

Block

2

BEVERAGES, FIBERS, TIMBER, MEDICINAL AND OIL YIELDING PLANTS

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BLOCK 2 : BEVERAGES, FIBERS, TIMBER, MEDICINAL AND OIL YIELDING PLANTS

The Block 2 of this course deals with the study of plant species which are used as a source of various useful products such as beverage, fibers, timber, medicines and oil. We have five units in this block. Each unit provides you a detailed description of crop plants that are source of beverages such as tea, coffee, fibers such as cotton, jute, oil such as mustard, groundnut, timber such as teak and pine. Some important medicinal plants species has also been described.

Unit 5 is solely devoted to beverages. In addition to cereals, legumes and spices, plants yield valuable non-alcoholic beverages. A detailed account of important beverages such as tea, coffee and cocoa has been presented which includes their origin, distribution, botanical details and processing.

A discussion on oils and fats has been given in Unit 6. These products of plant origin constitute the second major category of agricultural produce in India after cereals and legumes. Plant oils are extensively used as a cooking medium along with their importance as fuels, lubricants and in the manufacture of soaps and detergents. An account of important oil crops along with a detailed discussion on the morphology, oil production methods, chemical composition and uses of two major crops viz. mustard and groundnut form the main theme of this unit.

Unit 7 is on fiber yielding plants reaffirms their importance in providing us clothing. Plant fibers like cotton and jute have greatly influenced the advancement of human civilization. This unit comprises of a general account of important fiber crops and their uses as well as a detailed discussion on origin, types, morphology, harvesting and commercial processing of cotton.

Use of plant secondary metabolites as medicines form Unit 8. This unit deals with a description of some important medicinal plants like *Digitalis*, *Papaver*, *Rauvolfia*, *Artemisia*, *Catharanthus*, *Adhatoda* and *Ephedra*. Morphology, distribution, chemical composition, important medicinal properties and uses of these plants have also been included.

Unit 9 discusses the role of wood and timber yielding plants in the human society. A detailed account of two commercially important plants viz. teak and pine has been provided with reference to their morphology, wood characteristics and uses in furniture industry.

Objectives

After studying this block, you should be able to :

- ❖ differentiate between alcoholic and non-alcoholic beverages;
- ❖ explain the processing methods of preparation of tea;
- ❖ describe the chemical structure of plant fats and oils; and prepare a detailed account of groundnut and mustard crops
- ❖ enumerate the major fiber yielding crops of India; and prepare a illustrated account of processing of cotton fibers;
- ❖ appreciate and describe some medicinally important plant species;
- ❖ list the important properties of wood and fibers of commercial use; and
- ❖ explain the characteristics and advantage of teak wood.



UNIT 5

BEVERAGES |

Structure

5.1	Introduction	5.4	Summary
	Objectives	5.5	Terminal Questions
5.2	General Account of Alcoholic and Non-Alcoholic Beverages	5.6	Answers
5.3	Important Beverage Plants		
	Tea		
	Coffee		
	Cocoa		

5.1 INTRODUCTION

In the earlier units of this course you have studied about some economically important plants like cereals, legumes and spices. In the current unit you are going to read about some important beverage plants, their morphology along with their processing and uses. Beverage is a potable drink other than water. The word beverage is derived from the old French word 'boivre' that means 'a drink'. Hence beverages are liquid drinks intended for human consumption. In addition to satisfying thirst they relieve fatigue, stimulate the nervous system and have refreshing properties. Earliest beverage consumed by humans was probably the juice extracted from fruits. With time we came to know about vast array of refreshing and stimulating drinks / beverages to quench our thirst. Depending on the presence or absence of alcohol beverages can be categorized into two groups i.e. (i) alcoholic and (ii) non alcoholic beverages.

Objectives

After studying this unit, you should be able to:

- ❖ differentiate between alcoholic and non-alcoholic beverages;
- ❖ describe some important non alcoholic beverages like tea, coffee and cocoa;
- ❖ describe morphology, processing and uses of tea, coffee and cocoa; and
- ❖ discuss the steps involved in processing of tea.

5.2 GENERAL ACCOUNT OF ALCOHOLIC AND NON ALCOHOLIC BEVERAGES

There are two types of beverages- non alcoholic and alcoholic. As their name indicates alcoholic beverages contain alcohol and are derived from different cereals and fruits. They act as depressants i.e. they lower the activity of the brain. They are classified in two types -fermented (alcohol is formed by the fermentation of sugars) and distilled (obtained by successive distillation of fermented liquors). Wine and beer are the oldest alcoholic beverages. Wine is produced by fermentation of fruit juices, mainly grapes and contains 7-16 percent alcohol. Beers are made by fermentation of cereals mainly barley and contain 3-8 percent alcohol. Its nutritive value is higher due to the presence of sugars, dextrin, proteins and phosphates. Some other fermented beverages include cider from apple juice, perry from pear juice, palm wine from juices of palm inflorescence and chicha from maize kernels. Distilled beverages include whisky which is obtained from fermented juices of different fruits and Rum which is made from sugarcane juice or molasses. Gin is prepared by distillation of fermented malt of barley and rye.

Non alcoholic beverages have refreshing and stimulating properties due to the presence of caffeine in small amounts. Caffeine imparts wakefulness with increased production of digestive juices and has marked diuretic action. The beverages that are consumed on large scale throughout the world have been summarized in Table 5.1.

Table 5.1 : Major alcoholic and non-alcoholic beverages consumed throughout the world.

Beverage	Global consumption
Non- Alcoholic	
Tea	6.3 billion kg
Coffee	10 million tons
Fruit Juice	95, 934 million liters
Alcoholic	
Beer	189.05 million Kiloliters
Wine	234 million hectoliters

Three major non-alcoholic beverages are tea, coffee and cocoa. In this unit we will study about these three beverages. A graphic account of main alcoholic and non alcoholic beverage is given in Figure 5.1.

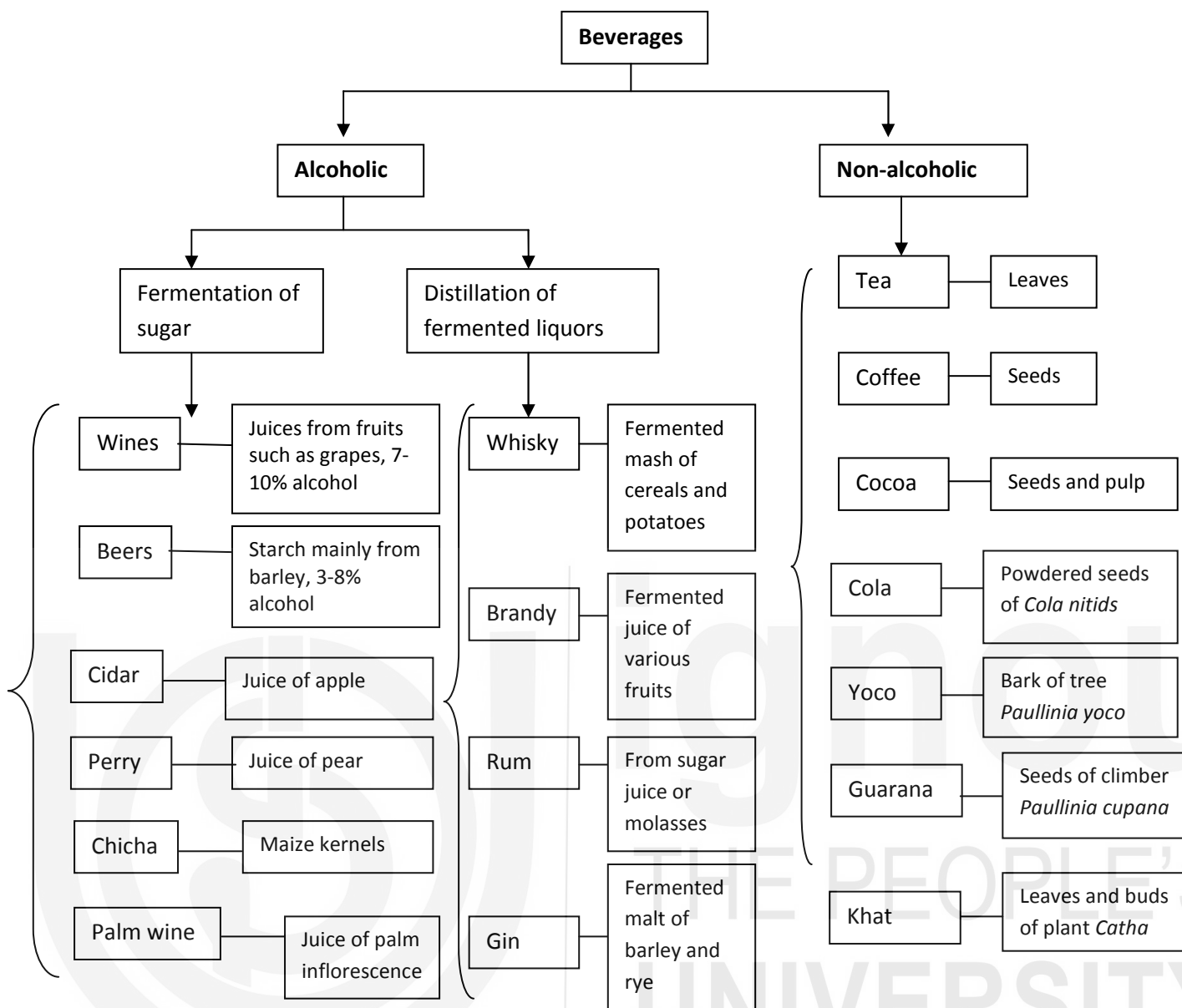


Fig. 5.1: Various alcoholic and non-alcoholic beverages.

5.3 IMPORTANT BEVERAGE PLANTS

Plants are the major source of non-alcoholic beverages. Let us now study about some important beverage plants: Tea, Coffee and Cocoa.

5.3.1 Tea

Botanical Name: *Camellia sinensis* (L) syn. *Thea sinensis* (L).

Family: Theaceae (=Ternstroemiaceae)

Vernacular name: Chai

n=15

Tea is the most popular and favourite non-alcoholic drinks that gained importance during the last century. It is consumed in almost all the countries of the world. More than 50 percent of world's population consumes tea regularly. It is believed to be indigenous to South Western China, Northeastern India

(Assam) and the adjoining areas of upper Burma. Most of the world's tea comes from Asia, with lesser quantities from Africa and South America. China, India and Srilanka are the largest producers of tea. In India tea is cultivated in Brahmaputra and Surma valleys of Assam, northern district of Bengal, Kerala and Nilgiri and Annamali hills. Some other tea growing areas include Ranchi, Dehradun, Kangra and Kumaon districts. High altitude areas of Darjeeling district produce tea of excellent quality. The detailed morphology, cultivation, uses and processing of tea is discussed below.

Tea is prepared from the dried leaves of *Camellia sinensis*. The legendary Chinese emperor Shen Nung is said to have discovered the stimulatory properties of tea leaf extract around 2700 BC. First tea was used as a medicine. Tea drinking became a social custom in China in 5th century AD. It was brought to Japan by Buddhist monks in early eighth century. It spread to other Asian countries by the seventeenth century. The Turks introduced tea from China to the West in late sixteenth or early seventeenth century. Since then the habit of drinking infusions of tea increased throughout the world. Britain became the chief tea consuming nation of the western world.

Morphology

The tea plant is an evergreen tree or shrub which can grow to a height of 30 to 50 ft. The plant is not allowed to grow beyond plucking height. The bushes are often pruned back to encourage maximum leaf production. The leaves are alternate, generally elliptic to lanceolate with toothed margins. The leaves are glabrous (Fig 5.2). The under surface of young tender leaves is densely covered with soft hairs that vanish with age. Old leaves contain numerous oil glands which impart characteristic fragrance and aroma to leaves. Yellow centered white or pinkish fragrant flowers are born in leaf axils either singly or in clusters of few and produce a three-celled woody capsule at maturity. Each compartment of capsule contains a brown seed, about 1.25 cm in diameter.

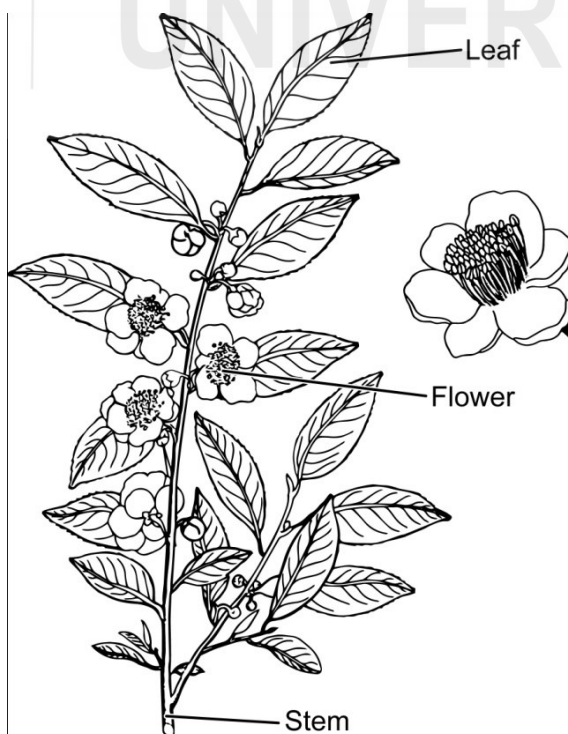


Fig. 5.2: A branch of tea plant showing leaves and flowers.

Cultivation

Tea is now widely cultivated in the tropical and temperate regions extending from 40° N in Russian Trans Caucasia to 33.5° Argentina. India is second largest tea producing nation with estimated production around 179.01 million kgs reported in July 2021.

Tea plant grows well in tropical and warm temperate climates with plenty of rainfall. The plant is grown in open fields or terraced hill sides, where rainfall is evenly distributed throughout the year. An average monthly temperature of 21-32° C is essential for its growth. It cannot withstand long spells of dry weather. Prolonged drought damages the tea crop. Plants thrive best in deep well drained, acidic soils (pH 4.0 – 6.0) free from lime and rich in humus. It is a shade loving plant and shows more vigorous growth under partial shade provided by leguminous trees like *Albizia procera*, *A. chinensis*, *A. stipulata*, *Dalbergia assamica*, *Gliricidia sepium* etc. Tea is tolerant of high levels of aluminum. Aluminum is also a diagnostic character for determining good tea soil. It is helpful in uptake of manganese and phosphorous.

Varieties

Tea has about 1000 varieties. Cultivated forms are generally grouped into two types, namely the Chinese tea (*C. sinensis* var *sinensis*) and Assam tea (*C. sinensis* var *assamica* Mast). Besides these two varieties hybrid teas (*sinensis* X *assamica*) are also cultivated. Most of the tea cultivated outside China Japan and Assam is hybrid tea. China tea is a slow growing, herb with multiple branches, around 1 to 2 m tall with life span of about 100 years. It has relatively narrow, short dark green leaves, 4-7 cm long with a dull flat surface pointing upward. It is hardy and with stand cold winters. Flowers are borne singly.

Assam tea plant is a quick growing, less hardier, single stemmed tree with height of 6.0-18.3 m which has economic life of 40 years. Leaves are larger (15-30 cm long), pale green with glossy upper surface. Flowers are borne in clusters of 2-4. Crop yield is greater than Chinese variety.

Propagation of Tea

Tea plants are usually propagated by seeds sown in nurseries. Seedlings are transplanted into the field when they are about 30cm in height. Seeds are sown 4"-8" apart. Vegetative propagation is done by single internode cuttings taken immediately above the leaf and axillary bud. Regular pruning is done to keep the plant bushy. After about 10 years the bushes are often cut back to ground level allowing suckers to replace old bush. Harvesting or plucking is an important operation in tea industry involving a lot of labour. Plucking is started when the plant is 4-5 years old. The quality of tea depends on the age of plant as the tannin content in leaves is variable with their age. The young leaves with more tannin make better tea than the older leaves. Plucking is usually done by hand by women and children. The percentage of tannin in the tea plant is as follows: bud-25; first leaf-28, second leaf-2, third leaf-4, stalk between second leaf and bud-12, and stalk between second and fourth leaf-6. It is clear from above description that picking of terminal bud with first and second leaf gives best quality tea. Plucking can be done at the interval of 7-10

days, as the new shoot develops very fast. In cold climate growth of plant is very slow in winter months so the plucking is also delayed but in hotter regions 25-30 pluckings can be made in a year. The yield decreases substantially as the plant becomes 40-50 years old.

Chemical composition: The distinctive character of the beverage is mainly due to three principle constituents- the essential oils, the alkaloid fraction and polyphenols (or tannins). The aroma and flavour of tea is due to the presence of an ethereal oil, theol. The stimulating and refreshing quality of tea is attributed to theine while the bitterness and astringency of the leaves is due to the tannins. The caffeine content of the processed tea leaves varies from 2.5-4.5 per cent i.e. twice than that of roasted coffee beans (1.0-2.0 per cent). The tannins in tea leaves undergo a major change during preparation of black tea as their concentration is reduced from 28 to 12 per cent. A cup of tea provides 4 calories without any added ingredients, with the addition of table spoon of milk and a tea spoon of sugar it becomes 40 calories. Tea also contains few B complex groups of vitamins and nicotinic acid. Indian teas have larger content of tannin than the Chinese varieties which are known for their delicacy. Letpet tea is fermented or pickled tea grown mainly in Myanmar, Thailand and China. It is used as a pickle instead of drink.

Processing of tea depends on the type of tea desired. Mainly three kinds of teas are prepared commercially i.e. black tea, green and oolong tea. Almost 80 percent of the tea is processed into black tea.

Black Tea : It is the most important of all types of tea. Four steps are involved in preparation of black tea.

- i) **Withering:** Harvested fresh leaves are either dried in sun or heated in shallow trays to minimize moisture content. Tea leaves are withered for about 24 hours with warm air passing over it on well ventilated in door shelves or racks and leaves are exposed to sun. Withering results in decrease in the water content and leaves become soft and flaccid.
- ii) **Rolling:** Leaves are either rolled by hand or sent to rolling machines. Several rolling and breaking operations damage the leaf cells so that the juice and enzymes are released and whole rolled mass gets smeared with them. Rolling also facilitates fermentation. After half an hour of rolling the leaves are removed in aluminium trolleys to a sifter and ball breaker. This machine has a long and flat metal sheet with perforations, fixed on a frame which makes reciprocating motion; so the broken leaf and fine particles fall below and rest is taken out after sieving to be rolled for a second time with increased pressure.
- iii) **Fermentation:** Rolled tea leaves are carried to fermentation rooms in an atmosphere of high humidity and low temperatures. Leaves are spread on aluminium or glass sheets for oxidation. Temperature of 24-27° C is considered to be ideal for fermentation of tea leaves. During fermentation tannins (polyphenols) present in tea are partly oxidized and the leaves change colour and turn bright coppery red. As a rule, shorter the fermentation, the more pungent would be the liquor obtained and the longer the fermentation, the softer liquor and deeper colour is obtained.

- iv) **Drying or Firing:** It is done to stop further oxidation of the leaf and to reduce moisture content to 3-5 per cent. Fermented leaves are conveyed through air chambers at (90-100° C) or so for about 25-30 minutes. Dried leaves have only 3-4% moisture.
- v) **Grading:** The tea so prepared is graded into various kinds. Indian tea is essentially graded in three grades i.e. leaf, broken waste and dusts (smallest particles). Leaf grades (orange pekoe, pekoe) give better tea than 'broken' grades (broken orange pekoe, broken pekoe etc.)
- vi) After grading tea is packed in tea-chest lined with aluminium foil paper to protect leaves from moisture.

Green Tea: About 20 per cent of the tea consumed all over the world is the green tea. Preparation of green tea does not involve the processes of withering and fermentation. The steps include in its making are

- i) Heating or steaming
- ii) Rolling and
- iii) Drying

Heating or steaming: The leaves are generally plucked without stalk and heated in an iron pan or steamed. Steaming makes the leaves pliable for rolling and protect them from fermentation and blackening. This process inactivates the enzymes *polyphenol oxidase* and prevents the oxidation of polyphenols. The leaves are rolled and dried almost in a similar way to black tea. Drying retains the greenish colour of leaf. Tea obtained by iron pan firing is of better quality. To improve the colour of leaves polishing is done with soapstone or French chalk. The tannin and caffeine content is higher in green tea in comparison to black tea. In China and Japan most teas are made of this type. In India small quantity of green tea is manufactured in North India.

Oolong Tea: It is an exclusive produce of Taiwan (Fermora) and a favourite tea of Americans. The manufacturing process is similar to that of black tea but it is semi-fermented. Light fermented tea has a characteristic flavour because of the particular variety of tea grown under a particular set of soil and climate conditions of femora.

Oolong Tea is basically oxidized black tea giving it a dark colour and rich matty aroma. The processing involved four steps i.e. withering, light fermentation, rolling and drying. Withering is done in strong sunlight followed by slight fermentation. Tea leaves are rolled and dried. Rolling is an important aspect of oolong tea. Leaves are rolled in tight balls or thin strands. Most oblong teas especially those of fine quality involve unique tea plant cultivars that are exclusively used for particular varieties. Health benefits of different types of teas are given in table 5.1.

Table 5.1: Health benefits of various types of tea.

Type of tea	Health benefits
Green tea	Prevent cardiovascular diseases. Reduce neurological disorders like Alzheimer's and Parkinson's disease. Reduce risk of stroke.

Black tea	Protects lungs from damage. Reduce risk of stroke. Help in maintaining a normal blood pressure.
Oolong tea	Protect heart by reducing cholesterol. Possess anticancerous properties. Fluoride help in keeping the teeth strong. Strengthen immune system.
White tea	Lower cholesterol level. Keep blood sugar under control.
Chamomile tea	Possess anticancerous properties. Used in treatment of bowel syndrome. Stop gastrointestinal inflammation.

C.T.C tea

In north India, a variation was introduced in processing of tea. The variation consists of use of a machine named 'crushing, tearing and curling (CTC) machine'. The machine has parallel stainless steel rollers revolving inward at different speeds. The rollers are about 1m long, 15 cm in diameter and grooved concentrically and spirally. The concentric grooves of one roller are made to inter mesh of those of the varying degrees. The withered leaf is lightly rolled without pressure. The fine leaves are separated and coarse leaves are fed into the machine several times. The leaves get mangled between the rollers. The leaves are passed in machine for few minutes, time given for rolling is considerably less, hence reducing the time for whole manufacturing process.

In each of these types, the tea is further classified according to its size and final grades. Interestingly these grades bear fancy names can you give some names like Assam CTC tea, Ketley. Fresh plucked tea leaves contain:

Water : 75-80% (dry weight percentage)

Polyphenols : 25-28%

Protein : 20%

Caffeine : 2.5-4.5%

Crude fibre : 27%

Carbohydrates : 4%

Pectin : 6%

Sugars : 12 kinds

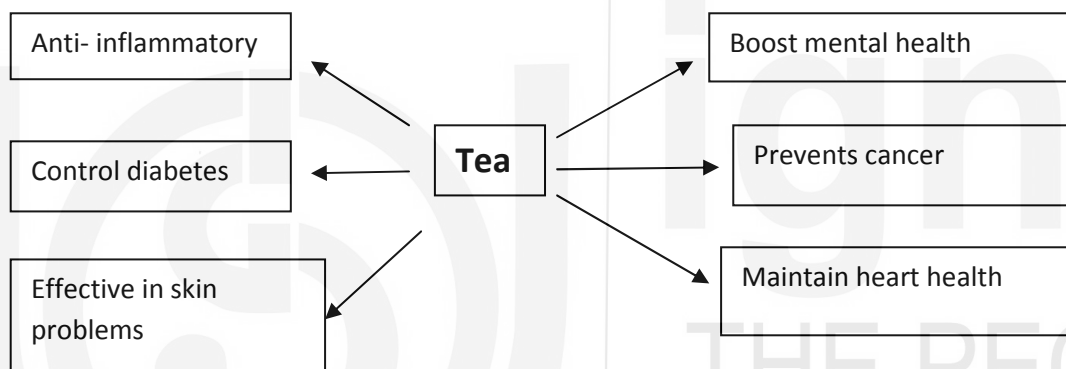
Organic compounds : 6 types

Uses

- Tea is the most popular non alcoholic beverage consumed worldwide.
- Tea is considered a health promoting drink as proved by the detailed researches in humans and animal models as depicted in Fig. 5.3.

The health benefits of tea include:

- It contains antioxidants good for health.
- It is able to reduce blood pressure hence reducing the risk of heart attack and stroke.
- It helps in weight loss.
- It may help protect bones.
- It may reduce the risk of various types of cancers.
- Tea especially green tea is a rich source of flavonoids and bioactive compounds that can lessen stress, relieve inflammation and are good for overall health.
- Some herbal teas are known for their medicinal values.

**Fig.5.3: Health benefits of tea.****SAQ 1**

State whether the following statements are true or false:

- Assam tea is slow growing, multi stemmed bush with economic life of almost 100 years.
- About 80 per cent of total tea processed is black tea.
- Oolong tea is originated in Australia.
- Green tea is unfermented tea and considered as good for health.
- Letpet tea is fermented or pickled tea from Myanmar.
- The distinctive taste of tea is attributed to its polyphenol or tannin content.
- Japan is a leading tea exporting country.
- Old tea leaves with more tannin are considered better than young leaves and buds.

5.3.2 Coffee

Botanical Name: *Coffea spp.*

Family: Rubiaceae

Vernacular name: coffee

n=11

Domestication of coffee began nearly 500 years ago and it became popular as beverage only since eighteenth century. It is one of the most important non alcoholic drinks consumed by one third of world's population. It is one of the important commercial crops of the tropical countries. For better economic returns it is intercropped with banana and figs. Coffee is indigenous to Abyssinia Plateau (Ethiopia) from where it was taken to Arabia and in the 17th century coffee seeds were brought to India by Baba Budan and raised in the Baba Budan hills (Karnataka). British planters took keen interest in coffee plantation and large coffee estates were established near Chikmagalur (Karnataka) in 1826, in Manantody (Wyanad) and Shivroys in 1830 and in Nilgiris in 1839. The plant was introduced in Java and islands of Indonesian archipelago in the seventeenth century. In nineteenth century it was carried to America. The coffee production centre shifted to Brazil by the 20th century. Brazil is the world's largest coffee producing country.

Genus *Coffea* comprises about 90 species of which four are important for making beverage. Maximum species are native of Africa and Madagascar. *Coffea arabica* is most widely cultivated and only polyploid species (tetraploid, $4X=44$) *C. canephora* or *robusta* coffee is a diploid spp. ($2X=22$) indigenous to Congo basin and Uganda where it is grown wild in warm and humid climate. Robusta coffee was found to be good substitute for arabica type. U.S.A is a greatest coffee consuming country. Few important species of genus *Coffea* include:

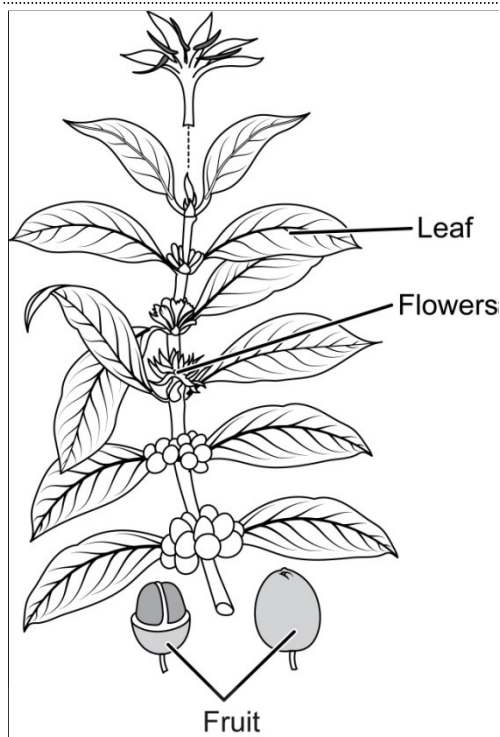
- i) *C. arabica* (Arabian coffee)
- ii) *C. robusta* or *C. canephora* (Congo coffee or Pierre Robusta coffee)
- iii) *C. liberica* Bullex Hiern (Liberian coffee)
- iv) *C. excelsa* A Chiv (Excelsa coffee)

Most of the world production (about 80 per cent) of coffee is obtained from *C. arabica*. It produces the best quality coffee.

Morphology

Coffee plant is a shrub or small tree attaining the height of 15-30 ft under cultivation. The plant is not allowed to grow beyond 4-5 ft. Plant bears white axillary flowers 2-3 times a year. The fruits are two-seeded drupes (Fig. 5.4) with 3 distinct layers.

The coffee berries have tough red coloured exocarp fleshy mesocarp and thin membranous endocarp. Coffee beans contain caffeine, a volatile oil, glucose, dextrins, proteins and fatty oil. The seeds are ellipsoidal, bean like, about 0.5 inches in length and are covered by a thin shining testa when ripe the seeds are hard and green.



(a)



(b)

Fig. 5.4: a) A branch of the coffee plant showing leaves, flowers and fruits; b) picture of a coffee plant in nature.

Cultivation

Coffee plant thrives best in hot and humid climate where the average rainfall is 30-50 inches per annum and the temperature ranges between 55 °F - 80 °F. It needs well drained and manured loam soils. Plants grow better on highlands at a height of about 4500 ft. Seeds are sown first in seed beds. The seedlings are then transplanted in row about a foot apart. The plant starts fruiting after three years and continues to do so for about 30 years. Planting, pruning and picking of the berries is done by hand. Fruits are picked when they are fully ripe.

Processing

The coffee berries are processed by two methods:

i) Dry method

ii) Wet method

i) **Dry method** : In the Eastern Africa and nearby regions, where the water scarcity is there, the collected fruits are dried in sun for 2-3 weeks. Fruits are turned over to permit uniform and thorough drying. They may be bagged and stored in warehouses or separated immediately from the dried skin and pulp either by hand pounding or by using hulling machines.

ii) **Wet method** : The Fruits are placed in water, the heavy and ripened fruits sink down and separated from the floating leaves twigs and light seeds. Seeds are then fed into a pulping machine for separating pulp from the seeds. Depulped seeds are subjected to bacterial fermentation

Chicory is the most common adulterant of coffee. Besides this dried peas are also added in coffee as adulterant.

that removes mucilage adhering to the endocarp. After fermentation seeds are dried in sun. Dry seeds are passed through a decorticating machine, so that endocarp is peeled off and dry polished seeds are obtained. Polished beans are roasted, powdered and brewed before use. The taste of coffee depends largely on the method and extent of roasting. Over roasting is avoided as it makes the seeds acrid and bitter. Powdered coffee loses its aromatic quality and flavour if not packed immediately in sealed containers. Flow chart showing steps in the processing of coffee is given in Figure 5.5.

Picking of fruits

Pulping

Fermentation

Drying

Hulling

Polishing

Grading

Roasting

Grinding

Packing

Fig.5.5: Various steps involved in processing of coffee.

Uses

- The presence of stimulative alkaloids in coffee makes it a much wanted beverage. It relieves fatigue and stimulates nervous and vascular systems of the body. A cup of coffee contains 3 times more caffeine than tea.
- Caffeine is used in several drugs. It relieves headache.

- It increases the flow of urine (diuretic) and aids in digestion by stimulating the secretion of digestive juices and increasing intestinal peristalsis.
- In Sumatra coffee leaves are used like tea leaves to prepare beverage.
- In India the residues from the coffee processing are used as fertilizer and mulch.
- It is given along with ergot to relieve pain of migraine.
- It has therapeutic value in the treatment of bronchial asthma as it relaxes smooth muscles of bronchi.

SAQ 2

Fill in the blanks.

- For greater economic returns Coffee is often intercropped with
- The characteristic aroma and flavor of coffee is due to
- is the world's largest coffee producing country.
- is most widely cultivated and only polyploid species of Coffee.
- is a common Coffee adulterant.

5.3.3 Cocoa

Botanical Name : *Theobroma cacao* L.

Family : Sterculiaceae

Vernacular name : Cocoa

n = 10

Cocoa and chocolate are two major products obtained from the roasted kernels of ripe seeds of the cocoa tree, a native of low lying areas of tropical central and South America. Cocoa and chocolate are the most nutritious of all beverages. Initially it was grown in Brazil, Ecuador and other neighboring regions. Today it is extensively grown in Africa (Ghana and Nigeria), Java and Sri Lanka. Nearly two thirds of the world production of cocoa is from Africa while the rest is from South and Central America, Brazil, West Indies, Indonesia, Sri Lanka and India. In India it is cultivated on Malabar coasts and valleys of Nilgiris. After processing cocoa is exported to temperate countries. Europe consumes more than 50% and America consumes about 40% of world's production of cocoa.

Morphology

It is a branched erect tree with height of 15-25 ft. The main stem usually attains height of 2-4 ft and gives out many branches. Branching pattern of tree

Word 'Theobroma' is derived from Greek words- 'Theos' meaning God and 'Broma' meaning food. Hence cocoa is also called as 'Food of the Gods'.

is characteristic and unusual. Branching is profuse and starts when plants are only 0.9-1.5m tall. Main stem divides into 4-6 lateral branches that arise at the same point and collectively called as “jorquette” or fan. Soon, an axillary bud develops into a vertical orthotropic shoot just below the jorquette. This shoot is called as ‘chupon’ which again forms a jorquette few feet higher up and another chupon arises just beneath the second jorquette. The process may repeat for third or even the fourth time producing a leafy canopy.

The leaves are spirally arranged on the main stem and subsequent chupons but are alternately placed on the jorquette branches. The mature leaves are dark green, about 37 cm long and 7.5 cm broad, oblong-oval or elliptic-oblong with prominent veins and veinlets. The short petiole has two articulations. The flowers arise in clusters in cushions on the main stem and old branches. Flowers are tiny, bisexual, regular, pedicellate and white, yellow or rose coloured. Only a few of the many thousand flowers develop into fruits (Fig. 5.6a). Flowering and fruiting continues throughout the year.

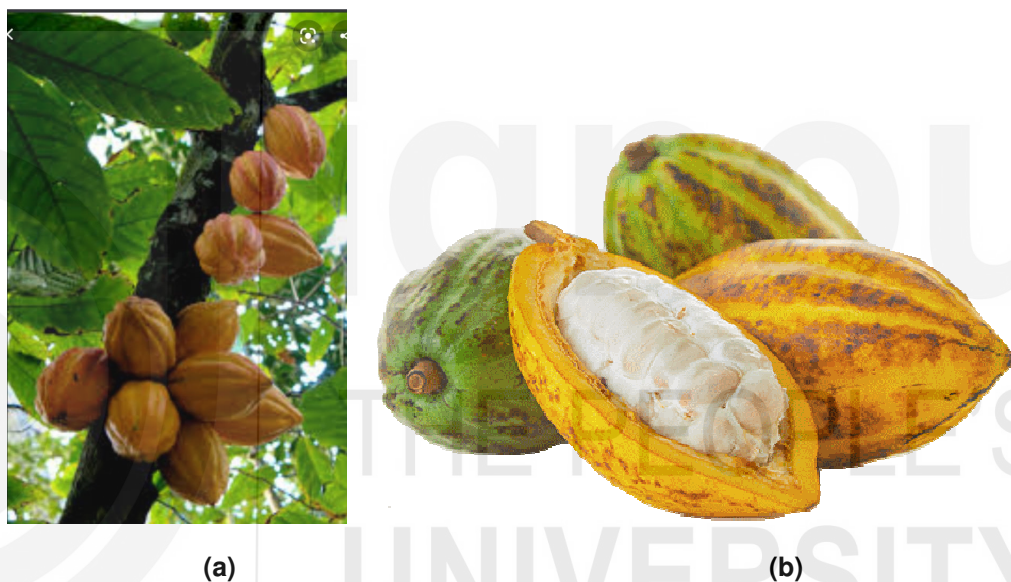


Fig. 5.6: a) Main stem of Cocoa tree bearing fruits; b) Fruits of Cocoa.

The mature fruits are berry but commonly called as pod and are composed of thick leathery, smooth or corrugated pericarp. Fruits vary in shape and colour in different varieties. They may be green, yellow, red, orange or purple (Fig. 5.6 b). Inside the pod are 20-40 flat or round seeds, The ‘cocoa beans’ are embedded in a white pink or brown aromatic, mucilaginous, sweet or little acidic pulp. Seed are arranged in rows.

Varieties: Commercially its two major varieties can be distinguished.

- i) Criollo, and
- ii) Forastero

Criollo Cocoa - Mainly grown in Venezuela, Columbia and Central America. The ripe pods are yellow or red. The surface of pods is rough and warty. They are deeply furrowed and have pointed ends. Seeds are large, rounded and contain white or pale violet cotyledons with pleasing aroma. It produces superior quality of cocoa, but due to low adaptability, susceptibility to diseases and lower yield, its cultivation is restricted.

Ferastero Cocoa - The pods are less furrowed, smooth and with rounded ends. Pod is green when immature turning yellow at maturity and has a thick wall. Beans are flat and dark purple lacking the superior aroma of criollo and have a 'harsh' flavour with bitter taste. Fonastero cocoas are hardier and more vigorous, highly productive and resistant to disease. They are distributed in Brazil, West Indies, South America and West Africa.

Cultivation

Cocoa is the crop of the warm, humid tropics and is grown mainly at low elevations usually below 304 m. It requires minimum rainfall of 45 inches per annum and temperature above 60°F. Crop thrives well in deep well drained and manured soils under the shade of big trees. The plants are grown by seeds or by vegetative propagation (buddings, cuttings etc). Fruiting starts at the age of 4 to 5 years and continues for 50 or more years. Fruits mature fully within six months of fertilization.

Harvesting proceeds almost all through the year, but the bulk of the crop is collected in two flushes, occurring between October and February and from May to August. Fruits are detached from the tree when they are fully ripe with the help of a hook shaped knife mounted on a long pole. The fruits are then split open and the seeds along with pulp are removed for further processing.

Processing

Fruit are split open and the seeds and pulp are scooped out. Pulp containing seeds is kept in wooden boxes or medium sized baskets for about 4-12 days for fermentation depending on the variety. Fermentation takes place by yeast and bacteria which disintegrates the pulp and mucilaginous seed coat. The colour of seeds changes with fermentation and it develops a chocolate brown colour. Seeds develop a characteristics flavour and aroma. The fermented seeds are then dried in the sun for about a week. The moisture content of dried seeds is reduced to 6 per cent.

Preparation of Cocoa and chocolate: The seeds are polished, roasted and powdered before they are used for the manufacture of chocolate. The beans are roasted at high temperatures in iron drums. Roasting results in increase in the fat (50 per cent) and protein contents, decrease in tannin content and in development of characteristic aroma due to the result of the complex chemical reactions occurring in the cotyledons.

The seeds are broken in pieces called 'nibs'. The nibs are made into an oily paste called 'liquor'. Removal of oily cocoa butter and making powder of residue results in cocoa. If the cocoa butter is left in and sugar is added, chocolate is formed.

Uses

- Cocoa is an excellent beverage. The high fat content of the bean is reduced to half (25 per cent) and the extracted fat is sold as cocoa butter.
- Cocoa butter is used as a medicine. It is used to protect chapped hands and lips. It is also used as a fine edible fat.
- It is used in the preparation of chocolates, candies and cakes.

- Cocoa and chocolate are rich in nutrients like fats, proteins and carbohydrates, so they are highly nutritious.
- The 'cake' gives caffeine like alkaloid theobromine which is used in soft drinks, 'colas' and other purposes.
- The cocoa shells are used as cattle feed and as fertilizer. They are also used as flavouring agent and as an adulterant of cocoa and chocolate.

Other Caffeine containing beverages

Mate: It is obtained from the leaves of various species of *Ilex* chiefly *Ilex paraguariensis*. It is also called as Paraguay tea.

Cola: It is obtained from the seeds of *Cola nitida* seeds are called as cola or kola nuts.

Khat: In north-eastern Africa a beverage called Khat is obtained from the leaves of *Catha edulis*.

Yoco: In Peru, Ecuador and Southern Columbia this beverage is obtained from the bark of Yoco (*Poullinia yoco*).

Cassine: From *Ilex vomitoria* of Mexico a tea like beverage is obtained.

Other non-alcoholic beverages are normally called soft drinks. These are usually juices of fruits like orange, lemon, apple, pineapple, strawberry. Fruits juices are rich in sugars and are good source of energy. Nowadays use of synthetic flavours is increasing in commercial soft drinks. Other soft drinks include malt beverages, ginger ale and soda water.

SAQ 3

- a) Match the contents in column I with those of column II.

Column I	Column II
i) Food of the Gods	a) Bud first leaf and softer parts of stalk.
ii) Oranges Pekoe	b) Special pattern of branching in cocoa
iii) Jorquette	c) Pear juice
iv) Wine	d) <i>Theobroma</i>
v) Arabusta	e) Barley
vi) Beer	f) alcoholic beverage from fruit juices

- b) Fill in the blanks:

- Two major varieties of cocoa are and
- Cocoa is obtained from seeds of
- is the most nutritious non alcoholic beverage.
- Cocoa is more vigorous, highly productive and disease resistant variety.

5.4 SUMMARY

- Beverages can be grouped in two categories (i) alcoholic, and (ii) non-alcoholic beverages.
- Non-alcoholic beverages are stimulants and refreshing as they contain chemicals like caffeine and other related alkaloids. Three main alcoholic beverages are tea, coffee and cocoa.
- Alcoholic beverages are depressants and can be classified as fermented and distilled ones like, beer and whisky.
- Tea, coffee and cocoa all are tropical crops.
- Tea (*Camellia sinensis*) is most popular non alcoholic beverage. It is believed to have originated in Southwest China and northeastern India. China and India are largest tea producers. Tea leaves are used as beverages after processing. Three basic types of tea include black tea, green tea and oolong tea.
- Black tea is fermented to bring about various chemical changes in leaf to impart its peculiar taste and aroma. Green tea is unfermented tea, while oolong tea is semi fermented.
- Coffee (*Coffea arabica*, *C. cabuohora*, *C. liberica*, *C. excelsa*) is indigenous to Ethiopia. It is an evergreen shrub and seeds (beans) are used in the preparation of beverage. Processing is done by dry or wet method. Coffee has very stimulating effect. America is the largest consumer of coffee. Instant coffee is prepared by vapourising a strong infusion of coffee in vacuum. Tamarind seeds, roasted beans, peas and grains are common coffee adulterants.
- Cocoa (*Theobroma cocoa*), a native of South and Central America is the most nutritious of all the beverages. Two major products cocoa and chocolate are obtained from roasted kernels of ripe seeds of cocoa tree are used for preparation of beverage. Seeds with pulp are separated out of fruit and fermented, dried, polished and roasted. Cotyledons are ground into an oily paste called 'bitter chocolate'. Cocoa and chocolate are manufactured from cocoa by adding sugar. Cocoa contains fats, proteins, carbohydrates and vitamins which enhance its nutrition value greatly.

5.5 TERMINAL QUESTIONS

1. Write the botanical name, family, morphology and uses of tea.
2. Give a brief account of alcoholic and non-alcoholic beverages.
3. Discuss the dry and wet methods of processing of coffee.
4. Write botanical name, family, and morphology of coffee.
5. Describe morphology, processing and uses of cocoa with special reference to its branching pattern.
6. Discuss the processing of black tea in details.
7. What are the agroclimatic conditions for growing tea?

5.6 ANSWERS

Self-Assessment Questions

1. i) False; ii) True; iii) False; iv) True; v) True; vi) True; vii) False; viii) False.
2. i) Banana or fig
ii) Caffeine/essential oils
iii) Brazil
iv) *Coffea arabica*
v) Chicory
3. a) i) *Theobroma*
ii) Bud first leaf and softer parts of stalk
iii) Special pattern of branching in cocoa
iv) alcoholic beverage from fruit juices
v) Pear juice
vi) Barley
b) i) Criollo and Forastero
ii) *Theobroma cocoa*
iii) Cocoa
iv) Forastero

Terminal Questions

1. Refer to Subsection 5.3.1.
2. Refer to Section 5.2.
3. Refer to Subsection 5.3.2.
4. Refer to Subsection 5.3.2.
5. Refer to Subsection 5.3.3.
6. Refer to Subsection 5.3.1.
7. Refer to Subsection 5.3.1.

Acknowledgements

Fig. 5.6 : https://www.google.co.in/imgres?imgurl=https%3A%2F%2Fwww.acai.eu%2Facai%2FCustomUpload%2F37403570340037003560369035003200322032003280%2FKakao_Fruchtpueree_Fine_Fruits_Club_A055SK_500x500px.gif&imgrefurl=https%3A%2F%2Fwww.acai.eu%2Fproductdetails%2Fcocoa-fruit-puree-40x100g.aspx&tbnid=Gh_VDvE0T7 NwIM&vet=12ahUK Ewj1_qVz4XzAhVkn3IKHSAzCW0Q MygHegUIARDsAQ..cocoa%20fruit&ved=2ahUKEwj1_qVz4XzAhVkn3IKHSAzCW0QMygHegUIARDsAQ

UNIT 6

OILS AND FATS |

Structure

6.1	Introduction	6.4	Summary
	Objectives	6.5	Terminal Questions
6.2	General Account	6.6	Answers
6.3	Important Oil crops		
	<i>Cocos nucifera</i>		
	<i>Olea europea</i>		
	<i>Ricinus communis</i>		
	<i>Sesamum indicum</i>		
	<i>Carthamus tinctorius</i>		
	<i>Arachis hypogea</i>		
	<i>Brassica</i> sp.		
	Major Uses of Oil Crops		

6.1 INTRODUCTION

Earlier units have introduced you to various crop plants of economic importance. Information about important cereal, legume, spice and beverage crops has also been provided to you. Interestingly, some plants have also been found to provide oils that are used for cooking and other purposes. The present unit will provide you information about the major oil yielding crop species found throughout the world. In India, groundnut and mustard are the major oil yielding crops species.

Objectives

After studying this unit, you should be able to:

- ❖ describe the major oil producing crop species;
- ❖ describe cultivation and uses of groundnut; and
- ❖ describe mustard species and its role in our lives.

6.2 GENERAL ACCOUNT

Oils, fats and waxes have been used by humans since prehistoric times. The fats used earlier by humans were of animal origin. The Chinese and Hindus extracted oil from the oil bearing materials with the help of ancient mills. Ghani/Kolhu driven by bullocks has been mentioned in the ancient Indian history. Ghani is still used in many rural areas in India. The ancient Egyptians and Phoenicians used vegetable oils for food and massaging their bodies. Egyptians spread the knowledge of fats to Hebrews and later to Greeks. They also used oil in making soaps and weaving.

Fats and oils contain carbon, hydrogen and oxygen in different proportions. Vegetable oils and fats are triglycerides of complex fatty acids. Fatty acids can be saturated or unsaturated. The saturated fatty acids include palmitic acid and stearic acid. The palmitic acid is present abundantly in vegetable fats. Oleic, linoleic acid and linolenic acids are the common unsaturated fatty acids. Oils are liquid at room temperature while fats are solid or nearly solid. The triglycerides of unsaturated fatty acids are liquid while the glycerides or saturated fatty acids are semi-solid. Glycerides of saturated fatty acids with 12 or more carbon atoms are solid at ordinary temperature. Coconut oil, palm oil, cocoa butter and shea butter are the examples of fats. Waxes are fatty acid esters of monohydroxy alcohols and are found as protective coverings on the surface of leaves and stems. They prevent loss of water through transpiration.

Vegetable oils have been classified into three different types depending upon their ability to absorb oxygen from the atmosphere. These include non-drying, semi-drying and drying oils. Non-drying oils remain liquid at room temperature. They are glycerides of saturated acids and oleic acid. The iodine number is less than 100. They never undergo oxidation to form a film, e.g. groundnut, palm, olive and castor oils. Semidrying oils are intermediate between drying and non-drying oils. They have large amounts of linoleic and saturated acids. They absorb atmospheric oxygen slowly forming an elastic film. Iodine number is between 100 and 130. These include sesame, sunflower and corn oil. Drying oils are rich in glycerides of unsaturated fatty acids, particularly linoleic and linolenic acid. Such oils readily absorb atmospheric oxygen, and form a tough, elastic film. These oils are used as solvents in paints and varnish industries. These oils are obtained from linseed, soybean, safflower and hempseed.

Most of the vegetable oils are present in the seeds of the plants. They are present in the form of droplets in endosperm and cotyledons. Crude vegetable oil and fats are extracted from the oil bearing cells by exerting mechanical pressure and solvent extraction. Prior to extraction, the seed coats are removed and kernels are reduced to thin flakes. Mechanical pressure is applied to extract out the fat from the tissue. This is done by hydraulic pressing or screw pressing. The solvents such as gasoline, benzene, petroleum ether and other hydrocarbons are applied to extract oil from the tissues. The fatty acids are removed from the extracting solvents by distillation. The extracted oil is then subjected to refining process to get purity and have removal of water, dirt, pigments and odiferous compounds. Vegetable fats contain considerable amounts of tocopherol which is a naturally occurring antioxidant for example sesamol is an antioxidant obtained from sesame oil and gossypol is present in cotton seed oil. Antioxidants are added to vegetable oil in order to increase their stability.

6.3 IMPORTANT OIL CROPS

Many plants produce vegetable oils. Around 12 oil yielding crop species have been identified and they account for about 90 per cent of the world's total oil production. These mainly include groundnut, coconut, rape seed, sesame seed, linseed, safflower, cotton seed, sunflower, castor bean and soybean.

India is one of the major oilseed producing countries of the world. Oil seed crops occupy about 13 per cent of the total cropped area in our country. Groundnut, castor, linseed, sesame and rape are the five major oil seed crops grown in India. Gujarat is the largest producer of oil seeds followed by Andhra Pradesh, Tamil Nadu, Madhya Pradesh, Uttar Pradesh and Maharashtra.

Mustard and groundnut are the two oil yielding crops that you will be studying in detail in the subsequent section. A brief discussion is first provided on the basis of other major oil yielding crops like coconut, olive, castor, cotton seeds, linseed, sesame.

6.3.1 *Cocos nucifera*

Family : Araceae

Vernacular name : Coconut

n = 16

It is believed to have originated in Pacific coast of tropical America and carried by winds to Asia. The Indo-pacific region has been suggested to be its place of origin from where it got scattered in coastal regions of the world. Philippines, Indonesia, India, Vietnam, Mexico, Malaysia and Srilanka are the largest producer of coconut. All parts of the plant are useful but 'copra' or the kernel is of outmost importance. In India, it is grown in states of Kerala, Tamil Nadu, Karnataka and Andhra Pradesh.

Morphology

The plant is a tall tree with a height around 15-30 m. The trunk is inclined and marked with prominent rings. The stem is unbranched with a swollen base of adventitious roots. The stem tip is surrounded by large paripinnate leaves about 5-6 m long each weighing about 10 to 15 kg. Inflorescence is spadix which is produced in the axil of leaves (Fig. 6.1). The inflorescence is enclosed in a spathe. The male flowers are numerous (200-300), borne singly or in groups of two or three on the upper part of the floral axis. The female flowers are few in number and located at the base of the inflorescence. The plant keeps on flowering all the year round and the fruit takes 9-12 months to ripen. The mature fruit is a fibrous drupe, ovoid in shape and weighing around 1-2 kg. Outer tough covering of fruit is called exocarp. It is green and smooth in early stages (Fig. 6.1). The middle mesocarp is thick and fibrous and yields coir of commercial importance. Endocarp is hard, dark brown, with ridges on outside and three depressions as eyes at the basal end. Within the endocarp (shell) is enclosed a single hollow seed adhering firmly to the solid endosperm referred to as meat or copra. The plant requires plenty of sunlight with an average temperature of 27-32°C and well distributed rainfall for growth.

For commercial use the fruits are dehusked. The endosperm is removed and dried. The dried copra contains about 60% of oil content. Lauric acid (44-51 per cent), myristic acid (13-18 per cent), palmitic acid (7-10 per cent) is the major constituents of coconut oil.

Cultivation

The plant requires plenty of sunlight for its growth. The plant thrives well at temperature of 27-32° C and rainfall of about 120-250 cm. The plant grows well on variety of soils including coastal sands, alluvial, lateritic and clayey soils.

Uses

The fresh kernels are also eaten raw or used in preparation of puddings, sweets, curries, chutneys. The liquid endosperm is used as a refreshing drink. Coconut possesses laxative and diuretic properties. Coconut oil besides used for cooking, is also used in the preparation of lubricants, detergents, soaps and cosmetics.

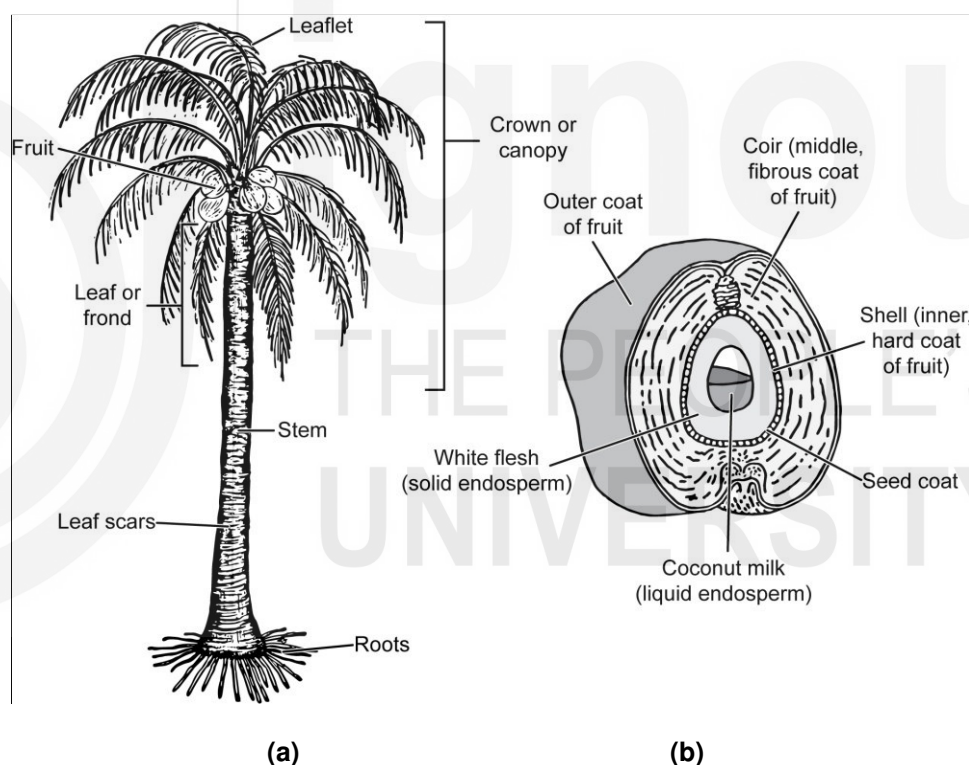


Fig. 6.1: a) Coconut plant; and b) section of a coconut fruit showing its internal structure.

6.3.2 *Olea europea*

Family : Oleaceae

Vernacular name : Olive

n = 23

Olive oil is obtained from fruits of olive trees. The tree is native of Western Asia. The countries of the Mediterranean region account for 98 per cent of the total world olive oil production. The major countries of olive oil production include Italy, Spain, Greece and Turkey.

Morphology

The plant is a xerophytic tree having a height of about 15-18 m. The fruit is a one seeded drupe which may be globular, oblong or crescent shaped (Fig. 6.2). The fruit is initially green in colour but becomes purple, black or red on maturity. The plant thrives well in warm, dry summer with an average temperature of about 18°C. The flowering and fruiting requires an ideal temperature of about 10°C. The plant generally grows in areas of semi arid soils with low rainfall (60-75 cm).

For green olives, the fruits are picked by hands. Mechanical shakers are employed to harvest oil from olives. The fruit possesses an oil content of about 25 to 60 percent. The mature fruit pulp contains about 75 percent of the oil.

Cultivation

Plant grows well in regions with warm can dry summer and an average temperature of 18° C. The plant can be grown in many types of soil.

Uses

Over 90 percent of the olive cultivation is done for oil but rest is used for making pickles, and used as a garnishing in curries, soups and other dishes. Olive oil is used in cooking, preparation of cosmetics and pharmaceuticals.

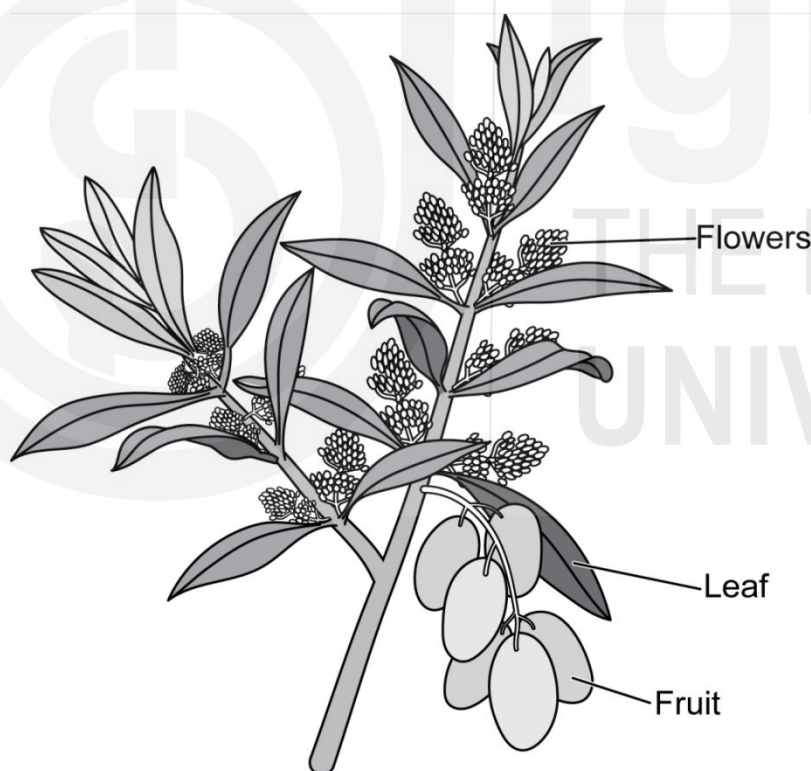


Fig. 6.2: Diagram of olive plant showing inflorescence.

6.3.3 *Ricinus communis*

Family: Euphorbiaceae

Vernacular name: Castor

n = 10

The plant is indigenous to North Africa and grown under tropical and subtropical regions as an annual crop. The major castor producing countries

include Brazil, Thailand, Ethiopia, Russian Federation, Sudan and Tanzania. In India it is mostly grown in the states of Gujarat, Andhra Pradesh, Orissa and Karnataka.

Morphology

The plant is a tall, glabrous, perennial plant about 1.5 m in height. The plant can reach up to 13 m in height. The plant has well marked nodes and prominent leaf scars. The leaves are large, palmately lobed and present in an alternate manner. The female flowers are produced in an upper part of the panicle while male flowers develop in lower plant. The fruits are spiny or smooth (Fig. 6.3). Castor bean is the seed of castor and show variations in size and color. Castor beans are harvested for seeds and the seeds are decorticated with the help of hullers. The kernels yield about two third of the fixed oil (50 per cent of the weight of the seed). The seed cake contains compound called ricin that acts as a blood coagulant. The castor oil contains ricinoleic acid (90-95 per cent), linoleic acid (4.5 per cent), palmitic and stearic acids.

Cultivation

The crop grows in soils ranging from sandy or clayey loams. The temperature between 20-30°C and rainfall of 30-90 cm has been considered as ideal for the growth of the crop.

Uses

The oil is used for paints, varnishes, lubricants (for automobile, engines) and manufacture of various chemicals (sebacic acid) used for the production of nylon fibers, plasticisers. Hydrogenated castor oil is used in the manufacture of ointments, bases, waxes polishes and for illumination.

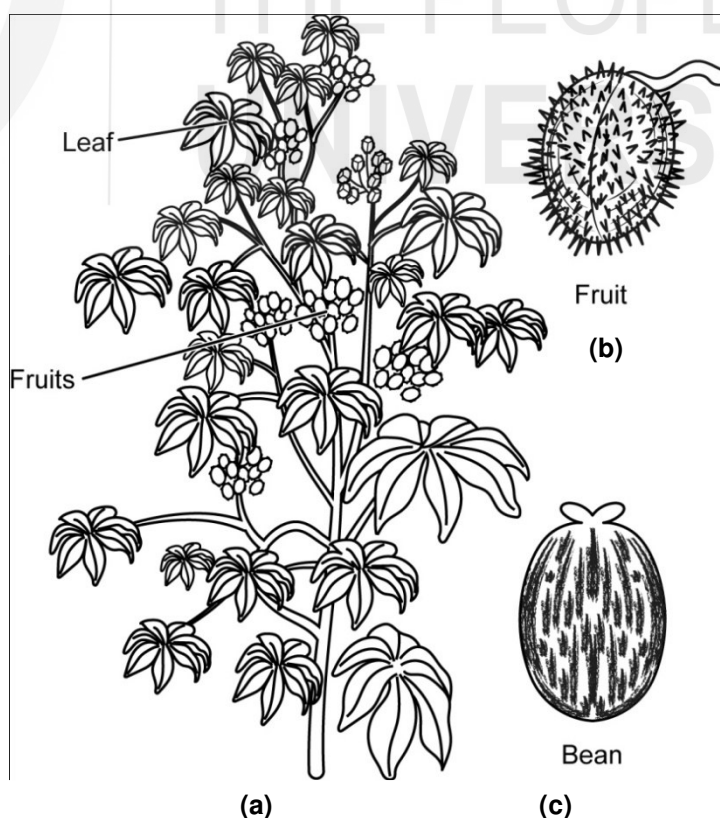


Fig 6.3: a) Diagram of a castor plant with flowers; b) Fruit of castor; c) Bean or seed of castor.

6.3.4 *Sesamum indicum*

Family: Pedaliaceae

Vernacular name: sesame

n=13

The plant has been cultivated since ancient times in drier parts of Mediterranean regions, Africa and India. The major production has been reported from countries such as India, China, Uganda, Nigeria, Mexico, Ethiopia and Tanzania. In India, it is cultivated mainly in the states of West Bengal, Maharashtra, Tamil Nadu, Rajasthan, Andhra Pradesh, Karnataka and Gujarat. The crop thrives well in hot dry, tropic areas with the rainfall ranging from 50 to 100 cm.

Morphology

The plant is erect, bushy, annual growing up to 2 m in height, with longitudinally furrowed and densely hairy stem. The lower leaves are broad, lobed while the upper leaves are lanceolate. The flowers are bell shaped white, pink or mauve in color (Fig. 6.4a). The flowers are borne singly or in groups in the axil of leaves. The fruits are capsules which are hairy, oblong, ovoid or upright with short triangular beaks (Fig. 6.4b). The seeds are compressed, pear shaped white or brown in color.

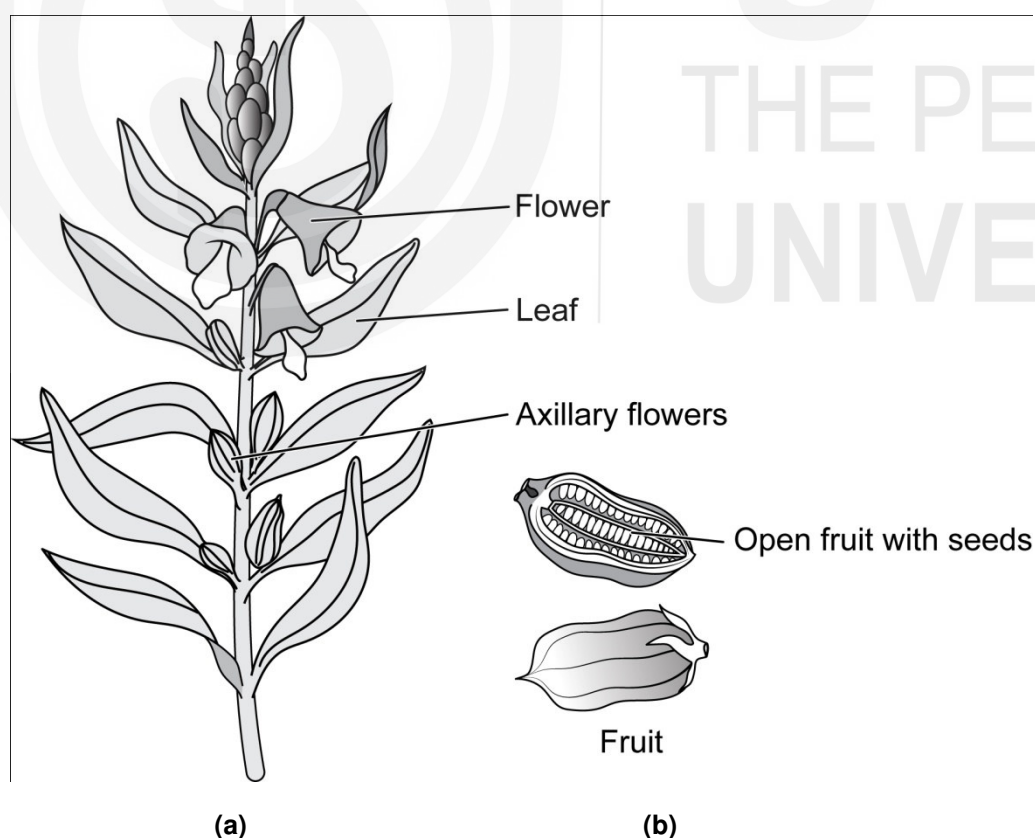


Fig 6.4: a) Sesame plant; b) fruit.

The seeds contain 50 per cent of the oil and 25 per cent of protein. The oil is rich in unsaturated fatty acids. The oil contains oleic acid, linoleic acid, palmitic and stearic acid. The oil contains compounds, sesamin and sesamol.

Cultivation

The plant grows well in hot dry tropics with an annual rainfall of 50 to 100 cm.

Uses

The seeds are used in various sweets and confectionery. The seeds are also used as a garnish for bakery products such as cakes, biscuits and breads. The sesame oil is used for edible purposes. Low grade oils are used as illuminants. Sesame oil is also used in medicines as a carrier or suspending agent for antibiotics, vitamins, steroids and insecticidal preparations.

6.3.5 *Carthamus tinctorius*

Family : Asteraceae

Vernacular name : Safflower

n = 12

Safflower is an annual plant grown mainly in India, United States of America and Mexico. It is also grown in some parts of Australia, Spain, Portugal and Turkey. Two types of oil is obtained from safflower. One is polyunsaturated which is used in soft margarines, salad dressing and as surface coating and the other one is monounsaturated oil which is primarily used as cooking oil. Some Middle East countries grow this plant on a small scale for its dried flowers which serve as a substitute of saffron.

Archeological records suggest that safflower was first cultivated in Egypt around 1600 B.C. The plant was cultivated for its flowers. The reddish orange flowers were sewn sideways on narrow strip of papyrus or cloth to form long garlands that were wrapped around neck and bodies of mummies. Later on the flower was also used for the dye to colour cloth. By the early nineteenth century the plant became one of the important sources of dye. The dried flowers are sold as coloring agents. The species was first domesticated in the near east as a dye plant and subsequently used as a source of oil in the Old World subtropics.

Safflower was used as a source of oil during Roman period in Egypt. But in the nineteenth century only its potential as oil yielding crop was realized.

Morphology

The plant is an annual herb which is highly branched and grows to a height of 30cm to 1.2m. Leaves are arranged in the form of a rosette at the base of the stem. The leaves are generally borne in a spiral manner and at irregular intervals. At the tip of branches, leaves are arranged very closely and form involucre bracts of inflorescence. The leaves are entire, rigid, spinulose-serrate. The inflorescence is formed at the tips of each branch of plant. All florets are irregular and tubular (homogamous). Flowers are bisexual and orange red in colour. The fruit is achene which is obovoid with pappus. The seed contains 24 to 36 per cent drying oil.

Decorticated seeds give a better quality of oil. The oil is extracted by crushing seeds in a 'ghani' (country oil press) or by hot dry distillation. Other methods of oil extraction for commercial purposes include hydraulic press, expellers and solvent extraction.

The oil content varies between 20 to 30 per cent. The fatty acid constituents of oil include myristic acid, stearic acid, arachidic acid, oleic acid and linoleic acid.

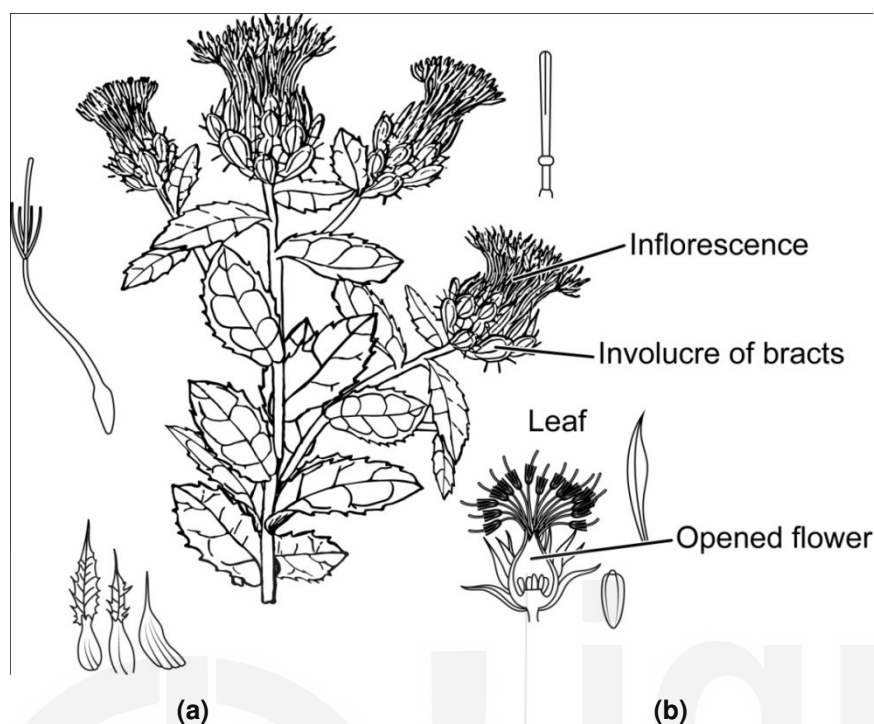


Fig 6.5: a) Safflower plant; b) fruit.

Cultivation

In India, the crop is cultivated in Andhra Pradesh, Maharashtra, Karnataka and Madhya Pradesh. In plains, it is a dry winter crop but cultivated as both rain fed and irrigated crop. It can grow on dry areas and poor sandy soils. Black cotton soil, loams and light alluvial soils are good for its cultivation. For extraction of dye it is grown as a pure crop while as an oilseed crop it is sown mixed with wheat, jowar, barley and gram. The crop is sown in the month of October-November and harvested by February- March.

Uses

Oil produced by plant is used for cooking purposes. Oil is generally refined, bleached and hydrogenated to produce edible oil. The fast drying capacity of oil makes it useful as a raw material for manufacture of paints and varnishes. Oil is also used for illumination purpose and in manufacture of soap. Charred safflower oil is used for healing of sores and treatment of rheumatism. The protein rich oil cake is used as a cattle feed.

SAQ 1

a) Answer in one word:

- i) Botanical name of coconut
- ii) The part of the coconut that is used for extracting oil.
- iii) The family of olive
- iv) Botanical name of castor
- v) Major compounds present in sesame oil

- b) State whether these statements are true or false:
- i) In ancient times, Egyptians and Phoenicians used vegetable oils for cooking food and massaging their bodies.
 - ii) Fats and oils contain carbon, hydrogen, oxygen and sulphur in different proportions.
 - iii) Palmitic acid and stearic acid are unsaturated fatty acids.
 - iv) Groundnut, palm, olive and castor are examples of non-drying oils.
 - v) Drying oils are rich in glycerides of unsaturated fatty acids particularly linoleic and linolenic acid. They readily absorb atmospheric oxygen.
- c) Mention the place of origin of the following oil yielding crops
- i) coconut
 - ii) sesame
 - iii) olive
 - iv) castor

6.3.6 *Arachis hypogaea*

Family: Fabaceae

Vernacular name: groundnut, peanut

n = 20

The plant is a native of Brazil and became widely distributed throughout South America. The Portuguese introduced the crop to West Africa while the Spaniards introduced the crop to China, Japan, Malaysia, and India. About 85 per cent of the world production comes from the countries China, India, United States of America, Nigeria, Indonesia, Sudan, Senegal and Zaire. The major groundnut producing states in India are Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra, Gujarat, Madhya Pradesh and Rajasthan.

Morphology

The plant is a low growing herb about 0.3 to 0.6 m tall. The leaves are compounds each having two pairs of opposite leaflets. The flowers are 5-7 cm long, yellow, sessile present in the clusters of two or four (Fig. 6.5). The sepals are fused to form a long calyx tube. The corolla is papilionaceous and possesses ten monadelphous stamens adnate at the base. The monocarpellary ovary is surmounted by a long filiform style. The ovaries are pushed down in the soil due to formation of a positive geotropic stipe or gynophores (peg). After penetration in soil the peg loses its geotropic character and grows horizontally. Ovary develops into fruit. The fruit is an elongated oblong, indehiscent pod containing two to three seeds. The dry pericarp of the fruit is fibrous, and possesses reticulate markings. The mature seeds vary in shape and size and are mostly ovoid or cylindrical 1 to 2 cm long. The seed coat is represented by a papery covering (skin) having pink to purple color. The embryo consists of large radicle, a leafy plumule and two white fleshy cotyledons.

The varieties of groundnut include bunch or erect type and runner or spreading type. Bunch type is of short duration and matures in three to four months. It produces small or medium sized pods in cluster of near the base of the plant. One or two rounded seeds are produced in thin shelled fruit. Runner variety takes four to six months to mature and produce medium size pods which contain one to three seeds in a thick shell.

The shelled nuts contain 26 per cent protein and 45 percent of oil. The kernels are rich source of phosphorus, vitamins particularly thiamine, riboflavin and niacin. The fatty acids in seeds are oleic acids (56 per cent), linoleic acid (25 per cent), palmitic acid (6-12 per cent). Arachin and conarchin are the two important proteins found in the seed.

Cultivation

The plant is cultivated extensively in the tropical and subtropical regions of the world. It is also found in the warm temperate areas. The crop requires a warm season with abundant sunshine for normal development with annual rainfall of about 100cm. A frost free growing period of four to six months is required with dry weather during fruit ripening and harvesting. The crop is generally sown on loose sandy soil. The crop can be propagated vegetatively by cuttings.

Uses

The seeds have a high calorific value. The seeds are eaten raw or roasted. Ground nut are the largest source of vegetable oil. About two third of the world production of groundnut is used for production of oil. The oil is also used for the production of ghee after hydrogenation. Lower grade oil is used for manufacture of soaps and lubricants. The cake left after use is used as manure.

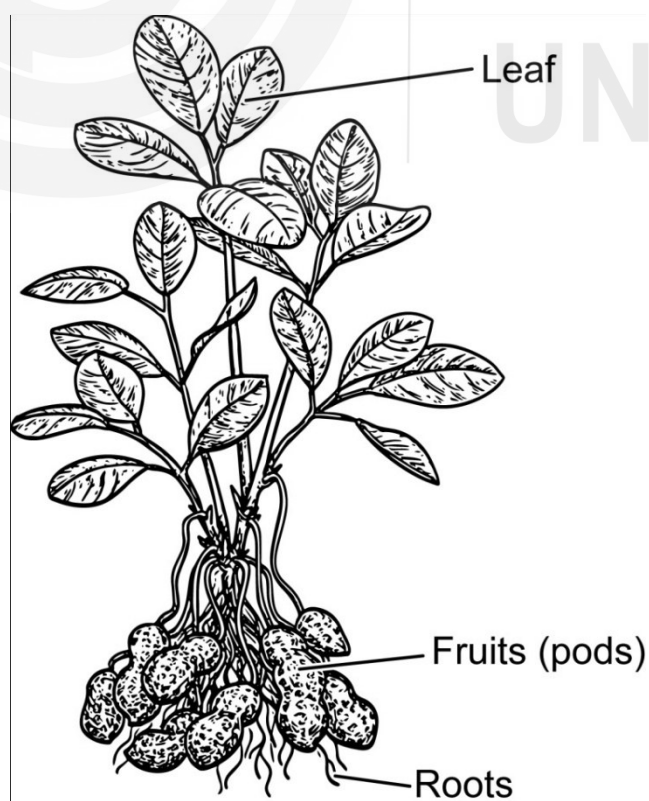


Fig 6.6: Diagram of a peanut plant and Shelled fruit.

6.3.7 Brassica sp.

Family : Brassicaceae (Cruciferae)

Venacular names : mustard, rape

n = 8-11

Many annual and biennial species of mustard occupy various regions of the North temperate areas of the old world i.e. Mediterranean region. Europe, Central and Southern Asia and China have been considered as the three major centers of its genetic diversity. The species spread to tropical and subtropical areas. The *Brassica* varieties have been classified as vegetable producing and oil yielding. The species is widely cultivated for their oil include *Brassica napus* and *B. juncea*, which are cultivated in China and Japan, *B. napus* and *B. praecox* found in Europe and America and *B. napus*, *B. campestris* found in Russia and Mediterranean region. *Brassica campestris* and *B. juncea* are the major oilseed crops found in India. *Eruca vesicaria* subsp. *sativa* (arugula) have been grown in many parts of Punjab.

The major world production of the rape comes from China, India and Pakistan. They together account for 45 per cent of total world production. Other countries that produce rape are Canada, Germany, France, United Kingdom, Poland, Denmark and Australia. The bulk of mustard seed production comes from Canada, Nepal and Denmark. India has the largest acreage and production of rape and mustard in the world. The major rape and mustard producing states are Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, West Bengal and Bihar.

Morphology

Rape and mustard plants are slender, erect, branched annual herbs about 30-45 cm. They are covered with a waxy coating called bloom. The leaves are auricled usually lyrate (pinnatipartite). The flowers are yellow and born in corymbose raceme (Fig. 6.7). Each flower has four sepals, four free claw petals, tetradynamous stamens and a bicarpellary syncarpous, unilocular/bilocular superior ovary. The fruit is siliqua or silicula dehiscent from the base towards upward with the seeds attached to the replum. The seeds are small, spherical yellow brown to black in colour (mucilaginous or non-mucilaginous).

The pungency of the rape and mustard oil is because of the essential oils present in them. The oil content of seeds of *Brassica* varies for 30 to 45 per cent depending upon the variety and climatic conditions under which the plants are grown. Most of the varieties have high content of erucic acid (40-50 per cent of total fatty acids). Other fatty acids include oleic and linoleic acids accounting for about 47 per cent and 20-30 per cent respectively. Other saturated fatty acids include palmitic acid and stearic acid.

Cultivation

Rape and mustard varieties adapt to cool moist climate and rich sandy loam soils. They are grown in tropical and subtropical countries as winter crops.

Uses

The young tender leaves of mustard are consumed as a vegetable. Mustard seeds are used as condiment in the preparation of pickles and for flavouring curries and vegetables. The oil extracted from seeds is used for cooking and other activities such as lubricants, grease, soaps and synthetic rubber. Erucic acid content of oil is used for lubricating jet engines and in manufacture of plastics. The inferior quality oil is used for illumination. Mustard oil is also used for beauty purposes as it makes the skin soft. The oil cake is used as a live stock feed and fertilizer. Mustard is also used as a green fodder crop and green manure. The mustard oil is also medicinally very important. The essential oil of mustard oil is an irritant and needs to be used in small quantities to avoid blisters that can be caused on skin.

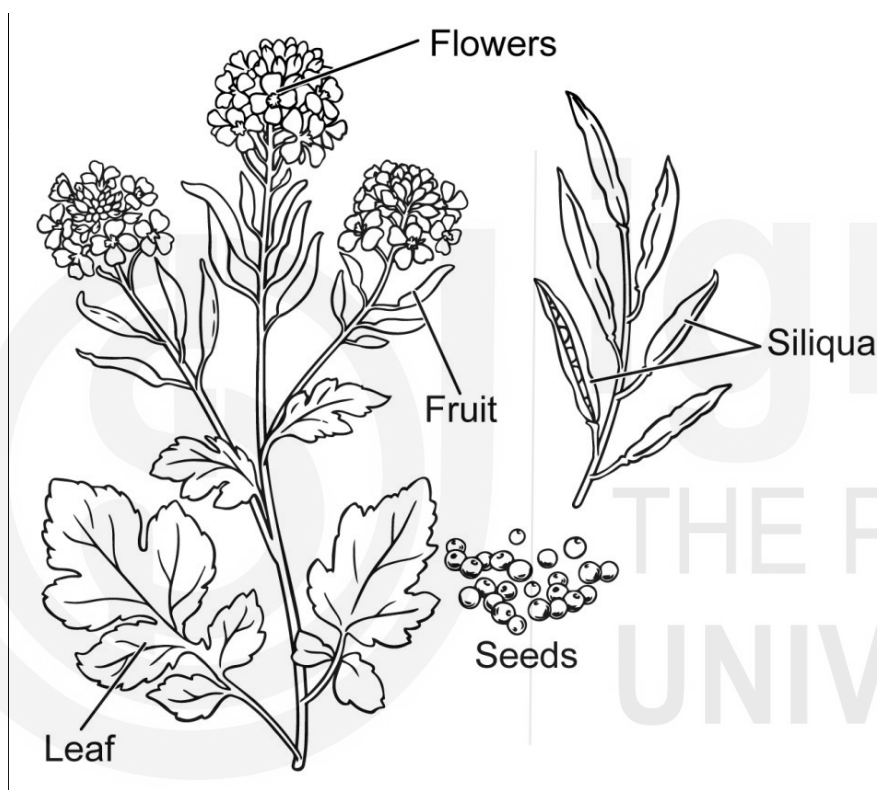


Fig.6.7: A branch of mustard plant showing inflorescence and flowering.

SAQ 2

- Enlist the six major states of cultivation of mustard in India.
- Match the oil crops in Column I with their families given in the Column II.

Column I		Column II	
a)	groundnut	i)	Brassicaceae
b)	mustard	ii)	Euphorbiaceae
c)	coconut	iii)	Fabaceae
d)	castor	iv)	Araceae

6.3.8 Major Uses of Oil Crops

Olive, soybean, corn, and cotton seed are used as cooking oils and also in the manufacture of oleomargarine which consists of 80 per cent refined and hydrogenated oil and small amounts of emulsifying agents such as lecithin, monoglycerides, salt and vitamin A. Oil cake left after extraction of oil is also used as a livestock feed as it is rich in protein. Some oil cakes such as those obtained from castor, linseed are toxic and not suitable for cattle feed.

Vegetable oils besides having uses as food have various industrial and pharmaceutical usage. They contribute a lot to our daily diet. They have high reserve of energy. All fats have a high caloric value in comparison to proteins and carbohydrates. The consumption of fats and lipids gives a feeling of satisfaction. It delays onset of hunger as they take more time to digest. They add flavor to food and make the meals more palatable. They are source of water soluble vitamins A, D, E, K and provitamin A.

Oils and fats are also used in the manufacture of many non-edible oil products such as candles, paints, varnishes, detergents, inks, polishes, cosmetics and lubricants.

6.4 SUMMARY

- Some plants provide oils used for cooking and other purposes. The major oil yielding crop species found throughout the world include groundnut, mustard and olive.
- Vegetable oils and fats are triglycerides of complex fatty acids. Fats are mixture of triglycerides of various fatty acids and can be saturated or unsaturated. The saturated fatty acids include palmitic acid and stearic acid while the unsaturated fatty acids include linoleic acid and linolenic acids.
- Ground nut seeds are the largest source of vegetable oil. About two third of the world production of groundnut is used for production of oil. The oil is also used for the production of ghee after hydrogenation. Lower grade oil is used for manufacture of soaps, lubricants. The cake left after oil extraction is used as manure.
- In mustard or rape, the seeds are used as the source of oil. The oil content of seeds of *Brassica* varies for 30 to 45%. The pungency of the oil is because of the essential oils present in them. Most of the varieties have high content of erucic acid (40-50%) of total fatty acids.
- The young tender leaves of mustard are consumed as a vegetable. Mustard seeds are used as condiment in the preparation of pickles and for flavoring curries and vegetables. The oil extracted from seeds is used for cooking and other activities such as lubricants, grease, soaps and synthetic rubber.

6.5 TERMINAL QUESTIONS

1. Enlist the major uses of mustard oil. What contributes to the pungency of the mustard?

2. Describe in brief the characteristic features of peanut plant.
3. Give the botanical name and family of the plant from which we obtain coconut oil. Discuss its morphology.

6.6 ANSWERS

Self-Assessment Questions

1.
 - a)
 - i) *Cocos nucifera*
 - ii) Kernel
 - iii) Oleaceae
 - iv) *Ricinus communis*
 - v) sesamin and sesamolin
 - b)
 - i) True; ii) False; iii) False; iv) True; v) True
 - c)
 - i) Pacific coast of tropical America and the Indo-pacific region
 - ii) Dry parts of Mediterranean regions, Africa, India.
 - iii) Western Asia
 - iv) North Africa
2.
 - a) The major rape and mustard producing states are Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, West Bengal and Bihar.
 - b)
 - i) Fabaceae
 - ii) Brassiaceae
 - iii) Araceae
 - iv) Euphorbiaceae

Terminal Questions

1. Refer Subsection 6.3.7.
2. Refer Subsection 6.3.6.
3. Refer Subsection 6.3.1.

FIBRE YIELDING PLANTS |

Structure

7.1	Introduction	7.4	Summary
	Objectives	7.5	Terminal Questions
7.2	General Account	7.6	Answers
7.3	Important Fibre crops		
	Cotton		
	Coconut		
	Sunhemp		
	Jute		
	Kenaf		
	Hemp		
	Flax		

7.1 INTRODUCTION

Earlier units in this course have provided information about uses of various crop plants. Crop plants have been cultivated since ancient times for various uses such as food, wood and medicines. Plants have been cultivated in different parts of the world for getting cereals, pulses, spices, fibres, oils, beverages and timber. This present unit will provide you information about the important fibre yielding crops grown in different parts of the world with major emphasis on crops of commercial importance such as cotton. Cotton is one most important natural fibre. The fibre of the crop plants is used for the textile purposes.

Objectives

After studying this unit, you should be able to:

- ❖ enumerate the region of origin of fibre crops;
- ❖ discuss about the different type of fibres;
- ❖ describe the important fibre crops of the world;
- ❖ describe the morphology, cultivation, varieties and uses of major fibre crops.

7.2 GENERAL ACCOUNT

The use of fibre obtained from plants for clothing has been recorded since prehistoric times. Early humans obtained fibre from plants which later on was spun and weaved to get threads by interlocking strands. Fibre consists of long narrow cells having thick walls but narrow lumen. The cells are non-living but impart strength and rigidity to the plant body. They occur singly or in groups/bundles closely cemented to each other. Many plant species are rich source of vegetable fibre. Vegetable fibres are mainly composed of cellulose which forms its main structural component. This macromolecule is made up of many glucose units. Plant fibres have been classified into different types depending upon the morphological nature and structure. They are mainly classified into three types- 1) soft stem or bast fibres, 2) hard leaf or structural fibres and 3) surface fibres.

Bast fibres - These fibres are found associated with the phloem, pericycle and cortex. They are found mostly in dicotyledonous plants. They are durable and capable of resisting bleaching. Commercial bast fibres are produced by plants mainly- flax, jute, hemp, kenaf.

Structural fibres - They include strands of small, short lignified cells ensheathing xylem and phloem. They are mainly found in leaves of monocotyledonous plants. They are highly lignified and coarser.

Surface fibres - This type of fibres are produced on the surface of stems, leaves, fruits and seeds. The fibres arise as epidermal outgrowths of the seeds or inner wall of fruits. Cotton is the main plant in this category.

According to their use the fibres are classified as textile fibres, brush fibres, filling fibres, natural fibres and paper making fibres. The fibres that are used in the manufacture of fabrics are called textile fibres. For manufacture of fabrics, the fibres are twisted together into threads or yarn and woven. Cotton, along with some quantities of flax, ramie and hemp are used for this purpose. Some fibres are used in the manufacture of brushes. These include sisal and istle (hard fibres), broomcorn (inflorescence of *Sorghum vulgare*) and strong and stiff fibres of piassava (fibres from palm leaves and stem). Flat strands or strips are woven into hats, baskets and roof of houses. Some fibres are used for filling of cushions and mattresses. These include cotton, jute, hard fibres and several grasses. Various wood fibres, grasses and sedges are used for making paper.

7.3 IMPORTANT FIBRE CROPS

The major fibre yielding species include cotton, coconut, jute, hemp, flax, kenaf etc..

7.3.1 *Gossypium*

Family: Malvaceae

Vernacular name: cotton

The cotton has been cultivated in South East Asia and Central America since ancient times. India has been the most primitive center of cotton from where it was introduced to China and Egypt around 600 B.C. In the nineteenth century its cultivation spread in tropical, subtropical and warm temperate parts of the world. Its cultivation has been noted throughout India, Myanmar, Malaysia, China, Korea and Japan. India and Africa are the largest producers of cotton mainly of *G. arboreum*.

The four cultivated cotton species with large number of varieties and hybrid forms are classified into two types i.e. i) American or the new world cotton represented by *G. hirsutum* and *G. barbadense*, ii) the Asiatic or the old world cotton consisting of *G. arboreum* and *G. herbaceum*.

G. arboreum (Ceylon cotton)

The plants are annual or perennial shrubs with the height up to three meters. The leaves are five to seven lobed (Fig. 7.3). The fruits or bolls are tapering structures profusely pitted having prominent glands in the pits. The fruits open widely when ripe. They contain up to 17 seeds per loculus. The seeds are covered with grayish green or rust colored short hairs called fuzz.

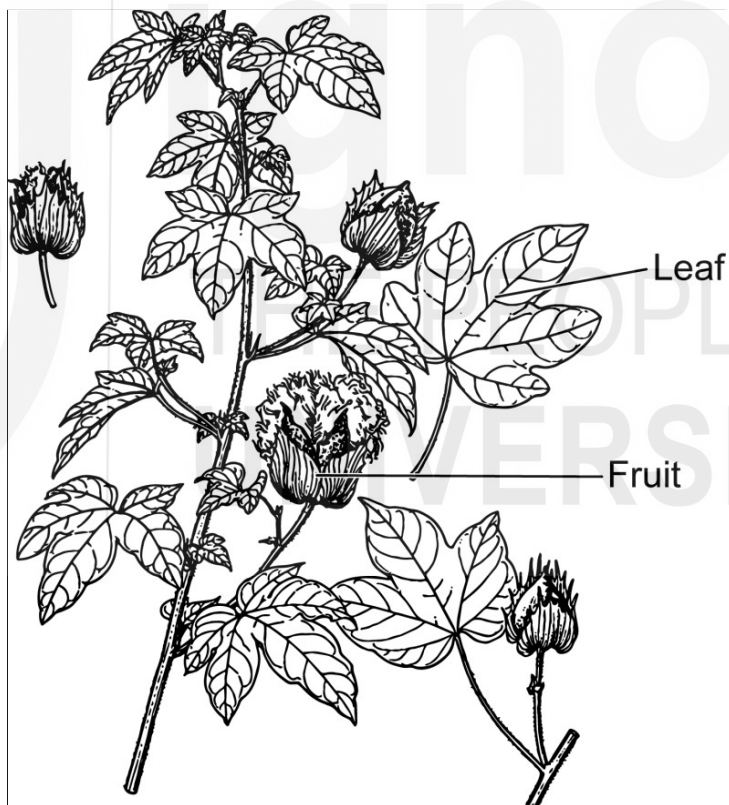


Fig. 7.1: A flowering branch of *G. arboreum*.

G. herbaceum (Levant cotton)

n=13

The species is native to tropical Africa, Middle East and grown in China, Indonesia, India, Pakistan, Iran, Iraq, Turkey, Greece.

The plants are shrubby, reaching a height of 1 m. The leaves are three to five lobed. The incisions in the leaf extend to half the length of the lamina. The bracteoles are widely flaring and boll is three celled, rounded, beaked and

smooth surfaced (Fig. 7.2). The fruit opens at maturity with three to four loculi each having up to 11 seeds. The seeds bear two coats of hairs, long lint hairs and short fuzz hairs.

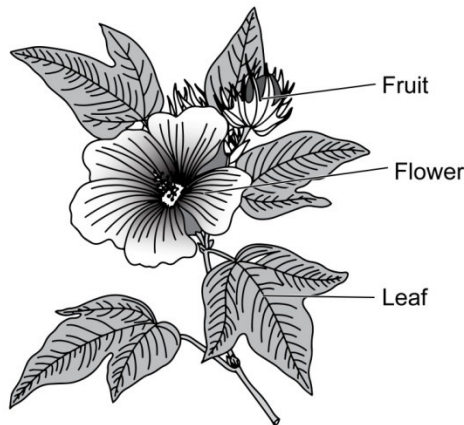


Fig. 7.2: A flowering branch of *G. herbaceum*.

G. barbadense

n=26

The plant is native of South America. It is known for its lint length and fineness of the lint. It has two varieties – Sea Island cotton and Egyptian cotton. Sea Island cotton is one of the finest varieties of cotton and largely grown in West Indies, Fiji and islands of the coast of Florida, Georgia and Southern Carolina. The fine spun yarn is used in the manufacture of laces, cambric and fine hosiery. Egyptian cotton is grown under irrigated conditions of Nile river valley of Egypt and Sudan. The fibre is durable and hence used in the manufacture of goods that require huge strength such as automobile tyre fabric and high quality hosiery.

The plants are tall, annual shrubs reaching a height up to three meters. The plant bears few ascending vegetative branches. The leaves are three to five lobed (Fig. 7.3). The corolla is bright yellow in color with red to purple spots near the base. The bolls are usually large, dark green and prominently pitted with oil glands. The bracteoles are large divided at the apex with 10-15 long acuminate teeth. The fruit is three to four valved each having five to eight seeds having fuzzy ends. In Sea Island cotton, the fibres are white, light/cream coloured, soft and lustrous.



Fig. 7.3: A flowering branch of *G. barbadense*.

G. hirsutum (upland cotton)

n=26

The cotton is native to Mexico and Central America. It is grown in most parts of the world. It constitutes 95 per cent of the world production. Besides United States it grows in Brazil, Uganda, Africa, Iraq, China, Turkey, Greece, India and Pakistan. Most of the world's cotton comes from USA, China, India, Pakistan, Uzbekistan, Turkey, Brazil, Turkmenistan, Greece and Australia. India ranks third in the production of cotton. The major cotton producing states in India are Maharashtra, Gujarat, Andhra Pradesh, Karnataka, Punjab, Haryana and Madhya Pradesh.

On the basis of length of staple its two varieties are recognized which include American upland short staple cotton with the length of about 16 to 27mm and American upland long staple cotton with the length of 28 to 38 mm.

Morphology

The plants are generally shrubs or trees with vegetative branches. The main stem of the plant is monopodial in growth and possesses spirally arranged leaves. The leaves bear two kinds of buds- axillary and extra axillary. The plant shows dimorphic branching. The vegetative branches are monopodial while the fruiting branches are sympodial. The vegetative branches develop from the axillary buds of the nodes of lower stem while the fruiting branches arise from the extra axillary buds of the upper nodes. Vegetative branches are morphologically similar to the main stem and do not bear flowers. The secondary (fruiting) branches bear a flower at the tip. From the axil of the subtending leaf, a branch develops that terminates into a fruiting point. The flowers are borne opposite to the leaf on the fruiting branch. The leaves are large, palmately lobed (three to five lobed) cordate, hairy. The flowers are large, showy, white or pale yellow and usually without purplish spot at the base. The flowers are surrounded by involucres of bracts that are generally persistent. The flowers turn pink or red on second day of blooming. The bolls are large, rounded, green and smooth leathery capsules. The fruit consist of three to five locules or chambers (Fig. 7.4). The seeds are covered all over with a long hairs or lint or short hairs or white fuzzy coating.

The capsule cracks at maturity along the sutures and contents expand into a white fluffy mass which is pushed outside the carpel. The cotton fibres represent epidermal elongations of the seed coat cells. The fibres attain maturity and full length during the first twenty five days of boll development. A mature fibre looks like a translucent, flattened twisted more or less tubular structure with broad base and an untwisted tapering apical end. A raw cotton fibre consists of 94percent cellulose, protein 1.3 per cent, pectic substances 0.9 per cent. The fibres are classified as long staple and short staple fibres. The long staple fibres are of American or Egyptian origin and have length of 1 to 2.5 inches, good texture and lusture. Short staple fibres are of Indian origin and have length of about 0.3-0.7 inches and are coarse and lustureless.

Cotton bolls are handpicked. The fibre is taken out and it is spun into yarn and woven into cloth. The fibre passes through various processes such as ginning, baling, carding, picking and combing. Because of its superior quality, cotton is widely used in textile industry.

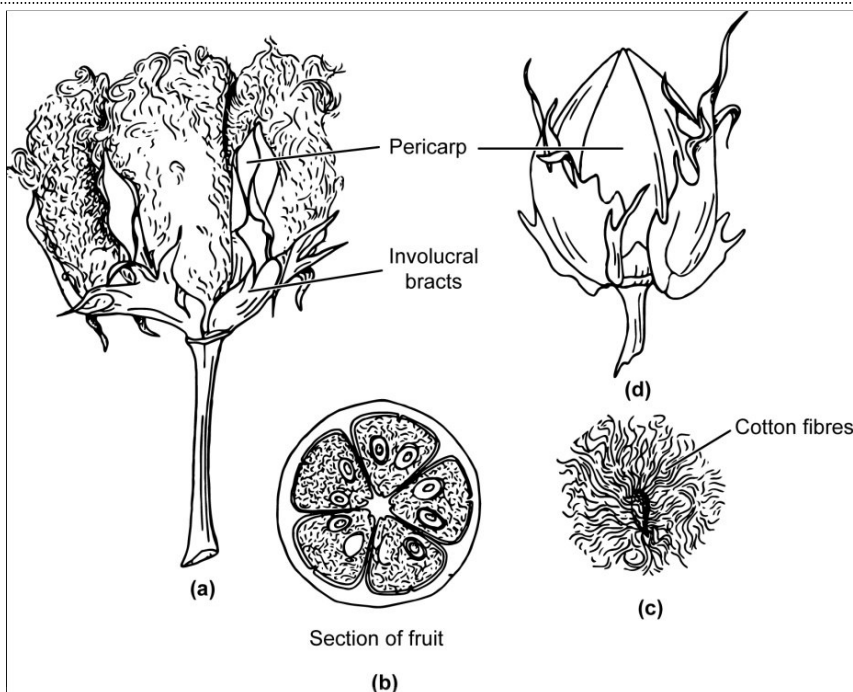


Fig. 7.4: a) Fruit of *G. hirsutum* along with stem; b) T.S. of fruit showing ovules; c) cotton fibers; d) Fruit.

Cultivation

Cotton is a tropical crop. The crop requires abundance of sunshine and a warm temperature of 21-43°C. The cultivation requires adequate soil moisture i.e. about 100 cm of rainfall during early stages of growth and a dry season during flowering and fruiting. Harvesting is done six months after sowing.

Uses

The fibre possesses high tensile strength and remarkable resistance. The fibre is used to make innumerable clothing and furnishing items. The absorbent cotton (prepared by removing waxy or oily coating) is used in bandage making and medical purposes.

SAQ 1

- a) Which part of the cotton plant yield fibres?
 b) Match the following:

Column A

- i) finest varieties of cotton
- ii) new world cotton
- iii) main stem of cotton
- iv) old world cotton
- v) native of South America
- vi) dark colored and inferior quality of cotton

Column B

- 1. Asiatic
- 2. *G. barbedense*
- 3. Egyptian
- 4. *G. hirsutum*
- 5. Sea Island
- 6. monopodial

7.3.2 *Cocos nucifera*

Vernacular name: Coconut

Family: Arecaceae

n = 16

Commercial coir is obtained from the fibrous husk of the fruits of coconut palm. The fibre is light with high elasticity and high resistance. India is the largest producer of coir and its products. About 40 per cent of the nuts produced are used for production of fibre. The fibre is used in the manufacture of mats, rugs, carpets and bags. The fruits are harvested when still green to obtain coir. The fruit is dehusked. The husk is then subjected to retting to remove tough interstitial mass. After retting the husks are taken out of water and thoroughly and repeatedly washed to remove dust.

Fibre obtained from coconut has resilience, durability and resistance to water and used in the manufacture of cordage, cables, coir fibres are used in the manufacture of mats, cushion seating, packing material and boards.

Distribution, morphology, cultivation and uses of coconut has already been discussed in Unit 6 Oils and fats.

7.3.3 *Crotolaria juncea*

Vernacular name: sunhemp

Family: Fabaceae

n = 8

It is a species of Asian origin and grown since prehistoric times. It is used as a source of bast fibre in India. It has spread to other countries and grown for fodder or green manure. It is grown as a commercial fibre crop in India, Bangladesh and Pakistan. In India, Orissa, Madhya Pradesh, Uttar Pradesh, Bihar, Maharashtra and West Bengal are the major sun hemp producing states.

Morphology

The plant is a tall, erect annual about 1-3 m tall with strong tap root system penetrating the soil. The roots produce nodules which are branched and lobed (Fig. 7.5). All vegetative parts of the plant are covered with hairs. The leaves are small, lanceolate and subsessile. Flowers are small, yellow and borne in axillary racemes. The fruit is a long pod with pointed beak and contain kidney shaped seeds. Out of the three varieties, green, white and Dewghuddy, white variety produces nearly 60 per cent of the fibre.

Cultivation

The crop is well adapted to tropical and subtropical climate with light loamy well drained soils. Sunhemp is widely cultivated in tropical and subtropical areas of the world. It is grown at a large scale in India, Bangladesh and Brazil. The plant grows well at temperature of 18-27° C and areas that receive rainfall below 200 mm.

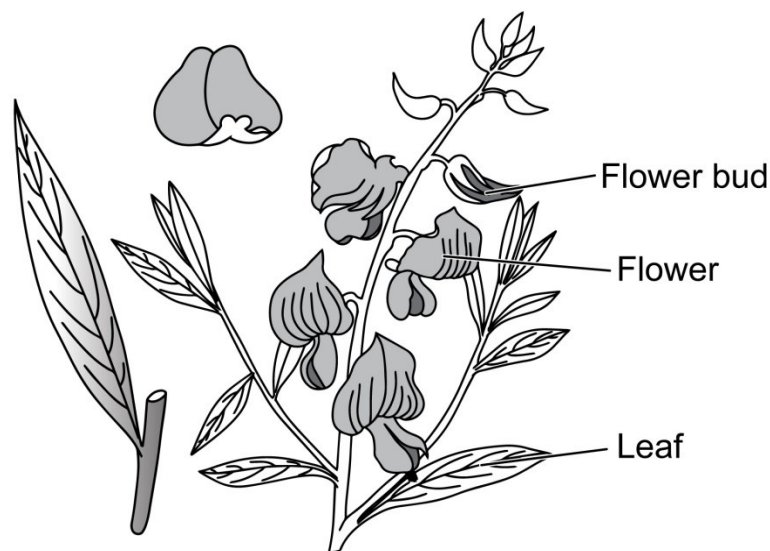


Fig. 7.5: Flowering twig of sunhemp.

Uses

The bast fibre produced by the plant consists of ribbon shaped strands which are light in grey to yellow in color. The fibres possess great tensile strength and durability. The fibre strands are lustrous and resistant to moisture. The fibre is used in the manufacture of ropes, twines, cords, canvas, matting and soles for shoes.

7.3.4 *Corchorus* spp.

Vernacular name: Jute

Family: Tiliaceae

$n = 7$

It is one of the most important source of bast fibres. It is widely cultivated along with cotton among all the natural fibres. The fibre is obtained from stem. The two most cultivated species are *C. capsularis* and *C. olitorius*. It is believed that the plant derived its name from 'Korkorus' which was used by Greeks. In India this fibre has been used as a sack-cloth since ancient times. In earlier times India produced about 99 per cent of the total jute but today about 80 per cent of the total production comes from India and Bangladesh. It has been also cultivated in China, Thailand, Russian Federation, Vietnam and Myanmar. In India, it is mainly produced in the states of West Bengal, Bihar, Assam and Andhra Pradesh.

Morphology

The plants are woody branched annuals which can grow up to 3.5 m in height having simple ovate, serrate margined leaves. Flowers are solitary, or arranged in cymes. *C. capsularis* is tall branched annual with ovate glabrous leaves containing a glycoside 'corchorin'. Flowers are yellow, small and produce globular, wrinkled capsules flattened at the top. The plants of *C. olitorius* are also tall bearing shining upper and a rough undersurface. The flowers are yellow, large and produce long, cylindrical ridged capsule with elongated beak (Fig. 7.6).

Cultivation

C. capsularis is grown as a rainy season crop which grows well on warm, humid, rich loamy soil with annual rainfall ranging from 150-250 cm, temperature of 17-38° C and humidity around 70-90 per cent. The plants are harvested at the stage when 50 per cent of fruiting is there because both yield and quality of fibre is good. The fibres are separated by retting. The process usually takes 10-30 days and time of the process depends upon the maturity of the crop, water, temperature and depth of immersion. Generally the bundles of fibres are stacked upright in about 0.6 m of water for two to three days. The retting removes the bark.

Uses

The fibres are yellow in colour and possess silk like lustre. They are stiff, brittle and possess low stretch ability and durability. The fibres contain about 63 per cent cellulose. The major use of jute is in the manufacture of sacks, bags, rugs, ropes, blankets, carpets, curtains, upholstery etc.

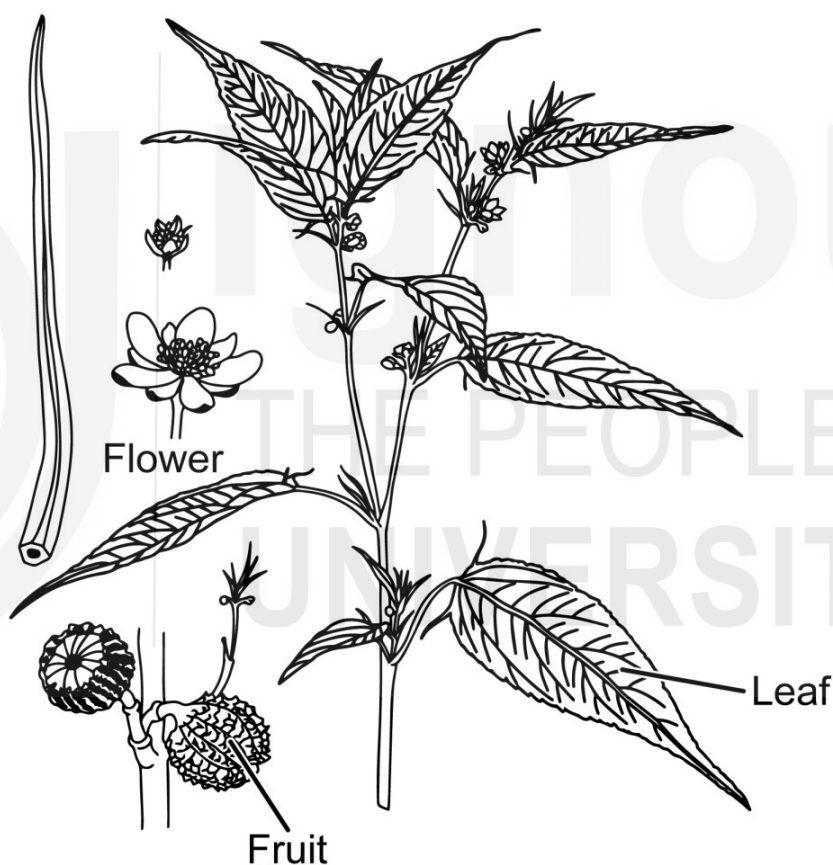


Fig 7.6: Flowering branch of *Corchorus*.

7.3.5 *Hibiscus cannabinus*

Vernacular name: Kenaf, Java, jute

Family: Malvaceae

n = 18

The plant is used for fibre which is a substitute of jute. Kenaf is also known as Deccan hemp or Java Jute. The plant is grown in many countries of tropics and subtropics such as India, Thailand, Brazil, China, Cuba and Mexico. The fibre is extracted from the lower portion of the stem.

Morphology

The plant possesses a long, slender, unbranched stem about 2-3 m in height. The leaves are usually cordate or palmately divided. The flowers are large, showy and arise in the axil of leaves (Fig. 7.7). The fruit is globose capsule with a pointed tip. The fruit produces brown seeds at maturity. The major variety is *H. sabdariffa*. The fibre strands are long (1-3 m), coarser, tougher and stronger.

Cultivation

The plant is cultivated mainly in tropics and subtropics at temperature above 20° C. The plant prefers well-drained humus rich fertile soil. The plant requires rainfall of about 57 to 400 cm and annual temperature of 11 to 28° C for its growth.

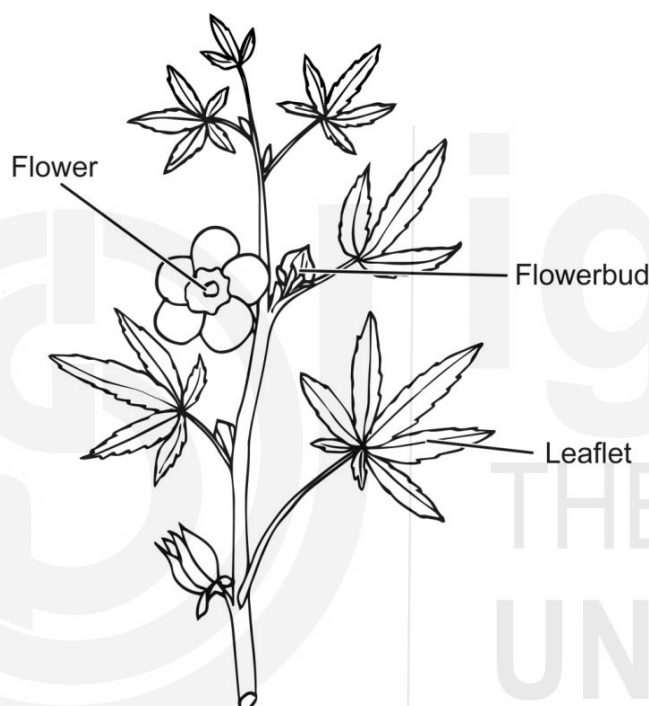


Fig 7.7: Flowering branch of kenaf.

7.3.6 *Cannabis sativa* (Hemp)

Vernacular name: hemp

Family: Cannabinaceae

n = 10

It is one of the oldest fibres known to mankind. It originated in central and western Asia. Later on it spread to China and Europe. The major hemp producing countries are Romania, Hungary, Poland, Yugoslavia, India, China, Japan, Chile, Peru, Iran and Turkey.

Morphology

The plant is a hollow stemmed annual bearing dark green palmately compound leaves (Fig. 7.8). The plants are dioecious. The female plants are shorter, robust while the male plants are taller and slender. Male flowers are

borne in axillary and terminal panicles. Female flowers are sessile and arranged dense in a spike. The fruits are smooth, shining achene enclosed by a calyx and large bract.

The fibre is obtained mainly from the male plants. The harvesting is done at the time of pollination. The premature harvesting can result in lower yield and weak, soft fibre. The delayed harvesting results in harsh and brittle fibre. The plant is chopped 2 to 3 cm above ground with the help of knife and the cut stems are spread on ground for drying followed by retting. The fibre strands are yellowish, grey or green and possess strength and durability.

Cultivation

The plant is grown in nearly all temperate regions of the world with temperatures ranging from 17 to 27°C and rainfall of about 75 cm per annum.

Uses

The fibre is used in the preparation of canvas, cables, webbing, twine, rope and artificial sponges.



Fig 7.8: Flowering branch of hemp.

Uses

Hemp is used in the manufacture of carpet, warp, canvas, webbing, sacking, rope, cables. Hemp oil is used in making paint, varnish, soaps.

7.3.7 *Linum usitatissimum* (Flax)

Vernacular name: flax or linseed

Family: Linaceae

The plant has been cultivated since prehistoric times. The presence of flax has been noted since old European and Egyptian civilizations. Nowadays it is cultivated in temperate parts of Europe. The leading producers are France, Russian Federation, Ukraine, Czech Republic and Egypt.

Morphology

The plant is an annual herb with slender stem bearing alternately placed small ovate, or lanceolate leaves. The flowers are white or blue present in loose, terminal leafy racemes or open cymes (Fig. 7.9). The fruit an indehiscent globular capsule enclosed in a persistent calyx.

Flax fibre is essentially a crop of temperate climate. The fibres occur in discrete groups or aggregates of many of cells in the pericycle (bast or stem fibres). The number of fibrous bundles is about 30 with each bundle consisting of ten to forty individual fibres. The fibres after extraction are dried in sun and subjected to the process of rippling, steeping, retting and hackling. The fibres obtained from leaves and stem are subjected to rippling while the fibres obtained from small branches are subjected to retting by immersing them in water tank for several days.

Cultivation

The plant grown well in sandy, loam soil and cool temperate climate.

Uses

The fibres are fine, durable and flexible. The fibres are used in the preparation of cambrics, damasks, sheetings, laces for apparels and household furnishings. The coarser grades are used in the manufacture of canvas, ducks, toweling, twine, bagging and industrial sewing threads.

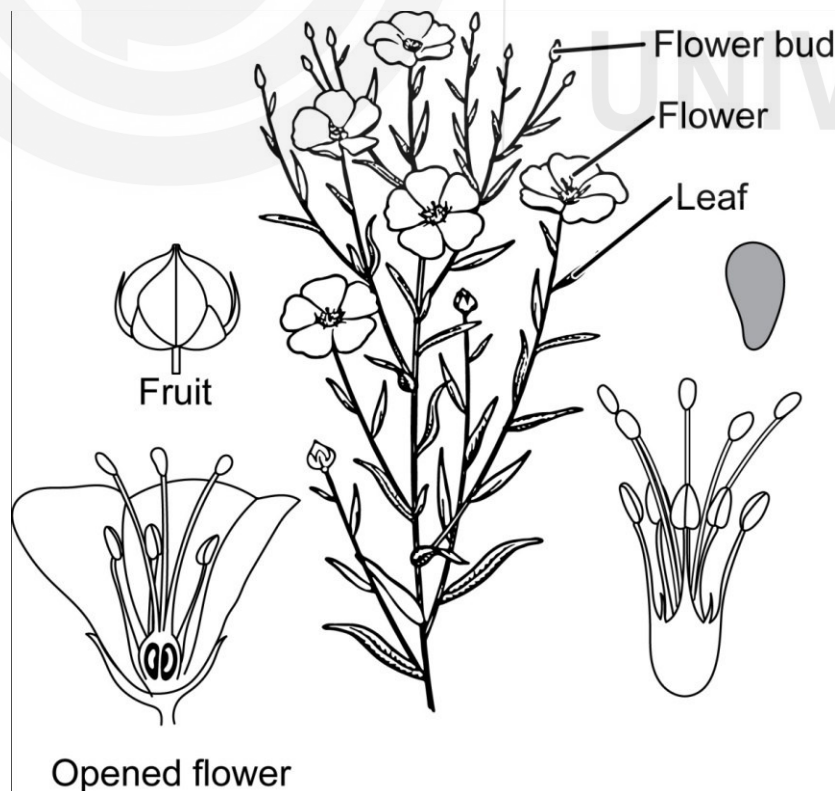


Fig. 7.9: Diagram showing flowering branch of *Linum*, an opened flower and fruit.

SAQ 2

- a) Fill in the blanks:
- Fibres are mainly composed of
 - Soft fibres obtained from plant stem are called as
 - For manufacture of, the fibres are twisted together into threads or yarn and woven.
 - Commercial coir is obtained from the fibrous husk of the fruits of
 - The botanical name of sunhemp is
 - plant derived its name from the word 'Korkorus' used by Greeks.
- b) Write the botanical names of the following plants:
- jute
 - flax
 - hemp
 - kenaf

7.4 SUMMARY

In this unit you have studied that:

- Many plant species are rich source of fibres. Depending upon the morphological nature and structure, plant fibres have been classified into different types mainly soft stem or bast fibres, hard leaf or structural fibres and surface fibres.
- The major fibre yielding species include cotton, jute, hemp, coconut and kenaf. Cotton is one of the most important commercial fibre crop. It has been cultivated in South East Asia and Central America since ancient times. The four cultivated cotton species include American or the new world cotton *G. hirsutum* and *G. barbadense* and the Asiatic or the old world cotton *G. arboreum* and *G. herbaceum*.
- Sunhemp, jute, coconut and flax are the other fiber producing plants that are cultivated on a large scale. Most of these varieties produce bast fibres which possess high tensile strength and durability.
- Commercial coir is obtained from the fibrous husk of the fruits of coconut palm. The fibre is light with high elasticity, high resistance. India is the largest producer of coir and its products.
- The bast fibre produced by the sunhemp plant possesses great tensile strength and durability. The fibre strands are lustrous and resistant to moisture. *Corchorus* is another important source of bast fibres.

7.5 TERMINAL QUESTIONS

1. Differentiate between bast and surface fibres.
2. Enlist the major uses of jute.
3. Describe the morphological features of the cotton plant.
4. Give brief description of morphology and uses of sunhemp.
5. Write short notes on:
 - a) kenaf
 - b) coconut
 - c) flax

7.6 ANSWERS

Self-Assessment Questions

1.
 - a) The fibres arise as outgrowths from the seeds or inner wall of fruits.
 - b)
 - i) Sea Island; ii) *G. hisutum*; iii) monopodial;
 - iv) Asiatic; v) *G. barbedense*; vi) Egyptian
2.
 - a)
 - i) cellulose
 - ii) bast fibres
 - iii) fabrics
 - iv) coconut palm
 - v) *Crotolaria juncea*
 - vi) Jute
 - b)
 - i) *Corchorus spp.*
 - ii) *Linum usitatissimum*
 - iii) *Cannabis sativa*
 - iv) *Hibiscus cannabinus*

Terminal Questions

1. Refer to Section 7.2.
2. Refer to Subsection 7.3.4.
3. Refer to Subsection 7.3.1.
4. Refer to Subsection 7.3.3.
5. Refer to Section 7.3.

MEDICINAL PLANTS |

Structure

8.1	Introduction	8.4	Summary
	Objectives	8.5	Terminal Questions
8.2	Distribution of Medicinal Plants	8.6	Answers
8.3	Important Medicinal Plants		
	<i>Digitalis</i>		
	<i>Papaver</i>		
	<i>Rauwolfia</i>		
	<i>Artemisia</i>		
	<i>Catharanthus</i>		
	<i>Adhatoda</i>		
	<i>Ephedra</i>		

8.1 INTRODUCTION

In the unit 7 of this course you have studied about fibre yielding plants. In this unit we shall be discussing about some important medicinal plants. Medicinal plants have been used in traditional medicine practices since prehistoric times. Medicinal plants play an important role in the life of the people. In ancient Indian texts, all the plants on this earth are considered as medicinal (*Jivak* in *Astanga Hriday* (Sutra: 9-10)). The medicinal plants could be defined in the simplest way as the plants which are used in official and various traditional systems of medicine throughout the world. We can say that, the medicinal plants are the plants that provide people with medicines to prevent disease, maintain health or cure ailments.

India has one of the richest, oldest and most diverse cultural traditions associated with the use of medicinal plants. Plants and plant based products have been used traditionally in India from the time immemorial. References of the healing power of plants are depicted in Rig -Veda (4000-1500 B.C.), Atharvaveda (1500B.C.), Upanishada (1000 B.C.) and Mahabharata and Puranas (700-400 B.C.). Charaka Samhita and Sushruta Samhita are the two important compendia on medicinal plants published between 1000 and 600

B.C. The invasion of Greeks and Muslims had a considerable influence on the use of plant-based medicines. The rise of Buddhism also gave an impetus to the study of herbal medicines in ancient India.

At present, many systems of medicines such as Ayurveda, Siddha, Unani, Homeopathy, Tibetan, tribal medicines, folk medicines constituting the Indian systems of medicine (ISM) are being practiced in India. Medicinal plants are used by majority of rural population in self help mode for their primary health care requirements. In recent years, demand for herbal medicines and cosmetic products is increasing globally. It has created a quantum jump in volume of plant material traded within and outside the country.

In modern medicine about 25 percent of drugs prescribed to patients are derived from medicinal plants. We can define medicinal plants more appropriately as a plant that possess therapeutic properties or exert beneficial pharmacological effect on human or animal body.

Objectives

After studying this unit, you should be able to:

- ❖ define the medicinal plants and outline the importance of medicinal plants;
- ❖ identify the sources of availability and distribution of these groups of plants;
- ❖ explain the origin, morphology, chemical composition and ecology of some important medicinal plants; and
- ❖ appreciate the uses of mentioned medicinal plants.

8.2 DISTRIBUTION OF MEDICINAL PLANTS

About 70 per cent of India's medicinal plants are found in natural habitat of Himalayas, tropical forests of Western and Eastern Ghats, the Vindhyas, Chotta Nagpur plateau and Aravalis. A large percentage of known medicinal plants occur in the dry and moist deciduous vegetation area compared to evergreen and temperate regions. About one third of all medicinal plants are trees, 32 per cent are herbs, 20 per cent are shrubs, 12 per cent creepers and 3 per cent are other forms.

Various plant parts like roots, bark, wood, stem or the whole plant in case of herbs are used for preparation of various medicines and related products (Fig.8.1).

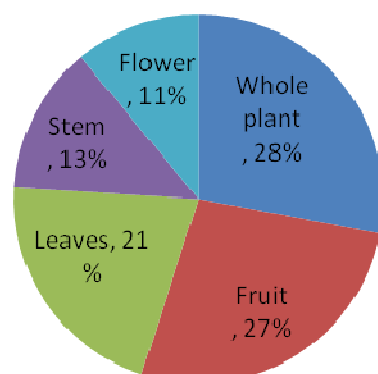


Fig. 8.1: Percentage of different plant parts used in Indian Medicines.

8.3 IMPORTANT MEDICINAL PLANTS

The Food and Agriculture Organization (FAO) estimated in 2002 that more than 50000 medicinal plants are used across the world. However the Royal Botanical Garden, Kew, in 2016, more precisely estimated that 17,810 plant species have a medicinal use.

Plants synthesize hundreds of chemical compounds for various purposes like defence against insects, fungi, pathogenic microbes, diseases and grazing by herbivores. A medicinal plant is grown for its secondary metabolites. Secondary metabolites are responsible for the therapeutic or aromatic properties of the plants. Alkaloids, steroids and essential oils are some of the examples of secondary metabolites. As medicinal plants are used for preparation of medicines, even a small quantity of pesticides or heavy metal is harmful to them. Therefore, the World Health Organization (WHO) has recommended development of Good Agricultural Practices (GAP) for medicinal plants to guarantee quality of drug. A large number of laboratories in the State Agricultural Universities, Indian Council of Agricultural Research (ICAR) and Council of Scientific and Industrial Research (CSIR) are engaged in developing GAP for medicinal plants.

Many ancient plant remedies for diseases have in some way or another played a significant role in modern medicine, for example, aspirin, is the most widely used medicine in the world and is entirely synthetic (a -, from acetyl; and - spirin, from *Spiracea* species of family Rosaceae, one of the sources of salicylic acid); but knowledge of the pain-relieving agent we know today as aspirin is traceable to the use of willow (*Salix* species, Salicaceae) bark by the ancient Greeks to alleviate pain. An active ingredient, salicin was isolated in 1827 from the leaves of willow. Salicin could not be taken internally, but a derivative, acetylsalicylic acid produced in Germany in 1899, provided relief from all types of pains. It is important to know here that the prototype of this drug was infact, a natural product obtained from plants. Similarly, many synthetic drugs have a botanical history - in the use of some sort of crude extract. The classical medical systems, such as Ayurveda of India and Chinese medicine depend on plant drugs. Although once viewed with a lot of scepticism by the western World, these systems have created lot of interest in the recent times as a source of alternative medicine. An inventory of medicinal plants used by people in different countries has been compiled by the World Health Organisation.

Modern drugs contain plant products like fatty acids and essential oils, gums, resins, alkaloids and steroids. Oils and gums are used as emulsifiers in many of the present drug preparations. Volatile oils and resins are often used to help penetrate tissues and also as antiseptics. The two major classes of plant-derived compounds used in medicine are: (1) steroids, and (2) alkaloids (see boxes 8.1 and 8.2). They can occur with one or more sugar molecules attached. Such forms are called glycosides and these are generally the medicinally active forms of the compound.

Box 8.1: Steroids

Steroids are complex compounds which have the following fundamental structure comprising four carbon rings called the steroid backbone.

The addition of different chemical moieties at different places of the backbone leads to the production of a variety of different steroidal compounds. Addition of sugar molecules to the steroidal backbone produces steroidal glycosides. These are also called secondary products, and no direct physiological functions of steroids in plants

have been found. On the contrary, they have a pronounced effect on animals, particularly vertebrates. Many biologists believe that the production of these compounds is for the protection of the plants from animals. The monarch butterfly in its larval stage (as a caterpillar) feeds on milkweeds, i.e., the members of Asclepiadaceae. Milkweeds are toxic to humans because they contain steroidal glycosides. Monarch larvae store these compounds in parts of their bodies and are not poisoned by the glycosides. When the caterpillars metamorphose into butterflies, these stored glycosides occur primarily in their wings. Thus, the butterflies become toxic to their vertebrate predators such as birds. Interestingly the birds quickly learn to avoid these toxin-containing butterflies.

Box 8.2: Alkaloids

Alkaloids as a group have no specific definition. The word alkaloid means alkaline but there is no uniform model for an alkaloid molecule. Alkaloid molecules generally have single or multiple rings and contain nitrogen. In plants, alkaloids have in the past been considered as waste products or secondary products of metabolism with no clarity about their roles. However, there is strong evidence to show that unlike steroids, alkaloids enter the primary metabolism of plants. They have also been found to play an important role in chemical defense in plants, specifically in controlling animal predation. In animals especially in mammals, the effect of many alkaloids, even in minute quantities, can be profound. The consideration of a plant as poisonous versus medicinal is often only one of dosage.

There are various methods to categorize or group medicinal plants. They can be classified in terms of i) chemical nature of the compounds involved, ii) effect they produce or iii) the source from which the drugs are obtained.

For convenience, we have grouped the plants on the basis of the source from which the drug is obtained.

8.3.1 *Digitalis* spp.

Family: Plantaginaceae (Scrophulariaceae)

Vernacular name: "Witch's Bells", foxglove

n = 7

Origin and Distribution: *D. purpurea* – Europe, United Kingdom and *D. lanata* – Austria, United States of America, Central Europe, England and Argentina are cultivated or well distributed. In India, *D. purpurea* is cultivated chiefly in Kashmir and the Nilgiri hills; while *D. lanata* is grown in Kashmir (at altitudes of above 2100 m) and Uttar Pradesh (Chakrata).

Cultivation: For cultivation, disease-free strains of the seeds are selected to produce healthy plants. Soil should contain manure and leaf mould. Seedlings are hand transplanted.

Morphology: The plants are biennial (rarely perennial) herbs (height 45-150cm). Leaves are simple, dorsiventral, lance-shaped to oval, alternate or opposite and covered with gray white pubescent hairs. A rosette of long-stalked leaves is formed in the first year. Inflorescence is raceme (Fig 8.2 a). Flowers are arranged in showy terminal elongated clusters, purple or yellowish, hermaphrodite, zygomorphic with protruding lower lip. The flowers are conspicuously spotted on the inner bottom surface of the tube (Fig. 8.2b). The fruit is a capsule.

Digitoxigenin

It is a cardenolide and aglycone found in digitoxin, obtained from foxglove plant. The compound Digitoxigenin obtained by hydrolysis of digitoxin. It is highly cytotoxic.

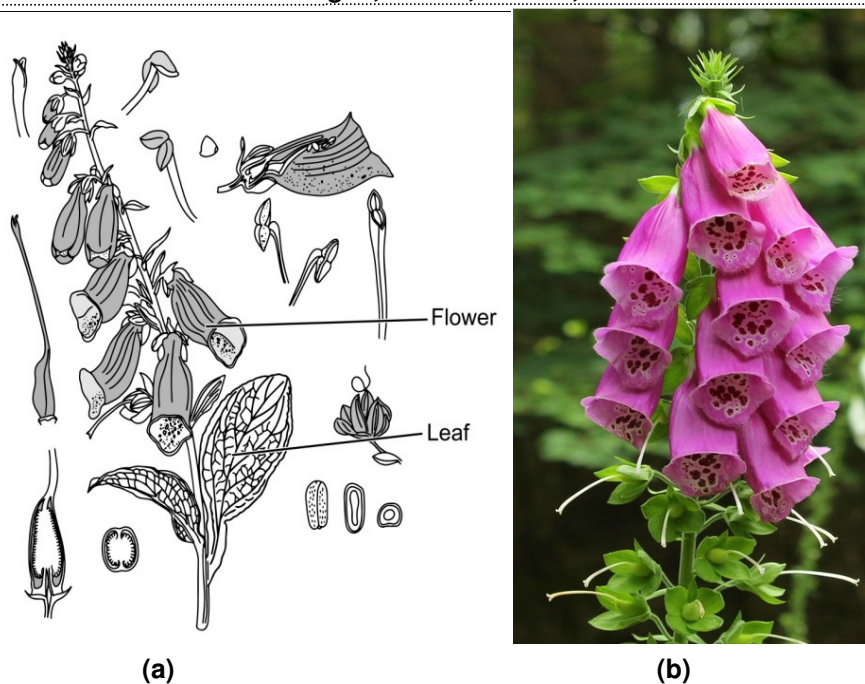
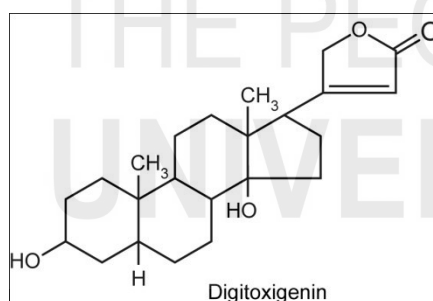


Fig. 8.2: a) A twig of *Digitalis purpurea* plant showing inflorescence; b) photograph showing a bunch of flowers in *Digitalis*.

Box 8.3: Glycosides

Glycosides are non-reducing organic substances which on hydrolysis yield aglycone usually known as genin, and sugar (occur as oxide rings). All cardiac glycosides are steroids or cyclopentanophenanthrene derivatives; they have an unsaturated lactone at C17 position. Digitalis glycosides are C 23 glycoside and have 5-membered lactone ring. Addition of sugar molecules to the steroidal backbone produces steroidal glycosides.



Harvesting of crop is done before flowering and then they are thoroughly dried at temperatures not exceeding 600 °C.

Chemical composition - The active constituents of *Digitalis* are mainly confined to the epidermal and subepidermal collenchyma and the endodermal cells. *D. purpurea* leaves contain 0.2 - 0.45 per cent of a mixture of cardenolides. The physiologically active glycosides digitoxin, gitoxin and gitalin are derived from the naturally occurring purpurea glycoside A, B and C respectively by the loss of a glucose residue.

Digitoxin is the most potent of the *Digitalis* glycosides. Its activity is 1000 times that of powdered digitalis. Digitalin is another active cardiac glycoside obtained from the seeds of *D. purpurea*. *Digitalis lanata* has stronger medicinal properties and its side effects are not as toxic as *D. purpurea*. The active glycosides of the leaves are digitoxin, gitoxin and digoxin.

Uses

1. Cardiac glycosides have a strong effect on the cardiac (heart) muscles.
2. When used medicinally they can also improve: (a) blood circulation in general, (b) relieve oedema (dropsy) which is often associated with heart attack, (c) reduce swelling in hands and ankles and (d) help renal secretion.

SAQ 1

Fill in the blanks.

- a) Seeds of *Digitalis purpurea* are the source of a glycoside used in the treatment of cardiac disorders.
- b) Alkaloids and are two major plant derived compounds used in medicine.
- c) In many drug preparations oils and gums are used as
- d) To guarantee the quality of drugs WHO has recommended the development of for medicinal plants.

8.3.2 *Papaver somniferum*

Family: Papaveraceae

Vernacular names: Opium, poppy Pasto, Post, Afim, Kashakasha, Khuskhus, Abini

n = 11

Origin and Distribution: The plant is native to Eastern Europe and Western Asia. It is widely distributed in Nepal, India, Turkey, Russia, Laos and Cambodia. In India it is cultivated in the states of Madhya Pradesh, Uttar Pradesh and Rajasthan.

Cultivation: In India, the opium poppy is cultivated as a rabi (winter) crop. The seeds are sown in October-November and the latex is collected the following March-April. The plants prefer a well drained sandy loam. It cannot tolerate extreme cold. Propagation is from seeds, and flowering starts after 90 - 115 days. Three to four days after flowering, petals fall and capsule development begins. When the capsule turns from green to yellowish, lancing (incisions are made in the capsule from starting, the bottom upwards with the help of specially designed tools) and is carried out in the afternoon and the opium is collected in the early morning.

Morphology: It is an erect, annual, glaucous herb (height 30- 100 cm). The leaves are ovate-oblong, with leaf bases embracing the stem. They are often shallowly pinnately lobed. Flowers are solitary, bisexual and actinomorphic (Fig. 8.3). Fruit is a capsule; seeds small with minute embryo, endosperm oily. All parts of the plant contain latex.

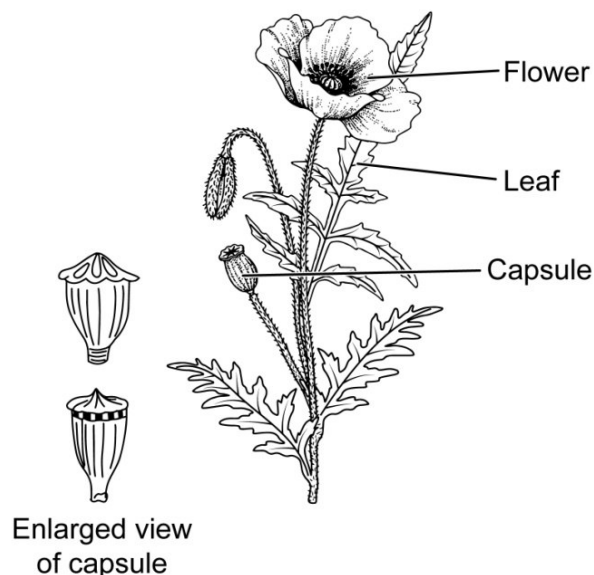


Fig. 8.3: A part of flowering twig of *Papaver somniferum*.

Chemical Composition : Opium (latex obtained from the capsules) is a complex blend of dextrose, pectin, wax, pigments, volatile oil, triterpenoids and alkaloids (20-30 per cent on a dry weight basis) occurring as salts derived from a number of acids including meconic, lactic, citric, succinic, sulphuric and phosphoric acid.

Crude opium contains about 40 alkaloids, and some of the important ones from the commercial and medicinal points of view are (as percentage of opium on a dry weight basis):

- i) morphine [named after Morpheus- the god of dreams] (9 -14 per cent).
- ii) codeine (2 – 3 per cent)
- iii) thebaine (5 – 7 per cent)
- iv) narcotine (noscapine, 5 – 8 per cent)
- v) papaverine (1 per cent)

Box 8.4: Morphine and its derivatives.

In an attempt to develop a non-addicting pain-killer, scientists discovered that morphine could be chemically altered by the addition of two acetyl groups. The end product is a semisynthetic compound known as heroin. It is an even more powerful analgesic than morphine, but it is physically addictive and produces pronounced withdrawal symptoms once the habit has become established. The main cause of death for heroin addicts is by overdose.

Uses

- Morphine is a powerful analgesic and narcotic, which also stimulates the central nervous system.
- Codeine is an important analgesic and an anticough agent, which is less sedative and less toxic in comparison to morphine.
- Thebaine is a convulsant (that induces violent irregular motions of the body), poison and is used only as a raw material for the manufacture of codeine or other semisynthetic analgesics and narcotic antagonists (neutralize the effect of narcotic) such as nalorphine and etorphine.

- Narcotine is generally used in the preparation of cough medicines.
- Papaverine is a smooth muscle relaxant and cerebral vasodilator. It has been used in the treatment of asthma and angina pectoris.
- The poppy seeds are quite nutritious and have a pleasant nutty flavour, and are often sprinkled on breads and cakes. The seeds are also a source of fatty oil called poppy oil used in the preparation of sweetmeats.

8.3.3 *Rauwolfia serpentina*

Family: Apocynaceae

Vernacular names: Snake root, Serpent wood, Chandrabhaga, Sarpgandha

n = 10, 11, 12, 22

The genus *Rauwolfia* was named after the 16th century German physician and explorer Dr Leonhard Rauwolf.

Cultivation: The plants grow in tropical or sub-tropical regions and flourish in hot humid conditions. These are best raised from root cuttings. Seeds and stem cuttings are also used for propagation. Although pharmaceutical companies have tried to mass cultivate the plants, they have not been successful and commercial supplies still come from nature. Indonesia was once a major source, but now its supplies have been exhausted. Presently, the leading producers are India and Thailand.

Morphology: *R. serpentina* is an erect, evergreen, perennating glabrous undershrub. The roots are greyish brown, tuberous and have a characteristic slightly wrinkled and coarse surface. The cylindrical, tapering and twisted taproot is of commercial value. The bark of the root is considered more valuable than the wood. Roots are harvested from 2- 3 year old plants after they have shed their leaves. At this stage they are richer in alkaloids than the roots dug at earlier stages. The leaves are simple, glabrous, lanceolate or obovate; and arranged in whorls of 3 or 4, crowding the upper part of the stem. The leaves and stems too contain small amounts of alkaloids. Leaves are simple, glabrous, lanceolate or ovate in shape and arranged in the whorls of 3 or 4. Inflorescence is generally terminal but sometimes axillary.cyme. Flowers are tubular, pinkish white or greenish white in colour. Fruits are small (0.5 cm), oval, fleshy drupes, they become shiny black when ripe (Fig. 8.4 and 8.5).



Fig. 8.4 Photograph of a flowering twig of *Rauwolfia serpentina*.

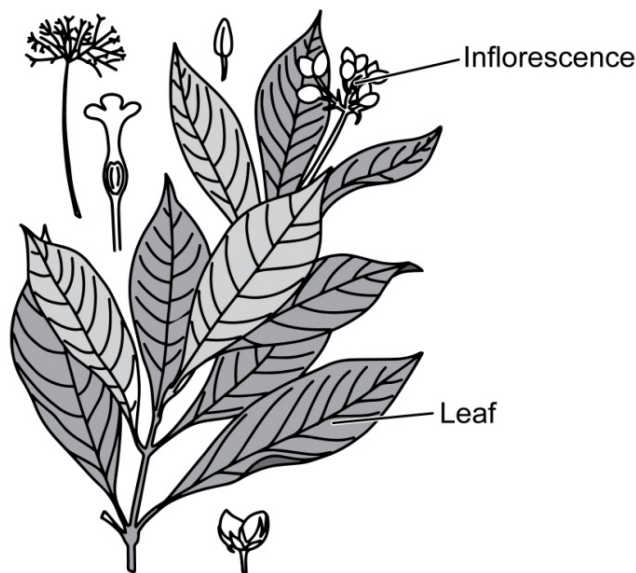


Fig. 8.5: A twig of *Rauwolfia serpentina* with inflorescence and a single flower.

Rauwolfia species contain about 80 or more alkaloids, of which reserpine, rescinnamine, ajmaline, ajmalicine and serpentine are of commercial importance. Of these, the most important is reserpine. It is chemically similar to serotonin, a substance in the brain and structurally is related to LSD (Lysergic acid diethylamide).

Uses

- For centuries in India, powdered taproots have been used for the treatment of "moon disease", or lunacy, and also against snakebites (hence the common names Chandrabhaga, Chota-chand and Sarpghandha) and insect stings. Reserpine was also used as medicine in U.S. in the treatment of the mental disorder known as schizophrenia.
- As a result of the discovery that reserpine was hypotensive and that it could lower blood pressure, it found even greater use in the treatment of high blood pressure (often in combination with other drugs) than of schizophrenia. The use of reserpine in hypertension therapy is based on the action of the drug in dilating blood vessels thereby reducing pressure.
- An extract of the leaves has been used as a cure for the opacity of the cornea.
- Extracts of roots are used for intestinal disorders; sometimes they are mixed with other plant extracts and used in the treatment of cholera, colic and fever;
- Root extract also stimulates uterine contraction and is used in child-birth.

8.3.4 *Artemisia annua*

Family: Asteraceae

Vernacular name- Mugwort, Wormwood, Sagebrush, Hindi name Nagdauna

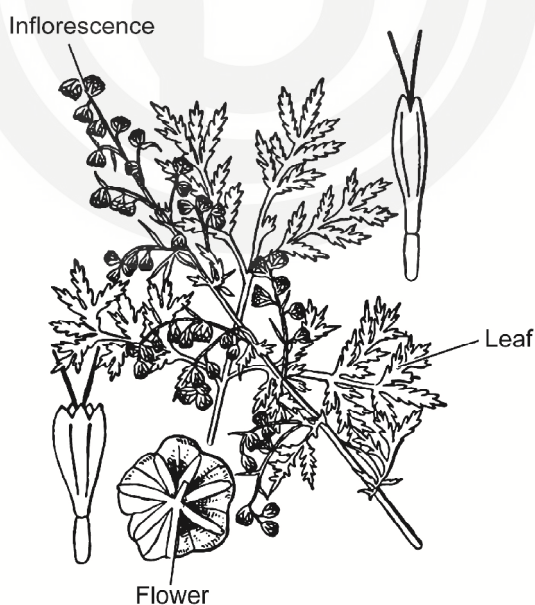
Origin and Distribution *Artemisia* comprises of a large genus with more than 200 species. *Artemisia annua* is a native of temperate areas covering Europe, Asia, Northern Africa and Alaska. It is a common invasive weed in North America. According to a saying it is named after the Greek goddess of the hunt, forests, and childbirth named Artemis.

Cultivation

The plant prefers sunny and warm conditions. Its optimal growth temperature lies within 20 and 25 °C. The rainfall of about 600 mm is required for the growth of the plant. *Artemisia* species grow usually in dry or semiarid habitats. It commonly grows on nitrogenous soils at wastelands and roadsides. Notable species include *A. vulgaris* (common mugwort), *A. annua* (sagewort), *A. absinthium* (wormwood), and *A. abrotanum* (southernwood). Drugs obtained from Roots, leaves and flowers.

Morphology

Artemisia plants are hardy, tall, perennial, herbs and shrubs. The plant grows from 30 to 100 cm in height. The stem is erect brownish or violet brown. The leaves have a length of 3-10 cm and are divided by deep cuts into two or three small leaflets. The leaves are dark green, pinnate, sessile with dense white tomentose hairs on underside. Inflorescence is capitulum. Small florets (5 mm. long) are radially symmetrical with many yellow or dark red petals. Numerous heads spreads out in racemose panicles (Fig. 8.6). The plant flowers from midsummer to early autumn.



(a)



(b)

Fig 8.6 a) A flowering twig of *Artemisia annua*; b) Photograph of *A. annua* plant.

These plant spp. are known for the powerful chemical constituents in their essential oils which is used in folk and modern medicine, and in the cosmetics and pharmaceutical industry. Most species have strong aromas and bitter tastes due to the presence of terpenoids and sesquiterpene

lactones, which discourage herbivory. *Artemisia* species are used as food plants by the larvae of a number of *Lepidoptera* species.

Chemical Composition: A sesquiterpene lactone, Artemisinin is produced in the glandular trichomes present on the leaves and floral buds of *A. annua*. Artemisinin is the therapeutic agent used for treating malaria. Traditionally, *A. annua* was used by the Chinese as a tea to treat “fever”. More recently, investigators have shown that tea infusions and oral consumption of the dried leaves of the plant have prophylactic and therapeutic efficacy. The essential oils of this aromatic medicinal plant contain volatile compounds like thujone (*A. vulgaris* plants are rich in an isomer alphathujone and camphor), isothujone, alpha pinene, beta pinene, myrcene, camphor, camphene, caryophyllene, cineole and artemisia ketone besides terpenes, terpenoids, and phenolic compounds.

Uses

- Different *Artemisia* oils and their compounds have been reported as effective antimicrobial, insecticidal, and antioxidant agent. It is also used for treatment of parasitic infections such as roundworms, pinworms, tapeworms, hookworms and flukes.
- Chinese mugwort, *Artemisia argyi*, is used in traditional Chinese medicine.
- Mugwort roots are general tonic and boost physical as well as mental strength. It is known to stimulate the secretion of gastric juices and improves digestion. Mugwort is helpful in relief from rheumatic pain. Excess dosages can cause some side effects like acidity and heartburn.
- Leaves and flower tops are used for therapeutic purposes. It is used for pain relief, treatment of fever and as a diuretic agent. It also stimulates bile secretion which corrects fat metabolism and improves intestinal movements and cures constipation.
- Plant contains sedatives, antidepressants and compounds having calming action on mind relieving mental stress, depression and anxiety.
- Use of mugwort is unsafe during pregnancy as it can stimulate uterine contraction increasing the chances of spotting and bleeding and in extreme cases may cause miscarriage.
- The aromatic leaves of some species are used for flavouring. *Artemisia arborescens* (tree wormwood, or *sheeba* in Arabic) is an aromatic herb indigenous to the Middle East used in tea, usually with mint.
- Artemisinin derived from *Artemisia annua* is used to treat malaria. Artemisinin derivatives are used for treatment of malaria caused by *Plasmodium falciparum* worldwide.
- *Artemisia cina* and other Old World species are the source of the antihelminthic drug, santonin.

SAQ 2

State whether the following statements are T (True) or F (False).

- a) The chief source of the alkaloid reserpine is *Claviceps purpurea*.
- b) The powerful analgesic and narcotic morphine and codien are obtained from *Papaver somniferum*.
- c) Poppy seeds are very nutritious and obtained from *Rauwolfia spp.*
- d) Two important anticancer alkaloids vincristine and vinblastine are obtained from *Artimisia* leaves.
- e) The most abundant alkaloid found in crude opium is papaverine.
- f) Mugwort relieves mental stress, depression and anxiety.

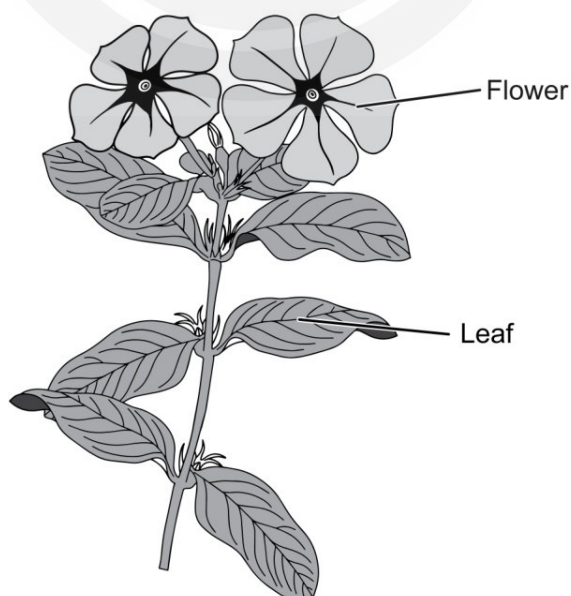
8.3.5 *Catharanthus roseus*

Family: Apocynaceae

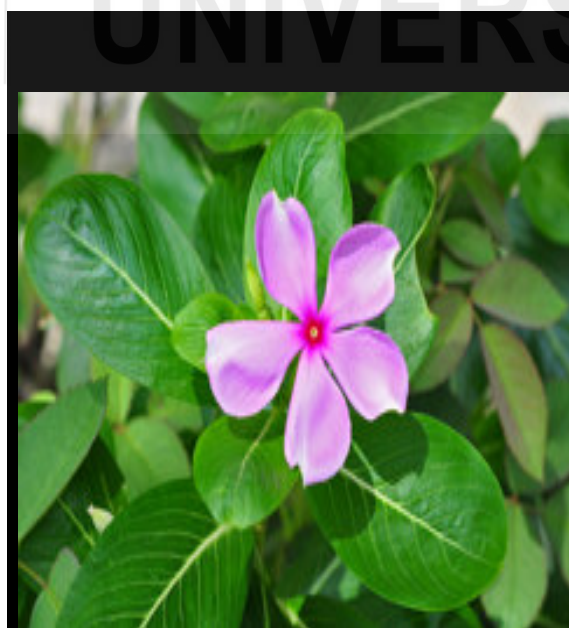
Vernacular name: Madagascar Periwinkle, Sadabahar

n = 12

Origin and Distribution The plant *Catharanthus roseus* (*Vinca rosea*, Fig. 8.7) is native to West Indies and Indian Ocean island of Madagascar. It is cultivated as an ornamental plant throughout the world and on commercial basis in India, Israel and the USA. In India it is cultivated on commercial scale chiefly in Ramnathpuram, Triunelveli, and Madurai districts of Tamil Nadu.



(a)



(b)

Fig. 8.7: a) Flowering twig of *Catharanthus roseus* b) Photograph of *Catharanthus* flower.

Cultivation: Fresh seeds are used for its propagation. The plant is well adapted to all types of soils and tropical climate. Annual rainfall of about 100 cm or more is ideal for its cultivation.

Morphology: It is a perennial, erect subshrub of height 1 m; it branches near the base and spreads over an area of some 60- 70 cm in diameter. Leaves are smooth, glossy, dark green up to 5 cm long. There are two flower varieties, alba (white) and roseus (pink) in the natural state, and several hybrids. The flowers are borne at the ends of the branching stems. The flowers are fragile, and have purplish-red or yellowish circular nectar guide at the mouth of the corolla tube. The fruit is a cylindrical follicle containing many black seeds.

Chemical Composition: The interest of the scientific community arose in this plant in 1950's after hearing of a "periwinkle tea" that was drunk in Jamaica for its antidiabetic properties. All parts of the plant contain alkaloids but leaves are used as a commercial source for the isolation of the two important anticancer alkaloids - vincristine and vinblastine. These are known to inhibit the growth of tumors. Today, we know that periwinkle is endowed with other medicinal properties also. In all, it contains more than 90 known alkaloid agents.

Uses

1. Vinblastine sulphate is mainly used for the treatment of Hodgkin's disease (cancer of the lymphatic system).
2. Vincristine sulphate is useful for treatment of leukaemia and lymphocytic leukaemia.
3. Long before modern researchers learned of this plant's medicinal properties, folk healers in faraway places used the Madagascar periwinkle for a number of medicinal uses. In India, wasp sting was treated with the juice from the leaves.
4. In Hawaii, an extract of the boiled plant is used to stop bleeding.
5. In Central America, it is used for gargle to ease sore throats and chest ailments.
6. In Cuba, Puerto Rico, Jamaica, and other islands, an extract of the flowers is commonly used as eyewash.

8.3.6 *Adhatoda vasica* L. (syn. *Justicia adhatoda*)

Family: Acanthaceae

Vernacular name: Malabar nut, Adulsa and Vasakat.

n = 17

Origin and Distribution This medicinal plant is native to Asia and widely distributed in India, Bangladesh, Nepal, Sri Lanka and Myanmar. It has been introduced elsewhere and used in Siddha Medicine, Ayurvedic, homeopathy and Unani systems of medicine. Plant grows in crowded areas along wasteland and roadsides throughout India.

Morphology *Adhatoda* is a large, perennial, evergreen shrub which reaches the average height of 3 m. Leaves are simple, ovate or lance-shaped about 10 to 15 cm in length and 4 cm. wide. They are oppositely arranged, smooth-edged, and borne on short petioles. Bark is yellowish in colour. Flowers are usually white arranged in large, dense, axillary spike inflorescence with large attractive white petals having purple line on lower lip. Fruits are small ovate or club-shaped capsules (Fig. 8.8).

Cultivation: The plant thrives well in loamy soil of hills and plains. The growth of the plant is best at temperature range of 20-27° C.

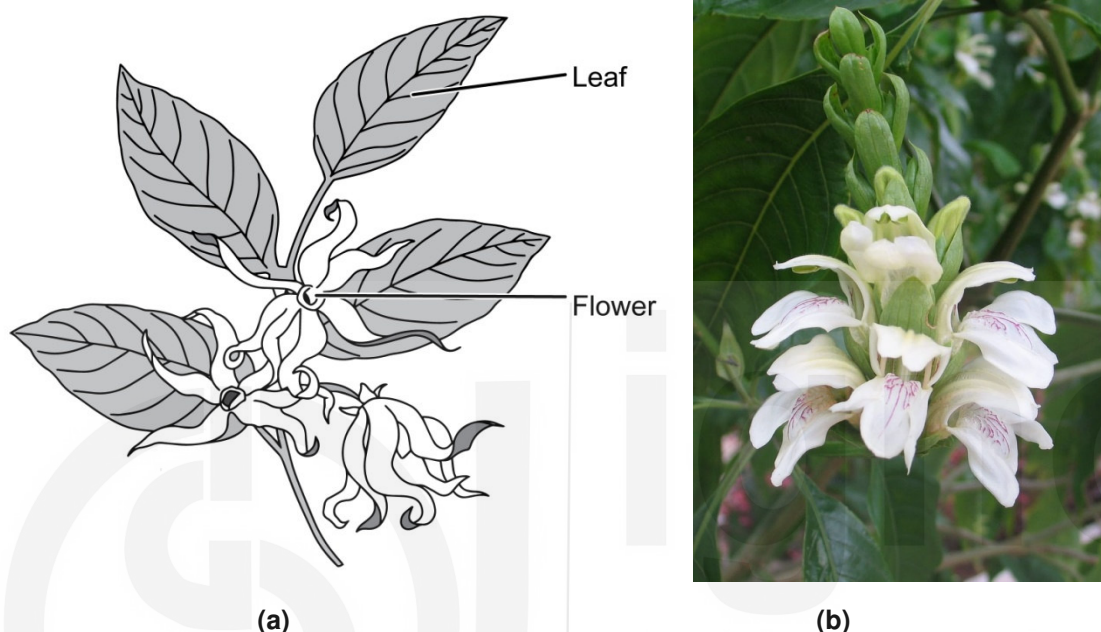


Fig. 8.8: a) A twig of *Adhatoda vasica* showing flowers; b) inflorescence in *Adhatoda*

Chemical composition The leaves of *Adhatoda vasica* contain phytochemicals such as alkaloids, tannins, saponins, phenolics and flavonoids. The most important alkaloids include vasicine, vasicol and adhatodinine. The vasicine yield of the herbage has been measured as 0.541 to 1.1% by dry weight.

Uses

This shrub has a number of traditional medicinal uses in Siddha Medicine, Ayurvedic, Homeopathy and Unani systems of medicine.

- In Ayurveda *A. vasica* is used for treating respiratory diseases. It is a main ingredient in medicines for cough, cold and asthma. It reduces the inflammation of lung airways.
- Vasicine compound found in *A. vasica* is bronchodilator which eases the breathing and reduces wheezing due to asthma.
- *Adhatoda vasica* also possess antibacterial and antimicrobial properties.
- According to Ayurveda it is beneficial in bleeding disorders and ulcerations. Its use can also be helpful in peptic and duodenal ulcer.
- *A. vasica* reduces hyperacidity in stomach. It also has shown good results in treatment of dyspepsia and gastritis. It is an appetite stimulant and improves appetite.

- It is a mild anti-hypertensive that is it reduces blood pressure.
- *A vasica* also reduces joint inflammation. In combination with other herbs it helps in reducing raised uric acid and pain and tenderness associated with gout. In gouty arthritis it is used in combination with giloy (*Tinospora cordifolia*) and amaltas (*Cassia fistula*)
- *Vasica* root decoction is found beneficial in decreasing the urea level and other nitrogenous wastes in blood.

8.3.7 *Ephedra sinica* L.

Family: Ephedraceae

Vernacular name: Joint Pine, Mahuang

n = 7

Origin and Distribution *Ephedra* is a genus of gymnosperms and the only genus of family Ephedraceae and order Ephedrales. This plant is of Chinese origin. Various species of *Ephedra* are widespread in arid and semi arid regions of South Western America, Southern Europe, Northern Africa, South west and Central Asia northern China and Mangolia. It grows in dry climate and is found worldwide except Australia. In India plant is found in dry parts of Punjab, Haryana, Rajasthan, Sikkim and Jammu and Kashmir.

Cultivation *Ephedra* is well adapted to arid and semi arid regions. Most *Ephedra* species grow on shores or on sandy soils with direct sun exposure. It is easily propagated by its rhizomes.

Morphology Plant is an evergreen shrub but some species are climbers, vines and rarely trees too. The prominent underground tap root system with many adventitious roots is present in *Ephedra*. The stems are green, ribbed, profusely branched, hard and photosynthetic. Leaves are scale like or needles upto 3 cm. long, opposite or whorled. Scale like leaves fuse at their base to form a sheath. Plants are mostly dioecious with male strobili in whorls of upto 10 cones, each consisting of a series of decussate bracts (Fig.8.9a). Female cones also occur in whorls. They have bracts which fuse around a single ovule. Each strobilus contains 1 or 2 yellow to dark brown seeds (Fig.8.9b).

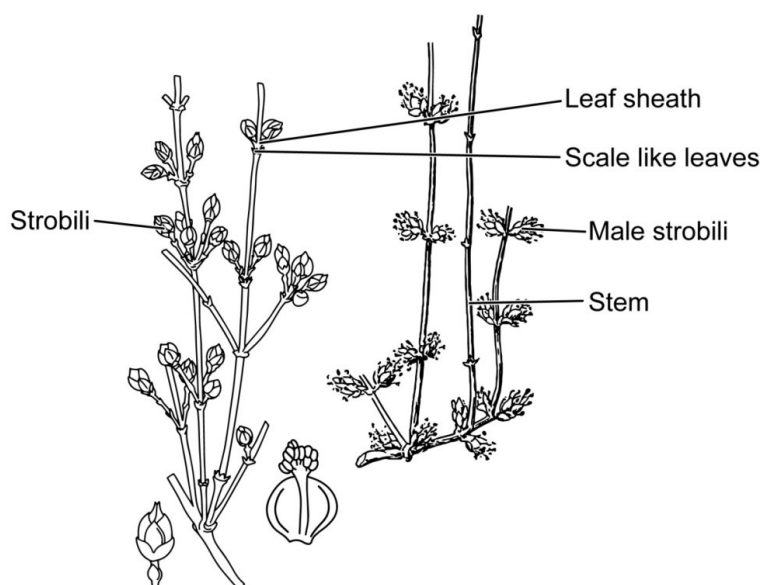


Fig.8.9: *Ephedra* plants showing male strobili, flowers, fruit and seed.

Chemical composition: Dried stem and leaves of the plant are used as medicine. *Ephedra* contains the alkaloids ephedrine, pseudoephedrine, nor pseudoephedrine, methyl ephedrine tannins, amino acids and phenolic compounds.

Uses

- *Ephedra* (*E. sinica*) has been used for centuries in traditional Chinese medicine primarily for treatment of hay fever, asthma and bronchitis.
- *Ephedra* is used for treatment of flu, cold, nasal congestion and headache. The dried stem and leaves of the plant have been used to make tablets, capsules, extracts and teas.
- *Ephedra* is also used for weight loss and obesity, sometimes in combination with aspirin and caffeine.
- The plant is known for enhancing energy level and sometimes taken by athletes to enhance their performance.
- According to recent researches by U S Food and Drug Administration (FDA) there is little evidence of Ephedra effectiveness except short term weight loss but it increases the risk of heart problems and stroke, so its use is banned in America.
- Adverse effects of *Ephedra* consumption may include severe skin reactions, irritability, nervousness, dizziness, trembling, headache, insomnia, profuse perspiration, dehydration, itchy scalp and skin, vomiting etc. More serious potential side effects include irregular heartbeat, seizures, heart attack, stroke, and even death.

SAQ 3

- a) Fill in the blanks with appropriate words
- Adhatoda* contains an alkaloid, which is a bronchodilator and eases in breathing.
 - Leaves of *Catharanthus* are the source of two anticancer alkaloids. and
 - Periwinkle is known for its and properties.
 - In Chinese medicine is used for treatment of hayfever, bronchitis and asthma.
 - is used for weight loss and obesity.
- b) Correctly match the medicinal plants given in column 1 with their use in column 2:

Column 1

Column 2

- | | |
|------------------------------|---------------------------|
| i) <i>Papaver somniferum</i> | 1. weight loss |
| ii) <i>Catharanthus</i> | 2. moon disease |
| iii) <i>Adhatoda vasica</i> | 3. analgesic and narcotic |

iv) <i>Ephedra</i>	4. anticancer drug
v) <i>Digitalis purpurea</i>	5. cardiac disorders
vi) <i>Rauwolfia</i>	6. bronchodilator and ease in breathing
vii) <i>Artemisia</i>	7. antimicrobial and insecticidal

8.4 SUMMARY

- *Digitalis* sp. (Foxglove) is a biennial rarely perennial herb belonging to the family Plantaginaceae (Former Scrophulariaceae). The leaves contain active glycosides digitoxin, gitoxin, and digoxin. These glycosides increase cardiac contractibility and are used for treatment of heart diseases.
- *Papaver somniferum* (Opium poppy) is an erect glaucous, annual herb of family Papaveraceae and yields opium. Crude opium contains about 40 alkaloids. Some important ones are morphine, codeine, thebaine, narcotine and papaverine known for their powerful analgesic and narcotic properties.
- *Rauwolfia* sp. (Serpentwood or Sarpagandha) belonging to the family Apocynaceae is an erect, evergreen, perennating, glabrous undershrub. Roots especially the bark of root is rich in alkaloids of which reserpine, rescinamine, ajmaline, ajmalisine and serpentine are of commercial importance. Powdered taproots are used for treatment of Moon disease, snake bite and also for mental disorder named Schizophrenia.
- *Artemisia* (Mugwort) belonging to the family Asteraceae is a tall herbaceous perennial plant with extensive rhizome system. Mugwort root extract is used as a general tonic. *Artemisia* contains sedatives, antidepressants and has calming effect on mental stress, depression and anxiety.
- *Catharanthus roseus* (Periwinkle) of family Apocyanaceae is a perennial erect shrub of about 1m. It is used for its antibiotic properties. Leaves of the plant contain two anticancer alkaloids – Vincristine and Vinblastin. Besides, this plant also possesses many other therapeutic properties.
- *Adhatoda vasica* (Malabar nut) of family Acanthaceae is a large shrub. It is used for treatment of respiratory ailments. It contains an alkaloid Vasicine which is bronchodilator and eases breathing. It also contains antibacterial and antimicrobial properties.
- *Ephedra* sp. (Joint pine) of Gymnosperm family Ephedraceae grows in arid and semi arid regions on shores and sandy soils. Plants are evergreen shrubs. It contains ephedrine alkaloids and used for treatment of cold, fever, flu, nasal congestion and headache. It is also taken for weight loss and as energy boosting drug.

8.5 TERMINAL QUESTIONS

1. Give the botanical names, family, general morphology and uses of any two: Poppy, Mugwort, Sarpagandha.
2. Discuss in brief the morphology, chemical composition and therapeutic uses of *Ephedra*. Why its use is banned in America?
3. Describe in brief the morphology, chemical composition and uses of *Digitalis purpurea*.

8.6 ANSWERS

Self-Assessment Questions

1. a) Digitalin; b) Steroids; c) Emulsifiers; d) good agricultural practices
2. a) False; b) True; c) False; d) False; e) False; f) True
3. a) i) Vasicine; ii) Vincristine, vinblastine; iii) Antidiabetic, anticancer
iv) *Ephedra sinica*; v) *Ephedra*
b) i) analgesic and narcotic; ii) anticancer drug; iii) bronchodilator and ease in breathing
iv) weight loss; v) cardiac disorders; vi) moon disease;
vii) antimicrobial and insecticidal

Terminal Questions

1. Refer to Section 8.3.
2. Refer to Subsection 8.3.7.
3. Refer to Subsection 8.3.1.

Acknowledgements

Fig. 8.2 b : Source:
[https://www.google.co.in/imgres?imgurl=https%253A%252F%252Fwww.verywellhealth.com%252Fthumb%252FCYs0kiHH-dozBXFez0xsNq_2OeM%253D%252F2018x2018%252Fsmart%252Ffilters%253Aano_upscale\(\)%252FGettyImages-646988534-5a5653bc980207003721e35f.jpg&imgrefurl](https://www.google.co.in/imgres?imgurl=https%253A%252F%252Fwww.verywellhealth.com%252Fthumb%252FCYs0kiHH-dozBXFez0xsNq_2OeM%253D%252F2018x2018%252Fsmart%252Ffilters%253Aano_upscale()%252FGettyImages-646988534-5a5653bc980207003721e35f.jpg&imgrefurl)

Fig. 8.4: : Source:
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TIMBER PLANTS |

Structure

9.1	Introduction	9.4	Different Uses of Wood
	Objectives	9.5	Summary
9.2	General Account	9.6	Terminal Questions
9.3	Important Timber Yielding Plants	9.7	Answers
	<i>Tectona grandis</i>		
	<i>Dalbergia sissoo</i>		
	<i>Pinus roxburghii</i> , <i>P. wallichiana</i>		
	<i>Cedrus deodara</i>		

9.1 INTRODUCTION

By now you have studied that we use plants for various purposes such as foods, beverages and medicines. In addition, several plant products provide us shelter and clothing.

From the time immemorial, food, clothing and shelter have been the three great necessities of mankind. Wood is the most familiar and most important forest products. The wood has contributed a lot to the advancement of civilization. Today, the wood is the most widely used commodity other than food and clothing. It is one of the most important and versatile of the raw materials of the industry.

Wood is produced as a result of secondary growth in gymnosperms and dicotyledonous plants. Woody tissues help in increasing weight of the plant. Besides timber and fuel, woody tissues yield many useful products such as gum, resin, turpentine, paper, rayon, cork, and rubber. Plant fibres also provide the raw material for various products such as cloth, mats, bags, and ropes. In this unit you will study about the timber plants and various uses.

Objectives

After studying this unit, you should be able to:

- ❖ list the important wood yielding plants and describe their important features;

- ❖ list the properties and characteristics of different woods and various uses;
- ❖ describe the processing of various woods for commercial use; and
- ❖ explain the process of papermaking.

8.2 GENERAL ACCOUNT

Wood has been an important and indispensable forest product used by mankind for ages. Primitive man used it for construction of shelters, implements and utensils. Several indigenous tree species from the natural forests are being used for various ways, as fuel, for construction, timber products, and as raw material in the paper industry. It became an inexhaustible natural resource because of overexploitation and decline in the forest area. Wood continues to play an important role in our lives, hence need to be used with proper care. Despite the availability of various metals and synthetic products, we have not been able to find substitutes for wood till date. Judicious utilization and care is needed to keep the forest plantations alive. You will now study about four such sources of wood which are used at commercial scale in India.

Timber plants are usually medium to large trees which are cut to extract the wood. It is also known as “**lumber**” in US and Canada. Timber trees are broadly classified into trees of soft, semi-hard and hardwoods. **Hardwood** is derived from angiospermous (mainly dicotyledonous) plants. They have a superior quality that last for years. Hardwood plants provide the best quality wood as they possess more resistance and are used for construction of high-end furniture, floors, ceilings and even houses. Wood obtained from oak, birch, beech, is called hardwood. **Softwoods** are obtained from gymnosperms (mainly coniferous). Softwood is generally used in the manufacture of products such as crates of vegetables, crafts and even paper.

Wood used in construction, furniture and paper pulp is timber and products produced or derived from them are timber products. The products produced from the stems are often called timber products. Products produced/derived from woody parts of plants are termed as wood products. Timber has a high strength to weight ratio.

8.3 IMPORTANT TIMBER YIELDING PLANTS

About 500 timber species are known whose trunk and branches provide wood. Some of the important timber trees are Khair (*Acacia catechu*), Babla (*Acacia nilotica*), Chatim (*Alstonia scholaris*), Itchri (*Anogeissus acuminata*), Kadam (*Anthocephalus chinensis*), Shimul (*Bombax ceiba*), Kamdeb (*Calophyllum polyanthum*), Batna (*Castanopsis tribuloides*), Shisham (*Dalbergia sissoo*), Garjan (*Dipterocarpus alatus*), Gamari (*Gmelina arborea*), Sundari (*Heritiera fomes*), Telsur (*Hopea odorata*), Sidha (*Lagerstroemia parviflora*), Aam (*Mangifera indica*), Tali (*Palaquium polyanthum*), Batna (*Quercus spicata*), Bhobinut (*Samanea saman*), Sal (*Shorea robusta*), Dharmara (*Sterospermum personatum*), Mahogany (*Swietenia macrophylla* and *S. mahagony*), Teak (*Tectona grandis*), Toon (*Toona ciliata*). International trade code of flora and fauna governs the timber species suitable for commercialization and export.

You will now study about four such sources of wood which are used on a commercial scale in our country.

9.3.1 *Tectona grandis*

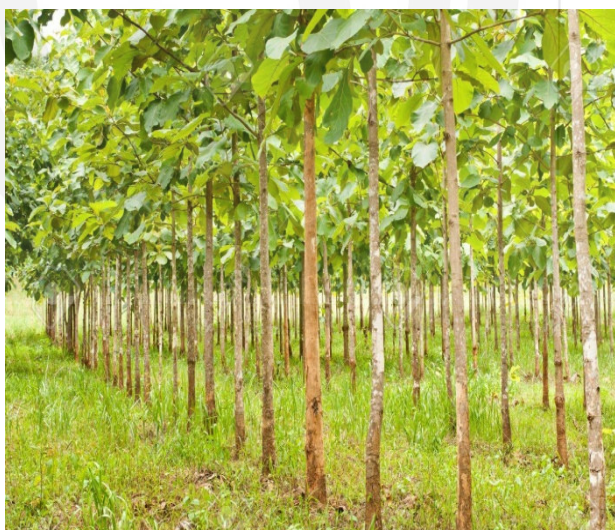
Family: Verbenaceae

Common names: Teak, Rangoon or Burma teak, Moulmein teak, Singur, Sangwan

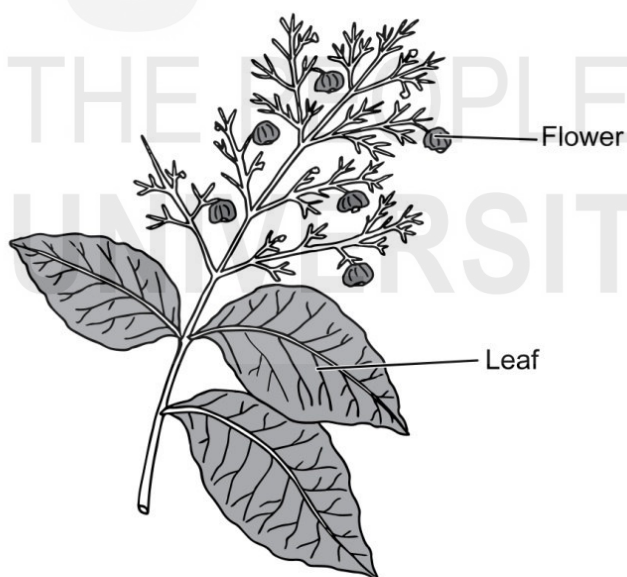
n = 12, 18

Distribution: It is native to South-east Asia and Malaya and is one of the most important commercial timber crops of the tropics. Myanmar and Thailand have extensive teak forests. In India, teak forests are present in the states of Madhya Pradesh, Maharashtra, Gujarat, Karnataka, Rajasthan, Kerala, Tamil Nadu, and Andhra Pradesh.

Characteristics: Teak is a large, deciduous tree with a probable age of over 200 years (Fig. 9.1a). Teak is a tropical, flowering tree growing up to 40 m in height and 1 m in bole diameter. The flowers are fragrant, white, and small. Leaves are large, ovate-elliptic, papery, often hairy on the lower surface (Fig. 9.1b). Fruits are globose. Teak is highly valued for its wood which is of superior quality. Highly durable and water resistant, it is used for boat building, exterior construction, veneer, furniture, carving, etc.



(a)



(b)

Fig. 9.1: a) Photograph showing teak plantations; b) A twig of *Tectona* showing flowering.

The sapwood is white and rather susceptible to attack by termites and wood rotting fungi. The heartwood is golden yellow to golden brown when freshly sawn, turning darker after exposure and is relatively immune to insect attack. The wood is greasy to touch and smells like old leather. It is hard, and does not warp, split, or crack and is thus valuable for general construction. It is resistant to decay and termites even when unprotected by preservatives and is

renowned for its stability. Teak wood is not very difficult to work with and it takes very good polish. The grain is normally straight, and the texture is coarse and uneven. The average weight is between 609-689 kg/m³ when dry. It shows distinct growth rings. The wood is ring porous and is marked by the presence of large vessels (Fig. 9.2). The vessels of early wood are distinctly larger than those of the late wood. The pores seem to be arranged in concentric circles when seen in a transverse section. Tyloses are quite common.

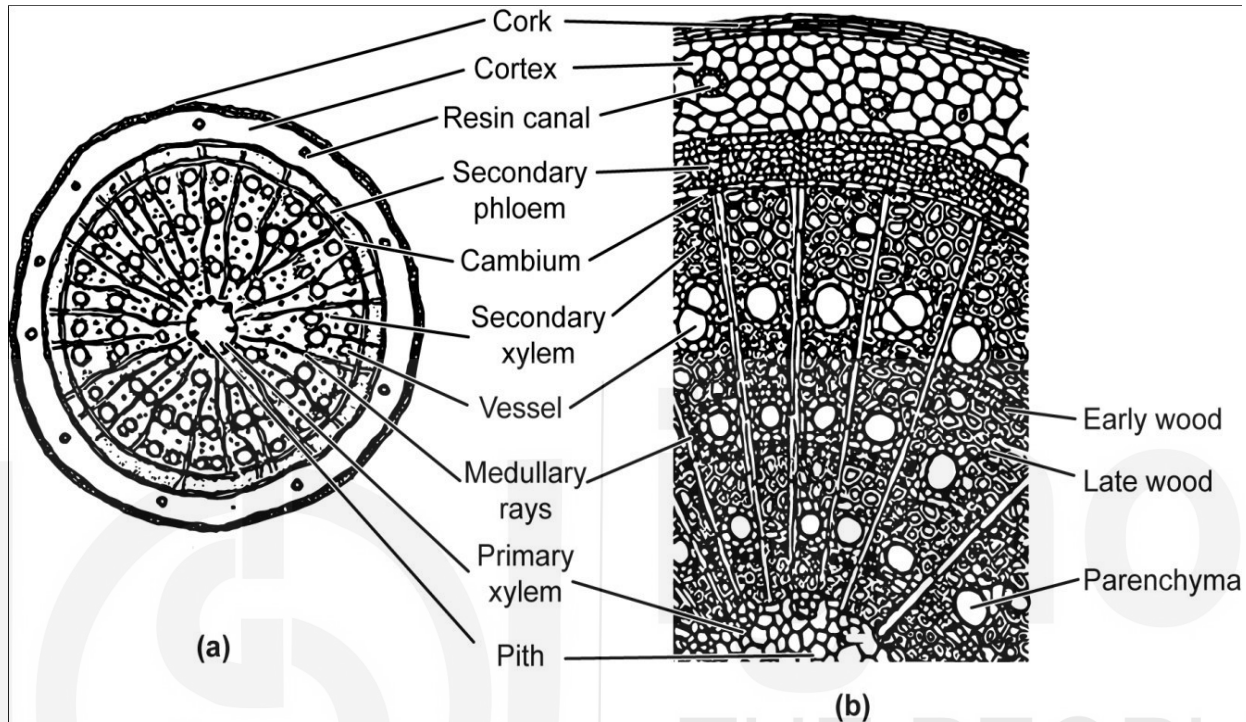


Fig. 9.2: a) A section of wood obtained from trunk of teak; b) Transverse section of *Tectona* stem.

Uses: Teak ranks among the best timbers of the world. It is the chief source for railway carriage and wagon wood of India. It is superior to oak in ship building. Its wood is used in construction of houses; building bridges; making cabinets and boats; for carving; plywood manufacture; for flooring; making toys, and in many other ways.

9.3.2 *Dalbergia sissoo* Roxb

Family: Fabaceae

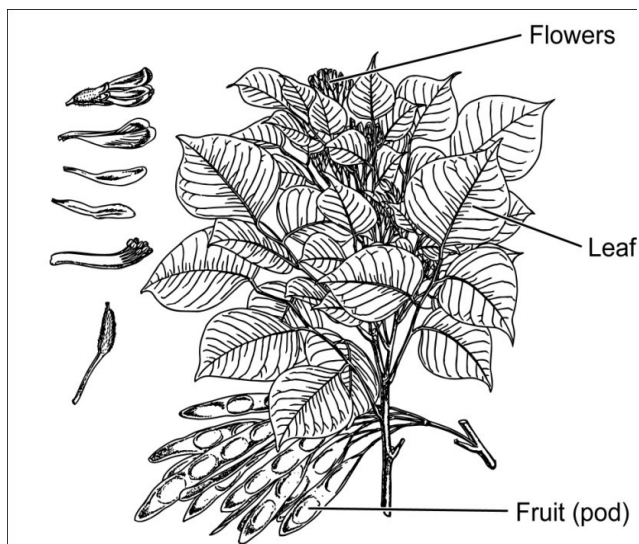
Common names: Shisham, Rosewood

n = 10

Distribution: *Dalbergia* is a genus of tropical trees providing valuable dark timber. *D. latifolia* (Indian rosewood) and *D. sissoo* (sissoo) are important Asian species and are amongst the finest of India's cabinet and furniture woods. Sissoo occurs throughout the sub-Himalayan tracts to Assam (Fig. 9.3a). Indian rosewood is found in central and southern India and also in sub-Himalayan tracts. Other common *Dalbergia* species are *D. nigra* (Brazilian rosewood), *D. melanoxylon* (African blackwood), *D. retusa* (cocobolo) and *D. stevensonii* (Honduras rosewood).



(a)



(b)

Fig.9.3: a) Photograph of tree of *Dalbergia sissoo*; b) Flowering twig of *Dalbergia*.

Characteristics: *Dalbergia sissoo* is a medium to large tree which grows up to 10 to 15 m metres in height. It is a deciduous tree. Leaves are compound, with about five alternate leaflets. Leafstalk (petiole) measures about 15 cm long, each leaflet widest at the base with a fine pointed tip (Fig. 9.3b). The trees have panicles of small, yellow or white papilionaceous flowers. Flowers occur in dense clusters on short stalks. The dry fruit is a pale brown pod, flat, thin and papery, about 7 cm. Seed are visible from within pod.

The sapwood is white to brownish, and the heartwood is golden brown to dark brown. The pale, straw-colored sapwood is clearly demarcated from the heartwood (Fig. 9.4).

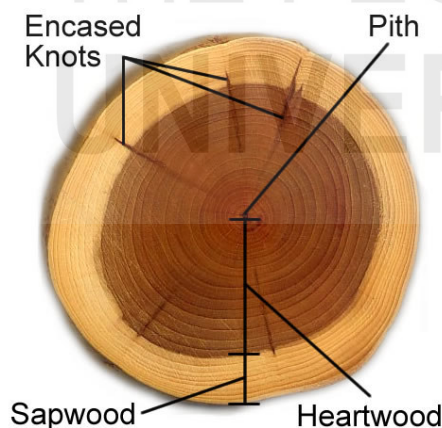


Fig. 9.4: T.S. stem of *Dalbergia* showing Heartwood and Sapwood.

It is a durable, heavy wood with an average weight of $800\text{--}850\text{ kg/m}^3$. In Indian rosewood the sapwood is yellowish, but the heartwood varies from dull brown to almost purple. It is a durable wood, especially under water. It weighs around $800\text{--}960\text{ kg/m}^3$. Although not easy to work with, it carves well.

Uses: *Dalbergia* provides wood for high class furniture and cabinets. It is valued as a construction and general-purpose timber and is used for railway sleepers, musical instruments, hammer handles, shoe heels and tobacco pipes. It is good for charcoal making and is used for decorative veneers as well.

9.3.3 *Pinus roxburghii*, *P. wallichiana*

Family: *Pinaceae*

Common names: Chir, Blue pine

n = 12

Distribution: In India, *Pinus roxburghii* (chir) and *P. wallichiana* (kail) are the two most popular species of *Pinus* that yield timber. *P. roxburghii* occurs in the outer hill ranges of Siwalik and the valleys of Himalayas. *Pinus wallichiana* occurs at higher altitudes. Pines are common in Himachal Pradesh, Jammu and Kashmir, Punjab, and Uttar Pradesh. Other commercial pine timbers come from *P. strobus* (American yellow pine), *P. monticola* (Western white pine), *P. sylvestris* (Scots pine), *P. ponderosa* (Ponderosa pine) and many more.

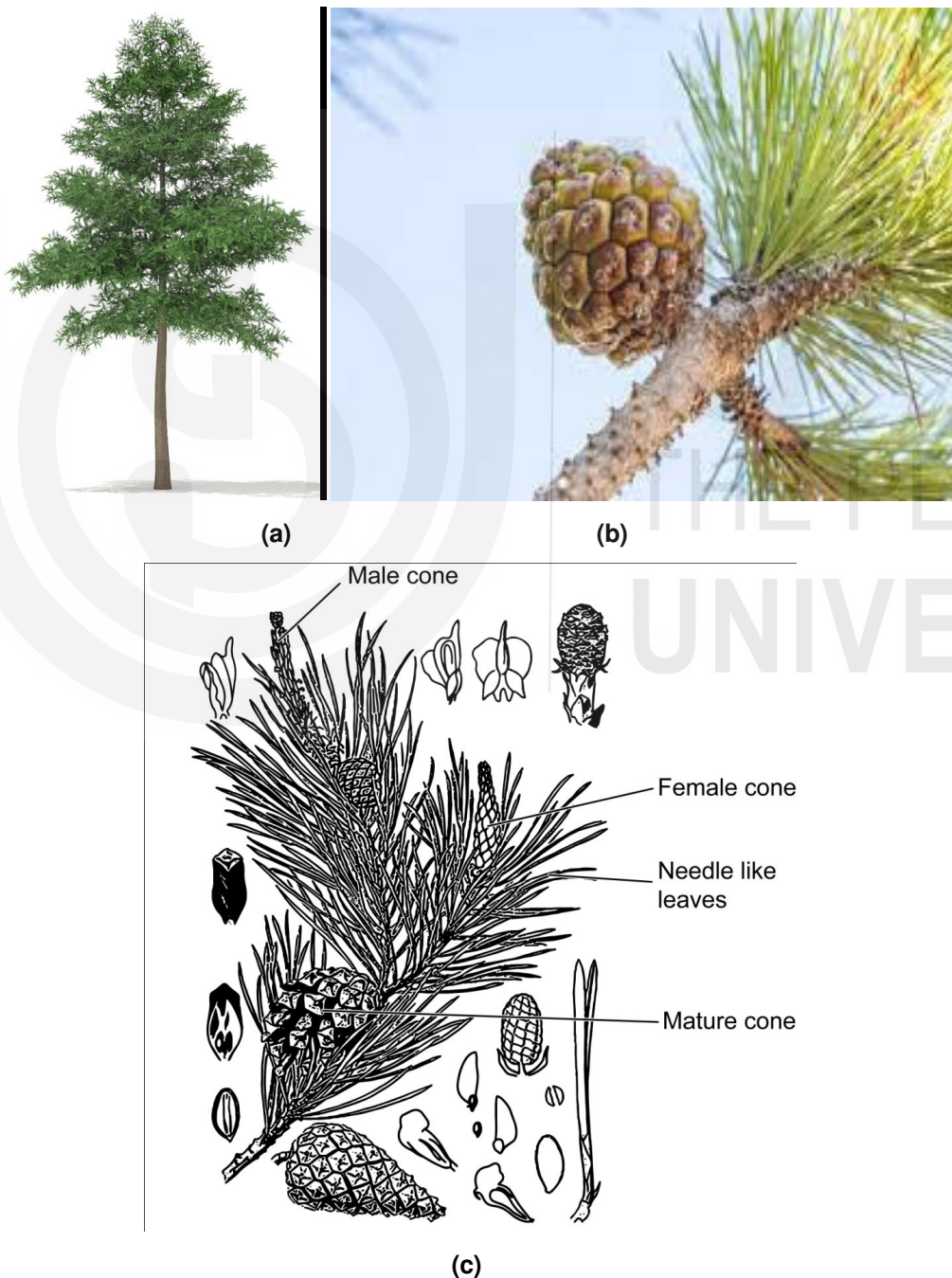


Fig. 9.5: a) Pine tree; b) branch of pine tree showing cone; c) Fruiting twig of Pine.

Characteristics: Pines are generally tall trees that bear characteristic needle-like leaves, and distinct male and female cones (Fig. 9.5 a, b, c). Pines have two types of branches, long shoots and short shoots, and three types of leaves, primordial, scale, and adult. The triangular scale leaves (lance-shaped), are borne on the long shoots of older trees. Both long and short shoots develop in the axils of the deciduous scale leaves. The needlelike photosynthetic adult leaves, with two or more resin canals, are borne in fascicles (bundles) of two to five (rarely, up to eight or solitary) at the tip of each short shoot.

Pine timber falls into two broad categories - the soft or white pines, and the hard, yellow or pitch pines. The former have soft, light-colored wood-tinged pink in the heartwood and nearly white in the sapwood. The latter have a resinous, heavy, hard, strong, and durable wood, with a pronounced, grain pattern. The wood is light, easy to work but not durable. The timber is straight grained and has little resin (Fig 9.6).



Fig.9.6: Bark and wood of Pine.

Soft pines, such as white, sugar, and piñon pines, have relatively soft timber, needles in bundles of five (less commonly, one to four), stalked cones with scales lacking prickles, and little resin. Their wood is close-grained, with thin, nearly white sapwood. The leaf sheaths of the leaf clusters are deciduous. Hard pines, such as Scotch, Corsican, and loblolly pines, have relatively hard timber, needles in bundles of two or three (rarely, five to eight), cone scales with prickles, and large amounts of resin. Their wood is coarse-grained and usually dark-coloured, with pale, often thick sapwood; the sheaths of the leaf clusters are persistent.

Uses

Soft pines are used for making matches, crates, boxes and rough carpentry work. Hard pine is used in construction of buildings, bridges and ships.

9.3.4 *Cedrus deodara*

Family: Pinaceae

Common name: Deodar, Himalayan cedar

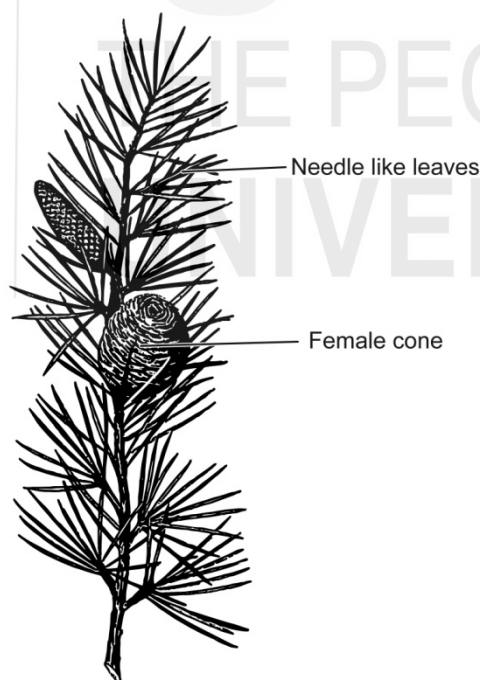
Cedrus has four species namely *C. atlantica* (atlas cedar), *C. brevifolia* (Cyprian cedar), *C. libani* (Cedar of Lebanon), *C. deodara* (Deodar Cedar Tree, Himalayan Cedar). There are some false cedars also reported from other areas. Even though false cedars aren't officially in the genus *Cedrus*, knowing the varieties commonly identified as cedar, especially in North America. These include Alaskan Yellow Cedar (*Cupressus nootkatensis*), Bermuda Cedar (*Juniperus bermudiana*), Eastern Red Cedar Tree (*Juniperus virginiana*), Incense Cedar (*Calocedrus decurrens*), Northern White Cedar (*Thuja occidentalis*), Port Orford Cedar (*Chamaecyparis lawsoniana*), Siberian Pine (*Pinus sibirica*), Spanish Cedar (*Cedrela odorata*), Western Red Cedar (*Thuja plicata*).

Distribution: The tree is native to mountainous areas of the Mediterranean region and one to the western Himalaya. Cedar is one of the most important and strongest Indian softwood growing mainly in the northwestern Himalayas in Kashmir, Himachal Pradesh, Uttar Pradesh and Punjab.

Characteristics: It is a tall tree about 45-60m in height. The tree has horizontal spreading branches giving it a characteristic skyscraper appearance. Trunks are large with massive, irregular heads of spreading branches. Young trees are covered with smooth, dark-gray bark that becomes brown, fissured, and scaly with age. The Leaves are needlelike, three-sided, rigid and scattered along the long shoots and clustered in dense tufts at the ends of short spurs. Female cones are large, barrel-shaped, resinous, greenish or purplish and borne on short stalks. They are covered by broad, thin, closely overlapping woody scales, each with a claw like projection.



(a)



(b)

Fig. 9.7: a) Cedar tree; b) Twig of cedar with leaves and cones.

Cedarwood is light, soft, resinous, and durable. Its sapwood is white in colour and the heartwood is light yellow, turning brown on exposure to air. The timber is durable and resistant to insects. Wood is fine and uniform in texture. True cedars are evergreen and have aromatic, often red or red-tinged wood that is resistant to decay and insects.

Uses

The wood is mainly used in making railway coaches, beams, posts, doors, window frame and construction of bridge. It is also used in making pencils, chests, closet linings, carving, fence posts and packing. Distilled oil from the wood is used in many toiletries.

SAQ 1

- a) Match the items in Column I with those of Column II.

Column I	Column II
i) Shisham	1. Verbenaceae
ii) Teak	2. Pinaceae
iii) <i>Dalbergia melanoxylum</i>	3. <i>Pinus sylvestris</i>
iv) Kail	4. <i>Pinus wallichiana</i>
v) Scots pine	5. African blackwood
vi) Pine	6. Fabaceae
vii) <i>Cedrus deodara</i>	7. Strongest Indian soft wood

- b) Name the wood which is used for the following purposes:

- Furniture making
- For making of musical instruments
- Construction of houses and bridges
- Making matches
- For carpentry work
- Making beams, posts, door and window frames

9.4 DIFFERENT USES OF WOOD

Woods are being put to different uses and processed to make them suitable for the requisite purpose. Different woods are used for different purposes. Some of the common examples are discussed below.

Processing wood for use: Trees are felled by cutting across the trunk as close to the ground as possible. The side branches are then removed, and the trunks are cut into suitable lengths, known as saw logs. The powered saws are now used instead of the hand saws in several parts of the world, hence the processing of fresh logs is becoming increasingly mechanized. Wood is unique among the various raw materials and no replacement has been found to it. Its uses are numerous such as fuel, construction work, furniture, containers, mechanically reduced products, chemically derived products and so on.

Fuel

The wood is used as a fuel for heating and cooking from prehistoric times. Recently this practice has been replaced to some extent by fossil fuels or electricity. Still, wood is largely consumed for fuel rather than any other purpose. Wood is an excellent fuel, since 90% of the oven dried wood is combustible. Woods vary greatly in their fuel value and this depends mainly on their density, chemical composition, and the amount of moisture. The hardwoods such as beech, oak, maple, and birch best fuel woods serve as the best fuelwood. The average calorific value of seasoned wood is around 4600 cal/kg.

1. Construction Materials

Poles - Employed chiefly for telephone, telegraph, and electrical transmission lines. Durable wood, which is light, straight, and strong to resist stresses, is used. Coniferous trees are the principal source of wood. Such woods are also used in construction of shelters.

Pilings - Used for the construction of docks, bridges, and wharves. These are straight, round timber, driven beneath water for construction work. Pines are commonly used and so is oak, the latter mainly for dock and harbour work and for marine pilings.

Posts - Used for the erection and maintenance of fence lines along farm and ranch boundaries, railroads, and highways. Strength, lightness, and durability are the main requirements. Any available local species can be used.

Mine timbers - Include a variety of wooden supports such as props or legs, crossbars or caps used in the construction of mine tunnels to prevent debris from falling or where the underground formations are likely to cave in. Mostly those hardwoods that are durable and strong and resistant to decay and corrosion are employed for the purpose.

Railroad ties or sleepers or cross ties - Used to support and hold railroad rails. The wood used need to be durable, treatable and able to withstand the impact and pressure of heavy and speedy traffic, hold spikes and screws and be easily available and inexpensive. Oak is the most widely used wood for this purpose. The wood is usually treated with preservatives and can last up to 30 years.

Veneers - These are thin sheets of wood of uniform thickness, produced by peeling, slicing, or sawing logs. Veneers are made by one of the following three methods - rotary cutting, slicing, or sawing. Of these, rotary cutting is the most common method employed. Logs selected for this process are debarked and softened by steaming or steeping in hot water. This facilitates cutting and minimises the danger of splitting. They are then crosscut to desired lengths. Many woods like *Douglas fir*, *Ponderosa pine* and *Poplars* are used. Fine veneers are made from expensive woods like walnut, teak, and rosewood.

Plywood - It is a thin board made up of an odd number of three or more very thin sheets of veneers glued together under pressure, ranging in thickness from 3-25 mm. Successive veneers are positioned in such a way that the grain of each is at right angles to the adjoining sheet (in a cross-banded way), making the structure as strong and even stronger than the wood itself. The major advantage of plywood over solid woods is dimensional stability and that it is

much less likely to warp or twist than ordinary wood. Plywood has the strength distributed in both directions, and the nails and screws can be driven close to the edge without any danger of splitting. Also, it can be molded, and it comes in much larger sizes and can be used for making partitions, walls and roofs. Durable timbers such as oak and teak are used. Plywood is used for inner cabinet work, roof and wall sheathing, flooring, automobile body parts, boards, ceilings, counters, desks, drawers, and furniture.

2. Containers

Cooperage - It's the art of making wood containers such as barrels, tubs, tanks, and the construction of wooden pipelines for transporting city water supplies. There are two principal divisions of the cooperage industry, namely, slack (or dry) cooperage made for packaging, storing, and transporting dry material, and tight (or wet) cooperage for holding liquids such as beer, whisky, and wine syrups. Woods selected for slack cooperage must be cheap, light, easy to work, elastic and free from warping. Pine, beech, oak, and maple are commonly employed. For making tight cooperage the inner walls are coated with an inert material such as paraffin, silicate of soda or glue to prevent leakage and contamination of liquids. Hardwoods, especially oak are commonly used because of their strength and durability, impenetrable nature, and thermal insulation properties. Woods used for the purpose are red gum, white ash, yellow birch, and Douglas fir.

3. Chemical Products

Wood is mainly made up of cellulose, hemicellulose, lignin and varying amounts of tannins, resins, gums, and latex. It serves as a basic raw material for deriving several chemical products using various methods. Some examples are given below:

Wood distillation - This is an ancient process. One of the chief sources of wood for destructive distillation is the waste left by lumbering operations and sawmills. The wood is heated in a cast iron or steel retort or oven in the absence of air. Charcoal residue is left behind in the retort, and the escaping vapors are conducted through water-cooled condensers. The condensate (pyroligneous acid) is allowed to settle, and tar and oils are separated out from the liquid above. Meanwhile the non-condensable gases are trapped and are used to help heat the oven.

Based upon the kind of wood used, distillation can be classified into hardwood and softwood distillation. Denser and heavier woods like sugar maple, birch, oak, and beech are employed in hardwood distillation and the products are:

- i) charcoal - the solid residue,
- ii) pyroligneous acid - a yellowish green, ill smelling liquor or condensate consisting of water, acetic acid, methanol, and dissolved tar,
- iii) wood tar - the water insoluble fraction that settles at the bottom of the aqueous pyroligneous acid, and
- iv) the non-condensable wood gas, used as fuel or for illumination purposes.

On the other hand, softwood distillation utilises resinous pinewoods, chiefly of long leaf and slash pines. The principal distillation products are charcoal, wood turpentine, pine oil, dipentine, pine tar, tar oils, wood gas and a small amount of wood alcohol (methanol) and acetic acid.

Tapping for naval stores industry - The term 'Naval Stores' was initially used to designate the pitch obtained by tapping pine trees. Pitch and its derivatives were used extensively by the European maritime industry in the late sixteenth century for caulking the planks of wooden sailing ships and for water proofing riggings and hawsers. The species used now-a-days are the long leaf and slash pines in the USA, maritime pine (*Pinus pinaster*) in Europe, and *Pinus roxburghii* in India. Besides pines, Douglas fir, spruces and larches are the other conifers tapped for the purpose. Three different types of products are obtained by this industry: (i) gum turpentine and gum rosin, derived from the gum (oleoresin) bled from living trees; (ii) wood turpentine and wood rosin, obtained by the action of steam and suitable solvents on macerated or chipped stumps and roots left behind after lumbering; and (iii) sulphate turpentine and sulphate rosin, important byproducts of pulp mills employing the sulphate process for pulping resinous woods.

Crude turpentine is collected by tapping when the trees have attained a girth of 23 cm or more. The bark near the base of the tree is shaved off and a shallow slanting cut is made a few centimeters above the ground level. A V-shaped metal trough is fixed to direct the flow of crude turpentine into a collecting vessel. A shallow wound is then made in the bark above the gutter, from which the exudates drips. Chipping on all sides takes 10-20 years; the tree is then abandoned as these wounds never heal because the cambium is removed in the process. The crude turpentine contains about 20% spirit of turpentine, 65% rosin, 5 to 10% water, some plant tissues and dust. It is distilled in steam distillation plants to isolate its useful components. The distillate consists of water and spirits of turpentine while the hot molten amber to dark-red residue that remains behind is the rosin of commerce.

Spirit of turpentine is used as a thinning material in the paint and varnish industry, as a solvent for rubber and gutta-percha, and for the manufacture of printing cloth, waters proofing compounds, leather dressings, synthetic camphor, many pharmaceuticals such as liniments and many other chemicals. Rosin is used for preparing paints and varnishes, polishes, waxes, soaps, oil cloth, 'linoleum', sealing wax, printing ink, roofing and floor covering adhesives, plastics, rubber, wood preservatives, disinfectants, drugs, and chemicals. Rosin is also used in the paper industry for sizing, i.e., for imparting luster and weight, and hindering absorption of ink or moisture. Rosin oil is used in the manufacture of greases, lubricants, and solvents.

4. Cellulose Derived Products

Cellulose is a carbohydrate $[(C_6H_{10}O_5)_n]$ and is an important component of cell walls. Cotton was originally used as a source of cellulose, but now wood pulp is generally employed. It is used in the manufacture of such products as paper and rayon.

Manufacture of wood pulp - Woods are converted into a fibrous mass (wood pulp) by any of the following three processes - (i) mechanical (most economical and highest yielding), (ii) chemical, and (iii) semi-chemical.

- i) **Mechanical pulping (or ground wood process)** - Only the light-colored and long-fibred coniferous woods especially spruce are used. In India, salai-wood (*Boswellia serrata*) is most widely used for the process. The debarked wood is ground against a rapidly revolving grindstone. The pulp obtained is washed and processed further (Fig. 9.8). The process is high yielding (about 95% of the dry weight of wood). However, lignin and other non-cellulose products do not get removed and the pulp and its products deteriorate in strength and turn yellow with age. But the paper has good opacity, bulk, and printing quality. Such pulp is largely used for newsprint, wrapping and wall papers.

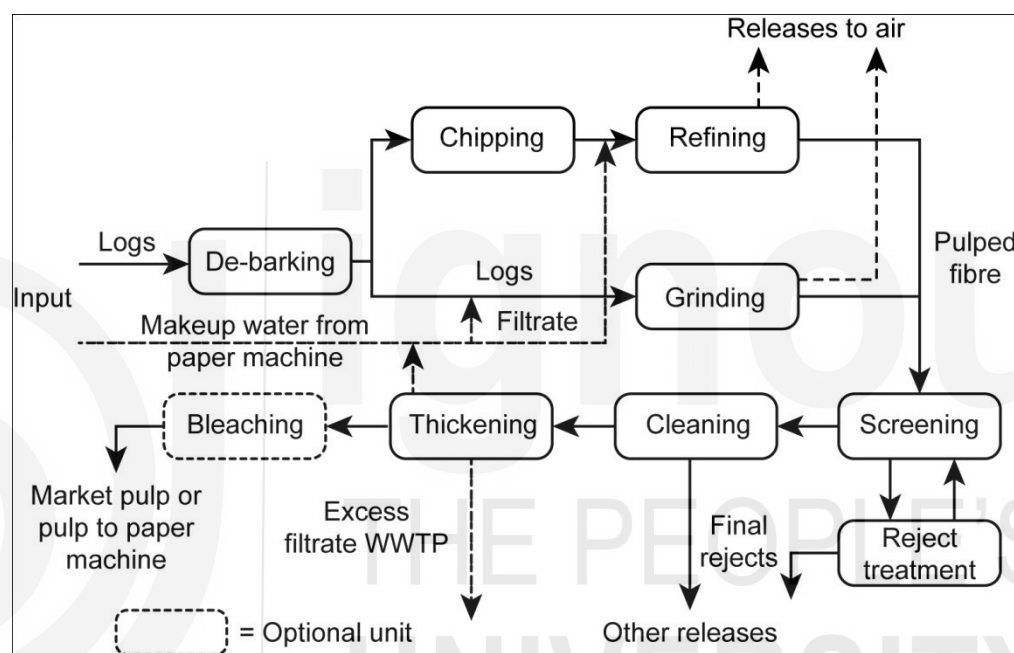


Fig. 9.8: Mechanical processing of wood to make paper.

- ii) **Chemical pulping**- Softwoods with little or no resin (spruce, fir, hemlock) and some hardwoods are used in this process. The wood chips are cooked in various chemical solutions at high temperatures to dissolve lignin, hemicellulose, and other non-cellulose components of cell walls, leaving behind nearly pure cellulose fibers in the form of a pulp. Although it is a low-yielding process (45-60%), it gives a high-grade paper, and most of the wood pulp currently used is prepared by chemical methods. The bark of the wood is removed, and the logs are reduced to small chips (12-25 mm long and 3-4mm thick). Pulping is carried out in large steel digesters by the sulphite, sulphate, or the soda process. Steam is blown in until the desired pressure and temperature are obtained. At the end of the cooking process, the entire steam is blown out through a valve at the bottom of the digester. The sudden release of pressure blows the chips apart and the fibers are separated. The sulphite pulp is used in the manufacture of printing, bond, tissue and wrapping papers, in rayon and newsprint. Soda pulp (mixed with sulphite pulp) is used in the manufacture of printing paper for books, and better grade magazines. Sulphate pulp is used for making a strong brown kraft wrapping paper (used in craft work and as cover paper), paper bags and paper board.

- (iii) Semi-chemical pulping - Hardwoods are generally used in this process. Wood chips are at first softened by mild chemical action and thereafter defibration is accomplished by mechanical action. This method yields 65-85% pulp of the dry weight of wood. The higher yield in comparison to chemical pulping is because of the retention of about 50% of the lignin and 30-40% of the hemi-cellulose. Neutral sodium sulphite is the chemical widely used in cooking. Wood is still in the form of solid soft chips after cooking and is defibered mechanically. These pulps are well suited for making corrugated board, roofing felt, insulating board, and low-grade wrappings. Good quality newsprint is manufactured from a mixture of semi-chemical pulp from softwoods and mechanical pulp from hardwoods.

5. Paper Making

Cotton and linen rags were the principal sources till the last century and are still used for the manufacture of the finest grade paper. Presently, wood fibers are the most important raw materials used. About 97% of the world's paper and paperboard is made from wood pulp, of which nearly 85% is derived from coniferous woods like spruces (*Picea* spp.), firs (*Abies* spp.) and pines (*Pinus* spp.). The hardwoods used in paper making are poplar (*Populus* spp.), birch (*Betula* spp.), beech (*Fagus* spp.) and eucalyptus (*Eucalyptus* spp). Other paper making materials include textile fibers such as jute, hemp, Manila and sisal hemp, crop wastes and rejects from textile factories or cotton linter recovered during the processing of cotton seed. In India, the main fibrous raw materials are bamboos (especially *Bambusa arundinacea* and *Dendrocalamus strictus*), sabai-grass (*Eulaliopsis binata*), bagasse and salai-wood (*Boswellia serrata*). Rags, hemp ropes, jute wastes, and wastepaper are also converted into pulp.

The pulp is then washed, screened, bleached, and lapped. Screening holds back knots, uncooked chips and other foreign matter and separates the pulp into different grades by regulating the size of perforations in the screen. The remaining non-cellulose fraction is removed by bleaching with chlorine and its compounds. It whitens the pulp and helps in the removal of residual lignin. The pulp may need to be bleached several times. Washing with water follows bleaching.

Pulp obtained from chemical and semi-chemical processes is subjected to a treatment called beating (Fig. 9.9). Besides separating the fibers from one another, it shortens and bruises them. Consequently, they cling firmly forming a uniform sheet on the paper-making machine later. The degree of beating influences the texture of the paper obtained. A variety of materials are added to the pulp stock in the beater to improve the quality of the paper. Mineral fillers give weight and opacity to the paper by filling the interstices. China clay, talc, calcium sulphate, zinc sulfide, titanium oxide and calcium carbonate are some important fillers. Sizings such as rosin, soap, wax, and starch make the surface smooth and impervious to ink. Currently, emulsions like polyvinyl acetate, polyesters, vinyl chloride and acrylic resins are also being used for sizing.

After the pulp has been mixed thoroughly with all the ingredients, it is sent to the paper-making machine. External sizings can be applied to dry sheets of paper. This paper is then calendared by passing it between pairs of highly polished rollers to impart a smooth finish.

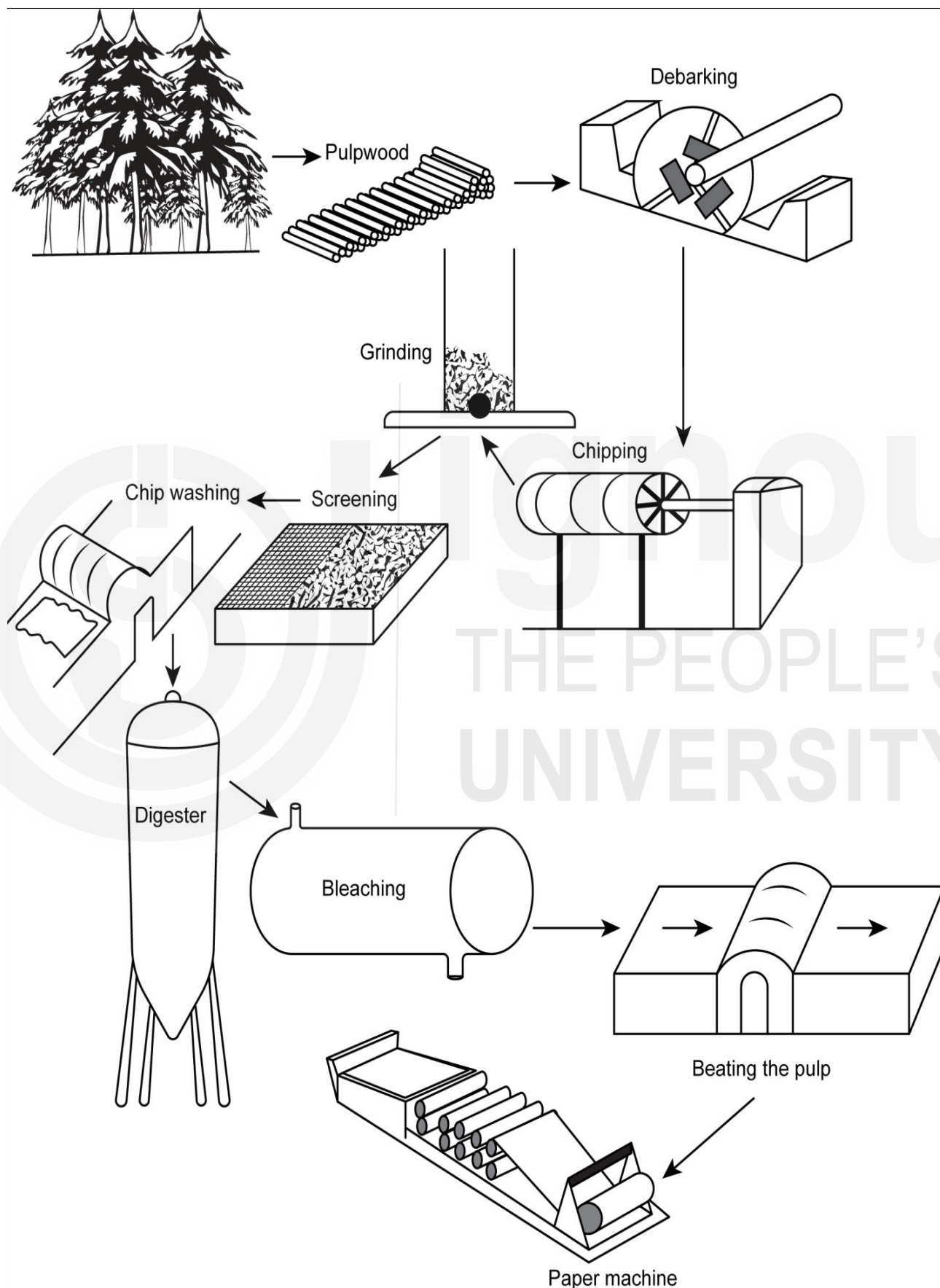


Fig. 9.9: Diagram showing chemical process of paper making.

SAQ 2

- a) State whether the statements are 'True' or 'False'
- The advantage of using plywood is that the tensile strength is equal in all directions.
 - The most valuable timber is obtained from Sal.
 - Plywood is made from common timber.
 - Timber from Himalayan Cedar is rarely attacked by white ants or fungi.
 - Seasoning of timber is done to increase its moisture content.
 - The heart wood represents the central core which is surrounded by annual rings.
 - Charcoal, pyroligneous acid and wood tar are the principal products of hardwood distillation.

- b) Match the items in Column I with those given in Column II

Column I	Column II
i) Veneers	1. hardwoods that are strong, resistant to decay and corrosion
ii) Poles	2. light, yet strong and durable
iii) Mine timbers	3. minimal splitting
iv) Fence posts	4. durable, able to take heavy pressure, able to hold spikes and screws
v) Railway sleepers	5. light, elastic and free from warping
vi) Slack Cooperage	6. light, straight, strong to bear stress and durable

- c) Answer the following in short:
- Average calorific value of seasoned wood.
 - Products of hardwood distillation.
 - Three processes involving in preparation of wood pulp.
 - Examples of hardwood used in making papers

9.5 SUMMARY

- Timber plants are usually medium to large trees which provide wood. These trees are broadly classified into trees of soft, semi-hard and hardwoods. Hardwood is derived from angiospermous (mainly dicotyledonous) plants, while Softwoods are obtained from gymnosperms (mainly coniferous).

- Teak, shisham, pine and cedars are the major timber yielding trees from the forests of India. These are important commercial timber crops. Distribution, wood characteristics and specific uses of these species has been discussed.
- Wood procured from diverse sources is used for various purposes such as fuel, construction material, containers, chemical products, medicines.
- Wood is processed to get pulp which is used in the manufacture of paper. Mechanical and chemical processing of the pulp is done to get paper.

9.6 TERMINAL QUESTIONS

1. Write a brief account of two commercially important timber yielding plants of our country. State its distribution, morphological characteristics and uses.
2. Write short notes on the following:
 - i) Wood distillation
 - ii) Taping for Naval stores
 - iii) Making of wood pulp
3. Give a brief account of various steps involved in making of paper.

9.7 ANSWERS

Self-Assessment Questions

1. a)
 - i) Strongest Indian soft wood
 - ii) Verbenaceae
 - iii) African blackwood
 - iv) *Pinus wallichiana*
 - v) *Pinus sylvestris*
 - vi) Pinaceae
 - vii) Fabaceae
 b) Refer to Section 9.3.
2. a)
 - i) True; ii) False; iii) True; iv) True; v) False; vi) True; vii) False
 b)
 - i) minimal splitting
 - ii) light, straight, strong to bear stress and durable
 - iii) hardwoods that are strong, resistant to decay and corrosion

- iv) light, yet strong and durable
- v) durable, able to take heavy pressure, able to hold spikes and screws
- vi) light, elastic and free from warping
- b) i) About 4600 cal/kg
- ii) Charcoal, pyroligneous acid, wood tar and wood gases
- iii) mechanical (most economical and highest yielding), chemical, and semi-chemical
- iv) poplar (*Populus* spp.), birch (*Betula* spp.), beech (*Fagus* spp.) and eucalyptus (*Eucalyptus* spp)

Terminal Questions

1. Refer to Section 9.3.
2. Refer to Section 9.4.
3. Refer to Section 9.4.

Suggested reading

Michael H. Ramage, Henry Burrige, George Fereday, Thomas Reynolds, Darshil U. Shah, Guanglu Wu, Li Yu, Patrick Fleming, Danielle Densley-Tingley, Julian Allwood, Paul Dupree, P.F. Linden, Oren Scherman The wood from the trees: The use of timber in construction. Renewable and Sustainable Energy Reviews Volume 68, Part 1, February 2017, Pages 333-359.

Acknowledgments

- Fig.9.1** : Source: <https://www.google.co.in/imgres?imgurl=https%3A%2F%2Fpreviews.123rf.com%2Fimages%2Fyotrak%2Fyotrak1207%2Fyotrak120700225%2F14653832-teak-trees-in-an-agricultural-forest-thailand.jpg>
- Fig. 9.2** : Source: https://plantlet.org/wp-content/uploads/2020/10/IMG_20201024_182510.jpg
- Fig.9.3** : <https://www.google.co.in/imgres?imgurl=https%3A%2F%2Fwww.quintadosouriques.com%2Fwp-content%2Fuploads%2F2021%2F05%2Fdalbergia-sissoo-1540375.jpg>
- Fig. 9.4:** : Source: https://vinishsethi.files.wordpress.com/2015/01/wood_cross_section_001.jpg
- Fig. 9.5** : a) https://www.google.co.in/imgres?imgurl=https%3A%2F%2Fs3.envato.com%2Ffiles%2F209044720%2Fcgaxis_models_69_03a.jpg&imgrefurl=https%3A%2F%2F3docean.net%2Fitem%2Fscots-pine-tree-pinus-sylvestris-94m%2F18308889&tbnid

- b) <https://www.google.co.in/imgres?imgurl=https%3A%2F%2Fus.123rf.com%2F450wm%2Falfredosaz%2Falfredosaz2010%2Falfredosaz201000157%2F157071537-stone-pine-branch-with>

Fig 9.6 : <https://www.google.co.in/imgres?imgurl=http%3A%2F%2Fwww.pinetum.org%2FLovett%2Fwhitelobbarkwood.jpg&imgrefurl=http%3A%2F%2Fwww.pinetum.org%2FLovett%2Fbarkandwood.htm&tbnid=d5uKTBH5Ihl7NM&vet=12ahUKEwj4spirzKH0AhUNS30KHViBB14QMygvegUIARDAAg..i&docid>

Fig 9.7 : a) https://www.google.co.in/imgres?imgurl=https%3A%2F%2Fupload.wikimedia.org%2Fwikipedia%2Fcommons%2Fthumb%2F9%2F96%2FMoroccan_Atlantic_cedar.jpg%2F170px-Moroccan_Atlantic_cedar.jpg

b) <https://www.google.co.in/imgres?imgurl=https%3A%2F%2Fwww.eekwi.org%2Fsites%2Fdefault%2Ffiles%2Fwhitecedarcloseup.jpg&imgrefurl=https%3A%2F%2Fwww.eekwi.org%2Fplants%2Fnorthern-white-cedar&tbnid=OMOfvbiJI7c9QM&vet=>



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GLOSSARY

Antihelminthic	:	Medicine used to destroy parasitic worms.
Axillary	:	Situated in or growing from an angle between a branch or leaf and the axis from which it arises.
Archaeological	:	study of remains (such as tools, pottery, jewelry, stone walls, and monuments) of past human life and activities.
Bacteriostatic	:	Compound or drug that inhibits growth and reproduction of bacteria.
Carminative	:	A drug that helps in preventing formation of gas in stomach or intestine.
Coagulant	:	A substance that causes blood or another liquid to get thickened
Decorticating	:	The process of removing the outer coverings (such as husk) from something seed.
Dorsal	:	Something present on the on or toward the upper side of the body.
Endemic	:	Growing or existing in a certain place or region.
Ethnological	:	Study of different societies and cultures.
Expectorant	:	A medicine used to treat cough or promotes the expulsion of mucus from the respiratory tract.
Fungiostatic	:	An agent that inhibit the growth of fungi.
Glabrous	:	Smooth surface.
Heterozygosity	:	Presence of two different alleles of a particular gene or genes by an individual.
Hybridization	:	The process breeding with an individual of another species or variety.
Impervious	:	Anything which is not influenced or affected by something.
Inventory	:	A detailed list of something.
Parched	:	Extremely or completely dried.
Perforation	:	Presence of holes in something.
Peristalsis	:	Contraction and relaxation of a tubular muscular system, especially the alimentary canal.
Phenotype	:	Observable physical characteristics of an individual.
Plaigiotropic	:	Plant part or organ that tends to take up an oblique or horizontal position with relation to the main axis.

Progenitor	:	Parent or direct ancestor of an organism.
Prostrate	:	Lying face down or bending downward.
Pungent	:	Something with a strong smell or taste.
Rudimentary	:	Not developed.
Sessile	:	Directly attached by its base without a stalk or peduncle.
Stimulant	:	An agent or drug that increases the functional activity or efficiency of an organism.
Stomachic	:	An agent or drug that stimulate gastric activity.
Ubiquitous	:	Something that is found everywhere or in several places at the same time.
Ventral	:	Something present on the upper or toward the front part of the body.



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