A TREATISE ON PHYTOCHEMISTRY

By

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He completed his postgraduate studies from Indian Board of Alternative Medicines, Calcutta. After completion of studies, he joined the Navjivan Pharma, Panchkula specializing in Herbal medicines. He was involved in clinical trials against Psoriasis, Leucoderma & Diabetes mellitus with herbal extracts in the Ayurvedic Wing of Sohana Eye Institute, Mohali.

Presently he is working as Medical Executive in Super Speciality Division, Ind-Swift Lab,Chandigarh, India on the isolation of the active constituents & standardization of medicinal Herbs. He was instrumental in launching standardized extracts of Allium sativum (garlic) & Hypericum perforatum (St. John's wort) for Ind –Swift limited, Chandigarh under the names Jovin & Garlee.

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Preface

Medicinal herbs are significant source of synthetic and herbal drugs. In the commercial market, medicinal herbs are used as raw drugs, extracts or tinctures. Isolated active constituents are used for applied research. For the last few decades, phytochemistry (study of plants) has been making rapid progress and herbal products are becoming popular. There has been dramatic rise in the sale of herbal products like *Allium sativum, Hypericum perforatum, Spirulina, Echinacea angustifolia, Ginkgo biloba* and *Silybum marianum.*

Owing to growing demand of herbals, the need of the hour is to intensify research in the field of medicinal herbs and to get authentical information on the subject. Herbal products are often questioned for quality control and assurance. Majority of the herbal products fails in the laboratory test for active constituents mentioned on the label. Extracts standardised to active constituents and marker compounds have definite advantage over the crude drugs.

Chemical composition of herbs is always a complex subject. A medicinal herb can be compared with a chemical factory due to presence of number of chemical constituents. The literature on this aspect is scattered and what is required today is a textbook covering all aspects including chemical formulas, structures and standards applicable to isolated constituents with special reference to biological activity. This book is an attempt in that direction.

This book has been written to meet all the requirements of the herbal drug industry. I strongly appeal to the students, researchers and doctors of alternative medicine stream including Ayurvedic, Siddha, Homeopathy and Unani to equip themselves with latest changes in medical herbalism. The book has been divided into 22 chapters and a good deal of attention has been paid to provide accurate information. Botanical sources of the isolated constituents have been mentioned, keeping in mind the importance of biological origin of the medicinal herbs.

Compiling a book on phytochemical aspects is always a difficult task due to lack of authentical material. Various institutions and books on Pharmacognosy, Chemistry, Botany, Ayurveda and Homeopathy were consulted to obtain accurate account. I have tried to avoid unnecessary details like experimental or isolation descriptions. Instead of that flow sheets have been depicted to make the subject more clear.

I am thankful to Dr A.S.Sandhu, Scientist, National Institute of Pharmaceutical Education and Research, (NIPER) Mohali, India, Dr.Samir Malhotra, Assistant Professor Pharmacology, Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh, India and Dr. Satish Narula, Professor, Horticulture, Punjab Agricultural University, Ludhiana, India for their valuable suggestions. I am also thankful to Mr.Amit Chopra and Mr.Ajay Tuli for assistance in drawing pictures.

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Chapter-1: Introduction

Medicinal plants are significant source of synthetic and herbal drugs. Medicinal plants have been used for the treatment of diseases since antiquity. India and China have been on the forefront when we talk about history of herbal drugs. The traditional systems of medicines viz. Ayurveda, Siddha, Unani, Western Herbal Medicine, Traditional Chinese Medicine and Homeopathy have roots in medicinal herbs. Herbal medicine has produced number of distinguished researchers and due to its accessibility to traditions it is still practiced even by lay practitioners.

Ayurveda, the ancient healing system of India, flourished in the Vedic era in India. According to historical facts, the classical texts of Ayurveda, Charaka Samhita and Sushruta Samhita were written around 1000B.C.The Ayurvedic Materia Medica includes 600 medicinal plants along with therapeutics. Herbs like turmeric, fenugreek, ginger, garlic and holy basil are integral part of Ayurvedic formulations. The formulations incorporate single herb or more than two herbs (polyherbal formulations).

The history of Traditional Chinese Medicine is glorious and they have preserved the herbal system beautifully. It originated about 3000 years ago and is a popular science in western countries. Some of the medicinal herbs mentioned in Chinese medicine are common with Ayurveda. Traditional Chinese medicine favors the use of medicinal herbs in natural form rather than extraction. The herbal drugs have different history in Europe and America and they have produced healers like Culpeper. The use of tinctures in Homeopathy is based on medicinal herbs.

Before the availability of synthetic drugs, man was completely dependent on medicinal herbs for prevention and treatment of diseases. The use of the medicinal herbs for curing disease has been documented in the history of all civilizations. The drugs were used in crude forms like expressed juice, powder, decoction or infusion. Although the formulations mentioned in ancient texts are difficult to understand in terms of scientific parameters, but some of them are reputed for their curative values.

Ancient healers, developed formulations based on medicinal herbs, were probably not aware about the chemical composition of the herbs. But the advancement they made despite the non-availability of scientific procedures is astonishing. The work on Terminalia chebula (myrobalan) mentioned in Charaka Samhita is quiet authentical and modern studies have revealed that the purgative activity mentioned in Ayurveda is justified by the isolation of chebulic acid, the active constituent of myrobalan.

Initially, the term Materia Medica was coined for the study of natural products. It is further classified into 4 branches.

Classification of Materia Medica

Materia Medica Proper Pharmacy Pharmacology Therapeutics

Table showing classification of Materia Medica

Materia Medica proper is defined as knowledge of natural history, physical characteristics, and chemical properties of drugs. It includes study of herbs, minerals and drugs from animal kingdom. The Ayurvedic equivalent for Materia Medica proper is Dravya-Guna, which is study of medicinal herbs in Ayurvedic terms. Now days the term Materia Medica proper is better known as Pharmacognosy.

Medicinal herb is a considered to be a chemical factory as it contains multitude of chemical compounds like alkaloids, glycosides, saponins, resins, oleoresins, sesquiterpene lactones and oils (essential and fixed). Some rare compounds like furanocoumarins, hydroxycoumarins, napthoquinones, acylphloroglucinols and sterones are also distributed plant kingdom.

The active constituents are usually secondary metabolites, derived from biosynthetic pathways present within the plant tissue. *Allicin*, a sulphur compound, present in garlic (Allium sativum) is considered to be the active constituent. It is produced from *alliin* by an enzymatic reaction in response to injury. Allicin due to its noxious smell protects garlic from attack of pests also. Thus an active constituent has therapeutic as well as protective activity.

The Ayurvedic texts describe a term 'virya' which seems to be the Ayurvedic equivalent of active constituent. Charaka Samhita has mentioned that therapeutic activity of a medicinal plant is due to factor known as virya. The formulations used in ancient texts are based on plant in natural form. They do not believe in extracting the active constituent from the plant. According to experts during extraction some significant virtues of the plant are lost.

According to one estimate nearly 70 % of the synthetic drugs are derived from medicinal herbs. With introduction of sophisticated techniques, the scientists started exploring the plant flora for active constituents. In 1803, Sertuner isolated a crystalline alkaloid, *morphine* from opium poppy (Papaver somniferum) which still remains a priced drug in medicine as analgesic. Sertuner's research unearthed the mode of action of herbal remedies. Later on the antitussive alkaloid, c*odeine* was isolated and it proved the fact that a medicinal herb can exert different pharmacological activities due to the presence of number of constituents. Later on drugs like a*tropine, arecoline, muscarine*, and h*yoscine* were purified for medicinal applications.

Drugs like v*inblastine, vincristine, reserpine, digoxin* are reputed drugs for the treatment of cancer and heart ailments. Recently *silymarin* (hepatoprotective), *taxol* (anti-cancer) and *artemisinin* (antimalarial) have figured high in pharmaceutical industry because of high therapeutic activity. *Hypericin* (antiviral) and h*yperforin* (antidepressant) have great

reputation as research based medicinal agents.

The chemistry of medicinal herbs is very complex. Not all the constituents present in the plant have therapeutic activity, some are poisonous e.g. pyrrolizidine and tropane alkaloids. Phytochemistry deals with study of chemical composition of the plant material (Phyto refers to plant). Plants are used in various forms varying from powders to extracts. Powder represents the drug in ground from and these types of preparations are considered to be crude. The Pharmacopoeia mentions standardised vegetable powders for therapeutic application.

Herbal systems of medicine have become increasingly popular in recent years. A recent study from America demonstrated that about 34% of the general population used one or the other system at least once a year. In India 76% of patients visiting the general medicine OPD of a tertiary care hospital use alternative therapies. In light of growing demand of herbal drugs, the quality control and assurance is primarily important. The standardised herbal extracts are considered to be more scientific than crude drugs.

The commonly employed technique for removal of active substance from the crude drug is called ***extraction***. Selection of the solvent is very critical in preparing the extracts, because the active constituent of the plants have affinity for solvents.

1. Water and petroleum ether are used for extraction of fixed and essential oils and sterones.
2. Chloroform and ether are used for extraction of alkaloids.
3. Water and alcohol are used for extraction of glycosides.
4. Tannins and phenols are extracted with alcohol and ethyl acetate.

Extracts are prepared by separating the soluble matter from vegetable tissues by application of a suitable solvent like alcohol, water or ether. The resultant liquid is concentrated by evaporation to obtain liquid extract or concentrated nearly to dryness to obtain solid extract. Depending on the solvent used, the extracts are classified as alcoholic, etheral or aqueous.

Classification of extracts

Solid extracts	**Liquid extracts**	**Alcoholic extracts**	**Aqueous extracts**	**Etheral extracts**
Sub types				
Dry extracts				
Soft extracts				
Examples	Examples			
Nux vomica	Ergot			
Opium	Colchicum			
Stramonium	Liquorice			

Table showing classification of extracts

1. The solid and liquid extract classification is based on method of preparation.
2. The alcoholic, aqueous and etheral extract classification is based on type of solvent used.

The ***standardised herbal extarct*** is a preparation, which contains a certain fixed proportion of the active constituent. For example, a standardised extract of Papaver somniferum contains not less than 9.5% of morphine. The concept of standardisation has great impact on quality of herbal products. Standardisation helps in adjusting the herbal drug formulation to a defined content of a constituent or constituents with therapeutic activity. The latest method of preparing herbal extracts is by successive macerating of the powdered drug in order of increasing polarity. This process is known as successive solvent extraction and carried out in special assembly known as Soxhlet apparatus.

Biological source of the drug has great impact on finished product in herbal drug preparation. Proper identification of the drug is significant for phytochemical screening, which further exerts importance on therapeutic activity of the medicinal herb. Thus presence of identification standard is must in finished product of an herbal drug preparation. A constituent of a medicinal herb, which is used for quality control and assurance of herbal product is known as ***marker compound***. A marker compound may or may not have therapeutic activity.

Commonly used herbal extracts are listed in the following table: -

S.No	Botanical Name	Standard	Percentage
1	Achellia Millefolium	Essential oil	0.04%
2	Adhatoda Vasica	Vasicine	0.5%
3	Allium Sativum	Allicin	0.6%
4	Andrographis Paniculata	Andrographolide	10%
5	Asparagus Racemosus	Saponin	30%
6	Azadirachita Indica	Azadiractin	2%
7	Bacopa Monneri	Bacoside	20%
8	Boswellia Seratta	Boswellic Acid.	40% & 70%
9	Camelia Sinensis	Epigallocatechin Gallate	0.2%
10	Capsicum Frutescens	Capsaicinoids	0.62%
11	Centella Asiatica	Asiaticoside	3%
12	Cholorella Emersoni	Chlorophyll	1%
13	Commiphora Balsamdendron Mukul	Guggulsterones	5%
14	Cratageus Oxycanthus	Vitexin	5%
15	Curcuma Longa	Curcumin	95%
16	Cynara Scolymus	Cynarin	1%
17	Echinacea Angustifolia	Echinacosides	4%
18	Embelia Ribes	Embellin	8%
19	Ephedra Sinica	Ephedrine	6%

20	Garcinia Cambogia	Hydroxy Cirtic Acid	50%
21	Ginkgo Biloba	Flavonoglycosides	24%
22	Glycyrrihiza Glabra	Glycyrrhizin	20%
23	Gymnema Sylvestre	Gymnemic Acid.	75%
24	Hydrastis Canadensis	Alkaloids	3%
25	Hypericum Perforatum	Hypericin	0.3%
26	Huperzia Serrata	Huperzine	5%
27	Momordica Charantia	Bitters	3%
28	Ocimum Sanactum	Ursolic Acid	8%
29	Passiflora Incarnata	Vitexin	4%
30	Phylanthus Niruri	Bitters	2%
31	Picrorrhiza Kurroa	Kutkosides	10%
32	Piper Methysticum	Kavalactones	30%
33	Pueraria Tuberosa	Disogenin	7%
34	Saraca Indica	Tannins	8%
35	Sereno Repens	Fatty acids	20-25%
36	Shilajit	Fulvic acid	50%
37	Silybum Marianum	Silymarin	70%
38	Spirulina Maxima	Phycocyanin	2.5%
39	Terminalia Arjuna	Tannins	8%
40	Terminalia Belerica	Tannins	40%
41	Terminelia Chebula	Tannins	60%
42	Tribulus Terrestris	Saponin	20% & 40%
43	Trigonella Foenum Graecum	Saponin	10%
44	Triphla	Tannins	40%
45	Uncaria Tomentosa	Saponins	2%
46	Valeriania Officinalis	Valerenic acid.	0.8%
47	Vitis Vinifera	Proanthocyanidins	95%
48	Withania Somnifera	Withanolides	1.5%
49	Zingiber Officinale	Gingerols	5%

Now days we talk about active constituents of phyto drugs. An ***active constituent*** is truly responsible for therapeutic activity of medicinal plant. The extracts are further subjected to chemical tests for identification of the plant constituents. The isolated constituents are of further importance to the pharmaceutical industry for applied research. A number of constituents like *hyperforin, schizandrins, huperzine, andrographolide, and picrrorhizin* are being investigated for application in medical field.

Chapter-2: Alkaloids

Introduction

Alkaloids are basically nitrogen bases. The amino acids act as building blocks for the biosynthesis of alkaloids. Majorities of the alkaloids contain a pyridine, quinoline, and isoquinoline or tropane nucleus and are responsible for physiological effects in man or in animal. The side chains in alkaloids are derived from terpene or acetate. Alkaloids have basic properties and are alkaline in reaction, turning red litmus paper blue.

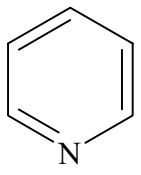
Alkaloids are basically compound ammonias, where one or more atoms of hydrogen are replaced by various radicals. Alkaloids combine with acids to form crystalline salts without the production of water. Majorities of alkaloid exsit in solid form like atropine and they contain oxygen. Some alkaloids like lobeline or nicotine occur in liquid from and contain carbon, hydrogen, and nitrogen.

Alkaloids have one peculiarity regarding solubility in organic solvents. They are readily soluble in alcohol and sparingly soluble in water. The salts of alkaloids are usually soluble in water. In nature, the alkaloids exist in many plants: in larger proportion in the seeds and roots often in combination with vegetable acids. Some alkaloid exsit in free state and some like helitropin as N-oxide. The solutions of alkaloids are intensely bitter.

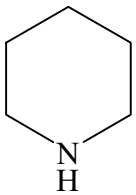
Nomenclature and chemistry

The name of alkaloids end in -ine suffix. The salts of alkaloids are official. Codeine, atropine, morphine, ergotamine and ephedrine are common examples.

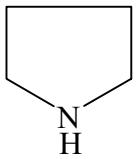
As we have discussed earlier that alkaloids are responsible for physiological effects in man or animals. The physiological effects are due to secondary metabolites arising from bio-chemical pathways operating in the plant cell. Alkaloids constitute the largest group of secondary chemical constituents. Basic structures of alkaloids are depicted below:



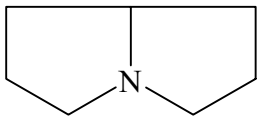
Pyridine



Piperidine



Pyrrolidine



Pyrrolizidine

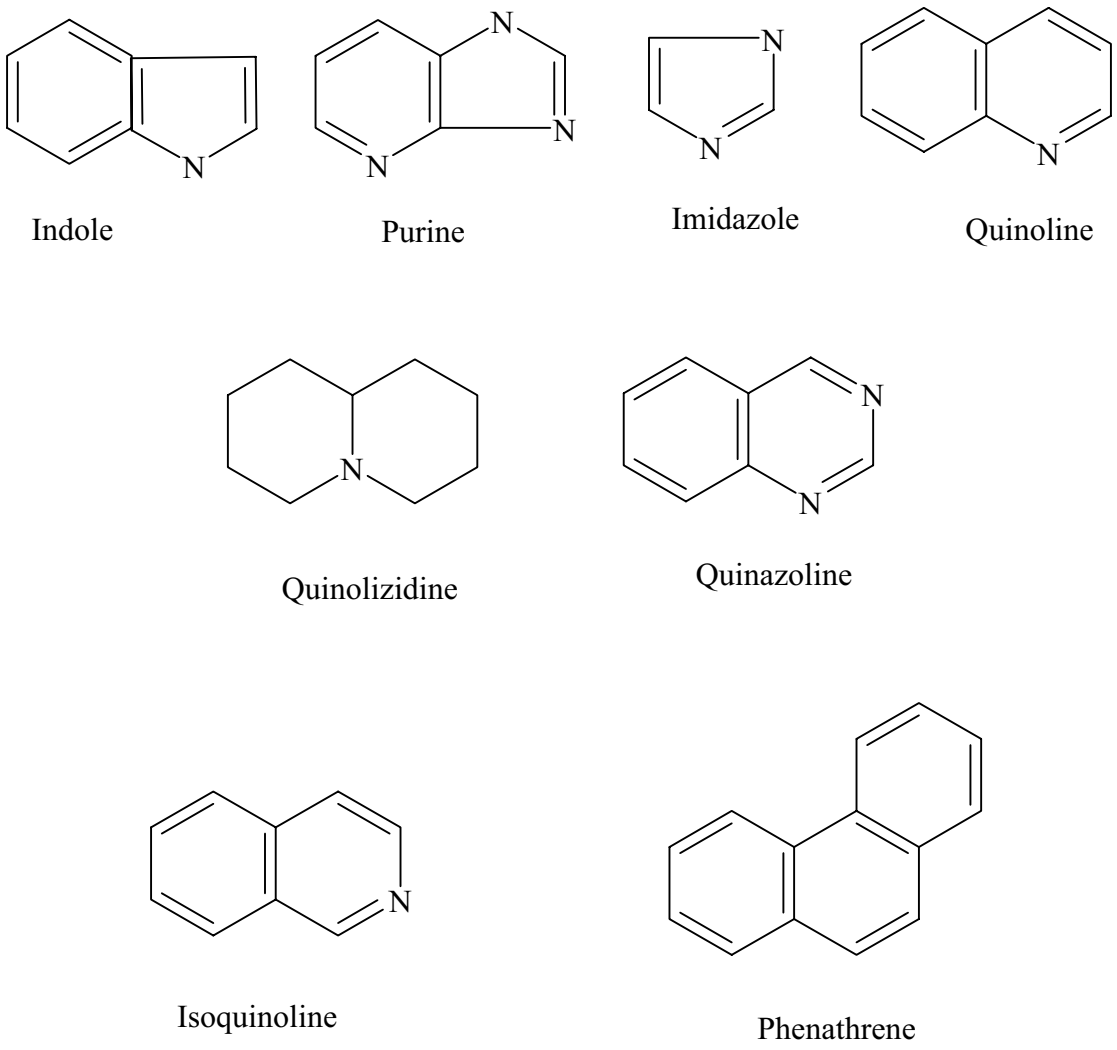
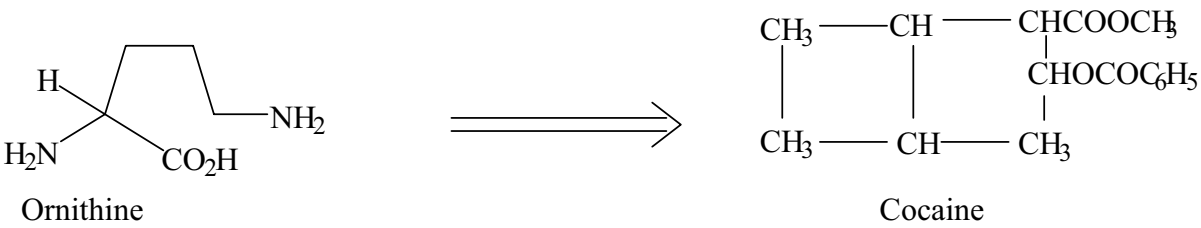
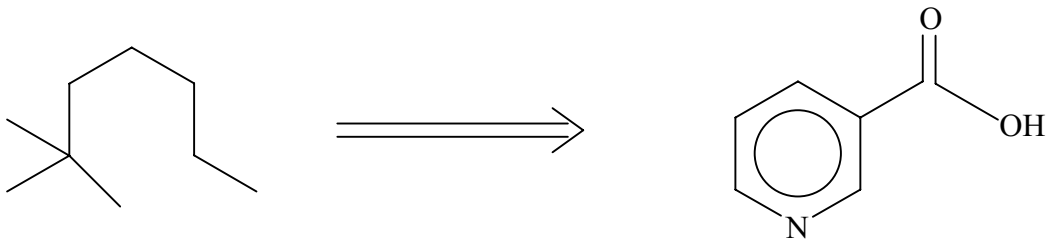


Fig 2.3: Structures of common alkaloids.

Amino acids act as precursor foe biosynthesis of alkaloids. Ornithine and lysine are common amino acids used as starting material for alkaloid biosynthesis. Cocaine and nicotine are classical examples form this series.





Lysine Nicotine

Fig 2.4: Diagrammatic representation of alkaloid biosynthesis.

Phenylalanine and tyrosine acts as precursor for opium alkaloid biosynthesis. Tryptophan is a significant source of Vinca alkaloids. Alkaloids are derived from anthranilic acid, which is an intermediate in biosynthesis of tryptophan. Some alkaloids are derived from acetate, terpene or shikimic acid. Shikimic acid is a significant metabolite as most of the aromatic constituents are derived from shikimic acid pathway.

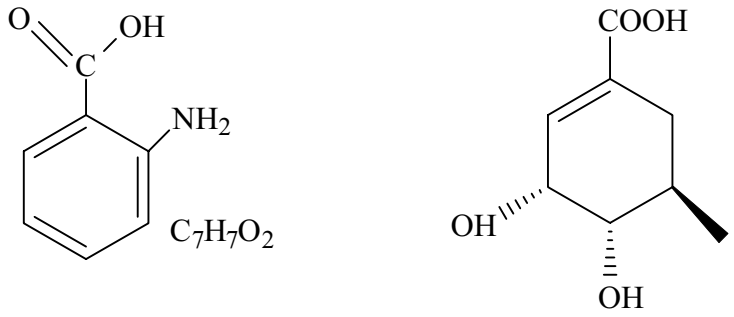


Fig 2.5: Showing structure of Anthranilic acid and Shikimic acid.

Alkaloids are significant source of pharmaceutical drugs. More than 12,000-alkaloids are known to exist in green flora and only few have been exploited for medicinal purpose. With the help of scientific procedures like chromatography and mass spectroscopy it is now possible to determine the molecular formulas and chemical structures of active constituents of medicinal herbs.

Classification

The alkaloids are classified according to various types:

1. Classification based on chemical structure

    A. Pyridine (Nicotine)
    B. Quinoline (Quinine)
    C. Isoquinoline (Papaverine)
    D. Phenanthrene (Codeine)

E. Pyrrolidine (Atropine)

2. Classification based on pharmacological activity e.g. Analeptic (Strychnine), Analgesic (Morphine), Anti cancer (Vinblastine).

   Rarely alkaloids are classified according to biosynthesis route.

Qualitative chemical examination of alkaloids

Mayer's reagent, Drangendroff's reagent, Hager's reagent or Wagner's reagent precipitates the alkaloids. Alkaloids are known to give characteristic color when treated with these reagents.

1. Mayer's reagent [cream precipitate]
2. Drangendroff's reagent [orange brown precipitate]
3. Hager's reagent [yellow precipitate]
4. Wagners'reagent [reddish brown precipitate]

Extraction of alkaloids

Although numbers of methods are used in extraction of alkaloids, the following method is commonly used.

Treat moistened drug with alkali so as to set free the base [as it exists in salt form] and then to separate free base with organic solvent.

(a) First plant is deffated with petroleum ether.
(b) Secondly drug is extracted with solvents.

By this method alkaloid salts are transferred to polar solvents. It also helps in removing pigments, sugars and other secondary constituents.

Alcoholic solution is evaporated to thick syrup and subjected to partition between aqueous acid solution and organic solvent. After continued extraction with solvent for some time, aqueous phase is made alkaline with sodium carbonate or ammonia. Basic aqueous solution is extracted with solvent followed by drying of alkaloid containing solution normally with sodium sulfate, filtered and evaporated to yield alkaloid residue.

Acalyphine

Source: Acalypha indica.
Biological activity: Expectorant.

Aconitine

Source: Aconitum napellus.
Molecular formula: $C_{34}H_{47}NO_{11}$.
Molecular weight: 645.33.

Melting point: 194-202 deg C.
Solubility:
A. Soluble in chloroform and benzene.
B. Slightly soluble in alcohol and ether.
C. Insoluble in water.
Physical form: Colorless, transparent crystals.

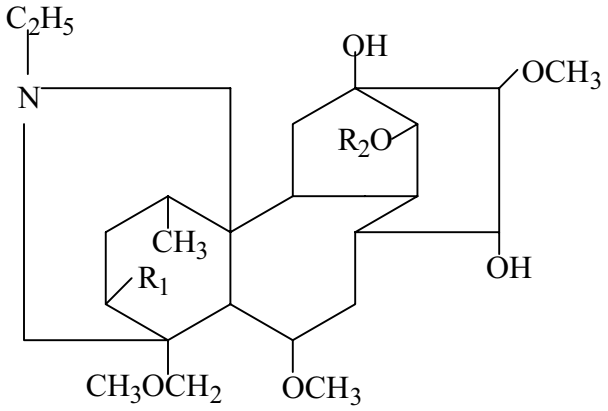


Fig. 2.6 : Structure of Aconitine

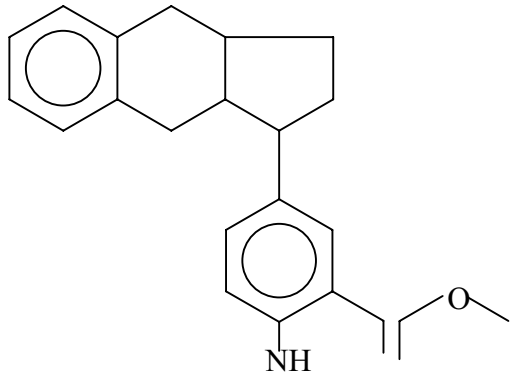
On hydrolysis, aconitine gives following reaction:

Aconitine----------→ Benzyl aconine + Acetic acid.

Extraction: Following process is used for isolation of aconitine.

Adhatodine

Source: Adhatoda vasica.
Molecular formula: C_{20} H_{21} N_3 O_2.
Molecular weight: 335.4.
Melting point: 183 deg C.
Biological activity: Not confirmed.



Fig, 2.8 : Structure of Adhatodine

Alstonine

Source: Alstonia constricta.
Molecular formula: C_{21} H_{12} N_2 O_3.
Molecular weight: 349.44.
Biological activity: Not confirmed.

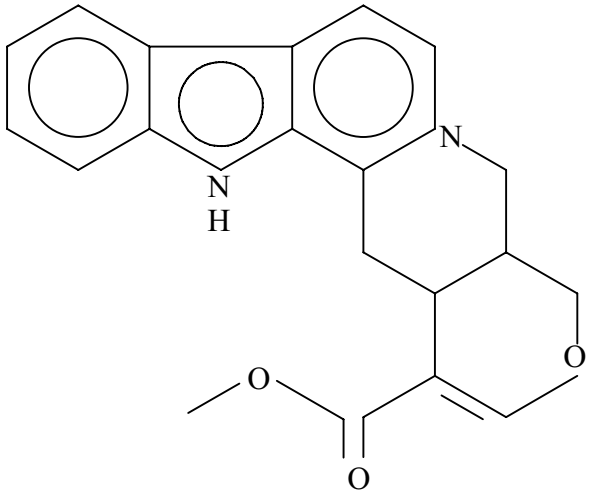


Fig. 2.9 : Structure of Alstonine

Alstonidine
Source: Alstonia constricta.
Solubility: Slightly soluble in petroleum benzene.

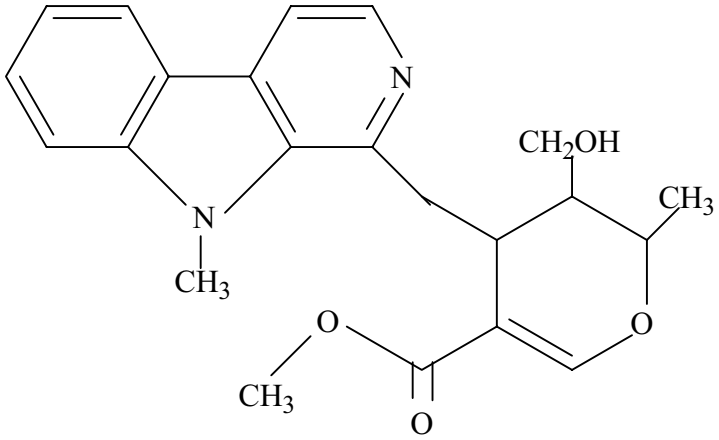


Fig. 2.10 : Structure of Alstonidine

Anabasine

Source: Withania somnifera.
Biological activity: Not confirmed.

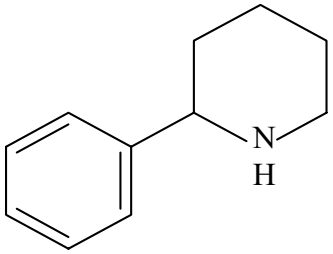


Fig. 2.11: Structure of Anabasine

Ajmaline

Source: Rawolfia serpentina.
Biological activity: Antihypertensive.

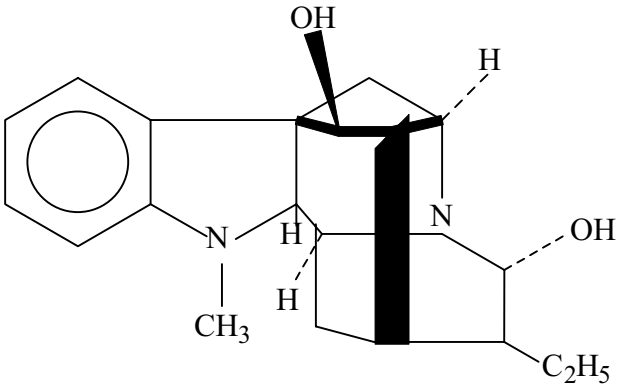


Fig.2.12: Structure of Ajmaline

Arecoline

Source: Arced catechu.
Biological activity: Cholinergic.

Atropine

Source: Atropa belladonna.
Molecular formula: $C_{17}H_{23}NO_3$.
Molecular weight: 289.41.
Biological activity: Mydriatic.

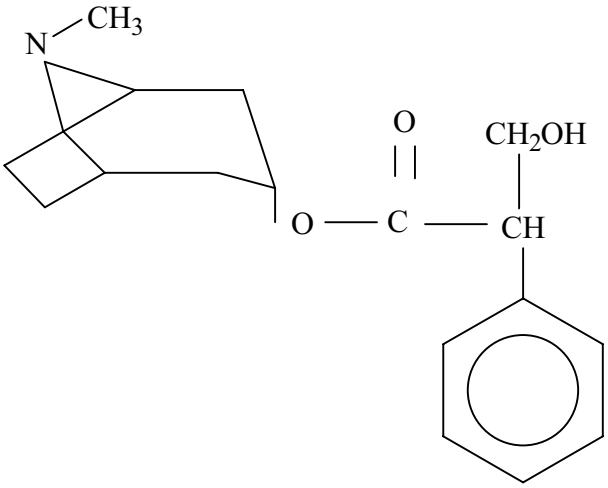


Fig.2.15: Structure of Atropine

Atisine

Source: Aconitum heterophyllum.
Molecular formula: $C_{46} H_{74} N_2O_3$.
Physical form: Atisine occurs in crystalline from.
Taste: Highly bitter.
Biological activity: Hypotensive.

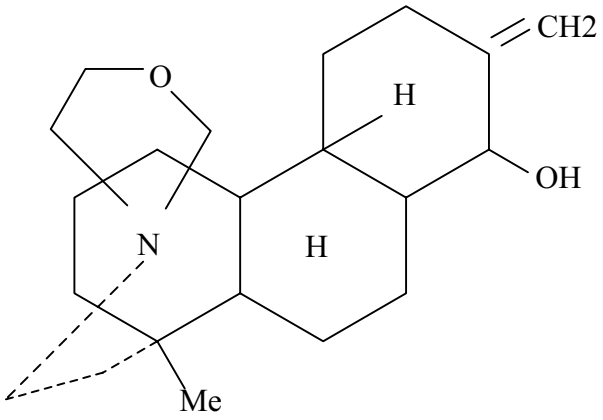


Fig.2.14: Structure of Atisine

Isolation: Wright isolated the alkaloid in 1878.The powdered rhizome of A. heterophyllum is extracted with a mixture of alcohol and tartaric acid by the process of percolation. On evaporation of the percolate, Atisine crystallizes.

Berberine

Source: Berberis aristata.
Molecular formula: $C_{20} H_{18} N O_4$.
Molecular weight: 336.39.
Solubility:
A. Soluble in water and alcohol.
B. Insoluble in ether.
Physical form: The alkaloid is yellow colored having bitter taste, exist in crystalline form.
Biological activity: Antiperodic.

Berberine combines with acid to form following salts.

1. Berberine sulphate
2. Berberine chloride.
3. Berberine phosphate.

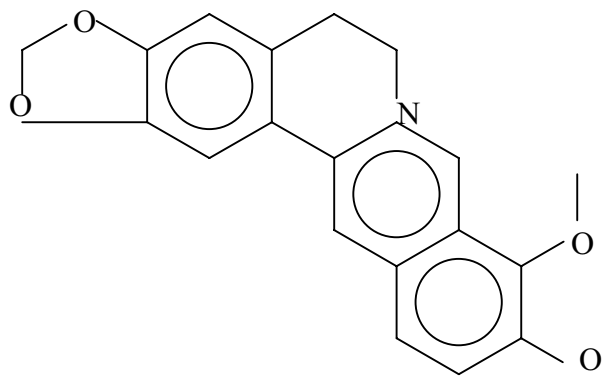


Fig 2.16: Structure of Berberine

Berbamine

Source: Berberis aristata.
Molecular formula: $C_{37}\ H_{40}\ N_2\ O_6$.
Molecular weight: 608.79.

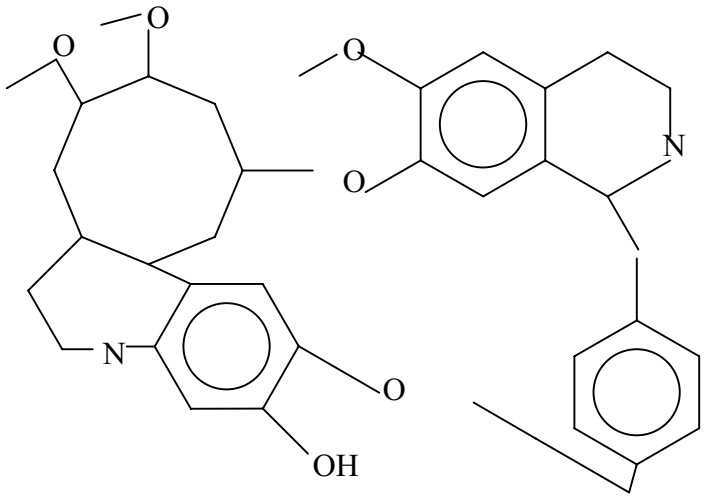


Fig 2.17 Structure of Berbamine

Betonicine

Source:
Molecular formula: $C_{17}\ H_{13}\ N\ O_3$.
Molecular weight: 159.21.

Melting point: 254 deg C.
Biological activity: Heamostatic.

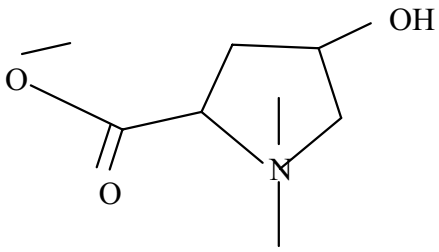


Fig 2.18: Structure of Betonicine

Bicuculline

Source: Corydalis species.
Molecular formula: C_{20} H_{17} N O_6.
Molecular weight: 367.2.
Melting point: 192-196 deg C.
Solubility:
A. Soluble in benzene and ethyl acetate.
B. Insoluble in water.
Biological activity: Convulsant.

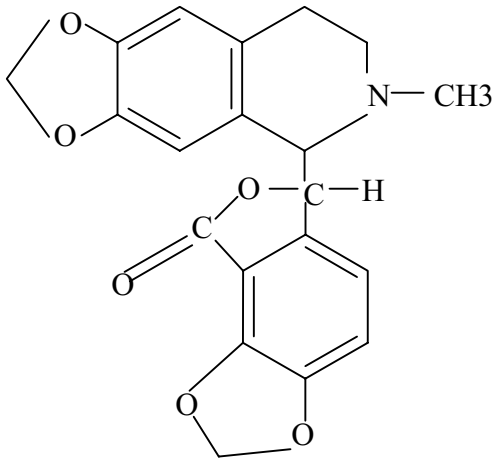


Fig 2.19: Structure of Bicuculline

Brucine

Source: Strychnos nux vomica.
Molecular formula: C_{23} H_{25} N_2 O_4.
Molecular weight: 395.
Melting point: 178 deg C.

Solubility:
A. Soluble in alcohol.
B. Slightly soluble in water.
Physical form: Brucine is a crystalline alkaloid, having weak bitter taste.
Biological activity: Local anaesthetic.
Salts: Brucine dihydrate.
Brucine sulphate hepahydrate.
Brucine tetrahydrate.

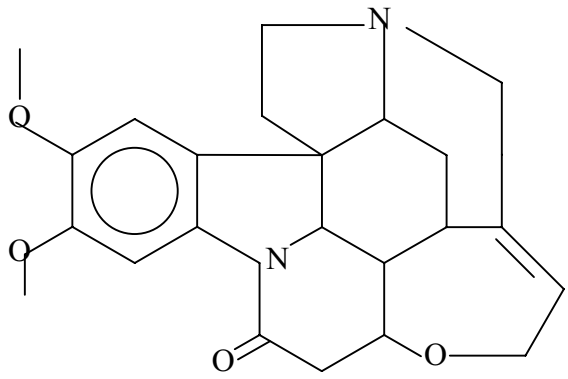


Fig 2.20: Structure of Brucine

Boldine

Source: Boldoa fragrans.
Molecular formula: $C_{21}H_{25}NO_4$.
Molecular weight: 355.
Biological activity: Expectorant.

Bufotenine

Source: Mucuna pruriens
Molecular formula: $C_{12}H_{16}N_2O$.
Biological activity: Cholinesterase inhibitor & hallucinogenic.

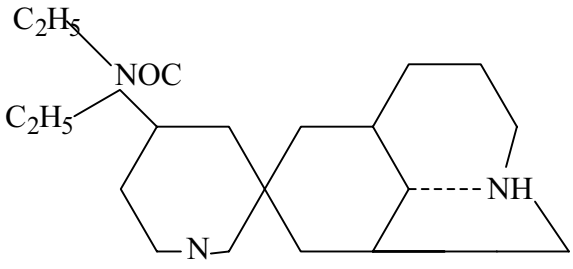


Fig 2.21: Structure of Bufotenine

Caffeine

Source: Camellia sinensis.
Molecular formula: $C_8 H_{10} O_2 N_4$, H20.
Molecular weight: 194.19.
Solubility:
A. Soluble in alcohol and water.
Physical form: Colourless, silky, inodorous, acicular crystals.
Biological activity: Central nervous system stimulant.

Campthothecin & Topotecan

Source: Camptotheca acuminata.
Biological activity: Anticancer.

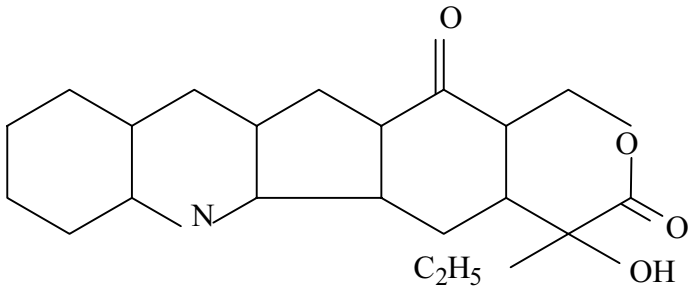


Fig 2.22 : Structure of Camptothecin

Canavanine

Source: Canavalia ensiformis.
Molecular formula: $C_{15} H_{12} N_2 0_4$.
Molecular weight: 176.21.
Biological activity: Anticancer.

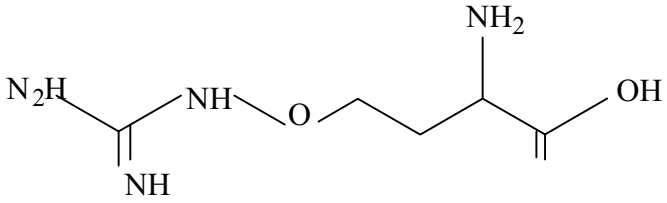


Fig 2.23: Structure of Canavanine

Carpaine

Source: Carica papaya.
Molecular formula: $C_{28} H_{50} N_2 0_4$.
Molecular weight: 478.80.
Melting point: 120 deg C.
Biological activity: Action like digitalis?

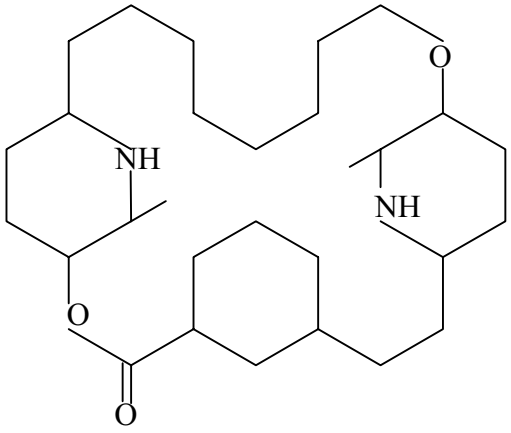


Fig 2.24 : Structure of Carpaine

Cathine
Source: Caltha edulis.
Molecular formula: $C_9 H_{13} N O$.
Molecular weight: 151.21.
Biological activity: Analeptic & bronchodilator.

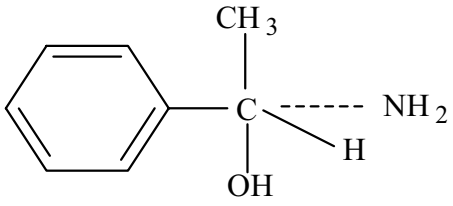


Fig 2.25: Structure of Cathine

Cathionine
Source: Caltha edulis.
Molecular formula: $C_9 H_{11} N O$.

Molecular weight: 149.19.
Biological activity: Analeptic & bronchodilator.

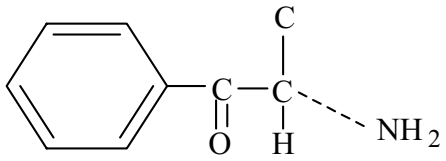


Fig 2.26: Structure of Cathionine

Cephaline

Source: Cephalis ipecacuanha.
Molecular formula: $C_{28}H_{38}N_2O_4$.
Biological activity: Antiamoebic.

Chelerythrine

Source: Sanguinaria canadensis.
Molecular formula: $C_{21}H_{18}NO_4$.
Molecular weight: 348.40
Biological activity: Narcotic.

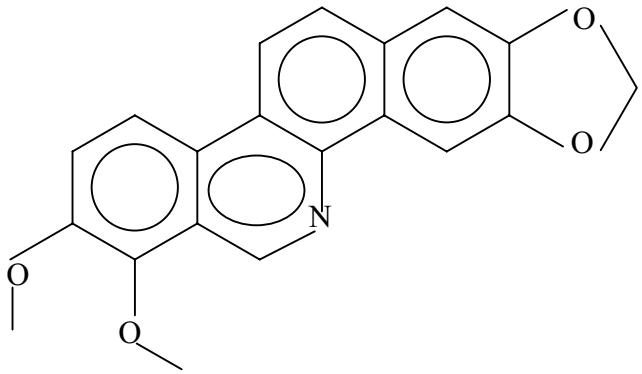


Fig 2.27: Srtucture of Chelerythrine

Cocaine

Source: Erythroxylon coca.
Molecular formula: $C_{17}H_{21}NO_4$.

Molecular weight: 149.19.
Solubility:
A. Insoluble in water.
B. Soluble in alcohol, ether and olive oil.
Physical form: Colorless alkaloid with monoclinic prisms. It has slight bitter taste.
Biological activity: Anaesthetic.

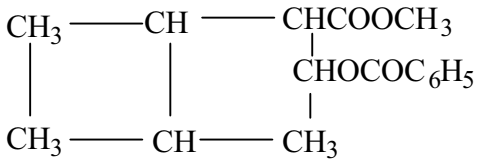


Fig 2.28: Structure of Cocaine

Codeine

Source: Papaver somniferum.
Molecular formula: $C_{18} H_{21} N O_3$.
Molecular weight: 299.40.
Melting point: 155 deg C.
Solubility:
A. Soluble in chloroform and ether.
B. Physical form: Colorless, odourless, bitter alkaloid having rhombic prisms.
Biological activity: Antitussive.

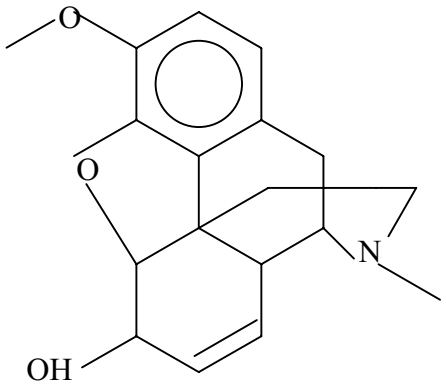


Fig 2.29 : Structure of Codeine

Colchicine

Source: Colchicum leuteum & C. autmnale.
Molecular formula: $C_{22}H_{25}NO_6$.
Molecular weight: 399.48.
Melting point: 142-150 deg C.
Solubility:
A. Insoluble in water.
Physical form: White colored crystalline alkaloid.
Biological activity: Anti gout.

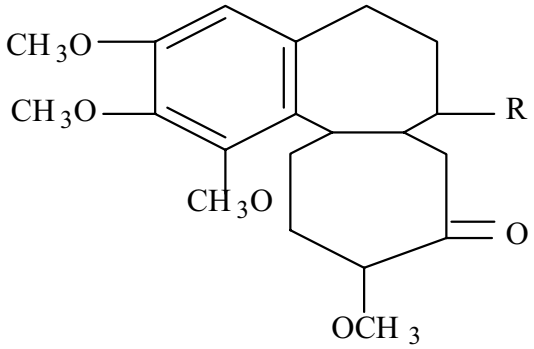


Fig 2.30: Structure of Colchicine

Conessine

Source: Halorrhena antidysenterica.
Molecular formula: $C_{24}H_4N_2O$.
Molecular weight: 356.6.
Melting point: 123 deg C.
Solubility:
A. Soluble in water and dilute acids.
Biological activity: Ameobicidal.

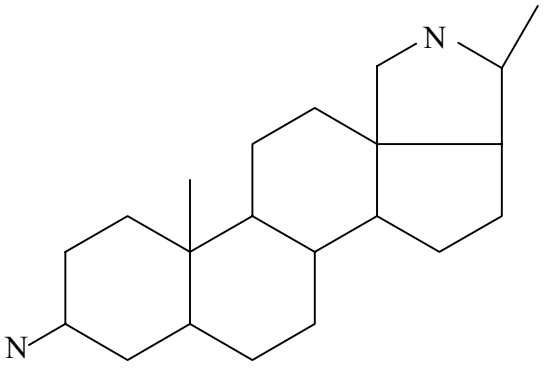


Fig 2.31 : Structure of Conessine

Conine

Source: Conium maculatum.
Molecular formula: $C_8H_{16}HN$.

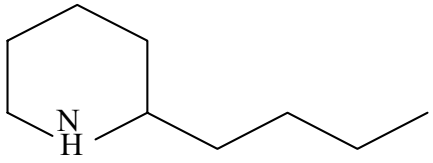


Fig 2.32 : Structure of Conine

Convolamine

Source: Convolvulus species.
Molecular formula: $C_{17}H_{23}NO_4$.
Molecular weight: 305.
Melting point: 114-115 deg C.
Solubility:
A. Soluble in acetone and ethanol.
Biological activity: Anaesthetic.

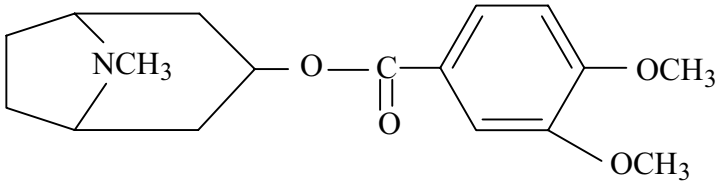


Fig 2.33: Structure of Convolamine

Convolvine

Source: Convolvulus species.
Molecular formula: $C_{16}H_{21}NO_4$.
Molecular weight: 291.
Melting point: 114-115 deg C.
Solubility:
A. Soluble in acetone, methanol and ethanol.
Biological activity: Anaesthetic.

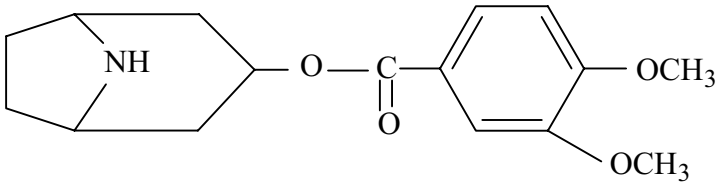


Fig 2.34: Structure of Convolivne

Corycavine

Source: Corydalis tuberosa.
Molecular formula: $C_{21} H_2 N O_5$.
Molecular weight: 357.43.
Melting point: 218 deg C.
Solubility:
Biological activity: Antihelmintic.

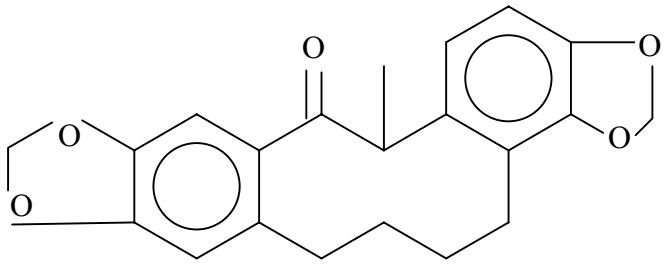


Fig 2.35: Structure of Corycavine

Corydaline

Source: Corydalis govaniana.
Molecular formula: $C_{22} H_{27} N O_4$.
Molecular weight: 369.5.
Melting point: 135 deg C.
Biological activity: Antiperiodic.

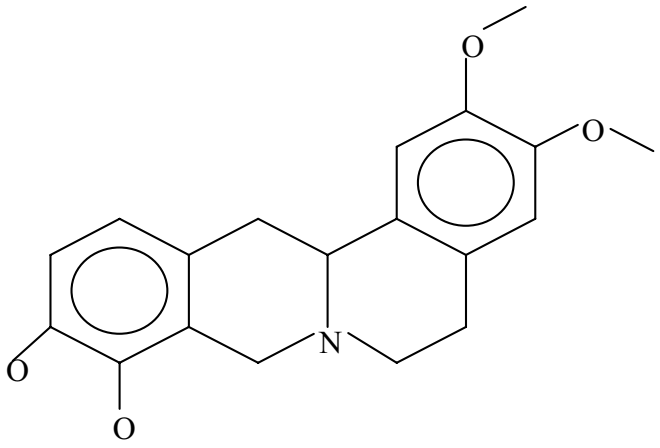


Fig 2.36 : Structure of Corydaline

Coptine

Source: Coptis teeta.
Molecular formula: C_{19} H_4 N O_4.
Molecular weight: 320.34.
Physical form: Colourless alkaloid with slight bitter taste.
Biological activity: Antiperiodic.

Cryptolepine

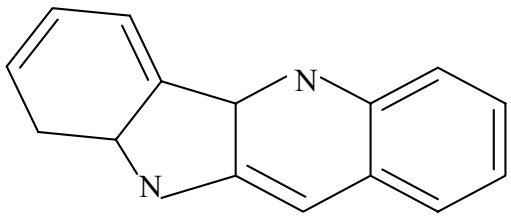


Fig 2.37: Structure of Cryptolepine

Cuscohygrine

Source: Withania somnifera.
Molecular formula: C_{13} H_{24} N_2O.
Molecular weight: 224.39.
Boiling point: 169 deg C.

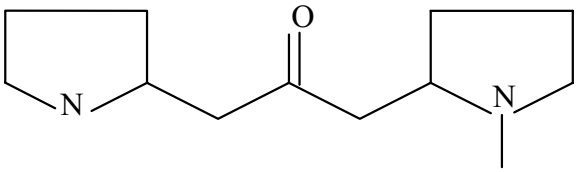


Fig 2.38 : Structure of Cuscohygrine

Daturine

Source: Datura alba, D.innoxia.
Molecular formula: $C_{17} H_{23} N O_4$.
Molecular weight: Not confirmed.
Melting point: Not confirmed
Biological activity: Not confirmed.

Delphinine

Source: Delphinium denudatum, Delphinium staphisagra.
Molecular formula: $C_{31} H_{49} N O_7$.
Molecular weight: Not confirmed.
Melting point: 191 deg C.
Solubility:
A. Highly soluble in alcohol, ether and chloroform.
B. Insoluble in water.
Physical form: Amorphous, yellow crystals.
Biological activity: Not confirmed.

Desoxypeganine

Source: Peganum harmala.
Molecular formula: $C_{11} H_{12} N_2$.
Molecular weight: 244.7.
Melting point: 225-226 deg C.
Solubility:
A. Soluble in alcohol and water.
B. Insoluble in acetone.

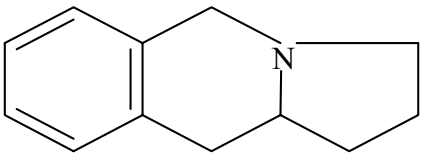


Fig 2.39: Structure of Desoxypeganine

Ditamine

Source: Alstonia scholaris.
Molecular formula: $C_{16} H_{19} N O_2$.
Melting point: 75 deg C.
Biological activity: Antimalarial?

Donaxine

Source: Arundo donax.
Molecular formula: Not confirmed.
Molecular weight: 174.
Melting point: 138-139deg C.
Solubility:
A. Soluble in alcohol and chloroform.
Biological activity: Acetylcholinsterase inhibitor.

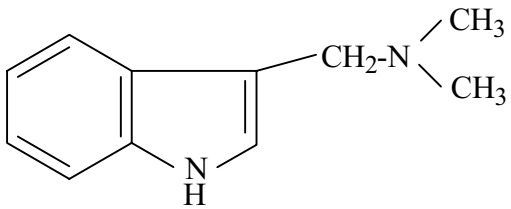


Fig 2.40 : Structure of Donaxine

Dubiosine

Source: Duboisia species.
Molecular formula: Not confirmed.
Molecular weight: Not confirmed.
Melting point: Not confirmed.
Biological activity: Mydriatic.

Ecliptine

Source: Eclipta alba.
Molecular formula: Not confirmed.
Molecular weight: Not confirmed.
Melting point: Not confirmed.
Biological activity: Hepatoproctetive?

Echitamine

Source: Alstonia scholaris.
Molecular formula: $C_{22} H_{29} N_2 O_4$.
Molecular weight: 383.53.
Melting point: Not confirmed.
Biological activity: Not confirmed.

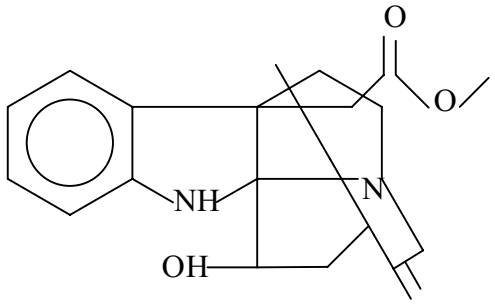


Fig 2.41: Structure of Echitamine

Elymoclavine

Source: Ipomoea nil.
Molecular formula: $C_{16} H_{18} N_2 O$.
Molecular weight: 255.3.
Melting point: 252 deg C.
Biological activity: Not confirmed.

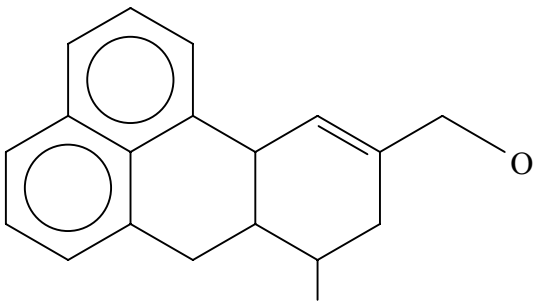


Fig 2.42 Structure of Elymoclavine

Ellipticine

Source: Ochrosia elliptica.
Biological activity: Anti cancer.

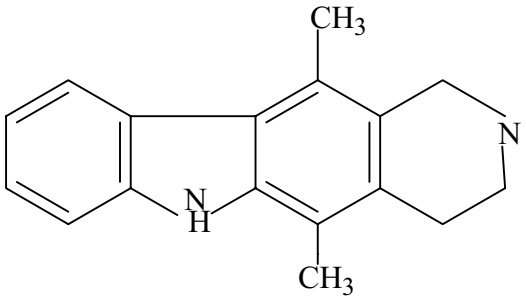


Fig 2.43 : Structure of Ellipticine

Emetine

Source: Cephalis ipecacuanha.
Molecular formula: $C_{28}H_{27}(CH_3)N_2O_4$.
Biological activity: Antiamoebic.

Ephedrine

Source: Ephedra sinica.
Solubility:
A. Soluble in water and alcohol.
Biological activity: Bronchodilator.

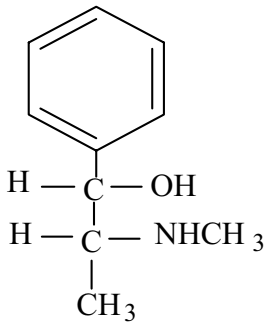


Fig 2.44: Structure of Ephedrine

Ergotamine

Source: Claviceps purpurea.
Solubility:
A. Soluble in alcohol and mineral acids.
Physical from: Colourless crystals, which become brown on exposure to light.
Biological activity: Ecbolic.

Fumarine

Source: Fumaria officinalis.
Biological activity: Cholagouge.

Galantamine

Source: Galanthus nivalis.
Molecular Formula: $C_{17}H_{21}NO_3$.
Molecular Weight: 368.27
Physical from: White Powder.
Biological activity: Cholinesterase inhibitor

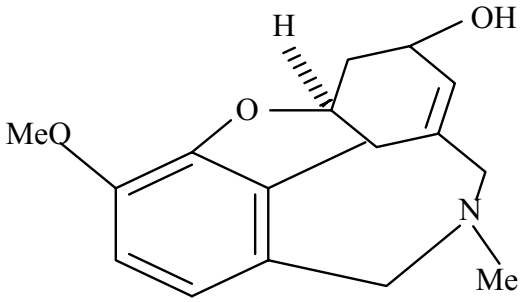


Fig 2.45: Structure of Galantamine

Graveoline

Source: Ruta graveolans (Rutaceae).
Molecular formula: $C_{17}H_{33}NO_3$.
Molecular weight: 279.
Melting point: 187-188 deg C.
Solubility:
A. Soluble in hot alcohol and chloroform.

Biological activity: Central nervous system (C.N.S) stimulant.

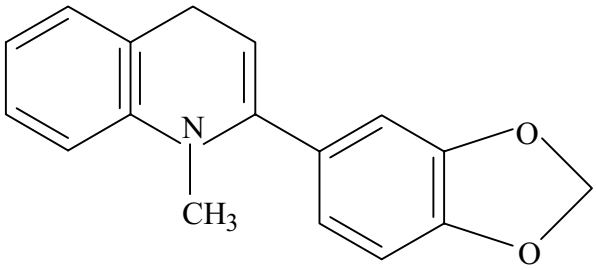


Fig 2.46: Structure of Graveoline

Grindelin

Source: Grindelia robusta.
Biological activity: Bronchodilator.

Gelsemine

Source: Gelsemium semepervirens.
Molecular formula: $C_{20}H_{22}N_2O_2$.
Molecular weight: 325.
Melting point: 178 deg C.
Biological activity: Convulsant.

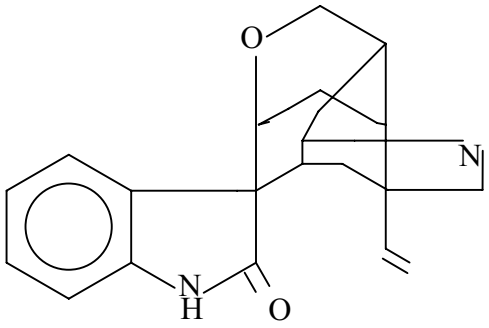


Fig 2.47: Structure of Gelsemine

Gelsiminine

Source: Gelsemium semepervirens.
Molecular formula: $C_{20}\ H_{22}\ N_2\ O_2$.
Molecular weight: 322.14.
Melting point: 178 deg C.
Biological activity: Convulsant.

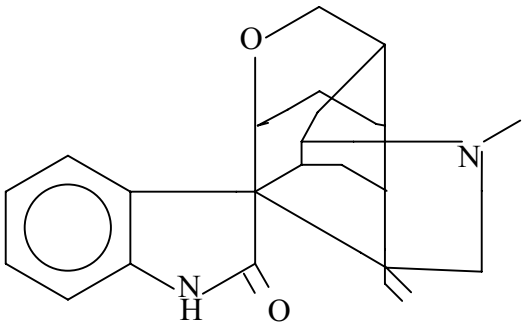


Fig 2.48: Structure of Gelseminine

Harmaline

Source: Peganum harmala.
Molecular formula: $C_{13}\ H_{14}\ N_2O$.
Molecular weight: 214.29.
Melting point: 250 deg C.

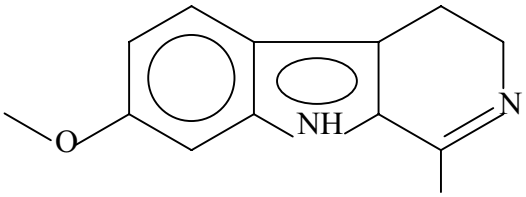


Fig 2.49 : Structure of Harmaline

Harmine

Source: Peganum harmala.
Molecular formula: $C_{13}\ H_{12}\ N_2O$.
Molecular weight: 212.27.
Melting point: 257 deg C.

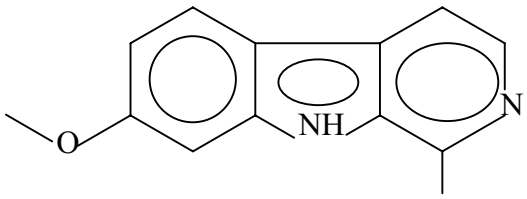


Fig 2.50 : Structure of Harmine

Hetisine

Source: Aconitum heterophyllum.
Molecular formula: C_{20} H_{27} N O_3.HCL.
Molecular weight: 365.
Melting point: 290 deg C.
Solubility:
A. Soluble in water.
Biological activity: The alkaloid has shown antiarrhytmic activity in animal models.

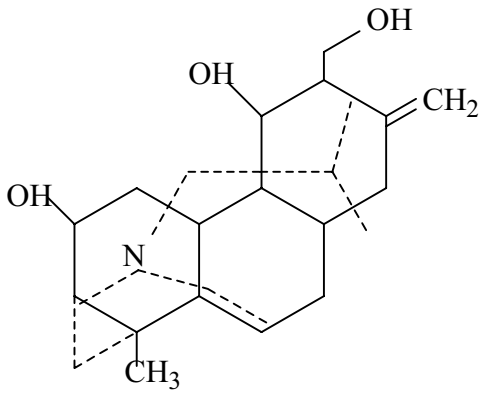


Fig 2.51: Structure of Hetisine

Hetratisine

Source: Aconitum heterophyllum.
Molecular formula: C_{22} H_{33} N O_5.
Molecular weight: 391.
Melting point: 259-260 deg C.
Solubility:
A. Soluble in chloroform and methanol.
B. Partially soluble in acetone and ethanol.
Biological activity: The alkaloid has shown antiarrhytmic activity in animal models.

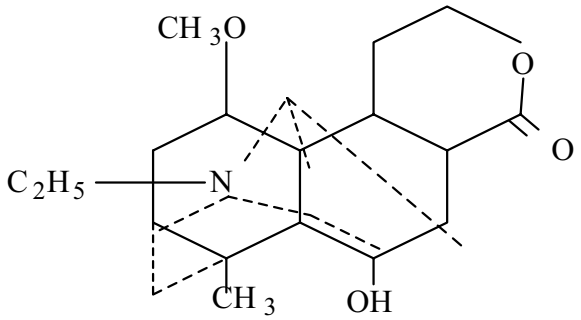


Fig 2.52: Structure of Heteratisine

Homoharringtonine

Source: Cephalotaxus fortunei.
Molecular formula: C_{29} H_{39} N O_9.
Molecular weight: 545.62.
Melting point: 125-132 deg C.
Biological activity: Antileukemic.

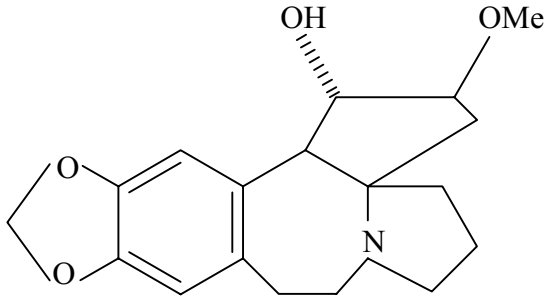


Fig 2.53: Structure of Homoharringtonine

Huperzine

Source: Huperzine serrata.
Molecular formula: C_{15} H_{18} O_6.
Molecular weight: 242.3.
Solubility:
A Soluble in ethanol.
Physical form: Brown powder having peculiar odour.
Biological activity: The alkaloid has potent gabaergic antagonist activity

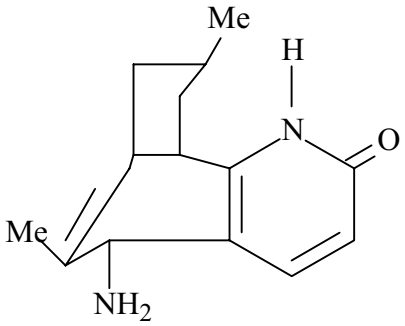


Fig 2.54 : Structure of Huperzine

Hydrastine

Source: Hydrastis canadensis.
Molecular formula: $C_{21}H_{21}O_6$.
Molecular weight: 383.39.
Melting point: 125-132 deg C.
Solubility:
A Soluble in chloroform.
B. Slightly soluble in methanol and ethanol.
C. Insoluble in water.
Biological activity: The alkaloid has potent gabaergic antagonist activity.

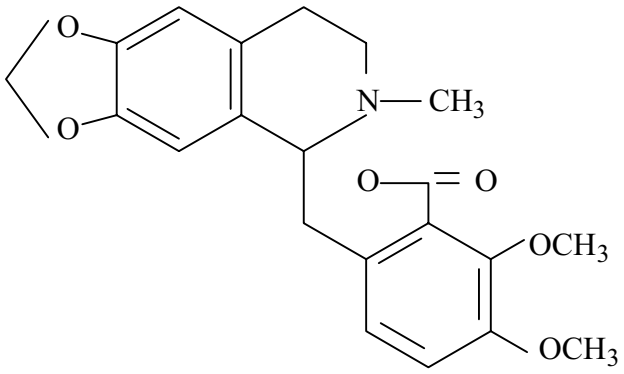


Fig 2.55: Structure of Hydrastine

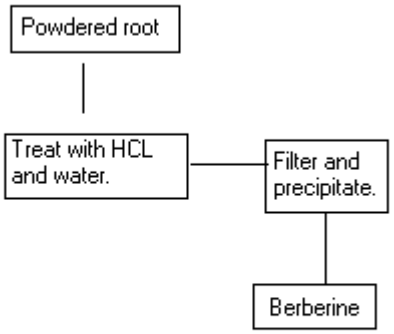


Fig 2.56: Flow sheet for berberine isolation.

Hygrine

Source: Withania somnifera.
Molecular weight: 225.
Boiling point: 169.

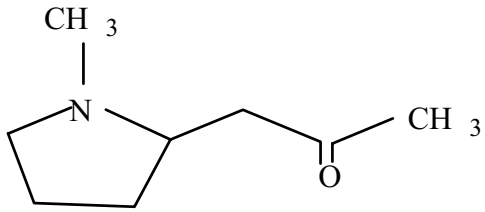


Fig 2.57: Structure of Hygrine

Hyoscine

Source: Hyoscyamus niger.
Molecular formula: C_{17} H_{21} N O_4.
Molecular weight: 303.39.

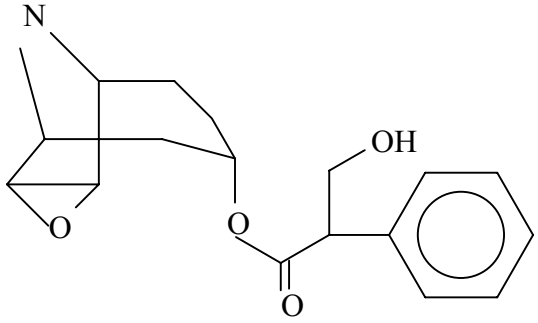


Fig 2.58: Structure of Hyoscine

Hyoscyamine

Source: Hyoscyamus niger.
Molecular formula: C_{17} H_{23} N O_3.
Molecular weight: 289.41.
Biological activity: Antispasmodic.

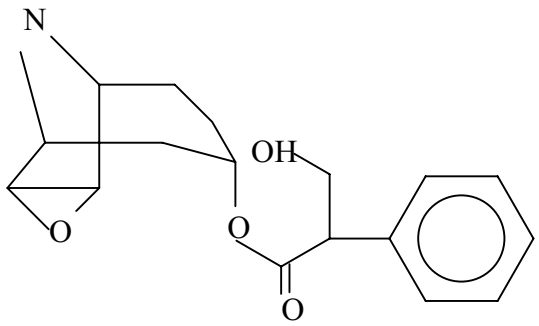


Fig 2.59: Structure of Hyoscyamine.

Ibogaine

Source: Terbernanthe iboga.
Biological activity: Hallucinogen.

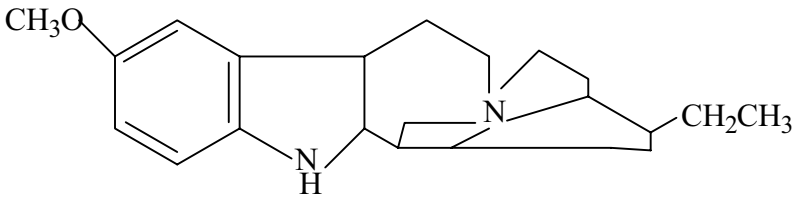


Fig 2.60: Structure of Ibogaine.

Indicine

Source: Helitropium indicum.
Molecular formula: C_{15} H_{25} N O_5.
Molecular weight: 299.41.
Melting point: 98 deg C.
Biological activity: Hepatotoxic.

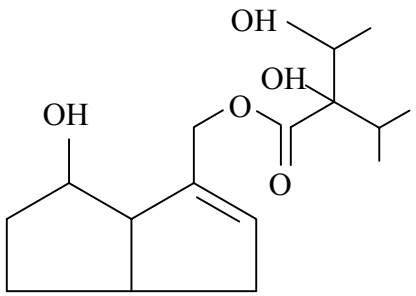


Fig 2.61: Structure of Indicine.

Kavain

Source: Piper methysticum.
Molecular formula: $C_{14}H_{14}O_3$.
Molecular weight: 230.26.

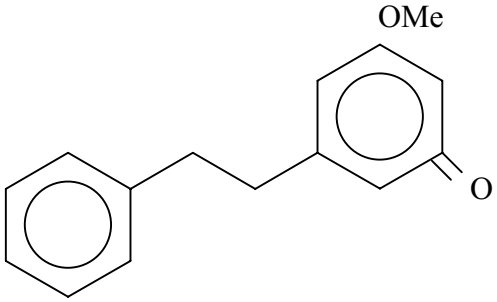


Fig 2.62: Structure of Kavain.

Laurotetanine

Source: Litsoea sabifera.
Molecular formula: $C_{19}H_{21}NO_4$.
Molecular weight: 327.41.
Melting point: 125 deg C.

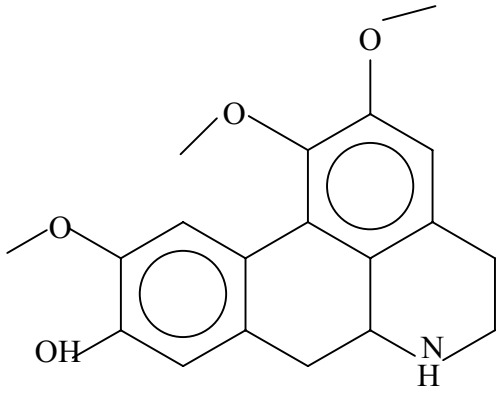


Fig 2.63: Structure of Laurotetanine

Lobeline

Source: Lobelia inflata.
Molecular formula: $C_{22}H_{27}NO_2$.
Molecular weight: 337.50.
Melting point: 131 deg C.
Biological activity: Narcotic.

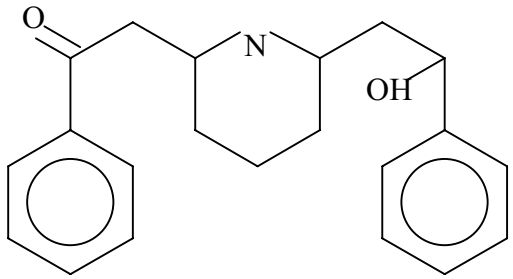


Fig 2.64: Structure of Lobeline

Magnolin

Source: Magnolia glauca.
Molecular formula: $C_{23}H_{28}O_7$.
Molecular weight: 416.5.
Melting point: 97 deg C.
Solubility:
A. Soluble in ether.

B. Insoluble in water.

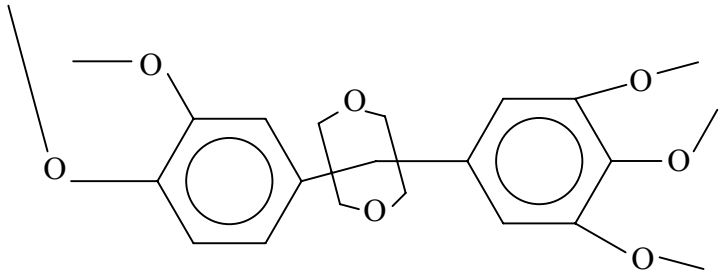


Fig 2.65: Structure of Magnolin

Mescaline

Source: Lophophora diffusa, Trichocerus species.
Molecular formula: $C_{11}H_{17}NO_3$.
Biological activity: Stimulant.

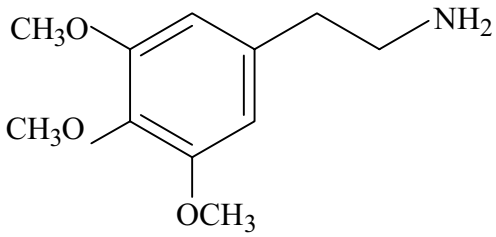


Fig 2.66:Structure of Mescaline

Michellamine-B

Source: Ancistrocladus korupensis
Molecular formula: $C_{46}H_{48}N_2O_8$.
Biological activity: Anti HIV.

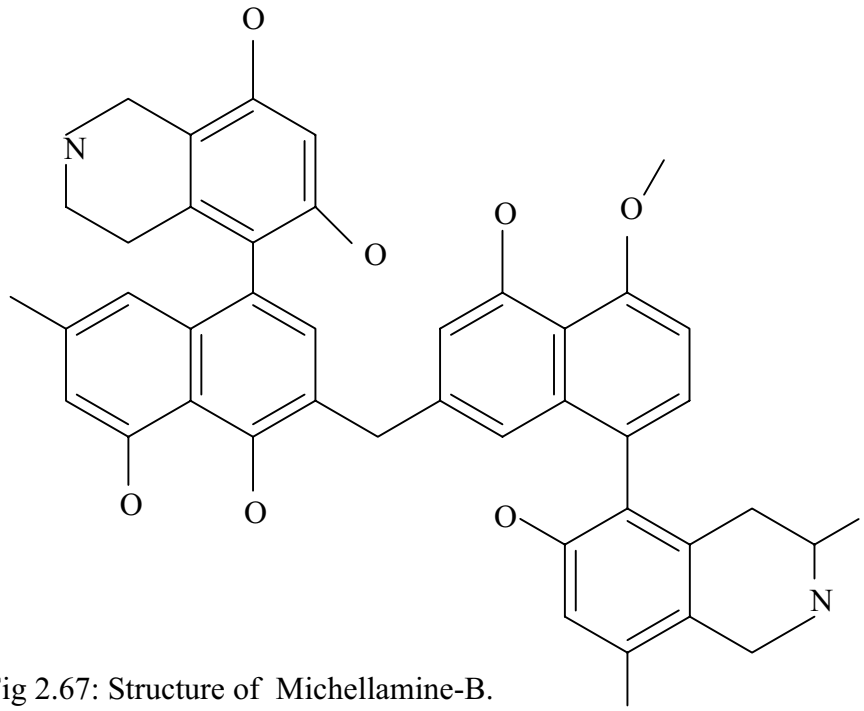


Fig 2.67: Structure of Michellamine-B.

Mitragynine

Source: Mitragyna cilita.
Biological activity: Analgesic.

Momordicine

Source: Momordica charnatia.
Molecular formula: $C_{36}H_{58}O_8$.
Biological activity: Anti diabetic.

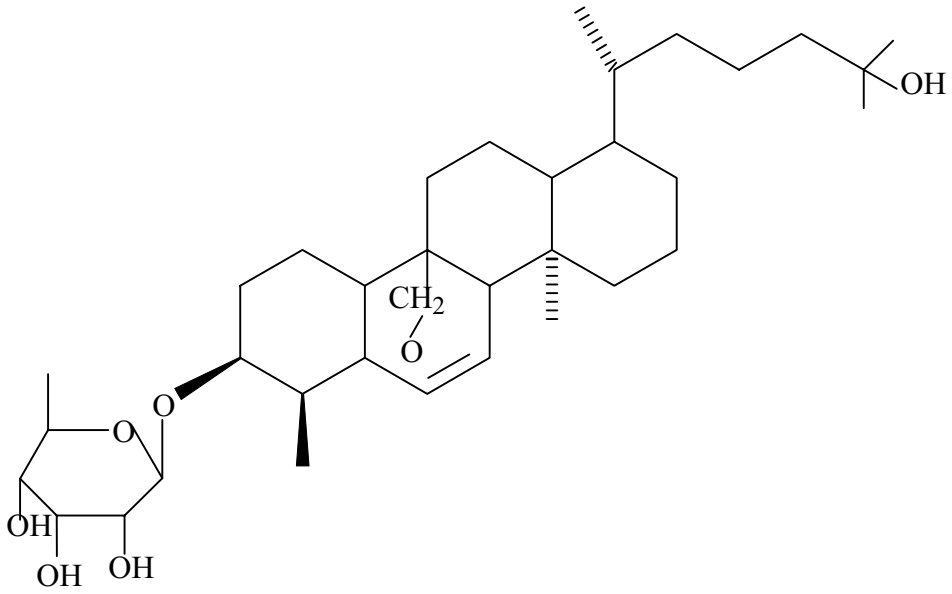


Fig 2.68: Structure of Momordicine

Monocrotaline

Source: Crotolaria retusa.
Molecular formula: C_{18} H_{25} N O_5.
Molecular weight: 335.44.
Melting point: 232-233 deg C.

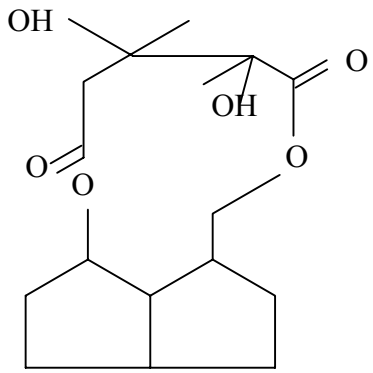


Fig 2.69: Structure of Monocrotaline

Morphine

Source: Papaver somniferum.
Molecular formula: C_{17} H_{19} N O_3.

Molecular weight: 285.37.
Melting point: 154-156 deg C.
Solubility:
A. Soluble in hot alcohol.
B. Insoluble in water and ether.
Biological activity: Narcotic analgesic.

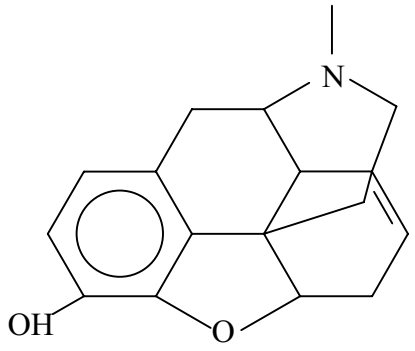


Fig 2.70: Structure of Morphine

Narceine

Source: Papaver somniferum.
Molecular formula: $C_{23}H_{27}NO_8$.
Molecular weight: 445.
Melting point: 145 deg C.
Solubility:
A.Soluble in water and alcohol.
B.Insoluble in ether.
Physical form: White, bitter crystalline alkaloid.
Biological activity: Hypnotic.

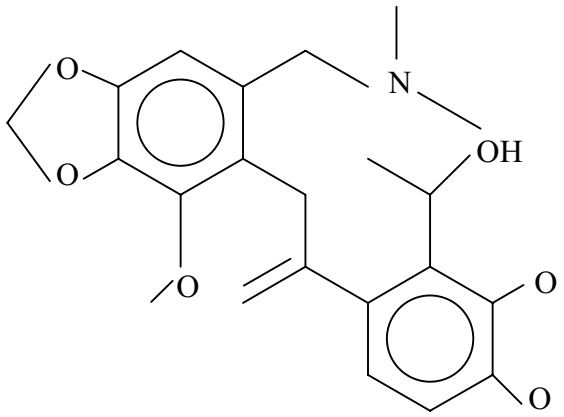


Fig 2.71: Structure of Narcine

Narcotine

Source: Papaver somniferum.
Molecular formula: $C_{23}H_{23}NO_7$.
Molecular weight: 413.46.
Melting point: 176 deg C.
Solubility:
A Soluble in chloroform, ether and alcohol.
B. Insoluble in water.
Physical form: Odorless, white, crystalline alkaloid.
Biological activity: Hypnotic.

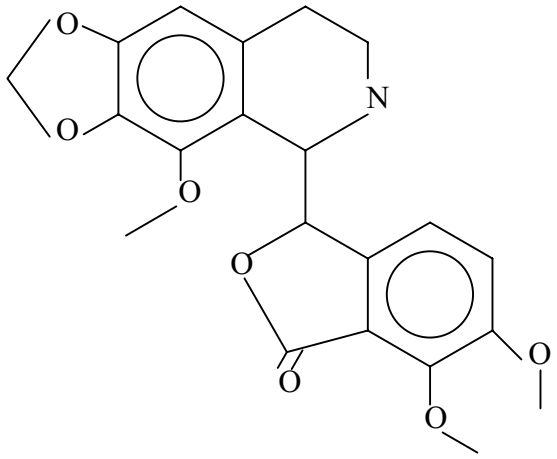


Fig 2.72: Structure of Narcotine

Napelline

Source: Aconitum ferox.
Molecular formula: C_{22} H_{33} N O_3.
Molecular weight: 359.
Melting point: 162-164 deg C.
Solubility:
A. Highly soluble in acetone and methanol.
B. Moderately soluble in ether.
Physical form: Yellow crystalline powder.
Biological activity: Antiarrhymtic agent.

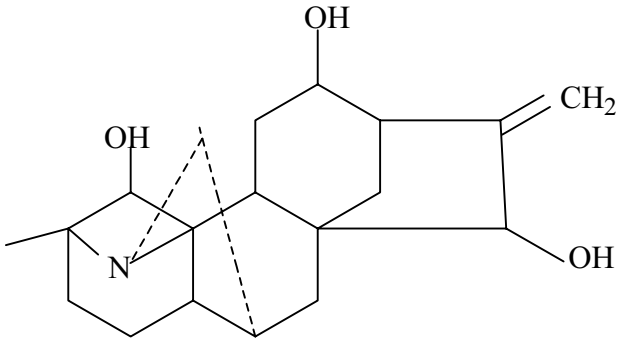


Fig 2.73: Structure of Napelline

Note: Estimation of the alkaloid is done by Mayer's reagent and it corresponds to 0.038 gm of napelline to 1c.c of the reagent.

Nicotine

Source: Nicotina tabaccum.
Molecular formula: C_6 H_5 N O_2.
Molecular weight: 123.12.
Melting point: 236 deg C.

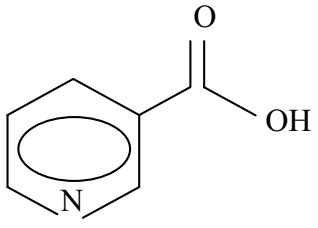


Fig 2.74: Structure of Nicotine

Nitidine

Source: Toddalia asiatica.
Biological activity: Anti AIDS.

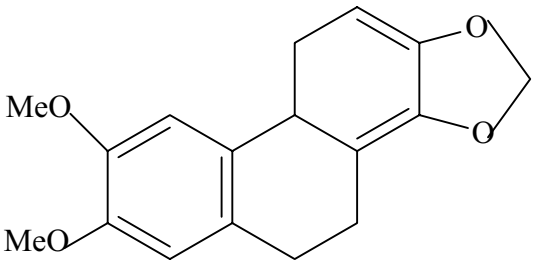


Fig 2.75: Structure of Nitidine

Noscapine

Source: Papaver somniferum.
Molecular formula: C_{23} H_{23} N O_7.
Molecular weight: 413.14.
Melting point: 175-176 deg C.
Solubility:
A Soluble in chloroform.
B. Insoluble in water.
Biological activity: Antitussive.

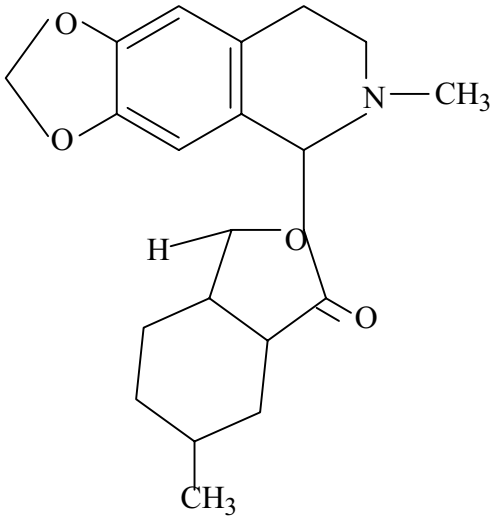


Fig 2.76: Structure of Noscapine

Oleanderin

Source: Nerium odorum.
Molecular formula: C_{32} H_{48} O_9.
Molecular weight: 576.80.
Melting point: 250 deg C.

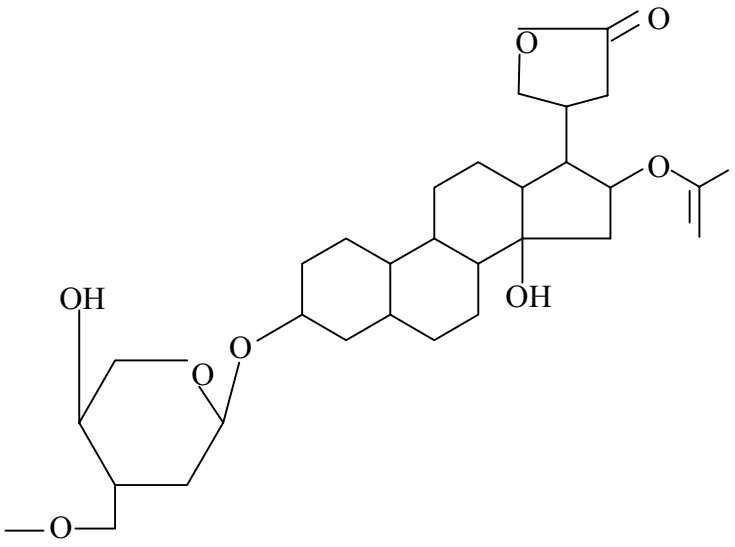


Fig 2.77: Structure of Oleandrin.

Oroxylin

Source: Oroxylum indicum.
Molecular formula: C_{13} H_{24} N_2O.
Molecular weight: 284.39.
Melting point: 232 deg C.

Oxycanthine

Source: Berberis aristata.
Molecular formula: C_{37} H_{40} N_2 O_6.
Molecular weight: 608.79.

Melting point: 208-214 deg C.

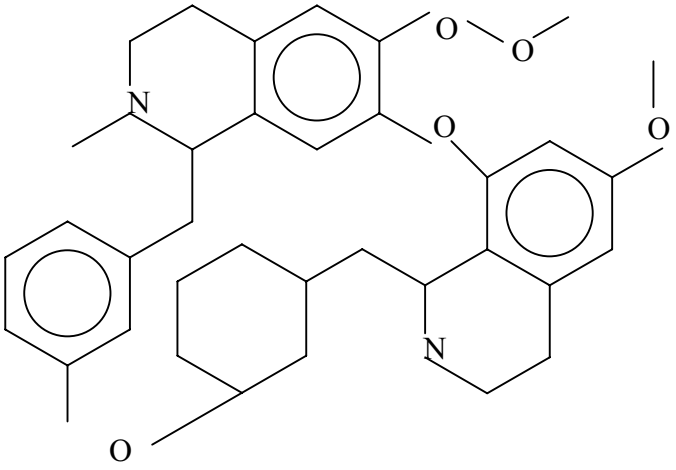


Fig 2.78: Structure of Oxycanthine

Papaverine

Source: Papaver somniferum.
Molecular formula: C_{20} H_{21} N O_4.
Molecular weight: 339.42.147.
Melting point: 147 deg C.
Solubility:
A Insoluble in chloroform.
B. Slightly soluble in alcohol and ether.
Biological activity: Narcotic and antispasmodic.

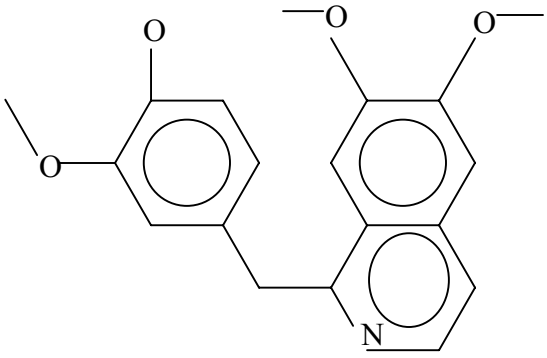


Fig 2.79: Structure of Papaverine

Peadalin

Source: Papaver somniferum.
Molecular formula: C_{23} H_{23} N O_7.
Molecular weight: 413.14.
Melting point: 175-176 deg C.

Solubility:
A Soluble in chloroform.
B. Insoluble in water.

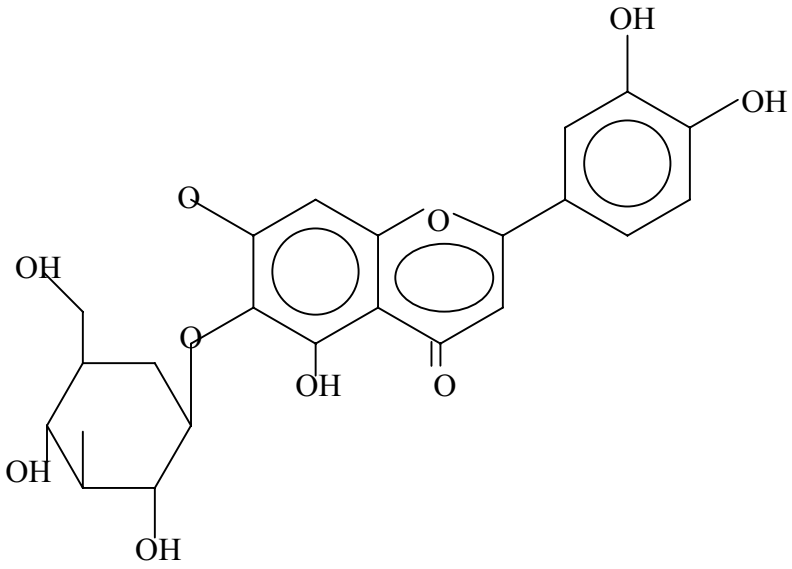


Fig 2.80: Structure of Peadalin

Pelosine

Source: Cissampelos pareira.
Molecular formula: $C_{37}\ H_{38}\ N_2\ O_6$.
Molecular weight: 606.77.
Melting point: 213 deg C.
Solubility:
A Freely soluble in acetone and alcohol.
B. Sparingly soluble in carbon disulphide.
C. Insoluble in water.
Physical form: Pelosine is an amorphous alkaloid.

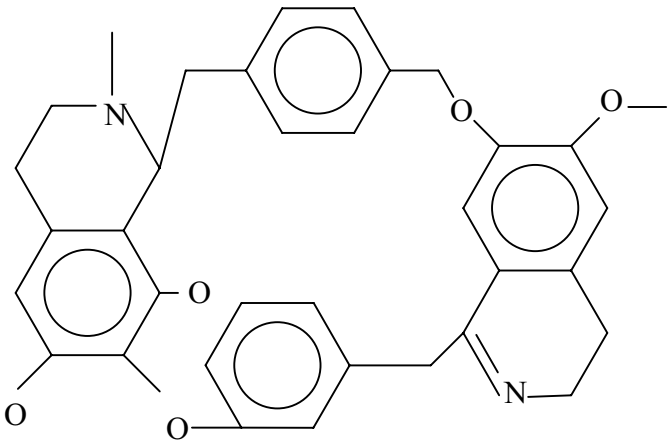
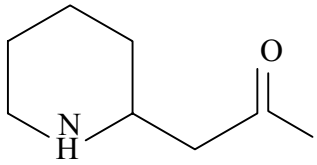


Fig 2.81: Structure of Pelosine.

Pelletrine

Source: Punica granatum.
Molecular formula: $C_8 H_{15} N O$.
Molecular weight: 141.24.
Boiling point: 91 deg C.
Biological activity: Antihelmenetic.



2.82: Structure of Pelletrine

Pinitol

Source: Punica granatum.
Molecular formula: $C_7 H_{14} O_6$.
Molecular weight: 194.21.
Boiling point: 186 deg C.
Biological activity: Antidiabetic.

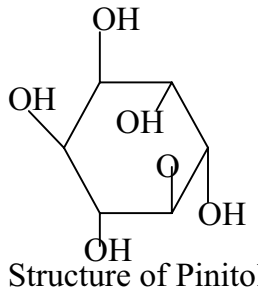


Fig 2.83: Structure of Pinitol

Protopine

Source: Papaver somniferum.
Molecular formula: $C_{20} H_{19} N O_5$.
Molecular weight: 389.65.
Solubility: Slightly soluble in water.
Biological activity: Calcium channel blocker and antiplatelet agent.

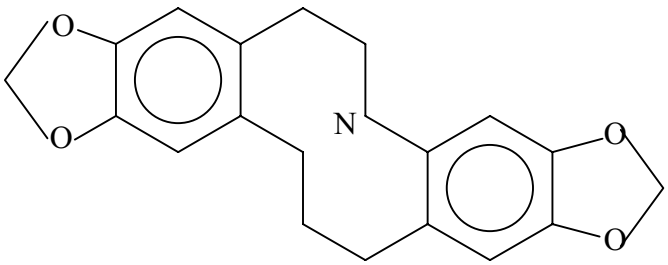


Fig 2.84: Structure of Protopine

Phyllanthin

Source: Phyllanthus niruri, P.urinaria.
Biological activity: Not confirmed.

Physalin

Source: Physalis minima.
Molecular formula: C_{28} H_{30} O_{10}.
Molecular weight: 526.58.
Melting point: 266 deg C.

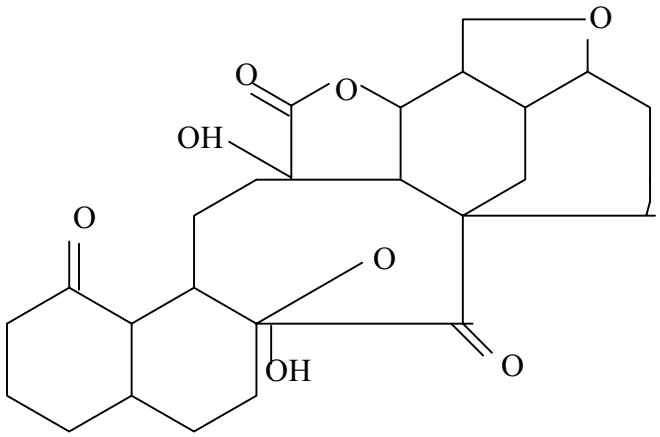


Fig 2.85: Structure of Physalin

Physostigmine (Eserine)

Source: Physostigma venenosum.
Molecular formula: C_{15} $H_{21}O_2$ N_3.
Physical form: Colorless or faintly yellow crystals, which become red on exposure to air and light.
Solubility:
A. Soluble in water and alcohol.
Biological activity: Cholinesterase inhibitor.

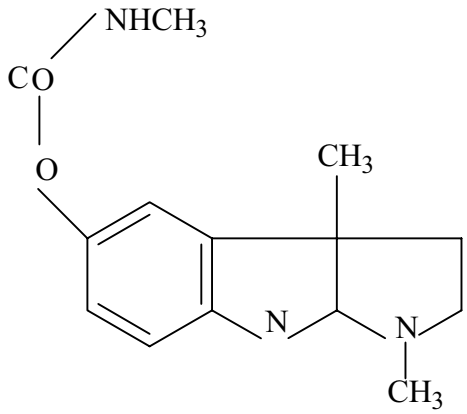


Fig 2.86:Structure of Physostigmine

Piperidine

Source: Piper nigrum.
Molecular formula: $C_5 H_{11} N$.
Molecular weight: 85.1 7.
Melting point: 8 deg C.
Solubility:
A. Readily soluble in water.
Biological activity: Antihelmintic.

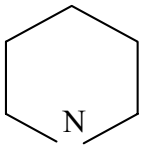


Fig 2.87: Structure of Piperidine

Piperine

Source: Piper nigrum.
Molecular formula: $C_{17} H_{19} NO_3$.
Molecular weight: 285.37.
Melting point: 129.5 deg C.
Solubility:
A. Soluble in alcohol, acetic acid and chloroform.
B. Slightly soluble in water.
C. Insoluble in water.
Physical form: Piperine is a feeble alkaloid, colorless, tasteless, odorless occurring in rhombic crystals.
Biological activity: Antipyretic.

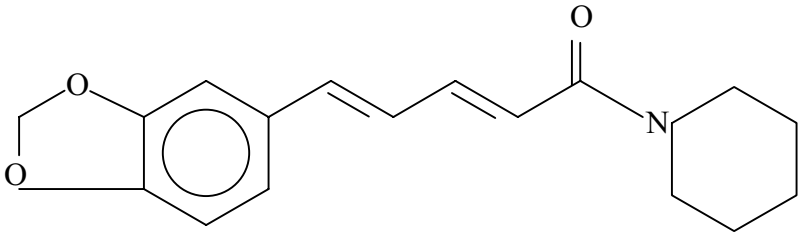


Fig 2.88: Structure of Piperine

Pseudochiratin

Source: Phyllanthus urinaria.
Biological activity: N.A.

Punarnavine

Source: Boehravia diffusa.
Biological activity: Diuretic.

Psilocin

Source:
Molecular formula: $C_{12}\ H_{16}\ N_2\ O$.
Molecular weight: 204.27.
Melting point: 173-176 deg C.

Psilocybin

Source:
Molecular formula: $C_{12}\ H_{17}\ N_2\ O\ P$.
Molecular weight: 284.25.
Melting point: 220-228 deg C.

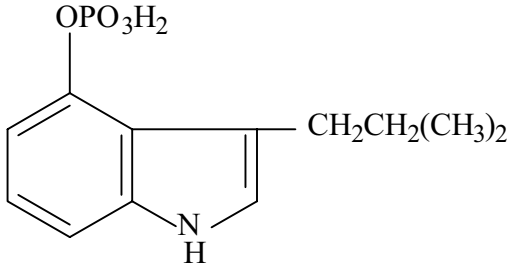


Fig 2.89 :Structure of Psilocybin.

Quinine

Source: Cinchona officinalis.
Molecular formula: $C_{20}H_{24}N_2O_2$.
Solubility:
A Soluble in ether and ammonia.
Physical form: White acicular crystals with bitter taste.
Biological activity: Antimalarial.

Quinidine

Source: Cinchona officinalis.
Molecular formula: $C_{20}H_{24}N_2O_2$.
Solubility:
A Soluble in ether and ammonia.
Biological activity: Antiarrthymic.

Rescinnamine

Source: Rawolfia serpentina.
Biological activity: Antihypertensive.

Ricinine

Source: Ricinus communis.
Molecular formula: $C_8H_8N_2O_2$.
Molecular weight: 164.16.
Melting point: 201 deg C.
Solubility:
A. Soluble in water, methanol and ethanol.
B. Less soluble in organic solvents.
Biological activity: Convulsant.

Rhynchophylline, Hirsutine & Mitraphylline

Rhynchophylline:
Source: Uncaria tomentosa.
Molecular formula: $C_{22}H_{28}N_2O_4$.
Molecular weight: 384.52.
Melting point: 216 deg C.
Biological activity: Antihypertensive.

Hirsutine:
Source: Uncaria tomentosa.
Molecular formula: $C_{22}H_{28}N_2O_3$.
Molecular weight: 368.52.

Melting point: 101 deg C.
Biological activity: Local anaesthetic.

Mitraphylline:

Source: Uncaria tomentosa.
Biological activity: Diuretic.

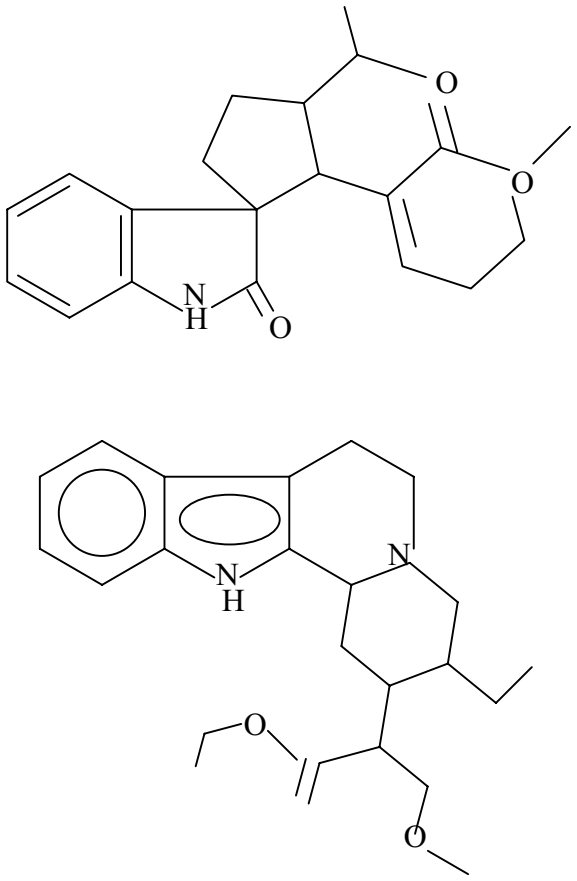


Fig 2.90: Structure of Rhynchophylline & Hirsutine

Salvinorin-A

Source: Salvia divinorum.
Molecular formula: C_{23} H_{28} O_8.
Molecular weight: 4328.46.
Biological activity: Anti addiction activity.

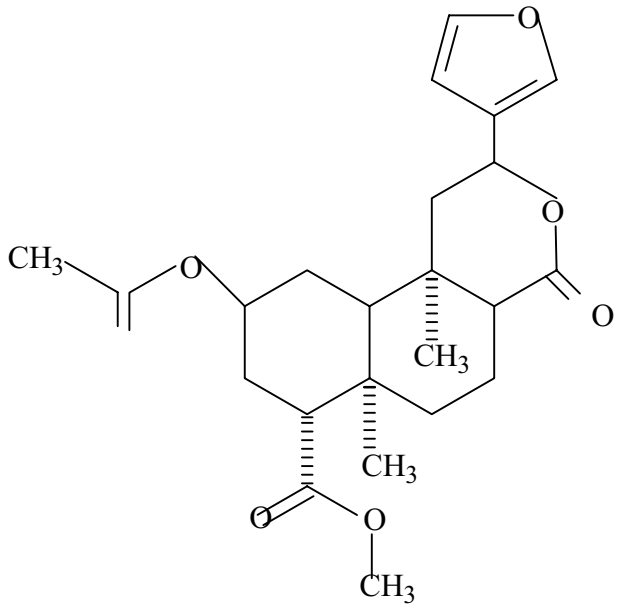


Fig 2.91: Structure of Salvinorin-A

Sanguinarine

Source: Sanguinarine canadensis.
Molecular formula: C_{20} H_{14}C N O_4.
Melting point: 242 deg C.
Biological activity: Antimicrobial.

Saussurine

Source: Saussurea lappa.
Biological activity: Antitubercular.

Scopolamine

Refer to Hyoscine.

Senecionine

Source: Crotolaria juncea.
Molecular formula: C_{18} H_{25} N O_5.
Molecular weight: 335.44.
Melting point: 232-3 deg C.
Biological activity: Antitumor.

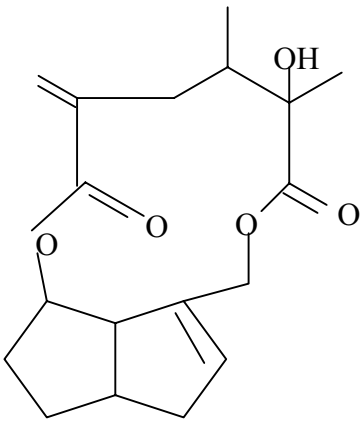


Fig 2.93: Structure of Senecionine

Solanine

Source: Solanum nigrum.
Molecular formula: C_{45} H_{73} N O_{16}.
Molecular weight: 884.19.
Melting point: 301-3 deg C.
Biological activity: Protoplasmic poison.

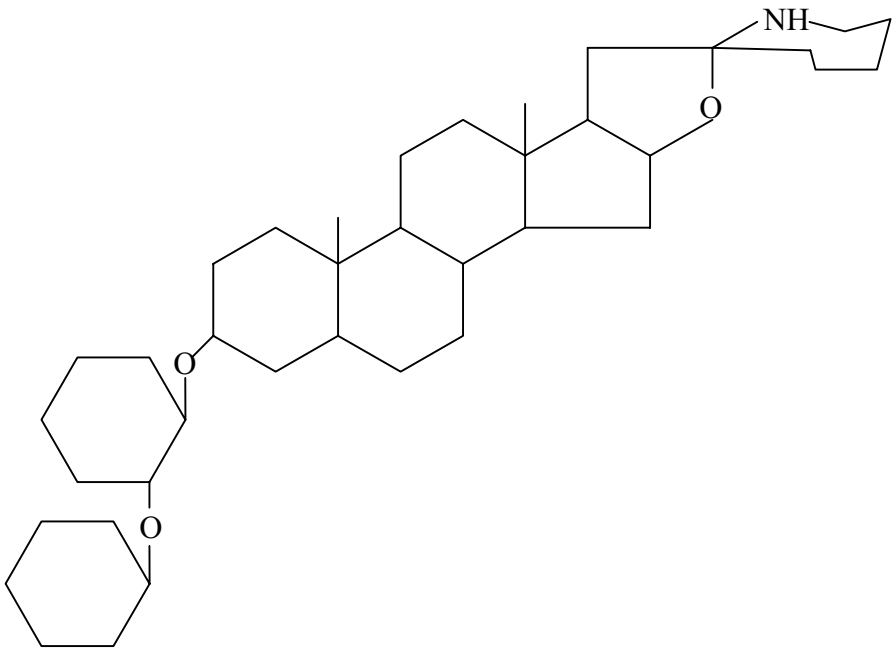


Fig 2.94: Structure of Solanine

Strychnine

Source: Strynchnos nux vomica.
Molecular formula: $C_{21}\ H_{22}\ O_2\ N_{\ 2}$.
Molecular weight: 334.4.
Melting point: 275 deg C.
Solubility:
A. Soluble in water, alcohol and chloroform.
B. Insoluble in ether.
Physical form: Strychnine is a colourless, odourless alkaloid having intense taste and occurs in prismatic crystals.
Biological activity: Convulsant.

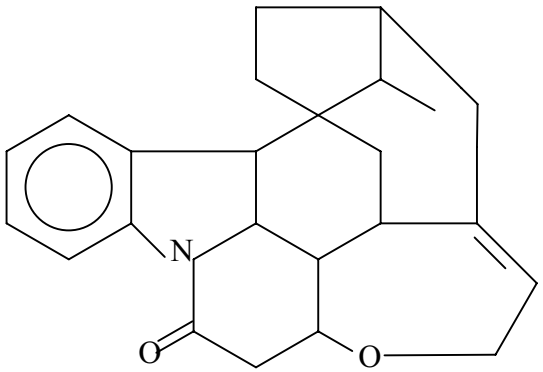


Fig 2.95: Structure of Strychnine

Tephrosin

Source: Tephrosia purpurea.
Molecular formula: $C_{23}\ H_{22}\ O_7$.
Molecular weight: 334.4.
Melting point: 198 deg C.
Biological activity: Antifeedent.

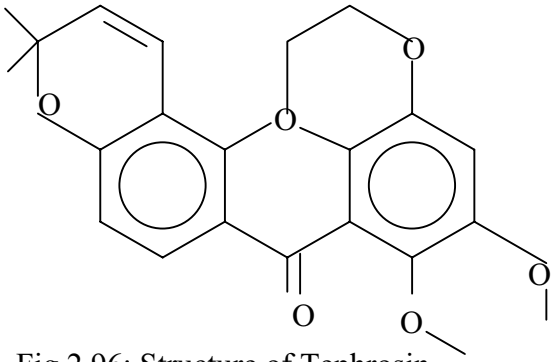


Fig 2.96: Structure of Tephrosin

Theabine

Source: Papaver somniferum.
Molecular formula: $C_{19}H_{21}NO_3$.
Molecular weight: 311.41.
Melting point: 193 deg C.
Biological activity: Spinal excitant.

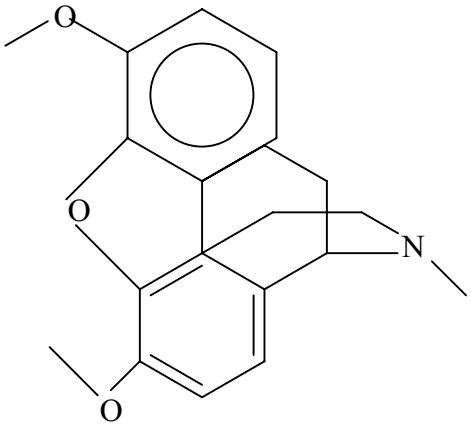


Fig 2.97: Structure of Theabine

Theobromine

Source: Theobroma cocoa.
Molecular formula: $C_7H_8N_4O_2$.
Molecular weight: 180.19.
Melting point: 350 deg C.
Biological activity: Bronchodilator.

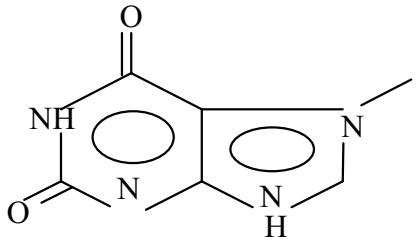


Fig 2.98: Structure of Theobromine

Theophylline

Source: Theobroma cocoa.
Molecular formula: $C_7H_8N_4O_2$.
Molecular weight: 180.19.
Melting point: 264 deg C.
Biological activity: Bronchodilator.

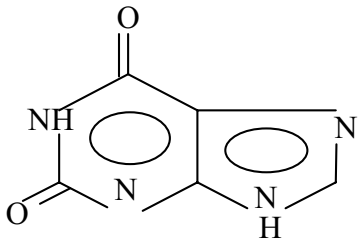


Fig 2.99: Structure of Theophylline.

Trigonelline

Source: Trigonella foneum graceum.
Molecular formula: $C_7H_7NO_2$.
Molecular weight: 137.15.
Melting point: 218 deg C.
Solubility:
A. Soluble in water.
B. Insoluble in ether and benzene.
Physical form: Colourless alkaloid having feeble taste.
Biological activity: Antidiabetic.

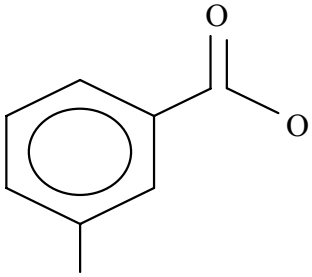


Fig 2.100: Structure of Trigonelline

Tropine

Source: Withania somnifera.

Molecular formula: $C_8 H_{15} NO$.
Molecular weight: 141.24.
Boiling point: 63 deg C.

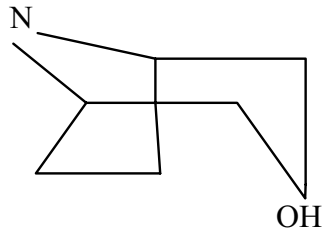


Fig 2.101: Structure of Tropine

Tylophorine

Source: Tylophora asthamatica.
Molecular formula: $C_{24} H_{27} NO_4$.
Molecular weight: 393.52.
Melting point: 292 deg C.
Biological activity: Bronchodilator.

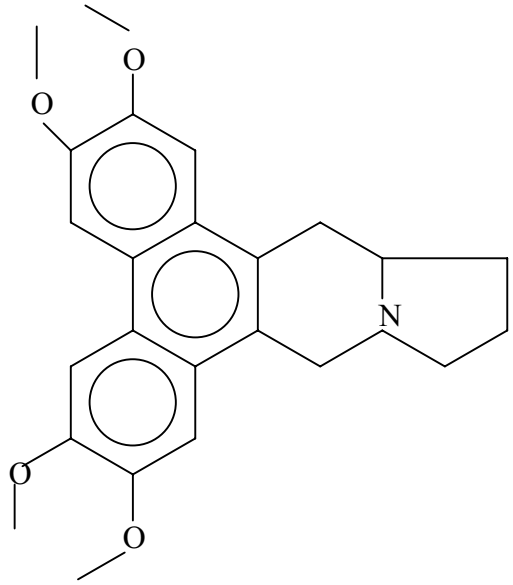


Fig 2.102: Structure of Tylophorine

Vasicine

Source: Adhatoda vasica.
Molecular formula: $C_{11} H_{12} N_2 O$.
Melting point: 182deg C.
Solubility:
A. Soluble in chloroform.
Biological activity: Bronchodilator.

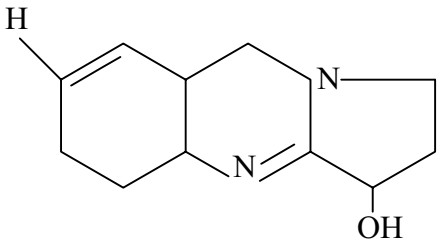


Fig 2.103: Structure of Vasicine

Vasicinone

Source: Adhatoda vasica.
Molecular formula: $C_{11}H_{10}N_2O_2$.
Molecular weight: 20.232deg C.
Melting point: 201 deg C.
Biological activity: Bronchodilator.

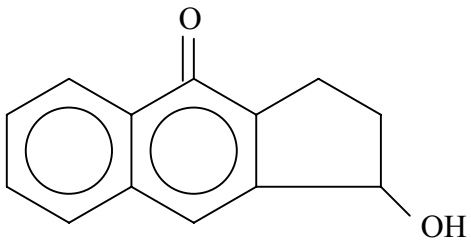


Fig 2.104: Structure of Vasicinone

Vertarine

Source: Schoenocaulon officinale.
Molecular formula: $C_{37}H_{51}NO_9$.
Solubility:
A. Soluble in water, ether and alcohol.
Physical form: A pale grey amorphous powder.
Colourless alkaloid having feeble taste.
Biological activity: Similar to pilocarpine.

Vinblastine

Source: Catharanthus roseus.
Biological activity: Anticancer.

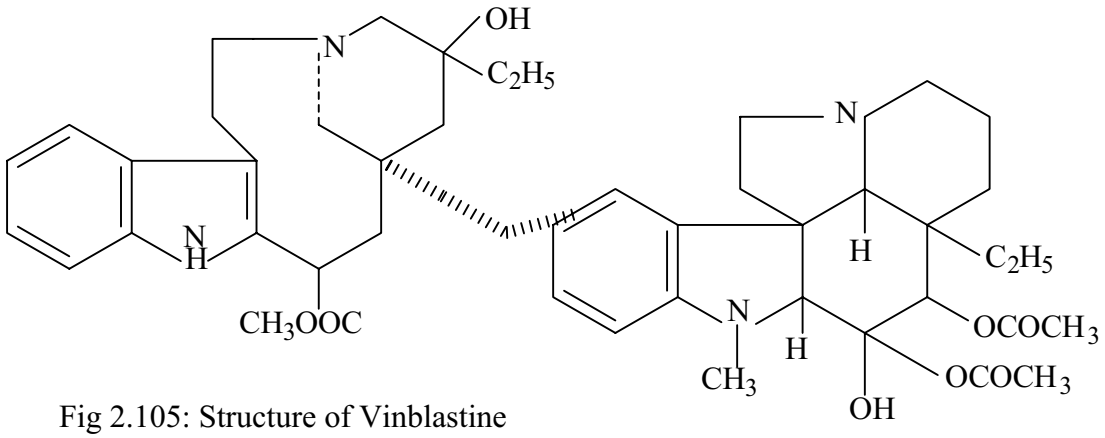


Fig 2.105: Structure of Vinblastine

Vincamine

Source: Catharanthus roseus.

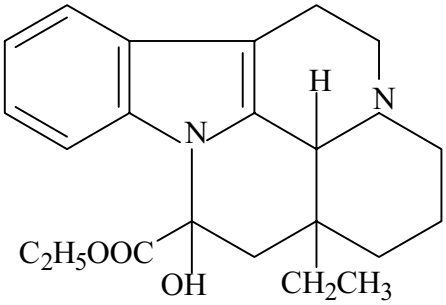


Fig 2.106: Structure of Vincamine

Vincristine

Source: Catharanthus roseus.
Biological activity: Anticancer.

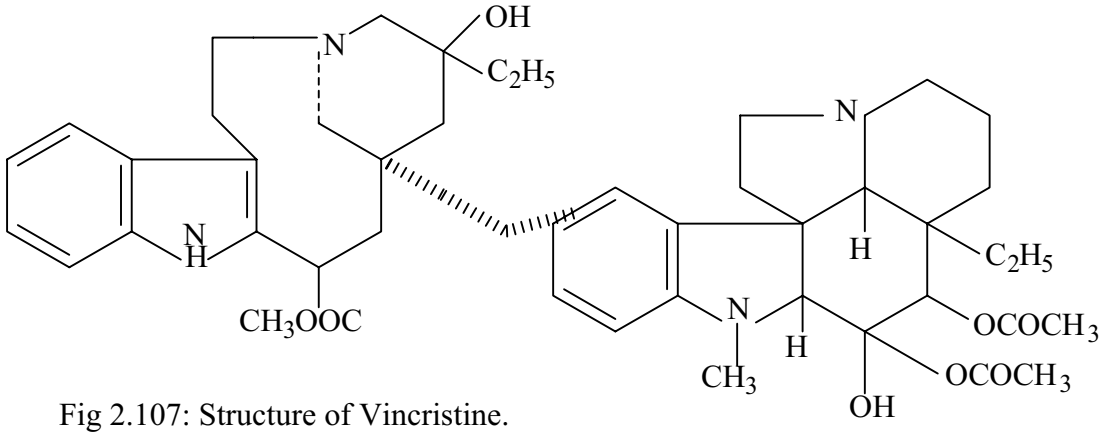


Fig 2.107: Structure of Vincristine.

Vinpocetine

Source: Catharanthus roseus.

Voacangine

Source: Voacanga africana.
Molecular formula: $C_{22}H_{28}N_2O_4$.
Biological activity: Analgesic.

Vomicine

Source: Strynchnos nux vomica.
Molecular formula: $C_{21}H_{24}N_2O_4$.
Molecular weight: 380.48.
Melting point: 279 deg C.

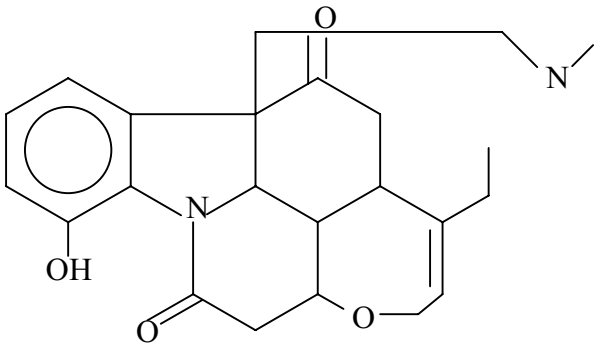


Fig 2.108: Structure of Vomicine.

Wedelolactone

Source: Eclipta alba.
Molecular formula: $C_{15}H_{10}O_7$.
Molecular weight: 302.25

Yohimbine

Source: Pausinystalia yohimbe.
Molecular formula: $C_{21}H_{26}N_2O_3$.
Molecular weight: 354.99.

Melting point: 241 deg C.
Physical form: Colourless, odourless powder.
Biological activity: Stimulant.

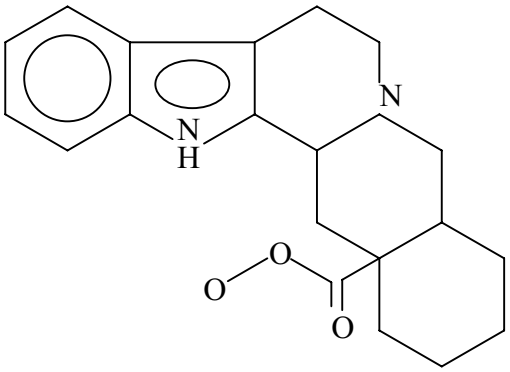


Fig 2.109: Structure of Yohimbine

Chapter-3: Bitters

Bitter principles are basically glycosides and are found commonly in plants of Genitiaceae. They are chemically unrelated but possess the common property of an intensely biter taste. Although this group of drugs is not used today, but once upon a time they were given to promote appetite and aid digestion. The bitters act on gustatory nerves, which results in increased flow of saliva and gastric juices. From chemistry point of view, the bitter principles contain lactone group. They many be diterpene lactones e.g.; Andrographolide or Triterpenoids e.g.; Amarogentin. The bitters have no action in general.

Some bitter principles are known to be astringent due to the presence of tannic acid. Gentiana lutea is the plant known to contain astringent bitter principles. They should not be prescribed with metals, as they are known to cause gastro-intestinal upset. Bitters have no detailed account in Herbal Materia Medica and are much of historic importance, Some like Amarogentin has recently received some importance because of antiprotozoal activity. Andrographolide is being investigated for Anti-Aids activity. Bitter also posses aromatic property due to the presence of volatile oils, e.g.; Citrus aurantium (orange peel). They are sometimes used as flavoring agents.

Amarogentin

Source: Swertia chirata.

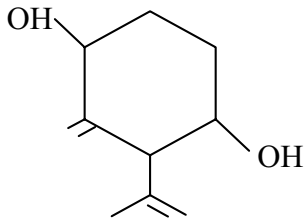


Fig 3.1: Structure of Amarogentin

Andrographolide

Source: Andrographis paniculata.
Molecular formula: C_{20} H_{30} O_{5}.
Molecular weight: 350.50.
Melting point: 235.3 deg C.
Solubility:
A. Soluble in water.
Biological activity: Hepatoprotective and antiallergic.

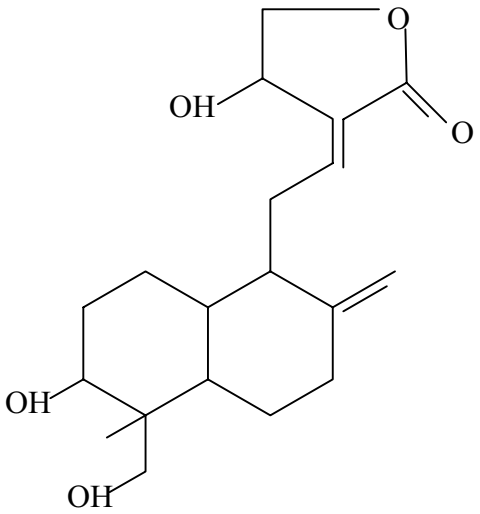


Fig 3.2: Structure of Andrographolide.

Calumbin

Source: Cocculus palmata.
Molecular formula: C_{20} H_{22} O $_{6}$.
Molecular weight: 358.42.
Melting point: 192-5 deg C.

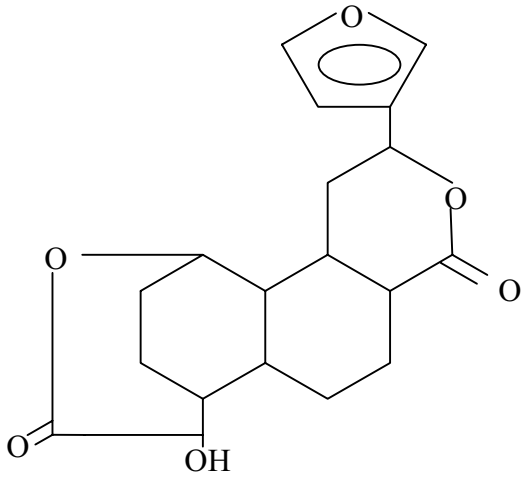


Fig 3.3 : Structure of Calumbin.

Gentiopicrin

Source: Swertia chirata.
Molecular formula: C_{16} H_{25} O $_{1/2}$.H2O.

Physical form: Yellow coloured crystalline substance.

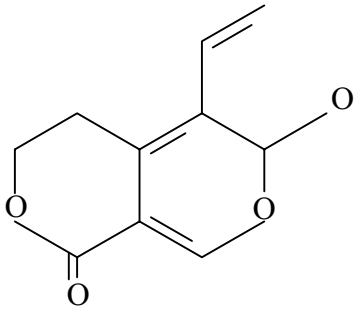
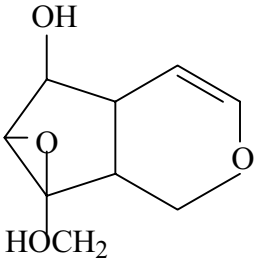


Fig 3.4 : Structure of Gentiopicrin

Kutkosides & Picrosides

Source: Picrorhiza kurroa.
Molecular formula: C_{23} H_{28} O $_{13}$.
Molecular weight: 513.
Melting point: 235.3 deg C.
Solubility:
A. Soluble in ether.
Biological activity: Hepatoprotective.



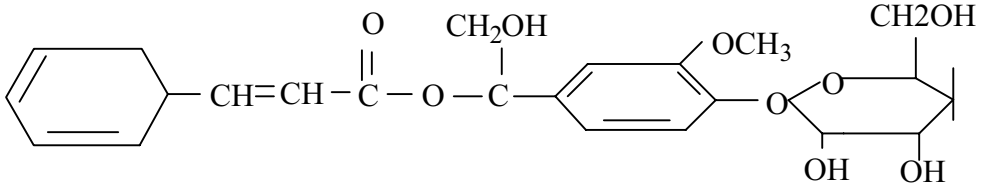


Fig 3.5: Structure of Picroside and Kutkin.

Quassin

Source: Picrasma excelsa.
Solubility:
A. Soluble in alcohol.

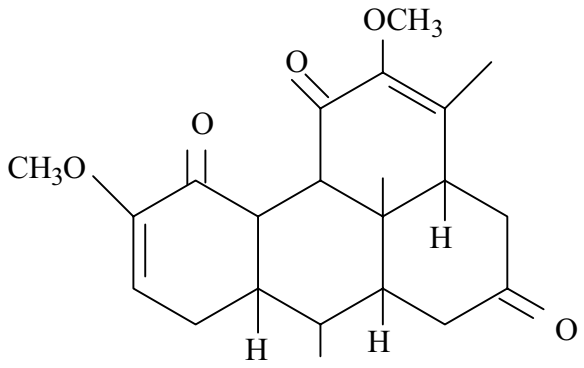


Fig 3.6: Structure of Quassin

Chapter-4: Caffeic acid derivatives

Phenolic compounds are widely distributed in plant flora. A variety known as polyphenols is found in fruits of some plants. They occur as natural colour pigments and are responsible for colour of the fruits.

Phenols are classified in two groups: -

A. Phenolic acids.
B. Flavonones, flavones, xanthones and catechins.

In this chapter, we will discuss in brief about caffeic acid and compounds derived from it. Caffeic acid is regarded as the commonest of phenolic compounds distributed in plant flora. It is produced by hydroxylation of cinnamic acid. Caffeic acid is distributed in Coffea arabica, Echinacea purpurea and Cichorium intybus. Qunic acid is the degradation product of caffeic acid. Chlorogenic acid is a dark coloured pigment and is most abundant phenolic compound in plants next to caffeic acid. It is known to cause allergic dermatitis among humans.

Caffeic acid

Source: Echinacea purpurea.
Molecular formula: $C_9 H_8 O_4$.
Molecular weight: 180.16.
Melting point: 194-98 deg C.

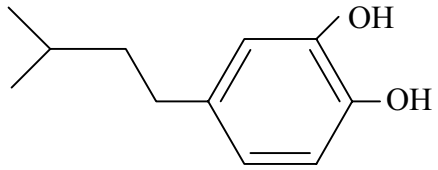


Fig 4.1: Structure of Caffeic acid.

Chlorogenic acid

Molecular formula: $C_{16} H_8 O_9$.
Molecular weight: 354.31.
Melting point: 207-9 deg C.

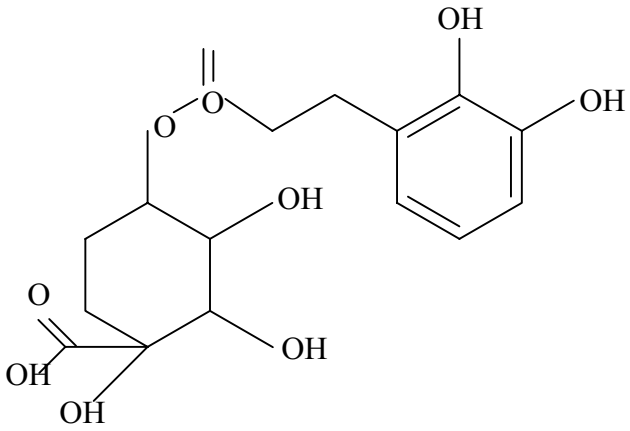


Fig 4.2 : Structure of Chlorogenic acid.

Cichoric acid

Source: Cichorium intybus and Echinacea purpurea.
Molecular formula: $C_{22}H_{18}O_{12}$
Molecular weight: 474.40.
Melting point: 206 deg C.

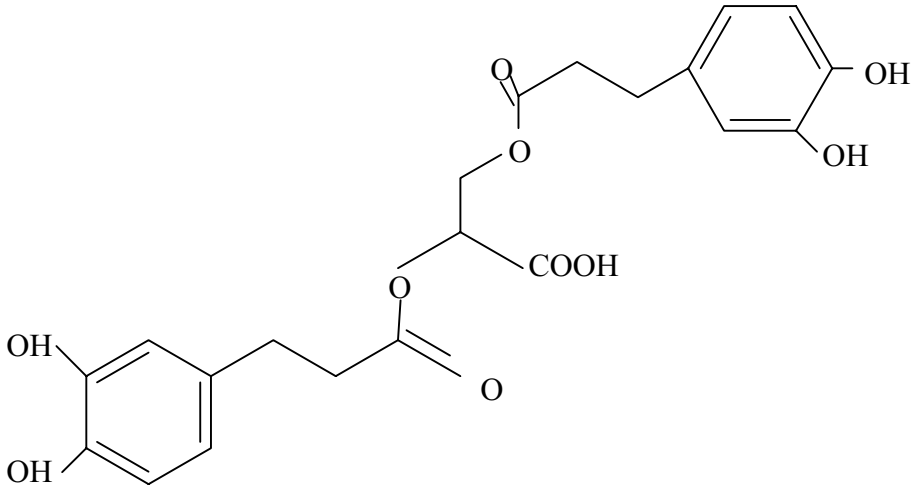


Fig 4.3: Structure of Cichoric acid.

Ferulic acid

Source: Ferula narthax.
Molecular formula: $C_{10}H_{10}O_4$.
Molecular weight: 194.20.
Melting point: 173-8 deg C.
Biological activity: Aphrodisiac.

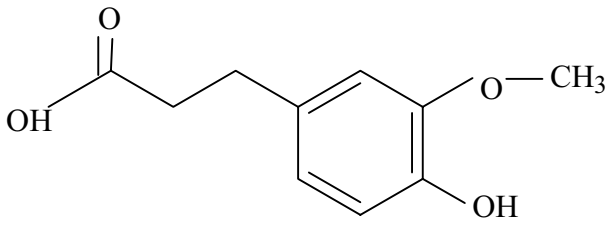


Fig 4.4 : Structure of Ferulic acid.

Other examples of caffeic acid derivatives are cherry acid, dicoffeayl tartaric acid and isocaffeic acid.

Chapter-5: Diarylheptanoids

Diarylheptanoids are rare compounds found in family Zingiberaceae. They are found in rhizomes of Zingiber officinale, Alpinia galangal and Hedychium spicatum. Recent animal studies have shown diarylheptanoids to be potent anti-inflammatory agents as they selectively inhibit cycloxygenase enzyme responsible for inflammation.

Gingerenone A and B and galangol are common examples. The pungent odour of Zingiber officinale and Alpinia galangal is due to the presence of these compounds. This group of compounds has not been thoroughly investigated for pharmacological activity.

Chapter-6: Flavones ,flavonoids and xanthones

Flavonoids are important group of polyphenols, widely distributed in plant flora. 4,000 flavonoids are known to exist and some of them are pigments in higher plants. Quercetin, kaempferol and quercitrin are common flavonoids present in nearly 70 percent of the plants. Soya flavones have recently gained importance due to variety of pharmacological activities.

Flavonoids are derived from parent compounds known as flavans.

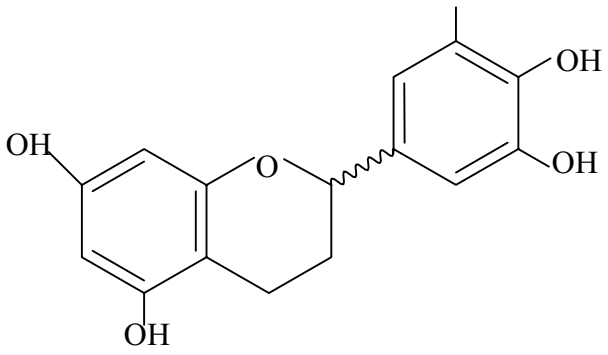


Fig 6.1: Structure of Flavan.

Following diagram represents the flavonoid molecule.

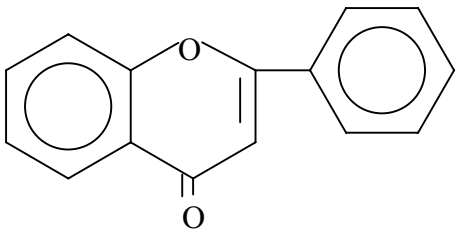


Fig 6.2 : Structure of Flavonoid.

Flavonoids are classified into five groups:

A. Flavones and flavonols.

They are yellow coloured and commonly found in majority of the plants.

Apigenin

Molecular formula: $C_{15}H_{10}O_5$.
Molecular weight: 270.25.
Melting point: 345 deg C.
Physical form: Light yellow crystals.

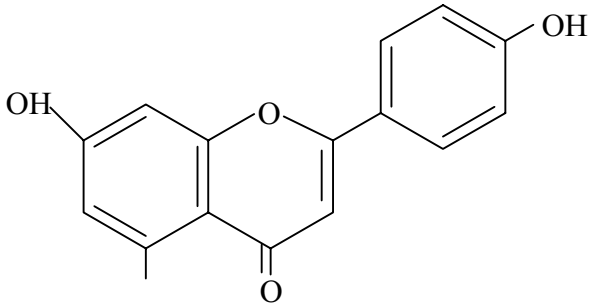


Fig 6.3: Structure of Apigenin.

Hyperoside

Molecular formula: $C_{21}H_{20}O_{12}$.
Molecular weight: 464.41.
Melting point: 242 deg C.

Kaempferol

Molecular formula: $C_{15}H_{10}O_7$.
Molecular weight: 338.3.

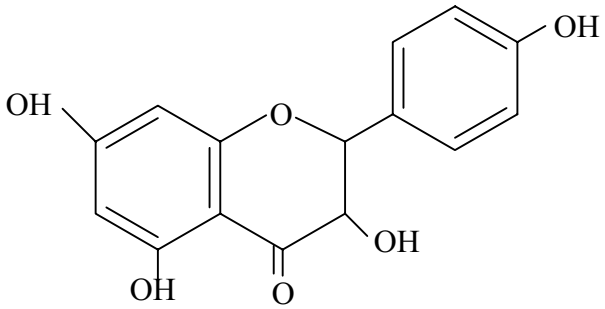


Fig 6.4: Structure of Kaempferol..

Rhamnetin

Molecular formula: $C_{16}\ H_{12}\ O_7$.
Molecular weight: 317.
Melting point: 305 deg C.

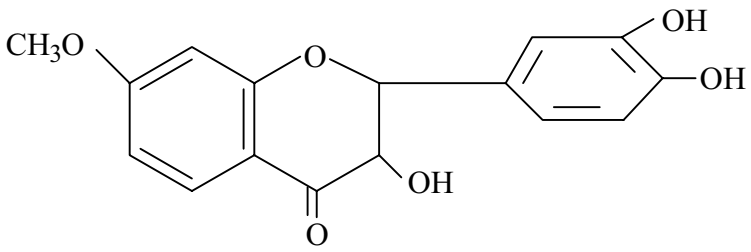


Fig 6.5: Structure of Rhamnetin.

Isorhamnetin

Molecular formula: $C_{16}\ H_{12}0\ O_{\ 7}$.
Molecular weight 317.
Melting point: 305 deg C.

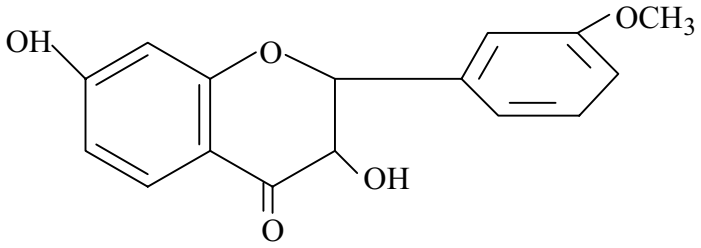


Fig 6.6 : Structure of Isorhamnetin.

Quercetin

Molecular formula: $C_{15}\ H_{10}\ O_{\ 7.}$
Molecular weight: 302.25.
Melting point: 314 deg C.

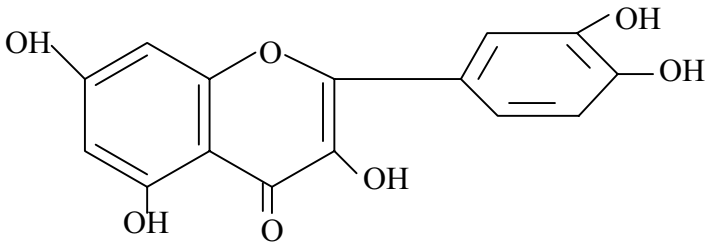


Fig 6.7 : Structure of Quercetin.

Quercitrin

Molecular formula: C_{21} H_{20} O $_{11}$.
Molecular weight: 448.41.
Melting point: 182-5 deg C.

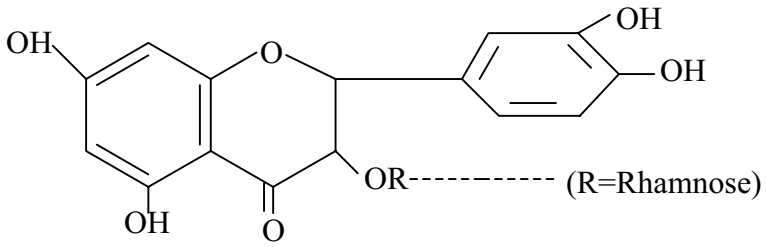


Fig 6.8 : Structure of Quercitirn.

Vitexin

Molecular formula: C_{21} H_{20} O $_{10}$.
Molecular weight: 432.41.
Melting point: 263 deg C.

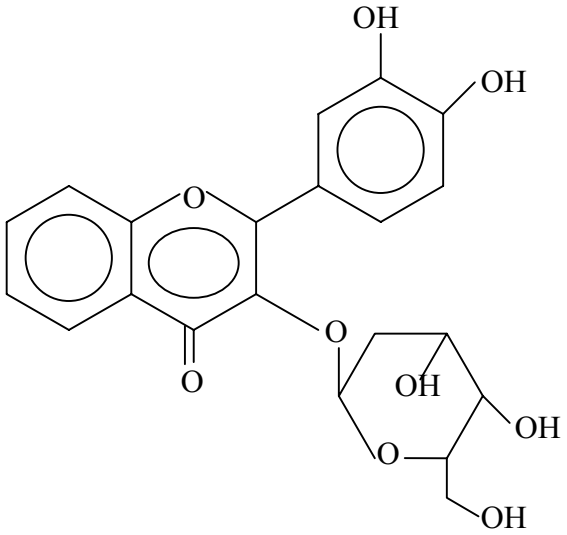


Fig 6.9: Structure of Vitexin.

B. <u>Flavonols.</u>

They are found in plants of Rutaceae.

<u>Naringin</u>

Source: Citrus medica.

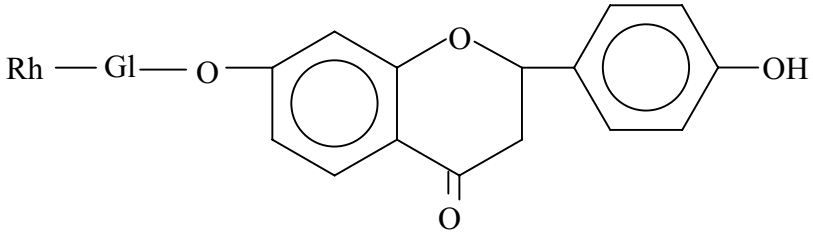


Fig 6.10: Structure of Naringin.

C. Anthocyanidins

Anthocyanidins are derived from flavonols. In nature, they are found as glycosides and are termed as anthocyanins. The have characteristic colour ranging from red to blue and they are responsible for colour of the fruits. Cyanidin and delphinidin are familiar examples.

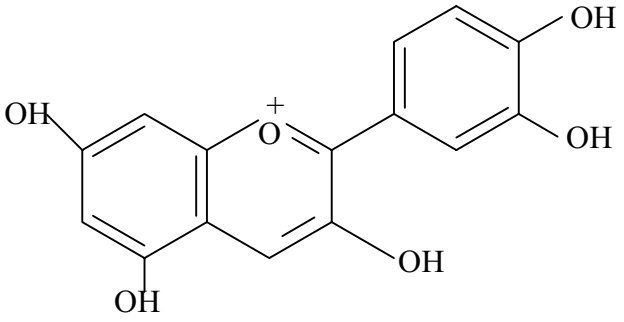


Fig 6.11: Structure of Cyanidin.

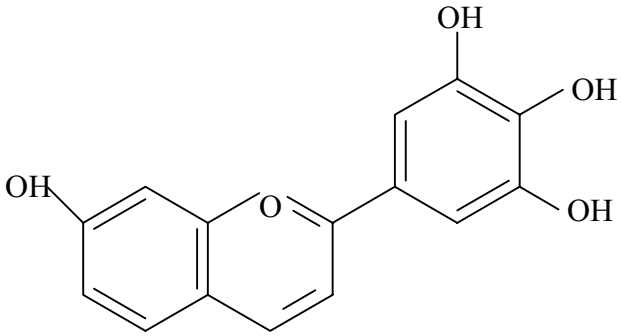


Fig 6.12: Structure of Delphindin.

D. Proanthocyanidins

Proanthocyanidins on hydrolysis yield anthocyanidins. Procyanidin and prodelphinidin are common examples. Prodelphinidin isolated from Rhynchosia minima has demonstrated antibiotic activity.

E. Catechin and leucoanthocyanidins

Catechins are also derived from flavones. The leucoanthocyanidins have an additional

hydroxy group. Catechin and epicatechin are common examples. They are found in Hypericum perforatum.

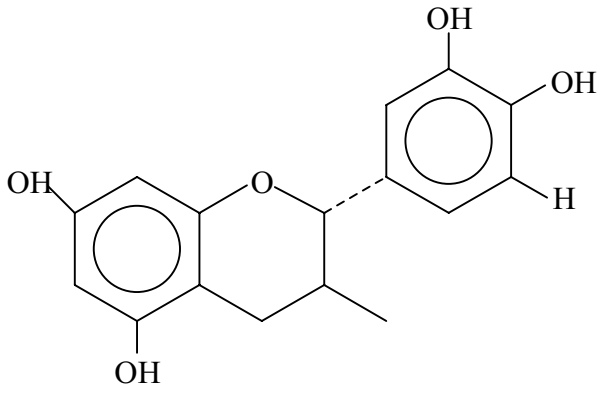


Fig 6.13: Structure of Catechin.

Isoflavones

Isoflavones are found in Glycine max (soybean). Clinical research has demonstrated soy isoflavones to be effective in menstrual diseases. They have antioxidant activity also. Isoflavones belong to a group of compounds known as phyto-estrogens. The isoflavone content of soybean is 10 t0 20 times more than other plants. Genistein is a potent tyrosine inhibitor, whereas daidezein has antioxidant activity. Recently isoflavones have been investigated for hypolipidemic activity.

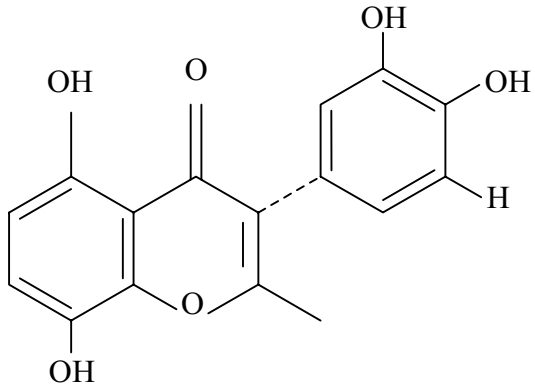


Fig 6.14: Structure of Genistein.

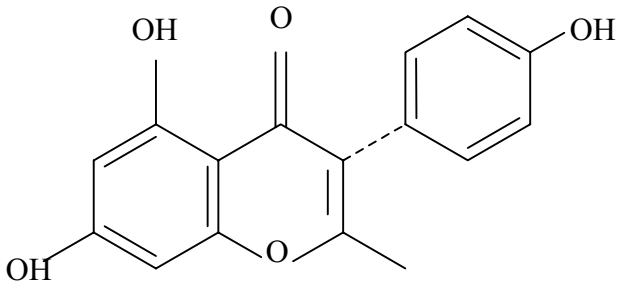


Fig 6.15: Structure of Daidzein.

Amentoflavone

It is a bioflavonoid present in Hypericum perforatum and some researchers claim it to be the antidepressant constituent of the plant.

Silymarin

Silymarin is a flavonol- lignan mixture obtained from seeds of Silybum marianum. Silymarin is a mixture of silybin, isosilybin, silychristin and silydianin. Silybin A and B are collectively known as silibinin. Silymarin is a reputed hepatoprotective drug.

Source: Silybum marianum.
Molecular formula: $C_{25}\ H_{22}\ O_{10}$.
Molecular weight: 482.4.
Melting point: 158 deg C.
Solubility:
A. Soluble in acetone and ethyl acetate.
B. Insoluble in water.

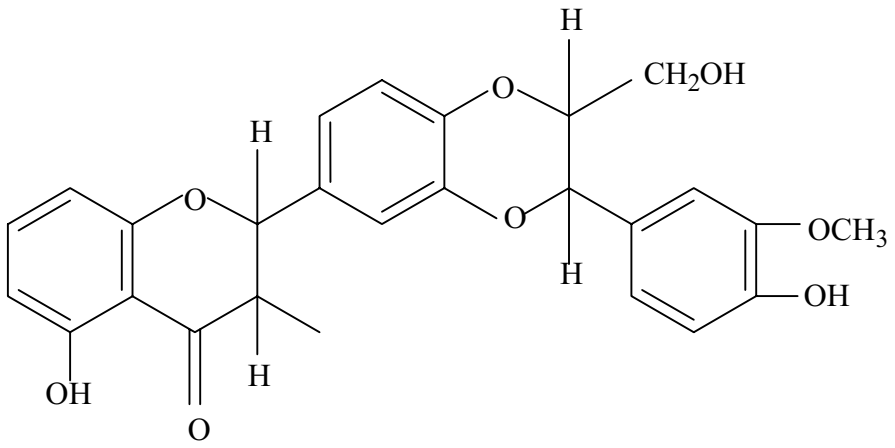


Fig 6.16: Structure of Silybin

Chapter-7: Furanocoumarins

Furanocoumarins are photosensitizing agents used in the treatment of pigment disorders. Ayurveda, the ancient science of India, has described the use of bawachi (Psoralia corylifolia) for the treatment of leucoderma. Psoralens isolated from the medicinal herb, are reputed drugs in the field of dermatology.

Furanocoumarins are formed when furor ring is joined with coumarins. The plants of Rutaceae, Leguminosae and Apiaceae are rich sources of furanocoumarins. Depending upon the structure, the furanocoumarins are divided into linear and angular types. Furanocoumarin containing preparations are used externally as well as internally for treatment of leucoderma, psoriasis and skin carcinoma.

Angelicene

Source: Angelica archangelica.
Molecular formula: $C_{11}H_6O_3$.
Molecular weight: 186.17.
Melting point: 135 deg C.
Solubility:
A. Soluble in chloroform.
B. Insoluble in water.

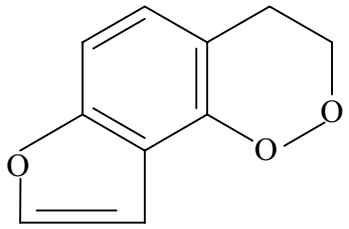


Fig 7.1: Structure of Angelicene.

Bergeptaen

Source: Psoralia corylifolia.
Molecular formula: $C_{12}H_8O_4$.
Molecular weight: 216.20.
Melting point: 189 deg C.

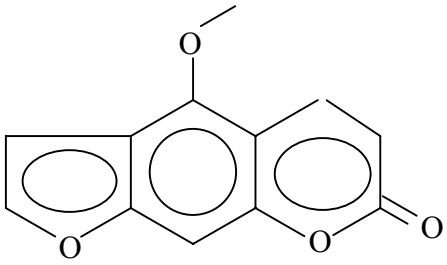


Fig 7.2: Structure of Bergapten.

Imperatorin

Source: Psoralia corylifolia.
Molecular formula: $C_{16}H_{14}O_4$.
Molecular weight: 270.30.
Melting point: 104 deg C.

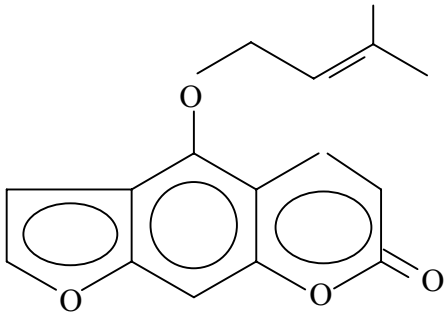


Fig 7.3: Structure of Imperatorin.

Isopimpinellin

Source: Psoralia corylifolia.
Molecular formula: $C_{13}H_{10}O_5$.
Molecular weight: 246.23.
Melting point: 151 deg C.

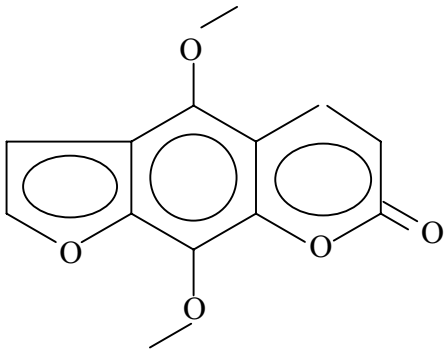


Fig 7.4: Structure of Isopimpinellin.

Oxsoralen (Tripsoralen)

Source: Heracleum scabridium.
Molecular formula: $C_{12}H_8O_4$.
Molecular weight: 186.
Melting point: 189-90 deg C.

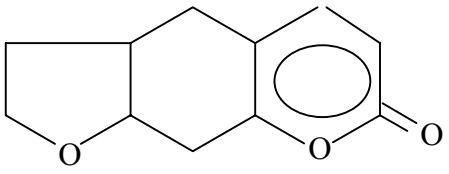


Fig 7.5: Structure of Oxsoralen.

Psoralen

Source: Psoralia corylifolia.
Molecular formula: C_{11} H_6 O_3.
Molecular weight: 186.17.
Melting point: 159 deg C.
Solubility:
A. Soluble in chloroform.
B. Insoluble in water.

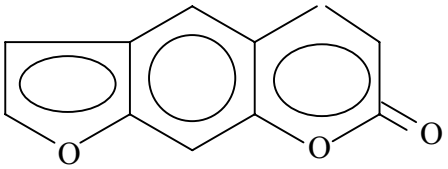


Fig 7.6: Structure of Psoralen

Sphondin

Source: Heracleum lantanum.
Molecular formula: C_{12} H_8 O_4.
Molecular weight: 216.20.
Melting point: 189 deg C.

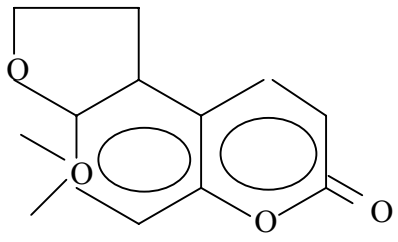


Fig 7.7: Structure of Sphondin.

Trioxsalen

Source: Psoralia corylifolia.
Molecular formula: C_{12} H_6 O_3.
Molecular weight: 232.20.

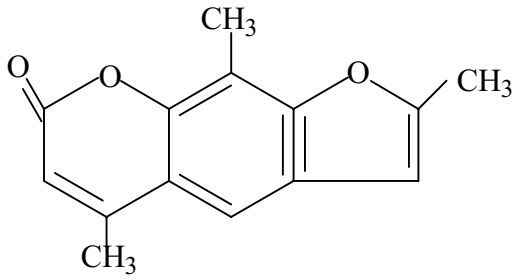


Fig 7.8: Structure of Trioxsalen.

Xanthotaxol

Source: Ammi majus.
Molecular formula: C_{11} H_6 O_4.
Molecular weight: 202.17.
Melting point: 252 deg C.

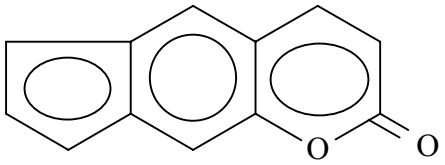


Fig 7.9: Structure of Xanthotoxol.

Furanocoumarins are present in Ficus carica, Apium graveolens, Ruta graveolens and Angelica gluca. Marmelosin present in Aegle marmelos is the precursor compound for psoralen biosynthesis. Marmesin, another furanocoumarin, has been reported to be significant source of psoralen.

Furanocoumarins are extremely toxic. They are known to cause photo-toxicity if not used under medical supervision. Furanocoumarins bind to DNA of the cell and interacts with fats and proteins. Phenylalanine, Umbelliferon, a hydroxycoumarin and isoprene, are precursor compounds for furanocoumarin biosynthesis. The furanocoumarins have shown antibacterial activity against Escherichia coli and Micrococcus luteus. They are hepatotoxic also.

Chapter-8: Furochromones

Furochromones are group of coumarins, derived from γ- benzopyrone. They are related to furanocoumarins and are present in plants of family Apiaceae and Rutaceae. Ammi visnaga is a potential source of furochromones like khellin and visnagin. Khellin was once used as coronary vasodilator drug.

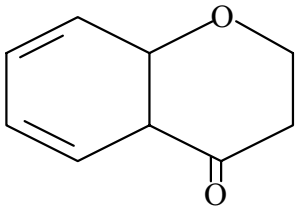


Fig 8.1: Structure of Benzopyrone

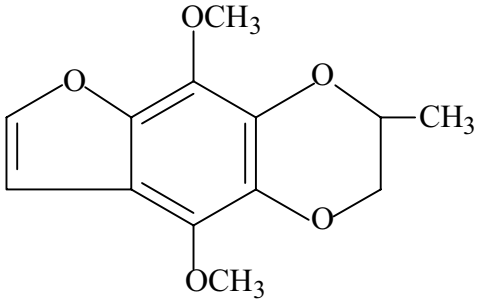


Fig 8.2: Structure of Khellin.

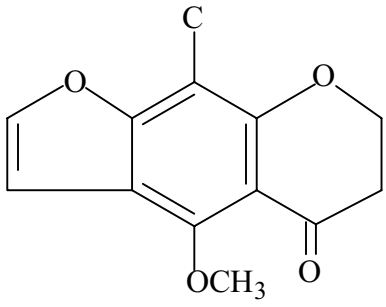


Fig 8.3: Structure of Visnagin.

Chapter-9: Hydroxycoumarins

Hydroxycoumarins represents another group of coumarins, which are widely distributed in Apiaceae and Gramineae.

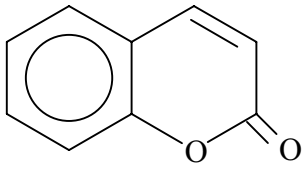


Fig 9.1: Structure of Coumarin.

Aesculetin

Source: Aesculus hippocastanum, Crategeus oxycantha.
Biological activity: Vasodilator and rubifacient.

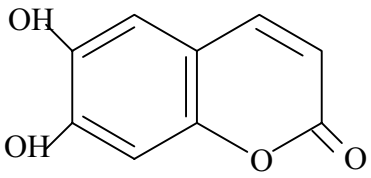


Fig 9.2: Structure of Aesculetin.

Herniarin

Source: Artemisia lactiflora.
Molecular formula: $C_{10}H_8O_3$.
Molecular weight: 176.18.
Melting point: 117-8 deg C.

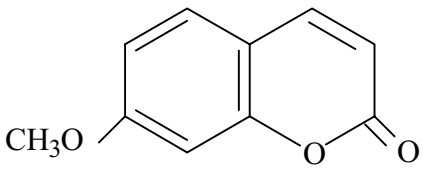


Fig 9.3: Structure of Herniarin.

Scopolin

Source: Aesculus hippocastanum.
Molecular formula: $C_{16}H_8O_9$.
Molecular weight: 354.24.
Melting point: 219 deg C.

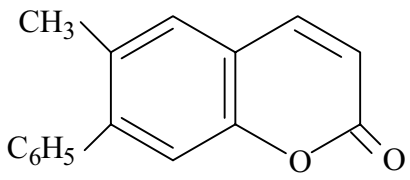


Fig 9.4: Structure of Scopolin .

Umbelliferon

Source: Angelica pubescens.
Molecular formula: $C_9H_6O_3$.
Molecular weight: 162.15.
Melting point: 226 deg C.

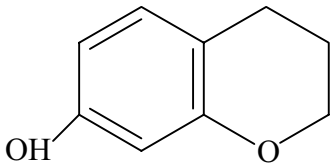


Fig 9.5: Structure of Umbelliferon.

Chapter-10: Glycosides

Introduction

Glycosides are water-soluble constituents, found in the cell sap. They are colourless, crystalline substances containing carbon, hydrogen and oxygen. Some glycosides are peculiar in having nitrogen and sulphur. Glycosides are neutral in reaction.

Chemically, glycosides contain a carbohydrate (glucose) and a non-carbohydrate part (aglycone or genin). Alcohol, glycerol or phenol represents aglycones. A glycoside can be readily hydrolysed into its components with ferments or mineral acids .A glycoside is represented by following diagram: -

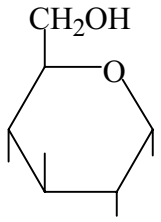


Fig10.1: Structure of Glycoside.

Glycosides differ in their solubility in water. Some are soluble in ether and alcohol. Amygdalin found in almonds is familiar example of a glycoside. Benzeldehyde is the decomposition product of amygdalin, responsible for odour and taste of almonds. Glycosides are optically active and are levorotatory.

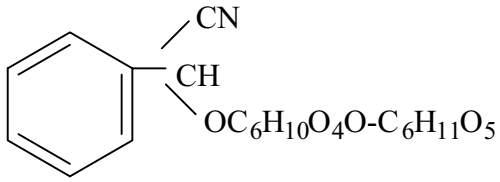


Fig 10.2: Structure of Amygdalin

Classification:

Glycosides are classified
A. On basis of type of sugar.
B. According to chemical nature of aglycone.
C. According to pharmacological action.

The latest classification is represented below: -

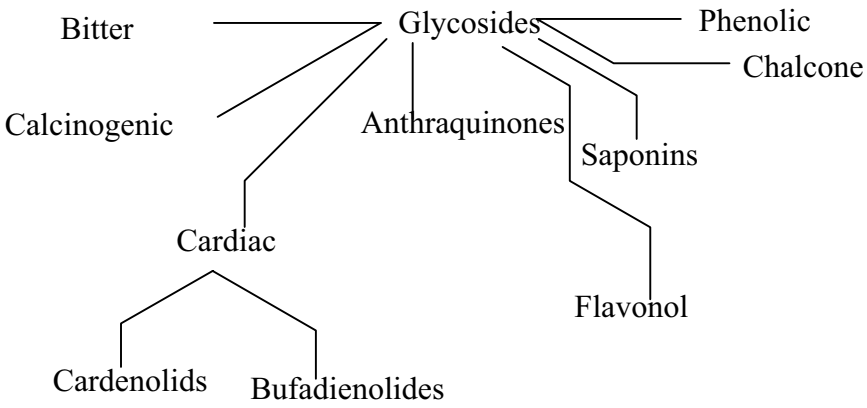


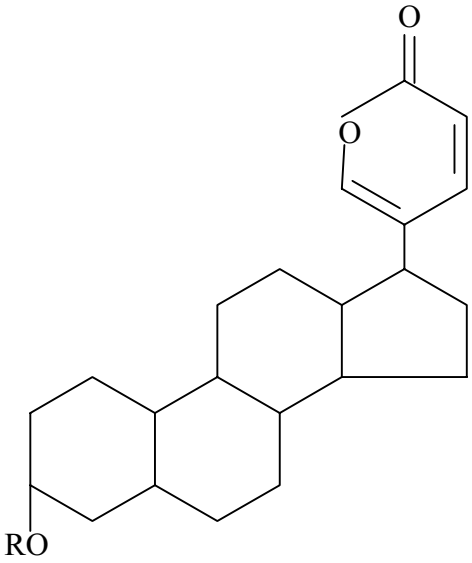
Fig 10.3: Classification of Glycosides

1. Cardiac glycosides

The group includes several medicinal herbs like Digitalis purpurea, Digitalis lanata Stropanthus gratus, Stropanthus kombe, Apocyanum cannabinum, Thevetia nerifolia and Helleborus niger. The active constituents of the plants are powerful glycosides and due to specific action on heart, they are known as cardiac glycosides or heart tonic.

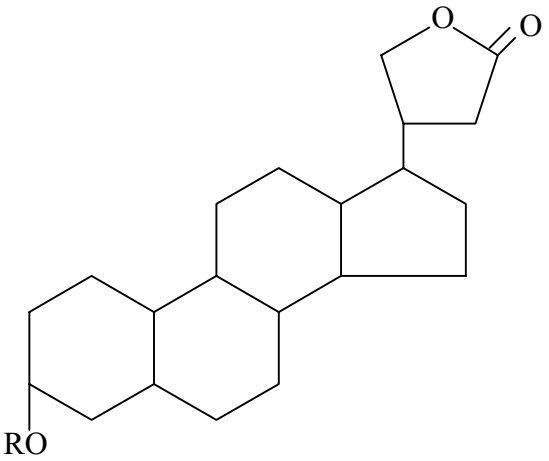
Cardiac glycosides are divided in two groups:

A. Bufadienolides: They are C 24 steroids. Hellbrien is a bufadienolide cardiac glycoside. On hydrolysis, it yields aglycone, hellbrigenin, which is more active than hellebrin.



Fif 10.4: Bufadienolide

B. Cardenolides: They have C 17 position unsaturated lactone. They are cyclo-pentanophenantherne derivatives and have hormonal nature. They act on kidney and heart. Digitalis glycosides belong to this group.



Fif 10.5: Cardenolide.

Digitalis glycosides deserve special mention. The glycosides are obtained from the leaves of Digitalis purpurea, when the medicinal plant is in flowering stage. Then isolation of the glycosides in pure from is difficult and they are present in association with saponins. Stoll and Kries proved that the glycosides are of two types:

1. They are known as glycosides-A and digitoxin is the main glycoside. The aglycone for this group is digitoxigenin.
2. The second type is known as glycoside-B and gitoxin is the main glycoside. The aglycone for this group is gitaligenin.

The glycosides obtained from Digitalis lanata are of three types:

1. Digilanid-A
2. Digilanid-B
3. Digilanid-C.

Some species of Digitalis are known to contain pregnane glycosides like digipupurin, diginin and digitalonin. Three glycosides, digitoxin, gitoxin and gitalin have been isolated in pure form for pharmacological application.

Adonidin

Source: Adonis vernalis.
Molecular formula: C_{21} H_{28} O $_4$.
Molecular weight: 344.49.
Melting point: 268-70 deg C.

Physical form: Yellow coloured, hygroscopic having bitter taste. It has neutral reaction.
Solubility:
A. Soluble in water and alcohol.

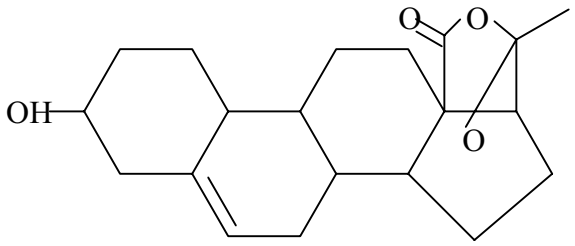


Fig 10.6: Structure of Adonidin.

Asclepiadin

Source: Asclepias currasvica.
Solubility: Soluble in water.
Physical from: Yellow coloured glycoside.

Apocyanin

Source: Apocynum cannabinum.
Structure not established.

Calotropin

Source: Calotropis procera.
Molecular formula: C_{29} H_{40} O $_{9.}$
Molecular weight: 532.69.
Melting point: 221 deg C.
Biological activity: Antitumor.

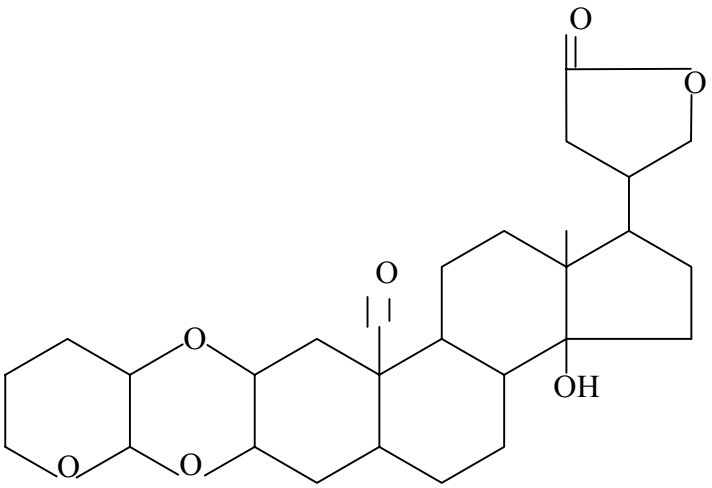


Fig 10.7: Structure of Calotropin.

Convollarin

Source: Convollaria majalis.
Solubility:
A. Soluble in alcohol.
B. Insoluble in water.
Physical form: Colourless prisms with bitter taste.

Convallotoxin

Source: Convollaria majalis.
Solubility:
C. Soluble in alcohol.
D. Insoluble in water.
Physical form: White coloured glycoside with bitter taste.

Note: Convallarin and convallamarin are obtained from Polygonum multiflorum also.

Digitoxin

Molecular formula: $C_{41}\ H_{64}\ O_{13}$.
Solubility: Soluble in chloroform and alcohol.

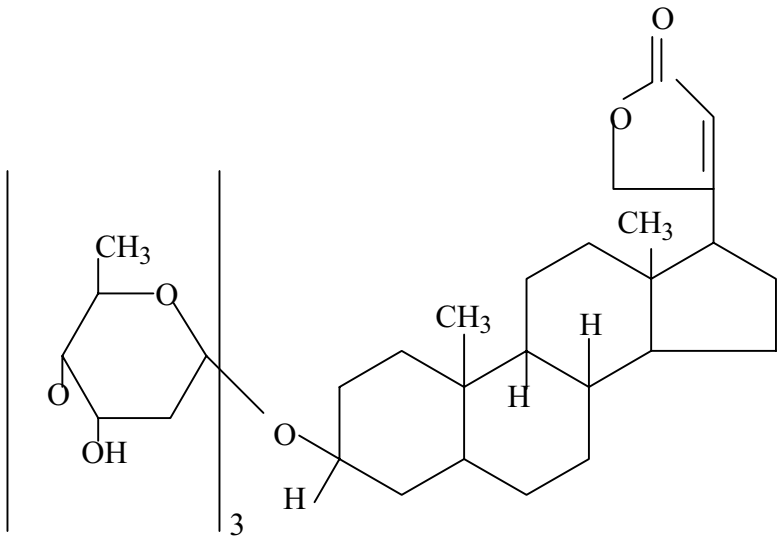


Fig 10.8 :Structure of Digitoxin

Digoxin

It is the active metabolite of digitoxin.

Digitoxin is used for the treatment of congestive cardiac failure. The aglycone particularly digitoxigenin is particularly active and the presence is must for glycoside action.

G-stropanthin

Source: Stropanthus gratus.
Molecular formula: $C_{29}H_{44}O_{12}$.
Molecular weight: 728.78.
Melting point: 173 deg C.
Solubility:
B. Soluble in water.
C. Insoluble in ether and chloroform.

Hellebrin

Source: Helleborus niger.
Molecular weight: 724.

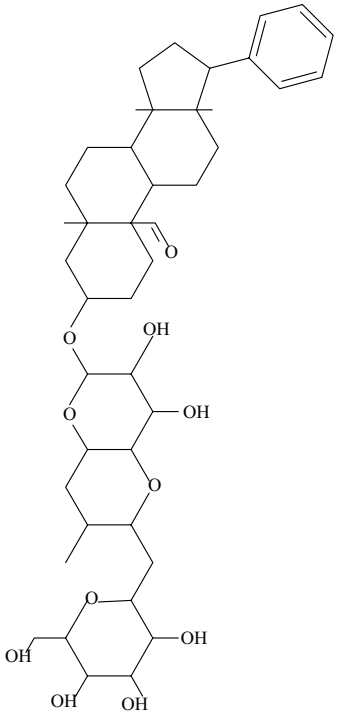


Fig 10.9: Structure of Hellebrin.

Scillaren-A

Source: Urginea indica.
The aglycone of Scillaren-A is known as scillaridin-A. The drug has weak action as compared to digitoxin and stropanthin.

Thevetin

Source: Thevetia nerifolia.
Molecular formula: $C_{42}\ H_{64}\ O_{19}$.
Molecular weight: 873
Melting point: 208-130 deg C.

Evonoside (Euonymus atropupurpurens) and uzarone (Xysmalobium undulatum) also have cardiac tonic activity.

2.Anthracene glycosides

Anthracene glycosides are also known as anthracenosides. They are purgative in nature. On hydrolysis, they give glycones like dianthrone, anthraquinone or anthrone.

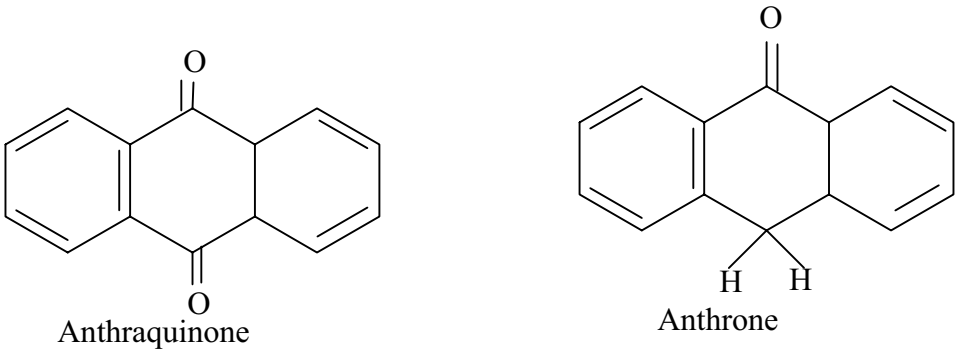


Fig 10.10: Aglycones of Anthracene glycosides.

The sugars are arabinose, rhamnose or glucose. Anthraquinones are the active constituents and are responsible for the biological activity of the anthracene glycoside containing drugs. In addition to use in treating constipation, they are used for the treatment of skin disease like psoriasis and ringworm.

Aloin

Source: Aloe vera.
Molecular formula: $C_{21}\ H_{22}\ O_{9}$.
Molecular weight: 418.4.
Melting point: 173 deg C.

A. Solubility: Soluble in alcohol.
B. Insoluble in ether.
Physical from: Odourless with bitter taste.

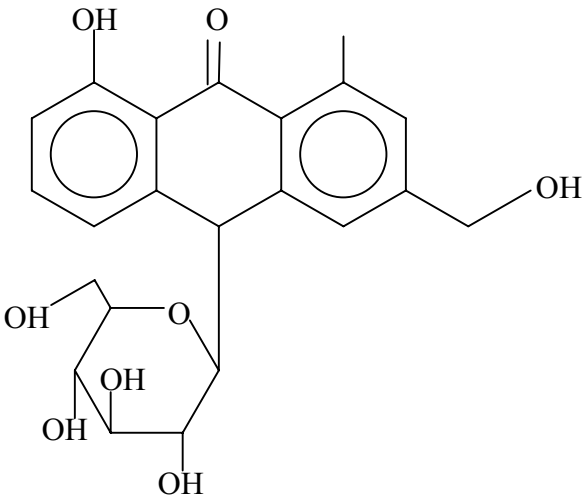


Fig 10.11: Structure of Aloin

Aloe-emodin

Source: Aloe vera.

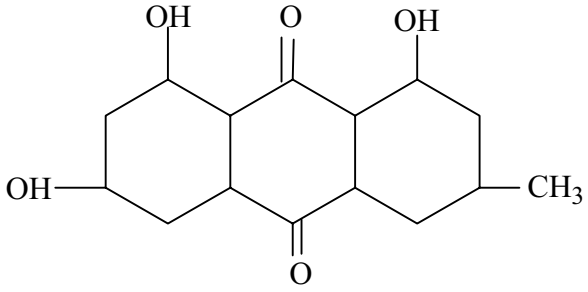


Fig 10.12: Structure of Emodin

Chrysophanol

Source: Cassia tora, Rheum emodi.
Molecular formula: $C_{15}H_{10}O_4$.
Molecular weight: 254.25.
Melting point: 196 deg C.

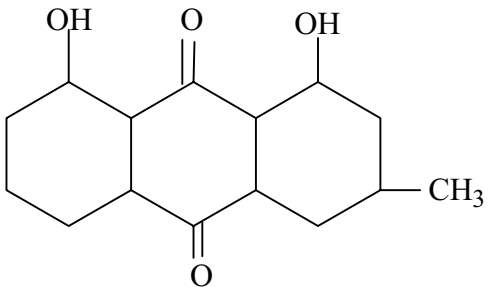


Fig 10.13: Structure of Chyrsophanol.

Frangulin

Source: Rhamnus frangula.
Molecular formula: C_{21} H_{20} O_{9}.
Molecular weight: 416.

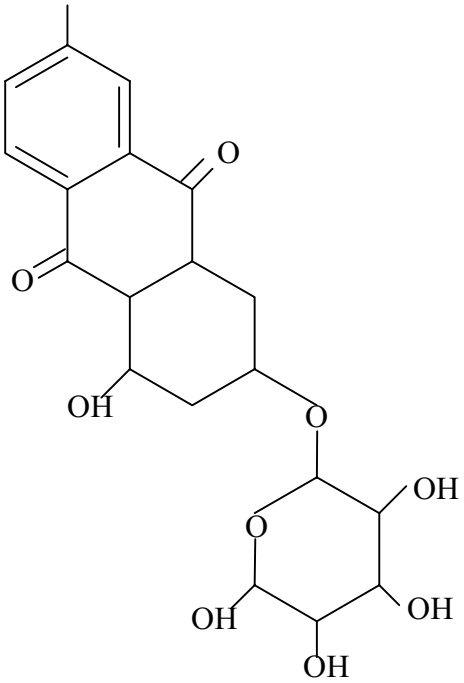


Fig 10.14: Structure of Frangulin.

Physicon

Source: Aloe vera.
Molecular formula: C_{16} H_{12} O_{5}.

Molecular weight: 284.28.

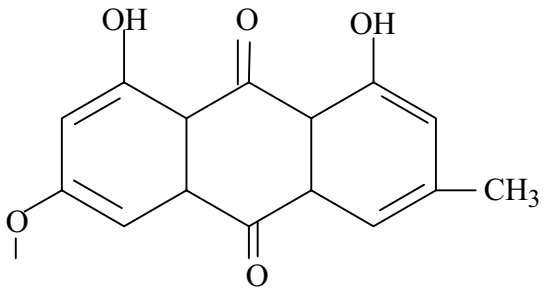


Fig 10.15: Structure of Physicon.

Rhein

Source: Aloe vera.
Molecular formula: C_{15} H_8 O $_6$.
Molecular weight: 284.23.
Melting point: 321 deg C.

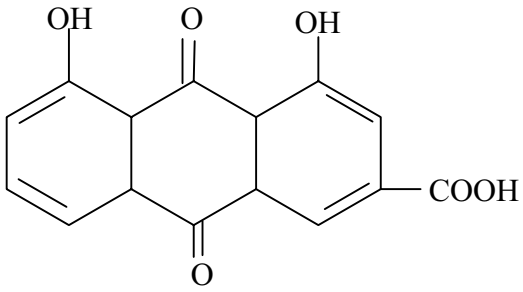


Fig 10.16: Structure of Rhein.

Sennosides

Source: Cassia angustfolia, Cassia acutifolia.
Molecular formula: C_{42} H_{38} O $_{20}$.
Molecular weight: 862.72.

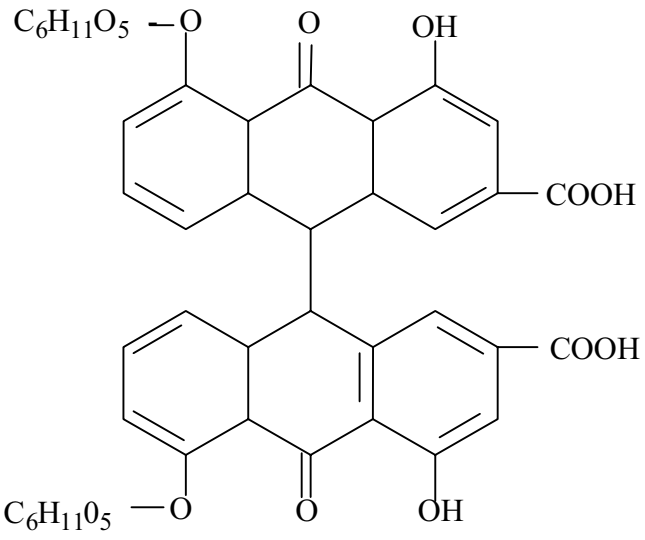


Fig 10.17: Structure of Sennosides

3.Chalcone glycosides

Chalcone is derived from combination of one molecule of cinnamic acid and three molecules of acetate or malonate.

Liquirtin

Source: Glycyrrhiza glabra.
Molecular formula: C_{21} H_{22} O_9.
Molecular weight: 418.43.

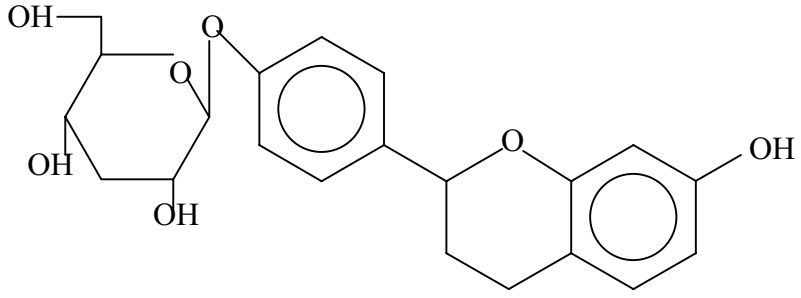


Fig 10.18: Structure of Liquitrin

Isoliquitrin

Source: Glycyrrhiza glabra.

Molecular formula: $C_{21}H_{22}O_9$.
Molecular weight: 418.3
Melting point: 185-6 deg C.

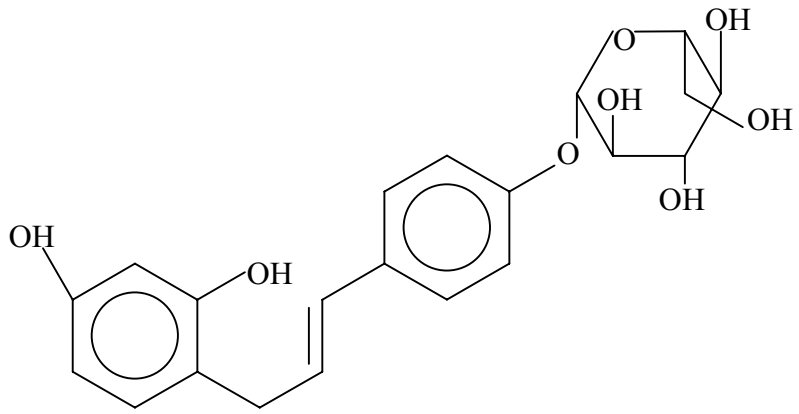


Fig 10.19: Structure of Isoliquitrin

Note: Liquirtin and isoliquitrin are responsible for colour of liquorice.

4.Coumarin glycosides

They have been discussed in chapter 7 and 9.

5.Calcinogenic glycosides

These glycosides are characterized by presence of metabolites similar to vitamin D.They are found in Cestrum diurnum.

6.Saponin glycosides

They have been discussed in chapter 17.

7.Apocartinoid glycosides

They are responsible for colour of the fruits band vegetables. They are found in Crocus sativus (saffron) in the form of crocin. Lycopene is a familiar example.

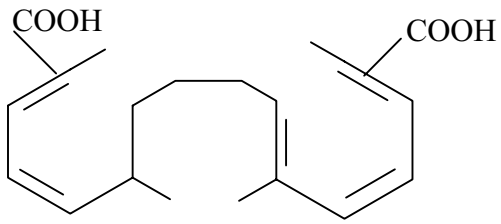


Fig 10.20: Structure of Crocin

Lycopene

Source: Solanum species.
Molecular formula: C_{40} H_{60}.
Molecular weight: 536.8.
Melting point: 172-3 deg C.

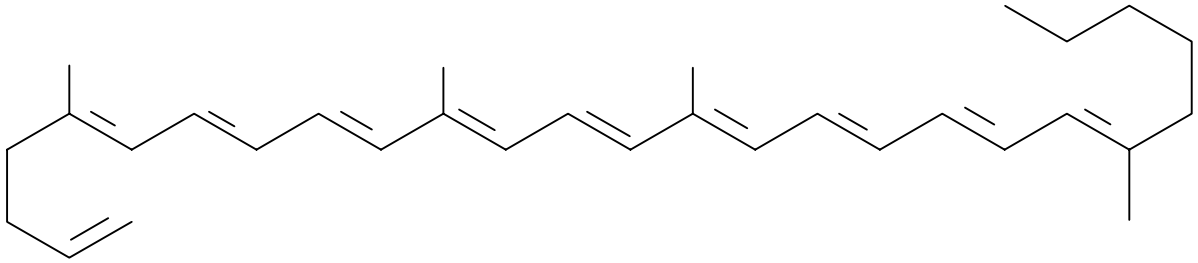


Fig 10.21: Structure of Lycopene.

Biological activity: Anti-oxidant.

8.Bitter glycosides

They have been discussed in chapter 3.

Here it is worthwhile to describe more glycosides.

Absinthin

Source: Artemisia absinthum.
Molecular formula: C_{15} H_{20} O_{4}.
Melting point: 159 deg C.
Physical form: Yellow coloured, amorphous with typical smell.
Solubility:
A.Soluble in chloroform.
B. Insoluble in water.

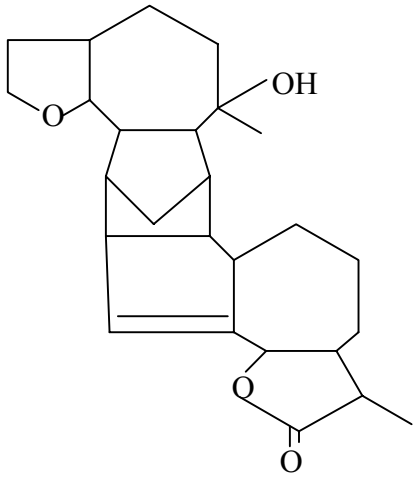


Fig10.22: Structure of Absinthin.

Acubin

Source: Plantago ovata, Vitex agnus castus.
Molecular formula: C_{13} H_{14} O $_8$.H2O.
Molecular weight: 181.

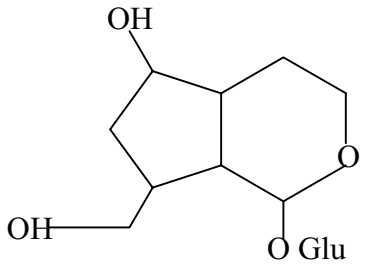


Fig 10.23: Structure of Acubin.

Aesculin

Source: Aesculus hippocastanum.

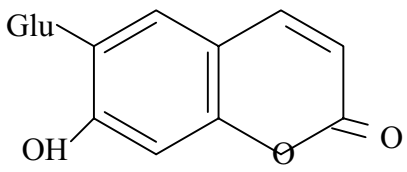


Fig 10.24; Structure of Aesculin.

Note: It is obtained from aesculetin.

Anemonin

Source: Ranaunculus scelretus.
Molecular formula: $C_{10}H_8O_4$.
Molecular weight: 192.18.
Biological activity: Counter-irritant.

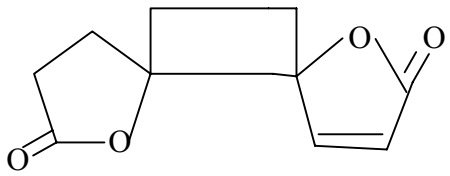


Fig 10.25: Structure of Anemonin.

Allamandin

Source: Allamanda catharatica.
Molecular formula: $C_{15}H_{16}O_7$.
Molecular weight: 308.
Biological activity: Purgative.

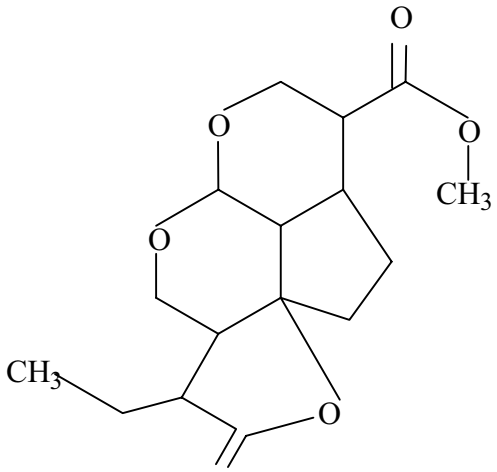


Fig 10.26: Structure of Allamandin

Arnicin

Source: Arnica montana.
Molecular formula: C_{12} H_{22} O_{2}.
Melting point: 40 deg C.
Boiling point: 83 deg C.
Physical form: Golden yellow amorphous mass.
Solubility:
A.Soluble in ether, alcohol and acetone.
B. Insoluble in water.

Cichorin

Source: Cichoruim intybus.
Molecular formula: C_{15} H_{16} O_{9}.
Molecular weight: 340.31.
Melting point: 215-20 deg C.

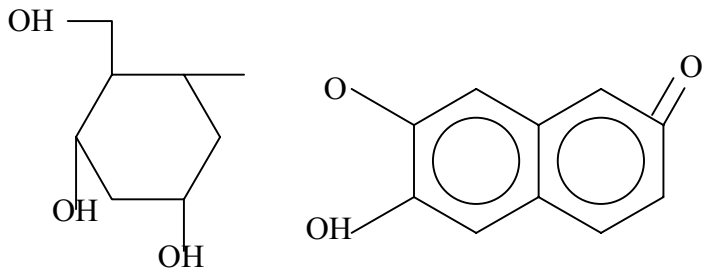


Fig 10.27: Structure of Cichorin

Cornin

Source: Cornus florida.
Molecular formula: C_{17} H_{24} O_{10}.
Molecular weight: 388.41.
Melting point: 182 deg C.
Biological activity: Antiperiodic.

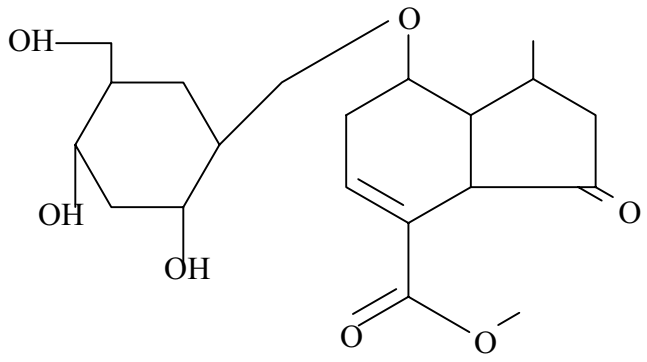


Fig 10.28: Structure of Cornin.

Cynarin

Source: Cynara scloymus.
Molecular formula: C_{25} H_{24} O $_{12}$.
Molecular weight: 516.49.
Melting point: 227-8 deg C.
Biological activity: Hypolipidemic.

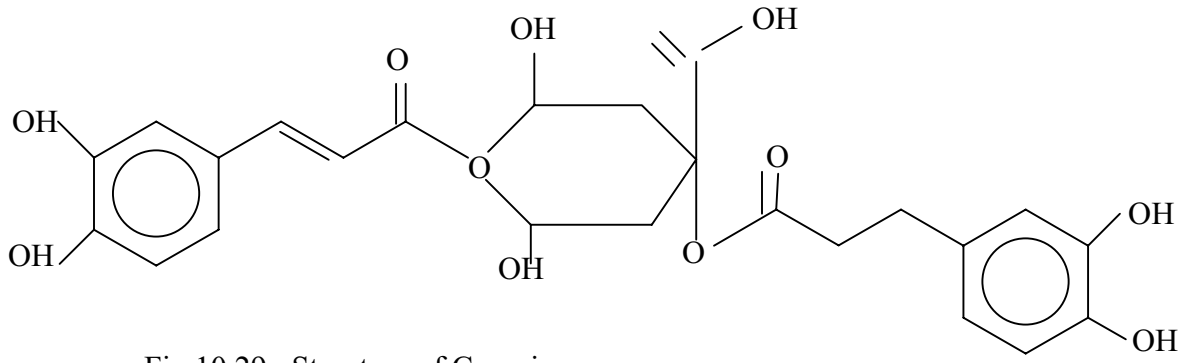


Fig 10.29: Structure of Cynarin.

Darutyne

Source: Siegesbeckia oreintalis.
Biological activity: Antirheumatic.

Eupatorin

Source: Eupatorium cannabinum.
Molecular formula: C_{18} H_{16} O $_{7}$.

Molecular weight: 344.

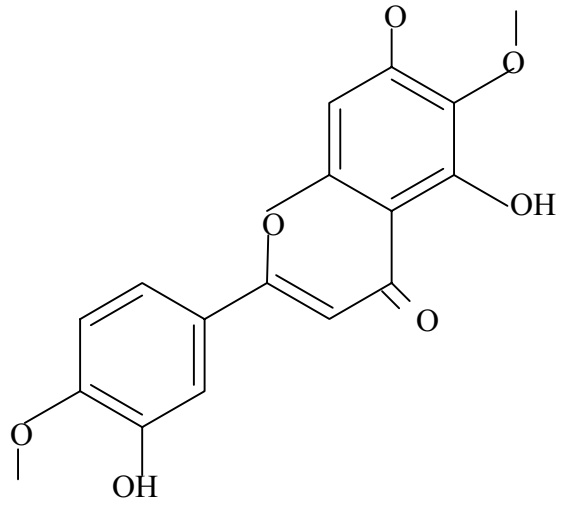


Fig 10.30: Structure of Eupatorin.

Gaultherin (Monotropin, Spiraein)

Source: Gaultheria procumbens.
Molecular formula: $C_{19}H_{26}O_{12}$.
Biological activity: Analgesic.

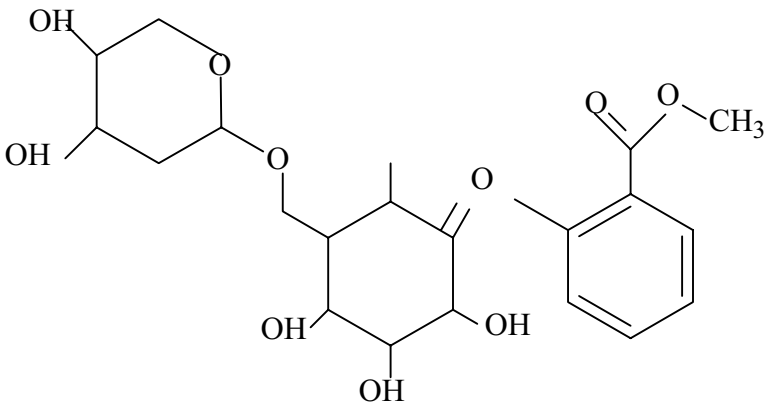


Fig 10.31: Structure of Gaultherin

Gymnemic acid

Source: Gymnema sylvestre.
Biological activity: Antidiabetic.

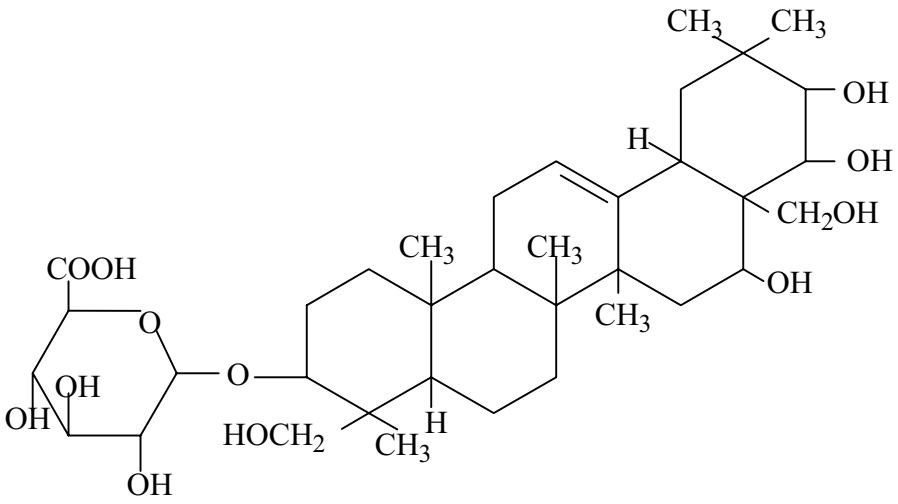


Fig 10.32: Structure of Gymnemic acid.

Leptandrin

Source: Veronica virginica.
Biological activity: Laxative.

Loganin

Source: Strychnos nux vomica.
Molecular formula: $C_{17}H_{26}O_{10}$.
Molecular weight: 390.43.

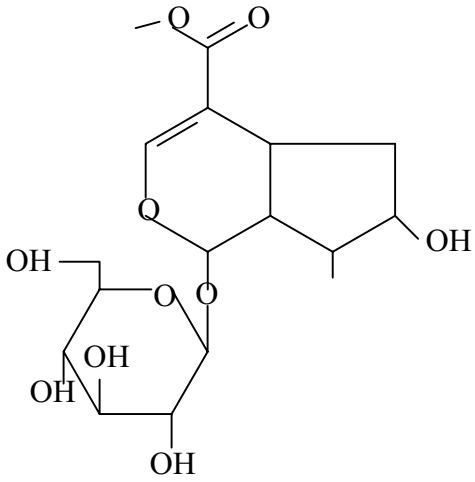


Fig 10.33: Structure of Loganin.

Murrayin

Source: Murraya exotica.
Molecular formula: $C_{16}H_{18}O_4$.
Molecular weight: 274.34.
Melting point: 157 deg C.

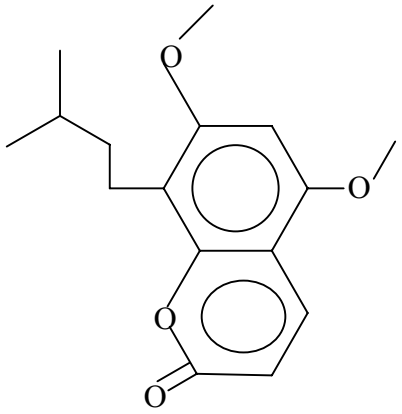


Fig 10.34: Structure of Murrayin.

Koenigin

Source. Murraya koenigii.
Molecular formula: $C_{19}H_{19}O_3$.
Molecular weight: 309.39.

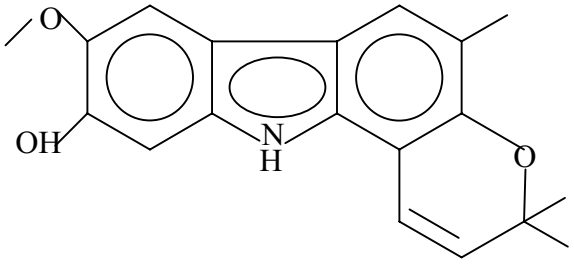


Fig 10.35: Structure of Koenigin

Protoanemonine

Source: Ranunculus scleretus.
Molecular formula: $C_5H_4O_2$.
Molecular weight: 96.09.
Melting point: 45 deg C.

Biological activity: Counter-irritant.

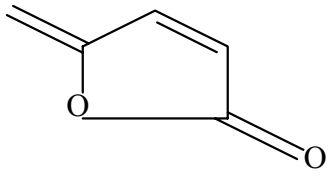


Fig 10.36: Structure of Protoanemonine

Ranunculin

Source: Ranunculus scleretus.
Molecular formula: $C_{11}H_{16}O_8$.
Molecular weight: 276.27.
Melting point: 141 deg C.
Biological activity: Counter-irritant.

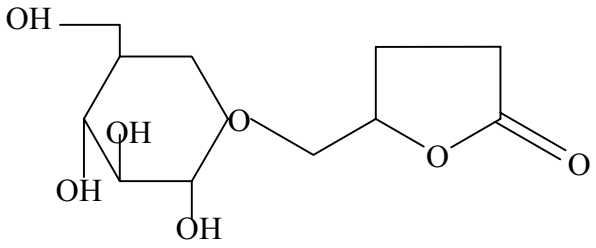


Fig 10.37: Structure of Ranunculin

Rutin

Source: Ruta graveolans.
Molecular formula: $C_{27}H_{30}O_{16}$.
Molecular weight: 610.57.
Biological activity: Anticoagulant.

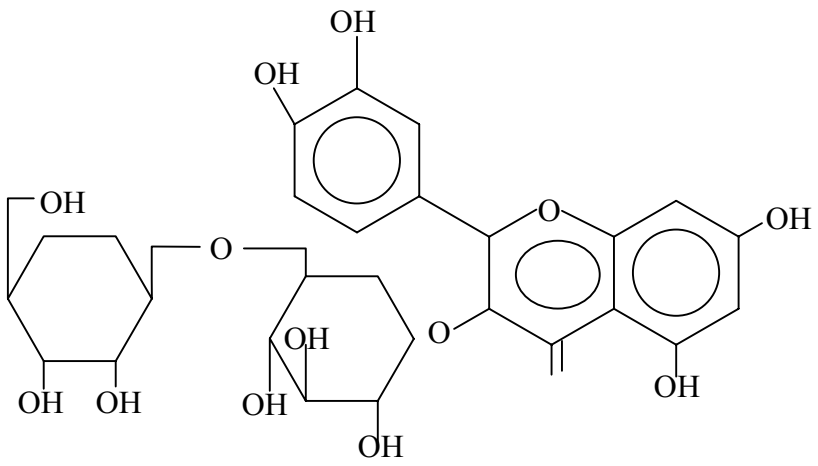


Fig 10.38: Structure of Rutin

Salicin

Source: Salix tetrasperma.
Molecular formula: $C_{13}H_{18}O_7$.
Molecular weight: 286.31.
Melting point: 204-7 deg C.
Solubility:
A.Soluble in water and alcohol.
C. Insoluble in ether.
D. Physical from: Salicin occurs as crystals and has bitter taste.
Biological activity: Analgesic.

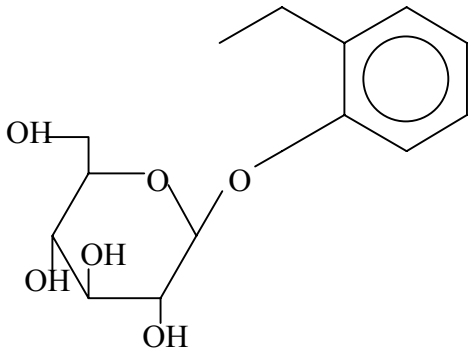


Fig 10.39:Structure of Salicin.

Xanthosturmarin

Source: Salix tetrasperma.
Solubility:
A.Soluble in water, alcohol and chloroform.
Biological activity: Antimalarial.

Chapter-11: Napthodianthrones

Napthodianthrones are derivatives of anthracene. Anthracenes heave been discussed in chapter 10. Th only theme of discussing napthodianthrones in separate chapter is that they have gained importance because of pharmacological investigation of hypericin. Napthodianthrones are known to cause photosensitivity. They are also present in Fagopyrum esculentum (buckwheat).

Fagopyrin

Source: Fagopyrum esculentum
Biological activity: Anticoagulant.

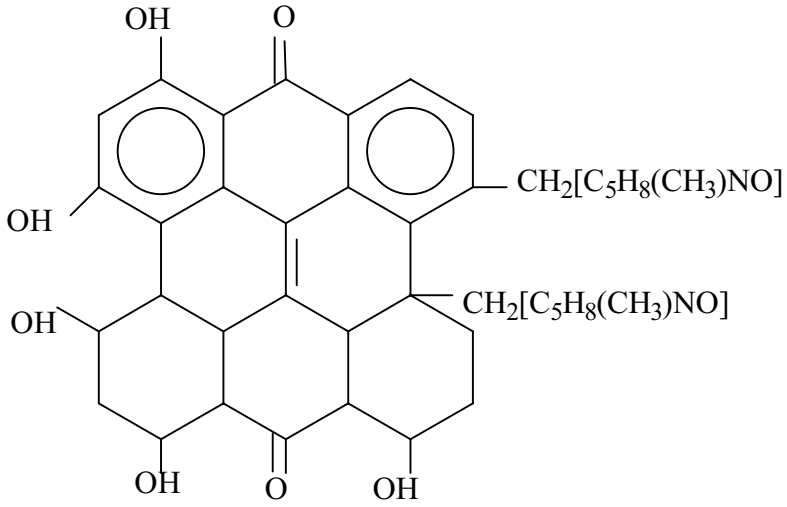


Fig 11.1: Structure of Fagopyrin.

Hypericin

Source: Hypericum perforatum.
Molecular formula: $C_{30}H_{16}O_{8}$.
Molecular weight: 504.4.
Melting point: 330 deg C.
Solubility:
A.Soluble in acetone and pyridine.
Biological activity: Antiviral.

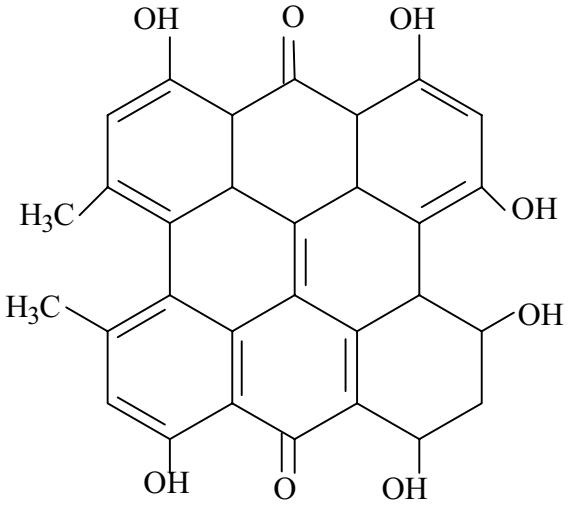


Fig 11.2: Structure of Hypericin.

Pseudohypericin

Source: Hypericum perforatum.
Molecular formula: $C_{30}H_{16}O_9$.

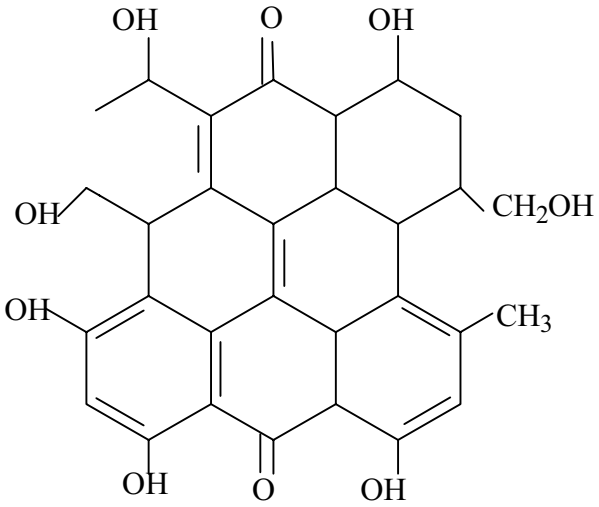


Fig 11.3: Structure of Pseudohypericin.

Chapter-12: Napthoquinones

Napthoquinones are phenolic compounds distributed in Rubiaceae and Verbenaceae. Shikanin obtained from Lithospermum canascens has hepatoprotective activity. Napthoquinones from Boraginaceae has shown hormone like activity.

Junglone

Source: Junglans nigra.
Molecular formula: $C_{10} H_6 O_3$.
Molecular weight: 174.
Biological activity: Sedative in animal models.

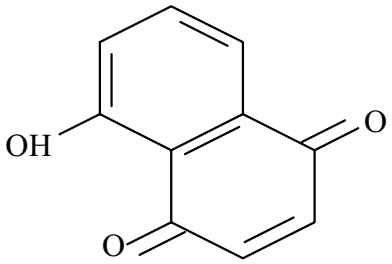


Fig 12.1: Structure of Juglone

Plumbagin (5-hydroxy-2- methyl-1,4-napthoquinone)

Source: Plumbago zeylanica.
Molecular formula: $C_{11} H_8 O_3$.
Molecular weight: 188.9.
Melting point: 78-79 deg C.
Solubility:
A.Soluble in alcohol and ether.
Biological activity: Irritant and abortifacient.

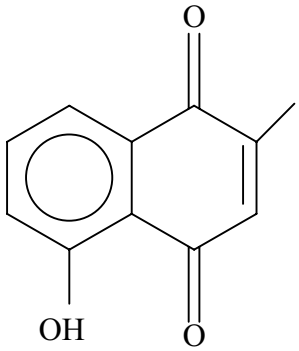


Fig 12.2: Structure of Plumbagin.

Chapter-13: Neutral principles

Neutral principles are bodies of unidentified character. They are widely distributed in Compositae. Some neural principles have been studied for structural determination and biological activity.

Cimicifugin

Source: Cimicifuga racemosa.

Elaterin

Source: Ecballium elaterium.
Molecular formula: C_{32} H $_{44}$O $_{8}$.
Molecular weight: 556.76.
Melting point: 234 deg C.
Solubility:
A.Soluble in alcohol and ether.
B. Insoluble in water.
Physical from: White hexagonal crystals, odourless and bitter.
Biological activity: Irritant and abortifacient.

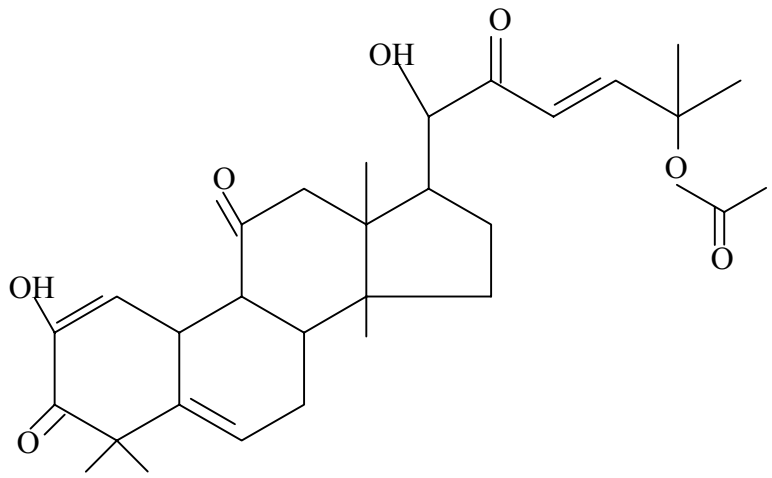


Fig 13.1: Structure of Elaterin

Picrotoxin

Source: Anamartia paniculata.
Molecular formula: C_{30} H_{34} O $_{13.}$
Molecular weight: 602.6.
Solubility:
A.Soluble in water and alcohol.

B. Freely soluble in glacial acetic acid.
Physical form: Colourless crystals with bitter taste.
Biological activity: Analeptic.

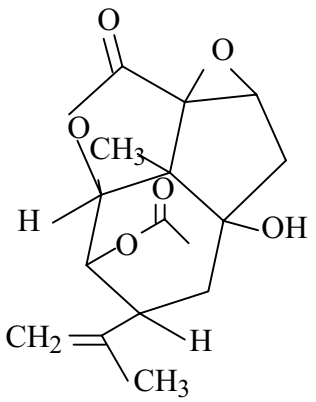


Fig 13.2: Structure of Picrotoxin.

Santonin

Source: Artemisia santonica.
Molecular formula: $C_{15}H_{18}O_3$.
Molecular weight: 246.33.
Melting point: 174 deg C.
Biological activity: Antihelmenthic.

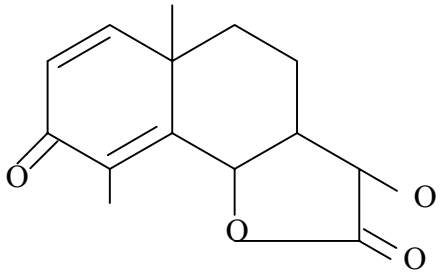


Fig 13.3: Structure of Santonin.

Chapter-14: Pyranocoumarins

Pyranocoumarins are class of coumarin compounds. They are rare compounds and only few of them have been investigated.

Costataolide-A

Source: Caulophyllum acuminata.
Molecular formula: C_{22} H_{26} O $_5$.
Biological activity: AntiHIV.

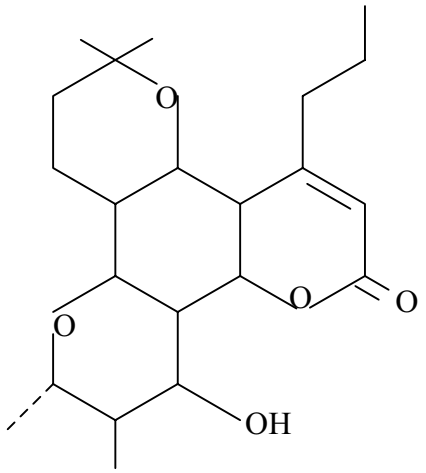


Fig 14.1:Structure of Costatolide-A.

Chapter-15: Phenols and Acylpholroglucinols

Phenolic compounds are widely distributed in plant flora. They constitute important part of glycosides (phenolic glycosides), flavonoids, napthodianthrones and tannins. Acylphloroglucinols are group of phenolic compounds having significant antidepressant activity.

Androsin

Source: Picrorhiza kurroa.

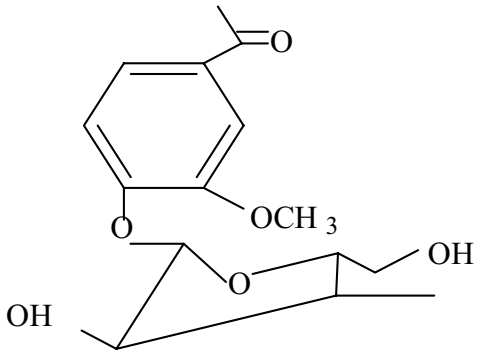


Fig 15.1: Structure of Androsin

Gossypiol

Source: Gossypium herbaceum.
Molecular formula: C_{30} H_{30} O $_8$.
Molecular weight: 518.6.
Melting point: 177 deg C.
Solubility:
A.Soluble in acetone, ethanol and alcohol.
B. Insoluble in water.
Biological activity: Contraceptive.

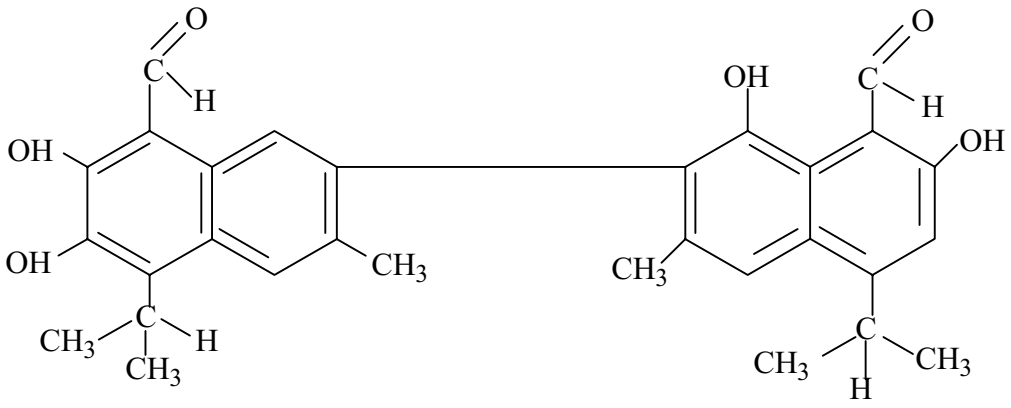


Fig 15.2 : Structure of Gossypiol.

Hyperforin

Source: Hypericum perforatum.
Biological activity: Antidepressant.

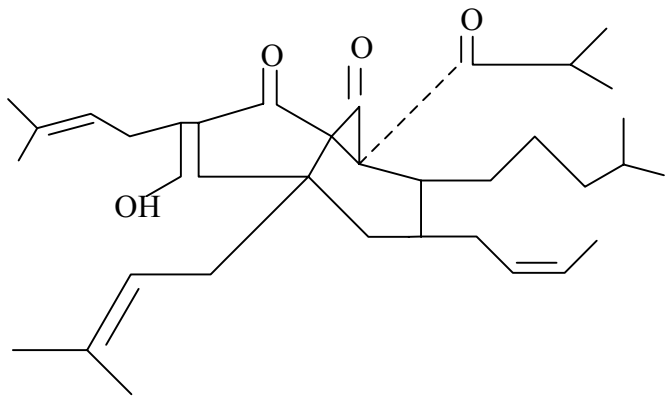


Fig 15.3: Structure of Hyperforin.

Recently, Adhyperforin has been isolated from Hypericum perforatum.

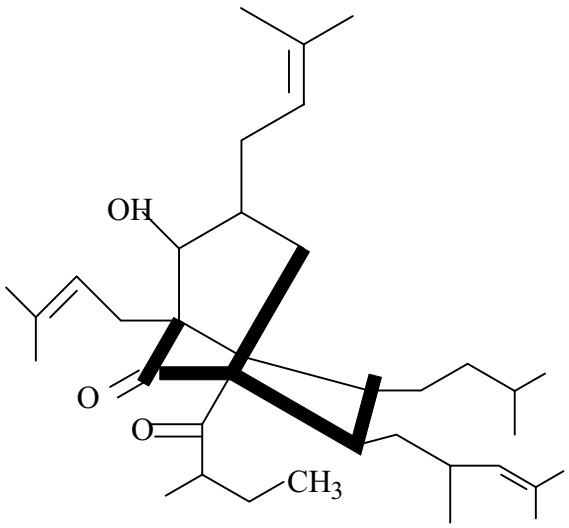


Fig 15.4: Structure of Adhyperforin

Hyperpapunone

Source: Hypericum papaunum.

Acylphloroglucinols are present in Dyropteris filix mass and Humulus lupulus. The pholoroglucinols found in ferns are combined with butyric acid. Aspinidol and filicic acid are the main constituents.

Chapter-16: Resins, oleoresins & gum-resins

Resins are obtained by oxidization of volatile oils. Resins are brittle, non-volatile, solid substances. Sometimes resins are among the products of oxidization of terpenes. The chemical composition of resins is very complex and contains various compounds including acids. Resins are soluble in alkalies, alcohol and insoluble in water. They are obtained from plant exudates and are produced in special ducts. Sometimes resins are produced as a result of injury of the plant part. Turpthein and jalapin are common resins found in Convolvulaceae.

Oleoresins are natural products of resin mixed with volatile oils.

Gum- resins are plant exudates and are mixtures of gum and resin and often volatile oils. When gum -resins are dissolved in water, gum becomes soluble and resin is kept in suspension. Asfoetida is a familiar example.

Balsams are combinations of resins or oleoresins with aromatic acids like benzoic acid or cinnamic acid or both. They are viscous and obtained from the trunk of certain plants.

Boswellic acid

Source: Boswellia serrata.
Molecular formula: $C_{30}H_{48}O_3$.
Molecular weight: 456.78.
Melting point: 289 deg C.
Biological activity: Anti-inflammatory.

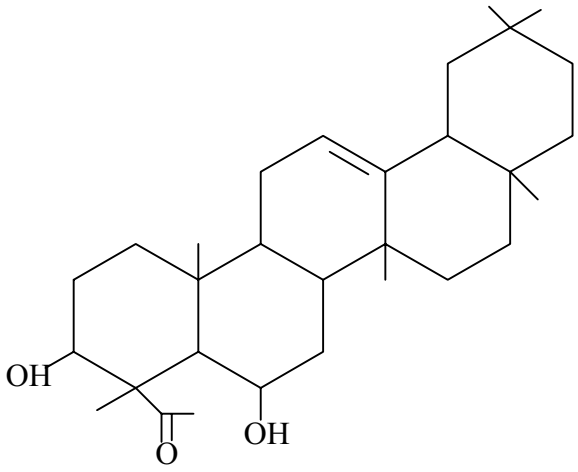


Fig 16.1: Structure of Boswellic acid.

Cannabinol

Source: Cannabis indica.
Molecular formula: $C_{21}H_{26}6O_2$.
Molecular weight: 310.47.
Melting point: 76-77 deg C.
Biological activity: Narcotic.

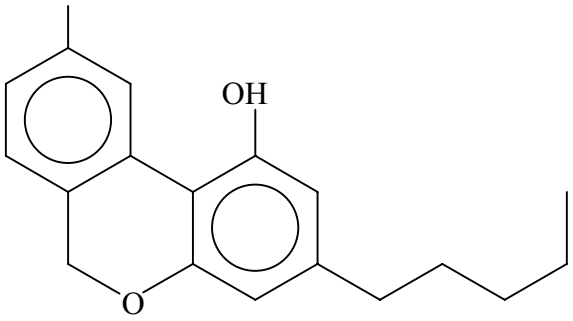


Fig 16.2: Structure of Cannabinol.

Capsiacin

Source: Capsicum annum.
Molecular formula: $C_{18}H_{27}NO_3$.
Molecular weight: 305.46.
Melting point: 65 deg C.
Solubility:
A.Soluble in acetone, ethanol and alcohol.
B. Insoluble in water.
Physical form: Highly pungent crystals.
Biological activity: Counter-irritant.

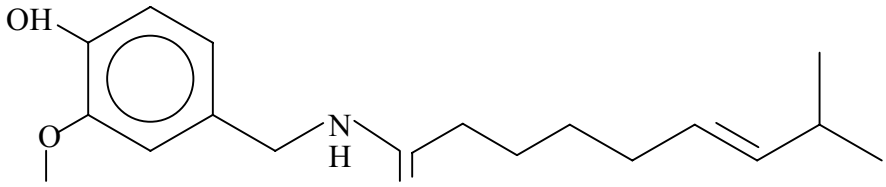


Fig 16.3: Structure of Capsiacin.

Chavicin

Source: Piper nigrum.
Molecular formula: $C_{17}H_{19}NO_3$.
Molecular weight: 285.37.
Melting point: 245-60 deg C.

Solubility:
A.Soluble in water, ether and alcohol.
Physical form: Dark green coloured pungent constituent.

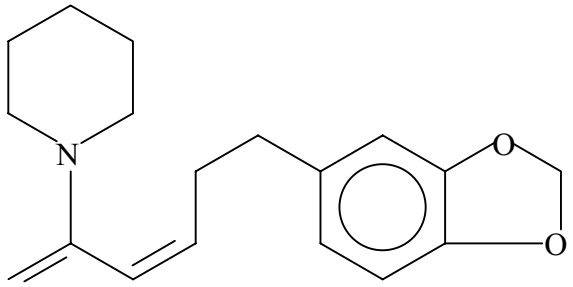


Fig 16.4: Structure of Chavicin

Embelin

Source: Embelia ribes.
Molecular formula: $C_{17}H_{26}O_4$.
Molecular weight: 294.
Melting point: 143 deg C.
Biological activity: Antihelmenthic.

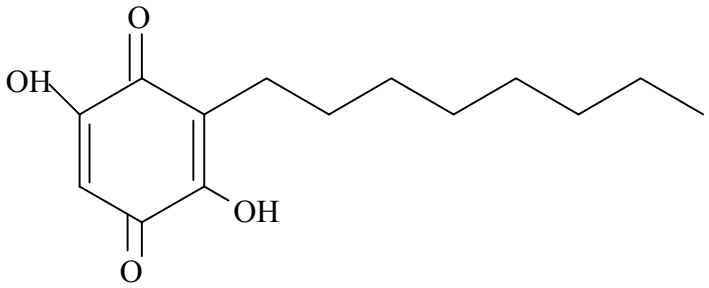


Fig 16.5: Structure of Embelin.

Galangin

Source: Alpinia officinarum.
Molecular formula: $C_{15}H_{22}O_4$.
Molecular weight: 270.25.
Melting point: 214-6 deg C.

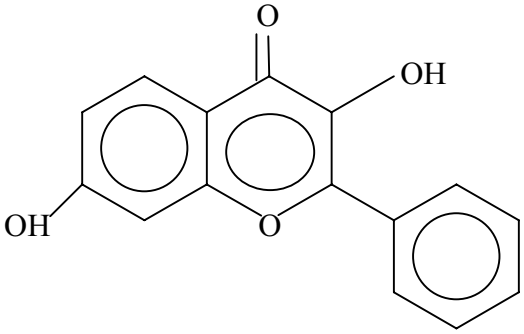


Fig 16.6: Structure of Galangin

Gingerol

Source: Zingiber officinale.
Molecular formula: $C_{15}H_{22}O_4$.
Molecular weight: 266.37.
Solubility:
A.Soluble in ether and alcohol.

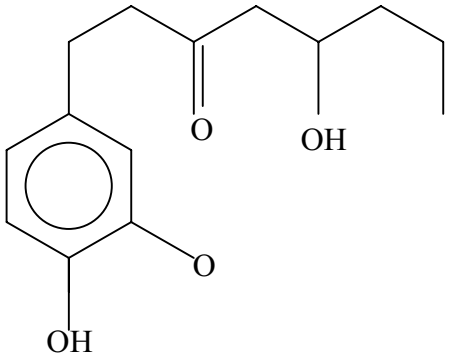


Fig 16.7: Structure of Gingerol

Guggulsterones

Source: Balsamdendrom Commiphora mukul.
Biological activity: Anti-inflammatory.

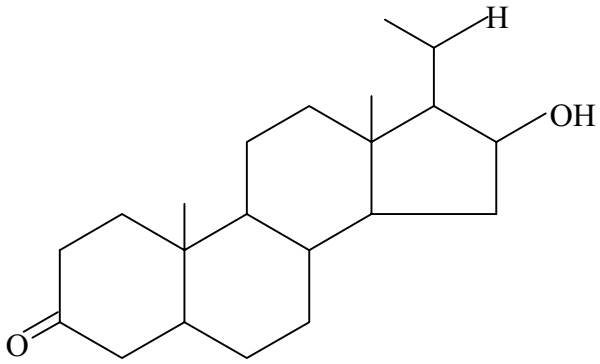


Fig 16.8: Structure of Guggulsterone

Kaempferide

Source: Kaempferia galanga.
Molecular formula: $C_{16}H_{12}O_4$.
Molecular weight: 300.28.

Melting point: 227-9 deg C.
Solubility:
A. Soluble in ether and benzene.

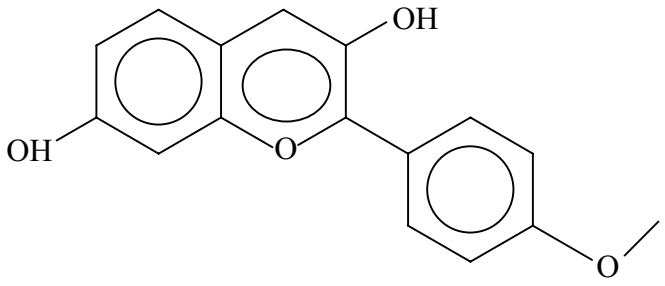


Fig 16.9: Structure of Kaempferide

Hautriwaic acid

Source: Dodonea viscosa.
Molecular formula: C_{20} H_{28} O $_4$.
Molecular weight: 332.4.
Melting point: 188 deg C.

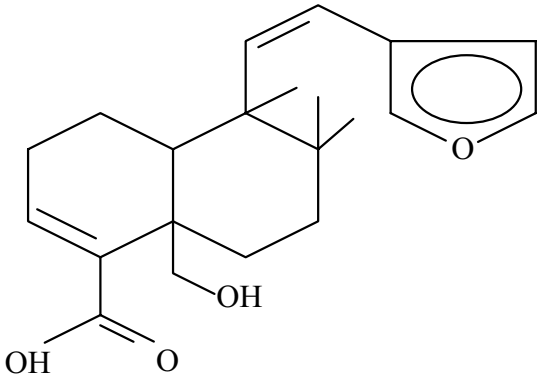


Fig 16.10: Structure of Hautriwaic acid.

Podophyllin

Source: Podophyllum hexandrum.
Molecular formula: C_{22} H_{22} O $_8$.
Molecular weight: 414.4.
Melting point: 114-118 deg C.
Solubility:
A. Soluble in ether and alcohol.
B. Slightly soluble in water.
Physical form: Light brown to green -yellow powder with typical herbaceous odour and bitter taste.

Biological activity: Caustic.

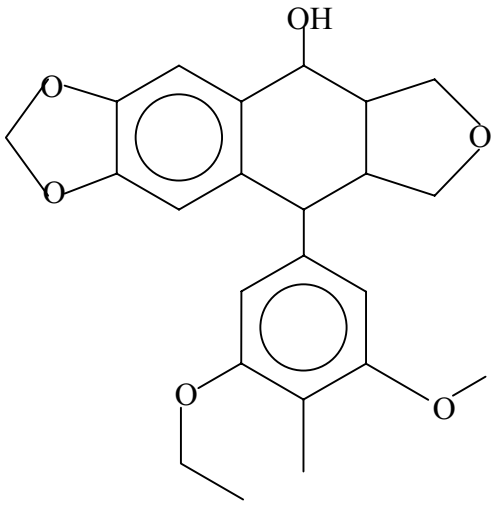


Fig 16.11: Structure of Podophyllin.

Tetrehydrocannabinol

Source: Cannabis indica.
Molecular formula: $C_{21}H_{30}O_2$.
Molecular weight: 314.51.
Biological activity: Narcotic.

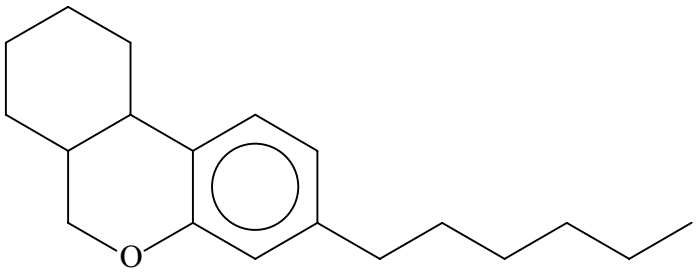


Fig 16.12: Structure of Tetrahydrocannabinol.

Chapter-17: Saponins

Saponins are glycosides found in number of plants. Saponins are regarded as high molecular weight compounds in which, a sugar molecule is combined with triterpene or steroid aglycone. The saponins are classified in two groups:

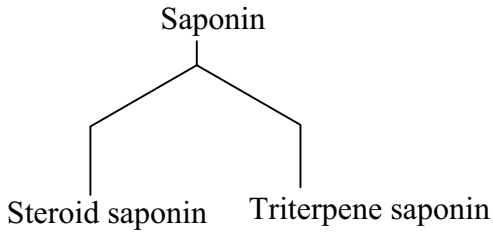


Fig 17.1: Classification of saponins

A. Steroid saponins.
B. Triterpene saponins.

Saponins have a characteristic feature of frothing. The term saponin is derived from Saponaria vaccaria; a plant, which abounds in saponins and once upon a time, used as soap. Saponins are soluble in water and insoluble in ether. Saponins like glycosides on hydrolysis give aglycones.

Saponins are extremely poisonous, as they cause heamolysis of blood and are known to cause cattle poisoning. Some saponins are important from therapeutic point of view, as in Digitalis pupurea, the presence of saponins is necessary for activity of cardiac glycosides. Recent studies have shown that saponins have hypolipdemic and anticancer activity.

Steroid saponins

Steroid saponins are composed of a steroid (C 27) nucleus with carbohydrate molecules. The steroid saponins on hydrolysis give aglycones known as saraponins. These types of saponins have anti-fungal activity. In animal models they have shown to inhibit smooth muscle activity. Steroid saponins are excreted after conjugation with glucouronic acid. They are used as raw material for biosynthesis of cortical steroid drugs.

Asparagosides

Source: Asparagus officinalis.

Avenocosides

Source: Avena sativa.

Disogenin

Source: Dioscorea floribunda, Trigonella foenum graceum.
Molecular Formula: $C_{23}H_{22}O_{6.}$

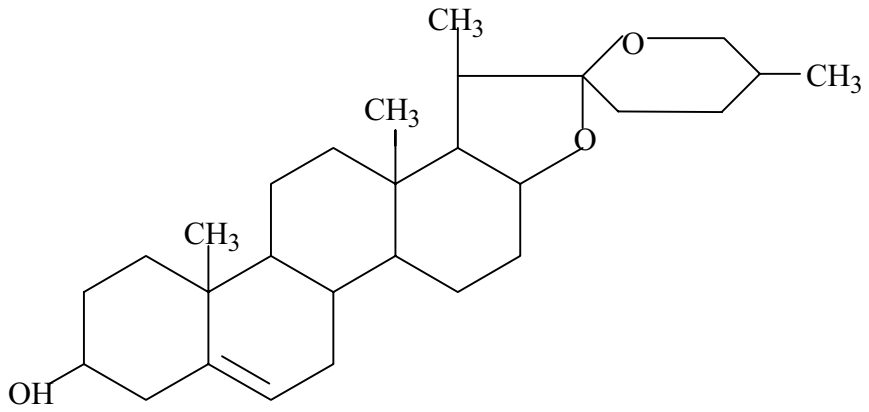


Fig 17.2: Structure of Disogenin.

Ecdysterone

Source: Achyranthes aspera.
Molecular formula: C_{27} H_{44} O $_{7.}$
Molecular weight: 480.7.
Melting point: 237.5 deg C.
Solubility:
A. Soluble in water and alcohol.
Biological activity: Anabolic.

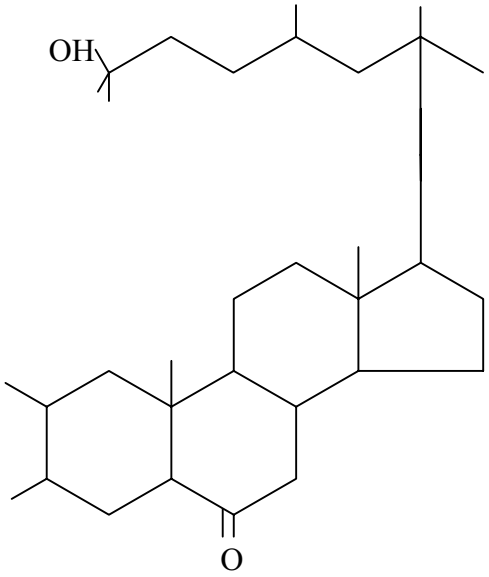


Fig 17.3: Structure of Ecdysterone

Tigogenin

Source: Costus speciosus.
Molecular formula: $C_{27}H_{44}O_3$.
Molecular weight: 416.71.
Melting point: 205-6 deg C.

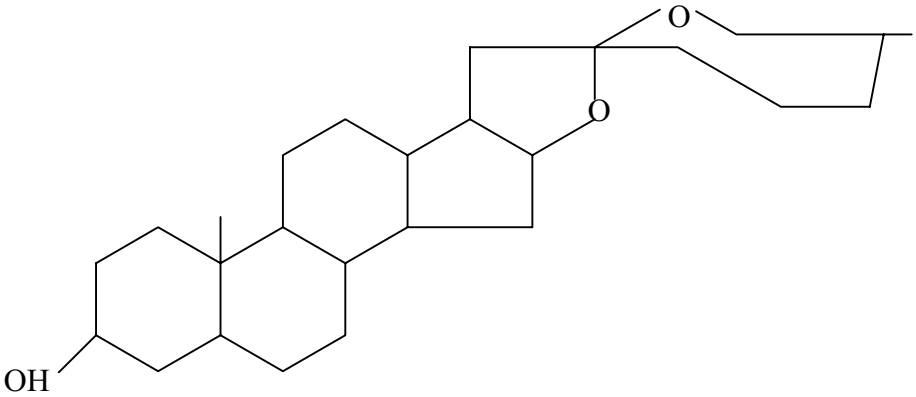


Fig 17.4; Structure of Tigogenin.

Triterpene saponins

Triterpene saponins are composed of a triterpene (C30) nucleus with carbohydrate molecule. On hydrolysis, they give aglycone called sapogenins. These types of saponins are β-amyrine derivatives.

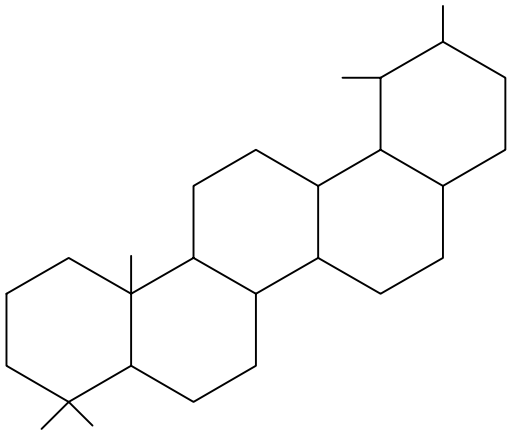


Fig 17.5: Structure of Amyrin

Asiaticoside

Source: Centella asiatica.
Molecular formula: C_{48} H_{78} O $_{18}$.
Molecular weight: 943.26.
Melting point: 230-3 deg C.
Biological activity: Antibacterial.

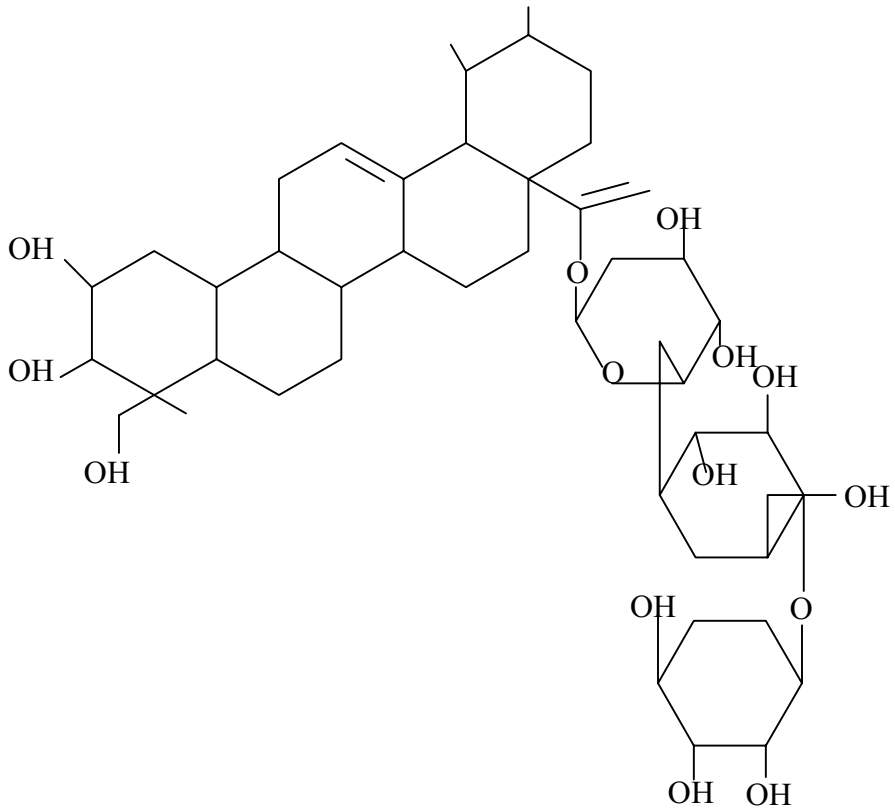


Fig 17.6: Structure of Asiaticoside

Bacoside

Source: Bacopa monneira.
Biological activity: Nootropic.

Cyclamin

Source: Cyclamen persicum.
Molecular formula: $C_{58}H_{94}O_{27}$.
Molecular weight: 1223.
Melting point: 230-3 deg C.
Biological activity: Antibacterial.

Glychyrhizin

Source: Glychyrhiza glabra.
Molecular formula: $C_{42}H_{62}O_{16}$.
Molecular weight: 882.92.
Biological activity: Antiviral.

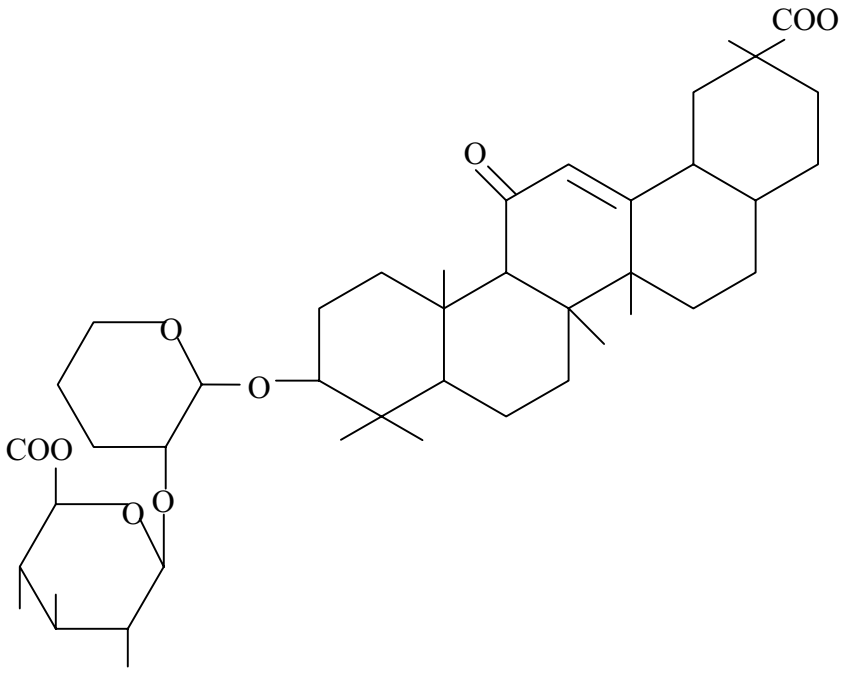


Fig 17.7: Structure of Glychyrhizin.

Panaxadiol and panaxatriol

Source: Panax ginseng.

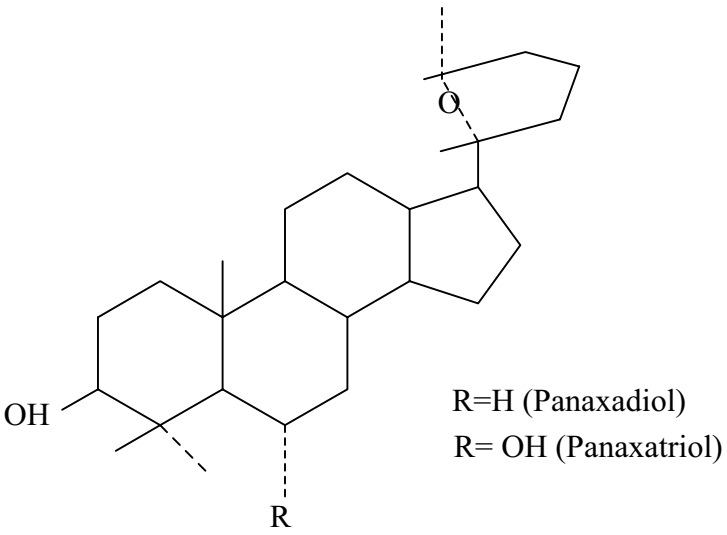


Fig 17.8 :Structure of Ginseng saponins

Chapter-18: Sesquiterpene lactones

Sesquiterpene lactones constitute significant group of phytochemicals. The sesquiterpenes are widely distributed in plant flora particularly in Compositae. The pharmacological activity of the sesquiterpenes ranges from neurotoxic to antimicrobial. The chemistry of sesquiterpenes is very complex. They are formed by condensation of three isoprene molecules followed by oxidation.

Artemisinin

Source: Artemisia annua.
Molecular formula: $C_{15}H_{22}O_{5}$.
Molecular weight: 282.3.
Melting point: 156-7 deg C.
Solubility:
A. Soluble in ether and acetone.
B. Insoluble in water.
Biological activity: Antimalarial.

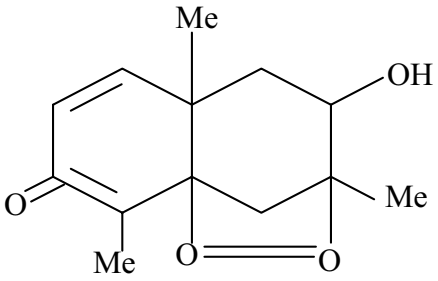


Fig 18.1: Structure of Artemisinin

Camphor

Source: Cinnamomum camphora.
Physical form: Camphor has characteristic odour and aromatic taste.
Biological activity: Antipruritic and antiseptic.

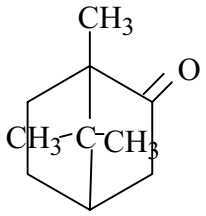


Fig 18.2: Structure of Camphor.

Eugenol

Source: Eugenia caryophyllus.
Molecular formula: $C_{10} H_{12} O_{2}$.
Molecular weight: 164.12.
Melting point: 9 deg C.
Boiling point: 254 deg C.

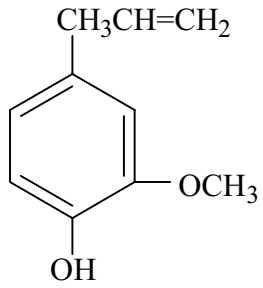


Fig 18.3: Sytructure of Eugenol.

Helenin

Source: Inula racemosa.
Molecular formula: $C_{15} H_{18} O_{4}$.
Molecular weight: 262.33.
Melting point: 141 deg C.

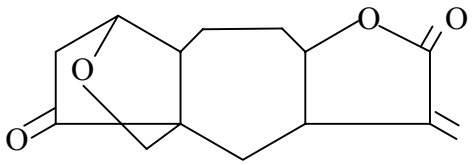


Fig 18.4: Structure of Helenin.

Jatamansin

Source: Nardostachys jatamansi.
Molecular formula: $C_{15} H_{20} O_{8}$.
Molecular weight: 328.29.
Melting point: 97-8 deg C.

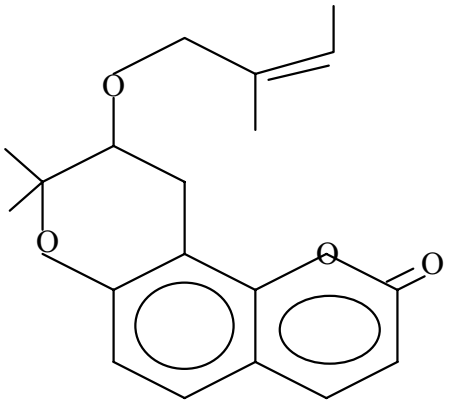


Fig 18.5: Structure of Jatamansin

Menthol

Source: Mentha spicata.
Physical form: Menthol has characteristic odour and aromatic taste.
Biological activity: Antipruritic and antiseptic.

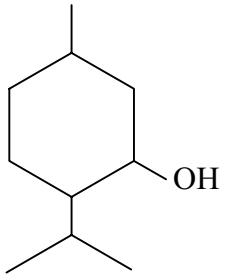


Fig 18.6: Structure of Menthol

Parthenolide

Source: Tanacetin parthenium.
Molecular formula: C_{15} H_{20} O_{3}.
Molecular weight: 248.2.
Solubility:
A. Soluble in ethanol.

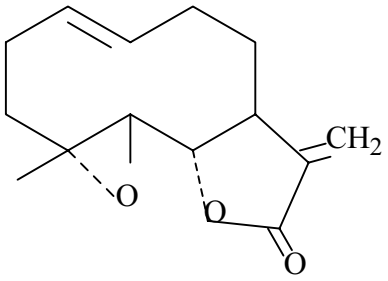


Fig 18.7: Structure of Parthenolide

Valerianic acid

Source: Valeriana officinalis.
Molecular formula: C_{15} H_{22} O_{2}.
Molecular weight: 234.37.
Melting point: 142 deg C.
Physical form: Liquid with typical smell and odour.
Biological activity: Sedative.

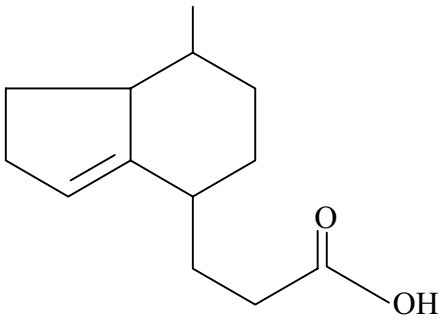


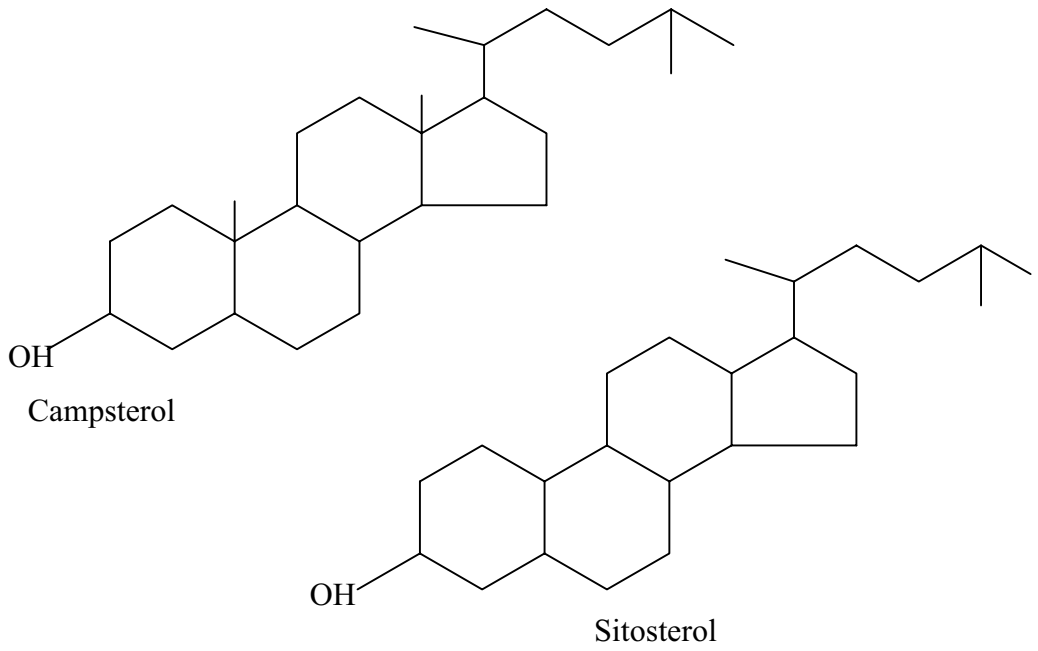
Fig 18.8: Structure of Valerianic acid.

Chapter-19: Sterols

Sterols are derivatives of steroid .As discussed in chapter on saponins; some chemical constituents present in plant flora resemble with steroids. Modern clinical studies have supported their role as anti-inflammatory and analgesic agents. β-sitosterol has significant hypolipidemic activity.

Sterols are present in Terminalia arjuna, Serenoa repens, Yucca filamentosa, Smilax glabra and Rubus aculeatus. Ruscogenins in animal models have shown electrolyte-like activity on the cell wall of the capillaries. Balasamdendron commiphora mukul contains guggulsterones, well-documented natural anti-inflammatory agents. Glychyrhiza glabra contains glychyrhizic acid, which has structure similar to hydrocortisone.

The sterols like compounds are sometimes refereed to as phyto-estrogens because of hormone like activity. Shatavarins present in Asparagus racemosus has significant anticholinergic activity.



Campsterol

Sitosterol

Fig 19.1: Structure of common plant sterols

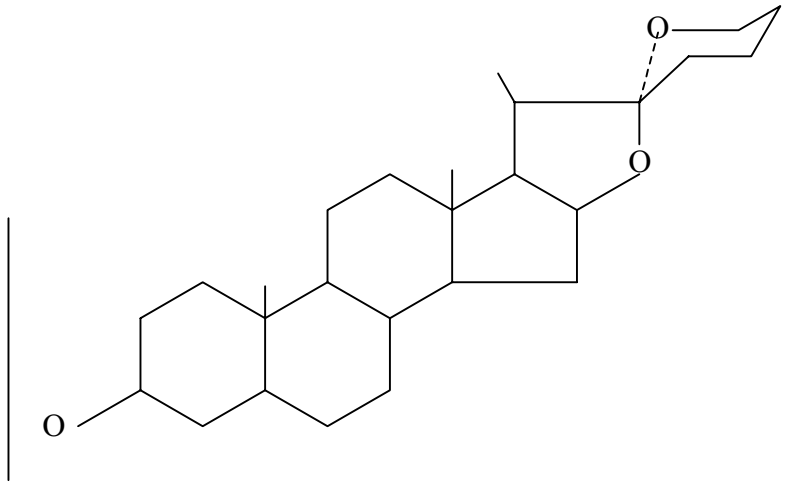


Fig 19.2: Structure of Shatavarin

Protodioscin

Source: Tribulus terrestris.
Molecular formula: $C_{51}\ H_{84}\ O_{22.}$
Molecular weight: 1049.2.
Solubility:
A. Soluble in water and methanol.
Biological activity: Antimalarial.

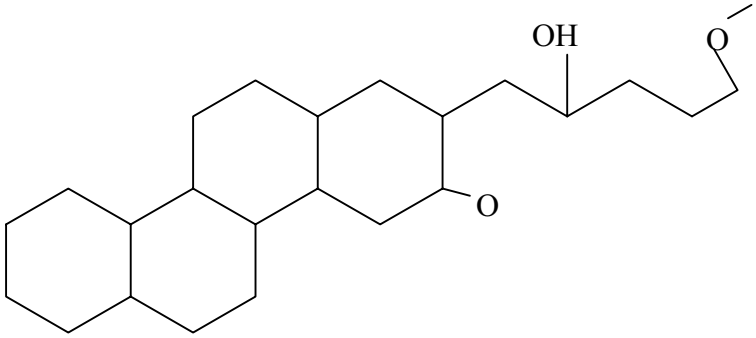


Fig 19.3: Structure of Protodioscin

Withanolides

They are a group of naturally occurring oxygenated ergostane type steroids having lactone in side chain and 2-en-1-one system in ring A. Withanolides isolated from the leaves of Withania somnifera have shown significant antitumor and immunomodulator activity. Coagulin F and coagulin G isolated from Withania coagulens have anti fungal properties. 3 beta –hydroxy2, -3-dihydrowithanolide F present in fruits has significant hepatoprotective $ anti-inflammatory activity. Withaferin A and withanolide E have immunosupressant activity.

Withaferin-A

Source: Withania somnifera.
Molecular formula: C_{28} H_{38} O_6.
Molecular weight: 470.66.
Melting point: 253 deg C.
Biological activity: Anticancer.

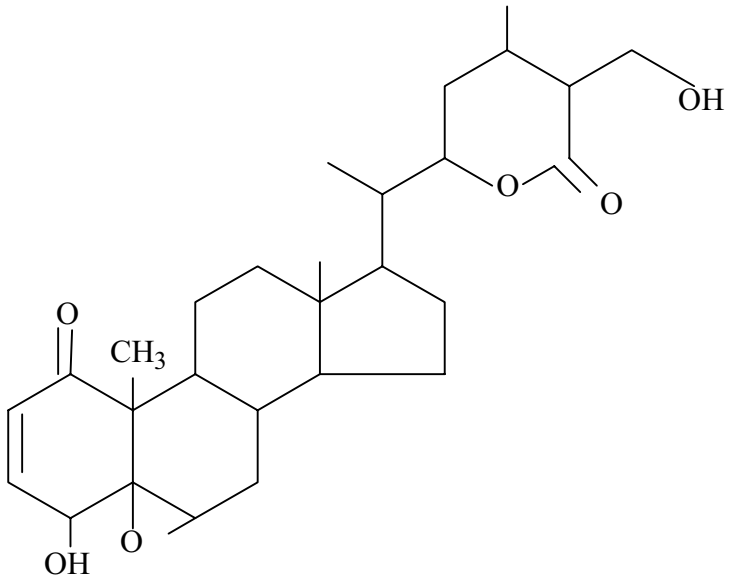


Fig 19.4: Structure of Withaferin-A

Chapter 20- Tannins

Tannins are widely distributed in plant flora. They are phenolic compounds of high molecular weight. Tannins are soluble in water and alcohol and are found in root, bark, stem and outer layers of plant tissue. Tannins have a characteristic feature to tan, i.e. to convert the things into leather. The tannins are acidic in reaction and it is attributed to the presence of phenolic or carboxylic group. Tannins form complex with proteins, carbohydrates, gelatin and alkaloids.

Tannins are classified in two classes:

1. Hydrolysable tannins.
2. Condensed tannins.

Hydrolysable tannins upon hydrolysis give gallic and ellagic acid. Depending on the type of acid produced, the hydrolysable tannins are known as gallitannins or egallitannins. On heating, they from pyrogallic acid. They are found in Rheum emodi, Arctostaphylos uva-ursi, Aegle marmelos, Quercus infectoria and Hamamelis virgininana.

Condensed tannins are formed by condensation of catechin units. These types of tannins are also known as phalbatannins. They are powerful antioxidants and are present in Vitis vinifera, Cinchona officinalis, Acacia catechu, Lawsonia inermis and Pinus sylvestris. They have been discussed in chapter 6.

Tannins are used as antiseptic and this activity is due to presence of phenolic group. Tannin rich medicinal plants are used as healing agents in number of diseases. In Ayurveda, formulations based on tannin rich plants have been used for treatment of diseases like leucorrhorea, rhinnorhoea and diarrhoea. Triphala (combination of fruits of Terminalia chebula, Terminalia belerica and Embelica officinalis) and Asoka-arishta (alcoholic preparation of Saraca indica) are familiar examples of tannin containing formulations. Some of tannins are potential carcinogenic agents.

Chebulinic acid

Source: Terminalia chebula.
Molecular formula: $C_{41}H_{34}O_{28}$.
Molecular weight: 974.75.
Melting point: 234 deg C.
Solubility:
A. Soluble in water and alcohol.
Physical form: Colourless, odourless powder with characteristic odour and astringent taste.

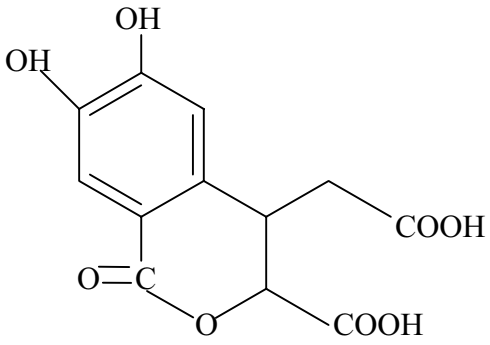


Fig 20.1: Structure of Chebulinic acid

Ellagic acid

Source: Terminalia chebula.
Molecular formula: $C_{14} H_6 O_{8.}$

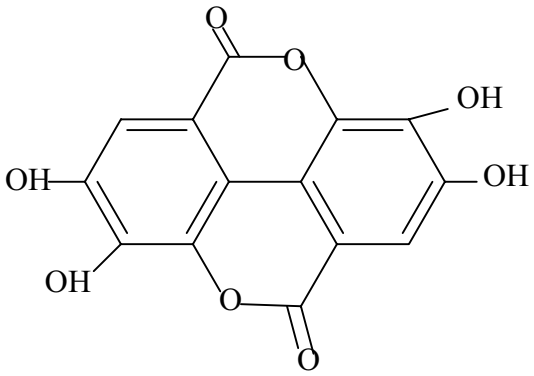


Fig 20.2: Structure of Ellagic acid

Gallic acid

Source: Quercus infectoria.
Molecular formula: $C_7 H_6 O_5$ COOH.
Molecular weight: 170.1.

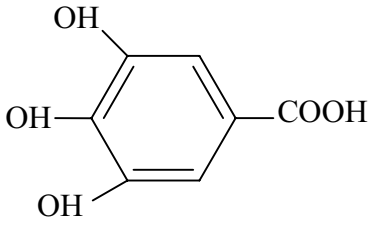


Fig 20.3: Structure of Gallic acid

Pyrogallic acid

Source: Gallic acid
Molecular formula: $C_6 H_6 O_3$.
Molecular weight: 126.1.

Tannic acid

Source: Quercus infectoria.
Molecular formula: $C_{14} H_{10} O_9$.
Molecular weight: 201.
Solubility:
A. Soluble in water, glycerin and alcohol.
Physical form: Light brown or yellowish white powder with characteristic odour and astringent taste.

Chapter 21- Terpenes

Terpenes are flammable unsaturated hydrocarbons, existing in liquid form. They are found in essential oils, resins or oleoresins. They are used as intermediate for the synthesis of sesquitrepenes and terpenoids. They are classified as mono, di or triterpenoids.

Ajoene
Source: Allium sativum.
Molecular formula: $C_9 H_{14} O S_3$.

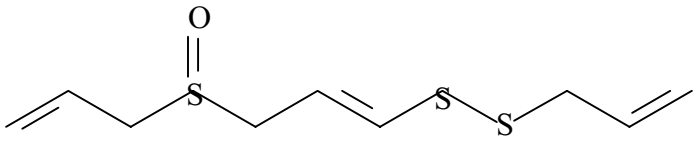


Fig 21.1:Structure of Ajoene

Allicin
Source: Allium sativum.
Molecular formula: $C_6 H_{10} O S_2$.
Molecular weight: 162.28.
Solubility:
A. Soluble in water, benzene and ethanol.
Biological activity: Hypolipidemic.

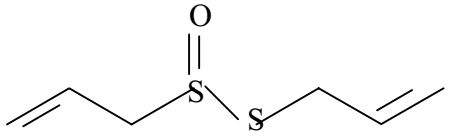


Fig 21.2:Structure of Allicin

Allin

Source: Allium sativum.
Molecular formula: $C_6 H_{11} N O_3 S$.
Molecular weight: 177.24.

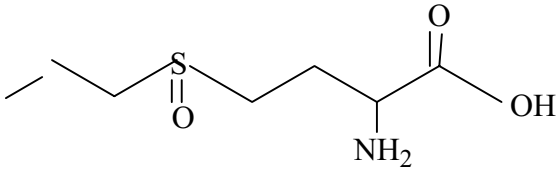


Fig 21.3: Structure of Allin

Ascaridol

Source: Chenopodium ambrosoides.
Molecular formula: C_{10} H_{16} O $_2$.
Molecular weight: 2.5 deg C.

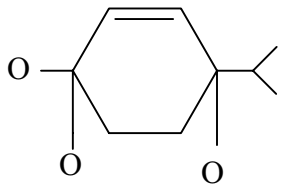


Fig 21.4: Structure of Ascaridol

Argopyrene

Source: Artemisia drancuculans.

Azadirachtin

Source: Azadirachta indica.
Molecular formula: C_{36} H_{44} O $_{16}$.
Molecular weight: 720.

Carnosolic acid

Source: Salvia officinalis.

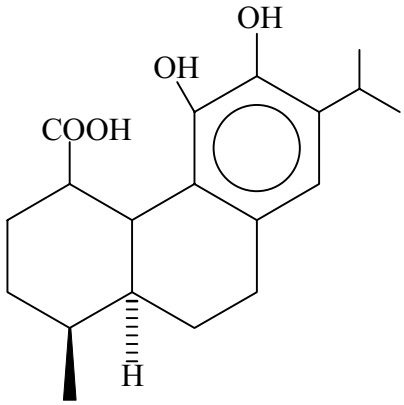


Fig 21.5: Structure of Carnosolic acid.

Forskolin

Source: Coleus forskolin.

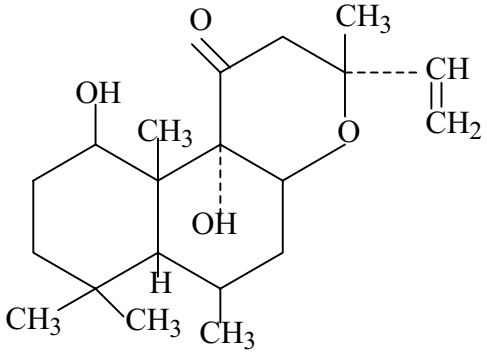


Fig 21.6: Structure of Forskolin

Matricarin

Source: Matricaria chamomila.

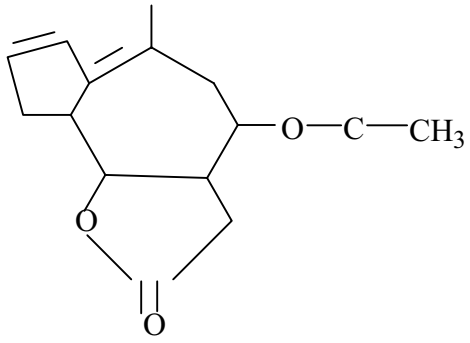


Fig 21.7:Structure of Matricarin

Methysticin

Source: Piper methysticum.
Molecular formula: $C_{15}H_{14}O_5$.
Molecular weight: 258.57.
Melting point: 158-9 deg C.

Myristicin

Source: Myrisatica officinalis.
Molecular formula: $C_{11}H_{12}O_3$.

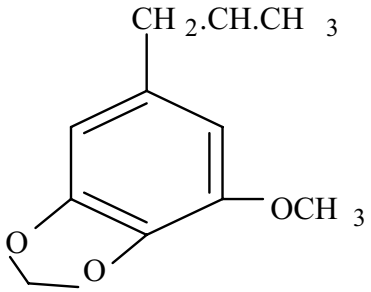


Fig 21.8: Structure of Myristicin

Nepetalactone

Source: Nepeta cataria.

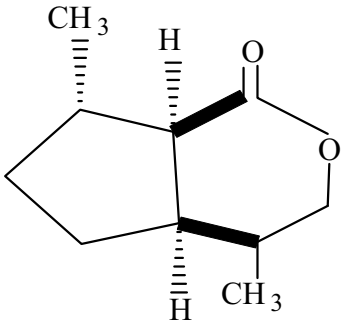


Fig 21.9: Structure of Nepetalactone

Picrosalvin

Source: Rosmarinus officinalis.

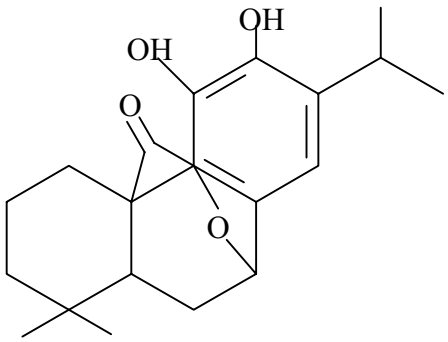


Fig 21.10: Structure of Picrosalvin

Prostratin

Source: Homolanthus nutans.
Molecular formula: C_{22} H_{30} O $_6$.

Biological activity: Anti HIV.

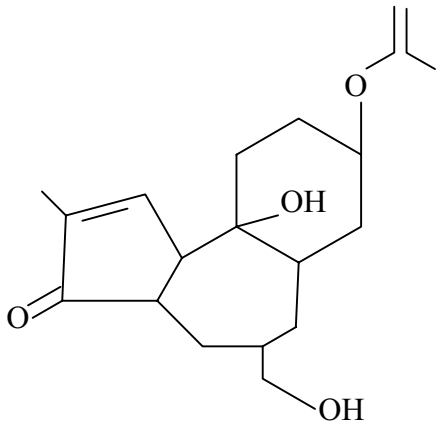


Fig 21.10: Structure of Prostratin

Rosmarinic acid

Source: Rosmarinus officnalis.

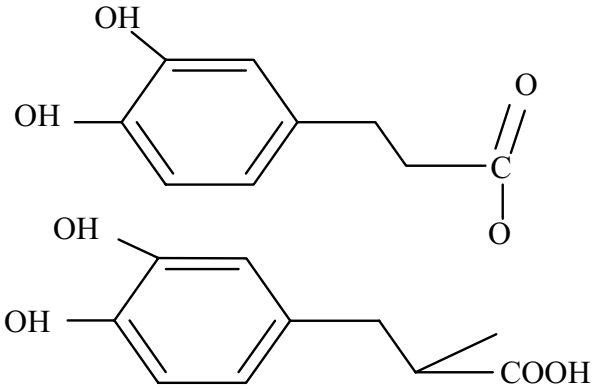


Fig 21.11: Structure of Rosmarinic acid.

Stevioside

Source: Stevia species.
Molecular formula: $C_{38}H_{60}O_{18}$.
Molecular weight: 804.9.
Melting point: 201-5 deg C.
Solubility:
A. Soluble in water and ethanol.
B. Insoluble in methanol.
Biological activity: Hypolipidemic.

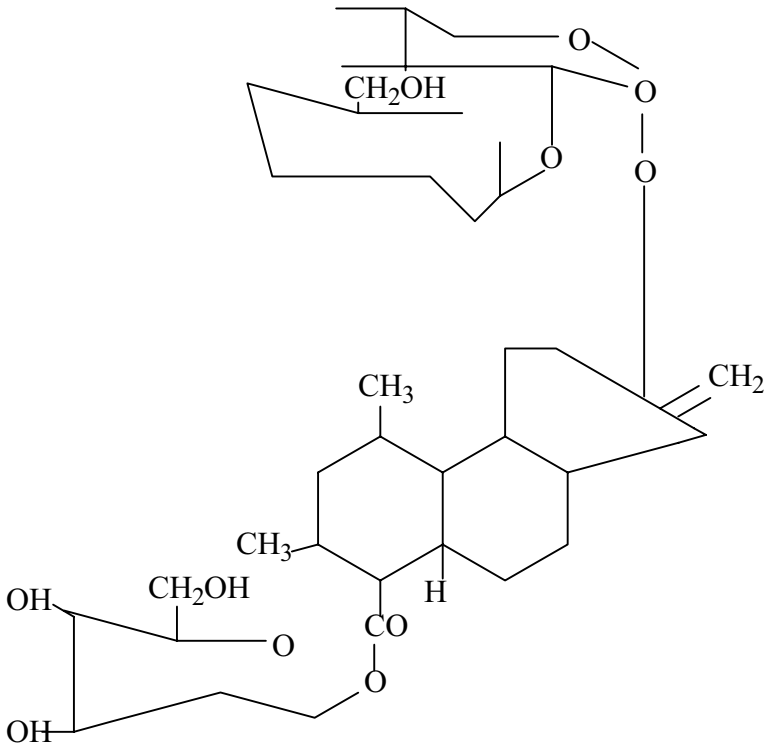


Fig 21.12: Structure of Stevioside

Taxol

Source: Taxus brevifolia.
Molecular formula: $C_{47}H_{51}NO_4$.
Molecular weight: 853.99.
Melting point: 213-6 deg C.
Biological activity: Antitumor.

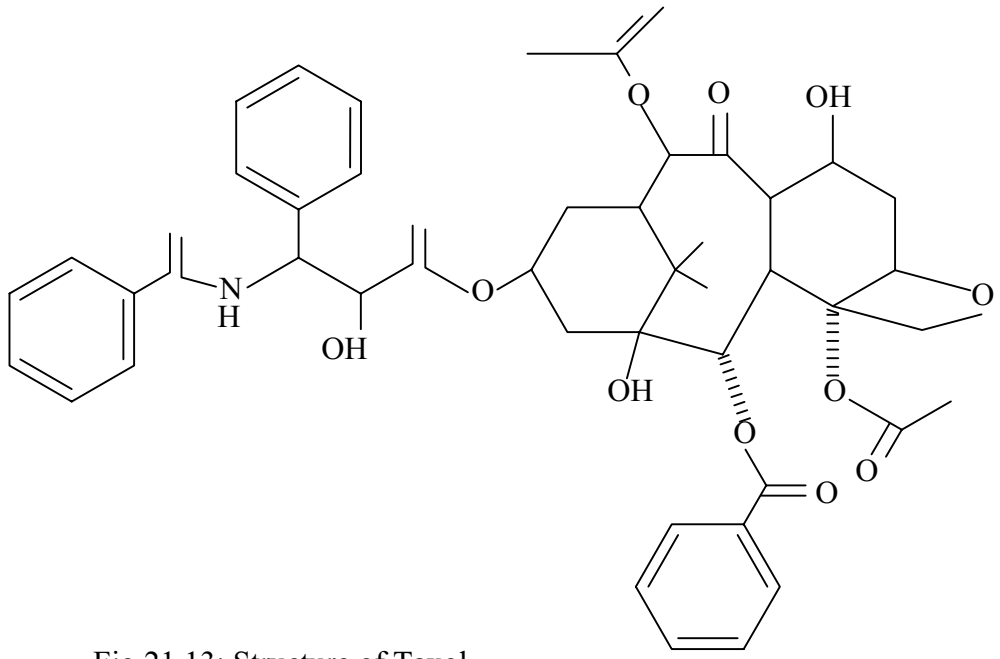


Fig 21.13: Structure of Taxol

Taxine

Source: Taxus baccata.
Molecular formula: $C_{37}H_{49}NO_{10}$.
Molecular weight: 667.87.
Melting point: 121-4 deg C.

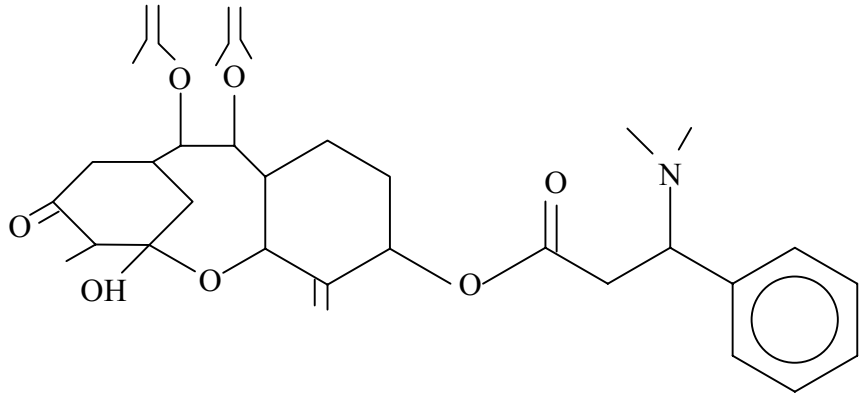


Fig 21.14: Structure of Taxine

Ursolic acid

Source: Salvia officinalis.
Molecular formula: $C_{18}H_{16}O_7$.
Molecular weight: 456.7.
Biological activity: Antibacterial.

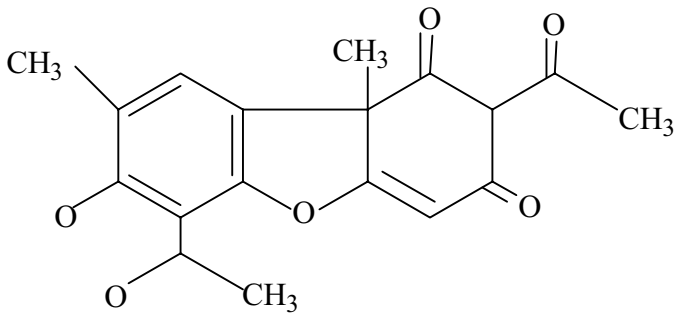


Fig 21.15 : Structure of Ursolic acid

Chapter 22- Miscellaneous compounds

Abrin

Chemical class: Lectin
Source: Abrus precatorius.
Molecular formula: $C_{12}H_{14}N_2O_2$.
Molecular weight: 216.28.
Melting point: 216.28 deg C.

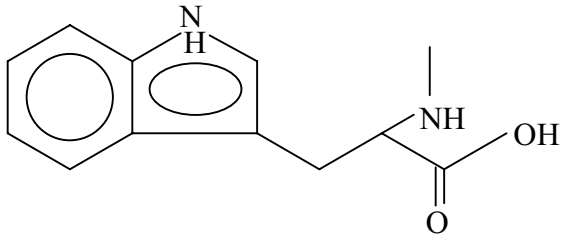


Fig 22.1: Structure of Abrin

Asarone

Source: Acorus calamus.
Biological activity: Carcinogenic.

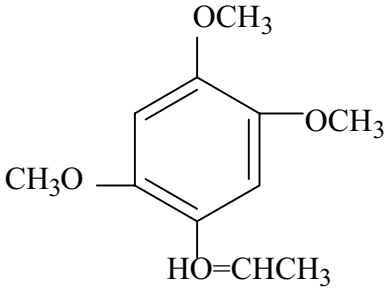


Fig 22.2 : Structure of Asarone.

Betulinic acid

Source: Betula alba.
Biological activity: Anticancer.

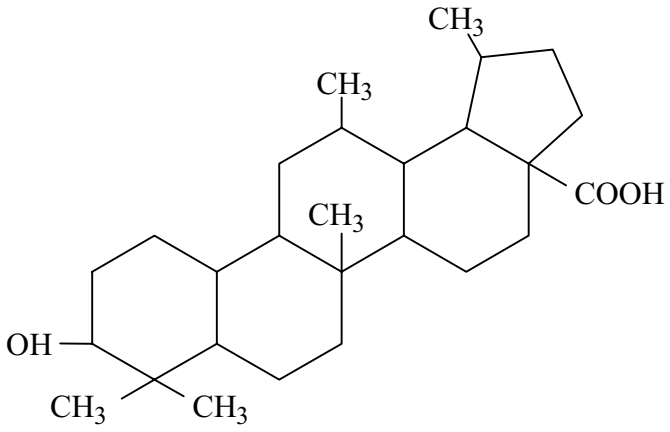


Fig 22.3: Structure of Betulinic acid

Curcumin

Source: Curcuma longa.
Molecular formula: C_{21} H_{20} O_6.
Molecular weight: 368.91.
Melting point: 183 deg C.
Biological activity: Hepatoprotective and anti-inflammatory.

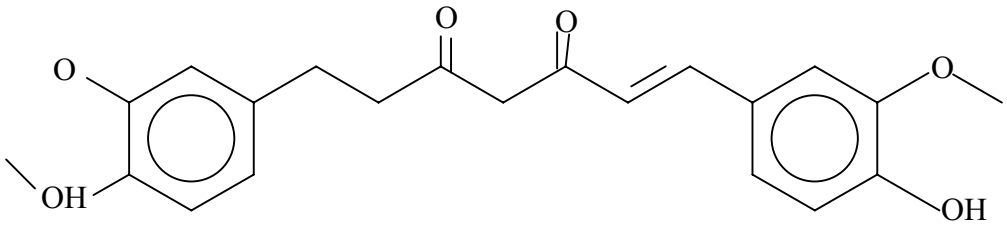


Fig 22.4: Structure of Curcumin.

Plaunotol

Source: Croton sublyratus.
Molecular formula: C_{20} H_{34} O_2.
Molecular weight: 306.49.
Biological activity: Antiulcer.

Usnic acid

Source: Usnea palmata.
Molecular formula: C_{18} H_{16} O_7.
Biological activity: Antibacterial.

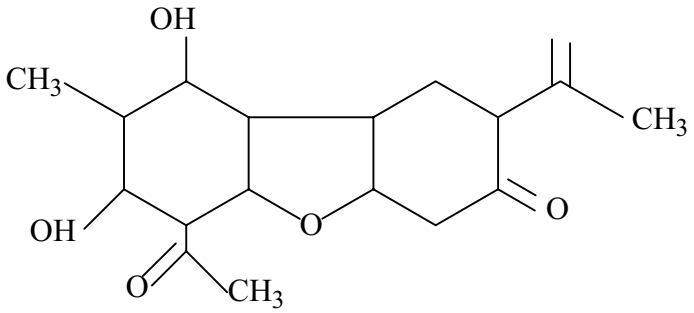


Fig 22.5: Structure of Usnic acid.

Glossary

Active constituent – an herbal drug or herbal drug preparation its entirety is regarded as active constituent.

Adaptogen- an agent that invigorates or strengthens the system

Alterative- an agent used for purifying blood.

Anabolic- an agent having steroidal action.

Analeptic- an agent used to boost respiration and circulation.

Anodyne- an agent tahr relieves pain on local application.

Antiarrthymic- an agent used for treatment of heart disease.

Antibiotic- an agent used for killing microorganisms.

Anticoagulant- an agent used for preventing blood clotting.

Antidepressant- an agent used for counteracting depression.

Antihelmintic- an agent used to kill worms.

Antiperiodic- an agent used for preventing relapsing fever.

Antipruritic- an agent used to cure itching.

Antirheumatic- an agent used for curing arthritis and rheumatism.

Analgesic- an agent used for preventing pain.

Anti-inflammatory- an agent used for preventing inflammation.

Antipyretic- an agent used for lowering the fever.

Antiseptic- an agent used form preventing the growth of microorganisms.

Antispasmodic- an agent used for reliving the spasms of voluntary and involuntary muscles.

Aphrodisiac- an agent used to stimulate sex urge and maintain vitality.

Aperient-an agent used for mild laxation.

Ayurveda- the ancient healing system of India.

Bruising- a process of smashing of different parts of a medicinal herb in a pestle and mortar.

Cathartic-an agent used to relieve severe constipation

Carminative- an agent used to dispel gas from the intestine and prevent distension.

Cholagogue- an agent used to promote the flow of bile.

Choleretic- an agent that stimulates the formation of bile

Convulsant- an agent which induces seizures.

Counterirritant - (See Rubefacient.)

Crude drug- the form of the medicinal herb unchanged by processing other than separation of parts, drying or grinding.

Decoction- a process of boiling a coarsely bruised drug in water in tinned pots with covers for a definite period.

Diaphoretic- an agent used for increasing perspiration through the skin.

Diuretic- an agent used for increasing urine flow.

Ecbolic- an agent used for stimulating uterine musculature.

Elutriation- a process of separation of the coarser particles of a powder from the finer ones.

Emetic- an agent used for inducing vomiting.

Emollient- an agent, which softens the skin.

Expectorant- an agent used to promote the expulsion of mucus form the respiratory tract.

Expression- a process of pressing out juice or oil from plant products.

Extract- an process of manufacturing of concentrated preparations of the active principles of the vegetable drugs.

Fluid extract- a liquid extract of raw plant material, usually of a concentration ratio of 1 part raw herb to 1 part solvent.

Febrifuge- an agent used to reduce fever.

Hemostatic- an agent used to prevent flow of blood.

Hepatoprotective- an agent used for preventing injury to the liver.

Hygroscopic- a substance that readily attracts and retains water.

Hypnotic- an agent used to induce sleep.

Hypolipidemic- an agent which reduces high levels of cholesterol.

Incineration- a process of heating the organic substances with access of air, so that all the carbonaceous matter is burnt.

Infusion- a process of treating a moderately comminuted drug in a muslin bag soaked in cold or hot water.

Levigation- a process of grounding of solid substance with water to make a paste and dry.

Maceration- a process of soaking a ground up drug in a solvent and expression of fluid from it.

Marker compound-chemically defined constituents of an herbal drug, which are of interest for control purposes, independent of whether they have any therapeutic activity or not.

Medicated oil- oil preparation obtained by steeping the medicinal herb in oil for several days or months.

Sifting- a process of passing a powdered drug through a sieve to obtain powder of uniform strength.

Nervine- an agent used for improving the function of the nerves.

Nootropic- an agent having memory enhancing activity.

Pharmacy- the study of scope, the preparation of materials in suitable forms for use in Medicine.

Rubifacient- an agent used for increasing the blood supply to the skin, when applied locally.

Sedative- an agent used for calming the functional activity of the body.

Standardisation- a process of fixing the quantity of active constituent of a medicinal agent.

Stimulant- an agent used for boosting metabolism and circulation.

Stomachic- an agent used to promote stomach function.

Tincture- alcoholic solution of active constituents of vegetable drugs.

Trituration- the process of rubbing solid substances into finer ones with the help of a pestle and mortar.

Tonic- an agent used to increase energy and vigor in a specific part of the body.

Vasodilator- an agent used to dilate the blood vessels.

Vulnerary- an agent used to promote the healing of new cuts and wounds.

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