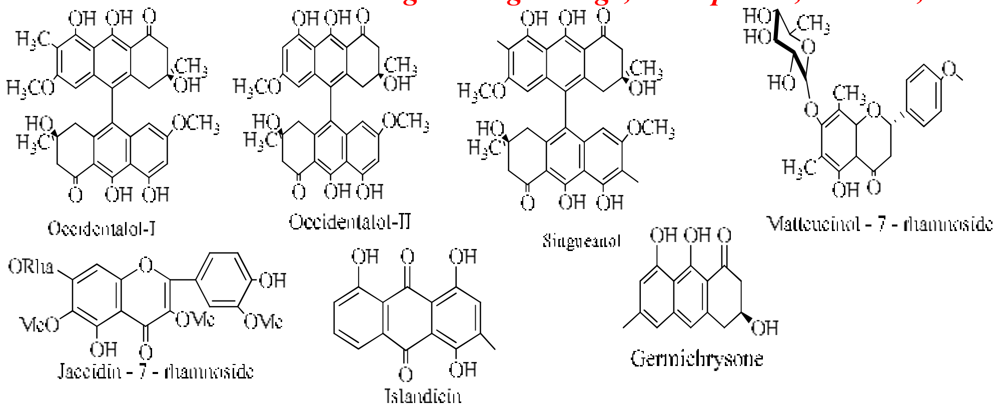


Figure 1.18: Chemical structures of some of the compounds present in *C. occidentalis*

Rastogi etal[87] documented that the plant *Cassia angustifolia vahl* contains β-sitosterol , sennoside A, B, C,D and aloe-amine in free and compound form. Different authors[88-90] indicated the presence of Sennosides A and Sennosides B from the leaves of *C. angustifolia*. Wang *etal* [91] isolated two new naphthalene glycosides from the seeds of *C. angustifolia* . Noor Khan etal[92] elucidated the presence of a novel oleanen type triterpenoid from butanolic seed extracts of *C. angustifolia.*gupta etal[93] identified the presence of 1' -hydroxy - 3, 6, 7, 8 - tetramethoxy - 2 - isopropyl anthraquinone , 1, 5,7,-trihydroxy - 8 - methoxy - 3 - Methyl anthraquinone from the seeds and also Lemli etal[94] observed 6 – hydroxy musizin glycoside in *C. angustifolia* seeds are represented in Fig-1.19 .

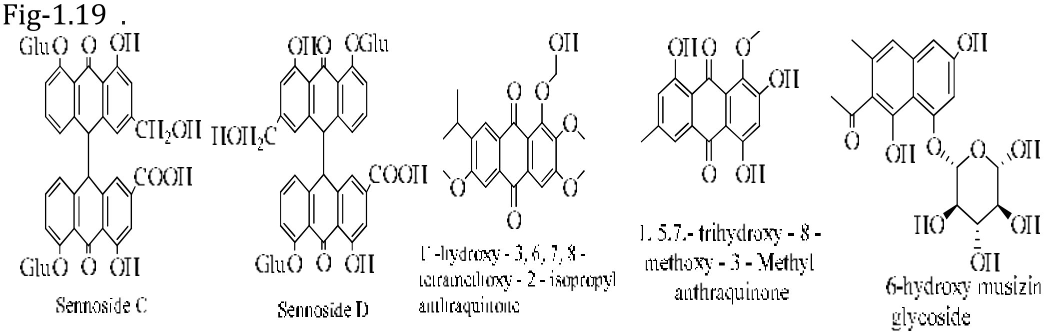


Figure 1.19: Chemical structures of some of the compounds present in *C. angustifolia*

Kalashnikova etal[95] revealed the presence of Chrysophanein ,Glucoate emodin,Emodin-8-O- ß -gluco pyranoside,Sennidine and Glucorein from the roots of *Cassia acutifolia Delile* and Rastogi[96] documented the presence of Gluco aloe-emodin,rhein-8-monoglucoside ,aglycone sennidin in the leaves and pods are shown in Fig-1.20.

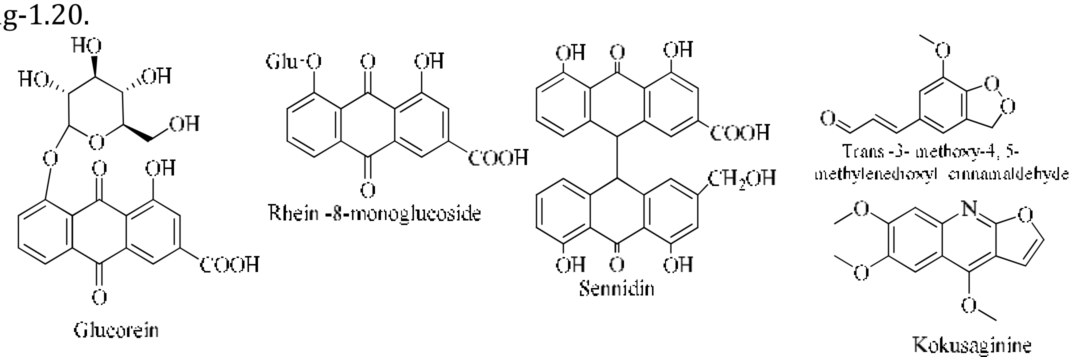


Figure 1.20: Chemical structures of some of the compounds present in *C. acutifolia*

Gonzalez etal[97] indicated the presence of Trans -3- methoxy-4, 5- methylenedioxyl cinnamaldehyde ,Catechin Dihydroxy benzaldehyde,3, 4, 5- trimethoxy benzadehyde from the leaves of *C.grandis L.F.* and from the root Valencia etal[98] report on the isolation of Kokusaginine and Fabioline 1,1'- biperidine .

Conclusion:

Among the cassia species only few species have been investigated phytochemically and the researchers are still focus on these species to find out the active molecules, since it is not exhausted. Emodin,chrysophanol and rhein are found to be present commonly in this genus and it is suggested to be chemotaxonomic markers of this genus[99] .The plant kingdom also holds many species of plants containing bioactive rich molecules having greater medicinal values, which are yet to be discovered.

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