III UNIT

Resins and Resin Combinations

Resins, in general, are amorphous solid or semisolid substances that are invariably water insoluble but mostly soluble in alcohol or other organic solvents. However, physically they are found to be hard, translucent or transparent and fusible *i.e.*, upon heating they first get softened and ultimately melt. But chemically, they are complex mixtures of allied substances, such as: **resin acids, resin alcohols** (or **resinols**), **resinotannols, resin esters, glucoresins** and the like.

Another school of thought considers **Resins** as amorphous products having an inherent complex chemical entity. These are normally produced *either* in schizogenous or in sehizolysigenous ducts or in carities and are regarded as the end products of metabolism. The physical general characteristic features of resins are namely: hard, transparent, or translucent and, when heated they yield usually complex mixtures that comprise of resin acids, resin alcoholds, resinotannols, esters and resenes. Some researchers do believe that the resins are nothing but the oxidation products of the **terpenes.**They are found to be mostly insoluble in water, but soluble in ethanol and organic solvents. They are electrically non-conductive and combustible in nature.

Resins shall now be discussed at length in their various aspects as enumerated here under:

(a)Distribution of Resins in Plants
(b)Occurrence in Plants
(c)Physical Properties of Resins
(d)Chemical Properties of Resins
(e)Solubility
(f) Preparation of Resins
(g)Chemical Composition of Resins
(h)Classification of Resins.

1 Distribution of Resins in Plants

Interestingly, the **resins** and resinous substances are more or less extensively distributed throughout the entire plant kingdom, specifically the *Spermatophyta i.e.*, the seed plants. Notably, their presence is almost rare and practically negligible in the *Pteridophyta i.e.*, the ferns and their allies. However, the resins have not been reported in the *Thallophyta i.e.*, the sea-weeds, fungi etc.

Therefore, all these findings and observations lead one to the fact the *resins* are the overall and net result of metabolism in the *higher plants,* since the majority of them belong to the phyllum *Angiosperum i.e.*, seed-enclosed flowering plants, and *Gymnosperm i.e.*, naked-seed non-flowering plants.

In general, the most important and extensively studied resin-containing families are, namely: *Pinaceae* (*Colophory* or *Rosin*); *Leguminosae* (*Tolu Balsam* and *Balsam of*

Peru); *Dipterocarpaceae*(‘*Garijan*’—a Balsam substitute for copaiba); *Burseraceae* (Myrrh) and *Umbelliferae* (Asafoetida).

2 Occurrence in Plants

In the plants resins usually occur in different secretory zones or structures. A few typical examples of such plant sources along with their specific secretary structures are given below:

(*i*) **Resin Cells** : *Ginger–Zingiber officinale* Roscoe (Family: *Zingiberaceae*);

(*ii*) **Schizogenous Ducts** : *Pine Wood–Pinus polustris* Miller.

or Schizolysogenous (Family: *Pinaceae*).

Ducts or Cavities

(*iii*) **Glandular Hairs** : *Cannabis–Cannabis sativa* Linne’. (Family: *Moraceae*)

The formation of **resins** in the plant is by virtue of its normal physiological functions. However, its yield may be enhanced in certain exceptional instances by inflicting injury to the living plant, for instance: *Pinus*. Furthermore, many resisnous products are not formed by the plant itself unless and until purposeful and methodical injuries in the shape of incisions are made on them and the secretions or plant exudates are tapped carefully, such as: **Balsam of Talu** and **Benzoin**. In other words, these resins are of pathological origin. One school of thought has categorically termed the secretion exclusively obtained from the naturally occurring secretory structure as the ***Primary Flow,***whereas the one collected through man-made-incisions on the plant *i.e.*, abnormally formed secretary structures, as the **Secondary Flow.**

In normal practice, it has been observed evidently that resins are invariably produced in ducts as well as cavities; sometimes they do not occur in the so called specialized-secretory structures, but tend to get impregnated in all the elements of a tissue, for example: **Guaiacum Resin—**is obtained from the heartwood of *Guaiacum officinale* Linn. and *G. sanctum* Linn., (Family: *Zygophyllaceae*) *i.e.*, it is found in the vessels, fibres, medullary ray cells and wood parenchyma. In this particular instance, the resins occur as **tyloses,** achieved by chopping off the conduction in these areas so as to enhance the effective usage of root pressure and the capillaries in forcing both the nutritive contents and forcing water to reach the top end of these tall trees.

It is pertinent to mention here that in some exceptionally rare instances the resin occurs as a result of sucking the juice of the plant by scale insects and converting the sucked-juice into a resinous substance that ultimately covers the insect itself and twigs of the plant as well, for instance: *Laccifer lacca* (Family: *Coccidae*)-**Shellac**.

.3 Physical Properties of Resins

The various physical properties of **resins** can be generalized as detailed below:

1. **Resins,** as a class, are hard, transparent or translucent brittle materials.

2. They are invariably heavier than water having the specific gravity ranging from 0.9-1.25.

3. **Resins** are more or less amorphous materials but rarely crystallisable in nature.

4. On being heated at a relatively low temperature **resins** first get softened and ultimately melt down thereby forming either an adhesive or a sticky massive fluid, without undergoing any sort of decomposition or volatilization.

5. On being heated in the air *i.e.*, in the presence of oxygen, resins usually burn readily with a smoky flame by virtue of the presence of a large number of C-atoms in their structure.

6. On being heated in a closed container *i.e.*, in the absence of oxygen, they undergo decomposition and very often give rise to **empyreumatic products** *i.e.*, products chiefly comprising of hydrocarbons.

7. Resins are bad conductors of electricity, but when rubbed usually become negatively charged.

8. They are practically insoluble in water, but frequently soluble in ethanol, volatile oils, fixed oils, chloral hydrate and non-polar organic solvents *e.g.*, benzene, n-hexane and petroleum ether.

.4 Chemical Properties of Resins

The various chemical properties of **resins** may be summarized as stated below:

1. Resins, in general, are enriched with carbon, deprived of nitrogen and contain a few oxygen in their respective molecules.

2. Majority of them undergo slow atmospheric oxidation whereby their colour get darkened with impaired solubility.

3. Resins are found to be a mixture of numerous compounds rather than a single pure chemical entity.

4. Their chemical properties are exclusively based upon the functional groups present in these substances.

5. Consequently, the resins are broadly divided into **resin alcohols, resin acids, resin esters, glycosidal resins** and **resenes** (*i.e.*, inert neutral compounds).

6. Resins are regarded as complex mixtures of a variety of substances, such as: **resinotannols, resin acids, resin esters, resin alcohols and resenes.**

7. One school of thought believes that resins are nothing but **oxidative products of terpenes.**

8. They may also be regarded as the end-products of *destructive metabolism.*

9. The acidic resins when treated with alkaline solutions they yield soaps (or **resin-soaps**).

Note The solutions of resins in alkalies distinctly differ from ordinary soap solutions by virtue of the fact that the former cannot be easily ‘salted-out’ by the addition of NaCl, unless it is used in large excess quantity.

5 Solubility

The solubility of various types of **resins** are as follows:

1. Majority of **resins** are water-insoluble and hence they have practically little taste.

2. They are usually insoluble in petroleum ether (a non-polar solvent) but with a few exceptions, such as: colophory (freshly powdered) and mastic.

3. Resins mostly got completely dissolved in a number of polar organic solvents, for instance: ethanol, ether and chloroform, thereby forming their respective solutions which on evaporation, leaves behind a thin-varnish-like film deposit.

4. They are also freely soluble in many other organic solvents, namely: acetone, carbon disulphide, as well as in fixed oils and volatile oils.

5. Resins dissolve in chloral hydrate solution, normally employed for clarification of certain sections of plant organs.

6 Preparation of Resins

So far, no general method has either been suggested or proposed for the preparation of resins. In fact, there are *two* categories of resinous products, namely: (*a*) **Natural Resins;** and (*b*) **PreparedResins,** have been duly accepted and recognized. Therefore, this classification forms the basis of the methods employed in the preparation of the *two* aforesaid resins.

A. Natural Resins:

These resins usually formed as the exudates from various plants obtained either normally or as a result of pathogenic conditions (*i.e.*, by causing artificial punctures), such as: mastic, sandarac. These are also obtained by causing deep incisions or cuts in the trunk of the plant, for instance: **turpentine.**They may also be procured by hammering and scorching, such as: **balsam of Peru.**

B. Prepared Resins:

The resins obtained here are by different methods as described below:

(*i*) The crude drug containing resins is powdered and extracted with ethanol several times till complete exhaustion takes place. The combined alcoholic extract is either, evaporated on a electric water-bath slowly in a fuming cup-board or poured slowly into cold distilled water.

The precipitated resin is collected, washed with cold water and dried carefully under shade or in a vacuum desiccator,

Examples: **Podophyllum; Scammony** and **Jalap.**

(*ii*) In the case of *alco-resins*, organic solvents with lower boiling points are normally employed *e.g.*, solvent ether (bp 37°C); acetone (bp 56.5°C), for their extraction. However, the volatile oil fraction can be removed conveniently through distillation under vacuo.

(*iii*) In the instance of **gum-resins,** the resin is aptly extracted with 95% (v/v) ethanol while leaving the insoluble gum residue in the flask (or soxhlet thimble).

7 Chemical Composition of Resins

The copious volume of information with regard to the **'chemistry of resins'** is mainly attributed by the meaningful research carried out by Tschirch and Stock, who advocated that the proximate constituents of resins may be classified under the following heads, namely:

(*i*) *Resin Acids*

(*ii*) *Resin Esters and their Decomposition Products i.e., Resin Alcohols* (*Resinols*) and *Resin Phenols*(*Resinotannols*).

(*iii*) *Resenes i.e.*, the chemical inert compounds.

However, it has been observed that in majority of the known **resins** these *three* aforesaid categories evidently predominates and thus the resulting product consequently falls into one of these groups. It is worth mentioning here that representatives of all the three said groups are rarely present in the same product.

Given below are some typical examples of resin substances that predominates the *three* classes suggested by Tschirch and Stock, namely:

A. **Resin-Esters** : *Examples:* Ammoniacum; Asafoetida; Benzoin; Balsam of Peru and Tolu; Galbanum; Storax;

B. **Resin-Acids** : *Examples:* Colophony; Copaiba; and

C. **Resenes** : *Examples:* Bdellium; Dammar; Mastic; Myrrh; Olibanum.

A few important and typical chemical constituents that have been duly isolated and characterized from various **naturally occurring resins** are discussed below:

(*iii*) *Resenes i.e.*, the chemical inert compounds.

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C. **Resenes** : *Examples:* Bdellium; Dammar; Mastic; Myrrh; Olibanum.

A few important and typical chemical constituents that have been duly isolated and characterized from various **naturally occurring resins** are discussed below:

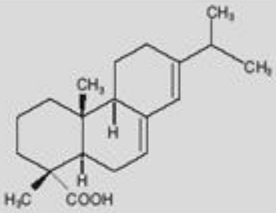
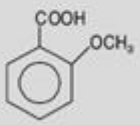
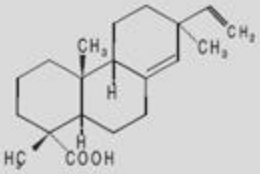
1. Resin Acids

Synonyms Resinolic Acid.

The **resin acids** essentially contain a large portion of carboxylic acids and phenols. However, they occur both in the *free state* and as their *respective esters*. They are usually found to be soluble in aqueous solutions of the alkalies, thereby forming either soap like solutions or colloidal suspensions.

Resinates, *i.e.*, the metallic salts of these acids find their extensive usage in the manufacture of inferior varities of soaps and varnishes.

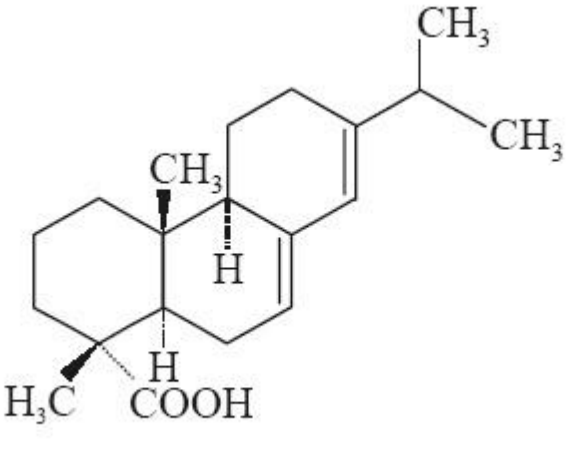
A few typical examples of resin acids are enumerated below:

S. No.	Name	Chemical Structure	Source(s)
1	**Abietic Acid**		Colophony, Rosin
2	**Copaivic Acid** **and Oxycopaivic Acid**	—	Copaiba
3	**Guaiaconic Acid**		Guaic
4	**Pimaric Acid**		Burgandy Pitch, Fankicense
5	**Sandracolic Acid**	—	Sandarac
6	**Commiphoric Acid**	—	Myrrh

Out of all the six commonly found resin acids *Abietic Acid* shall be discussed here under:

Abietic Acid (Synonym Sylvic Acid)

Chemical Structure 13-Isopropylpodocarpa-7, 13-dien-15-oic acid; (C_{20} $H_{30}O_2$).



Abietic Acid

It is a **tricyclic diterpene** embedded with four isoprene units. It is studded with four methyl moieties and a carboxylic acid function. Besides, it also has two double bonds one each in ring-Band ring-C of the phenanthrene nucleus.

Preparation It is a widely available organic acid, prepared by the isomerization of **rosin.*** It may also be synthesized from **dehydroabietic acid.****

The commercial grade of abietic acid is normally obtained by heating either rosin alone or with mineral acids. The product thus achieved may be glassy or partly crystalline in nature. It is usually of yellow colour and has a mp 85°C *i.e.*, much lower than the pure product (mp 172-175°C).

Characteristic Features It is obtained as monoclinic plates from alcohol and water. Its physical parameters are: mp 172-175°C; $[\alpha]^{24}_{D}$ -106° (c = 1 in absolute alcohol); UV_{max} 235, 241.5, 250 nm (ε 19500, 22000, 14300). It is practically insoluble in water, but freely soluble in ethanol, benzene, chloroform, ether, acetone, carbon disulphide and also in dilute NaOH solution.

Identification It readily forms the corresponding methyl ester as methyl abietate (C_{21} $H_{32}O_2$), which is colourless to yellow thick liquid bp 360-365°C, d^{20}_{20} 1.040, and n^{20}_{D} 1.530.

Uses

1. It is used for manufacture of esters (ester gums), such as: methyl, vinyl and glyceryl esters for use in lacquers and varnishes.

2. It is also employed extensively in the manufacture of ‘metal resinates’ *e.g.*, soaps, plastics and paper sizes.

3. It also assists in the growth of butyric and lactic acid bacteria.

2. Resin Alcohols

In general, resin alcohols are complex alcohols having higher molecular weight. These are of *two*types, namely:

(*a*) ***Resinotannols:*** The resin alcohols which give a specific tannin reaction with iron salts are termed as **resinotannols.**

A number of **resinotannols** have been isolated from the plant kingdom. It is an usual practice to name them according to the resins in which they are found, such as:

Alocresinotannol – From *Aloe* species viz., *Aloe barbedensis* Miller, (Curacao Aloes); *Aloe perryi*Baker, (Socotrine Aloes); *Aloe* ferrox Miller, *Aloe africana* Miller, *Aloe spicata* Baper. All these belong to the natural order *Liaceae.*

Ammoresinotannol – From *Ammoniacum i.e.*, the oleo-gum-resin from *Dorema ammoniacum* D. Don. (Family: *Umbelliferae*).

Galbaresinotannol – From *Galbanm i.e.*, the oleo-gum-resin from *Ferula galbaniflua* Boiss et Bubse (Family: *Unbelliferae*).

Peruresinotannol – From Balsam of Peru *i.e.*, the balsam obtained from *Myroxylon balsamum* var Pereirae (Royle) Harms (Family: *Fabaceae*);

Siaresinotannol – From Sumatra Benzoin (Benzoin, Styrax) *i.e.*, the gum exuded from *Styrax benzoin* Dryander (Family: *Styracaceae*).

Toluresinotallol – From Balsam of Tolu *i.e.*, the Balsam obtained from *Myroxylon balsamum*(Linn.) Harms. (belonging to the family. *Leguminosae*).

(*b*) ***Resinols:*** The resin alcohols that fail to give a positive reaction with tannin and iron salts are known as *resinols. The following* are some typical examples of *resinols*, for instance:

Benzoresinol – From Benzoin which is purely a pathological product obtained either from *Styrax benzoin* Dryander and *Styrax paralleloneurus* Brans. (*Sumatra*

Benzoin) or from *Styrax tonkinensis* Craib. (*Siam Benzoin*) belonging to family *Styraceae*.

Storesinol – From storax which is the balsamic resin usually obtained from the trunk of *Liquidamber orientalis* Mill. family *Hamamelidaceae*.

Gurjuresinol – From Gurjun Balsam that is the aleo-resin obtained from *Dipterocarpus turbinatus*Gaertn. F. belonging to family: *Dipterocarpaceae*.

Guaiaresinol – From Guaiacum Resin obtained from the heartwood of *Guaiacum officinale* Linn. and *Guaiacum sanctum* Linn. belonging to family: *Zygophyllaceae*.

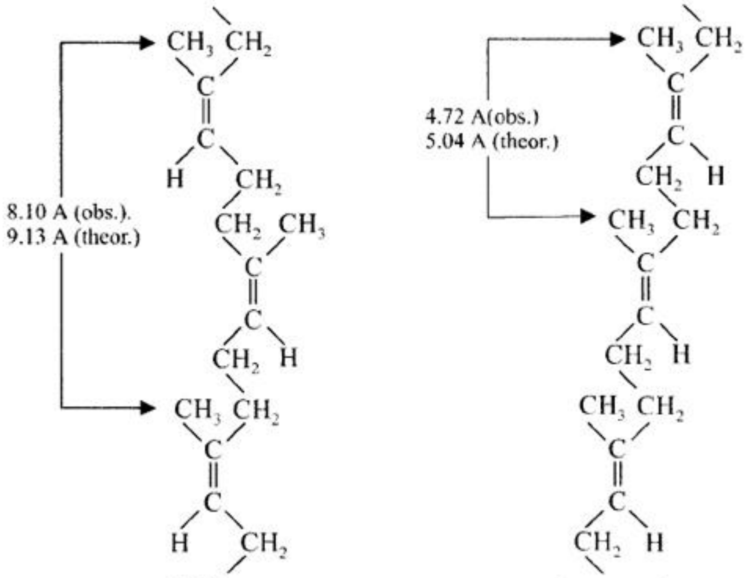
3. Resenes

These are oxygenated compounds, but are not affected either by alkalies or acids. In fact, they are more or less neutral substances being devoid of characteristic functional groups, and, therefore, do not exhibit any characteristic chemical properties. Interestingly, they are immune to oxidizing agents and variant climatic conditions, a fact which essentially attributes the resins containing them one of their major plus points for the manufacture of **varnishes.** A few important examples of *resenes are* as follows:

Dracoresene – Derived from the scales of the fruit of Dragon's Blood *i.e.*, *Daemonorops draco* Bl. (and other species) belonging to the natural order (*Arecaceae*).

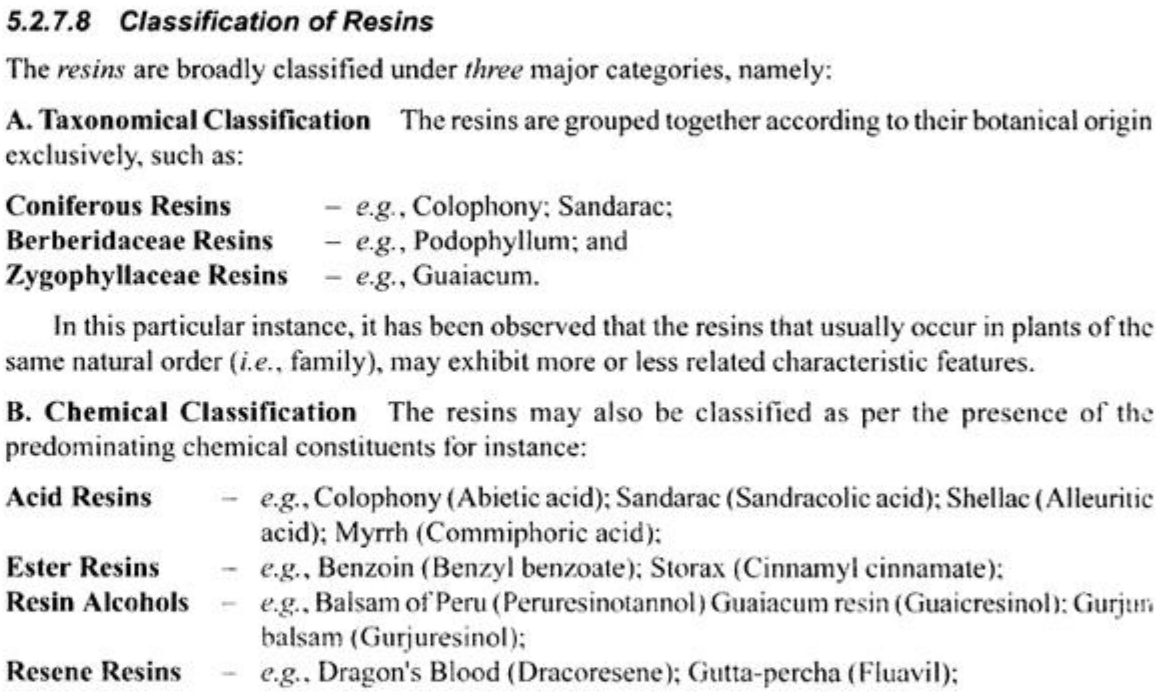
Masticoresene – Derived from Mastic-an oleo-resin obtained from *Pistacia lentiscus* Linn belonging to family: *Anacardiaceae.*

Fluavil – Obtained from **Gutta-percha** and also from the bark of various trees. Guttapercha is hard and has a very low elasticity. X-ray diffraction studies have revealed that rubber is composed of long chains built up of isoprene units arranged in the *cis*-form, whereas gutta-percha is the *trans*-form as shown below:



Rubber
cis-form

Gutta-percha
trans-form



5.2.7.8 *Classification of Resins*

The *resins* are broadly classified under *three* major categories, namely:

A. Taxonomical Classification The resins are grouped together according to their botanical origin exclusively, such as:

Coniferous Resins – *e.g.*, Colophony; Sandarac;
Berberidaceae Resins – *e.g.*, Podophyllum; and
Zygophyllaceae Resins – *e.g.*, Guaiacum.

In this particular instance, it has been observed that the resins that usually occur in plants of the same natural order (*i.e.*, family), may exhibit more or less related characteristic features.

B. Chemical Classification The resins may also be classified as per the presence of the predominating chemical constituents for instance:

Acid Resins – *e.g.*, Colophony (Abietic acid); Sandarac (Sandracolic acid); Shellac (Alleuritic acid); Myrrh (Commiphoric acid);
Ester Resins – *e.g.*, Benzoin (Benzyl benzoate); Storax (Cinnamyl cinnamate);
Resin Alcohols – *e.g.*, Balsam of Peru (Peruresinotannol) Guaiacum resin (Guaicresinol); Gurjun balsam (Gurjuresinol);
Resene Resins – *e.g.*, Dragon's Blood (Dracoresene); Gutta-percha (Fluavil);

Glycoresins – *e.g.*, Jalap Resin from Jalap *i.e.*, *Ipomea purga* Hayne; (Family: *Conrulvulaceae*) Podophylloresin from the dried roots and rhizomes of *Podophyllum hexandrum* (*P. emodi*) Royle. (Family *Berberidae*).

C. Constituents of Resin Invariably, to maintain the simplicity, resins may also be classified according to the major constituents present either in the *resin* or *resin combinations*.

Examples: **Resins; Oleo-resins; Oleo-gum resins; Balsams.**

After having been exposed to the various aspects of *resins* with regard to their physical and chemical, properties, occurrence and distribution, preparation, chemical composition and classification, it would be worthwhile to gain some in-depth knowledge about certain typical examples belonging to Resins; **Oleo-resins; Oleo-gum-resins; Balsams;** and **Glycoresins**

6. Podophyllum

Synonyms Podophyllum resin; May apple; Mandrakes Root; Indian apple; Vegetable calomel.

Biological Sources Podophyllum is the dried rhizomes and roots of *Podophyllum peltatum* L., family: *Berberidaceae,* known as *American Podophyllum;* and from *Podophyllum hexandrum* Royle (*Syn. P. emodi* Wall. ex Hook. f. & Th.) usually called *Indian Podophyllum*.

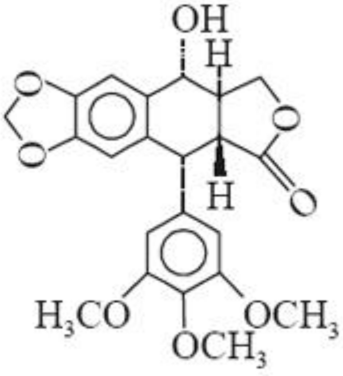
Preparation Extract powdered **podophyllum** (1 killo) by means of slow percolation until it is almost exhausted of its resin content, using ethanol as the menstruum. Carefully concentrate the percolate by evaporation until the residue attains the consistency of a thin syrup. Pour the resulting syrupy liquid with constant stirring into 1 L of distilled water containing 10 ml of concentrated HCl and previously cooled to a temperature less than 10°C. Allow the precipitate to settle down completely, decant the clean supernatant liquid and wash the precipitate with two 1000 ml portions of cold distilled water slowly, dry the resin and powder it.

Characteristic Features It is a light brown to greenish-yellow powder, or small, yellowish, bulky, fragile lumps usually becoming darker in shade on exposure to either heat (> 25°C) or light (uvrays).

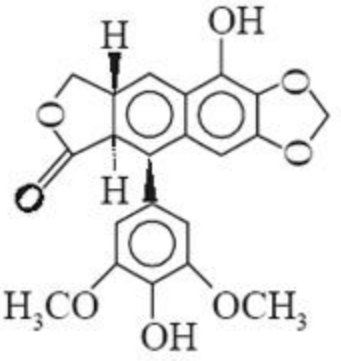
It has a characteristic faint odour and a bitter acrid taste. It is freely soluble in ethanol, usually with a slight opalescence. It is also soluble in dilute alkaline solution. It is found to be not less than 65% soluble in chloroform and 75% soluble in ether.

Chemical Constituents Podophyllum contains 3.5 to 6% of a resin whose active principles are **lignans,** which are essentially C_{18}-compounds related biosynthetically to the **flavonoids,** and are derived by dimerisation of two C_6-C_3 units. The most important ones present in the **podophyllumresin,** are **podophyllotoxin** (20% in *American Podophyllum*) and in much higher quantum almost upto 40% in *Indian Podophyllum*. Besides, it also contains α-**peltatin** (10%) and β**-peltatin** (5%).

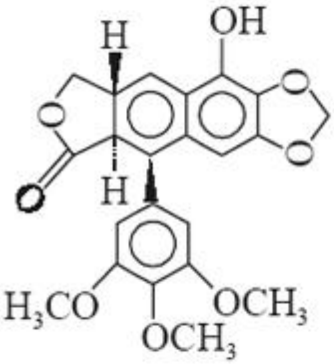
It is pertinent to mention here that a host of **lignan glycosides** are also present in the plant, but by virtue of their water-soluble properties, they are almost eliminated during the normal preparation of the resin.



Podophyllotoxin



∝-Peltatin



β-Peltatin

Interestingly, all the three above mentioned chemical constituents are present both in free state and as their respective glycosides. The Indian Podophyllum is devoid of α**-and** β-**peltatins.** The resin also comprise of the closely related **dimethylpodophyllotoxin** and its glycoside; and **dehydropodophyllotoxin,** as well as **quercetin**-a tetra-hydroxy flavonol.

Chemical Tests

1. **Podophyllotoxin** (*active lactone*) present in the resin when dissolved in alkali, cooled to 0°C and subsequently treated with an acid it yields an unstable gelatinous *podophyllic acid*.

2. The resulting **podophyllic acid** when treated with dehydrating agents easily loses a molecule of water and gives rise to **picropodophyllin** (*inactive lactone*), which being an isomer of **podophyllotoxin.**

The resins obtained from the American and Indian podophyllum are not quite identical and these two drugs of the trade may be distinguished chemically as given below:

(*a*) Prepare an alcoholic extract from *each* resin and filter. Add a few drops of strong solution of cupric acetate 5% (w/v) to each of the above two filtrates. The **American podophyllum** containing α-and β-peltatin produces an instant bright green colouration, while the **Indian podophyllum** (devoid of peltatin) fails this test.

(*b*) An alcoholic solution of **Indian podophyllum** resin readily gelatinizes on being treated with alkali hydroxide, while the American resin does not gelatinize. This is due to the fact that the former contains **podophyllic acid** and it gives the alkali salt of this acid which is gelatinous in nature.

Uses

1. It is used as a drastic but slow-acting purgative.
2. Podophyllotoxin possesses anti-tumour (antineoplastic) properties and may be used in the treatment of cancer.
3. It is invariably prescribed with other purgatives, henbane or belladonna to prevent gripping in infants.

4. Cannabis

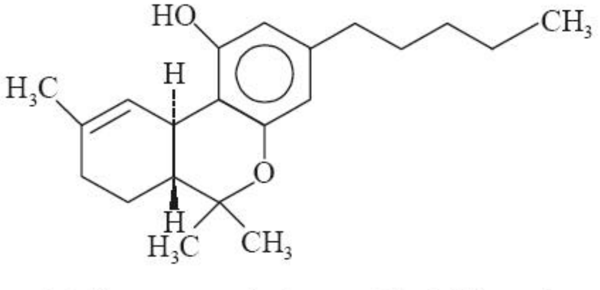
Synonyms Indian Hemp; Indian cannabis; Marihuana; Marijuana; Pot; Grass; Weed; Bhang; Ganja; Charas, Hashish.

Biological Source Cannabis consists of the dried flowering tops of pistillate plants of *Cannabis sativa* L., (*C. satira* var. *indica* Auth.), belonging to family: *Moraceae*.

Preparation After years of intensive and extensive research carried out on the selective cultivation of *Cannabis,* two of its *genetic types* have been evolved, namely: (*i*) Drug Type, and (*ii*) Hemp Type.

These *two* distinctly separate genetic types of **Cannabis** shall be described briefly as stated below:

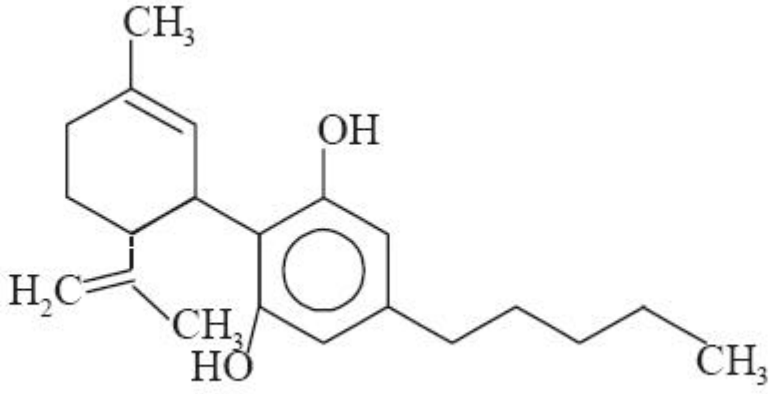
A. Drug type (Cannabis): It is, in fact, the rich (upto 15%) in the psychoactive constituent (–)-Δ9-*trans*-tetra-hydrocannabinol (Δ9-THC) as shown below:



(–)-Δ^9-*trans*-Tetrahydrocannabinol (Δ^9-THC)

The Δ9-THC is usually concentrated into a **resin** that is secreted right into the *trichomes* located on the small leaves (bracts) and *bracteoles* (*i.e.*, the leaf-like structure which encloses the ovary) of the flowering tops of the *female plant.* Interestingly, for the specific drug usages either the resin (*hashish*) is employed or the flowering tops of the female plant (*marijiana*). Nevertheless, the male plant also generates an equivalent quantity of the active constituents; however, it is not concentrated into a resin but found throughout the entire plant.

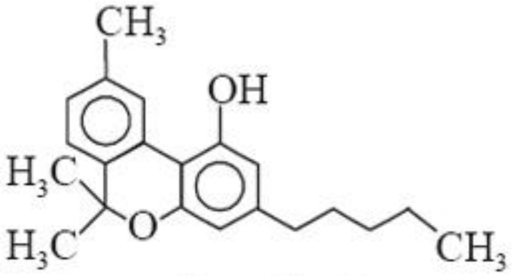
B. Hemp Type (Cannapis): It contains surprisingly very little active principal. **Cannabidiol** is the predominant **cannabinoid** present in it as given below:



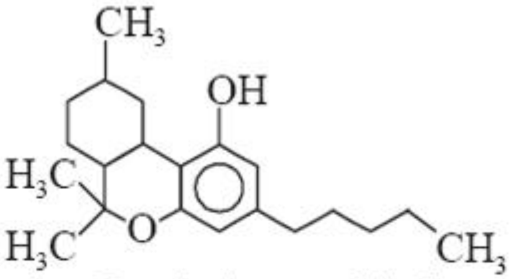
Cannabidiol

The hemp-type cannabis also possesses the elongated **bast*** fibers which is very much desired in the manufacture of ropes.

Chemical Constituents The chemical constituents Δ9 THC and cannabidiol present in the drugtype and hemp-type cannabis have already been discussed above. Besides, the resin contains several active constituents, such as: **cannabinol, cannin, cannabol, tetrahydrocannabinol, cannabigerol,cannabichromene** and **Δ8-tetrahydrocannabinol.**



Cannabinol



Tetrahydrocannabinol

It also contains choline, volatile oil and **trigonelline.** However, the Indian Hemp seeds contain 20% of fixed oil.

Chemical Tests

1. Shake 0.1g of resin with 5 ml petroleum ether (60-80°C) and filter. To 1 ml of the filtrate, add

2 ml of 15% solution of HCl gas in ethanol, when a red colouration appears at the junction of the two layers. However, after shaking, the upper layer becomes colourless while the lower one attains a distinct orange pink colour, which finally vanishes upon addition of water.

2. Extract 1g of resin with methanol, filter and evaporate to complete dryness. Again extract the resulting residue with petroleum ether (60-80°C), filter directly into a separating funnel and extract the ethereal layer successively with 5% (w/v) Na_2CO_3 and 5% (w/w) H_2SO_4. Wash the ethereal layer with distilled water, decolourise with powdered activated carbon, if necessary, and evaporate the filtrate. Add to the residue a few drops of N/10 alcoholic KOH solution, when a purple colouration is obtained.

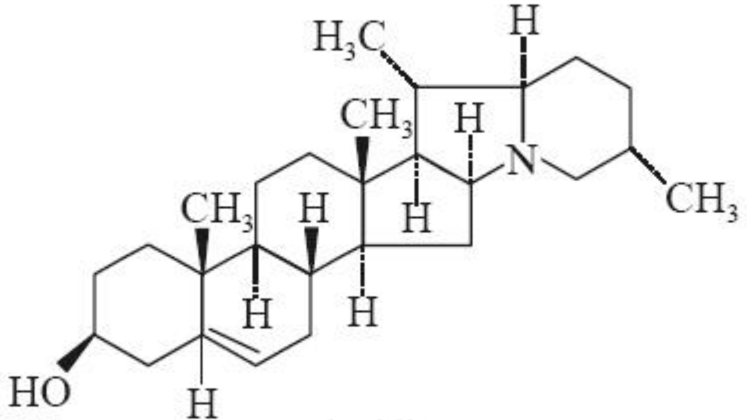
Uses It has been used as a sedative in equine colic.

3 Solanidine

Synonym Solatubine.

Biological Source The plant of *Capsicum annuum* L. (*Solanaceae*) (**Chili, Peppers, Paprika**) contains **solanidine**.

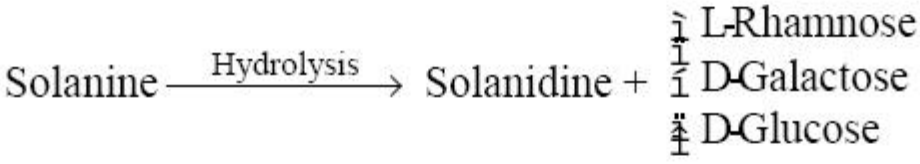
Chemical Structure



Solanidine

(3b)-Solanid-5 en-3-ol; ($C_{27}H_{43}NO$).

Isolation It is obtained by the hydrolysis of **solanine** which yields one mole each of L-Rhamnose, D-Galactose, and D-Glucose as shown below.



Characteristic Features

1. The long needles obtained from chloroform-methanol have a mp 218-219°C. It usually sublimes very close to its mp with slight decomposition.

2. It is specific rotation $[\alpha]_D^{21}$ -29° (c = 0.5 in $CHCl_3$).

3. It is freely soluble in benzene, chloroform, slightly in methanol and ethanol; and almost insoluble in ether and water.

Identification Tests The same as described under A.1. earlier in this section. Besides, it has the following specific features for the corresponding derivatives, namely:

(*a*) **Hydrochloride Derivative: ($C_{27}H_{43}NO.HCl$):** Prisms from 80% alcohol and gets decomposed at 345°C.

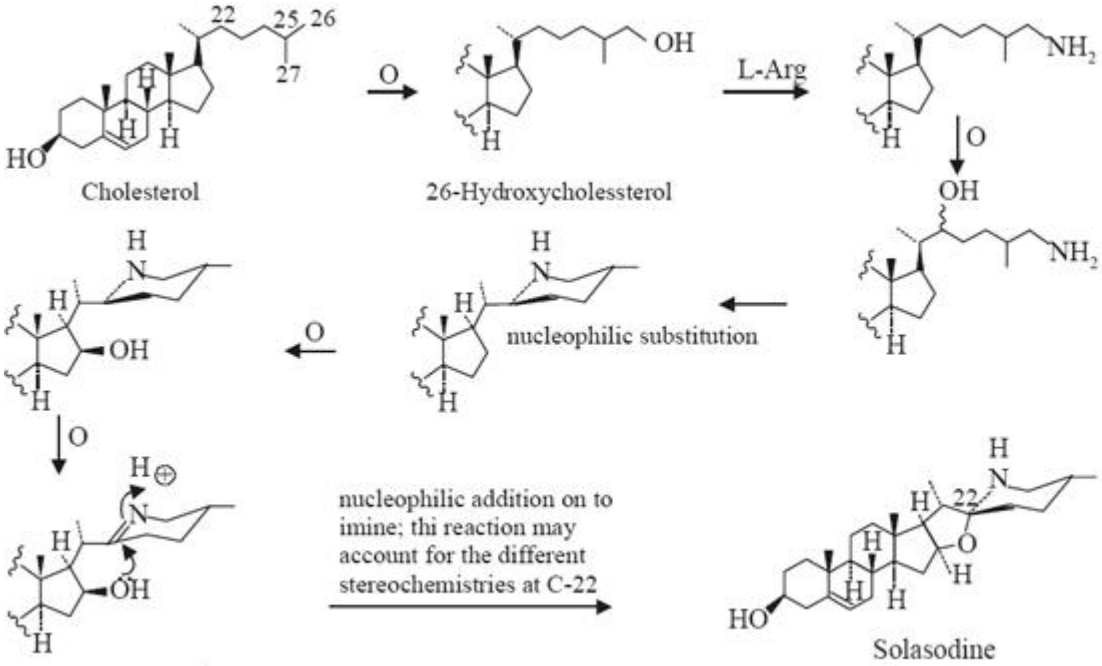
(*b*) **Methyliodide Derivative: ($C_{27}H_{43}NO.CH_3I$):** Crystals from 50% (v/v) ethanol and decomposes at 286°C.

(*c*) **Acetylsolanidine Derivative: ($C_{29}H_{45}NO_2$):** Crystals obtained from ethanol having mp 208°C.

Biosynthesis of Solasodine, Tomatidine and Solanidine Like the **sapogenins**, the **steroidal alkaloids** are also derived from *cholesterol*, with suitable side-chain modification during the course of biochemical sequence of reactions as given under.

From the above biochemical sequence of reactions it is evident that:

(*i*) L-arginine seems to be used as a source for N-atom through amination *via* a substitution process upon 26-hydroxycholesterol,



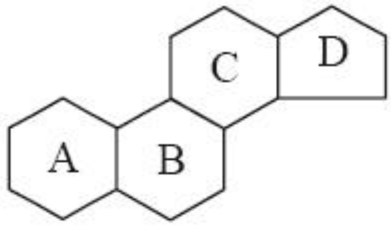
Biosynthesis of Solasodine, Tomatidine and Solanidine

(*ii*) Another substitution affords 26-amino-22-hydroxycholesterol to cyclize thereby forming a heterocyclic piperidine ring,

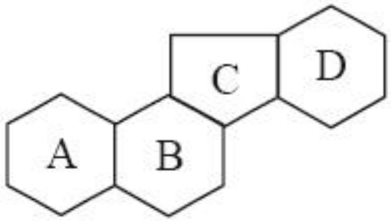
(*iii*) After 16β-hydroxylation, the secondary amine is oxidized to an imine, and the ultimate *spirosystem* may be envisaged by virtue of a nucleophilic addition of the 16β-hydroxyl on to the imine, and (*iv*) This specific reaction, however, establishes the configurations, *viz:* 22R-as in the case of **Solasodine,** and 22S-as in the case of **Tomatidine**.

B. Veratrum Alkaloids The **Veratrum alkaloids** represent the most important and medicinally significant class of steroidal alkaloids. It is, however, pertinent to mention here that the *basic ring systems* present in the Veratrum alkaloids are not quite the same as seen in the usual steroidal nucleus, as present either in the cholesterol or in the aglycone residues of the cardiac glycosides

(A). Interestingly, one may observe in the structures of Veratrum alkaloids that the ring 'C' is a fivemembered ring while ring 'D' is a six-membered ring (B) which apparently is just the reverse of the pattern in the regular steroidal nucleus as depicted in next page.



(A)



(B)

Examples

(*a*) Alkamine portion of the **ester alkaloids of Veratrum,** *viz.*, **Protoverine, Veracevine, Germine.**

(*b*) **Alkamine aglycones of glycosidic veratrum alkaloids,** *viz.*, **Veratramine.**

In general, the majority of **Veratrum alkaloids** may be classified into *two* categories solely based on their characteristic structural features, namely:

(*i*) Cevaratrum alkaloids, and

(*ii*) Jeveratrum alkaloids

These *two* categories of **Veratrum alkaloids** shall now be discussed individually in the sections that follows:

7. Shellac

Synonyms Lacca; Lac.

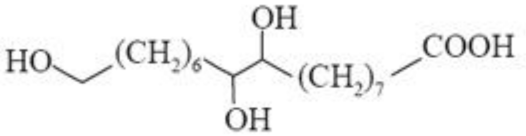
Biological Sources **Shellac** is the resinous excretion of the *insect Laccifer* (Tachardia) *lacca* Kerr, order *Homoptera* belonging to family: *Coccidae*. The insects usually suck the juice of the tree and exerete '*stick-lac*' more or less continuously. The various host trees are, namely: *Butea frondosa*Koen. ex. Roxb. (Family: *Leguminosae*) and *Butea monosperma* (Lam.) Kuntze; *Aleurites moluccanna*(L.) Willd. (Family: *Euphorbiaceae*)-**Varnish Tree;** *Ficus benjamina* Linn., (Family: *Moraceae*); *Zizyphus jujuba* (Lam.) (Family: *Rhamnaceae*). However, the *whitest shellac* is produced while the **Kusum tree**is the host *i.e.*, *Schleichera trijuga* (Willd.) (Family: *Sapindaceae*).

Preparation The resin which is stuck on the smaller twigs and branches is normally serapped by means of knives. The resulting resin is subsequently powdered and extracted either with water or with alkaline solution so as to remove the colouring matter. The residual product is dried, melted in narrow bags suspended over a fire. The contents of the bags *i.e.*, the molten shellac, are squeezed out mechanically so as to force the liquid shallac through the cloth on to a previously cleaned surface of tiles to obtain the product as flat cakes. The product may also be obtained as thin sheets by streching the semi-cooled product on the tiles with the help of a scrapper (or spreader). The thin sheets thus obtained get hardened after cooling and are subsequently broken up to obtain the flakes of shellac for the commercial market.

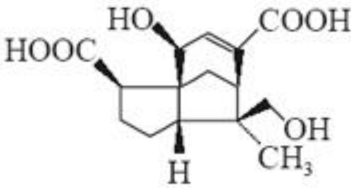
Characteristic Features Shellac is a brittle, yellowish, transparent/translucent sheets or crushed pieces or powder. It does not has any specific odour and taste. Its mp is 115-120°C and d 1.035-1.140. Its solubility in alcohol is 85-95% (w/w) (very slowly soluble); in ether 13-15%; in benzene 10-20% and in petroleum ether 2-6%. It is sparingly soluble in **oil of turpentine.** It is practically insoluble in water, but soluble in alkaline solutions, in aqueous solution of ethanolamines and in borax solutions with slightly purple colouration.

Chemical Constituents The major component of **shellac** is a resin that on being subjected to mild hydrolysis yields a complex mixture of aliphatic and alicyclic hydroxy acids and their polyesters respectively. Interestingly, the composite of the resultant hydrolysate solely depends on the source of shellac and the time of collection.

The major component of the aliphatic fraction is **aleuritic acid,** while the major component of the alicyclic fraction is **shellolic acid.***

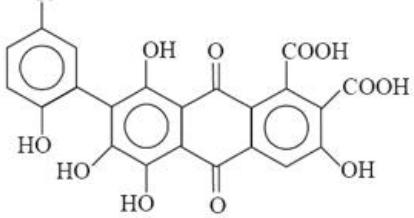


Aleuritic Acid
(9, 10, 16-Trihydroxy palmitic Acid)

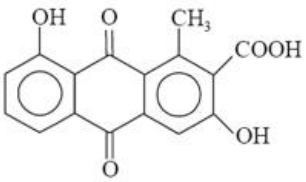


Shellolic Acid
(10β, 13-Dihydroxycedr-8-ene-12, 15-dioic acid)

However, it also contains the isomers of **shellolic acid** along with small amounts of **kerrolic acid**and **butolic acid.** The colouring matter is due to the presence of **laccaic acid,** which is watersoluble,as given below:



Laccaic Acid -A: R= $CH_2CH_2NHCOCH_3$
Laccaic Acid -A: R= CH_2CH_2OH
Laccaic Acid -A: R= $CH_2CH(NH_2)COOH$



Laccaic Acid-D

Note Laccaic acid-A is the major component while the rest are present in relatively smaller quantities.

Uses

1. It is used chiefly in laquers and varnishes.
2. It is also employed in the manufacture of buttons, sealing wax, cements, inks, grinding wheels, photograph records, paper.
3. It also finds its use in electrical machines and for stiffening hats.
4. It is also used for finishing leather.
5. It is extensively used for coating tablets and confections.
6. It has also been used for preparing *sustained release medicament*formulations

1. Asafoetida

Synonyms Asafetida; Asant; Devil's dung; Food of the Gods; Gum Asafoetida.

Biological Sources Asafoetida the oleo-gum-resin is obtained as an exudation of the decapitated rhizome on roots of *Ferula assafoetida* L.; *Ferula foetida* Regel, and some other species of *Ferula*,belonging to the nature order *Umbelliferae*.

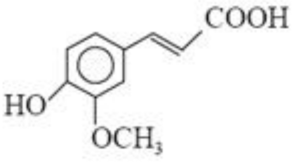
Preparation Asafoetida is generally present as a milky liquid in the large schizogenous ducts and lysigenous cavities. However, these ducts and cavities are located more intensively in the cortex region of the stem and root. The drug is obtaining chiefly from the stem.

The fully grown plants are usually cut down to the crown region during the spring. The exposed surface is protected by a dome-like covering made up of twigs and leaves. After about a month, the hardened resinous substance is collected by scrapping. Likewise, the stems are also cut off and thereby additional collections of **asafoetida** are made frequently at an interval of 10 days unless and until the exudation ceases to ooze. Furthermore, it is also collected from the root by exposing its crown and excising the stem. The oleo-gum-resin exudes from the cut surface of the root and the former is collected soonafter it gets dried. Thus, the entire collection of **asafoetida** from the various portions of the plant are mixed together and dried in the sun.

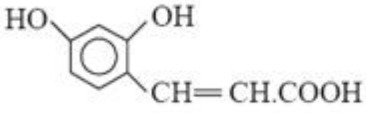
Characteristic Features The drug occurs normally as soft mass or irregular lumps or ‘tears’ or agglomeration of tears. The tears are brittle and tough. **Asafoetida** has a strong, alliaceous, persistent garlic-like odour and having a bitter acrid taste. This **oleo-gum-resin** when triturated with water it gives a milky emulsion.

Chemical Constituents Asafoetida contains volatile oil (8-16°C) gum (25%) and resin (40-60%).

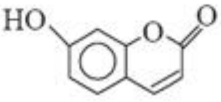
The volatile oil essentially consists of some organic sulphides solely responsible for attributing the characteristic garlic-like odour. The resin cousists of **notannol, asaresinotannol** *i.e.*, the **resinalcohols,** which are present partially in the free state and partially in the combined form with **ferulic acid.** It also contains **umbellic acid** and **umbelliferone;** the latter is found combined with ferulic acid, but it gets generated on being treated with dilute HCl.



trans-Ferulic Acid



Umbellic Acid



Umbelliferone

There are *three* sulphur-compounds that have been isolated from the **asafoctida resin,** namely:

(*a*) 1-Methylpropyl-1-propenyl disulphide,
(*b*) 1-(Methylthio) propyl-1-propenyl disulphide, and
(*c*) 1-Methylpropyl-3-(methylthio)-2- propenyl disulphide.

Interestingly, the latter two (*i.e.*, ‘*b*’ and ‘*c*’) have pesticidal properties.

Chemical Tests

1. It forms an instant milky-white emulsion when triturated with water owing to the presence of gum.
2. The freshly fractured surface when treated with a drop of sulphuric acid (conc.), it gives rise to a reddish-brown colour which on being washed with water changes to violet colouration.
3. Likewise, when the freshly fractured surface is treated with nitric acid (50%), it produces a green colour readily.
4. Boil 1 g asafoetida powder with HCl (50%), filter and make the filtrate strongly alkaline with NH_4OH (conc.), it gives a blue fluorescence. It is also known as the **Umbelliferone Test.**

Uses

1. It is abundantly used in India and Iran as a common condiment and flavouring agent in food products.
2. It is also an important ingredient in *Worcestershire Sauce*.
3. It is used as a repellant [2% (w/v) suspension] against dogs, cats, deer, rabbits etc.
4. It is used seldomly as an antispasmodic, carminative, expedorant and laxative.
5. It is still employed in veterinary externally to prevent bandage chewing by dogs.
6. It is also used as a powerful nerving stimulant especially in nervous disorders related to hysteria.

2.10 Balsams

Balsams are the resinous mixtures that essentially contain large quantum of benoic acid, cinnamic acid or both, or esters of these organic aromatic acids.

A galaxy of typical examples of naturally occurring *balsams* will be discussed in the sections that follow, namely: **Storax; Peruvain Balsam; Tolu Balsam;** and **Benzoin.**

1. Storax

Synonyms Styrax; Sweet oriental gum; Levant Storax; Purified or prepared Storax; American Storax; Liquid Storax;

Biological Source **Storax** is the *balsam* obtained from the trunk of *Liquidamber orientalis* Mill., termed as **Levant Storax,** or of *L. styraciflua* L., known as **American Storax** belonging to the natural order *Hamamelidaceae.*

Preparation The natural balsam *storax* is a pathological product formed as a result of injury caused to the plant. It generally, exudes into the natural pockets between the bark and the wood and may be located by exerscences on the outerside of the bark. These pockets, that may contain upto 4 kg of the balsam, *are* conveniently tapped with the help of strategically positioned gutters, and the product is ultimately allowed to fill into containers. The crude storax, thus collected, is further purified by dissolving in ethanol, filtration and subsequent evaporation of the solvent to obtain the pure storax.

Characteristic Features The **balsam storax** is a semiliquid grayish, sticky, opaque mass (*Levant Storax*), or a semisolid sometimes solid mass softened by gentle warming (*American Storax*). In general, **storax** is transparent in thin layers, possesses a characteristic agreeable balsamic taste and odour. It is, however, denser than water. It is almost insoluble in water, but completely soluble in 1 part of warm ethanol, ether, acetone and CS_2.

Chemical Constituents **Storax** contains the following chemical compounds, namely: **α- and β-storesin** and its **cinnamic ester** (30-50%), **styracin** (5-10%); **phenylpropyl cinnamate** (10%); **free-cinnamic acid** (5-15%); levorotatory oil (0.4%); small amounts of **ethyl cinnamate, benzyl cinnamate,** traces of **vanillin** and **styrene** (($C_6H_5CH=CH_2$).

Besides, *Levant storax* contains free **storesinol, isocinnamic acid, ethylvanillin, styrogenin,** and **styrocamphene.**

In addition to these, **American Storax** contains **styaresin** (*i.e.*, -cinnamic acid ester of the alcohol **styresinol,** an isomer of **storesinol**) and **styresinolic acid.** It also yields upto 7% of a dextrorotatony volatile oil, styrol and traces of vanillin.

Chemical Tests

1. **Benzaldehyde Test**—Treat 1 g of **storax** with 5 ml of $K_2Cr_2O_7$ solution (10% w/v) followed by a few drops of concentrated sulphuric acid (36 N) it produces benzaldehyde, which may be detected easily as the odour of bitter almonds.

2. Mix 1g of **storax** with 3 g of pure sand (SiO_2) and 5 ml of $KMnO_4$ solution (5% w/v) and heat it gently. It gives a distinct odour of benzaldehyde.

Uses

1. It is used in fumigating pastilles and powders.

2. It finds its application in perfumery.

3. It is employed as an imbedding material in microscopy.

4. It is used as an expectorant, antiseptic and stimulant.

5. It is employed as a preservative for fatty substances *e.g.*, lard and tallow.

6. It is also used as a flavouring agent for tobacco.

7. It is a vital ingredient of **"Compound Benzoin Tincture".**

2. Peruvian Balsam

Synonyms Balsam Peru; Indian balsam; Black balsam; China oil; Honduras balsam; Surinam balsam.

Biological Source Balsam Peru is obtained from *Toluifer pereiare* (Klotzsch) Baill. (*Myroxylon pereiare* Klotzsch) belonging to family: *Leguminosae*.

Preparation Peruvian Balsam is a pathological product and is obtained usually by inflicting injury to the trees. Most of the world's commercial supply comes from El Salvador, although some is also produced in Honduras.

It is prepared by beating the stems of the trees with mallet. After a week the injured areas of the stem are scorched so as to separate the bark from the stem and after a similar duration the bark is peeled off completely. The desired balsam starts exuding freely from all the exposed surfaces, which are then covered carefully with cloth or rags to absorb the exuding balsam. The cloth or rags that are completely soaked with the balsam is then removed and boiled with water in a large vessel slowly.

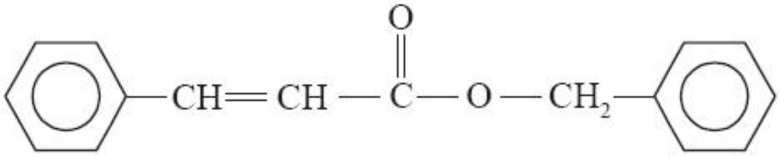
Thus, the balsam gets separated and settles at the bottom of the vessel. The supernatant layer of water is removed by decantation and the residual balsam is dried and packed in the containers.

Characteristic Features It is a dark brown, viscid liquid having a pleasant aromatic odour. It has a peculiar warm bitter taste and persistent aftertaste which resembles like vanilla. The **Balsam Peru** is transparent in thin films. It does not harden on being exposed to atmosphere. It is brittle when cold. It is almost insoluble in water and petroleum ether but soluble in ethanol, chloroform and glacial acetic acid.

Chemical Constituents Peruvian balsam contains free benzoic and cinnamic acids (12-15%); benzyl (40%); esters of these acids (5.2-13.4% **cinnamein**); and volatile oil (1.5-3%).

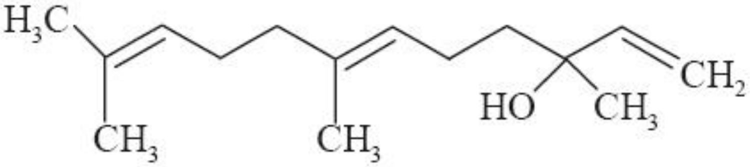
The fragrant volatile oil contains toluene, styrol, benzoic and cinnamic acids.

It also contains total **balsamic acids,** which is calculated on the basis of dry alcohol-soluble matter ranging between (35-50%).



Cinnamein
(Benzyl Cinnamate)

The **resins esters** (30-38%) are chiefly composed of **peruresinotannol cinnamate** and benzoate, vanillin, free cinnamic acid and **peruviol** (or **nerolidol**).



Peruviol (Nerolidol)

Uses

1. **Peru balsam** is a local protectant and rubefacient.

2. It also serves as a parasiticide in certain skin disorder.

3. It is used as an antiseptic and **vulnerary*** and is applied externally either as ointment or alone or in alcoholic solution.

4. It acts as an astringent to treat hemorrhoids.

3. Tolu Balsam

Synonyms Thomas balsam; Opobalsam; Resin Tolu; Balsam of Tolu.

Biological Source Tolu Balsam is a balsam obtained from *Toluifera balsamum* L., (*Myroxylon toluiferum* H.B.K.), belonging to family: *Leguminosae*. It is also obtained from *Myroxylon balsamum* (Linne') Harms. Family: *Fabaceae.*

Preparation Tolu Balsam is considered to be a pathological product produced in the new wood formed as a result of inflicted injury. For its preparation, it is an usual practice to make ‘V’ shaped incisions deep into the body of the main trunk. The exudate thus produced is collected either in cups or gourds held strategically just at the base of each incisions. **Balsam of Tolu** is collected from these cups, mixed and packed in air-tight sealed tins.

Characteristic Features It is a yellowish-brown or brown semifluid or nearly solid resinous mass. It has a characteristic aromatic vanilla-like odour and slightly pungent taste. It is usually brittle when cold. It is found to be transparent in thin layers, and shows numerous crystals of cinnamic acid. It is almost insoluble in water and petroleum ether, but freely soluble in ethanol, benzene chloroform, ether, glacial acetic acid and partially in CS_2 or NaOH solution.

Chemical Constituents The drug contains **resin esters** (75-80%) *viz.*, **toluresinotannol cinnamate** along with a small proportion of the benzoate; volatile oil (7-8%)-containing chiefly **benzyl benzoate;** free cinnamic acid (12-15%); free **benzoic acid** (2-8%); **vanillin** and other constituents in small quantities. It also contains **cinnamein** (5-13%).

Chemical Tests

1. An alcoholic solution of **Tolu Balsam** (0.2% w/v) where treated with a $FeCl_3$ solution (0.5% w/v), the appearances of a green colour takes place.

2. Treatment of 1 g of the drug with 5 ml of 10% w/v $KMnO_4$ solution when subjected to gentle heating yields benzaldehyde.

Uses

1. It is used extensively in perfumery, confectionery and chewing gums.

2. It is used widely as an expectorant in cough mixture.

3. It also finds its application as an antiseptic in the form of its tincture.

4. Benzoin

Synonyms Bitter-almond-oil camphor.

Biological Source Benzoin in the **balsamic resin** obtained from *Styrax benzoin* Dryander and *Styrax paralleloneurus* Perkins, generally known in trade as **Sumatra Benzoin;** whereas, *Styrax tonkinensis* (Pierre) Craib ex Hartwich, or other species of the section Anthostyrax of the genus *Styrax*, known commonly in the trade as **Siam Benzoin** both belong to the family: *Styraceae.*

Preparation Benzoin is also a pathological product that is obtained by incising a deep-cut in the bark. It has been observed that after a span of about eight weeks, the exudating **balsamic resin** tends to become less sticky in nature and firm enough to collect. The entire exudate is usually collected in *two* stages, namely:

Stage 1: *First tapping*-yields *almond tears*, and

Stage 2: *Second tapping*-yields a more fluid material.

Characteristic Features

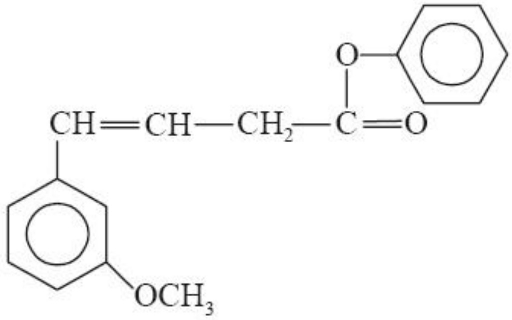
Sumatra Benzoin: It is pertinent to mention here that in pharmacy, only the **Sumatra Benzoin** is used. It occurs as blocks or irregular masses of tears having variable sizes usually imbedded either in an opaque or translucent matrix. It is rather brittle, and from within the tears are milky white in appearance. It generally becomes soft when warmed and gritty when chewed. The matrix is grayish brown to reddish in colour. Its taste is quite agreeable, balsamic and resembles to that of **storax.** It has a resinous and aromatic taste.

Siam Benzoin: The smaller tears of **Siam Benzoin** are darker in colour. It occurs largely in separate concavo-convex tears which are yellowish brown to rusty brown externally, whereas milky white internally. The tears are fairly brittle but normally become soft and plastic like on being chewed. It has a vanilla-like fragrance.

Chemical Constituents The chemical constituents of the *two* types of **Benzoin** are given below:

(*a*) **Sumatra Benzoin:** It contains free balsamic acids, largely cinnamic acid (10%), benzoic acid (6%)-along with their corresponding ester derivatives. Besides, it also contains **teriterpene acids,** namely: **19-hydroxyloleanolic** and **6-hydroxyoleanolic acids, cinnamyl cinnamate, phenyl propyl cinnamate, phenylethylene** and lastly the traces of vanillin. It yields not less than 75% of alccohol-soluble extractives.

(*b*) **Siam Benzoin:** It chiefly comprises of **coniferyl benzoate** (60-70%), benzoic acid (10%), **triterpene siaresinol** (6%) and traces of vanillin. It yields not less than 90% of alcoholsoluble extractives.



Coniferyl Benzoate

Chemical Tests

1. When 0.5 g of **Sumatra Benzoin** powder is warmed with 10 ml of KMnO4 solution (5% w/v) in a test tube, a faint and distinct odour of benzaldehyde is developed. **Siam Benzoin** gives a negative test.

2. When 0.2 g of **Siam Benzoin** powder is digested with 5 ml of ether for 5 minutes and filtered; 1 ml of the filtrate is poured into a clean china-dish containing 2-3 drops of concentrated H_2SO_4 and mixed carefully, a deep purplish red colouration is developed instantly. **Sumatra Benzoin** gives a negative test.

Uses

1. Compound benzoin tincture is frequently employed as a topical protectant.

2. It is valuable as an expectorant when vapourized.

3. It finds its usage as a cosmetic lotion usually prepared from a simple tincture.

4. **Siam Benzoin** has been proved to be a better preservative for lard than the **Sumatra Benzoin.**

. Turmeric

Synonyms Curcuma; Indian Saffron; Tumeric.

Biological Source Turmeric is obtained from the rhizome of *Curcuma longa* Linn. (*Curcuma domestica* Valeton) belonging to the natural order *Zingiberaceae*.

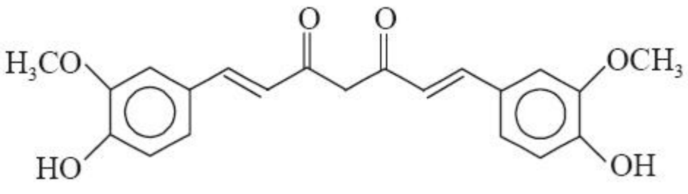
Preparation The plant is normally harvested after 9-10 months when the lower leaves start becoming yellow. The rhizome is carefully dug out from the soil with a blunt knife without damaging it. The fibrous roots are discarded. The raw green **turmeric** is cured and processed by boiling the rhizomes with water for a duration ranging between 12-14 hours. Subsequently, the cooked rhizomes are dried in the sun for 5-7 days. Cooking process helps in achieving *two* objects, namely:

(*a*) Gelatinization of starch, and

(*b*) Yellow colouration, due to *curcumin*, spreads over the entire rhizome.

Characteristic Features Turmeric has an aromatic pepper-like but somewhat bitter taste. It gives curry dishes their characteristic yellowish colouration.

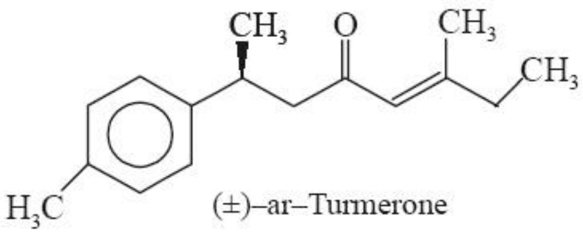
Chemical Constituents It contains volatile oil (5-6%), resin and substantial quantity of **zingiberaceous starch grains.** The marked and pronounced yellow colour in **turmeric** is due to the presence of **curcuminoids** which essentially contains **curcumin** as given below:



Curcumin

(Orange-yellow crystalline powder, mp 183°C)

The **curcuma oil*** obtained from turmeric contains **(±)-ar-turmerone** as given below:


(±)–ar–Turmerone

The volatile oil contains a host of chemical substances, such as: ***d*-α-phellandene, *d*-sabinene, cineol, borneol, zingiberene,** and **sesquiterpenes.**

Turmeric also contains some other chemical constituents, namely: ***p,p*-dihydroxy dicinnamoylmethane; *p*-α-dimethy benzyl alcohol; *p*-hydroxy-cinnamoylferuloylmethane; 1-methyl-4-acetyl-1-cyclohexene;** and **caprylic acid.**

Chemical Tests

1. **Turmeric** powder when triturated with alcohol it imparts a deep yellow colour to the resulting solution.
2. The powdered drug when treated with sulphuric acid it imparts a crimson colour.
3. The aqueous solution of turmeric with boric acid gives rise to a reddish-brown colouration which on subsequent addition of dilute alkali changes instantly to greenish-blue.
4. **Turmeric** powder when reacted with acetic anhydride and a few drops of concentrated sulphuric acid (36 N), it readily gives a violet colouration. Interestingly, the resulting solution when observed under the ultraviolet light (preferably in a **uv-chamber**), it exhibits an intense red fluorescence, which is due to the presence of **Curcumin.**

Uses

1. It is extensively used across the globe as a condiment as curry powder.
2. It is employed as a colouring agent for ointments.
3. It is used medicinally as a tonic, as a blood purifier, as an anthelmintic and finally as an aid to digestion.
4. It is used extennally in the form of a facial cream to improve complexion and get rid of pimples.
5. A small quantity of turmeric when boiled with milk and sugar; it helps to cure common cold and cough symptoms.

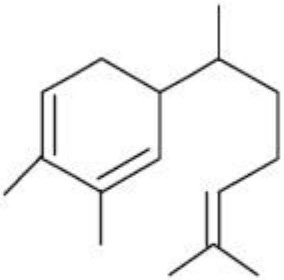
4. Ginger

Synonyms Gingerin.

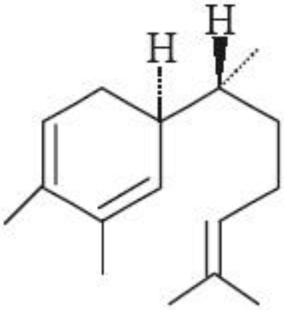
Biological Source It is the **oleoresin** obtained by the method of percolation of the powdered rhizomes of *Zingiber officinale* Roscoe, belonging to the Family: *Zingiberaceae.*

Preparation The rhizomes are sliced, dried and powdered. The powdered ginger is extracted either with acetone or ether or ethylene dichloride by the method of cold percolation repeatedly till the gingerin is no longer present in the marc. The solvent is removed by distillation under reduced pressure. Ethanol gives the max yield of the oleoresin. The average yield of the **oleoresin** is 6.5% but it may range between 3.5 to 9.0% based solely upon the source of the plant product and to a great extent on the technique adopted in the course of preparation.

Characteristic Features It is a dark brown, aromatic and pungent viscous liquid.



Zingiberene
(a)

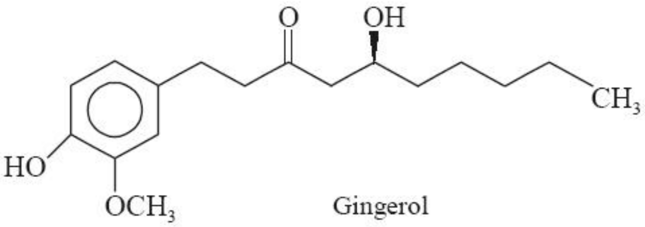


(–)-Zingiberene
(b)

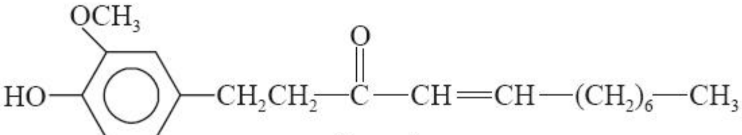
Chemical Constituents Ginger contains volatile oil (1-3%), which comprises of **zingiberene, α-curcumene, β-sesquiphellandrene** and **β-bisabolene. Zingiberene** (*a*) has two chiral centres.

The *acyclc chiral centre* has been stereochemically related to that in **(+)-citronellal,** and the *cyclic chiral centre* to that in **(–)-phellandrene.** Hence, **(–)-zingiberene** has the absolute configuration

(*b*). The **oleooresin** contains the pungent **gingerols** and **shogaols.**



Gingerol



Shogaol

Uses

1. It is used as a flavouring agent, carminative, aromatic and stimulant to gastrointestinal tract (GIT).

2. **Ginger** finds its wide applications in soft drinks, beverages, ginger beer and wine.

3. It is extensively used for culinary purposes in ginger-bread, biscuits, puddings, cakes, soups and pickles.

Enzyme

Papain

Synonyms : Papain, Papayotin

Biological Source: Papain is the dried and purified latex obtained from the milky juice of unripe fruits of Carica papaya Linn, family Caricaceae.

Geographical Source :Papaya is indigenous to tropical America and cultivated in almost all parts of the world. On large scale it is cultivated in SriLanka, Tanzania, India, Hawaii, Florida, Philippines, South Africa and Australia. In India it is successfully cultivated in Maharashtra, Bengal, Bihar and Uttar Pradesh. The two major industries Enzochem laboratories Ltd. Yeola, Nasik and Biocon Limited, Bangalore produce large quantities of commercial papain.

Cultivation, Collection and Preparation: C. papaya is an herbaceous tree of 10-15 m. height. It is normally dioecious but rarely monoecious. Papaya thrives best on the welldrained soil. The fruits are borne near the top of the trunk, gregariously packed at the base of the leaves (Fig. 1.) The fruits are spherical to cylindrical weighing up to 4.4 kg. Shallow incisions are given on the full grown, green unripe fruits on the four sides. Milky juice flows freely for a few seconds but soon coagulates. Incisions and collection of latex is done at weekly intervals till the fruit exudes latex. The collected coagulated latex is shredded and dried under sun or by artificial heat to yield crude papain. The crude papain is purified by dissolving in water and precipitating with alcohol. Isolation of proteolytic activity based fractions of crystalline papain is best accomplished at pH 5.3 from dried latex. The term papain is currently applied to both the crude dried latex and the purified crystalline proteolytic enzyme.

Characteristics: Purified papain is white or grayish white, slightly hygroscopic powder. It is completely soluble in water and glycerol, and practically insoluble in most organic solvents. Its potency varies according to process of preparation. Papain can digest about 35 times its own weight of lean mean. The best quality papain digests 300 times its own weight of egg albumin. It should be kept in well-closed containers. The best pH for its activity is 5.0 but it functions also in neutral and alkaline media. Total ash value should not exceed 1 %.

Chemical Constituents: Papain is referred to as vegetable pepsin as it contains enzymes similar to those in pepsin. The papain molecule consists of one folded polypeptide chain of 212 amino acids with molecular weight upto 23400 dalton. N-terminal amino acid sequence of papain has been illustrated in (Table2). Papain contains several proteolytic enzymes such as peptidase-I, rennin like milk coagulating enzyme, amylolytic enzyme and a clotting enzyme similar to pectase. Peptidase - I has the ability to convert proteins into dipeptides and polypeptides. I P EYV DWR QK GAVT PV KNQ GS CG S CW Fig. 2 : N- terminal amino acid sequence of papain

Uses: Being proteolytic enzyme papain is used as a digestant for proteins. It shows the proteolytic activity much like pepsin but, unlike pepsin, it can act in acid, neutral or alkaline media. It can be combined with other enzymes such as amylases to produce digestive aids. It is extensively used as a meat-tendering agent in the meat packing industries. Papain (10%) is used in ointment for wound debridement, that is, for the removal of dead tissue. It is also used in the treatment of contact lenses to prolong wearing time in keratoconic patients with papillary conjunctivitis.

Streptokinase

Synonym: Estreptokinase, Plasminokinase

Biological Source: Estreptokinase, Plasminokinase is a purified bacterial protein produced from the strains of group C Beta - haemolytic S. griseus

Preparation: Streptokinase is a bacterial derived enzyme of serine protease group. The ancestral protease activity lies within the first 230 amino acid residues at the N-terminal part of the protein that evolves from serine protease due to the replacement of histamine at 57th amino acid by glycine. The amino terminal residue polypeptide chain shows sequence homology to serine protease. Duplication and fusion of gene generate an ancestral streptokinase gene. Streptokinase is produced by fermentation using streptococcal culture and is isolated from the culture filtrate. It is produced in the form of a lyophilized powder in sterile vials containing 2, 50,000 to 7, 50,000 IU.

Characteristics: Streptokinase is a bacterial protein with half-life of 23 minutes. Its anisolylated plasminogen activator complex (APSAC) has a higher half life of 6 hours.

Chemical Constituents: Streptokinase is the purified bacterial protein with about 484 amino acid residues. Its schematic representation is given in (Fig. 5). N Streptokinase C Gly Asp Ser 1 57 102 195 230-245 415 484 Duplication and fusion Mutation Fig. 5: Scheme for evolution of streptokinase gene and protein Uses: Streptokinase is the first available agent for dissolving blood clots. It binds to plasminogen in a 1:1 ratio and changes molecular conformation. Thus, the complex formed becomes an active enzyme and promotes the activity of fibrinolytic enzyme plasmin. Plasmin breaks fibrin clots. Anistreptase or the anisolylated plasminogen streptokinase activator complex (APSAC) can also be used in a similar way for degrading blood clots. Streptokinase and anistreptase are both used in the treatment of pulmonary embolism, venous and arterial thrombosis and coronary artery thrombosis. It is also sometimes administered along with heparin to counter act a paradoxical increase in local thromb

Hyaluronidase

Synonym: Spreading factor, Hyalase

Biological Source: Hyaluronidase is an enzyme product prepared from mammalian testes which shows the capability of hydrolysing hyaluronic acid like mucopolysaccharides. Skin is considered as the largest store of hyaluronidase in the body.

Preparation: Hyaluronidase enzyme is found in type-II Pneumococci, in group A and C haemolytic streptococci, S. aureus and Clostridium welchii. Hyaluronidase manufacturers define their product in terms of turbidity reducing (TR) units or in viscosity units. Prepared solution for injection usually contains 150 TR units or 500 viscosity units dissolved in 1ml. of isotonic NaCl solution.

Characteristics: Hyaluronidase for injection consists of not more than 0.25 µg of tyrosine for each USP hyaluronidase unit. Due to its action on hyaluronic acid, it promotes diffusion and hastens absorption of subcutaneous infusions. It depolymerises and catalyses hyaluronic acid and similar hexosamine containing polysaccharides. Chemical Constituents: Hyaluronidases are a group of enzymes such as 4- lycanohydrolase, hyaluronate 3-glycanohydrolase and hyaluronate lyase. They are mucopeptides composed of alternating N-acetylglucosamine and glucuronic acid residues. Hyaluronidases catalyse the breakdown of hyaluronic acid.

Uses: Hyaluronidase for injection is used in the conditions of hypodermoclysis. It is used as a spreading and diffusing agent. It promotes diffusion, absorption and reabsorption.

Gelatin

Synonym: Gelatinum

Biological Source: Gelatin is a protein derivative obtain by evaporating an aqueous extract made from bones, skins and tendons of various domestic animals Some important sources are, Ox, Bos taurus, and Sheep, Ovis aries belonging to family Bovidae, order Ungulata of the class Mammalia.

Preparation: The process of manufacture of gelatin vary from factory to factory.. However, the general outline of the process is given below:

Raw material: Bones, skins and tendons of Bovideans is collected and subjected to liming operation. Liming Process: The raw material is first subjected to the treatment known as “liming”. In this process, the skins and tendons are steeped for fifteen to twenty and sometimes for fourty days in a dilute milk of lime. During this, fleshy matter gets dissolved, chondroproteins of connective tissues gets removed and fatty matter is saponified. The animal skin is further thoroughly washed in running water.

Defattying: In case of bones, the material is properly ground and defatted in close iron cylinders by treatment with organic solvents such as benzene. The mineral and inorganic part of the bone is removed by treatment with hydrochloric acid.

Extraction: The treated material from bones, skins and tendons is boiled with water in open pans with perforated false bottom. This process can also be carried out under reduced pressure. The clear liquid runs of again and again and is evaporated until it reaches to above 45 per cent gelatin content.

Setting: The concentrated gelatin extract is transferred to shallow metal trays or trays with glass bottom. It is allowed to set as a semisolid gelly.

Drying: The gelly is transferred to trays with a perforated wire netting bottom and passed through series of drying compartments of 300 C to 60 0C increasing each time with 100 C. About a month is taken for complete drying. Bleaching: In case of darker colour, finished product is subjected to bleaching by sulphur dioxide. Bleeching affords a light coloured gelatin.

Characteristics: Gelatin occurs in the form of thin sheets or as shredded flakes or powder. It is nearly colourless or pale yellow devoid of odour and taste. Gelatin is hard and brittle but breaks with short fracture after preliminary bending. It swells in cold water and completely dissolves when heated. It is soluble in acetic acid and glycerin but insoluble in alcohol and organic solvents. A2 per cent hot aqueous solution gelatinizes on cooling. Gelatin reacts with hydrochloric acid to obtain glutin-peptone.

Chemical Tests:

1. When heated with soda lime, it gives out fumes of ammonia.

2. Gelatin is precipitated fro solution on addition of trinitrophenol or tannic acid.

3. It produces white precipitate on addition of mercuric nitrate (Millons reagent). The white precipitate turns brick red on warming.

4. Presence of chondrin in gelatin can be detected by its insolubility in acetic acid and its failure to produce a precipitate with lead acetate, alum, ferric chloride and copper sulphate.

Chemical Constituents: Gelatin consists of a major proportion of protein glutin. Gelatin should be free from protein chondrin which comes from the chondrinogen of connective tissues. It yields about 0.6 to 2 per cent of ash and 12 to 17 per cent of moisture. Uses: Gelatin is used as a nutrient and as a styptic. It is largely used for the manufacture of hard and soft gelatin capsules. It is also used for the preparation of suppositories, pesseries, pastilles and pastes. It is a component in the bacteriological culture media. Gelatin is also employed in the micro encapsulation of drugs, in injections and perfumes. It is used for the production of absorbable gelatin sponge and gelatin films.

Malt Extract

Synonym: Diastase, Malt extract Biological Source: Malt extract is the extract obtained from the dried barley grains of one or more varieties of Hordeum vulgare Linne, family Poaceae.

Geographical Source: Barley is widely cultivated throughout the world. The major producers are USA, Russia, Canada, India and Turkey. It is also cultivated in highlands of China and Tibet.

Cultivation, Collection and Preparation: Barley is one of the oldest cultivated cereals. It is an annual erect stout herb resembling wheat. The crop becomes ready for harvest in about four months after sowing. The grains are threshed out by beating with sticks or trampling by oxen. Dried barley grains are artificially germinated by keeping their heaps wet with water in a warm room. When the caulicle of the grains starts protruding out, the germinated grams are dried. Dry germinated barley or dry malt is subjected to extraction. The malt is infused with water at 60OC. An infusion is concentrated below 60OC under reduced pressure and then dried. Less purified malt extract contains sugars, and amylolytic enzymes. Its further purification affords diastase.

Characteristics: Malt extract contains enzymes, which are most active in neutral solution. The acidic conditions destroy the activity. It converts starch into disaccharide maltose. The enzyme is destroyed by heat. Many heat sterilized malt extracts do not contain diastase. It is completely soluble in cold water, more readily in warm water. The aqueous solution shows flocculant precipitate on standing. Limit for arsenic should not exceed 1 part per million.

Chemical Constituents: Malt extract contains dextrin, maltose, traces of glucose and about 8 % of amylolytic enzyme diastase. Uses: Malt extract and purified diastase, both are used as amylolytic enzymes and as an aid in digesting starch. They are used as bulk producing laxatives.

UNIT-IV

Menthol

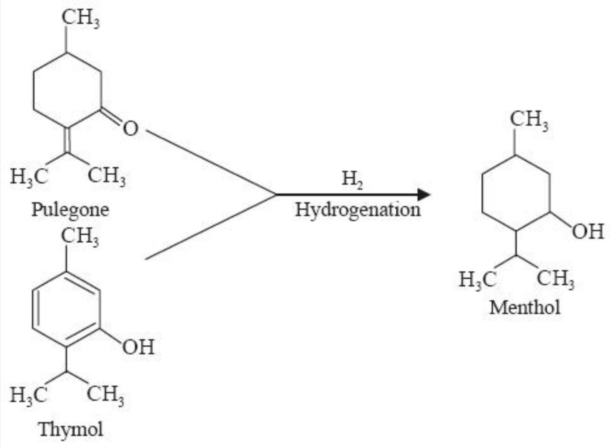
Synonyms 1-Menthol; 3-Menthanol; Menthan-3-ol; Peppermint camphor, Hexahydrothymol.

Biological Sources It is found in the **peppermint oil** obtained from the fresh flowering tops of the plants commonly known as *Mentha piperita* Linn., or other allied species of *Mentha*, belonging to family *Labiatae*.

Geographical Source Various mentha species are duly cultivated in various parts of the world. It grows both abundantly and widely in Europe, while it is cultivated in Japan , Great Britain, Italy,France, United States, CIS countries, Bulgaria and India.

Preparation It is normally prepared from *Japanese Peppermint Oil*, from the flowering tops of *Mentha avensis* Linne' var *piperascens*, by subjecting it to refrigeration below –22^{o}C whereby the menthol crystallizes out distinctly. The crystals of **menthol** are separated by filteration and squeezes between layers of filter papers to remove the adhering oil and finally purified by recrystallization.

Synthetic racemic menthol is prepared by the hydrogenation of either **pulegone** or **thymol** as shown below:



It may also be prepared from **pinene**.

Description

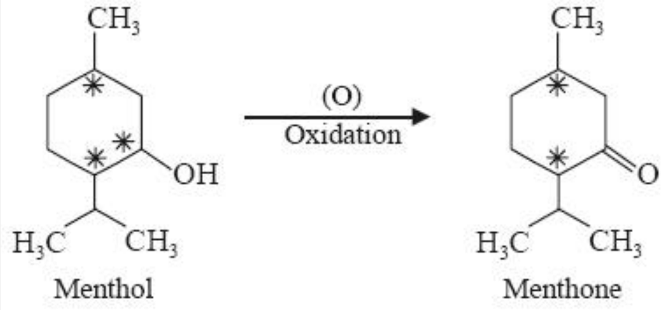
Colour : Colourless

Odour : Pleasant peppermint like odour

Taste : Characteristic, aromatic and cooling taste

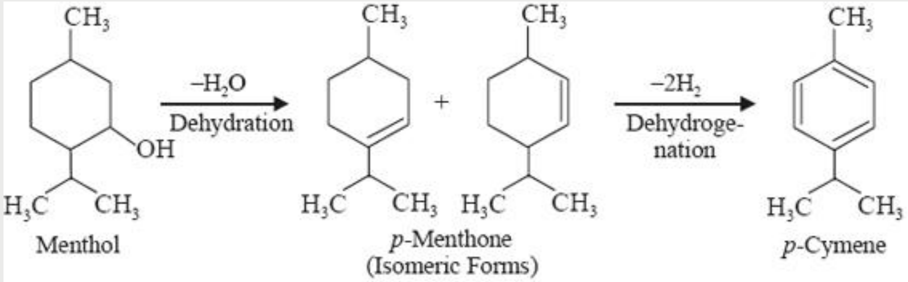
Shape : Hexagonal cyrstals usually needle like, prisms; crystalline powder; fused masses.

Chemical Structure Menthol has three chiral centres (*), hence it would give rise to eight (2^3) optically active isomers and four racemic forms. **Menthol** on oxidation gives menthone (a ketone), by the sacrifice of one chiral centre; therefore, the resulting menthone must exist in four (2^2) optically active isomers and two recemic forms and all, these have been actually prepared.

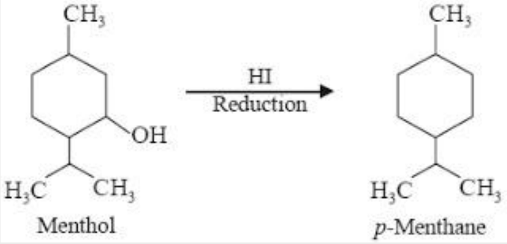


Special Features following are the special features of **menthol**, namely:

(*a*) **Dehydrogenation: Menthol** first on dehydration yields two isomeric forms of p-menthane, which on subsequent dehydration gives rise to **p-cymene** as follows:



(*b*) **Reduction: Menthol** on reduction with hydroiodic acid yields **p-menthane** as under:



Chemical Tests

1. When 10 mg crystals menthol are first dissolved in 4 drops of concentrated sulphuric acid and then a few drops of vanillin sulphuric acid reagent are added it shows an orange yellow colouration that ultimately changes to violet on the addition of a few drops of water.

2. A few crystals of **menthol** are dissolved in glacial acetic acid and to this solution a mixture of 3

drops of H_2SO_4 and 1 drop of HNO_3 are added. It fails to produce either green or bluish green colouration (**Thymol** gives a green colouration).

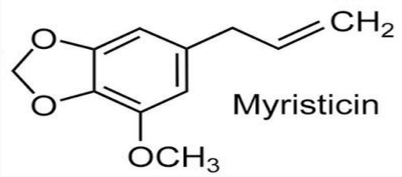
3. **Menthol** provides a plethora of compounds of diagnostic value for differential identification, for instance: **menthoxy acetate; p-nitrobenzoate; d-camphor sulphonate; acid phthalate; phosphoric acid-complex;** and **3,5-dinitrobenzoate.**

Uses

1. It is used profusely in various types of mouth washes, toothpastes and similar oral formulations.
2. It finds its enormous use as a flavouring agent for chewing gums, candies, throat lozenges and also certain mentholated cigarettes.

NUTMEG

- Dried ripe seeds of *Myristica fragrans* (Fam. Myristicaceae), deprived of its arillus and testa, with or without a thin coat of lime.
- Nutmeg yields not less than 25% of fats, and not less than 5% of volatile oil.



Active Constituents:

1. Volatile oil (5-15%).
2. Fat (30-40%) and phytosterols.
3. Starch, amylodextrin, coloring matter and saponin.

Uses:

1. As stimulant, carminative and flavoring agent.
2. The oil is used externally in chronic rheumatism.

- Myristicin and elemicin are structurally closely related to amphetamines (some of which exert hallucinogenic effects). Therefore, Nutmeg has drawn attention as a psychotropic agent, this action is possibly due to myristicin and elemicin. In large doses they are toxic, producing convulsions, an action due to the **mace** (**dried arillodes**).

Chemical Identification:

- On microsublimation, powdered Nutmeg yields a sublimate of colorless crystals.

Mace:

- It consists of flattened lobed pieces. When soaked in water and restored to its original form, it is seen to be cup-shaped. It is of a dull reddish color, translucent and brittle.
- Its odor and taste resemble those of Nutmeg.
- Mace contains 4-5% of volatile oil, which appears to be identical with that obtained from Nutmeg.

Cardamom

- Dried ripe/nearly ripe seeds of *Elettaria cardamomum* (Fam. Zingiberaceae), recently separated from the fruit.

- Cardamom seed contains not more than 3% of foreign organic matters and yield not less than 3% of volatile oil.

Active Constituents:

1. Volatile oil (2.8-5.2%). The oil contains a high percentage of terpinyl acetate, cineole and smaller quantities of other terpenes, terpene alcohols and esters. The loss of oil from seeds kept in the pericarp is small, while a loss of about 30% of the oils from the free seeds occurs in 8 months.
2. Starch, and Fixed oil.

Uses:

- Aromatic stimulant and carminative.
- Flavoring agent.
- As condiment.
- In manufacture of liquors.

Clove

Biological Source	Dried flower buds of ***Syzygium aromaticum***(***Eugenia caryophyllata***/***Caryophyllus aromaticus***)
Family	**Myrtaceae**
Geographical Source	The plant grows in warm climates such as that of the Molluca islands, Tanzania, Sumatra, Madagascar, Indonesia, Sri Lanka, India and Brazil. It is also cultivated in Zanzibar and Pemba.
Morphology/Macroscopical Characters	▪ The plant is a tall evergreen plant about 20m high with leaves leathery in texture. ▪ Clove can be bifurcated into the head and the stalk region. ▪ The head portion containing the buds have four projecting calyx teeth or lobes or sepals. A hood which hides numerous stamens is formed by the folding of the four petals which are above the lobes (sepals). ▪ The stalk portion of the clove consists of a cylindrical hypanthium above which lies a bilocular ovary consisting of numerous

ovules.

Organoleptic properties: The clove flower buds are around 10-17.5 mm long and 2mm thick and are dark brown (almost black) in colour. Cloves have a strong aromatic and pungent taste followed by numbness (analgesia) and a spicy odour .

In a transverse section of the hypanthium, in the region below the ovary of the clove the following observations are made:
Going from outside (epidermis) to the inside (columella),

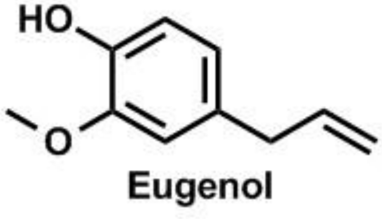
- The epidermis of clove has a thick cuticle with **anomocytic stomata** and straight walled cells.
- There is presence of **schizolysigenous oil glands** which are ellipsoidal in shape in the parenchyma.
- **Calcium oxalate crystals clusters** too are present in the parenchymatous cells. They are around 5-25 µm in diameter. They are shaped as **acicular needles**.
- **Vascular bundles** (lignified and thickened) are found in the oil glands zone and in the outer region of the columella.
- Between the columella and the vascular bundles is the region of aerenchyma which is composed of **air cells** and supports the columella.
- Collumella is also rich in calcium oxalate crystals and has a ring of vascular bundles in its outer ring.
- **Pollen grains** are 15-20 µm in diameter and triangular in shape.

Microscopic Characters

- **Starch grains are absent.**

Chemistry

- Clove consists of **14-21% of volatile oil**which gives the characteristic odour and

	flavour to the compound. Volatile oil content is about 5% in stem and 2% in leaves. • The main component of distilled clove bud oil is **eugenol** (60-90%) and the others are acetyleugenol (3%), sesquiterpenes (α-caryophyllene and β-caryophyllene), gallotannic acid, vanillin, furfural etc. Flavanoids, lipids, carbohydrates and vitamins are also present.  Eugenol • Other constituents like tannins, gums, resins and glucoside sterols are also present in the bud.
Chemical Tests	On treating with strong KOH solution, clove shows needle shaped crystals of potassium eugenate.
Adulterants/Allied drugs/ Substitutes	**<u>Adulterants</u>:** • **<u>Exhausted cloves</u>**: Cloves which have been exhausted of volatile oil do not sink in freshly boiled and cooled water compared to the ones rich in volatile oil (as they are heavier than water). • **<u>Blown cloves</u>**: If the cloves are left for a longer period of time on the trees, the buds open up and the petals shed away. • **<u>Mother cloves</u>**: Ripe fruits of cloves (brown, ovoid and one seeded), identified by starch in the seeds and less volatile oil. • **<u>Clove stalks</u>**: Can be detected by the presence of prismatic calcium oxalate crystals found unlike the original acicular needles. Also identified by presence of isodiametric sclereids.
Uses	Clove is used as a spice and as a carminative. Topically when clove oil is applied it has

counter-irritant action. It is also used as an analgesic (pain-killing) and antiseptic (bactericidal) in oral health and dentistry. It's analgesic, antiseptic and expectorant (cough-suppressing) activity makes it a very good herbal treatment for symptomatic relief of sore throat and coughing. Non-medicinally it is used in perfumes, for oil painting or as mosquito repellant.

Other proposed uses:

- Eugenol present has antipyretic effects and also inhibits prostaglandin biosynthesis (showing antidiarrheal effect).
- Antithrombotic activity and inhibition of platelet aggregation has also been reported.
- Clove oil also shows anticarcinogenic properties due to the sesquiterpenes present.
- Clove also is being used for its spasmolytic and anti histaminic properties.
- It also has antibacterial, fungistatic, anthelminitic and larvicidal properties.

FENNEL

SYNONYMS: Large Fennel, Sweet Fennel, Fennel Fruits, , Fructus Foeniculli

BIOLOGICAL SOURCE: Fennel is the dried, ripe fruits of foeniculum vulgari Mill

FAMILY: Umbelliferae

GEOGRAPHICAL SOURCE: Fennel is indigenous to Mediterranean region of Asia and Europe. It is widely cultivated in Nepal, Russia , India , Japan , Southern Europe , China and Egypt

CULTIVATION: Fennel is stout , glabrous , aromatic herb and cultivated as a garden or home yard crop at all attitude upto 2000m . It grows in any good soil , but thrives best in rich , well-drained loam or black sandy soil containing sufficient lime .It is propagated mainly by seeds , but can also be grown by root or crown division . Seeds are sown broadcast by hand or by shallow drill in oct-nov in the plains and Mar-Apr on the hills. The plants are thinned out to about 30 cm apart. Occasional wedding , and irrigation once a week are done . The crop is harvested before the fruit are fully ripe . The steams are cut with the sickle and spread out in loose sheaves to dry in the sun . The dried fruit are threashed out and cleaned by winnowing

MORPHOLOGY: The drug consist partly of whole cremocarp and partly of mericarps . The fruits is 0.5-1.0cm long , 2-4mm board . Shape is slightly curved and oval . Surface is glabrous with 5 straight prominent primary ridges and bifid stylopod at the apex . Colour is greenish brown , odour is aromatic and taste is distinct , sweet and aromatic

MICROSCOPY:

- The transverse section of the mericarp shows the two prominent surface, the dorsal surface and the commisural surface. The commisural surface has a carpophore and two vittae and the dorsal surface has five ridges.

- Epicarp consists of polygonal cells of epidermis covered by cuticle.

- Mesocarp has parenchyma cells with five bicollateral vascular bundles, each in the region of primary ridge. The parenchyma cells contain fixed oil, aleurone grains and rosette crystals calcium oxalates.

- Endocarp consists of testa and endosperm. Testa is a single layered tangentially elongated cell with yellowish colour. Endosperm consists of thick walled polyhedral, colourless cells

CHEMICAL CONSTITUENTS

Fennel contains volatile oil (2-6.5%) and fixed oil (12%) . The main constituents of the volatile oil are phenolic ether , anethole (50-60%) and the ketones , fenchone (18-20%) which gives the fruit its distinct odour and taste , the other constituents of volatile oil are methyl chavicol, anisic aldehyde , anisic acid , dipentene , limonene and phellandrene

USES

Fennel is used as stimulants , aromatic , stomachic , carminative , emmenagogue and expactorant . Anethole is used in mouth and dental preparations . Fennel is useful in diseases of the chest , spleen and kidney .

ADULTERANTS

Fennel is generally adulterated with exhausted Fennel . The alcohol – exhausted Fennel looks like fresh Fennel and contains 1-2% volatile oil. The steam-exhausted fennel fruits are darker in apperance . They contain little volatile oil and are heavier then water . It is also adulterated with undeveloped or mould-attack fruits .

Fibers

Natural fibres are greatly elongated substances produced by plants and animals that can be spun into filaments, thread or rope. Woven, knitted, matted or bonded, they form fabrics that are essential to society.

Like agriculture, textiles have been a fundamental part of human life since the dawn of civilization. Fragments of cotton articles dated from 5000 BC have been excavated in Mexico and Pakistan. According to Chinese tradition, the history of silk begins in the 27th century BC. The oldest wool textile, found in Denmark, dates from 1500 BC, and the oldest wool carpet, from Siberia, from 500 BC. Fibres such as jute and coir have been cultivated since antiquity.

While the methods used to make fabrics have changed greatly since then, their functions have changed very little: today, most natural fibres are still used to make clothing and containers and to insulate, soften and decorate our living spaces. Increasingly, however, traditional textiles are being used for industrial purposes as well as in components of composite materials, in medical implants, and geo- and agro-textiles.

In this section we present profiles of 15 of the world's major plant and animal fibres. They range from cotton, which dominates world fibre production, to other, specialty fibres such as cashmere which, though produced in far smaller quantities, have particular properties that place them in the luxury textiles market.

Plant fibres	***Animal fibres***
Plant fibres include seed hairs, such as cotton; stem (or bast) fibres, such as flax and hemp; leaf fibres, such as sisal; and husk fibres, such as coconut.	*Animal fibres include wool, hair and secretions, such as silk.*

Goodfibers

The **cotton** fibre grows on the seed of a variety of plants of the genus *Gossypium*. Of the four **cotton**species cultivated for fibre, the most important are *G. hirsutum*, which originated in Mexico and produces 90% of the world's **cotton**, and *G. barbadense*, of Peruvian origin, which accounts for 5%. World average **cotton** yields are around 800 kg per hectare.

The fibre

Cotton is almost pure cellulose, with softness and breathability that have made it the world's most popular natural fibre. Fibre length varies from 10 to 65 mm, and diameter from 11 to 22 microns. It absorbs moisture readily, which makes **cotton** clothes comfortable in hot weather, while high tensile strength in soap solutions means they are easy to wash.

CNR-ISMAC, Biella, Italy

Uses of cotton

An estimated 60% of **cotton** fibre is used as yarn and threads in a wide range of clothing, most notably in shirts, T-shirts and jeans, but also in coats, jackets, underwear and foundation garments.

Cotton is also used to make home furnishings, such as draperies, bedspreads and window blinds, and is the most commonly used fibre in sheets, pillowcases, towels and washcloths.

Its is made into specialty materials suitable for a great variety of applications: fire-proof apparel, cotton wool, compresses, gauze bandages, sanitary towels and cotton swabs. Industrial products containing **cotton** include bookbindings, industrial thread and tarpaulins.

Jute

Jute is extracted from the bark of the white **jute** plant, *Corchorus capsularis* and to a lesser extent from tossa **jute** (*C. olitorius*). It flourishes in tropical lowland areas with humidity of 60% to 90%. A hectare of jute plants consumes about 15 tonnes of carbon dioxide and releases 11 tonnes of oxygen. Yields are about 2 tonnes of dry **jute** fibre per hectare.

The fibre

Dubbed the "golden fibre", **jute** is long, soft and shiny, with a length of 1 to 4 m and a diameter of from 17 to 20 microns. It is one of nature's strongest vegetable fibres and ranks second only to cotton in terms of production quantity. **Jute** has high insulating and anti-static properties, moderate moisture regain and low thermal conductivity.

CNR-ISMAC, Biella, Italy

Uses of jute

During the Industrial Revolution, **jute** yarn largely replaced flax and hemp fibres in sackcloth. Today, sacking still makes up the bulk of manufactured **jute**products.

Jute yarn and twines are also woven into curtains, chair coverings, carpets, rugs and backing for linoleum. Blended with other fibres, it is used in cushion covers, toys, wall hangings, lamp shades and shoes. Very fine threads can be separated out and made into imitation silk (*below*).

Jute is being used increasingly in rigid packaging and reinforced plastic and is replacing wood in pulp and paper.

Geotextiles made from **jute**are biodegradable, flexible, absorb moisture and drain well. They are used to prevent soil erosion and landslides .

The animal **wool**

Sheep (*Ovis aries*) were first domesticated 10 000 years ago. They currently number about 1 billion head, in 200 breeds, worldwide. Sheep are shorn of their **wool** usually once a year. After scouring to remove grease and dirt, **wool** is carded and combed, then spun into yarn for fabrics or knitted garments. Merino sheep produce up to 18 kg of greasy **wool** a year.

The fibre

Wool has natural crimpiness and scale patterns that make it easy to spin. Fabrics made from **wool**have greater bulk than other textiles, provide better insulation and are resilient, elastic and durable. Fibre diameter ranges from 16 microns in superfine merino **wool** (similar to cashmere) to more than 40 microns in coarse hairy **wools**.

Uses of wool

Wool is a multifunctional fibre with a range of diameters that make it suitable for clothing, household fabrics and technical textiles.

Its ability to absorb and release moisture makes woollen garments comfortable as well as warm. Two thirds of **wool** is used in the manufacture of garments, including sweaters, dresses, coats, suits and "active sportswear". Blended with other natural or synthetic fibres, **wool** adds drape and crease resistance.

Slightly less than a third of **wool** goes into the manufacture of blankets anti-static and noise-absorbing carpets, and durable upholstery (**wool**'s inherent resistance to flame and heat makes it one of the safest of all household textiles).

Industrial uses of **wool** include sheets of bonded coarse **wool** used for thermal and acoustic insulation in home construction, as well pads for soaking up oil spills.

Silk

Silk is produced by the silkworm, *Bombyx mori*. Fed on mulberry leaves, it produces liquid **silk** that hardens into filaments to form its cocoon. The larva is then killed, and heat is used to soften the hardened filaments so they can be unwound. Single filaments are combined with a slight twist into one strand, a process known as filature or "**silk**reeling".

The fibre

A **silk** filament is a continuous thread of great tensile strength measuring from 500 to 1 500metres in length, with a diameter of 10-13 microns. In woven **silk**, the fibre's triangular structure acts as a prism that refracts light, giving **silk** cloth its highly prized "natural shimmer". It has good absorbency, low conductivity and dyes easily.

Uses of silk

Silk's natural beauty and other properties - such as comfort in warm weather and warmth during colder months - have made it sought after for use in high-fashion clothes, lingerie and underwear.

It is used in sewing thread for high quality articles, particularly **silk** apparel, and in a range of household textiles, including upholstery, wall coverings and rugs and carpets.

It is also being used as surgical sutures (*below*) - **silk** does not cause inflammatory reactions and is absorbed or degraded after wounds heal.

Other promising medical uses are as biodegradable microtubes for repair of blood vessels, and as moulded inserts for bone, cartilege and teeth reconstruction.