UTTARAKHAND OPEN UNIVERSITY
Teenpani Bypass Road, Transport Nagar, Haldwani - 263 139
Phone No. : (05946) - 286002, 286022, 286001, 286000
Toll Free No. : 1800 180 4025
Fax No. : (05946) - 264232, email : <info@uou.ac.in>
h p://www.uou.ac.in

FR 02

Forest Products and Utilization

FR 02

Forest Products and Utilization

Department of Forestry and Environmental Science
School of Earth and Environmental Science

Uttarakhand Open University
Haldwani, Nainital (U.K.)

FR 02

Forest Products and Utilization

Department of Forestry and Environmental Science
School of Earth and Environmental Science
Uttarakhand Open University

Board of Studies

Compilation by

Department of Forestry and Environmental Science, (SoEES),
Uttarakhand Open University

Cover page design

Krishna Kumar Tamta, Beena Tewari Fulara, H.C. Joshi

Printed at: Uttarayan Prakashan, Haldwani, Nainital (Uttarakhand)

Table of Contents

Unit 1: Introduction to Forest Products and Utilization

Unit Structure

1.0 Learning Objectives

The aim of this course is to acquaint the learner with:

- concept and definitions of forest products and utilization
- classification of forest products
- importance of forest products

1.1 Introduction

In the previous course, you learned various concepts with regard to silviculture of trees particularly on germination, tree growth, development, regeneration of forest crop and finally various kinds of silvicultural systems under which different kinds of forest are maintained or managed. By this time it is clear to you that, the forests are maintained for deriving a diversity benefits which include pure economic gains as well ecological and other indirect benefits which are essential for the survival of human beings. When the object of management is economic then the main objective of maintaining a forest planation is to derive wood as the main principal product and maximization of its production. However, in addition to this, there are many other useful products which are derived directly or indirectly from forests or forest soils. Although most of these by-products are comparatively of less value than that of wood however, they add in benefits of the plantation owner. Such by products are generally referred to as **minor forest products (MFPs) or non-wood forest products** (NWFPs).

In this unit, we will discuss the concept and definition of forest utilization. We will also discuss the various kinds of forest products including wood based as well as non-wood based products and their importance.

1.2 Forest Utilization: Concept and definition

Forest Utilization is that branch of Forestry which deals with the most suitable and most beneficial methods by which forest produce is collected and converted into useful products. The term "forest utilization" includes all those activities which are required in order to produce goods and commodities from forests and its derived products. It is considered as a science as well as an art, and is considered as an important branch of forestry. The science of Forest Utilization may be defined as "a systematic arrangement of the most appropriate methods of harvesting, converting and profitably disposing of forest produce, in accordance with the results of experience and study" [1]. In general, Forest Utilization includes the knowhow of harvesting, conversion and disposal of major and minor forest produce, and study of forest based industries. Thus, as a discipline, it can be divided into four parts:

- workforce (labour) management
- logging or cutting exercises
- transportation of raw material and,
- manufacture of products

1.3 Classification of Forest Products

The forest products can be divided into two main classes:

A) **Major Forest Products or wood based products:** It includes all wood and wood based products. Such as timber, fire wood, charcoal etc.

B) **Minor Forest Products or Non-wood based products:** It includes all forest based products other than wood and wood based products. Such as fodder grass, fodder leave, hay, fibre, tans, dyes, oils and other products of distillation, drugs, spices and condiments, wild edibles, fruits, seeds, nuts, gums, resins, kattha, lac, silk, honey, wax, horns, hides, bones, ivory etc.

1.4 Importance of Forest Products

India is a country of biodiversity. It has very rich forest wealth having more than 4,000 woody plant species. Therefore, a wide range of choice regarding timber / wood is available for different purposes. Apart from wood based products, forests are also a source of non-wood based forest products. The importance of the forest based products can be assessed by the variety of uses they are put into by human civilization. Various uses of forest products are described as following:

1.4.1 Major Forest Product or wood based products

Wood based products are mainly classified into two types based on their uses - **Timber** and **Fuelwood**. Generally, timber is classified as round timber, squared timber or sawn timber. Timber is put to diversity of uses such as in super-structures, structures in contact of ground, structures in contact of water and many more other uses. Timber obtained from different species is put to a diversity of uses. The uses are described as follows:

- **In the construction of superstructures**, timber is used in constructing roofs of buildings, side beams and rafters, columns, windows, doors etc. It advisable to use light and durable woods in houses. Timber used in construction of roofs should be light weight and at the same time must be durable with good strength. Timber uses in floor or wall are usually such that which does not warp or shrink easily and therefore, is usually seasoned well before use. Timber used in superstructures of bridges should have qualities like withstanding climatic fluctuations as it remains exposed to sun, rain or storms. Further, it must be able to withstand heavy load. As far as species used in construction of superstructures is concerned, the species used are sal (*Shorea robusta*), Shisham (*Dalbergia sissoo*), Teak (*Tectona grandis*) are mainly used northern India and greater part of Indian Paninsula whereas Deodar (*Cedrus deodara*) is the main timber for superstructures in Himalayas. Other timbers which can be used in constructing houses and manufacturing of furniture are as follows: *Pterocarpuus, dalbergioides, P. marsupium, Mesuaferrea cedrellatoona, Micheliachampaca, M. excela, Lagerstroemia parviflora, Acacia catechu, Acacia arabica, Adina cardifolia, Anogeissus latifolia, Ougeiniadal bergioides, Depterocarpus tuberculatus, Eugenia jambolana, Terminalia tomentosa, Terminalia belerica, Pinus longifolia, Pinus*

excelsa, Abies pindrow, Albizzia lebbek, Albizzia procera, Cupressus torulosa, Dalbergia latifolia and Gmelina arborea etc.

- **Timbers which can be used in contact with the ground** include pillar and pile of bridges, telegraph and electricity poles, fence posts, railway sleepers etc. Timber used in pillar and pile of bridges should have high durability, high strength and should be least affected by fungi. Species used for the purpose are *Xyliadol adriformis, Fagraea fragrans, Shorea robusta, Pterocarpus dalbergioides, Mesua ferrea, Acacia catechu, Dalbergia sissoo, Careya arborea, Hardwickia binate, Lagerstroemia spp.* etc. Whereas timber used in house posts, telegraph/ electricity poles or fence posts should be such which can withstand fungal attack as some portion of these remain buried inside the earth and always exposed to moisture and liable to be attacked by fungi. All the species mentioned above for pillar and pile are also suitable for this purpose and other species in this category are *cassia fistula, Pterocarpus santalinus, Lagerstroemia parviflora, Pterocarpus marsupium, Albizzia lebbek* and *Albizzia procera etc.*
- **Timber used in mine propsor mining: timber** is needed to support the mine galleries. It is also employed in moist locality, still air, and often in contact with damp soil, therefore, is liable to be attacked by fungi causing decay. Therefore, such timber must have properties like durability, high strength, and less liable to be attacked by fungi. Timber of following species are suitable for the purpose and employed in different mine areas – *Terminalia tomentosa, Diospyros melanoxylon, Boswelli aserrata, Buchanania latifolia, Erythrina suberosa, Cochlospermum gossypium, Dalbergia paniculata* and *Sterculiaurens.*
- **Timber used in railway sleepers** should have qualities like high durability, be able to withstand fungi and insect attack and be able to tolerate climatic fluctuations. It should also be hard and tough enough to resist the cutting action of the rail or chair placed on it and the strain to which it is subjected by the constant passing of heavy traffic over it. Further, timber should be free from other wood defects such as knots, warping and split. Species used for making railway sleepers are mainly *Tectona grandis* (teak), *Cedrus deodara* (deodar), *Shorea robusta* (sal). However, other species such as *Mesua ferrea, Lagerstroemia parviflora,*

Pterocarpus marsupium and *Terminalia tomentosa,* are also employed but to a lesser extent.

- **Timbers suitable for use in contact with water** should have properties like decay resistant, high durability. Species used for the purpose are *Bombaxmala baricum, Butea frondosa, Ficus religiosa, Ficus glomerata, Emblica officinalis, Terminalia belirica, Tectona grandis, Shorea robusta, Cedrus deodara, Mesua ferrea, Acacia catechu, Acacia arabica* etc.
- **Timber is also used in manufacture of agriculture implements and machineries**. They are used in sugar-mills, oil-mills, spinning wheels, rice pounders, hand-looms etc. The properties of wood used for the purpose, should be hard and tough. The species include *Tamarindus indica*, *Acacia arabica, Albizzia lebbek, Albizzia procera, Shorea robusta, Aegle marmelos, Dalbergia sissoo, Terminalia tomentosa, Hardwiskia binate, Adina cordifolia* etc.
- Timber used in Boat and Ship should have qualities to bear high strains, should be strong, elastic, free from defects. Wood of many species is used in different parts of boat/ship. These species are *Tectona grandis, Pterocarpus dalbergioides, Albizzia lebbek, Eugenia jambolana, Shorea robusta, Shorea assamica, Dalbergia sissoo, Cedrus deodara, Gmelina arborea, Mesua ferrea, Cedrella tona, Terminalia tomentosa, Terminalia arjuna, Terminalia belerica, Adina cardifolia, Melia indica, Cassia fistula, dlbergialatifolia*, etc.
- **Timber used in paneling, windows, staircases, doors, furniture etc**. generally obtained from *Dalbergia latifolia, Juglans regia, Albizzia lebbek, Pterocarpus dalbergioides, Dalbergia sissoo, Cedrella toona, Shorea robusta, Adina cardifolia, Mangifera indica, Morus alba, Cedrus deodara, Pinus longifolia*etc is used. For these purposes, wood should be well seasoned, warp free and defects free.
- Other uses of wood include preparation of wooden vessels, matches, pencils, bows, fishing rods, carving purposes etc. In addition to this, wood is also used for packaging, granaries, tea boxes etc. Other uses of wood include getting energy for cooking, heating homes and boiling water etc. In many of the places, still old methods of cremation or funerals are practiced where a lot of wood is required for burning the body.

- Wood in making various parts in aeroplanes and Gliders. Wood is required for general constructional work such as spars, covering purposes, propeller manufacture, targets and model aircrafts. Earlier, the timber used in spars was obtained from Sitka spruce which is of North American origin. The Indian substitutes are Indian spruce (*Picea morinda*) and Indian fir (*Abies pindrow*). Other possible alternatives are Andaman white dhup (*Canarium euphyllum*), champa (*Michelia spp*.) and bonsum (*Phoebe goalparensis*). Timber suitable for aircraft quality synthetic resin bonded plywood, the species commonly used in Europe are birch and maple, similarly Indian birch and maple are also found suitable. Aircraft propellers, in early days, were made by carving them out of a solid block of wood.
- Wood is used in the manufacture of agricultural implements such as ploughs, harrows, rollers and clod-crushers. For this purpose, a strong, hard, tough timber is required. Babul (*Acacia arabica*), axlewood (*Anogeissus latifolia*) , raj-brekh (*Cassia fistula*), satin wood (*Chloroxylon swietenia*), jamun (*Eugenia jambolanasyn Syzyzium cumini*), sissoo (*Dalbergia sissoo*),dhaman (*Grewiati liaefolia*), tendu (*Diospyros melanoxylon*), sandan (*Ougeinia dalbergioides*), mesua (*Mesua ferrea*), *Prosopis spicigera*, *Pterocarpus* species, kusum (*Schleich eratrijuga*), sal (*Shorea robusta*) and ber (*Zizyphus jujuba*) are all used for agricultural implements different kinds.
- In boat and ship-building industry, strong wood is required for the construction of small as well as larger ships. Teak (*Tectona grandis*) is the best species in ship-building timber around the world. It is particularly used because of its properties like small coefficient of expansion/ contraction and its durability. It is practically the only timber used for naval work. The best teak during british period was extracted and transported from Burma and was known as "**Admiralty" teak**. The other good species used for the purpose was European oak, but due to the presence of tannic acid, it impaired with iron and resulted in corrosion.

Table 1. List of species which are used in ship/ boat making

Used in Boat/ Ship	Name of species
All parts	*Acacia arabica*
Keels and knees	*Acacia catechu*
All light boats	*Artocarpus chaplasha, Artocarpus hirsuta*
Knees and Frames	*Dalbergia sissoo, Dalbergia latifolia*
Masts and Spars	*Caloplryllum lomentosum, Caloplryllum inoplryllum, Cedrus deodara, Casuarina equisetifolia, Lagerstroemia lanceolata*
Oars and Helms	*Casuarina equisetifolia, Cedrus deodara, Celtis australis, Dipterocarpus sp., Fraxirlus floribunda, Grewia sp. Lagerstroemia parviflora, Morus spp., Pinus species*
Rafts and Life Saving Apparatus	*Ochroma sp., Endospermum malaccense, Tetramel esnudiflora, Sterculia campanulata*

Source: Fisher, 1896

Teak also corrodes iron to a certain extent, and modern fastenings are now-a-days generally made of yellow metal or galvanized iron which does not corrode. In India, a number of timbers have been used for boat and ship building purposes as listed in Table 1.

- In Boot lasts and shoe heels are in great demand in our country particularly of ladies' shoe heels. It is a tough wood which should not be very hard. Species like Sissoo (*Dalbergia sissoo*), jhillgan (*Lannea grandis*), *Gardenia species*, ber (*Zyziphusjujuba*), *Polyalthia cerasoides*, kaim (*Mitragyrza parvifolia*), gamari (*Gmelina arborea*), Jarul (*Lagerstroemia flos-reginae*) and *Acer* spp. are considered suitable for this purpose. *Dalbergia sissoo* is the most popular wood for boot and shoe lasts in North India whereas maple and bird cherry are considered to be the next best. For shoe heels, mango has been found very satisfactory.
- Wood is also used in making of brushes such as hair brushes, brooms, horse brushes and scrubbing brushes and even making of simple shaving brush. The species suitable for the purpose are *Diospyrosmel anoxylon* (tendu), *Chloroxylons wietenia*, *Dalbergia latifolia* (roewood)*, Dalbergia sissoo* (Sissoo) and *Pterocarpus dalbergioides* etc. For cheaper utility types of toilet brushes, such timbers as *Adina cordifolia* (Haldu), *Cedrela toona* (toon) and *Mangifera indica* (mango) are used.
- **Cart and carriage manufacture:** The wood used for the purpose should have property like resistant to various stresses and strains. The species suitable for the purpose are *Dalbergia sissoo*, *Diptero carpus species*, *Dysoxylum malabaricum*, *Eugenia jambolana*, *Lagerstroemia species, Terminalia sp.*, *Ougeinia dalbergioides*, *Acacia arabica*, *Acacia catechu*, *Hardwicki abinata*, *Shorea robusta and Mesua ferrea* etc.
- **Construction and general joinery works in houses and buildings, bridges and similar structures**: The demand for this type of work is naturally very large in India, where the timber utilized in superstructures exceeds that of all other industries both in quantity and value. Similarly light and strong wood is required for floor and wall planking. Best species for the purpose are *Shorea robusta, Tectona grandis* and *Cedrus deodara* are best. Some other species are also used such as *Abies pindrow* (Himalayan silver fir), *Acacia Arabica, Adina cordifolia* (haldu),

Albizzia lebbek, *Albizzia odoratissima, Albizzia procera, Artocarpus Species, Cedrela toona*, *Dalbergia latifolia* (Indian rosewood), *Dalbergia sissoo* (sissoo) etc.

- Majority of the houses in rural India are dependent on forests for cooking energy and heating homes particularly during winters in Himalayan hills. Further, energy for burning dead bodies in mostly part of the country still use wood.

1.3.2 Minor Forest Products or Non-wood Forest Products

All those forest produce other than timber and firewood obtained from forests are known as minor forest products or Non-wood forest products (NWFPs). These include honey, wax, lac, silk, wild edibles, resin, dyes, nuts, spices and condiments, and various medicinal plants. The main categories of minor forest products are as follows:

i) Grasses for domestic animals
ii) Fibre yielding and thaching grasses
iii) Oil yielding grasses
iv) NWFPs from stems and roots of trees and other plants (fibres, tans, dyes, oils, starchy products, drugs, spices,
v) NWFPs from leaves (fodder, liter and manure, thatching, tans, dyes)
vi) NWFPs from flowers, fruits and seeds (edible flowers, fruits and seeds; oils and other extracts, tans, dyes, fibres)
vii) NWFPs as exuded products (gums, resins, sugary sap)
viii) Animal products (Lac, silk, honey, wax, hides, horns, bones, ivory)
ix) Mineral products (building stones, road metal, clay, slate, limestone, mica, laterite, sand, etc.)
x) Miscellaneous products (edible mushrooms, lichens for dyes and medicines etc.)

Summary

- This unit deals with the concepts, classification and importance of forest utilization.
- Forest Utilization is that branch of Forestry which deals with the most suitable and most beneficial methods by which forest produce is collected and converted into useful products.
- The forest products can be divided into two main classes such as major forest products **(**timber, fire wood, charcoal) and minor forest products (fodder grass, fodder leave, hay, fibre, tans, dyes, oils, drugs, spices and condiments, wild

edibles, fruits, seeds, nuts, gums, resins, kattha, lac, silk, honey, wax, horns, hides, bones, ivory etc.)

- The importance of the forest based products can be assessed by the variety of uses they are put into by human civilization. Various uses of forest products are uses as major Forest Product or wood based products and uses as non-wood forest products.
- Timber obtained from different species is put to a diversity of uses such as in the construction of superstructures, timbers for pillar and pile of bridges, telegraph and electricity poles, fence posts, railway sleepers; timbers used in mine props or mining, timber used in railway sleepers, timbers suitable for used in boats and ships, manufacture of agriculture implements and machineries, in paneling, windows, staircases, doors, furniture, other uses of wood include preparation of wooden vessels, matches, pencils, bows, fishing rods, carving purposes etc. Wood in also used in making various parts in aeroplanes and Gliders. The other uses of wood includes manufactures of boot lasts and shoe heels, making of c**art and carriage manufacture, Construction and general joinery works in houses and buildings, bridges and similar structures.**
- Majority of the houses in rural India are dependent on forests for cooking energy and heating homes particularly during winters in Himalayan hills. Further, energy for burning dead bodies in mostly part of the country still use wood.
- Minor Forest Products or Non-wood Forest Products all those forest produce other than timber and firewood and such products include honey, wax, lac, silk, wild edibles, resin, dyes, nuts, spices and condiments, and various medicinal plants.

References

[1] W. R. Fisher, Manual of Forestry Vol V- Forest Utilization, London: Bradbury, AGNEW & CO. , 1896.

[2] R. Troup, Indian Forest Utilization, Calcutta: Calcuta Goverment Printing Presss, 1907.

UNIT 2: Logging and Ergonomics

Unit Structure

2.0 Learning Objectives

After studying this unit, you shall be able to:

- Understand the concept of harvesting
- Explain the harvesting procedure and harvesting rules
- Describe the various harvesting implements
- Define and explain logging and conversion

2.1 Introduction

In the previous unit, we have discussed forest utilization and various kinds of wood based and non-wood based products. Wood products include timber and fuel wood. The timber is put to a variety of uses such as house building, in railways and furniture industry. However, before a tree is utilizable, it has to be harvested under defined rules and converted to different sizes of timber.

In this unit,we will discuss wood harvesting and conversion of wood in detail. It is the harvesting of wood which is the first step before it is put to different kinds of uses. The method of harvesting should be such that that it causes least damage to surrounding live trees as well as the felled crop. Therefore, there is required to have a sound knowhow of the various factors which govern the efficient harvesting. Such factors include harvesting implements, harvesting season, harvesting procedures and the availability of sufficient labour force. At the end, we will also discuss the temporary conversion in the forest and also final conversion of wood into various utilizable forms.

2.2Harvesting or felling implements

Those implements which are used for various cutting operations such as felling trees, cutting wood, pruning branches or other cutting purposes, are called as harvesting or felling implements. The shape and size of these implements may vary from one place to another place and from time to time but majority of them are used worldwide with same basic concept. These implements are classified according to the use they are put into. The wood cutting implements are used for hewing, sawing, splitting or grubbing-up the wood. Accordingly tools are also categorized as hewing tools, sawing tools, splitting tools and grubbing tools.

Hewing tools include felling-axes, trimming-axes and the billhook. **Sawing tools** include different kinds of saws. **Splitting tools** include wooden wedge and cleaving axes. **Grubbing tools** are those which are used to extract and split stumps and roots. It includes mattock, the pick, the pick axe, and the grubbing axe. Short saws, wedges, crowbars are also used for splitting and removing stumps.

The different kinds of wood working tools are described as follows:

2.2.1 Billhook

Billhooks are more or less like **'L'** shape with a wooden handle and metal body. It resembles more or less to a large knife or chopper. The metal body is usually made of iron. It is particularly useful in cutting brushes, small poles, bamboos, lopping branches, preparing small segments of fuel wood and similar other purposes for which other tools such as axe or saw are not suitable.

Billhooks

2.2.2 Axes

Axe is one among the important cutting tools which is mainly used for felling trees, trimming, pruning and splitting the wood. It consists of two parts – the axe head (made up of iron with a steel edge welded on it or sometimes it is made of entirely of steel) and a handle (made up of wood). There is a hole in the axe head into which the handle fits in and is termed the eye. The sharp edge portion of the head, the cutting part, is called **blade**. The edge of the blade should have slight curvature for better penetration in the wood and it also helps in preventing tempering of the corners. Generally, axes weigh from 1.5 to 2 kg, however, it may vary depending upon the type of timber to be cut, however, in no case, it should be too large or heavy, as it causes fatigue to the woodcutter and thus, efficiency is reduced. **Wooden handle** is usually round and the length of the handle varies from 70 to 120 cm. Based on the purpose of uses, the axes are of mainly four kinds- the felling axe, trimming axe, splitting axe and grubbing axes and these are described as follows:

Axe

A felling axe is the one which is used mainly for felling purposes, however, it can also be used for trimming, splitting, grubbing up roots, and other purposes. A good axe should have sharp blade with slightly curved so that its center meets the wood first whereas a straight-edged blade is liable to be broken at the corners and thus, renders it less effective.

The trimming is the one which is used for pruning the trees or cutting branches of fallen trees or for rough squaring of the timber. Trimming can be done with felling axe however; a heavy axe is needed in order to rough-squaring timber usually, with 5kg or more in weight with broad blade. They have a long handle about 3 to 4 feet which generates best momentum for trimming or squaring the timber.

Splitting axe is used for cutting wood longitudinally along the grains. A splitting axe should be heavy in order to give better results.

The Grubbing axe is intended for digging ground and cutting through the roots of trees and stumps. Its characteristic feature is a long narrow slightly curved blade, the

length of which is about 12 inches, the cutting edge being 2 to 4 inches broad. In actual practice, any old felling axe can serves the purpose of a grubbing axe.

2.2.3 Saws

Saws are the implements which have teeth on one or both sides. They usually have long blade and short handles. They are used for felling, crosscutting and reducing the larger logs into smaller one i.e., scantlings, sleepers and other converted materials. There are certain advantage of the saws over axe. The main advantage is that the wastage of wood is minimal with saws. Saws are made up of iron as well as steel. The steel saws are usually the best saws. Saws are broadly of two types- hand saw and power saws.

Hand saws are operated manually by hands. Based on the number of person involved in its operation, saws are called **one-man or two-man** saws.The length of one handed saw varies from 1.5 to 2.5 feet whereas two-handed saws is usually between 3 to 6 feet. The length depends upon the diameter of the piece to be sawn. One handed saw is mainly used for removing branches and for pruning.

A saw consists of a broad blade or plate of steel of small thickness, one edge of which is toothed. They are cheap in cost, easy to use and their maintenance is also low. A specialized kind of hand saws used for cutting of wood perpendicular (against) to the wood grain is called as a **crosscut saw.**Crosscut saws may be small or large depending upon the kind of work. Small crosscut saws are used for fine work like wood-working whereas generally large saws are used for forest works like felling of trees and conversion into logs.

Thecharacteristics of hand saws are its length, breadth, thickness and tooth form, which make saw more efficient for some particular job. Therefore, selection of the type of saw blade depends upon the kind of job to be performed. The long saws have a risk of buckling (i.e., sticking in wood which causes bending) in comparison to short saws. Sawwith very short length are very tiring to work with on account of it being too light. The blade of a saw should be thickest at the cutting edge, tapering gradually to the back. The choice of length of saw depends upon the diameter of the tree to be cut and the ease of arm movement. Suitable stroke length lies in the range 80 to 100 cm. An allowance of 5 to 15 cm should be given at both ends for fixing handles and protection of arms.

Important terms in relation to saws

Face of the tooth - Edge of the tooth facing the direction of cutting
The back of the tooth- The opposite edge
The space - Point to point distance of two adjacent teeth
The gullet - Entire opening between two adjacent teeth
The pitch of a tooth- Angle between the face of a tooth and the line passing through the points of the teeth (angle)
The set of the teeth- Extent to which the teeth are bent to either side of the plane of the blade
The gauge- Thickness of the saw blade
The kerf - Width of the cut made by the saw
Action of the saw- a combined cutting and tearing action of saw teeth

The breadth of the saw is also important as the amount of friction depends upon it. Friction in narrow saws is lesser than on the broader ones. The saws which are either 85 mm broad along the whole length, or 90mm at the ends and 120 mm at the middle, have proved to be the best[1].

Thickness of saw blade should not be very thin as it makes guiding and controlling the saw difficult. Again thick saws produce broad kerf (width of saw cut) and consume higher energy for sawing. For saws 80 mm broad and165 cm length, a thickness of about 1.82 mm has proved quite suitable[1].

Length of crosscut saws
(According to diameter of trees)

Length of saw (cm)	Diameter of stems (cm)
140-150	30
165-170	30-70
180-200	80-100 and over

Source: [1]

Shape of the teeth is also an important feature. The sawdust produced in sawing occupies on an average about six times the space occupied by the wood from which it is produced; thus unless the gullets are made sufficiently large there will not be

sufficient room for the sawdust to lodge between the teeth until each stroke of the saw is finished, in which case the saw will be prevented from cutting. Some of the most effective saws are the M-tooth saws of different kinds. These are specially designed to afford the largest possible amount of gullet-space between the teeth, in comparison to the number of teeth in a given length. Another plan is to have a tooth cut off or shortened at intervals; this is an old-fashioned method not adopted in modern saws. For saws which cut both ways the teeth should be symmetrical; for those which cut only one way the teeth are not symmetrical, the cutting face being at right angles, or nearly so, to the line joining the points of the teeth.

Sharpened saws: The saw should have sharped edges in order to achieve efficient cutting action. For saws which cut only in one direction the cutting faces of the teeth should be filed alternately on one side and on the other. In the case of saws which cut in both directions both faces of the teeth are filed, the teeth being filed alternately on one side and on the other. The filing is done with a triangular or flat file, and care should be taken that it is evenly done on all teeth, otherwise the line of the teeth will become uneven and the saw will lose much of its cutting power, while the projecting teeth will be liable to break. To ensure the line of the teeth being kept even after repeated filing special perforated saw blades have been devised. Saws used in saw-mills can be sharpened rapidly by means of a special machine in which an emery wheel is brought in contact with each tooth in turn.

Shapes of saws: Two handed saws comprise off straight, or bow or curved kinds. **A straight cross cut** saw is usually 4.5 to 5 feet long and 4.5 to 5.75 inches breadth. The handles are placed at right angles to the cutting edge of the saw, which consists of triangular teeth, with some shortened ones, and the blade is slightly convex. Such saws are used in broad-leaved forests, where there is much large timber is to be cut.

The **bow saw** has a straight thin blade which is fixed at two ends of a bow in order to keep it straight.

The curved cross-cut saw has a curved blade towards its teeth. In the middle the teeth are often longer than towards the ends which are used only rarely. These cross cut says are best for coniferous trees. In this kind of saw the back of saw is straight. There is another kind of saw known as Thuringian or Saxon saw which has both front and back of the blade in curvature shape.

2.2.4 Tools used for splitting wood

The splitting of wood is carried out by wooden / iron wedge and cleaving-axe.

Wedges are employed for splitting logs or fuel wood, and for assisting in the felling of trees and the longitudinal sawing of timber. Wedges may be made of either iron or of wood, or partly of iron and partly of wood. Wooden wedges are made of hard tough wood, and are sometimes strengthened by an iron band round the top.

The cleaving-axe is more or less similar to felling axe. However, it differs from felling axe in its back which is flat, in its weight which is more, and in size which is larger. It is generally made of steel.

2.2.5 Tools used for extracting and splitting stumps and roots

Such implement include mattock, the pick, the pick axe, grubbing axe, forest devil etc.

The mattock (one foot long and 2 to 2.5 inches broad and made of steel) is used for digging into the ground and severing small roots. The pick is sharply pointed tool is used on stony ground. Mattock and pick may be combined in the form of the common pick-axe.

The forest devil is another powerful tool used for extracting stumps and pulling over trees whose roots have been cut through. It consists of two strong iron chains between which a wooden lever works. It consists of a strong wooden handle, to which a long chain remains attached. One end of the chain A is fastened to a neighboring strong root, stump, or tree, and the other is attached to the lever, at its fulcrum. The second chain B is placed round the tree or stumps to be extracted, which must naturally offer less resistance than that to which A is fastened; it is connected with the lever alternately by means of two short chains each terminating in a hook. By then moving the lever backwards and forwards and hooking first one and then the other of these chains into links of B, the tree or stump may be extracted.

2.2.6 Miscellaneous tools

Other tools includes cant hook, debarking spade, measuring stick, log hook and stem tightened etc.

- **Cant-hook** – Purpose is to act as lever to roll, stop and turn logs.
- **Pickaroons** - A pickaroon is a wood-handled, metal-topped log handling tool. It is a short pole, 85-100 cm long, with a recurved pike or hook for drawing or pulling small logs.

- **Debarking Spade** – It is fitted with a bent blade which is used for debarking logs.
- **Measuring stick** – Fitted with marking ends, it is used for measuring log length.
- **Log hook** – It is used for dragging, lifting and rolling.
- **Stem tightener** – Its function is to prevent the stems from splitting at butt ends. It consists of 13mm wire rope having a steel core. It is laid round the stem just above the felling cut and tightened with the help of a lever mechanism. The wire rope is held fast with the help of a clamping device which consists of a guide groove for the rope, a movable support and a wedge.

2.3 Harvesting Season

Sources: [2][3][4]

The best season for harvesting depends on several factors and circumstances which include the climatic conditions, availability of work-force, and mode of felling on the kind of tree species to be harvested.

Climatic conditions are most often is one of the most important factor in which season of felling depends. Our country has tropical as well as temperate climates each characterized with well-marked seasons. In mountains particularly in Himalayas above 2000 m altitude, heavy snowfall is usual occurrence in winter; therefore, felling is not possible during this time. Felling is usually carried out from April onwards and is generally completed before the rainy season. In the plains and sub-montane tracts, felling is done in winter from October to March. Winter felling in general advisable on account of tree growth being minimal. Felling in very hot weather is avoided as the logs dry rapidly and results in splitting and cracking.

Another factor on which harvesting of crop depends in the availability of work-force. Supply of labour itself largely governed by climatic conditions. The labour supply is usually low during the seasons when important agricultural work is carried out. In the plains and lower hills of our country, the general rule is to carry out harvesting as soon as the forests become dry enough to allow work after the receding of monsoon. This usually from October or November. In the Himalayas felling at the higher altitudes is done in the warm season, work being suspended during the winter owing to the depth of snow and the severity of the climate, therefore, the woodcutters descend to the lower valleys and work there.

The fuel trees should be harvested in dry hot weather to promote rapid drying. Felling in winter, when snow is on the ground, prevents breakage of the trees in falling and also protects seedling growth from damage.

Mode of felling is another factor that governs season of felling particularly when damage to the young crop is to be considered. If harvesting is supposed to cause damage to young growth, it should be done during the season of rest i..e, in the hot season. From the point of view of durability in the timber the best season to fell is when there is least reserve material in the wood, that is, immediately after a new flush of leaves appears. Clear-felling may be done at any season of the year, unless they are to be immediately followed by sowing or planting.

Modes of transport and market demands are other factors which affect, to some extent, the season of felling.

2.4 Harvesting Procedure [2][1][4]

2.4.1 Harvesting rules

There are certain fundamental principles which lead to good harvesting. These include the production of the maximum material with the minimum of waste, the least damage to surrounding forest / undergrowth/ the felled trees, and the nature of the locality as regards facility of export. Certain felling rules have been laid down based on the above mentioned considerations. These rules are as follows:

(1) Trees should be felled in a manner and in the direction in which they will do least damage to the forest growth

(2) Trees should he felled in a manner and in the direction in which they will do least damage to themselves in falling

(3) Trees should be felled in such a direction that the logs can be extracted most easily

(4) Trees should not be felled during a strong wind. This is necessary as the direction of falling cannot be guided during a strong wind.

(5) Trees should be felled as low as possible in order to reduce unnecessary waste.

(6) Felling should usually begin at the top of a slope and proceed downwards. This is particularly because the trees present down the slope minimizes risk of cut trees from sliding downwards.

(7) As a general rule, only as many trees should he felled at a time as can he converted and removed within the next few days. This is particularly necessary where there is danger of insects attacking the felled timber. In the case of timber not liable to insect attacks this rule does not hold.

(8) Valuable trees should be felled by the saw or by the saw and axe combined and not by the axe alone. Felling by the axe alone causes production of a lot of waste material.

2.4.2 Methods of harvesting [2]

Trees may be felled in two ways:

- Cutting above the ground
- Cutting through the roots in such a way that the whole tree along with roots comes out

The latter method is followed where the extraction of the stumps is desired for the purpose of clearing the grounds or where tree is of much value for example sandalwood.

2.4.2.1 Harvesting above ground

Harvesting trees above the ground is done with the help of axe or saw or by both using axe and saw. When tree is to be felled by **axe alone**, a cutis made on the opposite side of the treat its base which should be as close to ground as possible. The first cut should extend a little beyond the center followed by a second cut, a few inches above the level of the first cut on the opposite side of the tree. The second cut should be made to meet the first cut, so that the tree is cut through. The fall of the tree in the intended direction is assisted by driving billets of wood or wedges into the cut. However, in some instances, help of rope previously fixed in upper part of tree is also taken to make the tree fall in right direction. Felling with axe alone results into generation of lot of waste while creating the notches. Further, the wedge-shaped end of the log needs to be trimmed off during the conversion of timber. However, this method is also advantageous in the sense that it does not demand skilled labour but a normal person can do the operation easily. The other advantage with axe is that it can be applied easily in rocky or mountain or difficult places. Further, only axe (assisted by

bill hook) is used when felling is carried out with an intention to produce coppice shoots. This is because the rough stump produced by saw is not suitable for coppice shoot.

2.4.2.2 Felling with the Saw alone

When saw alone is used for felling of the tree, then the saw operation has to be initiated on the side opposite to the intended fall of tree. As the sawing proceeds, wedges are driven in behind the saw in order to prevent the saw from sticking and to guide the fall of the tree. The main advantage of this method is that it produces least waste than other methods. Disadvantage of this method is that it is difficult to operate saw without the assistance of wedges particularly for large trees. The fall may at times be guided by the use of a rope or the thrust-pole.

2.4.2.3 Felling of tree with Axe and Saw together

A'<' shaped small cut or notch is created with axe on the side toward which the tree is intended to fall. The saw cut is made with the help of a crosscut saw exactly opposite to the undercut at a level about 2.5 cm above the base of the undercut. As the saw penetrates about double the width of the saw blade, a wedge is inserted and sawing continued. As the sawing proceeds further, the wedges are made to inserted deep. The deviation from the intended direction of fall is corrected by driving in wedges and sawing more or less in one or the other side. As the saw cut moves close to the undercut, the tree begins to fall. This method is the most satisfactory among the three methods as the fall of the tree is easy to guide by reason of the axe-cut, while the waste is little more than where the saw alone is employed.

2.4.2.4 Feeling with the Billhook

This is restricted to small trees, saplings and also in coppice-shoots which have resulted into a dense growth where it is difficult to work with axe. Saplings are felled with one blow of the billhook, however, more blows in opposite directions are needed when stem is too thick.

2.4.3 Extraction (Utilization) of stumps and roots

2.4.3.1 Extraction of stumps

The extraction of stumps may have to be carried out for it is required to clear the land for cultivation, building sites, roads, etc. and also stumps and roots of valuable species

are utilized. For example, the stumps of sandalwood trees yield a large amount of oil, stumps of *Acacia catechu* are rich in cutch, and are extracted for cutch manufacture.

The chief methods of extraction of stumps are:

i) Through mechanical appliances

ii) Dragging with the help of draught animals

iii) By blasting with gun powder or dynamite

The extraction of stumps is through mechanical appliances is carried out by means of grubbing-axes, saws, wedges or with the help of machines. The first step in extraction of stump is clearing the soil around the stump by digging for exposing the side roots as far as they are utilizable. These roots are cut close to the stump and removed. The utilizable side roots are also collected. The digging of the earth is continued towards tap roots until they are exposed. After this the stumps can be pulled out with the help of forest devil. The hook livers or ordinary livers may also be employed.

Extraction through draught animals is done by attaching a rope or chain to stump and this is made to pull by oxen or elephant.

In blasting method, a hole is created vertically downward in the stump at or near its centre with a big augur. Then the hole is filled with blasting powder and blasting fuse is introduced and the hole is clogged by clay. After this the fuse is ignited and blasting results into splitting of stump. This method cab be modified and several stumps may be exploded together by electricity. The stumps are first charged with dynamite as explained above and the holes are clogged. The fuse in each stump is connected by a wire to that of the next stump until a complete circuit is obtained, when the whole group of stumps is exploded simultaneously by an electric battery situated at a safe distance from the stumps.

2.4.3.2 Felling by the Roots or uprooting trees

When trees are required to be felled from root level, first of all it is required that the earth is removed so as to lay bare the principal roots. The next step is to cut through the roots with an axe or small hand-saw in two places. The section of the roots between the cuts is taken out by levers in order to give access to the main roots beneath. In the absence of tap root, the roots on the opposite side of the intended direction tree fall are cut in the last. When last roots are cut, the tree is pulled over with ropes or pushed over with the thrust-pole at the same time. When tap root is also

present, its cutting is done at last. While cutting taproot, the first cut should be made on the side to which the tree is to fall, and the last cut, the largest cut, is made on the opposite side. Final cut of tap root should be assisted by pulling with rope and pushing with thrust pole in the direction of intended fall.

2.4.4 Labour management

Availability of labour in India varies from place to place. Sometimes it is also difficult to find suitable forest labour. Forest dwellers are best forest labors as they are habitual to forest life. On account of agriculture based economy in our country, most of the people are familiar with forest work. However, there is experienced crisis of labors particularly when crops have to be harvested or sown. Further, in hilly regions also there is scarcity of labour as local population is low and, therefore, labour from outside is often brought in for forest work. In the Himalayas, imported labour is generally recruited and brought to the forests by a contractor. Forest labours are therefore, of two types- local labour and imported labour.

The local labors are not always available and thus remain fluctuating. Such labour is often employed regularly every year for construction of forest roads, clearing fire lines and in departmental burning operations.

Imported labour are brought from outside and they may settle in the forest for one or more season but never permanently. Such labour may be collected departmentally or by contractors, and is often employed on extraction and conversion activities.

One of the important point that should always be considered priority is about the wages of labour. Wages should be appropriate, so that they remain satisfied and remain there for longer duration. Low pain labour on the other hand goes away before completion of forest activities and thus crisis of labour may be faced. While deciding the fair wages, the local conditions, distance of forest from villages, prevailing cost of food supplies and skill of the person should be considered.

2.5 Summary

- In this unit, we have discussed wood harvesting and conversion of wood.
- Harvesting is effected by various factors such as harvesting implements, harvesting season, harvesting procedures and the availability of sufficient labour force.

- The wood harvesting implements are used for hewing, sawing, splitting or grubbing-up the wood. **Hewing tools** include felling-axes, trimming-axes and the billhook. **Sawing tools** include different kinds of saws. **Splitting tools** include wooden wedge and cleaving axes. **Grubbing tools** are those which are used to extract and split stumps and roots. It includes mattock, the pick, the pick axe, and the grubbing axe. Short saws, wedges, crowbars are also used for splitting and removing stumps. The different kinds of wood working tools are discussed in detail.
- Harvesting Season is another factor on which harvesting depends. The best season for harvesting depends the climatic conditions, availability of work-force, mode of felling and the kind of tree species to be harvested.
- There are certain fundamental principles which lead to good harvesting these are called harvesting rules. Rules are based on the concept that harvesting of trees should cause least damage to the forest growth, least damage to themselves, should not be felled during a strong wind, waste generation is least, felling from top of the slope, removal of timber at the earliest from harvesting site.
- Harvesting of trees is done in two ways- cutting above the ground and cutting through the roots in such a way that the whole tree along with roots comes out. Felling can be done with saw alone or with Axe and Saw together. Other implements used for felling include the Billhook, however, it is restricted to small trees, saplings and also in coppice-shoots.
- The extraction of stumps is done in order to clear the land for cultivation, building sites, roads or stumps and roots of valuable species fetch good price in the market. The main methods of stump extraction include the use of mechanical appliances, dragging with the help of draught animals or by blasting with gun powder or dynamite.
- Labour management is another factor which greatly influence the harvesting operations. Availability of labour in India varies from place to place. Sometimes it is also difficult to find suitable forest labour. Further, in hilly regions also there is scarcity of labour as local population is low and, therefore, labour from outside is often brought in for forest work. In the Himalayas, imported labour is

generally recruited and brought to the forests by a contractor. Forest labours are therefore, of two types- local labour and imported labour.

-

References

[1] T. Mehta, *A Handbook of Forest Utilization,* International Book Distribution, 1981.

[2] R. Troup, *Indian Forest Utilization,* Calcutta: Calcuta Goverment Printing Presss, 1907.

[3] H. Trotter, *Manual of Indian Forest Utilization,* Oxford University Press, 1940.

[4] W. R. Fisher, Manual of Forestry Vol V- Forest Utilization, London: Bradbury, AGNEW & CO. , 1896.

Unit 03: Transport, Conversion and Storage of Wood

Unit Structure

3.0 Learning Objectives

At the end of this unit, the learner shall be able to:

- explain the transportation of harvesting produce
- explain the transportation of wood by land and water
- learn the conversion of wood
- discuss the storage of transported wood

3.1 Introduction

In the previous unit we have discussed about the harvesting of wood, season of harvesting, rough conversion at harvesting site and final conversion at road side or other location outside the forest area. However, one important step after initial conversion or rough conversion is the shifting of harvested wood to suitable places so that it can be put to various uses i.e., transportation of logs from harvesting site. Generally, the larger forest areas are situated in remote localities; therefore, some suitable means of transportation has to be ascertained so that the produce be taken to the market place. Further, after transportation to suitable locations, first requirement is to store them properly so that the wood may not deteriorate in quality and decrease in quantity.

In this unit, we will discuss about different ways of transportation of partially or fully converted wood to suitable locations by land as well as water. Further, after transportation to suitable locations, there is a need of storage in proper conditions so that quantity and quality of wood may be maintained. We will also discuss the conversion of logs into merchantable size according to market demand.

3.1 Transportation through land

Transport of wood or logs in land may be carried out by men, animals (Bullocks, mules, camels and elephants), by carts (cart hauled by a bullock/buffalo for transport of timber and other produce), by dragging(logs can be dragged on roads specially constructed for the purpose), by rolling(in areas of gentle slope, logs can be rolled) or by motor vehicle. Other means of transport are forest tramways, wire and rope-ways etc. Any of the above mentioned means of transport can be used provided that they are suitable and cost effective for the area.

3.1.1 Transport by roads

Most of the transportation of harvested material in India takes place by road. It may either be carried out by men or by beasts or by carts or motors. The presence of cart-roads results into efficient transport of wood from far remote forest areas and it is usually cheaper than transport by men or animals. Further, larger loads can be transported at a time by carts. Oxen and buffaloes are the main animals used in cars

or trucks. In some countries, transportation of logs is also done by using elephants in carts.

3.1.2 Carrying by men or by animals

Transportation by men is comparatively expensive, therefore, it is not advisable to use manpower particularly for long distances. A man can carry from 30 to 40 kg of head load. Logs can be carried by four to five men. The chief pack animals used for carrying wood in India are camels, bullocks, mules, and ponies. While using animals for transportation, it should be ascertained that abundance of fodder is available to feed animals so that they may be carried to long distances. Although transportation by carts are cheaper but it is not possible to use carts in all terrains. In such cases, animals are employed for the purpose. Animals should not be worked every day, but should be given a rest every few days.

3.1.3 Sledge-Roads

A sledge consists of a frame for carrying the wood, supported on a pair of longitudinal runners. Sledge is usually a practice conducted over snow. In Indian Himalayan regions sledging is also practiced but only for a limited period of time as the road do not remain covered with snow for longer period of time. In order for sledge roads to be effective, the slope gradient should be between 4^0 and 11^0 [1]. However, the sledging is possible only when there is no sharp curve otherwise sledging consumes more time or it may be difficult.

3.1.4 Rolling-Roads

This is particularly practices in hilly regions where sufficient slope is available to make the log roll down the hill and roads meant for the purpose are known as rolling-road. The rolling roads should have at least slope of 3° and not more than 10^0. Sharp curves are avoided as they break the movement of logs. The logs are rolled in batches of 10 to 20 with the help of levers of 6 feet long. The movement of foremost log of the batch is always kept under control with the help of stones and wooden wedges so that logs behind thus also remain under control and roll in the desired direction. After movement of all the logs to the first stop, the wedges are placed again at another 30 feet distance in front of logs. Now the original stones and wedges in first stop are removed and the logs are made to roll forward with the help of livers. Thus, logs are moved to a distance where wedges are already placed. This process is repeated constantly in order to

make controlled rolling movement of logs. However, this method is not suitable for transportation to long distances.

3.1.5 Dragging Paths

Dragging-paths are those paths along which timber is dragged from the forest to the nearest floating-stream, cart-road, or other line of export. Dragging-paths require little construction beyond the cutting of jungle and slight grading. In soft ground, billets of wood partly embedded in the ground are placed across the dragging-path. It is particularly necessary when the logs have to be dragged uphill. Practice of dragging is only carried out for short distances from forest to nearest roads or stream or water body.

3.1.6 Slides

Slides are particularly used in hilly regions for extracting logs, fuel or sleepers and other scantlings. In the slides, wood is made to slide down by its own weight either on dry or wet ground. In wet slides, water acts as a sliding medium in the slide. Dry slides may be either earth slides or wooden slides. “Shoots” is synonym of slides particularly in steep slopes where the wood slides down rapidly by its own weight. An **earth slide** is merely a natural hollow or artificially prepared depression running down the mountain. The slide way needs some preparation such as removal of rocks, boulders and other obstruction from the sliding path. The slope gradient of 20° and 60°may be used for the purpose but in slopes with gradient over 25° the logs start sliding down itself and therefore, there are required to construct some check-wall across the path at certain intervals. Below 20^0 slope gradients, the sliding of logs needs to be assisted with levers, however, care should always be taken to keep sliding of logs under control. Earth slides in the Himalayas are usually straight. Whenever there are curves, posts or walls needs to be erected in order to stop logs from leaving the slide path.

Dry Wooden Slides are slides which are made from round logs or from sawn timber fitted together. They are usually made trough-shaped and used for sliding logs, sleepers, scantlings and fuel down the hills. The best gradient is 15° to 25°, but an occasional change of gradient is desirable so that the speed of the logs may be checked by a more gradual slope at intervals.

Wet Slides differ from dry slides in the sense that they are continuously supplied with a continuous stream of water through intervals by side channels. Water acts as a

lubricant and thus, sliding process is made gentle and smooth. These slides are used mainly for transporting sleepers. The scantlings forming the slide are fitted tightly together to prevent leakage of water, therefore, accurate fitting of scantlings is required in contrary to dry slides. Wet slide operates best between at about 16°, however, a variation from 5° to 25° can also be used. The quantity of water required in steep slopes is less in comparison to low slope paths. Thus, water is primary requirement for wet slides and in hilly regions where water is available; the wet slide is mostly practices and is usually most satisfactory.

3.1.7 Forest Tramways

Forest tramways are a kind of light railway with narrow gauge and are useful in shifting heavy loads of harvested wood from forest area. This is very much appropriate when compared to transportation from ordinary roads. It needs less width than the roadway for cart-road, and hence the cost of cuttings and embankments is comparatively less. However, tramway should only be constructed when availability of produce is sufficient and continuous for extraction so as to make the tramway profitable. The gradient of a tramway depends on the load. The gradient from timber is less in comparison to gradient for fuel wood.

3.1.8 Wire Rope-Ways

Wire rope ways are strong wire ropes stretched between supports, and employed for the transport of timber or fuel from a higher to a lower level, the wood being tied to carriers, or wheels which move freely along the wire rope. No motive power is necessary as the load moves along the rope by gravity. Wire rope ways are especially useful for transporting produce across steep valleys, rivers or ravines. The advantage of transport through ropeway is that it causes least damage to forest in its construction, easily moved from place to place, and their working is not interfered with by floods or heavy snow.

3.2 Transport by water

There are three methods of transportation of wood by means of water. These are as follows:

- through floating
- through rafting
- with the aid of boats

3.2.1 Floating

This method is particularly used when streams are narrow and transport by other means is not possible. In this method, roughly converted logs, scantlings or fuel wood are transported through floatation. They are made to flow independently down streams to the distance river gains full breadth. As soon as river breadth is increased, the logs are tied together to form rafts so that the risk of losing logs be minimized or avoided. The rivers or channels suitable for this method should have following characteristics:

- channel should be wide enough to allow free movement of logs otherwise blockage will result and movement of logs will be obstructed
- the stream should have enough depth so that the logs float without touching the bottom
- the bed of the stream should be as free as possible from obstructions
- the course of the stream should have least sharp bends as it would cause logs to get collected at stream banks and create obstacle for other logs

Usually, transportation through floating method needs some kinds of improvement in the river channel so that floatation of the logs is smooth and obstacle free. This is done by blasting of rocks or large stumps with dynamite to clear the movement of logs. Further, careful monitoring of the stream is needed in order to avoid locking of logs together or piling of the logs in river banks or at bends. Sometimes, floating timber get carried into backwaters where they become stranded. This may be prevented by anchoring a chain of logs across the mouth of the backwater, to keep floating logs in the main stream, or by erecting a fixed boom in the bed of the stream. The other way to keep the stream obstacle free is to monitor the stream continuously and to clear it every year.

Season of Floating in the Himalayan streams usually commences after the floods of the rainy season are over i.e., early November, and continues until about the middle of June, so that the timber may be collected and rafted to market before the rivers become swollen by the monsoon rains. **Collection of Floating Timber** is carried out at point from where they can be easily transported in the form of rafts. From this point onwards timber transportation takes place as rafts till the point where they reach roadside.

3.2.2 Rafting

Rafting is a method of timber or wood or log transport in which several logs are tied together and thus, move together in a structure known as rafts. Rafts may be of logs, sleepers and other scantlings, bamboos or fuelwood etc. Transportation through rafting may be carried out in rivers and canals along with water current and the rafts are directed in adequate path with the help of poles. Those rivers are suitability of rafting in which least obstacles are present and is free from projecting or submerged rocks and has suitable depth for the free movement of rafts. Like floating, rafting is also carried out after floods are over as rafting cannot be carried out during high flood seasons as managing raft movement is very difficult. For this reason the rafting season on rivers usually commences after the rains and continues till the water becomes too low or again rises at the commencement of the next rains.

The size of a raft depends largely on the nature and breadth of the river or other channel by which the timber is to be transported. The width of the raft depends on that of the rafting channel whereas the length depends on the number and sharpness of bends in the channel. In case of straight channel, there is scope for easy movement of longer rafts contrary to channels with abrupt bends. The logs in the raft are tied together in order them to move together in the direction of the water flow. The logs in raft should be more or less of equal length so that longer logs may not get trapped. Similarly, t**he bamboo rafts can also be made however, they can be made to move even in** small streams provided that the small rafts are made. These small rafts on reaching a large rafting-river can be fastened together into large rafts. The commonest method of constructing bamboo rafts is to cut small holes through the bamboos near one end and to pass a piece of split bamboo through the holes of 20 to 25 bamboos side by side and fastening at the end.

Rafts of sleepers and scantlings are placed in pairs i.e., one sleeper on the top of other, and arranged transversely to the direction in which the raft is to move. The sleepers are kept together by being lashed with ropes to longitudinal sleepers placed over them. Such rafts are guided by two men, one in front and the other behind. Rafts of scantlings are also made up in the same way. When the sleepers or scantlings are too heavy to float by themselves they may be mixed with scantlings of lighter woods, or supported by bamboos. Sleepers or scantlings may be successfully brought down floating streams on small bamboo rafts, to which they should be securely fastened.

Control of Raftsin Rivers is one of the important requirements in order to check the logs from being detached. If rafts are not fastened securely together then they are liable to be detached due to collision with rocks or other obstacles or any other accidents. This in turn results into breaking of whole raft and drifting away of individual logs. Such timber which after detaching from raft floats without control is called as "**drift timber**" and there are chances of such timber to get lost or stolen.

3.2.3 Transporting through boats and ships

The common method of transporting logs particularly those which do not float by themselves is to suspend them under water and tightened firmly across the hulls of boats or to fasten them to the thwarts of the boat without the aid of cross-poles. Usually up to three logs can be attached to either side of the boat. However, it is difficult to transport timber upstream this way as the fastenings may break as a result of water resistance. Fuel billets are also loaded into boats and transported by cargo on some rivers. When timber is transported in ships, they are usually first sawn into squares or scantlings in order to avoid unnecessary cost of transport.

3.3 Conversion of Wood

3.3.1 Initial Conversion of wood (Rough conversion) or logging

After the felling of wood is completed, the side branches of felled trees are removed from but upward by trimming axe and thus, clear bole is obtained. Severing of branches should smoothly done and as close to the bole as possible. Since it is difficult to transport the whole length of bole, therefore, this bole is cut into smaller pieces called logs, so that they can easily be transported to the market site, sometimes squaring of logs is also carried out at felling site. This is known as rough conversion of wood.

Before carrying out the rough conversion process, the bole is measured with measuring tape and meter marks are made on to the bole. If the timber is to be used as fuell wood then it is to be cut at meter points whereas if intended for meeting certain size of timber, then logging of that size is carried out. Rough conversion of tree should be given due importance as it is on this size of the logs that marketability and profitability of wood depends. The size of the lao should be such that it can easily meet the market requirements and thus, get appropriate price. However, if the purpose is to sale wood as fuel wood then it can be converted into small pieces. In such case

branches are also utilizable. The size of the pieces or logs depends on the purpose of the owner. Rough squaring is usually done with a trimming axe after making suitable sections of the tree bole. Thus, conversion in the forest of rough conversion of trees is simply the preparation of timber to meet the market demands. In our country, conversion of trees in the forest by hand sawing is the principal method and minimizes the cost of operation. After initial conversion in the forest, the logs or squared timber is re-sawn into planks or other usable forms before being finally utilized.

Timber of commerce is roughly classified as follows:

- Round Timber or logs.
- Roughly squared timber usually called balks or rough squares
- Sawn timber, such as squares, beams, sleepers, scantlings and planks.

Fuel wood is classified into four main classes based on their conversion at forest site:

- **Split Billets:** The larger pieces which have to be split to convenient size
- **Round Billets:** Pieces which are not too large to use in the round
- **Root and stump wood:** Pieces cut to convenient size from roots and stumps, and
- **Faggot-wood:** It includes small-sized branch-wood and other small material, which is tied up into bundles and is sold chiefly for domestic use.

3.3.2 Factors affecting the rough conversion of wood

There are certain factors on which the rough conversion of wood i.e., round timber or sawn timber, depends. These are as follows:

1. **Market demand** is the one important factor in which depends the size of the logs or roughly squared logs. In some markets small timber is required such as match industry or kattha industry; therefore, accordingly size of the log is made.
2. **Availability of skilled labour** is another factor on which size and shape of the logs depends. In places, where skilled labours are available, shape and size of the logs can be made as per market requirements whereas contrary to this, the areas lacking in skilled labour only round timber is converted.

3. **Availability of transport facilities**. If timber has to be transported through small vehicle or bullock cart, the logs cannot be of large size, whereas if it is to be transported through large vehicles (truck) the size can be large logs.
4. **Topography** of the felling site also decides the size of the log as transport of timber s difficult from hilly terrain. Therefore, timber is sawn in appropriate sizes which can be transported to roadside by manual labours without causing damage. In such cases sawn timber should be of such size which can be transported easily by man.

3.3.3 Stacking of converted material

After temporary or rough conversion of the wood, it is required to store the converted wood temporarily in the forest site before it is transported. The converted material is exposed to attack by fungi and insects, therefore, stacking of the logs is done ate the site so that it may season. Further, it is done in order to avoid the warping and cracking of timber. This stacking may be done either in the forest or in some central forest depot. The stacking is done in such a way that each class of timber has separate stack and at the same time care should be taken that stacks occupy the minimum space so that accounting and inspection is easy, and safety of timber is also ensured. Stacking of timber can be done in two ways- stacking of round timber and stacking of sawn timber.

A) Stacking of round timber: Stacking of round timber is done in such a way that slow and regular seasoning takes place. Therefore, stacking of such timber is done in shade in order to keep it away from direct sunlight and stack in such a way that it all logs receive air from all sides. Care should be taken not to place any timber lying on the ground particularly on moist or damp ground. While making stacks, the lowest tier of stack should consists of the largest and heaviest logs and placed parallel to each other. This tier should be raised to at least one foot off the ground by placing billets of wood below it. The next tier of log should be placed at right angle to it and subsequent layers of logs are kept right angle to its previous tier. The logs of each tier should be separated from those of the tier below and above them by a few inches of skidding. At any point of time, if it is required to pull any log, it can be done by first removing the skidding and then the log can be pulled out easily.

B) Stacking of Sawn timber: Stacking of Sawn timber should be done carefully as sawn timber gets easily warped. In the case of thick scantlings, the stacking is done in the similar way as for round timber. The only difference is that skidding between the various tiers is not required. The lowest tier, however, should be raised off the ground and placed on a perfectly level site, otherwise the scantlings may warp in seasoning. Space of an inch or two is kept between the scantlings in each tier by placing thin boards. After final tier, weights of stone or iron should be placed in order to prevent warping of the topmost stack. The stacking of sawn timber must be carried out soon after sawing as is liable to warp and split if not stacked.

C) The stacking Poles and Posts: The stacking Poles and Posts is done horizontally with the thick ends of the poles pointing to the side from where they are supposed to be removed in future for transportation. Such stack is made of rows of ten each. If required, heavy weights are also placed above the top row in order to straighten the poles. If such stacks are to be left at the site of staking for longer duration then a layer of skidding or a number of cross pieces should be placed below the lowermost stack. In some places, poles are often stacked vertically by leaning them against a tree, with their thick ends on the ground. This is particularly done for keeping the poles away from sunlight. Bamboos may also be stacked in the same way as poles.

D) Stacking of Fuel wood: Stacking of Fuel wood is done in such a way that fuel wood dries up rapidly. The places having dampness should be avoided for staking however, if it is unavoidable; the stacks should be raised above the ground. The stacking should be done as closely as possible, all gaps being carefully filled up. The stacking of fuel wood should be carried out according to its dimensions so that their accounting is easy. The height and breadth of the stack is always be kept constant.

3.3.4 Clearance of the area

After initial conversion of wood at the forest site, the area needs to be cleared off and the material stored in a temporary depot that is near the road head or water head from where it can easily be transported to permanent depot.

3.3.5 Conversion of timber

The conversion of timber implies the timber to meet the demands of all classes of markets whether local or distant. The felled tree is initially converted in the forest site

itself and from this site is taken away to permanent depot. Sometimes however, conversion is also carried out in the forest site also. The most fundamental rules of economic conversion is that as far as possible the use of axe is avoided and saws are highly preferred tools and this is because of the fact that waste generation is least in saws whereas axes produce a lot of waste. Thus, saws of different kinds can be employed for the purpose and accordingly the final conversion of partially squared timber or logs is carried out manly by two ways –

- **by hand saws**
- **by sawmills**

3.3.5.1 Conversion by Hand

Where it is not possible to convert the logs into scantlings through saw mills, the hand saws are used. One of the important step towards hand sawing is that placement of log in proper position and it varies according to the type of saw to be used. In order saws to move freely, it is required either to raise the logs six to eight feet above the ground on a skeleton platform of poles or by placing logs on the ground level over a pit dug in the ground. In both the cases one sawyer stands on the log and the other stands below it so that movement of saw is possible. It is important to note that careful and accurate squaring is of great importance otherwise much of the wood becomes useless or of low grade timber resulting in less price in the market. Square timber obtained in such a way can be converted into scantlings of required sizes. Marking at the ends of the squared timber is carefully carried out using a ruler and the external longitudinal lines which the saw blades are to follow are drawn by tightly stretching a string having wet in charcoal powder or other coloring agent so that full length marks are visible. Subsequently handsaws are made to cut the scantlings following the lines.

3.3.5.2 Conversion by Sawmills

Use of sawmills increases efficiency in sawing and larger amount of logs can be processed in shorter time duration. However, sawmill demands a large amount of money investment. Therefore, establishment of a saw-mill is advisable under the following conditions:

- a plentiful and regular supply of timber is available
- timber is brought to the mill in the round at a reasonable cost

- there exists at least one good line of export for the converted material from the mill,
- there is a sufficient demand for all the material that can be converted at the mill,
- the working of the mill is likely to realize a reasonable profit

On the other hand a sawmill should not be established where

- the timber is not available in sufficient quantity to keep the mill regularly employed,
- the timber available is largely hollow or unsound, so that the proportion of waste is very large,
- the timber cannot be extracted in the round except at a very high cost; in such a case conversion in the forest would usually be more profitable,
- unavailability of good market and thus no steady demand for converted material,
- availability of plentiful labour for hand conversion in the forest

Kinds of sawmills

Every sawmill consists of three essential parts,

(1) saw

(2) a mechanism which feeds the logs into the saw, and

(3) the motor which drives the mill

The mechanism consists of a movable carriage or bench on which the log is placed and moved towards the saw, or a roller-feed consisting of a series of revolving rollers which move the log along towards the saw. The roller-feed kind is suitable for even-grained soft woods, such as conifers, which are easily sawn, and not for hard or uneven-grained woods. The saw used in the mills are of three principal types as described below:

- the reciprocating frame-saw,
- the circular saw, and
- the band-saw.

A) **The reciprocating frame-saw:** It is a mechanical adaptation of the hand frame-saw. It consists of a frame, containing one or more saw-blade and the frame moves vertically up and down, sawing with the reciprocating motion employed in

all hand-sawing. Where the power is sufficient, as many as 20 parallel blades may be fixed at a time, their distance apart being adjustable at will, so that the thickness of the boards sawn may be regulated. These machine frame-saws containing a number of blades are termed as multiple saws. The advantage of the frame-saw as compared with the circular-saw is that it requires less power to drive and is less wasteful but on the other hand working with this mill is very slow.

B) **The circular-saw:** It consists of a flat circular steel blade with a continuous row of teeth round the margin. It works by revolving rapidly in one direction, like a wheel, round a horizontal axis. Where waste of wood is not of vital importance, and motive-power is cheap, the circular-saw is the best machine saw for general purposes, as it turns out its work with great rapidity. One of the chief disadvantages of circular-saws is that they cannot saw timber of very large girth.

C) **The band-saw:** Itis a long continuous flexible steel ribbon with teeth on one edge; it passes round two large revolving wheels, thus presenting a continuous cutting edge. Band- saws may work either vertically or horizontally. The band-saw has several advantages as follows:

- it can saw timber of large diameter,
- causes little waste
- requires less motive power than the circular saw and,
- turns out as much work as a circular saw and more work than a frame-saw

On the other hand the band-saw requires much care and skill in sharpening and adjusting, so that its use is not recommended where a skilled and experienced mechanic is not available. The breakage of the saws leads to enhancing the cost of operation.

The different kinds of converted timber are squares or balks, beams (usually rectangular), sleepers, scantlings and firewood.

3.4Storage of wood after transport- Wood Depots

A depot is a place where wood or other forest produce are stored. Depots may be classified broadly into two categories namely:

- forest depots or transit depots
- sale depots or permanent depots

3.4.1 Forest depots or Transit Depots

Forest depots or transit depots are temporary storage near or inside the forests. They are mainly formed for temporary storage of logs or roughly squared logs till they are transported to market or permanent storage areas.

3.4.2 Sale depots or permanent depots

These are the depots which are permanent and located in some central locations. The purpose of these depots is to store the forest produce relatively for longer time period till the produce is sold out. These depots usually located in such areas where the buyers may conveniently come and inspect the produce. Sale depotsare further divided into two categories based on their location in land or water and accordingly known as land depots and water depots.

Water depotsare generally established in a river or in still water or on the sea-shore. When depots are made in some river, they are always exposed to some risk due to uncertainty in water volume due to floods. Therefore, rivers are not suitable for long storage of timber. Water current is an important consideration when depot is to be made in water and such place should be have still water such as backwater. The logs must be fastened together end to end through chain. Depots in still water may be either natural lakes or ponds, or may be artificially constructed. A sea-shore depot should be well sheltered and should not be exposed to the open sea. A gradual slope is needed when such depots are to constructed in beaches. Usually there is risk of marine borers in sea sites therefore, wood should be stored for smaller duration.

3.5 Summary

- Transport of wood or logs in land may be carried out by men, animals (Bullocks, mules, camels and elephants), by carts (cart hauled by a bullock/buffalo for transport of timber and other produce), by dragging(logs can be dragged on roads specially constructed for the purpose), by rolling(in areas of gentle slope, logs can be rolled) or by motor vehicle. Other means of transport are forest tramways, wire and rope-ways etc. Any of the above mentioned means of transport can be used provided that they are suitable and cost effective for the area.
- Transport by roads is mostly used. The other methods includes transportation by men or by animals, through sledge-roads, rolling-roads, dragging paths,

slides, forest Tramways and wire rope-ways whereas in water transportation takes place by floating, rafting and with the help of boats and ships.

- Conversion of Wood means logging operations or making of smaller marketable sizes of bole which can be transported easily. This is known as rough conversion of wood. Timber of commerce is roughly classified as - Round Timber or logs. Roughly squared timber usually called balks or rough squares and sawn timber (such as squares, beams, sleepers, scantlings and planks). Whereas fuel wood is classified as - **Split Billets (**The larger pieces which have to be split to convenient size), **Round Billets (**Pieces which are not too large to use in the round), **Root and stump wood (**Pieces cut to convenient size from roots and stumps) and **Faggot-wood (**It includes small-sized branch-wood and other small material, which is tied up into bundles and is sold chiefly for domestic use).
- The main factors which affect the rough conversion of wood are market demand, availability of skilled labour, and availability of transportation and topography of the felling site.
- After temporary or rough conversion of the wood, it is required to store the converted wood temporarily in the forest site before it is transported. The converted material is exposed to attack by fungi and insects, therefore, stacking of the logs is done ate the site so that it may season. Further, it is done in order to avoid the warping and cracking of timber. This stacking may be done either in the forest or in some central forest depot. The stacking is done in such a way that each class of timber has separate stack and at the same time care should be taken that stacks occupy the minimum space so that accounting and inspection is easy, and safety of timber is also ensured. Stacking of timber can be done in two ways- stacking of round timber and stacking of sawn timber.
- After rough conversion of wood, it is temporarily stored in shade in the felling site till it is transported to permanent depot. The forest site is cleared off and the material stored in a temporary depot that is near the road head or water head from where it can easily be transported to permanent depot.

- The conversion of timber implies the timber to meet the demands of all classes of markets whether local or distant. The most fundamental rules of economic conversion is that as far as possible the use of axe is avoided and saws are highly preferred tools and this is because of the fact that waste generation is least in saws whereas axes produce a lot of waste. For this purpose, saws of different kinds can be employed such as **hand saws and sawmills.**
- A depot is a place where wood or other forest produce are stored. It is carried out in temporary or permanent depot based on whether wood is stored in harvesting site or some other area. Accordingly there are two depots- forest depots also called as transit depots and sale depots which are also called as permanent depots. Forest depots are made temporarily at harvesting site for storage for smaller duration whereas sale depots or permanent depots are constructed at location suitable for sale. Permanent depots may be made in land as well as water.

Reference and Bibliography

[1] R. Troup, *Indian Forest Utilization,* Calcutta: Calcuta Goverment Printing Presss, 1907.

[2] T. Mehta, *A Handbook of Forest Utilization,* International Book Distribution, 1981.

[3] H. Trotter, *Manual of Indian Forest Utilization,* Oxford University Press, 1940.

4] W. R. Fisher, Manual of Forestry Vol V- Forest Utilization, London: Bradbury, AGNEW & CO. , 1896.

Unit 04: Wood Based Products and Utilization

Unit Structure

4.0 Learning Objectives

At the end of this unit, the learner shall be able to explain:

- Woody plants and their characteristics
- Physical properties of wood
- Describe important woody plants
- Describe wood based products and industries

4.1 Introduction

In the previous units, we discussed about the various kinds of forest based products and their utilization. We also discussed the harvesting of wood, rough conversion at harvesting site and final conversion of the harvested wood at road side or at some other location outside the forest area. We also discussed the various means of transportation of wood to the desired location or industries where they are put to diversity of uses.

In this unit, we will discuss about the wood, various species yielding high valued wood, various kinds of wood and their physical properties. We will also discuss important wood yielding species and the utilization of various wood products in detail.

4.2 What is a wood and woody plant?

The word 'wood' is nothing but vascular cells and tissues (xylem and phloem) which have become solid due to lignifications over the years and has become solid. The process of lignifications takes place due to the production of certain chemicals and certain physical processes in the vascular tissue that causes cell walls to become more hard, strong and durable. It is also true that the process of lignifications is not confined to vascular tissues only or woody plants only, but it takes place in different cells or tissues of the plant body but the amount of lignifications in the vascular tissues of woody plants is very high when compared with other plants or tissues of other region in the plant body. Thus, woody plants are all those plants which contain lignified woody element in their vascular tissues and live a life of many years i.e., perennial. On the other hand, it is also true that lignifications is not an essential part of the life cycle of every cell but many cells remain entirely un-lignified throughout their whole existence and consist wholly of cellulose, for example sieve tubes are never lignified. Similarly, epidermal cells and guard cells of stomata in majority of plants remain un-lignified. However, in some plants guard cells get lignified for instance, ferns and gymnosperms often have lignified guard cell walls [1]

Woody plants may be trees, shrubs or climbing vines such as lianas, but essentially not herbs. The main difference among these is that the trees have a clear trunk called **bole**, whereas shrubs are woody perennials having many branches arising from their base whereas lianas are woody climber and need some support to grow.

4.3 Characteristics of Woody Plants

4.3.1 General Characteristics of woody plants

There are certain characteristics of woody plants. Important ones are as follows:

1) They are essentially vascular plants and possess specialized conducting tissues for conduction of water and nutrients i.e., xylem and phloem. It is the xylem tissues which get lignified in course of time and forms the wood in the mature plants.
2) They are essentially perennial plants living for many years.
3) They must possess a stem that persists from year to year and generally, called "bole" or "trunk" in trees. Many perennials such as ginger, fail to be classed as woody plants because their above ground portion dies at the end of season or year, however, the roots or underground stem remains alive all through the adverse conditions and produce a new stem in the following spring.
4) Typical woody plants exhibit secondary growth due to the presence of a tissue called cambium. It is through the growth and division of cells in cambium, that the growth of stem or bole takes place in diameter. In course of time, secondary thickenings also take place.
5) There are mainly five groups of plants i.e. Thallophytes, Bryophytes, Pteridopytes, Gymnosperms and Angiosperms. Of these vascular tissues have evolved first of all in pteridophytes and gradually advancement took place. Although woody elements are present in pteridophytes and some of the ferns are big similar to trees in size and shape (arborescent), yet they are not suitable to be converted into lumber due to inappropriate arrangement of vascular bundles. Timber producing plants i.e., trees mainly belong to Gymnosperms and Angiosperms, only. In Gymnosperms also, only the trees belonging to the Coniferales (Coniferae) produce the soft timber on a commercial scale.
6) Among the Angiosperms which constitute a large number of species i.e.., more than 150000 species, yet they all do not produce timber. Angiosperms are also categorized into two groups, i.e., Monocotyledons (monocots) and Dicotyledons (Dicots), based on the number of cotyledons present in the seed or embryo. Most of the monocots are herbaceous, however, bamboos, palms and yuccas have tree like woody elements in them, however, and they cannot be sown into lumber like in angiosperms because of unsystematic arrangement of vascular bundles. The main

timber of commerce is obtained from Dicots. However, all the species belonging to dicots do not produce timber; many of them are herbs and shrubs as well. Thus, it is now obvious that there are mainly two categories of timbers are available, one that is obtained from conifers and the other that is obtained from the angiosperms. The former is known as “softwood “whereas the later as “hardwood”. Softwoods are sometimes also known as nonporous woods and hardwoods as porous woods.

4.3.2 Characteristics of hardwoods

The cells forming the woody tissue are:

(a) Ducts (pores, vessels) formed by the resorption of the partition walls in a vertically running string of cells. Such ducts are characteristic of hardwoods.

(b) Sclerenchyma, cells of heavy walls and small lumina, usually forming long fibres.

(c) Parenchyma, cells of thin walls and large lumina, frequently containing grains of starch. Medulla or pith is found in the central column, in the primary, secondary, tertiary rays and (rarely) in medullary spots (birch). The central pith is:

- Heavy in maple, elder
- Triangular in birch, alder
- Broad leaved species are called "ring porous," if the spring wood of the annual ring contains strikingly large pores, or else "diffuse porous," if the ducts are evenly distributed over the entire ring. Sapwood and heartwood are merely distinguished by a difference of color, caused by incrustations of pigments, lignin, tannin etc., in the walls of rings formed a number of years before. The number of years elapsing before incrustation takes place is small in chestnut; and larger in yellow poplar, white oak, walnut where it is about thirty or forty years old.

4.3.3. Botanical characteristics of softwoods

a) The tissue of softwoods is more homogeneous than that of hardwoods. It is mainly formed by tracheae.

b) The cell walls formed in early spring are thinner and the lumina formed in early spring are larger than thoseformed in summer.

c) Parenchyma is found in the medullary rays and around the rosin ducts.

d) Ducts of the form found in hardwoods exist only close to the central pith column.

e) The medullary rays are very fine (microscopic), usually only one cell wide and about a dozen cells high. Thelowest string of cells in the ray is usually formed by tracheae (exception—red cedar).

f) Rosin ducts are not cells merely but unlike the ducts of hardwoods, hollow tubes, the walls of which are formed by parenchymatic cells. These ducts are running horizontally as well as vertically in *Picea*, *Pinus*,*Pseudotsuga* etc.

g) The tissue of the genera *Abies, Taxus, Juniperus, Thuja, Tsuga* etc. lacks the ducts.

h) Heartwood and sapwood of conifers are distinguished merely by a difference in color, due to incrustations of rosin in the inner heartwood rings. Heartwood is conspicuous in the pines and cedars whereas it is lacking in Spruces and firs.

4.4 Physical and chemical properties of Wood

4.4.1 Physical properties

The physical properties of wood may be defined as those properties which manifest without chemical change. It is the physical property of a wood which makes them saleable in the market. Important physical properties of wood are as follows:

- Colour
- Luster
- Fluorescence
- Ordour and Taste
- Weight and specific gravity
- Hardness
- Flexibility

a) Colour: Colour is one of the important characteristics of the wood on which its market demand and salability depends to some extent. It is on this feature that the qualities of finished products like furniture, doors etc. depends. It is this feature of wood that is sometimes useful in identification. Sapwoods are more or less white

sometimes with a yellow or pink tint whereas the heartwood is usually of darker shade mostly brown. The heartwood of some trees darkens appreciably upon exposure that of others tends to bleach. It is the fungi and bacteria which are frequently associated with discoloration of wood [2].

b) Luster: Luster is the property of wood that enables it to reflect light or in simplest words the shining ability or also is the ability of the wood to get polished well. The luster of wood mainly depends upon its anatomical structure and the infiltration products in it. It varies with the kind of wood and the plane in which it is viewed. Oily or waxy substances generally decease the luster whereas the corollary follows that woods with comparatively little infiltration are often quite lustrous [3].

c) Fluorescence: It is defined as the physical property in which some media has the capacity of emitting light when exposed to the action of certain rays of the spectrum and this light is usually quite different than the one reflected from various surfaces. Some examples of such woods are *Pterocarpus sp*., *Ougeiniadalbergioides, Stephegyne parvifolia* and *S. diversifolia* [2].

d) Weight and Specific Gravity: Specific gravityis the ratio of weight of a certain volume of wood or any other substance to the weight of an equal volume of water. In other words it is relative value of weight per unit volume compared with water or simply it is relative density where density of water is the standard for comparison. Thus, the higher the specific gravity of wood the more heavy it would be.

Specific gravity has a close connection with other physical properties of wood such as hardness, combustibility, heating power, seasoning power, durability etc. The specific gravity of wood varies considerably under different conditions, not only according to species, but also to locality and the mode of formation, the age of a particular tree, the part of the tree from which any piece of wood is taken, its degree of moisture, amount of resin it contains, and several other factors [4]. Wood of different trees show difference in specific gravity and this difference is attributed to following:

- Anatomical structure of wood
- Soil and locality
- Age of trees
- Amount of moisture in the wood

- Amount of resinous substances and other substances
- Part of the tree from which it has originated (heartwood is heavier than sapwood)

Higher the weight or specific gravity of a wood, the higher will be its suitability for use in the areas where high strength is needed such as house building, bridge construction etc.

Based on specific gravity or weight of wood, the tree species can be categorized in following categories based on average air dried weight of one cubic foot [5]:

Extremely heavy (>32 kg or >70 lbs): *Hardwickia binata, Tamarindus indica, Pterocarpous santalinus, Mesua ferrea*

Very heavy (27-32 Kg or 60 -70 lbs): *Pterocarpus indicus, Acacia catechu, Quercus dilatata, Quercus incana, Anogeissus latifolia, Santalum album, Terminalia tomentosa, Shorea robusta*

Moderately heavy (23-27 Kg or 50-60 lbs): *Casia fistula, Dalbergia latifolia, Quercus semecarpifolia, Terminalia chebula, Lagerstroemia parviflora, Melia indica, Albizzia lebbek, Dalbergia sisssoo, Careya arborea, Grewia tiliefolia*

Light (13.5 -18 Kg or 30-40 lbs): *Cupressus torulaosa, Michelia champaca, Cedrela toona, Gmelina arborea, Ficus bengalensis, Cedrus deodara, Aesculus indica, Abies pindrow, Ficus glomerata*

Very light (Less than 13.5 Kg or Less than 30 lbs): *Populus ciliata, Trewia nudiflora, Bombax malabaricum, Ailanthus excelsa, Sterculia colorata*and *Erythrina suberosa*

e) Hardness: The hardness of a body is its power of resisting the insertion of another body into its mass. Hardness of wood refers to the resistance it offers to penetration by another body or wear and tear in general. In simple words, those woods which are easily worked upon by instruments are termed as softwoods whereas in which working is difficult is termed as hardwoods. The factors on which the hardness of wood depends are its anatomical structure, the coherence of its fibers, the amount of resin present, degree of moisture and the kind of instrument used. Further, the resistance offered by wood to same instrument may differ in different directions. For example it is easier to cut the wood along the fibres than

right angles to the fiber or in oblique direction. Further, the condition of wood i.e., sound wood or decaying wood, has difference in resistance to wood working, the latter being easy to work upon. Woods have been classified based on hardness into six categories [5] as follows:

Extremely hard: Mesua ferrea, Hardwickia binata, Pterocarpus santalinus, Dalbergia latifolia

Very Hard: *Acacia catechu, Shorea robusta, Dalbergia sissoo, Pterocarpus marsupium, Cassia fistula, Terminalia chebula, Anogeissus latifolia, Lagerstroemia parviflora, Quercus incana, Quercus semecarpifolia*

Hard: *Tamarindus indica, Santalum album, Shorea robusta, Aegle marmelos, Melia indica, Zizyphus jujuba, Pterocarpus indicus, Acacia arabica, Albizzia lebbek, Terminalia belerica, Terminalia tomentosa, Taxus buccat*a

Moderately hard: Pterocarpus dalbergioides, Tectona grandis, Adina cardifolia, Careya arborea, Cedrus deodara, Pinus roxburghii, Cupressus torulosa, Juglans regia, Ficus bengalensis, Boswellia serrata

Soft: *Michelia champaca, Cedrella toona, Aesculaus indica, Bombax malabaricum, Gmelina arborea, Ficus glomerata, Salix spp. Populus ciliate*

Very soft: *Chlorospermum gossypium, Sterculia villosa, Sterculia urens, Sterculia colorata*

f) **Flexibility [5]:** Flexibility of wood means the capacity of wood to bent out of shape without breaking whereas in contrary to this the wood which cannot be bend without breaking is called brittle. The property of flexibility of wood has certain uses such as basket work, bent-wood furniture, planks for the curved sides of ship. Flexibility of those woods is maximum which have long straight fibers, free from knots and decay. Soft or light wood are more flexible than the hard or heavy woods. Moisture increases the flexibility whereas dryness decreases it. This property is made use of in bending the dry wood by temporarily putting them under steam or boiling water to increase their flexibility. The other factors include the age

of trees, habit of woody plant i.e., the climbers are most flexible among woody plants.

g) Elasticity[4] [5]: Elasticity is more or less similar to flexibility to a certain extent in the sense that it implies a capacity for being bent out of the original shape, however, it also means springing back to its original shape, whereas in flexibility springing power remains absent. Thus, an elastic wood has flexibility but a flexible wood need not have elasticity. Elasticity is a property required for carriage-shafts, bows, mast of ship. It is also affected by length and straightness of fiber and freedom from knots and unsoundness. However, the factors like moisture content Dryness increase elasticity provided it is not excessive, while moisture decreases it. Presence of resin in small quantities increase elasticity while more of fluid resin deceases it. Elasticity is directly proportional to specific gravity, therefore, the heavier woods are more elastic than the light or soft wood [5]. Based on their elasticity, woods are classified as follows:

A) **Very elastic:** Bamboos, canes, *Grewia spp., Hardwickia binnata, Anogeissus latifolia, Areca catechu, Mesua ferrea*

B) **Elastic:** *Acacia catechu, Casuarina equisetifolia, Shorea robusta, Pterocarpus santalinus, Artocarpus lakoocha, Acacia arabica, Albizzia lebbek, Dalbergia latifolia, Dalbergia sissoo, Pterocarpus dalbergioides*

C) **Moderately elastic:** *Mangifera indica, Tectona grandis, Melia indica, Cedrus deodara, Gmelina arborea, Michelia excelsa*

h) Fissibility [4]: Fissibility of wood means ease of splitting of wood by a wedge in the direction of fiber. Fissibility is chiefly affected by the structure of the wood and also to a certain extent by the elasticity of its fibers. Other factors on which fissibility depends are:

- Structure of wood has a direct relation with fissibility. Straight and long fibers make easy splitting of wood whereas twisted or non-homogenous fibers along with presence of knots, causes difficulty in splitting.
- Elasticity of wood also favour fissibility of wood.
- Moisture content also affects the fissibility of wood
- Frost or frozen wood is difficult to split
- Resin increases difficulty in splitting

4.4.2 Chemical properties wood

a) The walls of the tissue are formed by cellulose and by lignin. Cellulose transforms, entirely or partially, in the very year in which the cell is built, by incrustation and reduction into lignin. If a branch or a seedling does not enjoy enough light during summer to allow thorough ligni fication, then that branch or seedling is necessarily killed by the winter frost.

b) Wood and bark contain on an average 45 % of water (by weight). Conifers contain less water than broad-leafed species. The percentage varies irregularly with the seasons and with the precipitations.

c) Other substances found in the woody tissue are:

- In the sap and medulla—albumen, starch, sugar, oils.
- In the cell walls—tannin, rosin and pigments.

d) The specific gravity of pure wood fibre is 1.56.

4.5. Description of some important timber species [6]

4.5.1 *Abies pindrow* Royle

Trade name: Fir

Vernacularnames: Ragu

Weight: Approx. 33 lbs per cft (air-dry)

General description of the wood

- The wood is creamy white to light, colour of heartwood and sapwood same
- It is fairly soft, therefore, easy in wood working
- It give usually knot free timber
- Air seasoning is done
- Timber or logs or sawn wood should be seasoned as soon as possible after conversion as it is very apt to fungus attack.
- More or less similar to chirpine in strength, however, less strong to deodar
- Durability is very poor as it is apt to be attacked by fungus and white-ant

- It is suitable for all types of packing cases, containers and fruit crates. It is suitable for paper pulp

4.5.2 Acacia catechu

Trade name: Cutch

Vernacular name: Khair

Weight: 55 to 65 lbs per cft (air-dry)

Description:

- The sapwood is a creamy white and heartwood is a dull pink which darkens to a dull reddish brown on exposure.
- A very hard and very heavy wood
- No smell or no taste
- Straight-grained and medium textured wood
- A common characteristic of the wood is the presence of white specks of a powdery deposit known as 'kheersal' which can be seen with the naked eye.
- Cutch is an extremely strong and very hard timber
- It is considered as one of the most durable woods particularly heartwood is although the sapwood is not so durable
- On account of its hardness, sawing is somewhat difficult particularly when the wood is old and dry.
- It is chiefly used for the production of cutch and katha, but is a valuable timber also. It is very much required for posts in house construction and is also used for rice pestles, oil and sugar cane crushers, ploughs, tent pegs, bedpost legs, and keels and knees of boats.

4.5.3 *Adina cordifolia*

Trade name- Haldu

Vernacular names- Haldu

Weight - 40 lbs per cft (air-dry).

Description of the wood:

- Haldu is a yellow or straw-coloured wood
- The wood is lustrous with a smooth feel but without taste or smell
- Usually fairly straight-grained but sometimes with broadly interlocked bands of fibres
- The converted timber dries up easily even in open but, direct sun rays are avoided. The most usual defects are small surface-cracks and end-splitting, however,
- The logs are required to be converted as soon as possible since the seasoning is necessary to avoid in insect damage. It is better to remove the bark to ensure proper and best seasoning results.
- The wood is very hard even harder than teak
- Well-seasoned haldu wood is moderately durable

4.5.3 *Cedrela toona*

Tradename: Toona

Vernacularnames:-Tun, tuni,

Weight: 37 lb. per cft. (air-dry).

Description of the wood

- The wood is a pinkish brick-red, when freshly cut, toning to a light brownish red on exposure
- It yields light-weight and straight-grained timber
- The wood has a distinct cedar like smell
- Toon gets air seasoned quite easily and care is needed while making stack of the converted material. Conversion should be carried out during dry weather as far as possible, however, sometimes it is liable to warping during seasoning
- The strength of toon moderate however, in shear it is more or less equal to teak wood.
- Well-seasoned toon wood is quite durable, however, if logs are not converted and kept as such for long time then liable to be degraded by white ants.

- It is mainly used for furniture, granaries and house building as well. Also used in making match boxes, cigar boxes and tea boxes.

4.5.3 *Cedrus deodara*

Trade name: Deodar, Himalayan cedar

Vernacular names: Diar, deodar

Weight: About 35 lb per cft (air-dry)

Description of the wood

- The wood is of light yellow-brown colour
- It has a peculiar odour
- It is a medium weight wood
- It has usually even grained and of medium to fine texture, but the presence of large knots is a common feature
- Wood is easily air-seasoned, however, some surface-cracks and splitting may be seen
- Deodar is the strongest of the Indian conifers
- the seasoned heartwood of deodar is naturally durable but is liable to be attacked by white ants
- It was earlier used to be used for railway sleepers and construction work, house-building, furniture and other purposes. It is also suitable for light furniture, floor boards, posts and window frames.

4.5.4 Dalbergia sissoo

Trade Name: Sissoo or Shisham

Vernacular Name: Shisham

Weight: 50 to 55 lb per cft (air seasoned).

Description of the wood

- Sissoo is normally a golden-brown to dark-brown wood without purple coloration
- Wood has very rich grain
- It can be easily air-seasoned and kiln seasoned

- It is advisable to have green conversion and care full stacking for air seasoning. However, it dries out very quickly therefore, protection against too rapid drying is advisable in order to avoid any end-cracking
- It is slightly heavier and harder than teak
- The heartwood is quite durable when seasoned adequately however, sapwood is liable to be attacked by borers and fungi, thus perishable.
- It is amongst the finest timbers of India and extensively used in cabinet and furniture works. It is also used in house-building and floorings.
- It is used in large quantities by the Ordnance Department in India for gun-carriage wheels, wagon parts and other purposes. In railways, it is used for floor boards and carriage work

4.5.5 *Hardwickia binata*

Trade name: Anjan

Vernacular names: Anjan, kamra

Weight: Up to 69 lb per cft (air dry)

Description of the wood

- An extremely hard, heavy and durable wood. The heartwood is usually a dark reddish brown sometimes streaked with blackish markings. No characteristic odour or taste.
- Irregularly interlocked grain and of course texture.
- Seasoning is difficult. It develops surface cracks when drying and is liable to warp if not well piled.
- As far as possible, green conversion of wood is advisable and the converted material should be properly stacked with sufficient protection to prevent too rapid drying
- It is an extremely hard, heavy and fairly strong wood.
- It is a durable wood against rot and white ants, however, it was found to be attacked by borers [6].
- It is suitable for cart wheels, ploughs and machine bearings, posts and beams, tent pegs, brake blocks and go-down floorings.

4.5.6 *Juglans regia*

Tradename: Walnut

Vernacular names: Akhrot, akhor, khor

Weight: About 36 lb. per c. ft. (air-dry)

Description of wood

- Wood is of greyish-brown in colour although it varies in colour, sometimes being a dull grey, or even dark brown.
- Although as light wood yet strong wood and the strength can be comparable with that of teak. It is almost equal to teak in shock resistances.
- It is easy to work on the wood and gets a fine finishes.
- It is not a durable wood as it has chances to be attacked by white ant and fungus
- Walnut wood seasons slowly and shrinks considerably while drying out. It can be seasoned in air as well as kiln. It is recommended to have green conversion and stacking under shade with good air circulation. After adequate seasoning or drying it does not shrink, swell or split, even when exposed to adverse climatic conditions.
- As far as uses of the wood are concerned, it its lightness, strength, and good working qualities make it appropriate for high class cabinet-making, delicate carvings, army rifle parts and furniture making.

4.5.7 *Shorea robusta*

Trade name: Sal

Vernacular names: Sal

Weight: 50 to 56 lb. per c.ft

Description of wood

- It is a very hard cross-fibred heavy and reddish-brown wood which is probably the most extensively used wood throughout the India

- It is extremely strong wood and its heartwood is a naturally durable wood, and usually remains immune to attack by white ants and fungi for a long period of time
- Sal is a very heavy, hard, strong, tough wood. It is about 30 per cent heavier and 50 per cent harder than teak, and also about 20 to 30 per cent stronger. In shock resistance it is about 45 per cent above teak.
- Sal seasons extremely slowly. It develops characteristic small surface cracks during seasoning.
- It is highly used wood in railway sleepers, constructional wood and for a variety of other purposes such as for beams, rafters, flooring, bridge, railway carriage and wagon work, carts, tool handles, picker arms and tent pegs.

4.5.8 *Tectona grandis*

Trade name: Teak

Vernacular names: Sagun, sagwan

Weight: 38 to 43 lb per cft (air-dry)

Description of wood

- Sapwood greyish-white and heartwood light golden brown in colour
- The freshly harvested teak darkens rapidly on exposure or in seasoning
- Characteristic smell similar to smell of old leather
- It is a medium weight, strong wood of average hardness and of outstanding merit in retention of shape and durability.
- The heartwood is one of the most naturally durable woods of the world. It usually remains immune to white ant attack and insect attack for very long periods, however, sapwood is very perishable and quickly destroyed by rot, white ants or borers.
- Teak is a relatively easy wood to saw and work, and is popular in any workshop. It can be finished to a fair surface and takes polish well.
- The uses of teak are well-known. It is used in railway carriage, wagon, high class furniture, ship-building etc.

4.5.9 *Acacia Catechu* Willd.

Trade name: Khair

Vernacular names: Its chief name is "khair," but in Burma it is generally known as the "cutch tree". Other vernacular names are koir, Ass. Khoiru, Uriya Karangalh, bdgd, othalei, Tarn. Sandra, nalla sandra, Tel Khair, kaden, etc.

Weight: Weight 61 lbs.

Description of wood: The wood is of a bright red mahogany colour, slightly lustrous, with a close, firm, hard texture. As a tree it is very important, less for its timber than for the astringent products which it gives. In India this is catechu, an important catechol tan, but in Burma the tree is valued for cutch, a black shining extract used as a tanning material, and exported to Europe. The wood possesses many qualities which, were they better known, would bring a demand from many parts of the world. It is extremely hard and durable, highly suitable for cabinet work, and is not attacked by white ant.

4.6 Wood Based Products and Industries [2]

4.6.1 Veneers

Veneers are thin slices or sheets of woodof uniform thickness produced by peeling or slicing of logs. They were at first only made from beautifully grained and handsomely figured woods which, owing to their extreme cost, were seldom used in the form of solid boards. The veneer industry has increased in importance in great speed in the past few decades. It is generally considered a phase of 19th-century industrialism, however, historically veneers were used even in early Roman empires. Greece people were known for their knowledge and proficiency in veneer making, therefore, the Romans used to go to Greece to buy tables with veneered tops. Wealthy Romans paid very high prices for these tables of rare Eastern and tropical woods.

In the initial times of veneer development, veneers could not be much popularized on account of some reasons and principal reasons are comparatively cheaper prices of best wood particularly native species. With the gradual depletion of our timber supply, especially of the more valuable woods, it has become a necessity to develop much of our high-grade furniture, interior finish, doors, etc., with the veneer face, and the centers or cores composed of mediocre woods or low-grade woods. This situation, of course, contributes to the more efficient utilization of our timber supplies, since the best

woods or best quality of our more valuable woods can be reserved for the exterior faces and the interiors made up of the cheaper woods and lower grades.

Veneers found their principal use for fine furniture and cabinet work. In the recent years the demands for veneers have increased remarkably. Veneers are utilized for a great variety uses now such as fruit baskets, cheese boxes, crates and packing boxes, drawer bottoms, trunk stock, mirror backing, panels, doors, windows, cabinets, etc.

Method of veneer making: The modern use of fine-faced veneers in cabinet work is said to have been started by Sir Ishambard Brunei at the Chatham Dock Yards (England) in 1799. A shop was equipped in 1805 in Battersea (England) and veneers were made from mahogany and rosewood. It is said that the first circular veneer saw was invented in 1805 which cut veneers as thin as $1/16^{th}$ of an inch.

Prior to the twentieth century all veneers were produced by sawing. In this process logs were first cut into flitches (timber slab), and the flitches in turn were reduced to thin sheets of wood by driving them against a circular saw. This was both an expensive and wasteful procedure, since much of the best and clearest wood in a log was removed as slabs as and more than half the potential veneer in the flitches was reduced to sawdust in the cutting operation. There are at present five methods employed in the manufacture of veneers:

1. **The rotary cut process:** It consists of turning a log on a heavy lathe against a stationary knife, is the method by which about 90 per cent of all of our veneers are made. Continuous sheets of veneer are cut off down to a 6- to 10-inches core. Generally speaking, our lowest priced veneers are made by this process as it is a very cheap method of manufacture. Since it is a rotary process, cutting with the rings of annual growth, it does not bring out the quarter grain or figure of the wood as well as the other processes by which cuts can be made along the medullary rays. Most of the walnut veneers are made by the rotary method. Walnut stumps are also cut by this method in connection with a stay log. More waste is occasioned by this process than the others, due to the core left after cutting and the large amount of waste in clipping and trimming.
2. **Stay-log Cutting:** This is merely a modification of rotary cutting and was developed primarily for producing fancy face-veneers from quarter flitches and irregularly shaped materials such as burls, crotches, and stumps. To produce veneer, a flitch

or section from a stump is securely fastened to the flange with several heavy lag screws, and then turned against the knife. Back-cut veneers obtained from stump wood and crotches are usually handsomely figured because fiber alignment in materials of these kinds is very irregular. In fact much fiber is often cut across rather than along the grain with the result that the sheets of veneer are very brittle and special care must be exercised in handling them.

3. **Cone-cutting:** Cone-cutting produces circular sheets of veneer by taper-peeling a bolt in a manner similar to that of sharpening a wooden pencil. The contact angle of the knife determines the degree of taper, the approximate width of the sheet for a bolt of a given diameter, and the number of revolutions the bolt must make to produce a completely circular sheet. Only a very small amount of veneer is produced in this manner, as such veneers are ordinarily "short-grained" and hence quite brittle. Beautiful "wheel" or stellate figures result, and the veneers are used in the fabrication of panels for fancy, circular table tops.
4. **The slicing process:** It consists of rapidly moving a flitch of wood vertically downward against a cutting knife, is the method by which, much of our quarter-cut oak veneers are made. Mahogany, Spanish cedar, rosewood and other foreign woods showing a pleasing figure on the quarter grain are commonly sliced by this method. This method is least wasteful of the raw material of the three processes.
5. **Sawed veneers:** These are considered most valuable because this process tears the wood fiber less than the other processes and they can be worked up and finished to better advantage. Our most valuable mahogany and other foreign woods, especially those presenting a fine figure when cut on the quarter, are sawed. The method consists of moving a flitch of wood on a carriage against a circular saw which cuts a kerf of about of an inch. It is consequently a very wasteful process. Most of our sawed veneers are about of an inch in thickness.

Thicknesses of Veneer: Veneers are cut in a wide variety of thicknesses ranging from 1/500 to 1/2 inches or more. Most of the rotary veneers are cut between 1/40 to 1/8 inches, however, but those from 1/20 to 1/24 inches constitute the largest amount[2]. During the Second World War, rotary-cut mahogany veneers 1/64 inches in thickness were used in the manufacture of wing skins for aircraft.

Sawed veneers vary from ¼ to 1/32 inches in thickness, however, 1/20 inches stock being the most common.

The qualities desired in Veneer Woods: The qualities of wood used in veneer making should have following properties as listed below:

1. It should be reasonably low in price because the ultimate products for which veneers are largely used are viz. fruit baskets, crating, cooperage, novelties, packing boxes, cheese boxes, etc., and such uses should increase the overall prices of products for which they are used.
2. The woods must be available in sufficient quantities and readily accessible so that uniform products be manufactured.
3. The particular species should grow to a comparatively large size and must be symmetrical in shape.
4. The wood species should be free from defects i.e., various forms of checks, shake, frost cracks, rot, pitch streaks, etc.
5. The grain and fiber of the woods should be of such a nature that it readily adapts itself to manufacture. This, however, is of comparatively little importance as practically any wood can be made into veneers. Some, however, lend themselves to certain processes of manufacture better than others.

Utilization of Veneers

1. Veneers were originally used entirely for furniture purposes such as tables of all kinds, beds, dressing tables and other bedroom furniture, cabinets, pianos and other musical instruments, book cases, etc.
2. The other uses of veneers is for doors and door panels.
3. Veneers are also used for shipping containers, including packing boxes, cheese boxes, crating materials, veneer barrels, etc.
4. Fruit containers, including such products as berry cups, berry and fruit baskets and many forms of vegetable boxes.
5. Drawer bottoms, chair seats and mirror backing, which are usually classed together in the manufacture of veneers.
6. Veneers are also used in manufacture of sport goods.

7. Miscellaneous uses including such articles as automobile tops, egg cases, wooden dishes, hoops, hampers, toys etc.

4.6.2 Plywood and its manufacture

Plywood is a well-established trade term applied to composite wood panels composed of an odd number of sheets of veneer that are bonded together with a suitable adhesive in such a manner that the grain directions of the adjacent plies are at right angles to one another. The simplest plywood panel is a three-ply assembly. The inner layer is designated as the core to distinguish it from the two outer sheets, the face plies. In three-ply construction, the grain direction in the core is at right angles to that of the face plies. A five-ply panel is comprised of five layers of wood in which the grain directions of the core and faces all parallel one another. On each side of the core is a sheet of veneer bonded in such a manner that the grain lies at right angles to that of the core or faces. These sheets are known as **cross bands**. Panels composed of seven, nine, or more plies are similarly constructed. The term plywood is applied also to panels in which a lumber core of some predetermined thickness is used in place of the conventional veneer core.

The chief advantages of plywood panels over those of solid wood of the same dimensions may be summarized as follows:

- Greater uniformity in strength properties along the width and length of the panel;
- Reduction and equalization of shrinkage and swelling;
- Increased resistance to end checking and splitting; and
- if properly constructed, little or no tendency to twist or warp.

The manufacture of a plywood panel consists of following steps:

- preparing faces, cross bands, and cores;
- edge-gluing narrow pieces to form large sheets when required;
- lay-up and spreading of adhesive;
- pressing the glued lay-up into a panel;
- drying the panel; and
- finishing the panel

Utilization of Plywood

In recent years plywood has gained such popularity and its use has become so varied and diverse that only a general summation of its utilization is presented.

1. Plywood in Construction: Perhaps the greatest field of application for plywood is in construction. The ever-growing popularity of plywood in the construction field is largely due to the advantages it offers in comparison with solid lumber. These advantages are:

- the equalization of strength properties along the length and width of the panel achieved by alternating the direction of grain in successive plies;
- greater resistance to end checking and splitting, thus permitting nails and screws to be driven closer to an edge than is possible with solid wood;
- reduction and equalization of shrinkage and swelling;
- lightness, which makes handling of plywood on scaffolding easy;
- ease of cutting into any desired shape;
- applicability for construction of curved surfaces;
- good nailing and screw-holding capacity;
- availability in large sizes cut to exact dimensions;
- adaptability for sheathing purposes;
- high range of decorative effects possible

2. Plywood in Furniture and Cabinetwork: Plywood is widely used in furniture and cabinetmaking. Some of the principal uses are for table tops, case backs, drawer fronts and bottoms, mirror backs, foot and head panels in beds, radio-television cabinets, piano cases, sewing-machine cabinets, fixtures, and seats and backs of auditorium chairs, school and theater chairs etc. In fact, plywood is used in all parts of furniture. Furniture plywood is usually made to order in accordance with the manufacturer's specifications as to matching and size. Some furniture manufacturers prefer to buy three-ply panels to be used as a stock on which face veneers are glued at the furniture factory, so that any desired matched effect can be produced as needed. Cabinet work, such as cupboards, closets, bookcases, and medicine chests, provides another large outlet for plywood.

3. Industrial Uses: To meet the engineering requirements of light weight with maximum strength, there are on the market a number of metal faced plywood products. Such panels are used in truck bodies, boats, hospitals, and restaurants; more recently such panels have been used in the construction of streamlined trains. Plywood covered with heat- and acid- resistant resins is available for use for table tops, office equipment, and wall paneling.

Plywood made with water-resistant glues is extensively used in all classes of water craft. In small pleasure boats plywood is used as a structural and decorative material, while its use for interior paneling in large ocean liners is rapidly increasing. The automobile industry still consumes quantities of plywood, although much less than formerly, for floor boards, trunk shelves, and upholstering frames. During the war enormous quantities of plywood were used in airplane and glider construction. Millwork is another important outlet for plywood, one of the largest items being door panels of all kinds; large volumes of plywood are also used in trunks, traveling boxes, packing cases, and fruit and vegetable baskets and boxes.

4.6.3 Distillation and Saccharification of wood

4.6.3.1 Distillation of hardwoods

The heating or carbonizing of wood for the purpose of manufacturing charcoal has been in practice since long and it is believed that it is as old as civilization itself. In the manufacture of charcoal by the old process, the wood is heated to such temperatures that it is carbonized while the gases that pass off in the form of dense, heavy, black smoke have given rise to the modern processes of distilling wood.

According to the most authentic records the first successful wood distillation plant was established in New York State in 1850 by John II Turnbull, of Turn- bull & Co., Scotland. In the modern oven retort operation process requires from twenty- three to twenty-six hours for completion. In the wood distillation process, wood is heated to 450^0 F to 600^0 F in an oven. Temperature above 600^0 F is undesirable. This is an exothermic process in which the parts of the wood fibers break down under the intense heat and it occurs when temperature increases to about 300° F. After about six hours in closed chamber, the temperature attains an average of about 450° F and temperature is maintained between 450 and 6oo° F. After about six hours of heating, the pyro-ligneous acid starts to flow and the process is continued up to eighteenth

hours. The color of the pyroligneous acid gives indication of heat inside the oven and also if the wood fibers have broken down sufficiently. At the end of the heating process, the distillate forms tar to a large extent. After the eighteenth hour the latent heat in the oven settings is sufficient to complete the process to the end, but the heat is gradually decreased until the charcoal is withdrawn.

As the gases and vapors pass out through the nozzle of the oven, they are condensed into yellowish green, ill-smelling liquor called pyroligneous acid. A copper based pipe takes this condensate to the raw liquor "sump," a tank in the ground and so placed that the liquor will run into it by gravity. Meanwhile, non-condensable gas is trapped and taken off at the outlet of the condenser and used for fuel underneath the boilers or ovens or perhaps both. A simple gooseneck is used to trap off the gas. The pyro-ligneous acid is then pumped from the "sump" in the ground to a series of wooden settling tubs, at least five in number. The size of these tubs usually varies from 5 to 8 ft. in diameter and 6 to 8 ft. in height. The purpose of these tubs is to settle the tar and heavy oils. The heavy tar is taken to a wood tar still equipped with a copper condenser. This tar still is of wooden construction because the tar would "eat up" the copper in about a year. The residue remaining in the tar still is utilized together with residue from primary stills as boiler fuel.

The pyroligneous acid is then run by gravity to the primary steam-heated copper stills equipped with automatic feed in order to supply the still continuously. The residue or boiled tar, which gradually fills up in the still from the bottom, is distilled by itself and run off at intervals of a few days or whenever the deposit reduces the flow of distillate from the still. During this process, which is known as "**tarring down"**, the distillate is run into a separate tank and the light oils which rise to the top are drawn off. The acid liquor is then piped to storage tanks or tubs with the regular run from this still. The vapors from the copper still are conveyed through a large copper neck to an all copper tubular condenser encased in a steel water jacket. The flow of distillate from these condensers is piped to storage tubs.

From the storage tubs the acid liquor goes to the liming or neutralizing tubs. These are wooden tubs 12 ft. to 14 ft. in diameter about 4 ft. high and provided with an agitator operated by a shaft and bevel gear from the top. The liquor is neutralized by adding slaked lime, a small quantity at a time. The proper quantity of lime is commonly determined by the color of the liquor, which changes at the neutral point "between an

acid and alkaline substance to a wine color, followed by a straw color and the appearance of beads on the surface.

From the neutralizing tubs the liquor is pumped or forced by means of a steam ejector to the “limelee” stills. These stills are constructed of steel plate, the heat being applied by copper steam coils. The alcohol vapors pass off through an iron or copper neck, and are condensed in a copper condenser, and piped to storage tanks.

When the alcohol has been distilled off in the lime lee stills, the residue or acetate solution is forced by steam or air pressure to a settling pan located over carbonizing ovens. After the impurities settle and are drawn off the acetate liquor is run into a large shallow steam-jacketed steel pan, and boiled down to the consistency of mortar; it is then moved out and spread on brick, steel or concrete kiln floors over the ovens and thoroughly turned and dried; it is then moved into sacks for shipment as acetate of lime.

The alcohol liquor from the lime lee still is drawn from the storage tanks previously mentioned into a steel alcohol still provided with copper steam coils, and distilled off through a copper fractionating column consisting of a series of baffling plates having a tubular water-cooled separator at the top. By this process the lower proof products are thrown back for further distillation, while the more volatile vapors pass over through a condenser, the distillate being sold to the refineries as finished crude alcohol of 82 per cent purity.

Factors affecting wood distillation Yields: The yield of products from hardwood distillation plants varies considerably. The yield at any particular plant depends upon the following factor:

1. Temperature: The maximum and minimum temperatures used during the exothermic process.

2. The rapidity of heating: Too rapid heating will cause a nun h smaller and lower grade of product. Usually about ten hours is the time required to get wood up to the highest temperature. If heating is done too rapidly the color of the pyroligneous acid is much darker and the yields are consequently much lower.

3. The species of wood: The yield largely depends upon the species. Some species give better yield whereas other lesser yield and also the amount of distillate varies from species to species. It is a general consensus that maple is the best wood followed by

beech and birch. Oak and hickory are also desirable species, but if there is too much soft maple, poplar, or other inferior species are used the yields will be lowered.

4. The condition of the wood: It is generally assumed that the dryer and the more thoroughly the wood is seasoned, the better will be the product. It is also true that heartwood yields much larger and better products than sapwood.

5. Efficiency of the plant: This is determined by the kinds of the machinery and equipment, arrangement of the apparatus and many other factors connected with the efficiency of an operation.

The products of hardwood distillation include:

- wood alcohol
- acetate of lime
- charcoal
- Wood tar and
- Wood gas

The last two of the above mentioned products are practically always used as fuel under the boilers or retorts.

4.6.3.2 Distillation of softwoods

Distillation of softwoods is mainly carried out in order to extract the resinous content in them. It is largely the pines which have high resinous content. Two distinct methods of distillation have been evolved, namely, **destructive or dry distillation and steam distillation** with its later development called the **extraction or solvent process**. The principal requirement is that the wood should have sufficient amount of resin and there should be available as much of lightwood as possible. Lightwood generally consists of stumps and logs after the bark and sapwood have rotted off and is characterized by high resin content. Longleaf pine is the most satisfactory species used and is tapped for rosin and turpentine.

A) Destructive Distillation: The process briefly consists of heating the wood in retorts in the absence of air and the condensation of the resultant gaseous products. Retorts of cylindrical shape containing from one to four cords are used. They are usually placed in horizontal fashion in rows or batteries over a bricked-up furnace. The fire-box may be arranged to heat either one or two retorts. The wood is charged and drawn

from doors at either one or both ends of the retort. The distillation process usually requires about twenty four hours as is true of the hardwoods. The furnace fires are then drawn and the charcoal allowed to cool for twenty-four hours. The gases are condensed through copper condensers and the usual products are light oils, tar and pyroligneous acid, and also charcoal and the non-conducting gases. Light oils and tar are very complex and are usually separated into a variety of products depending upon the current market conditions. The light oils are obtained in two fractions, the one containing turpentine being condensed from a low temperature in separate tanks. In some plants the volatile products are mixed in one condenser. The pyroligneous acid contains the same ingredients as in the case of hardwoods, but in such small amounts that it is not advisable to refine it further, and it is usually allowed to run to waste. The tar is refined to produce oils and a good grade of retort tar may be sold in its original state. The turpentine is of good color, but has a characteristic odor, and is considered somewhat inferior to the spirits of turpentine secured by tapping the trees

B) Steam Distillation and Extraction: The introduction of steam distillation and extraction has been much more recent than distillation by the destructive process. The woods used for this branch of the industry are the same as have been described for the destructive process. The wood is reduced to small chips as in the case of reducing the wood for making paper pulp by the sulphite process. In some plants sawdust is also used. In the steaming process the chips are placed in vertical or horizontal retorts which are equipped with steam coils so that the wood can be reduced by live steam. The chips are steamed for three to four hours from low-pressure boilers, during which time the turpentine and pine oils are largely removed. The steam and oil fiber pass into a condenser and then into a separator, the oil and crude turpentine rising to the top and it is thus easily removed. After steaming, the ‘chips are subjected to a vacuum to dry them. In the extraction or solvent process a solvent called naphtha, benzol, gasoline, etc., is admitted to the retort and heated to boiling temperature by the steam coils. This solvent removes the rosin from the wood. The extracted chips after being freed of rosin as well as the petroleum solvents are discharged through a trap in the bottom of the retort and sent to the boiler house, where they are used for fuel for power and steam. The products, therefore, of this form of distillation are crude turpentine, a yellow oil consisting of wood turpentine and pine oil. This crude turpentine, if properly refined, produces a colorless uniform quality fluid which is very similar to the standard

spirits of turpentine. The rosin, however, is of comparatively low grade and does not command the same price as that derived from the tapping of the trees.

4.6.3.3 **Saccharification of wood**

In simple words, "sacfharificatlon" means "converting to sugar", therefore, Wood saccharification is the process of conversion of the cellulosic constituents of wood to produce simple sugars through acid hydrolysis. The sugars formed this way may be used for the propagation of yeasts which in turn is a high-protein food for human consumption, or may be fermented to produce industrial ethyl alcohol. The sugar obtained through this process may also be concentrated by evaporation to form molasses, which can be substituted for most of the uses of cane molasses. However, it is not suitable for human consumption on account of having pentose sugars in it.

Wood contains celluloses and hemicelluloses which are long chains polymers of sugars. Alpha-cellulose, which is the most stable carbohydrate constituent of wood, is composed largely of molecules of glucose, a sugar having 6 carbon atoms. The hemicelluloses contain molecules having both 5 and 6 carbon atoms. Only the 6-carbon sugars (hexoses, $C_6H_{12}O_6$) are readily fermented to alcohol by brewer's yeast whereas the 5-carbon s\igars (pentoses, $C_5H_{10}O_5$) remaining in solution in the beer after the hexose sugars are converted to alcohol. The pentose sugars are fermentable by various organisms, however the time required converting them to alcohol is too long to be commercially feasible. They can, however, be used in the production of yeasts which form high protein foods.

4.6.4 Pulp and paper industry

4.6.4.1 History of Pulp and Paper making

It is likely that the art of papermaking was transmitted from China across India to Persia and Arabia. The industry was gradually developed, but spread very slowly through Europe. This became an important center for papermaking and it is said that paper is still made there at the present time. The first paper mill in France was established in 1189; in Germany in 1390; and the date of 1330 is given as the time of the first paper mill in England.

Although the Egyptians are sometimes given credit for the earliest development in the manufacture of paper, more recent research has developed the fact that the Chinese were the first who invented the first manufacture of paper. Some school of thought say

that the name of paper has its origin from the word 'papyrus' which is a Latin name given to Egyptian sedge and bulrushes of Nile valley. Paper is said to have been used by the Egyptians as early as 2400 B.C. to make sheets for writing purposes as well as for wrapping and other mechanical uses. Others say that it is China where the art of papermaking was known long before the Christian era. Paper is composed of cellulose fibers and was invented in China about 105 AD. The technology was transferred from China to India, then to Persia, Arabia and then to Spain and other parts of the Europe. It is known that the Saracens carried the practice of the paper making to Spain after their conquest of that country in the 8th century. From Spain, the invention went to Italy where a paper mill was first operated at **Fabriano** in the year 1150. The first paper mill in France was established in 1189, in Germany in 1390, and in England in 1330. Wherever be the origin of paper, the paper invention was one of the most remarkable achievements of human civilization.

In the earlier days, paper was used to be made with hands. It helped in preservation of knowledge through writing on paper as well as a medium suitable for dissemination of knowledge from one person to another and one part of the world to other and thus, resulted in faster growth and development. Thus, paper is an essential commodity in the economy of modern life. About 80 per cent to 85 per cent of all present day paper has its origin from wood whereas before the middle of the 19th century, paper was entirely manufactured from other vegetable fibers. Vast improvements have been made and are still being made, not only in the processes themselves but in the use of raw material, and in refinements in labor-saving machinery. Large amounts of capital are required for participation in the industry. Until the early part of the 19th century, sheets of paper were made entirely by hand. Earlier a machine was developed in France for the purpose by Louis Nicolas Robert, but it could not be put to practical use due to its limitations. It was by Henry and Sealy Fourdrinier in England the paper making machine was developed. This is universally known as Fourdrinier wire and is the basis of modem paper making.

It is said that the use of wood for making paper dates from as recently as 1840 when Keller patented his process in Germany for a wood-pulp grinding machine. It was not, however, until 1854 that the process was placed upon a commercial basis. Now wood has been demonstrated to be the best available raw material. From time to time sporadic attempts are made to introduce other materials, but they are very much

expensive to assemble and transport, are unavailable in sufficient quantities, or do not make the desirable kinds of paper. Before wood was widely introduced about 1850, paper was entirely made from cotton and linen rags, esparto grass, hemp, straw and a number of other vegetable fibers.

4.6.4.2 Kinds of Paper

Generally, there are two classes of paper in common use such as papers for recording or printing and papers for mechanical purposes. The first type of paper are used in the fine ledgers, writing papers, printing paper for books, magazines and general printing purposes and news print used for newspaper. Newspaper is the cheapest of all paper and mechanical wood pulp forms the greater part of its substance. Writing papers are largely sized papers in the best grades, in which only selected rags are used. In the later stage, chemical wood pulp is used even in the expensive writing papers and it may be said that nearly all papers, excepting high-grade ledger, contain wood.

In the second group are the cardboards, pasteboards, wrapping papers, blotting and tissue papers, carpet and wall paper etc. Blotting paper is composed of short-fibered cotton and wood pulp cut fine in the beating engine. This paper is free from sizing of any kind and so is capable of absorbing water or other liquids. It can be dyed to any desired color without impairing its quality. Tissue papers are the thinnest of all papers and are generally made from rags or paper shavings with varying quantities of wood pulp. Wrapping papers are partly sized papers of coarse material and are largely made from mixtures of sulphite pulp and ground wood or wholly of sulphate pulp to form craft paper. Straw, jute and mixtures of hard fibers are also largely employed. Card board, pasteboard and other heavy forms of paper are generally made from a pulp formed of waste paper as well as from sugar cane refuse, waste fiber boxes, etc. They are sometimes made by pressing a number of sheets of other paper together in powerful presses with a suitable agglutinant. Papier-mache (bowls, ornaments, paper boxes and models, etc) is made chiefly from old paper Stock by boiling to a pulp. It is then mixed with glue and starch paste and pressed into moulds.

4.6.4.3 Requirements of Desirable Pulp Wood

The principal factors which determine the commercial utility of a given plant for paper making are:

1) Suitability of fibers for conversion into pulp,

2) Fiber yield per unit volume of raw material,

3) Quality of the resulting pulp for papermaking purposes,

4) Dependability of supply,

5) Cost of collection, transportation, and conversion, and

6) Degree of deterioration in storage.

Thus, in light of above mentioned principal factors, the main requirements which paper manufacturers hold as desirable in woods for making paper pulp are summarized as follows:

1. The wood should contain a long, strong and yet soft and tender fiber. Woods in which these characters stand out make the best paper and are used with comparative economy.
2. The wood should be relatively free from intercellular constituents, such as resins, gums, tannins, etc. Highly resinous woods and those containing large percentages of tannins, gums, etc., are converted into paper with considerable difficulty and are used only for the cheaper grades of paper.
3. The wood must be available in sufficient quantities, reasonably accessible and, therefore, fairly economical in price. Some woods are admirably adapted to the manufacture of pulp and paper, but are often eliminated because they are not sufficiently available or are in greater demand for other purposes.
4. White fibered woods are preferred since most papers are white or light in color. Bleaching at great expense is required to whiten some woods. Woods which are white or nearly so are much more in demand than those of deep or dark colors.
5. The wood must be sound, reasonably clear of knots, free from rot, dote, bark, pitch pockets, and other defects. Sound wood, clear of all foreign matter or defects is especially required in certain processes of pulp manufacture.
6. The wood itself should contain large quantities of available cellulose. Most woods contain between 40 per cent and 60 per cent of cellulose. Since the basis of all paper is cellulose, it is desirable to select a wood for pulp that contains cellulose in a form that is readily separated without loss by the destructive action of chemicals which are used in cooking processes.

4.6.4.4 Raw Materials

Raw material for the manufacture of pulp comes to the mill in a great variety of forms, chief of which are the following:

1. **Logs:** In the past much of the raw material was delivered to the pulp mills in the form of logs, but this is being superseded by delivery in shorter lengths.
2. **Bolts:** A large share of material is now delivered in a form of 4 ft. bolts, either in the peeled condition or with the bark still on.
3. **Chips:** For sulphite pulp some of the pulp mills are pressing their material in the baled form or in the loose state in carload lots.
4. **Sawmill Waste:** Considerable hemlock and spruce slabs and edgings are now being received in larger quantities from year to year.

4.6.4.5 Preparation and Treatment of Wood Pulp

When pulpwood is delivered to the mill in log length, it is first reduced to shorter lengths in the breakdown mill (also called cutoff mill), which generally consists of a log haul-up or a jack ladder, a slasher or swing-saw system, and a series of conveyers to carry the blocks and refuse from the mill. A slasher is designed to cut logs into bolts of the desired length. The pieces, called bolts or blocks, usually 2 to 4 ft. long, are then conveyed to the barking drums or to storage piles. Where logs of varying lengths and diameters have to be reduced to short blocks of uniform length, a swing-saw system is generally used in place of a slasher.

Before the blocks are reduced to chips, all the bark must be removed, if it has not already been done in the pulp-woods. The machines for removing bark are called **barkers**, and the process of removing bark is referred to as **rossing**. The main reasons for removing bark before pulping are:

- the fiber content of bark is very low,
- if left on the wood the bark would consume the chemicals and steam and occupy
- space without bringing any return,
- bark produces dirty pulp and paper,
- bark of some species contains too much resin

Before the **rossed wood** is converted into pulp it is usually washed in a tumbler type of washing drum and inspected for bark patches, which are removed with a knife barker. Larger blocks may be split into smaller pieces. Further treatment of the wood depends on whether a mechanical or chemical pulp is to be produced.

4.6.4.6 Production of Mechanical Pulp

Mechanical pulp, also called ground wood pulp, is produced by forcing rossed wood laterally against a revolving grindstone. By this means the wood is reduced to a fibrous mass which, after screening and subsequent thickening, is converted into pulp products. The process was perfected in Germany by Keller, who built the first successful wood grinder in 1840. The properties and uses of Mechanical Pulp are:

- The yield of mechanical pulp is usually about 90 per cent of the dry weight of wood, as compared to 40 to 50 per cent in chemical processes.
- Mechanical pulp is characterized in general by lack of strength and rapid deterioration and is therefore, used only in cheaper grades of paper and in boards. In order to add strength, mechanical pulp is usually mixed with some chemical pulp.
- The principal items made of mechanical pulp are newsprint, magazine and book paper, towels, cheap box paper and low grades of tissue and wrapping papers, wallpaper, box boards, wallboards, and other items which do not require strength or are intended to be used for only a short time.
- Mechanical pulp is also used as an absorbent for explosives in the manufacture of dynamite.

4.6.4.7 Production of Chemical Pulp

The object of chemical pulping is to separate wood fibers from each other with minimum mechanical damage; this is accomplished by suitable chemical action which removes the more soluble cementing materials, largely lignin and hemicelluloses, leaving behind a fibrous mass (pulp), consisting of more or less pure cellulose.

There are three processes of chemical pulping or chemical reduction:

- the sulphite process
- The sulphate process, and
- The soda process

A) Manufacture of Sulphite Pulp:

This method is used mainly for chemical pulping and more wood is reduced to pulp by the sulphite method than by any other process, therefore, it is the most important of method among the three. The sulphite method of manufacturing wood pulp is practically the same world over, however, some variation do occur with the local conditions. The preparation of wood is done by the same processes as for used in the case of manufacture by the mechanical pulp i.e., wood is cut to 2-ft. lengths and is either peeled in the woods or rossed or barked at the mill. Wood, however, is more carefully selected for this process.

The preparation of wood is followed by **chipping**. As the blocks of 2-ft. bolts come from the wood room they are passed on a conveyor to the chippers. The chipperman makes a firm inspection of each bolt before it goes into the machine, and the large blocks which escaped the splitter and the undesirable species are sent back. Any blocks having any bark attached are sent to the helper who removes the bark with a hatchet. The chipper is very similar to the rossing machine except that it is much heavier in construction. Chips are generally made of size about 5/8 inches in length and 1/16 to 3/16 inches in thickness.

After chipping process, screening is carried out. The chips pass from this belt into a large revolving screen, or in some cases, a flat jigger screen is used. As the chips pass along this screen which has small openings at the head end, gradually increasing in size, the fine slivers and dust are removed first. Next, the good chips themselves pass through the holes and the knots, and large pieces drop out at the lower end. These chips drop into a trough and are conveyed to a storage bin, directly over the digesters and cooking room, while the waste is conveyed to the boiler house and used for fuel.

Acid Manufacture and Storage: In the sulphite process, the acid plant is one of the most important parts of the mill. Acid making is a truly chemical process and in these mills it is as much a part of the industry as the cooking or reduction of the wood. The basis of this cooking liquor or acid is sulphurous acid and is made by passing sulphur dioxide gas through water.

Cooking: This is the chemical process which reduces the wood elements to soluble compounds leaving only the cellulose. It is carried out in large steel retorts, which taper to a neck at each end and vary in size according to the desired capacity.

Washing isafter the pulp has sufficiently cooled so that the blow-pits can be opened, it is washed thoroughly with water to remove all of the liquid which it contains. As soon as the stock is washed, it is pumped into the feed tank from which it passes onto the screens as needed. After washing, the pulp is pumped into the feed tank where it is mixed with a surplus of water so that the fibers are suspended individually. It is then pumped from this tank to the first line of screens. Here the best part of the pulp passes through the screens and is carried away by the water and goes out onto the press machines where it is collected.

Collection of Pulp on Lap or Press Machine: From the screens, the pulp passes out and into a tank which is equipped with a revolving cylindrical screen. As the screen revolves, the water passes through the meshes and outlet, leaving the pulp adhering to the mesh. The screen revolves, carrying the pulp upward and it is removed by a felt which is carried over a set of rolls where the pulp is deposited on a large wooden roll. This pulp is cut off from time to time, as it becomes thick and is folded up into bundles for shipment or use directly in the paper mill. Pulp made up in this way contain about 60 per cent of water.

Complete drying for dry pulp is never made in a mills where the pulp is going directly into paper as it is unnecessary to drive off all of this water. Dry pulp is made only for long shipment and long storage.

B) The Manufacture of Sulphate Pulp: It is now used chiefly on those conifers which do not lend themselves readily to reduction by the other processes. The high resinous content of many of our most abundant forest trees cut for lumber has been the great deterring factor in the use of these woods for paper pulp. The preparation of the wood for reduction by this process is the same as for the sulphite method. The boiling is done with a solution of caustic soda containing small amounts of sulphate and sulphide of soda. The sulphate of soda is used as the source of alkali and sodium sulphide in an incineration process.

Briefly the process includes the reduction of the wood billets and their digestion under pressure in a liquor containing a solution of various sodium compounds. These compounds consist of sodium hydroxide, sodium sulphide, sodium carbonate, and sodium sulphate. Of these compounds the first two are the active agents in the digesting process and combine with about 50 per cent of the weight of the dried wood

to soluble organic sodium salts. The time required for cooking depends upon the nature of the wood and the character of the pulp desired. After cooking, the pulp is separated from the waste liquor by washing in large tanks. The liquor is later evaporated and the residue is partly burned in rotary furnaces and after being subjected to high temperatures, the sodium sulphate is added to replace the soda lost during the recovery process. After cooking and washing, the pulp is run through press rolls and formed into bundles. Then, after drying, it is sent to the pulp mill.

C) Manufacture of Soda Pulp: The manufacture of wood pulp by the soda process was discovered about 1880. The preparation of the wood for use in the soda process is exactly the same as has been described in connection with the sulphite pulp. That is, the wood is barked and then chipped and screened. This process is applied especially to the reduction of various hardwoods and pine. Other hardwoods can also be reduced by this process.

The next step includes **digestion** of the material. The digestion is carried out by boiling the wood under pressure with chemicals with an objective to dissociate the valuable fibrous portion of the plant from the resinous and non-fibrous portion. As a result of this boiling the wood loses about one- half of its weight. In the manufacture of soda pulp, revolving digesters are most commonly used and are found to produce the best results. Here a pressure of from 60 to 80 lb. is also found to produce the best results.

Cooking is the next step in which the wood chips are emptied into the digesters and are covered with a 6 to 9 per cent solution of sodium hydroxide (caustic soda—NaOH) and cooking is carried out at a temperature of about 240° F. and a pressure of from 60 to 80 lb. for a period of from eight to nine hours. When the process is completed, the valve at the bottom of the digester is opened and the semi-liquid solution passes out as a result of the pressure in the retort. This is called " **blowing** " and the material passes into a large wooden tank called a "**blow-pit**." Here the steam which escapes is passed into the open air through a large pipe running from the top of the tank.

The next step is **washing.** This results in the pulp free from the spent cooking liquor and soluble portions. As the caustic soda is recovered by a well-defined process, the water used in washing is reduced to a minimum amount. All of this liquor is saved and is conveyed by pumps and pipe lines to an evaporator where the soda is recovered.

The next step in the process is **bleaching the fibers**.

4.6.4.8 Treatment of Pulp

Before pulp either mechanical or chemical, can be converted into paper or shipped as such, it must undergo a series of treatments such as screening, thickening and bleaching.

Screening is necessary to remove dirt, foreign material, knots, and other uncooked or unbroken pieces of wood from the pulp and to separate fibers into different grades, based upon their size. This operation is accomplished by means of a series of screens and can be divided into two stages: **coarse screening** and **fine screening**.

Thickening the Stock: After screening, thickening is carried out in order to enhance the stock thickness from 0.25 to 0.6 per cent solid to 3 to 6 per cent. These processes are called as slushing, deckering, dewatering, or concentrating. Thickening is accomplished by means of a decker. There are many designs of deckers, but a common type consists of a cylinder covered with a fine-mesh wire screen, revolving in a vat into which the thin stock from fine screens is delivered. The pulp accumulates on the wire mesh, while the water runs through it inside the cylinder. The water thus removed is called **white water** and usually is reused in thinning the stock for screening.

Bleaching ofPulp is the final step before paper is manufactured. The pulp after screening and thickening processes appears to have dull colour. The dullness in pulp at this stage is due to the presence of small amounts of non-cellulosic substances such as lignin, hemi-cellulose, tannins and resins that remain in pulp even after cooking. These impurities are chemically combined with the cellulose fibre and can be removed from the pulp only by chemical treatments that will first dissociate them from the cellulose. This operation is called **bleaching**. Bleaching not only whitens the pulp but also purifies it by removing some of the colorless non-cellulosic impurities which, if left in the pulp, would interfere with the subsequent paper manufacturing operation. A number of bleaching agents can be employed for the purpose, however, the most important is chlorine. Formerly calcium hypochloriie ($CaOCl_2$) bleach was made by agitating bleaching powder with water in an iron tank. The lime and other impurities were allowed to settle and the clear bleach liquor containing the hypochlorite drawn off and used in bleaching. Today practically all the hypochlorite used is made by absorbing chlorine in lime and allowing the undissolved lime to settle out. Though use of permanganates produce pulp of good brightness, but the results obtained donot

justify the higher cost of these chemicals. More recently, chlorites have been proposed and are now being tried on a commercial scale.

Lapping is the process of making sheets of pulp or bundles of pulp when the pulp made so is not to be used immediately at the mill or has to be transported or stored. In this process, most of the water from the screened stock is removed and made into sheets which can be placed in bundles, or laps. This further extraction of water is called **lapping**.

4.6.4.9 Paper Manufacture from Pulp

It includes following steps:

A) B**eating:** Paper manufacture begins with the operation called **beating**. In this operation the fibrous material (pulp) suspended in water is given a mechanical treatment which results in cutting, splitting, and crushing of the fibers. This causes stock to acquire characteristic slimy feel and is transformed into a compact and uniform mass of pulp which can be spread into sheets of desired characteristics. This way pulp fibers develop a property of strong adhesion when allowed to dry in contact with each other.

B) Sizing and Loading: When the pulp is bleached, certain amount of bleaching chemicals remains in the substance and it is necessary to remove this either by washing, or by the use of chemicals. Washing is generally considered the best as it readily removes the chlorine. After washing, the pulp is passed through the beater. During the beating operation, the sizing and loading are added. The manufacture of paper consists of the formation of a continuous sheet or web made of minute structural units of pulp. The processes of papermaking are of a mechanical and physical nature to a large extent in contrast to the manufacture of wood pulp by the various chemical processes. It is upon cellulose and a proper knowledge of its nature that the entire paper industry is based. In the manufacture of ink/water-resisting papers, the operation is practically limited to rosin as a “size”. It generally requires about 3 or 4 lb. of rosin to size 100 lb. of paper. The prepared rosin size is added to the pulp in the beater, together with alum or sulphate of alumina which finishes the reaction and fixes the rosin size upon the pulp. Starch, silicate of soda, soap, casein, gelatin, and many other substances are used as sizing for papers for special purposes.

In the manufacture of high-grade papers, it is necessary to fill up the surface pores so that the surface will be smooth. This is done by the addition of very fine clays, such as **kaolin**, **talc** or **sulphate** of **lime**, or **baryta**. There are other fillers and loading agents but these are the most common. The greater the percentage of filler used, it is obvious that the smaller is the proportion of wood pulp, and, therefore, paper that is heavily filled is not so strong and durable.

B) Coloring: The dyeing or coloring of paper pulp is also done during the beating process and requires considerable care and study. As cellulose is exceedingly inactive it is usually necessary to use mordents in order to fix the colors. Soluble coal tar dyes are very commonly used, but there are only comparatively few which are suitable for the coloration of paper pulps. Mineral pigments are often used as well to secure certain bright colors. Poorly dyed papers will bleach when moistened or if exposed to light. The coloring of paper pulps is still in the process of development.

C) Paper Machine: After the beating process, during which the size, filler and dyes are added, a trap door in the bottom of the beater is released and the mixture flows out through a pipe and into a tank called the stuff chest where it is stored until needed at the paper machine. The paper machine is the most intricate of specialized machines used in the paper mill and is the key to the successful making of paper. It consists of an endless wire screen called the fourdrinier wire which revolves around a series of rollers. On this screen, the pulp pours in a steady even stream and as the water which carries the pulp passes through the screen it leaves the fibers behind to form an endless sheet. This sheet which still contains a large percentage of water next passes on to a felt and is carried through three sets of very heavy rollers which are pressed together under great pressure. These press rolls squeeze out a large portion of the remaining water. The sheet then passes over a series of heated rollers which gradually dry out the remaining moisture and produce the finished sheets. Which are then converted into paper of different sizes as per need.

References

[1] Z. H., *The evolution of stomata. In: Zeiger E, Farquhar G, Cowan I, eds. Stomatal function.* Stanford: Stanford University Press, 1987.

[2] NELSON COURTLANDT BROWN, *FOREST PRODUCTS THEIR MANUFACTURE AND USE*. New York: JOHN WILEY & SONS, 1919.

Unit 5: Introduction to Non-Wood Forest Products

Unit Structure

5.0 Learning Objectives

After completion of this unit, you shall be able to:

- Define non-wood forest products
- Explain different kinds of NWFPs
- Describe the importance of NWFPs
- Discuss the methods of collection of NWFPs
- Discuss the status of NWFPs and policy and institutional challenges of NWFPs

5.2 Introduction

In the previous course in Semester I on Forest Products and Utilization, you studied about wood based products from forests which mainly comprised timbers and fuel wood. Apart from wood based products and resources, forests are also sources of various other useful products. Such products and resources other than wood and fuel wood are referred to as Non Wood Forest Products (NWFP). There is a great variation

in kind as well as value of such products from place to place. The forests not only source of great quantities woody reserves (timber and energy wood) but also are sources of non-wood resources based on plants and animals.Such products are generated not only in forest ecosystems but also in other ecosystems such as marine, water and deserts. In this unit, we will study about NWFPs, their kinds, status and importance.

5.3 Definition and concept of NWFPs

Under minor forest products is included all kinds of forest produce other than timber and firewood. It comprises animal, vegetable and mineral products. The term NWFP's are a reduced form for non-wood forest products which refers to include all kinds of forest produce other than woody resource (timber and firewood). Such products include all animal, vegetable and mineral resources / products found in forest areas. Earlier, the most widely used term was NTFP (Non-timber forest product) which is equivalent NWFP plus fuel wood and charcoal.

According to definition given by Food and Agricultural Organization(FAO, 1999), NWFPs are defined as, "Non-Wood Forest Products consist of goods of biological origin other than wood, derived from forests, other wooded lands and trees outside forests" . Thus, conceptually NWFPs (Non – Wood Forest Products) refers to all biological materials other than timber and fuel wood extracted from natural forests for human and animal use.

5.4 Classification or Kinds of NWFPs

Classification and Definitions of Forest Products (Advance version) was published as Supplement 6 to Volume XXV of the Timber Bulletin for Europe in Geneva in 1973. This was the result of work of the Joint FAO/ECE Working Party on Forest Economics and Statistics.

NWFPs include plant tissue used for fiber, building material, medicine, edible leaves, roots, flower, fruit, seed, nuts, honey, resin, glue, lac etc. and has both consumptive and exchange value. They have income potentials and provide employment opportunities. Earlier, before the National Forest Policy(GOI, 1988), NTFPs were popularly known as Minor Forest Products (MFP).NWFPs have great importance for

tribal people as they mostly consume most of the NWFPs without even adding any value to it. It has been a part of the socio-cultural life of tribal people since historical past. They used to conserve the forests from where such products were derived, thus, had a symbiotic relationship with their forests.

The NWFPs may be classified as follows:

A) NWFPs of Plant Origin

- edible plant products
- spices and condiments
- medicinal plant and aromatic plants
- fatty oil yielding plants
- gum and resin exuding plants
- tan yielding plants
- dye and colour yielding plants
- fibre and flosses yeilding plants
- bamboos & canes
- fodder and forage
- fuelwood, charcoal and briquette make
- bidi wrapper leaves and bidis
- other leaves for plantters, plates, bowls
- beads for ornaments and decoration
- saponinyeilding plants and marking nut

B) NWFPs of Animal Origin

- Honey and bees wax
- Insects and animals
- Lac and shellac
- Hides, skins and feathers
- Tusser and other silks
- Horns, bones, shells, ivory and musk

C) NWFPs of Mineral Origin

- Mica, sand, gravel and other minerals

5.5 Importance of NWFPs

The great numbers of NWFPs are available in diverse forests of our country in diverse types and amount. They are sources of protein, vitamins, fats, minerals and many more important basic compound necessary for human growth and development. Thus, they have edible value, medicinal value, and value as fibers, value as sources of chemicals, ornaments and other socio-economic importance. Wild products have been used by human society since long time in historical past and has played very important role in human societies both at household level as well as national level. The importance of NWFPs can be explained briefly in the following heads:

1.5.1 Edible importance of NWFPs

Many of the wild plants are source of edible fruits and nuts having high nutritional values. In the Indian Himalaya alone, there are 675 wild edible plant species are found, out of them 344 occur in the west Himalaya. Some of the important wild fruit yielding plants are *Aegle marmelos* (Bael), *Anthocephalus cadamba* (Kadam), *Diploknema butyracea* (Cheura), *Embilica officinalis* (Aola), *Myrica esculenta* (Kaphal), *Pinus gerardiana* (Chilgoza Pine), *Prunus armeniaca* (Wild Apricot), *Pyrus pashia* (Indian wild Pear), *Rubus ellipticus* (hisalu), etc.

1.5.2 Medicinal value of NWFPs

Many of the species from forests are known for their one or other properties used for curing various ailments. Local people have knowhow of using such plants and they generally used plants or parts of the plants in curing fever, headache, skin diseases, rheumatism and many more ailments. Some of the important wild medicinal plants are *Acacia catechu, Acorus calamus, Aloe vera, Artemisia annua, Azadirachta indica, Cinchona officinalis, Datura stramonium, Indigofera tinctoria, Lawsonia inermis, Tinospora cordifolia, Taxus baccata,* etc.

1.5.3 Uses as species and condiments

1.5.4 NWFPs as source of fibers

Forests have been traditional source for supply of NWFPs which are used as fibers and flosses. The most common examples are ropes, cordages, mattresses made by the rural people for several domestic purposes traditionally. Fibers of both vegetable

and animal origin have been used long before the dawn of history, for the spinning of the thread and cordage and weaving of coarse fabrics. Among the earliest of such fibers wax flax; cotton, the greatest of modern textile fiber came later. Some of the important fibers yielding plants of Uttarakhand are *Agave Americana, Bauhinia vahlii, Bombax ceiba, Butea monosperma, Cannabis sativa, Careya arborea, Erythrin asuberosa, Ficus bengalensis, Grewia optiva, Kydia calycina, Ougenia oojeinensis, Populus ciliate, Utrica dioca,* etc.

1.5.5 Fodder value for domestic animals

The custom of lopping trees for fodder is a common in our country. The best fodder leaves are the one which young and tender. However, this practice of lopping trees for fodder is an extremely harmful, as it not only damages the trees and produces a gnarled branch-system, but also deprives trees of nourishment, removes a considerable proportion of their assimilative organs, and robs the soil of what would eventually become manurial matter in the shape of dead leaves , moreover the timber of habitually lopped trees is liable to be misshapen and unsound. In spite of its bad effects, lopping has to be tolerated in many cases owing to the existence of rights to practise In such cases wherever the lopping is extensively and regularly done measures should be taken to regulate it in such a way that the least possible damage is done to the forest. The following are the principal measures which may be taken:

(1) The upper branches of the trees should be left intact for 5 to 10 feet, only the side branches should be cut; these should be cut with a smooth clean section, and flush with the stem.

(2) Lopping should not be allowed over the whole forest annually. The forest should be divided into blocks which should be opened in a regular rotation of two or more years.

(3) Lopping should be confined if possible to inferior species; the more valuable trees should be left intact. If this is done, the lopping may in certain cases even be beneficial to the forest.

(4) Lopping should not be carried out on ridges and exposed slopes, where as much leaf covering as possible is required and should be maintained.

(6) Advantage should be taken of fellings, cleanings, and thinnings, to obtain as much fodder as possible by lopping the branches of the newly felled trees, coppice coupes in particular can in this way be made to supply a large amount of green fodder.

Some of the most common species which can be used for fodder are as follows: *Acacia arabica*, *A. modesta, Acer species, Adina cordifolia, Aegilem armelos, Aesculus indica, Artocarpus lahoocha, Bauhinia spp., Betula utilis, Cassia Fistula, Cedrda toona, Dalbergia latifolia, Ficus species, Grewia spp., Hardwicki abinata, Morus serrata, Pterocarpus marsupium, Pterospermum acerifolium, Quercus floribunda, Q. leucotrichophora, Q. glauca, Salix spp., Shorea robusta Terminalia belerica, T. tomentosa, Ulmus wallichiana* and *Zizyphus spp.*

1.5.6 NWFPs as source of tans and dyes

Tannin and dyes are secretion products found almost universally in plant tissues in small or large amounts. However, economically important and commercially exploited plants are those that yield these natural products in large quantities. The name tannin is given to all those organic substances which have the property of combining with albumen and gelatin to form an insoluble compound which will resist decay. Raw animal hides treated with tannin are converted into the decay-resisting material known as leather. The name tannin, or tannic acid, is given to a class of organic substances which have the property of combining with albumen and gelatin to form an insoluble compound which will resist decay. This property of tannins is used in treating raw hides to form leather. Some of the important wild tannin yielding plants are *Quebracho Colorado* (Quebracho), *Castane adentata* (Chestnut) and *Acacia catechu* (Khair).

Similarly many plants also yield dyes used commercially for the coloration of fibers. Dyes are the name given to substances which are used for imparting colour. They are organic compounds having natural or artificial origin and are widely used for imparting colour to fabrics in textile industries. Some of the natural dye yielding wild plants are *Acacia catechu (Khair), Artocarpus heterophyllus, Pterocarpus santalinus, Alnus nepalensis and Myrica esculenta* etc.

1.5.7 Source of gums and resins

Gums and resins are plant exudations which may occur naturally or due to some injury in the plant parts. Gums are widely used as emulsifying and thickening agents in the

food industry, but they also find uses in other industries, from pharmacy to cosmetics and skin care products, to the manufacture of inks, paper, water colours and even the adhesive on the back of stamps. Some of the important gum yielding plants are *Acacia nilotica* (yields gum Arabic), *A. Senegal* (yields babool gum) and *Anogeissus latifolia* (yields ghatti gum) etc.

Similarly a number of plants yields resins of commerce used in paint and pharmaceutical industries. Natural resins are used in paints, varnishes and lacquers. Others resins such as the soft resins and balsams, are used as sources of fragrances and pharmaceuticals. The hard transparent resins, such as the copals, dammars, mastic and sandarac, are principally used for varnishes and cement, while the softer odoriferous oleo-resins (frankincense, elemi, turpentine, copaiba) and gum resins containing essential oils (ammoniacum, asafoetida, gamboge, myrrh, and scammony) are more largely used for therapeutic purposes and incense.

1.5.8 NWFPs as an opportunity for income generation and food security for rural poor

In the hills, agriculture is the key source of livelihood. Apart from agriculture and other activities, trading of economically valuable NWFPs species including other off-farm income generating activities are other livelihood activities to support daily household needs. Annual agriculture production is not enough to support the livelihood throughout the year, and as a consequence, they have to engage in other off-farm activities. The off farm activities are mainly collection of NWFPs and their marketing in nearby cities.

The rural poor cope up such situations by collecting NWFPs from the nearby forests for their household eating as well as by selling such products in the nearby markets. Majority of households, particularly in rural areas residing nearby forests, generate part of their income from the sale of forest based products.

NWFP species such as wild edible plants and medicinal plants have been regularly utilized in daily livelihood in the hill regions of India, Nepal and Pakistan. Wild edible plants are mostly consumed with daily meals whereas medicinal plants are used for primary health care at household whenever necessary and also trading for economic development.

The direct contribution of NWFPs include the supply of Products such as fruits, vegetables, resins, fibers, fuel-wood, charcoal, bush meat and medicinal plants which could be marketed for money or consumed at the household level. Plants such as *Phoenix reclinata* (date plam), *Tamaridus indica, Vauhinia* and various species of wrapping leaves constitute valuable sources of income particularly for rural women. Other forest products such as honey, *Acacia senegal* (gum Arabic), and medicinal plants of various kinds are major sources of income to both rural and urban dwellers. Forest-based activities such as mat-making and charcoal also contribute significantly to rural income. The ability of NWFPs to directly enhance people's income is a significant contribution to poverty reduction.

There are also indirect contributions of non-wood forest products to poverty reduction. These include their various roles in the ecosystem such as pollination of useful plant by nectivorous insect, dispersal of seeds by frugivorous birds and animals; contribution to soil fertility by soil micro and macro-organisms, watershed protection and the various roles of plants and animals in succession and ecosystem renewal. These various contributions ensure that the ecosystem can continue to supply the various goods and services upon which the livelihood of the people depends. Though these indirect uses are often not easily quantifiable, yet their contributions to human welfare are no doubt enormous.

1.5.9 NWFPs for household food security

The NWFPs are still being utilized in daily livelihood to mitigate the existing problem of food deficit, and nutritional demand or a supplement of food and nutrition. They provide livelihood benefits mainly by assisting households to cope at times of adversity such as sudden changes in their economic, social or bio-physical environments. It includes events like death of main earning member, or during crop failure due to droughts, floods, frosts or disease or in the years of less agricultural production.

Many products of both plant and animal origin are consumed by man either directly as food or as supplement to other food products. Some are eaten in raw form without prior cooking, boiling or processing while others are only consumable after processing. Whichever form, in which the products are consumed they play significant roles in

supplementing household food in-take particularly during the period of scarcity of food when the previous year's crops are exhausted and the new crops are yet to mature.

Condiments and flavour plants also play significant role in household dietary supplements. Species such as *Pipper sp., Occimum gratismum, Allium sativum* etc. are added to food to impact certain characteristic aroma or taste on the food. Many of these local condiments also serve medicinal functions in the body.

1.5.10 NWFPs for environmental amelioration

Many forest species both within and outside forest environments contribute immensely towards making our environment conducive for human beings as well as other members of the ecosystem. Many plant species also provide cover and breeding grounds for other plants and animals. Many mangrove (*Rhizophora* sp.) species provide spawning grounds for various species of fish. In many parts of the world, trees are used in microclimatic amelioration such as provision of shade, wind breaks and soil stabilsation. Some plant species help to reduce particulates in the air. Some may reduce Nitrogen oxides (NO2 and N2O) through foliar uptake while others are able to remove carbon from the atmosphere in form of Carbon monoxide (CO) (Smith, 1978). Most plants fix carbon dioxide in the process of photosynthesis. This is very vital in reducing the risk of global warming. Beautiful sceneries in dwelling places stimulate mental relaxation while the gaseous exchange between the plants and the atmosphere enhance good body functioning. These services function of the forest translates to improved productivity and healthy living environment, hence, reduces poverty incidence.

1.5.11 NWFPs and health uses

It has been said that 80% of total households particularly in the rural areas depend on natural herbs for medication (Ransome-Kuti, 1991). Recent trends have confirmed this observation, as the number of people depending on herbs for their health needs keeps increasing. Often times, the distances between rural communities and orthodox medical centers are quite considerable, hence, rural dwellers naturally rely on traditional herbs when the need arises. It is only when the situation gets out of hand that they seek modern medicinal assistance, for example, during complicated labour, fetal accidents and chronic illnesses.

As observed by Hoskins (1990), there is no clear distinction between food and medicine. Most products, which are consumed directly as part of daily meals or as supplement to other diets, do have medicinal properties. Examples of these include: *Vernoia amygdalena* (Bitter leaves), *Zingiber offficinale*, *Pipper guineense, Tetrapleura tertraptera* (Aridan plant), *Aframonum melegueta, Xylopia aethiopica* (Guinea pepper), *Alium* sp and honey. When medicinal plants are referred to, these definitely include those used for the treatment of both human and animal ailments. Herbal medicines, especially local herbal remedies have always attracted a great deal of interest to the layman. People use a range of treatment healthcare options, depending on their particular ailment, their socio-economic status or past experiences. Falconer (1991) reported that all the people interviewed in a study area in Ghana used herbal medicines while 80% of them rely on wild plants as their main medicine source. Generally, many Africans believe that certain illnesses are best treated using traditional medicines and these may include goiter, epilepsy, mental disorder and spiritual problems. The use of herbs in treatment of ailments thus saves rural dwellers the expenses they would have incurred in hospitals thereby boasting their economy.

The use of traditional medicine is not restricted to developing countries. According to FAO (2000), at least 25% of drugs used in modern pharmacopoeia are derived from plants, while many others are synthetic analogues built on prototype compounds isolated from plants. Few medicinal plants are cultivated, because the low price of materials harvested from the wild still makes cultivation financially unattractive. However, as natural forests are being lost to deforestation, through lumbering, fueling, agriculture, etc., For now wild sources of medicinal plants are important and will continue to be at least in the developing counties for some times.

Unit 6: NWFPs- Wild edibles, Fodder& Other direct use value

Unit Structure

6.0 Learning Objectives

After studying this unit, you should be able to:

- Enumerate wild edible plant species
- Discuss important wild edibles
- Explain fodder plants of Himalayan region

6.1 Introduction

NWFPs are an important source of food particularly wild edibles that add value to our food particularly of tribal and village folks. In the Indian Himalaya Region (IHR) alone 675 wild edible plant species are found; out of them 344 occur in the west Himalaya [1]. Despite this diversity of wild edibles, limited attempt have been made to assess the status of their occurrence and availability, harvesting trends, and the potential of wild edibles to generate income. In the present section we have tried to document in detail the most promising edible plants that occur in the Himalayan region. Apart from wild edibles, there has been an acute shortage of fodder to rear the domestic cattle. However, there are a number of species which are used as fodder in different parts if

India and world. In this unit we will discuss the important wild edibles plants and also enumerate important fodder species in brief.

6.2 Food / Wild Edibles, Fodder and Other Consumptive value

"Wild edible plants" are those wild plants with one or more parts that can be used for food. Wild edible plants can be any plant with one or more part having food or nutritive value. It can be any plant means that even a weed can be so if part of it is eatable. Human beings are dependent on plants for a number of his/her day today requirements. There are a great variety of flora present in our diverse forest which are yield a diversity of useful products for our daily needs.

Millions of people in our country are under poverty line and their daily food supplement constitutes much of wild edibles. Even in other developing countries also do not have enough food to meet their daily requirements and many others are deficient in one or more micronutrients [2].

Wild edibles play a major role in the life of tribal communities as they are mainly dependent upon many wild edibles as they constitute much of their daily food items. Tribal people have been using wild edibles since long time and had indigenous knowhow of many of such species as how to collect and use them or prepare food dishes. In this way, wild edibles play an important role in household food security. Further, many of these wild edibles have potential of bringing income to home on account of their marketability at comparatively higher prices.

Thus, wild plants, besides from being used by poor communities, are commonly used today as supplement for healthy diets in even the most developed region of the world [3]. It has been shown from studies that people in countries like China, India, Thailand and Bangladesh; many of wild edible plants are still consumed along with domesticated species [4].

Our country has a rich diversity of species on account of variety of climatic conditions and therefore, is regarded as one of the world's 12 mega diverse countries. There are recorded more than 47,000 plants species. There are about 800 wild plants which are known to be consumed as food chiefly by tribal communities [5].

6.3 Classification of Wild Edible Plants

Wild edibles have been classified by different authors in different ways. Some of the important classifications are – Hills's classification (1952), Brouk's Classification (1975) and Singh and Arora's Classification (1975). These are described as follows:

A) Hill's Classification (1952): Hill (1952) has classified edible / food plants as follows:

a) Food Plants: Food plants are sub classified as **Cereals** (rice, wheat, maize, etc), **Millets (**such as jowar, bajra, ragi etc.), **Pulses** (e.g., gram, pea, pigeon pea, lentil), **Vegetables** (e.g. radish, carrots, sweet potatoes, potatoes, brinjal, cabbage, beans), **Fruits** (e.g. orange, banana, apple, guava, mango).

b) Food Adjuncts: Food adjuncts are those edible plants which are used as flavouring agents in our meal such as **spices and condiments** (e.g., ginger, turmeric, cinamomum, cloves, and pepper condiments) and **beverages** (e.g., tea, coffee, cocoa etc.).

c) Drug Plants: This category includes **Medicinal plants (e.g.,** *Cinchona*, *Ipecac*, *Rauvolfia*), **Fumitories and Masticatories plants** (tobacco, opium, ganja etc.).

d) Industrial plants and plant products: It includes **fibres** (cotton, jute, hemp, flax etc,), **timbers** (e.g., teak, sal, sagun, mahogany etc.), **Rubber** (*Hevea*, *Ficus elastica*, etc.), **Gums and Resin (**Pine), **Essential oil** (mustard, castor, linseed, coconut, groundnut etc.), Tanning and dye (*Tsuga canadensis* (Hemlock), *Bixa orellana* etc), Sugar and Starch (E.g. sugarcane, sugarbeet etc.).

Brouk (1975) divided economically important plants into seven classes as follows:

(a) Plants consumed by Man: It includes various plants and plant products which are consumed by man wholly or partly for various purposes. It includes all the categories defined in Hills classification as food plants and food adjuncts.

(b) Plants consumed by livestock: It includes the plants and plants parts which are used as food for livestock as fodder e.g. various grasses, *Artocarpus heterophyllus*, *Bamboo species*, Reeds etc.

(c) Semantic plants: All those plants which has some special significance. A particular tree or flower is ranked as an abstract value and represent as a symbol for a state/nation. e.g. India‟s national flower is Lotus, Manipur State‟s flower and tree are – Siroy Lily (Lilium mackliniae) and Toon (Cedrela toona), Assam‟s State tree and flower are – Bamboo (Arundinaria griffithiana) and Champa (Michelia champaca) etc. Certain plants are also associated with magical properties and superstitious beliefs. Flowers are used to express our good feelings towards the person to whom these are presented e.g. rose, tuberose (*Polianthes tuberosa*) commonly known as Rajnigandha by the Bengalies, Champa etc.

(d) Shelter plants: Bamboo and other timber yielding plants.

(e) Ornamental plant: Ornamental flower like orchids etc.

(f) Industrial plants: Plants yielding beverages like tea, coffee, cocoa, rubber, etc.

(g) Medicinal plants: Plants having medicinal values.

Singh and Arora's Classification: It was Singh and Arora (1978) who first of all classified Wild edible plants only without including economically important plants in India. The classification given by Singh and Arora was based on the consumption or edible value wild plant species as whole plant or plant parts. According to them, the wild edibles may be broadly into categories as follows:

a) Plants with Edible Underground Parts: Underground parts of many wild plants are source of starchy food consumed by the tribal inhabitants living nearer to the forest tracts where the edible kinds occur; e.g. *Curcuma* spp., *Colocasia* spp., *Alocasia* spp., *Zingiber* spp., etc.

b) Plants with Edible Greens: Green leaves of many wild species are consumed by human's such e.g. *Portulaca oleracea*, *Chenopodium album*, *Amaranthus spinosus* etc. more than 200 such species have been reported so far in India.

c) Plants with Edible Flowers: Flowers, buds and inflorescences of some wild species have edible value such as *Madhuca longifolia*, *Bauhinia species*, *Alpinia galanga*, *Capparis spinosa*, *Rhododendron arboreum* etc.

d) Plants with Edible Fruits: Majority of these wild fruits are eaten raw when ripe e.g. *Zizyphus mauritiana*, *Elaeagnus spp*., *Elaeocarpus spp*. *Artocarpus* spp., *Fragaria spp*. *Myrica esculaenta, Rubus spp.,* etc.

e) Plants with Edible Seeds: Seeds, nuts and kernels of many species have high nutritive content, therefore, are consumed by human beings. Many have high market value even. It includes species of Pines, seeds of *Artocarpus heterophyllus*, *Sterculia spp*.,

d) Other edible kind: Many plants have consumption value other than the leaves, roots, flowers, fruits, seeds, nuts, and kernels are also used as foods. Examples of such kinds are bark of *Cinnamomum zeylanicum*, *Betula alnoides*, *Terminalia tomentosa* etc.

6.4 Wild edible plants of India

There are many forest trees and shrubs which have significance on account of edible value wither whole or some plant part. Such plants have proved to be very useful at times of acute and chronic food scarcity as during famines, wars and other extreme survival situations like natural calamities. Still many of such plants constitute the daily food items of many of the tribal in India and around the world. Global estimates indicate that even in the 21st century one third of the population is expected to face severe food insecurity. Therefore, WHO and FAO have given impetus on the discovery of new food resources. Among others, underutilized wild edible plants are considered as potential alternative for achieving nutritional security. According to a report published by Ministry of Environment and Forests, Govt. of India [6], there are nearly 3900 wild plant species which are used by tribal as subsidiary food. There are about sixteen tribes of the Nagas which still practice shifting cultivation and their staple crops constitute taro, potato and rice. The species which are considered as edible are (*Allium bakeri, Alpinia bracteata, Artocarpus chaplasha, Bauhinia purpurea, Callicarpa arborescens, Castanopsis indica, etc.*) (Rao, 1994). The 29 ethnic groups of the indigenous community of Manipur in northeastern India use as food about 400 species of wild plants, ranging from algae to angiosperms as food (GOI, 1994). According to an

estimate, there are 675 wild edible plant species reported from Indian Himalayan regions and out of these, 344 species are recorded from the west Himalaya [1].

Some of the important wild edible plants are described here in the following paragraphs:

1) Indian Gooseberry

Scientific name: *Embilica officinalis* GeartnSyn. *Phyllanthus emblica*

Family: Euphorbiaceae

Hindi name: Amla, Aonla

Sanskrit: Aamalaki

English Name: Emblic myrobalan

Nativity**:** The aonla tree is native to tropical Southeast Asia, particularly central or southern India, Pakistan, Bangladesh, Sri Lanka, Malaya, Southern China and to Mascarene Islands

General Characteristics

- Naturally the species is found in tropical and subtropical forests of Uttrakhand, U.P., H.P. M.P. and Rajasthan.
- Amla is a small to medium sized deciduous tree. It attains an average height of 10-20 m whereas the average girth of the main stem is 70 cm.
- It has thin light grey bark exfoliating in small thin irregular flakes, exposing the fresh surface of a different color underneath the older bark. It is glossy and exfoliating bark which cracks irregularly.
- Leaves are 1.0 -1.3 cm long, 0.3 cm wide, closely set in pinnate fashion which makes the branches feathery in general appearance.
- Flowers are unisexual, 4 to 5 mm in length, pale green in color, borne in leaf axils in a clusters of 6 to 10. Fruits are fleshy, almost depressed to globose shape, 2.1-2.4 cm in diameter, 5.3-5.7 g in weight, 4.5-5.0 mL in volume.
- Fruits are pedicel less, round globose or oblate, indented at the base. A capsular (drupaceous) berry with fleshy exocarp, smooth to obscurely 6 lobed.

Nutritive value: Nutritive value of Aonla is well known for its nutritional qualities. It is rich in amino acids, minerals and is regarded as one of the richest source of

vitamin C. These have shown resistance during storage and cooking. The fruit also contains considerably higher concentration of proteins, ascorbic acid, many more minerals.

2) Kaphal

Scientific name: *Myrica esculenta Buch.-Ham. ex D. Don*

Family: Myricaceae

Hindi name: Kaphal

Sanskrit name: Kaiphal

English name: Box myrtle

Table.1 Wild edibles with underground parts edible

Scientific Name	Local name	Life Form
Aconitum balfourii	Attis	*Herb*
Aconitum heterophyllum	Pattis	*Herb*
Allium carolianum	Jambu,Jangli Pyaj	*A Herb*
Allium cepa	Pyaj	*Herb*
Allium stracheyi	Jambu, Pharn	*Herb*
Alocasia macrorhiza	Elephant ear, taro	*Herb*
Angelica glauca	Chhipi, Gandhrayan	*Herb*
Asparagus racemosus	Shatavari	*Shrub*
Bergenia ligulata	Pashanabheda	*Herb*
Bergenia stracheyi	Shilpada, Pashanabheda	*Herb*
Coleus forkohlii	Patharchur	*Herb*
Corydalys cashmiriana	*Kashmir corydalis*	*Herb*
Costus speciosus	*Keukand, Kemuka*	*Herb*
Cotoneaster falconeri	*Ruins*	*Shrub*
Dactylorhiza hatagirea	*Shalampanja*	*Herb*
Dioscorea floribunda	*Yam*	*Herb*
Dioscorea villosa	*Wild yam*	*Herb*
Geranium wallichianum		*Herb*
Meconopsis aculeata		*Herb*
Mucuna atropurpurea		*Shrub*
Nelumbo nucifera		*Herb*
Nphrolepis auriculata		*Fern*
Nymphaea stellata		*Herb*
Paris polyphylla		*Herb*
Pleurospermum angelicoides	*Choru*	*Herb*
Polygonatum cirrhifolium		*Herb*
Polygonatum verticillatum		*Herb*
Polygonum affine		*Herb*
Sedum tibeticum		*Herb*
Trigonella maritima		*Herb*
Trigonella palustris		*Herb*

Source: Samant et al. 2001

General Characteristics: It is distributed between 900–2100 m asl in the Indian Himalayas from Ravi eastward to Assam, Khasi, Jantia, Naga, and the Lushi Hills and extending to Malaya, Singapore, China, and Japan (Osmaston 1927).

Morphology: It is a sub-temperate medium to large woody, evergreen, dioecious tree, is about 12 to 15 m in height. Both male and female trees are almost similar in appearance. The bark of the tree is light brown to black in colour. The leaves are lanceolate, ovate nearly entire or serrate and almost crowded towards the end of branches. The female

flower is very small, sessile, solitary and bracteates with sepals and petals are either absent or not visible. The inflorescence is a catkin, axillary in position and bearing about 25 flowers in thread like style. The inflorescence of staminate flower is compound raceme. Each staminate flower has about 12 stamens, each with very short filament. The fruits are succulent drupe with small ellipsoidal or ovoid to globose in shape, initially green and become reddish during ripening. It is perishable in nature and their shelf life does not exceed 2-3 days (Patel and De, 2006). The flowering season starts from the month of October and continues till the last of December. Similarly the fruit setting season starts from the month of November and ripe fruits are made available from April to June (Jeeva et al., 2011).

Table.2 Wild edibles with edible leaves

Scientific Name	LF
Allium carolianum	*Herb*
Allium stracheyi	*Herb*
Allium cepa	*Herb*
Amaranthus Paniculatus	*Herb*
Heracleum candicans	*Herb*
Heracleum lanatum	*Herb*
Centella asiatica	*Herb*
Sochus oleraceous	*Herb*
Soilanthes paniculata	*Herb*
Impatiens racemosa	*Herb*
Megacarpaea polyandra	*Herb*
Chenopodium bortys	*Herb*
Chenopodium foliolosum	*Herb*
Terminalia bellerica	*Tree*
Mentha longifolia	*Herb*
Origanum vulgare	*Herb*
Cinnamomum tamala	*Tree*
Polygonatum verticillatum	*Herb*
Malva parviflora	*Herb*
Sida acuta	*Herb*
Nelumbo nucifera	*Herb*
Nymphaea alba	*Herb*
PLantago lanceolate	*Herb*
Plantago major	*Herb*
Piper betleoides	*Shrub*
Fagopyrum debotrys	*Herb*
Fagopyrum esculentum	*Herb*
Fagopyrum tataricum	*Herb*
Polygonum apinum	*Herb*
Rheum austral	*Herb*
Rheum webbianum	*Herb*
Rheum specioforme	*Herb*
Rumex acetosa	*Herb*
Rumex hastatus	*Herb*
Urtica parviflora	*Herb*
Urtica dioica	*Herb*

Source: Samant et al. 2001

Nutritive Value: Kaphalis a well-known species which provides edible fruits and other by products. All the parts of the plant have huge nutritional and therapeutic importance. Fruits are used for syrups, jams, pickles, and preparation for refreshing drinks.

Other economic uses: The tree bark yields tannin used commercially for tanning and dyeing material. It is also used as astringent, carminative and antiseptic. In Khasi hills the bark of this species is used as a fish poison. Chemically, a substance known as 'myriconol' has been isolated from stem bark, which has lesser toxicity than related rotenone. The

bark also contains yellow colouring substances in the form of glycoside, quercitin, β-sitosterol taraxerol and trirterpindiol. Glutamine and aspargine are reported to the principle amino acids in *Myrica* species.

3) Cheura

Scientific name: *Diploknema butyracea* (Roxb.) H.J. Lam
Family: Sapotaceae
Hindi name: Cheura
English name: Indian Butter tree
Other local names: Phulwara, Fulwa, Pahari Mahua, Gophat

Nativity: Cheura is native to the sub-Himalayan tracts of India, China, Nepal and Bhutan [7].

General Characteristics

- It is distributed from India through Nepal to Philippines and from Uttarakhand eastwards to Sikkim and Bhutan. In Uttarakhand, it is found in temperate and subtropical forests, however, it is also found sporadically in tropical moist deciduous, semi-deciduous and evergreen forests of Andaman Islands between 400-1400 m.

Table. 3 Wild edibles with edible flowers

Scientific Name	LF
Bombax ceiba	*Tree*
Bauhinia purpurea	*Tree*
Bauhinia retusa	*Tree*
Bauhinia vahlii	*Shrub*
Bauhinia variegate	*Tree*
Mesua ferrea	*Tree*
Agapetes serpens	*Tree*
Indigofera atropurpurea	*Shrub*
Indigofera gerardiana	*Shrub*
Indigofera heterantha	*Shrub*
Ougeinia oojeinensis	*Tree*
Lamium album	*Herb*
Elsholtzia densa	*Shrub*
Woodfordia fruticosa	*Shrub*
Cymbidium longofolium	*Herb*
Dendrobium hookerianum	*Herb*
Rhododendron arboreum	*Tree*
Rhododendron lepidium	*Shrub*

Source: Samant et al. 2001

- It is a fast growing, medium sized deciduous tree. In Uttarakhand, it is distributed naturally throughout the forest of lower Himalaya between an altitude ranges of 300 – 1500 m and is found in restricted habitats in Pithoragarh district particularly the areas bordering Nepal and adjoining areas of Almora, Bageshwar and Champawat districts

- The Indian butter tree is a deciduous tree about 15 -30 m high. Tree may attain a height of 15 m and girth 1.8 m, fruits are berries, 1-3 seeded and contain about 2.0 cm long almond shaped kernel. The Leaves of Cheura are thinly coriaceous, obovate, alternate and usually clustered at apex of branch- lets. Flowering occurs from October to November onwards and fruiting in July-August.
- The plant and plant parts are of great nutritive value. The oil known as Cheura oil is extracted from the seeds and is generally marketed as Phulwara Ghee. The fruits are eaten and are sweet. Cheura is used as food, fodder and medicines in Kumaun hills and is also known as Kalp-Vriksha. The oil yield from seed is 42 - 47 %. It has palmitic acid (56.6 %), natural oleodipalmitin (62 %). Seed contains Di-hydroquercetin, an antioxidant used in confectionery industries. Its flowers are rich source of sugar and utilized for preparation of Gur (juggery) like products and for fermentation (alcohol). Large and fleshy Cheura fruits are considered of good quality. The price of the fruit is determined by the dryness of the fruit. Dried fruit fetches a higher price to a raw fruit.

4) Wild Apricot

Scientific name: *Prunus armeniaca* L.
Family: Rosaceae
Hindi name: Khubani
English name: Apricot
Vernacular names: Chulli, Shara, Khumani, Chulu
Nativity: Native of China

The wild apricot (*Prunus armeniaca*) yields oilseed crop of mid hills and dry temperate regions of the country.

General Characteristics

- The tree is about 10-15 m tall with a reddish brown bark.
- The fruits are edible whereas the seeds yield oil known as apricot oil. The fruit is reported to be rich source of carbohydrates (both mono and polysaccharides), polyphenols, carotenoids (ß-carotene), vitamins C and K,

thiamine, niacin, iron, organic acids, phenols, and volatile compounds viz. benzaldehyde, esters and terpenoids. The flesh is yellow or yellowish orange to firm and sweet. Apricot is a good source of sugars and vitamin 'A' and contains appreciable amounts of thiamine and iron. Fresh Indian wild apricots yield 86% of edible matter.

- The wild apricot fruits yield 22-38% percent kernels, which may be sweet or bitter depending on the type. Sweet kernels resemble almonds in taste and are used as its substitute in pastes and confectionery and can be added to apricot jams.
- In some areas fruit pulp is utilized for the preparation of distilled alcoholic liquor by some tribes in Himachal Pradesh and Uttarakhand.
- The fruits are highly perishable and can be preserved in a number of ways. They are frozen, candied or made into a paste. In some countries, fruit pulp is cooked and thinly spread on cloth and then rolled and dried and it constitutes an important food.
- A number of other products are prepared from fruits of apricot. Its fruits mixed with those of cultivated types are utilized in Himachal Pradesh in production of number of products like apricot jam, apricot nectar and apricot papad. The strained baby food from pulp is nutritious and a good source of calcium, phosphorus and iron. The oil of seed is edible and oil cake can be used as organic manure.

5) Chilgoza Pine

Scientific name: *Pinus gerardiana* Wall.
Family: Pinaceae
Hindi name: Chilgoza
Nativity: It is a native to Himalaya

General Characteristics

- It is distributed from Himachal Pradesh, J&K to Pakistan. It grows well between 1800-3400 m altitudes in the dry temperate forest of the Himalaya,

where the summer monsoon is weak and precipitation mostly occurs in the form of snow.

- Chilgoza pine is an important ecological and economic species having a restricted distribution in India. It is very much restricted in dry temperate region of North-Western Himalayas between altitudes of 1800 m to 3400 m above mean sea level. It is common in Afghanisthan and parts of Pakistan, i.e. Baluchistan. In India, it is found in the upper parts of Sutlej, Ravi and Chenab valley. It mainly occurs in Kinnaur, Pangi and Chamba of Himachal Pradesh. It has its further extention to Kishtwar and Astor in Jammu and Kashmir [8][9]. The species was subsequently (1839) introduced to England, where it was found to be frost-sensitive [10].
- The tree attain a height of 10-20 m tall with usually deep, wide and open crowns with long, erect branches. Trees with a girth of up to 4 meters (approx. 127 cm dbh) are reported. The seeds (pine nuts) are 17-23 mm long and 5-7 mm broad, with a thin shell and a rudimentary wing.
- **Nutritive value of** Chilgoza Pine is well known for its edible seeds which are rich in carbohydrates and proteins. The seeds are sold as dry-fruits by the name "Chilghoza".

6) Indian wild pear

Scientific name: *Pyrus pashia*
Family: Rosaceae
Hindi name: Nashpati
English name: Indian wild pear
Nativity: Pears are native to coastal and mildly temperate regions of the Old World, from Western Europe and North Africa east right across Asia.

General Characteristics

- They are medium sized trees, reaching 10–17 m tall, often with a tall, narrow crown; a few species are shrubby.
- It is a deciduous tree.
- Flowering takes place in March–April and fruiting in August–September.
- The pear fruit is a pome,

- Fruits are tasty when fully ripe. The fully ripe fruit has a reasonable flavor, sweet and very pleasant.
- A mature fruit contains about 6.8% sugars, 3.7% protein, 1% ash, 0.4% pectin.

Table 4. Wild edibles with edible fruits[1]

Scientific Name	Life Form	Scientific Name	Life Form
Actinida callosa	*Shrub*	*Fragaria vesca*	*Herb*
Aegile marmelos	*Tree*	*Horsfieldia kingii*	
Artocarpus chaplasha	*Tree*	*Humulus lupulus*	*Herb*
Artocarpus heterphyllus	*Tree*	*Litsea citrata*	*Tree*
Artocarpus lacucha	*Tree*	*Litsea cubeca*	*Tree*
Bunium persicum	*Herb*	*Livistonia jankisiana*	*Tree*
Buxus wallichiana	*Tree*	*Madhuca indica*	*Tree*
Cannarium bengalense	*Tree*	*Malus bacata*	*Tree*
Cannarium strictum	*Tree*	*Measa argentia*	*Tree*
Capparis spinosa	*Shrub*	*Measa indica*	*Tree*
Citrus media	*Tree*	*Melothria heterophylla*	*Herb*
Cotoneaster microphylla	*Shrub*	*Moringa aleifera*	*Tree*
Curdania javanensis	*Tree*	*Morus alba*	*Tree*
Cycas pectinata	*Shrub*	*Morus indica*	*Tree*
Daphnephyllum himalayense	*Tree*	*Morus laevigata*	*Tree*
Diospyros lancaefolia	*Tree*	*Morus nigra*	*Tree*
Diospyros malabarica	*Tree*	*Morus serrata*	*Tree*
Elaeocarpus floribundus	*Tree*	*Myrica esculenta*	*Tree*
Elaeocarpus lanceaefolius	*Tree*	*Nyctanthes arbortristis*	*Tree*
Elaeocarpus serratus	*Tree*	*Opuntia monocantha*	*Shrub*
Elaeocarpus sikkimensis	*Tree*	*Penanga gracilis*	*Shrub*
Emblica officinalis	*Tree*	*Persea armenica*	*Tree*
Ficus bengalensis	*Tree*	*Prunus cerasoides*	*Tree*
Ficus glomerata	*Tree*	*Prunus cornuta*	*Tree*
Ficus hirta	*Tree*	*Prunus persica*	*Tree*
Ficus hispida	*Tree*	*Prunus venosa*	*Tree*
Ficus hookeri	*Tree*	*Pyrecantha crenulata*	*Shrub*
Ficus macrophylla	*Tree*	*Pyrus pashia*	*Tree*
Ficus nemoralis	*Tree*	*Randia tetrasperma*	*Shrub*
Ficus obscura	*Tree*	*Rhus punjabensis*	*Tree*
Ficus palmata	*Tree*	*Rosa macrophylla*	*Shrub*
Ficus religiosa	*Tree*	*Rubus spp.*	*Shrub*
Ficus roxburghii	*Tree*	*Syzizium cuminii*	*Tree*
Ficus rumphii	*Tree*	*Terminalia chebula*	*Tree*
Ficus semecordata	*Tree*	*Trevesia Palmata*	*Tree*
Fragaria nubicola	*Herb*	*Zanthoxylum armatum*	*Shrub*

7) Raspberries / blackberries / dewberries

Scientific name: *Rubus ellipticus*

Family: Rosaceae

Hindi name: Hishalu

English name: Blackberries

Vernacular names: Raspberries, blackberries, and dewberries

General Characteristics

- Species of *Rubus* spp. (*Rubus elipticus*) are thorny shrub up to 3 m high and 2.5 cm in diameter, found in the temperate Himalayas from Kashmir to Sikkim at 1,200- 3,000m. It also occurs in the Western Ghat at higher elevations.
- Most of these plants have woody stems with prickles, spines, bristles, and gland-tipped hairs. The prickly shrub invades native forests principally in pig-disturbed habitats. The plant has underground shoots that contribute to its spread and allow it to rapidly regenerate following a fire.
- Flowering occurs in February-April followed by fruiting. The fruit is a round yellow cluster of druplets easily detaching from the receptacle. The fruits are edible and frugivorous birds spread the seeds. A purple to dull blue dye is obtained from the fruit. Additionally plant has many medicinal properties also which are discussed separately.
- The fruit is sometime sold in local markets in the Himalayan hills.
- Not only are raspberries delicious, they are nutritional powerhouses. One cup of raspberries has just 64 calories. While a cup contains five grams of sugar, these berries deliver a surprising 8 grams of fiber.
- Raspberries are an excellent source of vitamin C, containing 32.2 mg or 54% of the suggested daily intake. These delicate berries are also a good source of vitamin K, providing 12% of daily values.
- On the mineral side, raspberries are an excellent source of manganese, providing 41% of the suggested daily intake. Raspberries also contain some magnesium, copper, iron and potassium.

8) Bael

Scientific name: *Aegle marmelos*(L.) Correa
Family: Rutaceae
Hindi name: Bel, Sirphal
Sanskrit: Aadhararutha, Asholam, Bilva
English name: Golden apple, Stone apple
Nativity: It is native to oriental India.

General Characteristics

- It is a small to medium sized thorny tree about 10-12 m in height. It is recorded growing in wild habitats in foot hills of Himalaya, Chattishgarh, Bihar, West Bengal, Central as well as South India.
- The fruit is woody, grey or yellowish, round, 5 - 17.5 cm in diameter, containing numerous seeds embedded in a mass of sweet, orange coloured aromatic pulp. The ripe fruit is sweet and cooling. It is used in the form of sherbet or for making jams and preserves.

9) **Gular**

Scientific name: *Ficus glomerata* Linn. Synonym *F. racemosa*
Family: Moraceae
Hindi name: Gular, Atti
English name: Cluster Fig
Nativity: It is native to Australia

General Characteristics

- The plant grows all over India in different habitats and also in hills. The tree is an evergreen, medium tall, tree with height varying from 12-18 meters in height. The rich green foliage provides a good shade. The bark is reddish grey and often cracked.
- The leaves are dark green, 7.0-10.5 cm long, ovate or elliptic, in large clusters from old nodes of main trunk.
- Young shoots pubescent, scaberaous or glabrous, 3 to 6, long and glabrous, stipules are present, ovate or lanceolate, scarious or pubscent, three basal bracts present.
- male, female and gall flowers on the same receptacle; the male flowers present near the mouth whereas female flowers near the wall of receptacle and gall flowers more internal to these. Ripening of fruits takes place in different parts of the year.
- The fruit receptacles are 2-5 cm in diameter, pyriform, in large clusters, arising from main trunk or large branches. The fruits resemble the figs and are green when raw, turning orange, dull reddish or dark crimson on ripening.
- The seeds are tiny, innumerable, grain-like. The roots are long and brownish in colour. It's having characteristic odour and slightly bitter in taste

10) Bedu or wild fig

Scientific name: *Ficus palmata* Forsk.
Family: Moraceae
Hindi name: Bedu
English name: Wild Fig or Himalayan Fig
Nativity: It is native to North-Western India and Rajasthan regions

General Characteristics

- It is found to growing in forests in the Himalayan region, so also named as Wild Himalayan fig. It is mainly found up to 1,000 meters above the sea-level and it is distributed in Uttarakhand, Punjab and Kashmir in India, Nepal, Pakistan, Afghanistan, Iran, Arabian Peninsula, Somalia, Sudan, Ethiopia and South Egypt It prefers light (sandy), medium (loamy) and heavy (clay) soils, requires well-drained soil and can grow in nutritionally poor soil.
- It is a deciduous tree with a height ranging from 5 to 10 m.
- Leaves are alternate, broad, ovate and membranous with size range 12.92 cm long and 14.16 cm broad.
- Flowers are unisexual, monoecious, greenish white and very small.
- Fruitare edible with colour varying from deep violet to black.
- Seeds are numerous, round and very small.

11) Jamun or Indian Blackberry

Scientific name: *Syzygium cumini*(L.) Skeels
Family: Myrtaceae
Hindi name: Jamun, Jambul, Black Plum
English name: Indian Blackberry
Nativity: It is native to India, Burma, Ceylon and to the Andaman Islands
General Characteristics

- It is a large evergreen tree, found all over Indian plains as well as in Kumaon hills up to 1,600 m. It is often planted as an avenue tree, also in wild and semi-wild conditions in tropical and subtropical India i.e, Punjab, Haryana, Uttar

Pradesh, Maharashtra, Rajasthan, Gujarat, Madhya Pradesh, Bihar, Chhattisgarh, Jharkhand, Karnataka, Kerala, Tamil Nadu and Andhra Pradesh.

- Jamun fruit is a source of important vitamins and other compounds such as Vitamin C, Vitamin A, Riboflavin, Nicotinic acid, Folic acid, Glucose, Fructose, Maleic acid, Gallic acid, Cyanidin glycoside, Glycoside Jamboline, Triterpenoids, Tannins Gallitanins Essential Oil, Sesquiterpenes, Resin, Phytosterol
- Good quality jamun juice is excellent for sherbet, syrup and "squash". Jamun of good size and quality are sweet and may be added in sauces and jam. The inferior fruits can be utilized for juice which is often comparable to grape juice.
- Jamun vinegar, extensively made throughout India, is an attractive, clear purple, with a pleasant aroma and mild flavor.

12) Mulberry

Scientific name: *Morus alba* **L.**

Family: Moraceae

Hindi name: Shahtut

English name:

Other Names: White mulberry, silkworm mulberry

General Characteristics

- Mulberry is monoecious, deciduous tree and is of medium size with a height of about 30 m and width of about 1.8 m, it is distributed throughout Asia, Africa, Europe and South and North America and found in wide range of tropical areas and in hilly areas of Himalayas at the height of 3300 m.
- The leaves are used as fodder for silkworms and animals. In European countries it is grown for fruit production and it is also used as vegetable in different parts of the World, while in Japan mulberry leaves are used as tea and powder juice (Gerasopoulos and Stavroulakis, 1997; Ercisli and orhan, 2007; Katsube et al., 2009).

6.5 Fodder & Other direct use value

There are about 350 species from 116 genera growing throughout the region between 500 and 4500 m amsl (Singh and Singh, 2006). The Himalayan region support about 84 trees and 40 shrub species which are used as fodder (Negi, 1977). Some of the important fodder species of Uttarakhand are as follows:

6.5.1 Grasses as fodder

The principal component of wild forage is *Andropogon* spp. The other grass species making important fodder resources are *Cenchrus ciliaris*, *Bothriochloa ischaemum*, *B. intermedia*, *B. pertusa*, and *Bromus spp*.[11].

6.5.2 Leafy fodder

There are a number of species used in India for feeding animals as fodder. Important of these are as follows: [12]

- *Acacia arabica*
- *Acacia modesta*
- *Adina cardifolia*
- *Aegle marmelos*
- *Aesculus india*
- *Artocarpus lakoocha*
- *Bauhinia spp.*
- *Bauhinia spp.*
- *Carpinus viminea*
- *Cassia fistula*
- *Celtis australis*
- *Dalbergia latifolia*
- *Debregeasia velutina*
- *Desmodium elegans*
- *Diploknema butyraceae*
- *Ficus spp*
- *Grewia optiva*
- *Hardwickia binnata,*
- *Melia azedarach*

- *Melia indica*
- *Morus serrata*
- *Morus spp.*
- *Prunus cerasoides*
- *Quercus spp.*
- *Robinia pseudoacacia*
- *Salix wallichiana*
- *Shorea robusta*
- *Terminalia bellirica*
- *Terminalia tomentosa*

6.5.3 Leaves for Thatching

Leaves of many plants are also used by rural folks for thatching of their temporary or permanent house roofs. Among such plants majority belong to palm family. These are *Nepa fruticans*, *Pinanga gracilis*, *Licuala peltata*, *Livistonia jekiansiana*, *Cocos nucifera* whereas the main broadleaved species used for the purpose are *Tectona grandis*, *Bauhinia vahii*, *Butea frondosa.* [12]

Summary

NWFPs are an important source of food particularly wild edibles that add value to our food particularly of tribal and village folks. In the Indian Himalaya Region (IHR) alone 675 wild edible plant species are found; out of them 344 occur in the west Himalaya. Apart from wild edibles, there has been an acute shortage of fodder to rear the domestic cattle. However, there are a number of species which are used as fodder in different parts if India and world. In this unit, a detailed account of the important wild edibles plants and fodder species has been discussed. Wild Edible plants have been classified by various researches from time to time. The various classifications have been discussed in brief. Further, some of the important wild edible plants such as Indian Gooseberry, Kaphal, Cheura, Wild Apricot, Chilgoza Pine, Indian wild pear, Raspberries / blackberries / dewberries, Bael, Gular, Bedu or wild fig, Jamun or Indian Blackberry, Mulberry, Nepalese firethorn or Ghingaru**.**

Further, a brief account of fodder species has also been given. Among the important grass fooder species are *Andropogon* spp., *Cenchrus ciliaris*, *Bothriochloa ischaemum*, *B. intermedia*, *B. pertusa*, and *Bromus spp*. Among the leafy fodder species are *Acacia arabica, Acacia modesta, Adina cardifolia, Aegle marmelos, Aesculus india, Artocarpus lakoocha, Bauhinia spp., Bauhinia spp., Carpinus viminea, Cassia fistula, Celtis australis, Dalbergia latifolia, Debregeasia velutina, Desmodium elegans, Diploknema butyraceae, Ficus spp , Grewia optiva, Hardwickia binnata,Melia azedarach, Melia indica, Morus serrata, Morus spp., Prunus cerasoides, Quercus spp, Robinia pseudoacacia, Salix wallichiana, Shorea robusta, Terminalia bellirica, Terminalia tomentosa*

In addition to this, leaves of many plants are also put to diverse suses sucha s thatching of the house roofs. **Among these plants are** *Nepa fruticans*, *Pinanga gracilis*, *Licuala peltata*, *Livistonia jekiansiana*, *Cocos nucifera* among the palms and among the broadleaved species are *Tectona grandis*, *Bauhinia vahii*, *Butea frondosa.*

References

[1]. S.S. Samant, U. Dhar. Diversity, endemism and economic potential of wild edible plants of Indian Himalaya. 1997.

[2]. FAO. Wild Edible Plants. 2004.

[3]. Redzic. Wild Edible Plants and Their Traditional Use in the Human Nutrition in Bosnia-Herzegovina. *Ecology of Food and Nutrition.* 2006 . pp. 189-232 .

[4]. F Mazhar, D Buckles, PV Satheesh , F Akhter. Food sovereignty and uncultivated biodiversity in South Asia. New Delhi, India : Academic Foundation Report, 2007.

[5]. H.B. Singh, R.K. Arora. Wild edible plants of India. s.l. : ICAR, New Delhi, 1978.

[6]. Anonymous. s.l. : GOI, MoEF, 1995.

[7]. Brandis, Dietrich. Indian Trees an Account of Trees, Shrubs, Woody, Climbers, Bamboos and Palms, Indigenous or Commonly Cultivated in the British Indian Empire. s.l. : London Constable and Company Ltd., 1921.

[8]. Dogra, P. D. Gymnosperms of India–II. Chilgoza pine (Pinus gerardiana Wall.). Bulletin of the National Botanic Gardon No. 109. 1964.

[9]. *Geographic distribution of the pinus of the world, USDA Forest Service .* W. B. Critchfield, Jr.E.L. Little. 1966.

[10]. Farjon, A. Pines: drawings and descriptions of the genus Pinus. Antiquarian Booksellers Association of America Pub, New York, 220. 1984.

[11]. FAO. *Non-Wood Forest Products in Asia.* Bangkok : RAPA PUBLICATION 1994/28, 1994.

[12]. Troup, RS. Indian Forest Utilization. Calcutta : Calcuta Goverment Printing Presss, 1907.

[13]. Sangria, K.P. *Forest and Forestry.* New Delhi : National Book Trust India, 1967.

[14]. Kirpal, J.S. Verma and B.N. mahaforest.nic.in › stand_ord_file. *mahaforest.nic.in › stand_ord_file.* [Online] December 12, 1996. mahaforest.nic.in › stand_ord_file.

[15]. ICFRE. *Forestry Statitics INdia.* Dehradun : ICFRE, 2011.

[16]. IEA, International Energy Agency. *World Energy Outlook.* Paris : IEA PUBLICATIONS - 9, rue de la Fédération - 75739 PARIS CEDEX 15PRINTED IN FRANCE BY JARACH-LA RUCHE, 1998.

[17]. FAO. *Global Forest Resources Assessment.* Rome : FAO of United Nations, 2015.

[18]. *For • est For• est• ry.* Helms, John A. 2002, Journal of Forestry, pp. 15-19.

[19]. *A new definition of silviculture.* Spurr, S.H. 1945, Journal of Forestry, p. 44.

[20]. Khare, C.P. Indian Medicinal Plants: an illutrated disctionary. s.l. : Springer, 2007.

[21]. Patkar Atul N, Nilesh V. Desai, A Akkatai Range, Kamlakar S Kalekar, Rajashree Shahu. A Review on Aegle Marmelos: A potential medicinal tree. INternational Research Journal of Pharmacy . 2012.

[22]. *Indian gooseberry (Emblica officinalis): Complete pharmacognosy review.* Kaushik Vilas Kulkarni, 2 Shrishail M Ghurghure. 2018, International Journal of Chemistry Studies.

[23]. Venkateshwarlu, D. Definition of Forest- A review. *Opendevelopmentmekong.net.* [Online] https://data.opendevelopmentmekong.net › download › venkateswarlu.

[24]. Tewari A, Shah S, Singh N , Tamta KK. Diploknema Butyracea(Roxb.) Lamb.: A Viable Livelihood Option for Hill Communities of Central Himalayan Region. 6 (5): 393. 2015.

[25]. FS, Baker. Principles of Silviculture. California : McGraw Hill Book Company, INC, 1950.

Unit 7: NWFPs: Gums, Resins, Oleo-resins, Spices, Tans & Dyes

Unit Structure

7.0 Learning Objectives

After studying this unit, you should be able to:

- Define gums, resins, oleoresins and gum-resins,tans and dyes

- Describe gums and their sources
- Differentiate among resins, oleoresins and gum-resins
- Discuss the various kinds of spices and condiments
- differentiate between tannins and dyes
- discuss the importance and uses of tans and dyes
- discuss various types of tans and dyes
- discuss major plant species yielding tans and dyes

7.1 Introduction

Gums, resins, and oleo-resins are important NWFPs in India. According to an estimate by FAO, gums and resins are the most widely used and traded category of NWFPs other than items consumed directly as foods, fodders and medicines. It has been estimated that the world market for gums used as food additives at about US$ 10 billion in 1993, of which the two largest "forest" gums (gum arabic and locust bean) accounted for just over 12%; the remainder were mainly the seaweed gums, starches, gelatin and pectin (Coppen, 1995)(NAUDE, 1994). This takes no account of non-food uses of gums.

The gum has applications in food, pharmaceutical and miscellaneous technical industries. It is particularly useful in food based industries where its thickening, stabilizing, emulsifying and suspending properties are important. In the pharmaceutical industry they are used as binding agents in tablets and as suspending and emulsifying agents in creams and lotions. Some have specific applications in the dental and medical fields. It has also other applications in the printing and textile industries. Resins, oleoresins and balsams also have diverse applications in paints, varnishes and lacquers industries.

In this unit we will discuss about the gums, resins and oleoresins, spices, tans and dyes in detail.

7.3 Gums

According to FAO[1]defines gum arabic as the "dried exudation obtained from the stems and branches of *Acacia senegal* (L) Willdenow or closely related species".

Although most of the internationally traded gum arabic comes from *A. senegal*, yet the term "gum arabic" cannot be restricted to gum obtained from a particular species. In some cases, so-called gum arabic may originate from *Combretum*, *Albizia* or some other genus.

Broadly speaking, gum is a viscous substance which exudes from the cracks or wounds in the bark of many species of trees, shrubs and climbers. It is basically a translucent amorphous substances which are the products of degradation of the cell-wall of woody species andit exudes spontaneously from the tree bark[2]. Chemically they are complex polysaccharides (Carbohydrates) and the true gums are those gums which are formed as a result of disintegration of internal plant tissues, mainly cellulose decomposition. This process of gum formation is called as **gummosis**[2][3].

The gum exudation is a spontaneous action and it take place particularly when the bark cracks in response to prolonged heat or due to some disease or poor health. Large quantities of gum is generally exuded after a long dry hot season and this is more in diseased or unhealthy trees. Forest fires are also followed with large exudations. Intensive tapping for gums affects the health of trees to a considerable degree if continued for some years, and it is usual in Reserved Forests to give trees a periodic rest which are being tapped for gums after which tapping may be resumed for a further period.

Gums are mostly soluble in water, even if some gums are not soluble, they can absorb water and swell up to form mucilage or jelly. Whereas none of the gums is soluble in alcohol, organic solvent or oil. On heating, gums decompose completely without melting usually showing charring. In contrast to gums, most of the resins are soluble in alcohol and insoluble in water.

There are a number of trees in India which are source of gums and gum-resins. Some of these are of considerable commercial importance and are demand in the market, therefore, sold at high price. Some of the important gums yielding species are *Acacia arabica, Acacia senegal, Acacia catechu, Acacia modest* and *Acacia nilotica.* Other than *Acacia species Pterocarpus marsupium, Butea frondosa, Lanneagrandis* syn. *Odinawodier or Lannea coromandelica, Sterculia urens, Cochlospermum gossypium and Bombax malabaricum, Moringa pterygosperma, Boswellia serrata* and *Anogeissus latifolia* yield gum.

Some of the important species yielding gum are described in more detail in the following paragraphs.

7.3.1 Acacia gums[2]

- There are many species of *Acacia* which produce gums. These include *Acacia arabica, Acacia senegal, Acacia catechu, Acacia modesta* and *Acacia nilotica.*
- Collectively, the gum produced by different species of *Acacia* is known as *Acacia* gum. However, the gums produced by different species have specifically different names, for example, 'Gum Arabic' is the name for gum obtained from *Acacia Senegal*,
- Indian Gum Arabic is the name of gum obtained from *Acacia arabica*.
- The gum produced from *Acacia nilotica* is known as 'Babool Gum'.
- Gum arabic from *Acacia senegal* is a pale to orange-brown solid when broken gives a glassy fractured appearance. It is a complex, slightly acidic polysaccharide.
- The precise chemical and molecular structure differs according to the botanical origin of the gum, and these differences are reflected in some of the analytical properties of the gum. As a result, the functional properties and uses to which gum arabic can be put (and its commercial value) are also very dependent on its origin.
- It is very soluble in water. Gum Arabic has its high value due to good emulsifying, stabilizing, thickening and suspending properties on account of its high solubility in water and low viscosity.
- Ithas its applications in food and pharmaceutical industries. In pharmaceutical industries, it is used in tablet manufacture as has a good binding property. It is also used as a suspending and emulsifying agent, sometimes in combination with other gums. Other technical uses include uses in ceramics, where gum arabic helps to strengthen the clay and also in the manufacture of certain types of inks. Further, it is also used in textiles, paints and adhesives industries.

7.3.2. Tragacanth Gum[1]

- Tragacanth gum is obtained from *Astragalus* spp.
- It is a dried exudate produced by tapping the tap root and branches of the species
- Chemically, it is a complex mixture of acidic polysaccharides, mostly present as calcium, magnesium and potassium salts.
- Its swells rapidly in water to form highly viscous colloidal sols or semi-gels, which act as protective colloids and stabilizing agents. These properties make it suitable for diverse uses in foods and pharmaceutical industries. It was widely used in salad dressings and sauces, savoury spreads, milk shakes, ice creams, and confectionery and bakery products. It has advantage over other gums due to its stability under acid conditions. In pharmaceutical industries, it is used as a binder, suspender or emulsifier in tablets, ointments, lubricating jellies and oral suspensions, and particularly in dermatological creams and lotions. It is also used in toothpastes, hair lotions and other personal care products.

7.3.3 Locust bean (or carob) gum and Mesquite Gum[1]

- It is obtained from the seeds of *Ceratonia silique*, which has its origin from Mediterranean region, however, has also been introduced to the warmer parts India.
- It is a whitish powder resulting from the grinding of the seeds.
- The gum has relatively high viscosities at low concentrations. When suitably mixed with other gums, it offers wide applications as good stabilizing, thickening and emulsifying agent. It is employed in a wide range of products such as ice cream, baby foods and pet foods. It is also used in the manufacture of soft cheeses, bakery products, powdered desserts, sauces, salad creams and in many dairy products.
- The gum finds its biggest usage in paper industry where it is used to improve the physical characteristics of the paper.

- It has applications in textile industry either alone or in combination with starch and synthetics as a sizing agent for cotton and other natural fibers.
- It is also used as a print-paste thickener in both roller and screen printing to help provide greater purity and uniformity of shades and deeper penetration of dyes.
- Other uses include uses in oil-drilling fluids, and also in some pharmaceutical and cosmetics applications.
- The term "mesquite gum" is product from *Prosopis* spp., particularly *P. juliflora* by grinding endosperm of the seeds. However, it has limited production.

7.3.3 Gum Kino[2]

- 'Gum Kino' is name given to the gum produced by *Pterocarpus marsupium.* It is a large tree found on Central and South India.
- Gum has a big export potential particularly to Europe.
- The gum is obtained from the tree by making a longitudinal cut down the stem of the tree so that the wood is just exposed. V-shaped side cuts are then made to lead into this central channel, so that the formation has the appearance of a fish-bone. A bamboo tube is placed at the bottom of the main incision to collect the fairly liquid gum flowing downward. Tapping is usually done in the evening in the month of February and March.
- Good quality of gum kino is of a ruby red colour and contains about 75 per cent of tannic acid and is, therefore, important as an astringent in medicine and is one of the main constituent of medicines around the world.
- It is also a valuable medicine for diarrhea and dysentery.

7.3.3. Bengal kino gum[2]

- 'Bengal kino' is a gum product from *Butea frondosa*.
- The gum exudes from a scaror cut in the stem.
- The gum has an intense ruby colour with close resemblance with gum kino.
- It is also used in pharmaceutical industries.

7.3.4 Jhingan Gum[2]

- The *Lannea grandis* is a tree and is fairly common in North India.
- The tapping generally starts in March and continues till the rains starts.
- In order to tap the gum, a cut is made in the bark and the gum exudes in the form of drops.
- Tapping is usually carried out for 5 years and then stopped until the complete healing of the wound.
- It is commonly used as a mucilage for making ink and is also especially useful to confectioners owing to its great solubility in water.

7.3.5 Katira or Bassora Gum[2]

- 'Katira Gum' or 'Bassora Gum' is the gum produced by *Sterculia urens*, *Cochlospermum gossypium* and *Bombax malabaricum.*
- The gums flow naturally from the wound holes in the stems caused by decay or insect damage
- The gum is sweetish, cooling and sedative and is useful in coughs.
- Katira gum is used in cigar paste and therefore has great export demand. It also used in ice-cream industry.
- It is used as a substitute for gum tragacanth in calico-printing and leather-dressing.
- It also has astringent property and also used in medicinally in diarrhoea and dysentery.

7.3.6 Moringa gum[2]

- It is obtained from *Moringa pterygosperma*.
- It has a deep-red colour and found exuding from the tree similar to blood like drops which on coagulation forms a hard dark-red mass.
- This gum is also a kind of the gums of tragacanth series but has comparatively less commercial demand and mostly used on indigenous medicines.

7.3.7 Salai gum[2]

- Salai gum is produced from *Boswellia serrata*, a tree commonly known as 'the Indian olibanum tree'
- It is a gum-oleo-resin of a greenish-yellow colour, soluble gum and has a pleasant aromatic smell when burnt.
- On account of its aromatic smell, it has applications in as incense and in making up ointments particularly for rheumatism.
- According to an estimate, it has 8 per cent of turpentine, 55 per cent of good quality rosin and 22 per cent of a white soluble gum suitable as athickening agent in cloth printing.

7.3.8 Other species yielding gums[2]

- Dhaura gum is obtained from *Anogeissus latifolia*.
- Khair gum is produced from *Acacia catechu*
- 'semlagum' is name of gum from *Bauhinia retusa*
- Other species which yield gum are *Acacia leucophloea*, *Buchanania latifolia*, *Soymida febrifuga*. *Gardenia species* and *Styrax serrulatum*, which yield a gum benzoin similar but inferior to the true gum benzoin or gum Benjamin of commerce.

7.4 Resins, Oleoresins and gum-resins

Similar to Gums, resins are also products of cell degradation which are usually solid or semi-solid substances. In contrary to gums, they are insoluble in water but soluble in alcohol.

Resins are formed as a result of spontaneous evaporation of plant juices or by the activity of special gland cells. They exude from the tree trunk either naturally or by incision of the bark and outer layers of the wood.

Resins are manly made up of secondary metabolites (waste products). Most of the resins are a viscous liquid containing mainly the volatile terpenes and lesser components of dissolved non-volatile solids which make resin thick and sticky. Some resins also contain a high proportion of resin acids. It is presumed that resins originate

through reduction and polymerizations of carbohydrates. Resins are mainly distinguished into three types:

- resins or hard resins
- oleo-resins and
- gum-resins

7.4.1 Resins (or hard resins)[2][1][4]

Resins are usually solid, more or less transparent and brittle substances without odorant taste. The general characteristics of resins are as follows:

- resins are insoluble in water but soluble in organic solvents like alcohol, ether and turpentine
- they are brittle and amorphous in nature
- They are transparent or semi-transparent
- They have characteristic luster
- They are fusible
- resins give a smoky flame on burning in air
- They are nonvolatile and are very poor conductors of electricity.
- The hard resins contain only a little essential oil
- The hard resins are useful in preparation of best varnishes on account of their property of getting dissolved easily in alcohol.

Resins are generally classified as- 1) Resins from conifers (Pines) and 2) Resins from broad-leaved species,

A) Resins from conifers (Pines): Members of Pinaceae family mainly yields resins. There are mainly four species of pines in our country which produce resins which has commercial importance. These are *Pinus roxburghii*, *P. wallichiana (P.excelsa)*, *P. khasya* and *P. merkusii*. Among these *Pinus roxburghii* yields much quantity of rosin and turpentine whereas that of *Pinus wallichiana* although the quantity is comparatively less but the quality of resin is superior to that of *Pinus roxburghii.* The wood with excessive quantity of resin is used as torch during nights in villages and also as lightening of *chulhas*. Among all the above species the best resin is of *P. khasia* which

is more or less comparable to French or American resins, however, the quantity is poor[2].

One of the important conifers is *Agathis loranthifolia*, a native of Borneo and Sumatra, yields hard resins known as 'Dammar'[2]. However, in India it is a trade name for the resins obtained from certain species belonging to Dipterocarpaceae and Burseraceae.

B) Resins from broad-leaved species

As explained above, in our country 'Dammar' is a trade name given to hard resins obtained from the members of the family Dipterocarpaceae and a few species belonging to Burseraceae also. The term 'Dammar' is used for different resins in different countries. Originally it did not refer to any specific tree or resin. Gradually the word was being used as a collective term for a great variety of hard resins of quite different origin. The word actually is of Malayan origin, and is used by the natives to indicate a torch made of decayed wood and bark, mixed with oil and powdered resin. The 'dammars' are quite different chemically from the resins of coniferous origin. The dammar is insoluble in chloral hydrate whereas it is completely soluble in alcohol and turpentine. Dammar producing trees are mainly found in Southeastern Asia, particularly abundant in Malaya and Sumatra.

In India, there are six substances known as Dammar. These are Black Dammar, Sal Dammar, Rock Dammar, White Dammar, Green Dammar and Pwenyet Dammar.

- **Black Dammar** is a shining deep reddish-brown resin obtained from *Cannarium strictum*
- **Sal Dammar** is obtained from Sal trees (*Shorea robusta*)
- **Rock Dammar** is obtained from *Hope aodorata* and is yellow or whitish in colour
- **White Dammar** is obtained from *Vateria indica*
- **Green Dammar** is obtained from *Shoreatum buggaia*and is a dark coloured resin
- **Pwenyet Dammar** is the resin collected by certain bee species of genus *Melipona* (Trigona) and converted into a mass usually in the hollow of trees.

'Copals' comprise a large group of hard resins characterized by their hardness and relatively high melting point. They are found in many tropical and subtropical countries. The word 'copal' is of Mexican origin. The copals contain almost no oil, and yield a hard elastic varnish, which is much used for outdoor work. They are soluble in alcohol.

Historically, the copals have been classified according to their geographical origin:

- Congo copal
- West African copal
- East African copal
- South American copal
- East Indian and Manila copal

Whereas based on originating plants species following types of copals have been recognized:

- Zanzibar **copal**
- **Inhambane copal**
- Angola copals
- **Sierra Leone copal**
- **Kauri Copal or kauri gum**

Zanzibar **copal** is the hardest of all resins and most valuable copals. It is derived from are derived from *Trachylobium verrucosum*.

Inhambane copal is obtained from *Copaifera gorskianay*.

Congo copal **derived from *Copaifera demeusii***

Angola copals **derived from *Copaifera mopane***

Sierra Leone copal is a light-yellow, hard and brittle resin. It is obtained from *Copaifera **g**uibortiana* and *C. Sa**li**kounda*.

Kauri Copal or kauri gum is one of the most valuable of the hard resins. It is obtained from the kauri pine (*Agathis australis*.

Manila Copal has its name Manila from where first of its shipments was made, although now a day's most of the product is shipped from the Dutch East Indies. The source of all the East Indian, Philippine, and Malayan copals is *Agathisalba*.

Pontianak copal from Borneo is the hardest variety and is especially popular in the United States.

South American Copals is obtained from the South American locust (*Hymenaea courbaril*) a tall tree of Brazil and other parts of tropical America. It is the softest of all copals, and consequently the least valuable.

7.4.2. Oleoresins

0leoresins, as the name implies, are resins which contain a percentage natural essential oils, consequently they are more or less liquid in form. They have a distinct aroma or flavor. These essential oils are volatile odoriferous oils, generally liquids but sometimes solids, which are found, secreted in the intercellular spaces, where they combine with resin formations to produce the exudation products known as oleo-resins. Among the oleo-resins are included the turpentine, the balsams and elemis. Different oleo-resins are mentioned below:

(a) Turpentine: Turpentine is oleo-resins obtained almost exclusively from coniferous trees. For commercial purposes crude turpentine is obtained by tapping the trees. On distillation turpentine yield the essential oil or spirits of turpentine and rosin. The turpentine industry is one of the major industries based on forest products in India. Turpentine and rosin are produced in many European countries and in the United States, Indo-China etc[5].

(b) Balsams: Balsams are oleo-resins that contain benzoic or cinnamic acid and so are highly aromatic. The name is usually applied to same substances like Canada balsam which is true turpentine. True balsam contains much less oil than the turpentine. They yield essential oils on distillation. Balsam of Peru is obtained from *Myroxylon pereirae,* a tree of Central America. It is used in perfumes as a fixative for heavier odours. It is also used in medicine. There are several other oleo-resins which do not belong to either the turpentine or balsams. Among these may be **Copaiba** and **elemi**.

(c) Gurjun oil: The most important oleo-resins are obtained from certain species of *Diptero carpus* i.e, of which *Dipterocarpus turbinatus*. The best known *Gurjun* trees are from Burma and the Andaman's. Gurjun oil is used in the manufacture of varnishes and as an ingredient in lithographic ink.

(d) ***In oil:*** Another species of *Depterocarpus tuberculatus* yields oleo-resin which produces in oil.

(e) Thitsi oil: An oleo-resin of great interest and extreme value is that produced by *Melanorrhoe ausitata*. Tthitsi is name for Burmese varnish tree. The tree is peculiar to Burma and Siam, and the oleo-resin it yields is a natural varnish and one which may be characterized as having originated several distinct art industries peculiar to Burma.

(f) *Hardwickia pinnata* oil: It is fairly common in Mysore, Travancore and parts of Madras, yields an oleo-resin which is popular for the preservation of woodwork, especially in Kanara and Mangalore Divisions. The oils are used for painting on doors, windows, rafters, pillars, and ceiling planks etc.

7.4.3 Gum resins

Gum- resins, are mixture of both gums and resins and combine the characteristics of both groups. They also contain small amount of essential oils. They are usually produced by plants of dry arid regions, especially species of Umbelliferae and Burseraceae. These plants are abundant in Iran and Afganistan. Important gum-resins include gambage, asafoetida, galbanum, myrrh and frankincense and detailed as follows:

(a) Gambage: This is a hard, brittle, yellow gum-resin produced by several species of *Garcinia,* especially *G. hanburyi* of Siam and Indo-China and *G. morella* of India. It is used to colour golden lacquers, as a water colour pigments, and in medicine [5].

(b) Asafoetida: The sources of asafetida are *Ferula asafoetida* and allied species found in Iran and Afganistan. The gum-resin exudes from the roots when the stem is cut off. It has a powerful odour and a bitter acrid taste due to sulphur compounds present in the essential oil. It is used throughout the East for flavoring curries, sauces and other food products and as a drug [5].

(c) Galbanum: A gum- resin excreted from the lower part of stems of *Ferula galbaniflua.* It has a tenacious and powerful aromatic odour. It is used in medicine.

(d) Myrrh: One of the oldest and most valuable of the gum-resins derived from *Commiphora myrrh,* a large shrub or small tree of Ethiopia, Somaliland and Arabia [5].

(e) Frankincense: A fragrant gum-resin obtained from the stems of species of *Boswellia,* especially *B. carterii,* native to north-eastern Africa and Southern coast of Arabia. Its principal use is as incense in Roman Catholic and Greek churches.

One more category, which constitutes 75% of resins used, is unsaturated polyester resin. Ion exchange resin is another important class with application in water purification and catalysis of organic reactions.

Synthetic resins are materials with similar properties to natural resins—viscous liquids capable of hardening. They are typically manufactured by esterification or soaping of organic compounds. The classic variety is epoxy resin, manufactured through polymerization-polyaddition or polycondensation reactions, used as a thermo set polymer for adhesives and composites. Epoxy resin is two times stronger than concrete, seamless and waterproof. Accordingly, it has been mainly in use for industrial flooring purposes since the 1960s. Since 2000, however, epoxy and polyurethane resins are used in interiors as well, mainly in Western Europe. Use of natural resins in paints, varnishes and lacquers, in particular, has suffered as cheaper, synthetic chemicals have become available. Others, especially the soft resins and balsams, are used as sources of fragrances and pharmaceuticals, usually after preparation of a suitable solvent extract or distillation of a volatile oil.

The hard transparent resins, such as the copals, dammars, mastic and sandarac, are principally used for varnishes and cement, while the softer odoriferous oleo-resins (frankincense, elemi, turpentine, copaiba) and gum resins containing essential oils (ammoniacum, asafoetida, gamboge, myrrh, and scammony) are more largely used for therapeutic purposes and incense. Resin in the form of rosin is applied to the bows of stringed instruments (e.g. violin, rebec, erhu, sarangi, etc), because of its quality for adding friction to the hair. Ballet dancers may apply crushed rosin to their shoes to increase grip on a slippery floor.

Resin has also been used as a medium for sculpture by artists such as Eva Hesse, and in other types of art work. In the early 1990s, most bowling ball manufacturers started adding resin particles to the covers of bowling balls. Resin makes a bowling ball tackier than it would otherwise be, increasing its ability to hook into the pins at an angle and (with correct technique) making strikes easier to achieve. Resins used to be much more commonly utilized in industry, e.g. in the production of oil paints and

varnishes or to waterproof ships. These days their industrial uses have largely been diminished in favour of synthetic substitutes. Some resins have powerful medicinal properties that have long been utilized in herbal medicine, but others can be toxic. For example resins derived from certain plants of the *Artemisia* family or from the *Cypress* contain thujone, which is a known neurotoxin.

7.5 Spices

Spices and condiments are well known in our country and need no introduction since India is known the world over as "The Home of Spices". Spices constitute an important group of agricultural commodities which are virtually indispensable in the culinary art. The term Spice and Condiments applies to all those natural plant or parts or products which are used for imparting flavor, aroma, taste and piquancy to the food items.

Usually all aromatic vegetable products that are used for flavoring foods and drinks are included under spices. However, the term 'spice' is sometimes restricted to hard or hardened parts of plants, which are usually used in a pulverized state. An another word is 'Condiments' which includes those spices or other flavoring agents which have sharp taste and are usually added to food after it has been cooked. However, it is difficult to draw a clear-cut demarcating line among spices, condiments and other flavoring agents. Therefore, spices and condiments are categorized based on the part of plant yielding them. Accordingly, it is better to describe them as spices from roots/ barks/ buds/ flowers/ fruits/ seeds/ leaves and stems.

Although many of such plants are being cultivated by humans yet many plants still grow in wild conditions as their climatic conditions and requirements do not match with that under cultivation. A detailed list of spices and condiments is given in table*, however, only those species are described here which mostly come from natural conditions or forests. Some of the species yielding spices and condiments are described below:

Cardamoms (*Elettaria cardamomum*)**:** There are mainly two species yielding cardamoms. Small or true cardamom *(Elettaria cardamomum)* and another is big cardamom (*Amomum subulatum*). The true cardamom is a perennial herb, indigenous in South and West India, and Burma. It is found growing in wild condition in many areas of south India particularly Malabar and Madras. On account of its wide

acceptance and use in Indian kitchen, it is now extensively cultivated in gardens and orchards. In forests where the plant is plentiful, the other species and brushes growing nearby are cut down for ensuring the better growth of desired cardamom species.

The ripe fruits are collected in October and November, and are sun dried for 3 or 4 days. Sun dried cardamoms (known as green cardamoms) are considered the best although machine drying is also being practiced now.

Pepper (*Piper longum*)**:** Various species of pepper plants are found in the forests of India, the commonest being *Piper longum*, found in the damp evergreen forests of Bengal, Assam, and the West Coast. The fruits are gathered in January before they are ripe and are sun dried. The common kali mirch or golmirch is the fruit of *Piper nigrum* found in the forests on the west coast of Madras, and large quantities are used in India and also exported to foreign countries. It is also cultivated in Malabar.

Wild turmeric (*Curcuma aromatica*): It is a common forest species of South India and Bengal. The roots of the plant are used extensively throughout India as a substitute for true turmeric (*Curcuma longa*).

Curcuma angustifolia roots are known commercially as East Indian arrowroot, and are used all over India as a substitute for true arrowroot (*Maranta arundinacea*) for medicinal purposes and also as a food. It is a native of the central tracts of India from Bengal to Bombay and Madras and there is considerable trade in it in the Central Provinces and in Malabar.

7.6 Tannins and Dyes

Tannins are organic compounds, chiefly glucosidal in nature, which have an acid reaction and are very astringent. Their biological function is problematical. They may be concerned with the formation of cork or pigments, or with the protection of the plant. Tannins are of interest economically because of their ability to unite with certain types of proteins, such as those in animal skins, to form a strong, flexible, resistant, insoluble substance known as leather. Because of this property of 'Tanning' hides, tannin-containing materials are in great demand. Tannins also react with salts of iron to form dark blue or greenish-black compounds, the basis of our common inks. Because of their astringent nature they are useful in medicine. Although nearly all plants contain some tannin, only a few species have a sufficient amount to be of commercial

importance. Tannins arc found in the cell sap or in other definite areas in bark, wood, leaves, roots, fruits, and galls.

Tanning is a very old industry. The Chinese tanned leather over 3000 years ago. The Romans used oak bark for tanning skins. Tannin and dyes are secretion products found almost universally in plant tissues in small or large amounts. Tannins and dyes are comparatively simple chemical compounds of carbon, hydrogen and oxygen along with some nitrogen in case of dyes. However, economically important and commercially exploited plants are those that yield these natural products in large quantities.

The invention of indigo, the most important natural dye, is as old as textile making itself. History reveals that Chinese have recorded the use of dyestuff even before 2600BC. Herbal dyes were used to colour clothing or other textiles by bymid-1800, chemists began producing synthetic substitutes for them, by early 20th century only a small percentage of textile dyes were extracted from plants. Lately there has been increasing interest in herbal dyes, as consumers have become aware of ecological and environmental problems related to the use of synthetic dyes. The most important parts used in herbal dyes are seed, flowers, leaves, berries, stems, barks and roots.

In 1856 a British Chemist named William Henry Perkin, produced a brilliant mauve dyestuff from coal tar which was the **first synthetic dyestuff**. This led to an understanding of the chemistry of dyes and a number of synthetic dyes were developed with the result that by the end of the nineteenth century, the natural dyes were almost completely replaced by synthetic dyes. Interestingly there has been a flow of activity in the recent past relating to the use of natural dyes for colouring textiles as chemical dyes are involved with various environmental hazards associated with it in its manufacture and also in use.

7.6.1 Tannins: Definition and sources

The name tannin is given to all those organic substances which have the property of combining with albumen and gelatin to form an insoluble compound which will resist decay. Raw animal hides treated with tannin are converted into the decay-resisting material known as leather. The name tannin, or tannic acid, is given to a class of organic substances which have the property of combining with albumen and gelatin to

form an insoluble compound which will resist decay. This property of tannins is used in treating raw hides to form leather. Another property of tannic acid is to turn iron salts black. This property is made use of in the manufacture of ink. Tannin is found chiefly in parenchymatous tissue, such as bark and young wood, certain fruits and leaves and also in the galls formed on leaves and stems by insects: tannin also occurs in the extracts obtained from the wood of certain trees, the most important of which is *Acacia catechu* which produces the extract known as cutch.

7.6.2 Sources of Tannins

Nearly all the sources of tannin occur in the wild state, very few being cultivated. Tanning materials are obtained from different parts of the plant. On the basis of their presence in different plant parts, they are classified into the following four groups:

- Wood tans
- Bark tans
- Fruit tans
- Leaf tans

7.6.2.1 Wood tans

Those tree species which yield tannins from their wood are termed as **wood tans**. The species yielding wood tans are as follows:

i) *Quebracho colorado* (Quebracho)

ii) *Castanea dentata*(Chestnut)

iii) *Acacia catechu* (Khair)

Quebracho colorado used to be among the most important wood tans yielding species widely distributed in South America. The word “Quebracho” means “ax breaker as the wood is one of the hardest known woods having specific gravity of 1.30 to 1 40. Its heart wood contains 20-27 per cent tannin and is extracted with water by making small wooden chips. Our country imports a lot of quantity of the tannin from South America. Quebracho is used for all kinds of leather, either alone or in combination.

Castanea dentata (Chestnut) is another tree wood of which is a source of tannin used for tanning of all kinds of heavy leather. The tannin is extracted at high temperatures from chips of wood. The resulting solution is cleared, filtered, and evaporated. The

concentrate so resulted contains tannin up to 30 to 40 per cent. In Europe, the wood of another species *Castanea saliva* is utilized.

Acacia catechu (Khair) is used for obtaining "cutch" from its wood and is used for tanning purposes. The species has its distribution in Andhra Pradesh, Bihar, Gujarat, Madhya Pradesh, Jammu and Kashmir, Maharashtra, Punjab, Rajasthan, Uttar Pradesh and Uttarakhand. The tree grows in khair-sissoo forests, southern thorn forests and very dry teak forests. Cutch is used as blend along with wattle and is used for producing heavy leather. It is also used for dyeing leather.

7.6.2.2 Bark tans

Barks of several tree species yield tannins. Mangrooves are considered to be most important trees yielding bark tans. The important species of mangroves yielding bark tans are as follows:

- *Rhizophora mangle* (Red mangroove)
- *Rhizophora mucronata* (Asiatic mangroove)
- *Ceriopsrox burghiana* (Goran)
- *Ceriops candolleana*(Tangar, Palun, Parun))

Apart from mangroves, other species yielding bark tans are *Acacia mearnsii, Acacia nilotica*, *Acacia arabica*, *Acacia suma, Anogeissus pendula, Bauhinia purpurea, Bauhinia vareigata ,Buchanania latifolia, Cassia auriculata, Cassia fistula*, *Castanopsis spp*., *Emblic aooficinalis, Lagerstroemia parviflora*, *Quercusincana, Rhuscotinus, Rhusmysorensis, Shorearobusta, Tamarixaphylla, Terminalia alata, Terminalia tomentosa, Eugenia jambolana, Brideliaretusa, Terminalia arjuna*, *Tsuga canndensis, Zizyphus jujube, Zizyphus xylopyra*

Galls are found in many species of trees and shrubs, and are used for tannins. Some of the galls bearing species are *Tamarix spp.*, *Pistacia integerrima, Acacia leucophloea, Terminalia chebula. Terminalia tomentosa and Pongamia glabra.*

Bark contains most tannin in its inner living tissues, hence bark intended for extracting tannins should be taken from fairly young stems which have not yet reached the stage of producing hard outer bark. The vigorous stems contain more tannin in their bark

than stems of poor growth. Coppice shoots are considered most appropriate for the purpose.

In order to extract the tannin from bark, the bark is chipped off from the stem by debarking axes or debarking spade when the tree is harvested for timber or firewood. Only *Cassia auriculata*, which is a small shrub, is harvested solely for the production of bark. Trees with faster rate of growth contain more bark-tans than slow growing trees. Generally, the beginning of the growing season (mostly spring through summer) is considered to be the most optimum period for harvesting bark for collecting tans, as tannin content is the highest during this period. The bark is collected, dried, stored and marketed. Some important plants those yield bark tans are mentioned below:

***Acacia mearansii* (Wattle, mimosa, black wattle):** The species is a native of South Australia and has been planted successfully in India. It is cultivated in many parts of the country particularly Tamil Nadu, Nagaland, Kerala, hilly region in Jammu and Kashmir and Meghalaya, for its bark.. The bark yields an excellent quality of tannin. It is astringent, catechol type of tannin. The tannin obtained from this tree has important characteristic properties such as

- It increase the shelf life of liquor i.e., the liquor does not loose its stability.
- It penetrates into the dried hide of animals easily and rapidly. The leather produced with the liquid plant extract when exposed to light, becomes reddish in colour.
- The leather obtained by the tanning extract is firm and possesses an average degree of tanning, which can be further improved by retreating after acidifying the liquor.
- It is used in blends. It is also used in plywood industries in adhesive formulations.

***Cassia auriculata* (Avaram):**The species grows wild in the Deccan plateau and South India. It thrives best on dry stony hills and black soils. It also occurs in Andhra Pradesh, Maharashtra, Karnataka and Rajasthan. The bark contains 23% tannin. Avaram tannin obtained from the bark is regarded as one of the best known tanning material in India. It penetrates the hide very quickly and produces lightly tanned, pale coloured leather with good strength. It was used in the production of famous East Indian leather.

***Tsuaga Canadensis* (Hemlok):** Hemlok was one of the important source of tannins in America. Its continuous indiscriminate utilization of the tree has resulted into decrease in the population. It contains 8 to 14 per cent tannin and is suitable for sheepskins and other heavy leathers either alone or in combination with oak. Extracts are now available with a tannin content as high as 28 to 30 per cent.

***Acacia nilotica* (Babul):** Babul is a common species of northern and southern tropical thorn forests and southern tropical dry mixed deciduous forests. It is a native of India and widely occurs all over the country. It is found in almost all states of the country. Both bark and fruits of babul are used to extract tannin. It gives a dark coloured, firm and durable leather. The tannin content is comparatively higher in older tress than younger trees. The tannin content in the bark of branches is about 7-12 percent only. The deep colour and high non-tannin content are the two main drawbacks of this tree bark tan. It is considered to be good for heavy leather. The bark is largely consumed by tanneries in Kanpur.

***Cassia fistula* (Amaltash):** Amaltash is a widely distributed species found throughout the tropical India. It is found scattered in the tropical moist and dry deciduous forests and occasionally in the sal forests of the country. Tannin obtained from its bark is at least 12 per cent. It is commonly used by the tanners in southern part of Tamil Nadu. It produces smooth grained and pale leather. Instead of the bole bark, the twig branches are used for improved leather colour. It is used in the tannage of kips and light weight hides. Bark is sometimes used as a substitute for avaram bark in blends. It cannot be used alone. Tannin obtained however, possesses low penetrating power.

***Ceriopsrox burghiana* (Goran Mangroove):** It is evergreen mangrove tree, found in the coastal forests predominantly in Sunderbans (West Bengal), Tamil Nadu, Gujarat, Maharashtra, Andaman and Nicobar islands. The species produces valuable tannin material from its bark as well as leaves. The tannin content in the bark and leaves are 20-37 percent and 9-15 per cent, respectively. The tannin imparts red colour to leather. It is usually blended with myrobalans and Babul bark to get improved colour and shine. It can also be improved by decolorizing and bleaching. It is mostly used for manufacturing heavy leathers. The important characteristic of the mangrove liquor is its stability and low loss of tannin on standing, however, the tannin has low penetration power.

Ceriopstagal and *Rhizophora mucronata* are also mangrove trees similar to *C. roxburghiana,* which are used for tanning purposes.

***Terminalia arjuna* (Arjun):** It is a common tree of India and widely occurs in Madhya Pradesh, Maharashtra, Orissa, Uttar Pradesh, Bihar, Andhra Pradesh and Tamil Nadu. The tree grows in waterlogged areas. Tannin content in dry bark of the main stem is about 20-24 per cent while that in the lower branches is 18 percent. Tannin of this bark is widely used in large tanneries. It produces upper leather and very good quality sole leather. The bark of the tree is generally cut repeatedly to get fresh crop of bark. Tannin has also uses in medicines.

***Emblica officinalis* (Aonla):** It is a popular forest fruit tree distributed all over India in dry and moist deciduous forests. The twig bark is richer in tannin content and contains about 20 percent tannin whereas the stem bark yields 8-9 percent tannin. The tannin extracted from the bark of this tree is used locally.

***Terminalia alata* (Laurel):** The tree is a common associate of sal and teak trees in tropical semi-evergreen and moist and dry deciduous forests in Uttar Pradesh, Madhya Pradesh, Orissa, Maharashtra, Gujarat, Bihar and other parts of country. The tannin content in the bark is about 18.7 per cent. It produces red leather which is somewhat similar in appearance to mangrove tanned leather.

***Shorea robusta* (Sal):** It is a large evergreen tree. The species occurs in the northern and the central region of India. It ascends to 1000m elevation in the hills and found in the forests of Uttar Pradesh, Uttarakhand, Madhya Pradesh, Bihar, Orissa, West Bengal and Assam. Bark is widely used in local tanneries. It furnishes very tough leather with reddish tinge. The tannin is of condensed (catechol) type.

7.6.2.3 Fruit tans

There are many wild species which produce the fruits having high content of tannins of different kinds. These fruit tans are also equally important. Among the important fruit tans yielding plants are *Terminalia chebula*, *Terminalia bellerica* and *Emblica officinalis.* They are commonly known as myrabolams. Among these *Terminalia chebula* is very important and mainly utilized for its high tannin content. This tree occurs throughout the greater parts of India and found in Madhya Pradesh, Orissa, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, Himanchal Pradesh and Bihar

and warm valleys of Uttarakhand. Myrabolams are one of the most important tannin materials of the pyrogallol class, a class of tans which produce a brownish-coloured deposit on leather called bloom, as opposed to the other class of tans, the catechol class, which do not produce this bloom. Myrabolam tannin is not very astringent and penetrates the hide slowly. When used alone it produces a soft, mellow, and rather spongy leather which does not possess good wearing properties. It is, therefore, usually blended with other astringent and quickly penetrating tannins such as quebracho, wattle and mangrove, the red colour of which is thereby neutralized, and a brighter and more satisfactory colour is imparted to the leather.

The other species yielding fruit tans are as follows *Acacia arabica, Acacia nilotica ,Caesalpinia coriaria, Zizyphus xylopyrus, Emblica officinalis, Shorea robusta,Tamirandus indica,*

The pods of ***Acacia nilotica*** produce tannin of good quality. The tannin content is about 18-27 percent in the pods. Large quantities of pods of babul are used locally for tanning purposes in Maharashtra, Madhya Pradesh and Uttar Pradesh. In tanning industries, pods are used not only for tanning but also to soften and impart a good colour to the leather.

Caesalpinia coriaria (Divi-divi) is a small tree, native of South America and has been successfully cultivated in India. The parts of this tree yield divi-divi of commerce. Central and South American countries export a large quantity of this tanning material to different countries. The important feature of this species is that pods are rich tannin content and can be extracted easily. The leather usually becomes soft - spongy in moist conditions whereas but when applied with tans of this kind blended with other tans, the drawback can be overcome.

Zizyphus xylopyrus **(Kath bor) is** a common shrub species found generally in scrub forests. It is found in the sub- Himalaya tract, north-western India, Uttar Pradesh, Bihar, Rajasthan, central and southern parts of India. It has 9.3 per cent tannin in the nuts. The tan imparts black colour to the leather and is mostly used for tanning bags and purses, however, its penetration in animal hides is slow.

Emblica officinalis **(Aonla)** occurs in extensively in subtropical forest and tropical dry deciduous forests generally, mixed with teak and sal forests. The fruits of this species

are used for tanning along with other tan stuffs. The fruits contain 28 per cent tannin content.

Shorea robusta (Sal) seeds also contain tannins apart from its bark. The tannin obtained from the fruits of sal tree are hydrolysable type and belong the ellagi tannin class. The tannin content in the original and the de-oiled seeds is 7.2 and 9.6 percent, respectively. The phenolic constituents present in the seeds are corilagin, chebulinic acid, gallic acid and ellagic acid. The seeds can be used as blend with Babul, however, cannot be used as a self- tanning material.

***Tamirandus indica* (Tamarind)** is a large tree and occurs in moist deciduous and tropical dry evergreen forests. It is commonly found throughout the warmer parts of India. It is extensively planted in Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. The seed testa yields dark colour tannin used for tanning of leather. It is used with myrobalans and other hydrolysable tannins in the processing of heavy leather.

7.6.2.4 Leaf tans

Some of the plants also have tannin contents in their leaves but leaves are only used locally not commercially by large tanneries. Generally, village artisans and shoe makers use leaves for tanning leather on a small scale. Important leaf tanning material is obtained from leaves of *Anogeissus latifolia, Carissa spinarum, Emblica officinalis, Lawsonia inermis* and *Rhuscotinus*. Leaf galls found on several trees such as *Tamarix* spp., *Garuga pinnata*, *Prosopis cineraria, Terminalia* spp. etc. are also used locally for tanning purposes.

Anogeissus latifolia (Axle wood; Dhawa) is large deciduous tree occurs almost throughout the sub-Himalayan tract, Bihar, Chhota Nagpur, Central and southern parts of India upto 1000 m altitude. The tannin content in the dry mature leaves is about 32.5 per cent. Maximum tannin content up to 55 percent is found in young leaves. The tannin is hydrolysable type and finds limited and local use for tanning purposes. It produces pale coloured leather. The leather prepared is highly sensitive to light. The tannin is also used as mordant.

***Carissa spinarum* (Karunda):** The species is extremely common and gregarious in scrub forest along the foot hills of the Siwaliks (the outermost hilly tract of Himalaya). This thorny shrub is also found in the warm and dry valleys of Uttarakhand. Fruits are

also eaten raw and used for making pickle. It is also common in Central India. The tannin content in the leaves is about 9-15 percent however, tanning is slow and causes swelling in the hide.

7.6.3 Dyes

Nature expresses itself in a wide spectrum of colour all around us. Dyes are the name given to substances which are used for imparting colour. They are organic compounds having natural or artificial origin and are widely used for imparting colour to fabrics in textile industries. The earliest record of the use of natural dyes is from China, way back in 2600 B.C. Indians have been forerunners in the art of natural dying. However, the advent of synthetic dyes caused rapid decline in the use of natural dyes.

An interesting point about them is that unlike paint, they do not build up on the surface of the fiber but are absorbed into the pores of the material. This becomes possible because of two reasons. First, the size of the dye molecules is smaller than the size of the pores in the fibre. The dye molecules have a shape like narrow strips of paper, that is having length and breadth but relatively little thickness. This planar shape assists them to slip into the polymer system when the fiber, yarn or fabric is introduced into the dye bath. The second reason is the affinity of the dye to the fiber due to forces of attraction. The dye which has diffused or penetrated into the fiber is held there by the forces of attraction between the dye and the fiber.

Various parts of plants like roots, stems, bark, leaves, fruits and seed may contain colouring material which can be exploited commercially. Some plants have more than one colour depending upon which parts of the plants are used. Dyes are substances that impart colour to a material and are generally soluble in water.

7.6.3.1 Classification of Dyes

One can get coloring matter from almost all vegetable matter. However, only a few of these sources yield colorants which can be extracted and work out to be commercially viable. Similar is the case of colorants obtained from animal origin. The classification of natural dyes is based on the origin or source from which they are derived. Accordingly they are classified as follows;

- Natural dyes of vegetable origin
- Natural dyes of animal origin

- Natural dyes of mineral origin

Majority of the natural dyes have their origin from various plant species. In plant species, they are categorized based on which of the plant parts yield them. Accordingly dyes of natural origin are classified as follows:

- Wood dyes
- Bark dyes
- Flower dyes
- Fruit dyes
- Root dyes
- Leaf dyes
- Animal dyes

7.6.3.2 Wood dyes

Cutch dye: Cutch dye is obtained from the wood of *Acacia catechu* (Khair). The tree is widely distributed in India. It is characteristic species of Khair- sissoo forests, southern thorn forests, ravine thorn forests and very dry teak forests. It is used for dyeing fishing nets, sail cloth, mail bags, leather, canvas, etc. the cutch extract is considered as the most valuable dye among all the wood dyes. It is used as tan and also commonly as dyeing agent for silk and woolen fabrics.

Artocarpus dye: *Artocarpus dye* is obtained from the wood of *Artocarpus heterophyllus* and of *A. lakoocha*. The mixture of the wood gives a bright yellow dye. For obtaining the dye, the wood is cut into small pieces or chipped and boiled in water. The dye obtained from these species is used in dying industries for dyeing robes of monks and saints. It gives fast colour on silk cloth.

Brazilian dye: It is the trade name given to the dye obtained from the wood of *Caesalpinia sappan* commonly called as sappan. It yields a valuable red dye commercially known as Brazilian. It is cultivated as a hedge plant in many parts of South India. The dye is used for dyeing silk, cotton and woolen fabrics. The dye is mostly used for producing red and pink colours in calico printing. When dissolved with indigo colour, it produces purple colour.

Santaline dye: It is obtained from the heart wood of *Pterocarpus santalinus.* The tree is commonly known as the Red Sanders. It occurs mostly in Andhra Pradesh. It is a tree of southern tropical dry deciduous forest type, constituting a sub-type of forest called the Red sanders forest. The dye obtained is known as bright red Santaline dye. It is extracted from the heart wood of the tree. The dye obtained is used for dyeing leather and staining wood. It is also used as a colouring agent in pharmacy. A cloth dyed in a solution containing santaline dye mixed with alcohol or ether results in a beautiful pink colour cloth. The dye is used for dyeing silk and cotton clothes, when mixed with the Brazilian dye. A variety of colours can be obtained on woolen, cotton and linen cloth by the use of different mordant.

7.6.3.3 Bark dyes

The dyeing property in bark is meager. The maximum number of barks contains the tanning material. The bark mostly yield brown and black coloured dye. The plant species used for dyeing purposes are:

Acacias: The bark of few of acacia tree species viz., *Acacia concinna, A. farnesiana* and *A. leucophloea* yield a black dye (Mehta, 1981; Forest Utilization vol II).

Alnus species: The bark of *Alnus nepalensis* and *Alnus nitida* trees are used in dyeing to fasten the colour of the fabric previously dyed with brown dye of Himalayan madder (*Rubia cordifolia*). The tree is found in isolated patches along the cool and moist streams in Uttarakhand and other localities of Himalayan region.

Casuarina equisetifolia: The bark of this tree is used in dyeing and gives a light reddish colour. It is also used for toughening fisher men's net.

***Manilkara littoralis*:** The bark of this species yields a red colour dye.

***Myrica esculenta*:** The bark of this tree is rich in tannin content and it yields a yellow colour dye. This is an important tree that also yields delicious edible fruits and found in the temperate forests of Uttarakhand.

***Terminalia alata*:** It is used as a tanning as well as dyeing material. The bark of this tree gives black colour dye. Bark of the root of *Ventilago patina* is considered to be a valuable dye in the Decan and the Carnatic region of the country.

7.6.3.4 Flower dyes

Butea monosperma (Dhak): It is considered as the most popular tree to yield flower dye. The flowers on drying, yield an unstable yellow colouring matter. The colour is made less fugitive and dark with the addition of alum, lime or/ and alkali. In past, the dye was extensively used for dyeing sarees and other cotton and silk clothes.

***Toona ciliata* (Toon):** The flowers of this tree yield a red colouring matter. These are considered as an important source of natural dye stuff. It easily gives light yellow colour to the cotton and woolen fabrics, when immersed in boiling extract of flowers. The colour can be fasten by using suitable mordents.

***Nyctanthes arbortristis* (Harsingar):** The tube of the flower of this plant is rich in colouring material. It gives a beautiful orange or golden yellow colour, which is fugitive and is commonly used as an auxiliary to other dyes. The dye is often used to colour liquors.

***Mammea longifolia*:** The flower in the bud stage of this plant is used for dyeing silk fabric.

Crocus sativus: The stigma and the style of lavender flowers are used for the preparation of dye extraction having a deep yellow coloured dye, saffron crocus. Soon after the opening, the flowers are clipped and allowed to dry naturally or artificially. The colouring material is easily soluble in water and is used for colouring food and medicines (Mehta, 1981).

7.6.3.5 Fruit dyes

Mallotus philippensis: Commercially known as Kamela dye, it is common fruit dye almost throughout India. It is regarded as one of the best known fruit dyes. The dye is obtained from the red glands on the surface of the capsule of the tree species. The fruits are collected in large cloth bags or sacks and are lightly beaten for obtaining the dye. The dye is generally used for dyeing silk. It gives a bright orange or flame colour. When mixed with other mordants, the colour can be changed from pale yellow to dark red. It is also used for colouring oils, soaps, ice creams and soft drinks. The moderate size tree also grows in the sal forests of Shivalik foothills of Uttarakhand (Mehta, 1981; Forest Utilization vol II).

Bixa Orellana: The seeds of *Bixa orellana* yield a well known dye, commercially known as Annatto. The tree is mostly cultivated in South India. The major colouring matter in the seeds is bixin. The arils around the seed are used for extraction of dye. A bright yellow coloured dye is obtained from the seeds. The dye is used for calico printing, woollen and silk fabrics (Mehta, 1981; Forest Utilization vol II)

7.6.3.6Root dye

***Berberis aristata*:** The species is reported to yield one of the best yellow dyes in the country. The dye is readily soluble in water and alcohol. The colour changes from yellow to brown on addition of alkali. The dye is used for the manufacture of Morocco leather (Mehta, 1981) . The shrub grows extensively in Uttarakhand and has been exploited recklessly for the medicinal properties of its roots.

***Datisca cannabina*:** The root of the plant is commercially known as alkabir and yields a yellow dye. It is used for dyeing silk, wool and cotton. It is commonly used in Kashmir and throughout the Himalayas.

***Morinda coreia*:** The root bark yields a red colouring dye. The dye obtained from the root of the species is generally used for dyeing handkerchiefs, turbans etc.

Punic agranatum: The root of the species yield dyes of yellow and red shades.

Rubia cordifolia: The roots and the stem of the plant yield a red dye. The plant is common in the Himalaya.

7.6.3.7 Leaf dyes

***Indigo feratinctoria*:** Earlier, the shrub was extensively cultivated for the remarkable dye extracted from the leaves of the species. It was known as the king of dye stuff. The dye gives deep blue colour. It is widely used for its stability and strength of the colour (Mehta, 1981; Forest Utilization vol II).

***Lawsonia inermis*:** Commonly called as henna herb, it yields an orange coloured dye called as the henna dye. It gives a fast dye and is used for fabrics and leather. It is also used for dyeing hairs, nails and eyebrows (Mehta, 1981; Forest Utilization vol II).

7.6.3.8 Animal dyes

Animal dye is obtained from the lac insect (*Lacciferlacca*). It produces crimson red coloured dye. It once enjoyed wide commercial importance.

7.6.4 Process of dying

The febric or yarn to be dyed is first washed well followed by heating in the extract at different temperatures normally for about 30-40 minutes. The dying process from natural dyes involes three steps:

i) Extraction of colouring matter from the plant part

ii) Mordanting or creation of bond between dye and fibre

iii) Actual dying

The extraction of colour is done usually by powdering the material then boiling it in water for 10-20 minutes. Mordanting involves creation of bond between the colouring matter and fiber that makes fiber receptive to fye. Mordant is a chemical that when cooked with fiber attaches itself to the fiber molecules. The mordated fibers are then exposed to dye in suitable vessels normally earthen or steel vessels. Herbal dyes need mordant which are metallic salt of aluminum, iron, chromium, copper etc. for fastness to sunlight or also to washing. The vessel its self-acts as mordant.

Herbal dyes are considered best for natural fibers such as cotton, linen, wool, silk, jute etc. Wool or silk take colouring matter quite easily in comparison to cotton which need a complex series of pre-treatments before it absorbs the dye. However, with indigo it bond naturally.

Unit 8: NWFPs- Fibers and flosses, and Other Uses

Unit Structure

8.0 Learning Objectives

After studying this unit, you would be able to explain:

- fibers and flosses
- The importance and uses of fiber and flosses
- Major plant species and the plant part yielding fibers

8.1 Introduction

Plants yielding fibers are undoubtedly has place next to edible plants on account of their usefulness to humans for variety of uses. In the primitive time also, the main necessities of humans were- food, shelter and clothing, accordingly in course of time, these all were derived from plants. Although primitive man had options of using animal products such as skins and hides as clothing but he intended to get some form of clothing that was lighter and cooler than these. For his traps, bow-strings, nets and other sort of products for the same purpose, he needed some sort of ropes or cordage that was easier to procure than animal products for similar purposes. Moreover, some other type of covering for his crude shelters was desirable and all these needs were

admirably met by the tough, flexible strands that occurred in the stems, leaves, and roots of many plants. Almost from the beginning, plant fibers were used extensively than wool, silk and other animal fibers. With the more advancement of human civilization, the requirements also increased to manifold. IN the course of time, he invented more and more plant species in the wild having potential of yielding fiber and flosses. More than thousands of species have so far been recognized worldwide which yield fibers. However, there are few species which yield fibers of commercial importance and greater number of species and native ones used locally by primitive people in different parts of the world.

It has been now established that many fiber plant species have long been cultivated by man since Stone Age. Ancient Egypt was famous for its fine linen and India for cotton. IN the ancient times, cotton used to be the national textile of India. Many of plant species have already brought into cultivation, however, many of them are still growing in wild conditions in forests.

In the previous unit, we discussed about NWFPs which have importance on account of their being edible and have potential as sources for vitamins, minerals, carbohydrates, proteins and other compounds which are important for life processes. Next to edible plants come plants which yield fibers and flosses for clothing of human being. These fibers are used for making a variety of products which are needed in our day today life. Although many of the fiber yielding plants have been domesticated and are under cultivation since long, yet there are many other species in the wild which have potential of meeting fiber demand in the market. Fibers of both vegetable and animal origin have been used long before the dawn of history as discussed earlier, for the spinning of the thread and cordage and weaving of coarse fabrics. In this unit, we will discuss the various types of fibers and flosses in detail.

8.2What are fibers and flosses?

Fibers are nothing but the long sclerenchyma cells that offer rigidity to various plant parts such as stem and leaves. Generally, fibers are long cells with thick walls and small cavities, and are usually having pointed ends. The walls often contain lignin as well as cellulose. Fibers may occur singly or in small groups, but they are more likely to

form sheets of tissue with the individual cells overlapping and interlocking. They may be found in any part of the plants such as stems, leaves, roots, fruits and even seeds. Whereas the flosses cotton like material produced over fruits of certain tree species.

Some important forest trees and plants which produce silky flosses in their fruits. Some of the important wild plants yielding flosses are *Ceibapentandra* (silk kapok), *Bombax ceiba* (Shemul yield in Indian kapok) and *Cochlospermum religiosum* (yellow silk cotton tree or buttercup tree). The flosses are mainly used for stuffing pillows, mattresses etc. [1]

Before proceeding further into more details of different kinds of fibers or the plants which yield them, it is important to understand the nature of fiber. As we all know by now that plants are composed of cells and tissues of various kinds. Among the plants particularly woody plants, the stem and leaf cells include xylem and phloem cell which conduct fluid and food material below to top and top downward, respectively. Apart from these actions, they are also engaged in providing support to plants so that it remains in erected position. This support is mainly provided by cells of special kind known as vessels, xylem and phloem fibers. The walls of these cells in young stage are soft and thin, but as they grow older, they get thickened on the sides due to deposition of solid material. The vessels, the specialized cells for conduction of fluids, are short cells with varying form or oblong, however, sometimes much elongated like in Cotton whereas in other, several cells are joined end to end and the intervening partitions get dissolved, thus, allowing smooth conduction of liquids. However, in course of time, their side walls become thickened and develop within them fibrous matter of different kinds. However, vessels of any kind are not suitable for cordage or for textile fabrics but can be used in pulp and paper industry for paper making.

In the xylem tissue, apart from vessels, are found fiber cells. The fiber cells together with some vascular bundles constitute what is collectively known as wood and gives support to the plant. These woody fibers consist of elongated cells or tubes with tapering ends, which overlap each other, and by their union longitudinally form the fibers which are extracted for economic purposes. These are found in the wood, in the inner bark and in the leaves of plants.

8.3 Classification of fibers

Based on the origin of fibers, they are classified into four major categories as follows:

- Bast fibers (those fibers which occur in the outer parts of a stem as cortical fibers, pericyclic fibers, or phloem fibers).
- Wood fibers (xylemfibers)
- Leaf fibers (Sclerenchyma cells associated leaf)
- surface fibers (Fibers associated with the seeds)

The other way of classifying fiber is based on their economic uses. Accordingly they are classified into following six categories:

- Textile Fibers
- Brush Fibers
- Plaiting and Rough Weaving Fibers
- Filling Fibers
- Natural Fabrics
- Paper-making Fibers

Textile fibers are the most important fibers having huge demand in the market particularly in textile industry on account of their use in the manufacture of fabrics, netting, and cordages. Fabrics include cloth for wearing apparels, domestic use etc. Netting fibers, which are used for lace, hammocks, and all forms of nets, include many of the commercial fabric fibers and a host of native fibers as well. For this purpose the individual fibers are twisted together rather than woven. Twine, binder twine, fish lines, rope, hawsers, and cables are among the many kinds of cordage.

Brush fibers are tough and stiff fibers or even twigs, which are utilized in the manufacture of brushes and brooms.

Plaits are flat, pliable, fibrous strands which are interlaced to make straw hats, sandals, baskets, chair seats, and the like.

Filling Fibers are the fibers are used for stuffing mattresses, cushions etc.

Natural Fabrics include tree basts which are extracted from the bark in layers or sheets and pounded into rough substitutes for cloth or lace.

Paper-making fibers include wood fibers, textile fibers utilized in either the raw or in manufacturing paper.

Classification of the fibres is done on the basis of their origin, texture, morphology and uses. On the basis of origin, fibres can be classified into: (i) fibres from roots, (ii) fibres from stems, and (iii) fibres from leaves. On the basis of texture, fibres can be classified into the following three types:

Soft fibers: Fibers obtained from the innermost bark of the stem are called soft fibers, e.g. jute, hemp, flax, etc.

Hard fibers: Fibers obtained from leaves of plants are hard fibers, e.g., Manila hemp, etc.

Surface fibers: Fiber obtained from the surface of plant parts (stem, leaf, seed etc.) are generally called surface fibers.

On the basis of morphology, fibers may be classified into the following categories:

(i) Hair borne on the seeds or the inner wall of the fruits: Among the commercially important fibers in this group are Cotton, Kapok and Akund floss.

(ii) Fibers occurring in the innermost tissue or bark of the stem: Some of the commercially most important fibers are found in this group such as flax, hemp and jute. These are generally known as bast fibers or soft fibers to distinguish them from the hard fibers obtained from the leaves of several species.

(iii) Fibers obtained from the leaves of the plant and which are a part of the fibers of vascular system of the leaves: The most important fibers of this group are cordage fibers, abaca or Manila hemp and Sisal.

(iv) Woody fibers: It consist of various elements which constitute the fiber from vascular tissues of wood. These are mainly used in paper making.

8.4 Preparation of fibers and cordages

The fibrous tissues in the plants are formed by joining of elongated cells end to end and the cells of the tissues remain surrounded by mucilaginous and other resinous secretions. Therefore, separation of this material is one of the important prerequisites for making of fiber and cordages. In order to separate these materials in between the fibers, they are first beaten and followed subsequently by washing, thus, separating the fibers from the rest of the matter. However, sometimes the raw fiber material is soaked in water for some days (maceration) allowing fermentation to take place. This results in degradation of much of the binding material and thus, loosening of fibers take place which at this stage can be separated easily by beating and washing. Fibers obtained this way remain in bundles of fibers not in the form of completely separated fiber. Sometimes some portion of stem as stripped also gets mingled up. Therefore, from this stage, the fibers are required to be pressed between rollers, or processes of combing (also called heckling) are carried out. This results into parallel division of fibers and also results into separation of impurities. The longest of these fibers have length of not more than three to four feet in length, which are at this stage not sufficient to be converted into ropes of any length, or for weaving into cloth. The ends of such fibers are joined together by some adhesives and threads of long length are obtained. Such fibers are long enough for weaving.

8.5Fiber Yielding species

8.5.1 Fibers from stems [2] [3]

Many woody species produce bast fibers from their woody elements in the stem. Many such species yield long and strong fibers suitable for being converted into ropes, whereas others yield silky fibers which are suitable for making of fabrics in textile industries. Extraction process of fibers vary considerably from species to species, however, the process of separation of the fibers from each other is known as '**retting**' and is the most important process which consists of placing the stems in water for some time in order to initiate fermentation or microbial action which results in conversion of insoluble gummy matter into soluble substances, thus, are removed by the water causing softening of the tissues. The fibers afterwards are beaten in order to

detach gummy material and cleaned. The process of retting is usually carried out either in pools or in running water, and the time required for retting varies with the age of the plants, the temperature of the water, and with other conditions, and may last from a few days to a month or more. However, care must be taken that over-retting is avoided as it weakens the fibers and spoils their luster whereas under-retting results in the gummy matter still retained in fibers and thereby, making the separation and proper cleaning of the fibers difficult. On the other hand, there are certain fibers which are used without any retting at all, just as they come off the tree, and there are others, for example those of *Calotropis gigantea*, which are rendered useless if immersed in water. The majority of plants yielding useful fibres belong to the families Sterculiaceae, Tiliaceae, Leguminosae, Asclepiadaceae, and Urticaceae. The various plant species whose stem yields fiber are as follows:

Sterculi avillosa, Helictere sisora, Grewia optiva. Grewia tiliaefolia, Grewia vestita, Grewia laevigata, Grewia oppositifolia, Corchorus capsularis, Corchorus olitorius, Linumus itatissimum, Hardwicki abinata, Bauhinia vahlli, Spatholobus roxburghii, Marsdenia tenacissima, Cannabis sativa, Calotropis gigantea, Calotropi sprocera, Marsdenia tenacissima, Ficus cunia, Ficus religiosa , Ficus bengalensis, Boehmeria nivea, Trema orientalis, Girardinia heterophylla (the Nilgiri nettle), Antiaris toxicaria, Broussonetia papyrifera (paper mulberry), Streblus asper, Careya arborea, Cordia myxa, Kydia calyclna,

Other species having localized utilization are *Thespesia populnea, Moringa pterygosperma, Albizzia odoratissima, Erythrin asuberosa, Lannea grandis, Cerbera odollam, Milius avelutina. Berrya ammonilla, and Urena spp.*

8.5.2 Fibers from leaves [2]

There are many species whose leaves yield fibers. These fibers are mainly utilized for ropes and chordages. Among the important wild species are *Musa textilis, Caryo taurens (Kitool), Musa textilllis (manila hemp), Musa sapientum (the common plantain), Musa paradisiaca (the red plantain), Pandanus spp mainly Pandanus odoratissimus (Screw pines), Agave angustifolia, Agave cantala, Agave lurida, Agave sisalana, Caryo taureiis, Pandanus spp.* etc.

8.5.3 Flosses from the fruit or seeds [2] [3]

There are several forest trees and plants in India which produce silky flosses in their fruits.These tree flosses are known commercially as tree cottons, silk cottons or kapoks. They are usually too short to be used for spinning or weaving, but are used extensively for stuffing purposes such as in life-belts, pillows, mattresses, and quilts. Among these species are *Eriodendron anfractuosum (True Kapok), Bombax malabaricum (Indian kapok), Cochlospermum gossypium, Calotropis gigantea. There are many other floss-producing plants of local importance only. Among these are Calotropis procera, Holarrhena antidysenterica, Wrightia tomentosa, Cryptolepis bttchanani, Salix daphnoides, Populus ciliata, and Beaumontia grandiflora.*

8.5.4 Fiber from grasses

These are a number of grasses which yield fibers. However, such fibers are too coarse to be utilized in textiles however, they have much uses in cordages and mattings. Among these grasses are *Ischaemum angustifolium syn. Pollinidium angustifolium (bhabar or baib grass), Saccharum munja (Munja), Saccharum spontaneum (Ekra grass), Vetiveria zizanioides (Khus-khus), Heteropogon contortus syn. Imperata arundinacea, Saccharum nareng, Erianthus ravennae, Typhae lephantin (Elephant grass), Gyperus tegetum (Korai), Phragmites spp. (the sur reed), Themeda gigantea syn. Anthisteria gigantea (ulla), Desmostachy scynosuroides, syn., Eragrostis cynosuroides (dab) etc.*

8.6 Description of important fiber yielding species

Although there are many wild species growing in the wild conditions which may be utilized for by virtue of their fiber value, yet some of them are utilized for their high fiber value. Accordingly, some of them are described as under:

1) ***Sterculia villosa*** (Elephant rope tree), **Family**: Tileaceae

- This species is common throughout India and Burma.
- It yields a coarse, strong, whitish-pink fiber which strips off the tree in long broad flakes which have a peculiar net-like appearance.

- The fiber is used extensively for making elephant harness and dragropes, for tying rafts and for making bags and ropes for all purposes throughout India. Rope made from this fibre is said to become stronger, but it seldom lasts more than 8 monthsif constantly exposed to moisture.
- Other species of the genus *Sterculia* yielding fiber are *S. urens, S. foetida* and *S. colorata* but the best of these is *Sterculiavillosa*.

2) ***Helictere sisora*** **(**Indian screw tree), **Family:**Tileaceae

- It is a common shrub found in the drier forests of our country.
- It yields a light brown or greyish, soft and silky fiber which is comparatively less coarse and less strong than that of fibers obtained from *Sterculia* sp. It is more or less similar to China jute, however, is considered inferior to Bengal jute although it is more durable and it lasts twice as long as jute.
- Separation of bast from stem takes longer time, therefore, soaking in water is done for a longer period
- It is mainly used for making sacks and bags and also for sewing up gunny bags and making of cattle harness.
- The sacks and bags made of this fiber are often good after 5 years' use, whereas a jute bag seldom lasts more than 2 years.

2) ***Grewia optiva*** **(**Bhimal) **Family:** Tileaceae

- It is distributed from the foothills in the Western and North Western Himalayas from Uttarakhand, Himachal and Jammu and Kashmir to Nepal up to a height of 2000 m.
- It is a tree having solitary yellow flowers. The fruits are fleshy drupe with two to four lobed, olive green when immature and black when ripe. The fruits are edible.
- Almost all species of genus Grewia yield coarse strong yellow-brown fibers from its bark.
- Fibers are used locally for rope-making and domestic purposes. Traditionally the fibers are extracted by retting of branches which takes comparatively

longer time from 30-45 days to complete natural retting by microbial degradation.

- The other species of this genus are *G. tiliaefolia, G. vestita, G. laevigata, G. oppositifolia*.

3) ***Corchorus*** **sp.** (White Jute), **Family:**Tileaceae

Local Name: (*C. capsularis*, *C. olitorius*)

- These are cultivated species which yield the well-known jute of commerce. The species are annual and cultivated extensively in Assam, Bengal, Bihar and Orissa.
- There are two main species *Corchorus capsularis* and *Corchorus olitorius.* Although these are cultivated species and rarely found in growing in wild, but a learner must have knowhow of these plants.
- Commercial Jute is a true bast fiber consisting of fibro-vascular bundles.
- It is the cheapest and most easily manufactured of among all fibers and cheapest gunny bags are manufactured from it.

4) ***Linumu sitatissimum*** (The flax plant), **Family: Linaceae**

- This plant is also in cultivation extensively in Europe and India. In India, it is mainly cultivated for its oil that is known as Linseed oil. Climatic conditions of our country does not favour production of quality fiber from fabrics although it forms an excellent material for pulp and paper industry.
- It yields valuable fiber known as linen.

5) ***Hardwickia binata*** **Roxb.** (Anjan), **Family:** Leguminosae

- Anjanis a common tree species found in South India (Madras), West (Bombay), and the Central Provinces in deciduous forests. This tree yields extremely hard, heavy and durable timber which is commonly known as "Anjan".
- It is an endemic to India.

- The bark of stem and branches especially from the young shoots yield fiber which is of red-brown colour with high strength.
- The fiber is mainly used for cordage and rope-making. Such ropes are used in wells and other agricultural purposes.

6) ***Bauhinia vahlli*** Wight &Arn. (Malu), **Family:** Leguminosae

- Malu is a climbing shrub and found growing in the subtropical and temperate forests in Uttarakhand hills. It can reach to the tops of the trees by means of tendrils usually upto 9- 30 metres**.**
- It is harvested from the wild as a local source of food, medicines, fibre and tannins and other materials.
- It yields a quality fiber from its inner bark which is generally used in the preparation of very strong ropes. In order to extract the fiber, the outer bark of the harvested vine is first stripped off and discarded; the rest of the portion is soaked in water and twisted while it is still wet. Then the bark is boiled and beaten with mallets, which renders it soft and pliable for being made into ropes and string.
- The fiber is used for matting and basket making.
- The leaves are utilized for thatching, making umbrellas, plates, cups, rough tablecloths. It is locally used for wrapping the famous 'singori' sweets of Almora in Uttarakhand.

7. *Cannabis sativa* (Bhang), Family: Cannabaceae

- It is an erect annual herb reaches upto three meters in height and found in wild as well as cultivated for its medicinal and fiber value. It is also found in forest areas on old cattle stands and camping grounds.
- It produces the true hemp of commerce.
- It is used for the manufacture of ropes, twine, mats, sail-cloth, canvas, and tarpaulins.
-

8. *Caryotaurens* (Kitool), Family: Cannabaceae

- It is a kind of palm found in Assam, Bengal, Orissa, Madras, and Burma.
- It is one of the important wild species which yields fiber from its leave and the fiber is known as kitool.
- It is used by fishermen in preparing their nets and fishing lines. It is used in the preparation of bristles for brushes and in rope-making and also used extensively in making of soft brooms.

9.*Pandanus s*pp. (Screw pines), Family: Pandanaceae

- The best known species is *Pandanus odoratissimus*, a common shrub or small tree in the tidal forests of the Sunderbans and Burma. It is also found in the Andamans and on the West Coast.
- Fibers are obtained from the leaves
- It is used in making cordage, fishing nets, fishing lines and sacking

10. *Agave sp.,* Family:Agavaceae

- Leaves of variousspecies of *Agave*yield fibers. These are *A. angustifolia, A. cantata, A*. *sisalana* and A. *lurida.*
- The pulp from the fleshy leaves of the plant are scraped away by hand or by special machines, and the fibers are then washed and dried in the sun.
- The fibers are mainly used in non-textile areas such as in preparing ropes and mats.

***11. Ischaemum angustifolium syn. Pollinidium angustifolium* (Bhabar grass), Family Poaceae**

- It the common bhabar, baib, or sabai grass found on the bare slopes and forest blanks of the sub-Himalayan areas. It is also common in Bihar, Orissa, Bengal,Central India, and the east of the Punjab, and extends even into Afghanistan.
- Its chief use is for paper-making, however, it has also uses in making rough ropes and mats

Summary

In this unit we have discussed the fibers and flosses, their importance and detailed description of some of the major plant species yielding fibers. Fibers are nothing but the long sclerenchyma cells that offer rigidity to various plant parts such as stem and leaves. whereas flosses are small silky cells arising from the fruits or seeds. Some of the important wild plants yielding flosses are *Ceiba pentandra* (silk kapok), *Bombax ceiba* (Shemulyieldin Indian kapok) and *Cochlo spermumreligiosum* (yellow silk cotton tree or buttercup tree). The flosses are mainly used for stuffing pillows, mattresses etc.

Based on the origin, fibers are classified into four major categories - Bast fibers (those fibers which occur in the outer parts of a stem as cortical fibers, pericyclic fibers, or phloem fibers), Wood fibers (xylem fibers), Leaf fibers (Sclerenchyma cells associated leaf), surface fibers (Fibers or flosses associated with the seeds). Whereas based on the economic uses, fibers are classified into following six categories- Textile Fibers, Brush Fibers, Plaiting and Rough Weaving Fibers, Filling Fibers, Natural Fibers, Paper-making Fibers. Fibers from leaves are utilized mainly for ropes and chordages.

There are several forest trees and plants which produce silky flosses in their fruits. These tree flosses are known commercially as tree cottons, silk cottons or kapoks.

These are a number of grasses which yield fibers. However, such fibers are too coarse to be utilized in textiles however, they have much uses in cordages and mattings.

References

1. Directorate of Forest, Govt. of West Bengal. Forest Utilization. s.l. : Directorate of Forest, West Bengal, 2016.
2. Trotter, H. Manual of Indian Forest Utilization: Oxford University Press, 1940.
3. Troup, RS. Indian Forest Utilization. Calcutta: CalcutaGoverment Printing Press, 1907.
4. Sangria, K.P. Forest and Forestry. New Delhi: National Book Trust India, 1967.
5. Baker, Frederick S. Principles of Silviculture. California: McGraw Hill Book Company, INC, 1950.
6. FAO. Global Forest Resources Assessment. Rome: FAO of United Nations, 2015.
7. ICFRE. Forestry Statitics India. Dehradun: ICFRE, 2011.
8. Venkateshwarlu, D. Definition of Forest- A review. Opendevelopmentmekong.net. [Online]https://data.opendevelopmentmekong.net › download › venkateswarlu.
9. Kirpal J.S., Verma B.N. mahaforest.nic.in › stand_ord_file. mahaforest.nic.in › stand_ord_file. [Online] December 12, 1996. mahaforest.nic.in › stand_ord_file.
10. IEA. World Energy Outlook. Paris: IEA Publications , 1998.
11. John, A.H. Forest Forestry. 2002. pp. 15-19.
12. Spurr, S.H. A new definition of silviculture. 1945. p. 44.

Unit 09: NWFPs- Medicinal Plants and Their Uses

Unit Structure

9.0 Learning Objectives

After studying this unit, you should be able to:

- define medicinal plants
- enlist important medicinal plants of Uttarakhand
- Describe some important medicinal plants,
- Discuss the medicinal uses of some important medicinal plants

9.1 Introduction

Humans have always been dependent on plant resources for a variety of their requirements from food items, fibers, timber and many more. When humans suffered from some ailment, he found herbs useful in curing it. It has been confirmed by now that plants have many compound and chemicals which have defined role in curing many diseases. Such plants having some or other kind of healing property in them are known as medicinal plants.

According to an estimate, there are about 2,50,000 higher plant species on earth with about 80,000 species with some or other medicinal values. Our country is one of the world's 12 mega biodiversity centers with the presence of over 45000 different plant species. The high diversity of plants in our country is mainly attributed to the presence of 16 different agro-climatic zones, 10 vegetation zones, 25 biotic provinces and 426 biomes. It has been recorded that about 7000-7500 plant species have been in use for its indigenous medicinal uses by the traditional communities. There are many traditional systems of medicine prevailing in India since time immemorial such as Unani, Ayurveda and Amchisince ancient times. These all systems were based on herbal based medicines by using the whole plant or different part of the plants such as leaves, stem, bark, root, flower, seed, etc.

In this unit, we will be learn about medicinal plants, their local names, scientific names and families they belong to. Further, we will also discuss the various classifications of medicinal plants and also the various uses of medicinal plants found in India.

9.2 Medicinal Plants and their classification

According to World Health Organization (WHO), 2008, medicinal plants are defined as, "plants that contain properties or compounds that can be used for therapeutic purposes or those that synthesize metabolites to produce useful drugs".

Medicinal Plant are classified according to the part used, habit, habitat, therapeutic value etc, besides the usual botanical classification. The various ways medicinal plants are classified have been described as follows (Based on PP Joy et al 1998):

1. Classification Based on part used

i) **Whole plant:** *Boerhaavia diffusa*, *Phyllanthus neruri*

ii) Root: *Dasamula*

iii) Stem: *Tinospora cordifolia*, *Acorus calamus*

iv) Bark: *Saraca asoca*

v) Leaf: *Indigofera tinctoria*, *Lawsonia inermis*, *Aloe vera*

vi) Flower: *Biophytum sensityvum*, *Mimuso pselenji*

vii) Fruit: *Solanum species*

viii) Seed: *Datura stramonium*

2. Based on habit

i) Grasses: *Cynodon dactylon*

ii) Sedges: *Cyperus rotundus*

iii) Herbs : *Vernonia cineria*

iv) Shrubs: *Solanum species*

v) Climbers: *Asparagus racemosus*

vi) Trees: *Azadirachta indica*

3. Based on habitat

i) Tropical: *Andrographis paniculata*

ii) Sub-tropical: *Mentha arvensis*

iii) Temperate: *Atropa belladona*

4. Based on therapeutic value

i) Antimalarial: *Cinchona officinalis, Artemisia annua*

ii) **Anticancer:** *Catharanthus roseus*, *Taxus baccata*

iii) **Antiulcer**: *Azadirachta indica, Glycyrrhi zaglabra*

iv) Antidiabetic: *Catharanthus roseus, Momordica charantia*

v) **Anticholesterol**: *Allium sativum*

vi) Anti-inflammatory: *Curcuma domestica, Desmodium gangeticum*

vii) Antiviral: *Acacia catechu*

viii) **Antibacterial:** *Plumbagoindica*

ix) **Antifungal:** *Allium sativum*

x) **Antiprotozoal:** *Ailanthus sp*., *Cephaelis ipecacuanha*

xi) Antidiarrhoeal: *Psidium gujava, Curcuma domestica*

xii) **Hypotensive:** *Coleus forskohlii, Alium sativum*

xiii) **Tranquilizing:** *Rauvolfia serpentina*

xiv) **Anaesthetic:** *Erythroxylum coca*

xv) Spasmolytic: *Atropa belladona, Hyoscyamus niger*

xvi) Diuretic: *Phyllanthus niruri, Centella asiatica*

xvii) Astringent: *Piper betle, Abrus precatorius*

xviii) Anthelmentic: *Quisqualis indica, Punica granatum*

xix) Cardiotonic: *Digitalis sp., Thevetia sp.*

xx) Antiallergic: *Nandina domestica, Scutellaria baicalensis*

xxi) Hepatoprotective: *Silybum marianum, Andrographis paniculata*

5. Based on Ayurvedic formulations in which used

a) The ten roots of the Dasamoola (Dasamoolam)

i) *Desmodium gangeticum* (Orila)

ii) *Urariala gopoides* (Cheriaorila)

iii) *Solanum jacquinii* (Kantakari)

iv) *Solanum indicum* (Cheruchunda)

v) *Tribulus terrestris* (Njerinjil)

vi) *Aegle marmelos* (Koovalam)

vii) *Oroxylum indicum* (Palakapayyani)

viii) *Gmelina arborea* (Kumizhu)

ix) *Steriospermum suaveolens* (Pathiri)

x) *Premnas pinosus* (Munja)

b) The ten flowers of the Dasapushpa (Dasapushpam)

i) *Biophytum sensitivum* (Mukkutti)

ii) *Ipomea maxima* (Thiruthali)

iii) *Eclipta prostrata* (Kayyuniam)

iv) *Vernonia cineria* (Poovamkurunnil)

v) *Evolvulus alsinoides* (Vishnukranthi)

vi) *Cynodon dactylon* (Karuka)

vii) *Emelia sonchifolia* (Muyalcheviyan)

viii) *Curculigo orchioides* (Nilappana)

ix) *Cardiospermum halicacabum* (Uzhinja)

x) *Aerva lanata* (Cherula)

c) The four trees of the Nalpamara (Nalpamaram)

i) *Ficus racemosa* (Athi)

ii) *Ficus microcarpa* (Ithi)

iii) *Ficus relegiosa* (Arayal)

iv) *Ficus benghalensis* (Peral)

d) The three fruits of the Triphala (Thriphalam)

i) *Phyllanthus emblica* (Nellikka)

ii) *Terminalia bellerica* (Thannikka)

iii) *Terminalia chebula* (Kadukka)

9.3 Important Himalayan Medicinal Plants

Indian Himalayan Region (IHR) is a treasure house of medicinal plants. As many as 1648 medicinal plants have been reported from IHR (Samant et al.,1998). Some of the important medicinal plants are described in details:

9.3.1. Black Pepper

Botanical Name: *Piper nigrum* Linn.
Family: Piperaceae
English: Black Pepper
Ayurvedic names: Maricha, Vellaja, Uushna, Suvrrita, Krishnaa

Origin and Distribution: Black pepper is grown in many tropical regions of the world viz., Brazil, Indonesia and India. It is native to India and Indo-Malaysian region. Now, due to its commercial value, it has been under cultivation in Western Ghats, Karnataka, Maharashtra, Assam and Kerala.

General Description: *Piper nigrum* is one of the popular plant used in almost all families as spices as well as for its medicinal values. On account of its most common use as spices, it is known as "**The King of spices**". It is a woody perennial climbing vine growing up to 9 m (30 ft) or more in length. The rootlets arise at the nodes of the stem. The upper side of the leaves is dark green whereas lower side is pale green. The leaves are glossy, ovate and acutely tipped. Leaf size ranges from 12–24 cm. Inflorescence type is spikes or catkins and bear minute white coloured flowers. Each flower spike produces approximately 50–60 single-seeded dark red berries, approximately 4-6 millimeters in diameter, always appear on stems opposite the leaves. Fruits are spherical and lustrous red when ripen. The fruits are categorized as drupe. Seeds are almost spherical. It has been recorded that India is the largest producer (average 191,000 tonnes per annum) whereas Thailand has the highest productivity in terms of kg per ha is (3595 kg per ha).

Medicinal Uses: The plants has many medicinal uses as listed below:

- The fruit is stimulant, carminative, diuretic, anti-asthmatic
- It is used in fevers, dyspepsia, flatulence, indigestion and as mucous membrane and gastro-intestinal stimulant.
- Externally, it is stimulant to the skin
- Used as a gargle for sore throat

- Used with ginger and *Piper longum*for viral hepatitis
- The fruit yields piperine, piperatine and piperidine; amides, piperyline, piperoleins A &B, and N-isobutyl-cicosa-trans-2-trans-4-dienamide

9.3.2. Pippali

Botanical Name: *Piper longum* Linn.

Family: Piperaceae
English: Indian Long Pepper, Joborandi
Ayurvedic names: Pippali, Maagadhi, Maagadha, Maagadhaa, Maagadhikaa, Magadhodbhavaa, Vaidehi

Origin and Distribution: It is native of Indo-Malaya. It is now widely distributed in India, Nepal, Indonesia, Malaysia, Sri Lanka, Rhio, Timor and Philippines (Farooqui and Sreeramu 2001). In India it is found in Asom, Khasi Hills, lower hill of West Bengal, eastern Uttar Pradesh, Madhya Pradesh, Maharashtra and evergreen forests of Western Ghats in Kerala, Karnataka and Tamil Nadu. It is widely grown in Andhra Pradesh and Andaman and Nicobar islands.

General Description: Long pepper is a semi-erect or climber shrub. It is glabrous with slender branches. The branches are often of creeping type or trailing type. Leaves are simple, alternate, stipulate and petiolate or sessile at the upper end of the stem. The leaf lamina varies in shape over the same plant. The leaf is ovate or ovate oblong, acute, most often unequal sided or unequally cordate at base while the lower ones are usually cordate. All the leaves are entire, glabrous, membranous or slightly succulent and five to seven ribbed from the base. Inflorescence is spike with unisexual (dioecious), small, densely packed flowers and form very close clusters of small grayish green or darker grey berries. The female stalk is shorter than that of male stalk, which elongates during maturation. The stalk of female spike is thick in contrast to the male spike, which is slender.

Chemical Composition: Alkaloids piperine (4-5%) and piplartin have been reported in long pepper. Other alkaloids also have been reported which are designated as piperolactam a, piperolactam b and pellitorine. These have been

isolated from the cold ethanol extract of long pepper (Desai et al. 1988). Piper longumine (0.2 - 0.25%) is also reported in fruits. Further purification yielded six other alkaloids which are cepharadione b, cepharadione a, cepharanone b aristolactum, all- norcepharadione b, 2 hydroxy 1 methoxy 4 and h dibenzoquinoline -4, 5 (6 h) dione.

Medicinal Uses: The main plant parts which are used for medicinal purposes are fruits, roots, stem, female spike (dried spikes) and leaves. The various medicinal used described in literature are as follows:

- The root is used for stomachic, laxative, anthelmintic, carminative, improves the appetite, useful in bronchitis, abdominal pains, diseases of spleen and tumours.
- The ripe fruit is sweetish, pungent, heals stomach, aphrodisiac, laxative, diarrhoeic and antidysentric.
- In ayurveda, it is used for treating 'vata' and 'kapha' asthma, abdominal complaints, bronchitis, leucoderma, fevers, tumours, urinary discharges, piles, diseases of the spleen, pains, inflammations, leprosy, insomnia, hiccoughs, jaundice, and tuberculous glands.
- The root and fruit both are used in lumbago and gout.
- In unani system, the fruit is used as the tonic of liver, for stomachic, emmenagougue, abortifacient, aphrodisiac, diuretic, digestive, general tonic, useful in inflammations of the liver, pains in the joint, lumbago, and night blindness.
- It is prescribed after parturition to induce the expulsion of the placenta. ® The dried immature spike and the matured root in the form of decoction are extensively used in acute and chronic bronchitis and cough for getting gradual relief.
- Long pepper with ginger, mustard oil, butter milk and curds make an ointment for sciatica and paralysis.

- The roasted spikes are beaten up with honey and are given for treating rheumatism in Konkan (Maharashtra).
- Long pepper is a useful remedy in veterinary medication.

9.3.3. Cardamom (Small cardamom)

Botanical Name: *Elettaria cardamomu*m Maton. (Small cardamom)

Family: Zingiberaceae

English: Lesser Cardamom

Ayurvedic Name: Elaa, Sukshmailaa, Kshudrailaa, Bhrngaparnikaa, Tutthaa, Draavidi

Distribution: Cultivated either as pure plantation crop, or as subsidiary to coffee and arecanut in hilly forests regions of Western Ghats in Karnataka and Kerala, and in parts of Madurai, the Nilgiris and Tirunelveliin Tamil Nadu

General Description: Cardamom is a valuable spice that is obtained from the seeds of a perennial plant (*Elettaria cardamomum*). Cardamom originates from the coastal area of India. Cardamom is known as the "**Queen of Spices**". It is one of the highly priced spices in the world. It is a perennial tropical herb plant belonging to the ginger family (Zingibaraceae) and grows up to 6-10 feet.

There are two main types of cardamom, the small green cardamom (*Eletteria cardamomum*) and large red/black cardamom (*Amomum subulatum*Roxb). However, the most common type is the small green cardamom which is generally produced in the tropical regions of the world. Largest cardamom producer of the world is Guatemala followed by India.

Medicinal Uses: Cardamom possesses the following medicinal properties:

- It is antispasmodic (neuromuscular), aphrodisiac, expectorant, anthelminthic, antibacterial (variable), cephalic, cardio tonic, diuretic, emmenagogue, stomachic, carminative, anti-emetic, stomachic, anti-asthmatic
- Oil is antispasmodic, antiseptic, used for flatulence, loss of appetite, colic, bronchitis, asthma.

- Paste used as balm for headache and husk for rheumatism

Note: The large cardamom also belongs the same family but is different to the small cardamom. The botanical name of large cardamom is *Amomum subulatum* Roxb. It is mainly grown in India, Nepal and Bhutan. India is the largest producer with more than 85% of the production of India comes from Sikkim. It is also called greater Indian or Nepal cardamom, which is a native of the Eastern Himalayan region. Large cardamom is the most important perennial cash crop of the region and is widely cultivated with Himalayan alder (*Alnus nepalensis*) as a shade tree. Large cardamom is also known as **'black cardamom'**. The pods are used as a spice, in a manner similar to the green Indian cardamom pods, but it has a drastically different flavour, so it cannot be substituted in the same recipes, unless a different flavor is acceptable. Unlike green cardamom, this spice is used rarely in sweet dishes. Its strong, smoky flavour and aroma are derived from the traditional drying procedure, which involves drying over open flames.

6.3.4. Clove (Laung)

Botanical Name: *Syzygium aromaticum* (Linn.) Merr.&Perry. Syn. *Eugenia aromatic* Kuntze

Family: Myrtaceae

English: Clove

Ayurvedic Name: Lavanga, Devakusum, Devapushpa, Shrisangya, Shriprasuunaka

Distribution: The clove tree is frequently cultivated in coastal areas up to an altitude of 200 m amsl.

General Description: The "Clove" literally means the symbol of dignity. It is a precious and valuable spice of the world. It is an unopened flower bud growing on a tree belonging to the guava family. It is an evergreen tree, which grows to a height ranging from 8-12m, having large square leaves and sanguine flowers in numerous groups of terminal clusters. The flower buds are at first

of a pale color and gradually become green, after which they develop into a bright red, when they are ready for collecting. The production of flower buds, which is the commercialized part of this tree, starts after 4 years of plantation. Flower buds are collected in the maturation phase before flowering. The flower buds are at first of a pale color and gradually become green, after which they develop into a bright red, when they are ready for collecting. Cloves are harvested when 1.5–2 cm long, and consist of a long calyx, terminating in four spreading sepals, and four unopened petals, which form a small ball in the center.

Cloves are the aromatic dried flower buds, which are commonly used in various Indian food preparations (cuisines) such as biryanis, pickles, salads and is an important ingredient of Garam masala. Clove buds possess intense fragrance and burning taste. They have deep brown color, powerful fragrant odour which is warm, pungent, strongly sweet and slightly astringent.

Medicinal Uses: It has many medicinal properties. It is carminative, anti-inflammatory, antibacterial, anti-emetic and stimulant. It is also used in dyspepsia and gastric irritations. The oil is obtained from the flower bud which is employed as a local analgesic for hypersensitive dental lines and carious cavities.

9.3.5. Ginger

Botanical Name: *Zingiber officinale* Rosc.

Family: Zingiberaceae

English: Ginger

Ayurveda Name: Aardraka, Aadrikaa, Shrngibera, shrngavera, Katubhadra

Distribution: Native to Southeast Asia and now in cultivation mainly in Andhra Pradesh, Kerala, Maharashtra, Uttarakhand, Uttar Pradesh and WestBengal

General Description:

Medicinal Uses: The rhizome of the plant is used as anti-emetic, anti-flatulent, hypocholes terolaemic, anti-inflammatory, anti-spasmodic, expectorant,

circulatory stimulant and diaphoretic. It is also used in irritable bowel, diarrhoea, cold and influenza. Showed encouraging results in migraine and cluster headache.

The Ayurvedic Pharmacopoeia of India recommends dried rhizomes in dyspepsia, loss of appetite, tympanitis, anaemia, rheumatism, cough and dyspnoea; fresh rhizomes in constipation, colic, oedema and throat infections.

9.3.6. Turmeric (Haldi)

Botanical Name: *Curcuma longa* Linn. Syn. *C. domestica* Valeton.

Family: Zingiberaceae

English: Turmeric

Ayurvedic Name: Haridraa, Priyaka, Haridruma, Kshanda, Gauri,

Distribution: Cultivated all over India, particularly in Maharashtra, Tamil Nadu and West Bengal. It is a native of the Indo-Malayan region, distributed throughout tropical and subtropical regions of the world, being widely cultivated in Asiatic countries, mainly in India and China.

General Description: In India is popularly known as “Haldi” It is a perennial herbaceous plant, mostly cultivated in the tropical parts of the India. It grows up to a height of 1 m but has a short stem. The leaves are large which may attain a size up to 1 m long. Leaves are petiolate, oblong, and lanceolate, with blade up to 52 cm long and 8.5 cm wide. Flowers are yellow white in colour and originate during June to November on a spike. It can be propagated by vegetative means by rhizomes. Its rhizomes are oblong, ovate, pyriform, and often short-branched.

Medicinal Uses

- It is a household remedy and may be used as Anti-inflammatory, cholagogue, hepato-protective, blood-purifier, antioxidant, detoxifier and regenerator of liver tissue, anti-asthmatic, anti-tumour, anti-cutaneous, antiprotozoal, stomachic and carminative.
- It also reduces high plasma cholesterol.

- Its antiplatelet activity offers protection to heart and vessels. Also offers protection against DNA damage in lymphocytes.

9.3.7. Betel vine

Botanical Name: *Piper betle* Linn.

Family: Piperacee

Ayurvedic Name: Taambula, Naagvallari, Naagini, Taambulvalli, Saptashiraa, Bhujangalataa.

English: Betelpepper

Distribution: The plant is under cultivation in warmer and damper parts of India such as Assam, Bihar, Karnataka, Kerala, Uttar Pradesh and West Bengal.

General Description: The betelvine is known as 'pan'. Betelvine is a perennial, dioecious, evergreen climber that is grown in tropics and subtropics for its leaves that are used as a chewing stimulant. The vine spreads readily on account of rooting from the stems where it touches the ground. It has glossy and heart-shaped leaves. The leaves are alternate, entire, 5 to 10 cm long and 3 to 6 cm broad. The small flowers are produced on pendulous spikes at the leaf nodes. Betelvine leaves and stem have pungent aromatic flavour. Betel leaves chewing is considered as source of dietary calcium. Betel oil has several medicinal uses.

Medicinal Uses:

- Leaves of the plant are stimulant, carminative, astringent, antiseptic
- Essential oil from leaves is antispasmodic, antiseptic and used in respiratory catarrhs
- The leaves contains beta and gamma-sitosterol, hentriacontane, pentatriacontane, n-triacontanol, stearic acid and chavicol.
- The essential oil from leaves contained carvacrol, eugenol, chavicol, allyl catechol, cineole, estragol, caryophyllene, cardinene, pcymeneandeugenol methyl ether.

9.3.8. Periwinkle (Sadabahaar)

Botanical Name: *Catharanthus roseus* (L.)G.Don. Syn. *Vinca rosea* L.

Family: Apocynaceae

English: Madagascar Periwinkle

Origin and Geographical Distribution: It is a native to Wes Indies and Island of Madagascar in Indian Ocean region. It is now common in many tropical and subtropical regions of the world mainly in India, China, Indonesia, Israel, Madagascar, Philippines, South Africa, and USA. In India, it is extensively cultivated in the states of Tamil Nadu, Karnataka, Gujarat, Madhya Pradesh and Assam.

General Characteristics: It is an erect, perennial and evergreen herb. It is highly branched and attains the height of up to 1 m. The leaves are oblong or obviate, opposite, short petiolated, smooth with entire margin. The lower surface of leaf is light green coloured with prominent veins. Leaves are arranged in the opposite pairs. Flowers are white to dark pink with a dark red center known as eye. Flowers are borne on axils in pair. The calyx is linear-subulate. The corolla tube is cylindrical measuring about 30 mm in length. Anthers are epipetalous present on a short filament. The bicarpellate ovary is basally distinct with fused common style and stigma, which is ascribed to post genital carpel fusion (Walken 1975). The fruit is dehiscent, it consists of a pair of follicles containing up to 30 linearly arranged seeds with a thin black tegument.

Chemical constitution: This plant has largest number of alkaloids in the plant kingdom (Hui-Lin Li and Willaman 1972). Constable et al (1981) and Balsevich et al (1988) detected 60 alkaloids from leaves by means of supercritical fluid chromatography and mass spectrometry. Most important are Vincristine and Vinblastin. Root is found to have ajmalcine and serpentine. Four alkaloids possessing antibacterial activities are extracted from leaves. Moreover there are also two glycosidal principles, urosolic acid, leurosine, isoleurosine, previne, mitaphylline, lochnevin and perosine (Chatterjee, 2000).

Medicinal Uses: Alkaloids are the most potentially active chemical constituents of the plant. More than 400 kinds of alkaloids are present in the plant, which are used in pharmaceuticals, agrochemicals, flavor and fragrance, ingredients, food additives and pesticides. Whole plant is used for medicinal purposes. Some of the important uses are as follows:

- Root alkaloids **Ajmalcine** and Serpentine are used for allopathic medicines for cure of hypertension and other diseases.
- Leaf alkaloids **Vincristine and Vinblastin** are used in allopathic medicine to treat blood cancer.
- Leaves are used for curing diabetes, menorrhagia and wasp stings.
- Roots are used as tonic, for stomach ache, sedative and tranquilizer.
- There was a discovery of anti-neoplastic activities of a leaf alkaloid by Nobel etal (1958).
- The cytotoxic dimeric alkaloids are used for the treatment of certain type of cancer.

9.3.9. Rauvolfia

Botanical Name: *Rauvolfia serpentine* Benth.exKurz.

Family: Apocynaceae

English: Rauvolfia root, Serpentina Root, Indian Snake root

Origin and Geographical Distribution: It is indigenous to the moist, deciduous forests of south-east Asia which includes Bangladesh, Burma, Malaysia, Sri Lanka, Indonesia and the Andaman Islands. It is distributed in India, Nepal, Burma, Thailand, Bangladesh, Indonesia, Cambodia, Philippines and Sri Lanka. In India it occurs naturally in the foothills of Himalayan range. From Himalayan foothills it is distributed from Sal forest in north-west near Yamuna river, to the lower ravines of Asom and Meghalaya to the elevation of 1300-1400 m, via Shiwalik ranges of Shimla and Dehradun, eastern U.P, Bihar, Nepal, eastward of Sikkim, foothills of Darjeeling and Jalpaiguri reserves forests of north Bengal. It is also available in Andaman Island, Western Ghats

tract in Konkan, slopes of Annamalai hills of Tamil Nadu and south- west coast in Kerala state. The plant is also distributed sporadically in Andhra Pradesh, Bastar forests of Madhya Pradesh, Odisha and Chota Nagpur of Bihar (Dutta and Virmani, 1964; Sulochna, 1959). At present it is being cultivated in U.P., Bihar, T.N., Odisha, Kerala, Assam, West Bengal and Madhya Pradesh. Thailand is now the chief exporter of Rouvolfia alkaloids. Zaire, Bangladesh, Sri Lanka, Indonesia and Nepal are also small exporters (Guniyal et al. 1988 and Sarin, 1982). *Rauwolfia serpentina* or Sarpaghandha is also distributed in the foot -hill of Himalayan, up to the elevation of 1300–1400 m.

General Characteristics: Rauwolfia is an evergreen and perennial shrub. It can attain the maximum height of 60 cm. The roots are tuberous with pale brown cork. The leaves are in three whorls. They are elliptic to lanceolate or obvate. Lower leaf surface is pale green whereas upper surface is bright green in colour. It bears white flowers often tinged with violet colour. Flowers are irregular corymbose cymes. In Indian conditions, it flowers during March to May. The fruits are drupe, single or didymous.

It is an erect evergreen perennial under shrub with a cluster of branches (2 - 6) arising from the root. Leaves are simple having short petiole, it is glandular at the base, glabrous and bright green when young but becomes pale yellow before shedding. Leaf shape is elliptic-lanceolate and occur in whorl of 3 - 5 but may be opposite, particularly at the base of the stem. Leaf apex is acute to acuminate. Inflorescence is terminal or sometimes axillary. The flowers are abundant and form an inflorescence in compact cymes, forming a hemispheric head at the end of a long peduncle. Flowers are small, pedicellate and hermaphrodite. Calyx is glabrous, five-lobed and deep red. Petals are five in number, gamopetalous and white. Corollas are tubular and swollen in the middle. Stamens are 5, epipetalous, enclosed within the dialated portion of corolla tube. Carpels are 2, connate, style filiform and stigma large. Fruits are drupe, obliquely ovoid and purplish black in colour when gets matured. Seeds are ovoid and wrinkled. The main root grows upto 40-60 cm deep into the soil. Root is prominent, tuberous, usually branched. Outer bark of the root is corky

with irregular longitudinal fissures and posseses high alkaloid concentration. Thin branches have more alkaloid content.

Chemical constituents: The roots of *Rovwolfia* are reported to have more than 20 alkaloids, of these reserpine, rescinnamine, deserpidine, ajmaline, alstonine, neoajamaline, serpentine and alpha- yohimbine are pharmacologically important alkaloids. The extraction of alkaloid depends on the age of plant, the time of harvest, ecological condition of growth and also on the handling of material, ie. drying and storage.

Medicinal Uses: Roots, leaves and seeds are the main plant parts employed for the treatment of various ailments. Some important medicinal uses of the plant are as follows:

- The roots of this plant is used as sedative, to control high blood pressure and certain form of insanity.
- In ayurvedic system of medicine, roots of the plant are used for the treatment of insomnia, epilepsy, asthma, acute stomachache and painful delivery of child and also high blood pressure and insanity.
- It is an antidote for snakebites
- It is often employed to treat anxiety, insomnia, and insanity. In fact, in parts of India, *R. serpentina* is known as "**pagal-ka-dawa**" which translates to "the insanity cure."
- Other local cultures are the plant used as a relaxant and as a tranquilizer to put children to sleep for the night.
- The alkaloid reserpine isolated from the root is considered a sympathomimetic agent, one that targets the sympathetic nervous system.
- Reserpine has been found to lower blood pressure in remarkably low oral doses. CIBA, a pharmaceutical company based in Switzerland, marketed reserpine under the trade name Serpasil as the first major drug to treat hypertension. (In 1996, CIB A combined with Sandoz Pharmaceuticals, another Swiss company, and now exists under the new name Novartis.)

- Extracts from the root are used for the treatment of intestinal disorders, like diarrhea and dysentery
- It is used in common treatment for hypertension by generalized vasodilatation and thus, lowering of blood pressure on the vasomotor centre,
- It soothes the general nervous system by depressant action on the cerebral canters and therefore, used in insomnia and also in various central nervous system disorders, both physical and motor, including anxiety states, excitement
- It stimulates the bronchial musculature

9.3.10. Dioscorea

Botanical Name: *Dioscorea deltoidea* Wall. Ex Griseb

Family: Dioscoreaceae

English Name: Wild yam, Elephant's foot

Geographical Distribution: It is distributed throughout the tropical and subtropical regions in the world, mainly in West Africa, parts of Central America and the Caribbean, Pacific islands and South East Asia (Anand, 2011). In Asia, the plant is found mainly in Cambodia, Bhutan, Afghanistan, China, Pakistan, India (Western Himalaya), Nepal, Vietnam and Thailand.

Its habitat is found ranging from 450 to 3100 m altitude. In Himalayas it is found at altitude of 29000 feet (Gopichand et al., 2013). It is found in forest clearings, shrubberies, slopes and rocky substrates.

General Description: *Dioscorea deltoidea* is a perennial climber. Mostly it is found growing upto 3m (10 ft) in height. It is a hairless vine that is twinning clockwise. Rhizomes are ligneous (resembling wood), irregular, horizontal and alternately arranged. They may resemble ginger like shape. Stem is also twining, drying and have a purplish brown to brown groove. Leaves are alternate, simple, 5-11.5cm long and 4-10.5cm broad (Saikia et al., 2011). Morphology of leaves show that they are triangular ovate, long pointed, often

heart-shaped, 7- 9 nerved, hairless on upper side and velvety on the nerves beneath. Leaf stalks are slender, 5- 10cm long. Flowers usually are small, distant in clusters with 6 stamens and inferior anthers. Male flower spikes are solitary in leaves axils. They may be simple or sometimes branched slender, 7.5-25cm long. Female flowers are stalked, solitary and slender up to 15cm long. Capsule usually may be reflexed brown at maturity and purplish brown spots are observed.

Medicinal Uses:

- It acts as a vermifuge (worm repellent) for children specially. Its roots are found being active against uterine sedative.
- It is also used as bio-poison for fishes
- Its tubers are employed to treat bilious colic and to kill lice
- Its roots contain good amount of diosgenin used as starting material for hormone preparation.
- It is also used in soap making due to its saponin content. Studies indicate that it was used to wash clothes as detergent because of saponins present in this species.
- Traditionally *D. deltoidea* is found to be anti-rheumatic and treat ophthalmic conditions
- Jain (1975) and Kumari et al. (2012) has reported that the rhizome powder is taken orally to cure dysentery, abdominal pain and piles

9.3.11. Isabgol

Botanical Name: *Plantago major* Linn.

Family: Plantaginaceae

English Name: Broadleaf Plantain

Origin and Geographical Distribution: It has its origin from Eurasia (Persia)but is now naturalized almost throughout the world. It has its distribution in west Asia, westwards to Sind, Baluchistan, Spain and the Canary Islands.

(Kirtikar and Basu, 1953). In its wild form, it grows from sea level to 3500 m altitude (Sagar& Harper, 1964). It is also found in southern Spain and north Africa, Canary islands, Tasmania, Australia, Mexico and Turkmenistan. Commercial cultivation in India is done in north Gujarat, southern Rajasthan, in some places of Madhya Pradesh, Punjab and Haryana. The species is a common weed in most of the agricultural areas of the world including the places where tropical crops are grown (Anderson, 1999)

General Description: It is a small annual plant having a short, stout and erect herbaceous stem of about 30 cm tall. Tillers arise from the base of the plant. There is a rosette of leaves on each tiller. The leaves are narrow, finely acuminate, entire or distantly toothed, attenuated at base, usually 3 nerved. Inflorescence are either shorter or longer than leaves arising in the leaf axils and bear ovoid or cylindrical terminal spikes with sessile flowers subtended by a bract and arranged in a dense spiral. The bracts are 4 mm long and broadly ovate, concave, membranous and glabrous. The sepals have herbaceous midrib bordered by wide, membranous wings similar to that of bracts. Corolla is colourless, but midveins are often coloured brownish or red. The lobes are narrow to broadly oval. Style and filament are colourless or pink to dark red. The style is lengthier than stamens and protogynous. Ovary is superior, 2 celled with a single ovule in each cell. Seeds are albuminous with oily endosperm and straight embryo. They are deeply concave and are broadly elliptical to ovate or boat shaped. Length varies from 2-3.5 mm and width of 1-1.5 mm. It is pale brown to moderate brown with a dull surface. The convex surfaces have a small and elongated glossy brown spot. This spot is surrounded by a white portion extending to the concave surface and is called husk. The concave surface has a deep cavity in the centre of the base on which is present a hilum covered with a thin membrane (Osol and Ferrar, 1960). Root is a tap root which is 20-30 cm deep with many lateral roots which are almost perpendicular to tap root.

Chemical constituents: Seeds contain protein, a fixed oil, mucilage, some cellulose and traces of starch (Anon., 1968). A glycoside named aucubin was

isolated from the plant and reported to be pharmacologically inactive (Chopra et al. 1958). A sugar called plantiose was also isolated. Seeds contain pale yellow oil (11.42%), large amount of mucilaginous matter, inorganic ash and reducing sugar. The oil contains both saturated and unsaturated fatty acids. Saturated acids are composed of 32.77% palmitic, 60.37% stearic 6.80% lignoceric acid (Pendse, 1973). The seed during extraction with water yield mucilage, its constituents are d-xylose, 1-arabinose, d-galacturonic acid and 1-rhamnose (Smith and Montagomery, 1959). The husk is found to have a polysaccharide with a polyxylose backbone and pectin like compound containing galactouronate and rhamnose. The composition of these basic components may vary from species to species (Salyers et al. 1978). Isabgol oil is the by-product of isabgol husk and is found to have high protein with good amount of limiting essential amino acids. The content of oil is not much (8.6%), but its oleic or linoleic acid ratio (1: 27) ensures that it is good grade edible oil (Anon. 1989).

Medicinal Uses: Seeds and husk obtained from the seed. The various uses are as follows:

- The seeds are used as the demulcent, for cooling, for inflammatory and bilious derangements of the digestive organs.
- Seeds are also used as poultice to rheumatic and gonuty swelling.
- Decoction is used for curing cough and chronic diarrhoea.
- It is used for curing dysentery and irritation of intestinal tract.
- It stimulates the intestinal peristalsis mechanically by swelling up, on coming into the contact of water and this way it relieves the chronic constipation.
- The husk acts as an anti-diarrhoeal drug. It is good in chronic dysenteries of amoebic and bacillary origin. It is also beneficial in treating constipation and intestinal disorders.

- Leaves— cooling, astringent, diuretic, vulnerary, febrifuge. Used for diarrhoea, bacillary dysentery, hepatitis, urinary diseases, piles, ulcers and skin diseases. Leaves are used for cystitis with blood, haematuria and other bladder disorders

9.3.12. Honey Plant

Botanical name: *Ammi majus* Linn.

Family: Apiaceae (Umbelliferae)

English Name: Biship's Weed-Amee, Greater Ammi

Origin and Geographical Distribution: It originated in Egypt and grew in the Nile Valley especially Behira and Fayoom. It is found distributed in the basin of Mediterranean sea in Syria and Palestine. It is also found in some regions of Iran and the mountains of Kohaz (Ramadan, 1982). It is found wildly in Abbottabad, Mianwali, Mahran, Lahore and also in Europe, West Africa and Abyssinia. In India it is cultivated on an experimental scale in the places like Uttar Pradesh, Gujarat and Tamil Nadu. In India with the courtesy of UNESCO in 1955, 2 species, i.e. Ammi majus and Ammi visnaga were introduced in the Forest Research Institute, Dehradun, Uttarakhand.

General Description: It is an annual herb of 0.80 to 1.2 m height. The plant stem is erect and solid. The leaves are compound, light green, alternate, pinnately divided having lanceolate to oval segments. The plant has axillary and terminal compound umbels of white flowers. The fruits are ribbed, ellipsoid, green or greenish brown when immature, but turn to reddish brown at maturity. The seed tastes bitter and extremely pungent. Its odour is characteristically terebinthinate, which becomes strong on crushing. The plant has a long tap root. Two varieties are found, ie Ammi majus L. var. Sutton's Monica and Ammi majus L var. Horticulture.

Chemical constitution: Fahmy and Abu-shady in 1947 isolated ammoidin. It was reported to have xanthotoxin, bergaptenis opimpinellin, isoimperatorin, oxypeucedanin, heraclenin, oxypeucedanin hydrate, This species is one of the richest known sources of linear furocoumarins. This furocoumarins when

activated by sunlight acts as bactericidal, fungicidal, mollscicidal, larvicidal, nematicidal, insecticidal, ovicidal and viricidal, so it is considered as a natural pesticide. The fruit contains 1% of amorphous glucosidal principle, 0.45% tannin, 4.76% oleo resinous products, 3.2% of an acrid oily liquid, 12.92% fixed oil, 0.2% glucose, 13.83% proteins and 22.43% cellulose (Fahmy and Abu-Shady, 1947).

Medicinal Uses: The Flowers and fruits are the plant parts used for medical purposes. The important uses are as follows:

- The yellowish brown powder of fruit is prepared for use in the treatment of leukoderma (vetilago) since Atharva Veda (1400 BC).
- US (FDA) in 1982, approved it as a treatment for severe cutaneous psoriasis.

9.3.13. Belladonna

Botanical Name: *Atropaacuminata* Royle ex Lindl. Syn. *A. belladonna* auct. non L.

Family: Solanaceae

English: Indian Belladonna, Indian Atropa

Geographical Distribution: The plant is native to Europe, North Africa and Western Asia. In India, it is distributed in Kashmir and Himachal Pradesh up to 2500 m.

General Description: It is a branched herbaceous perennial herb attining a height of 6.0 ft. It has purplish stem, stout, undivided at the base but dividing a little above the ground into three to more, rarely 2 to 4 branches each of which branched freely. Roots are thick, fleshy, whitish, branched, about 6 inches long or more. Leaves 3 to 10 inches long, ovate, dull, darkish green, the lower solitary, the upper ones in pairs alternately from opposite sides of the stem, one leaf of each pair much larger than other, acute at apex, entire with short petiole, veins prominent in undersurface and depressed on upper surface. Plant is glabrous though soft downy hairs may occur in stems and leaves when they are

young. Flowers solitary in the axil of leaves, dark and dingy purlish colour, tinged with green, about an inch long, pendent, bell shaped, furrowed, the corolla with 5 large teeth or lobes, slightly reflexed, flowering time from June to early September. Fruits berry and five-cleft calyx spreads round the base, shining black colour, full of dark inky juice, sweet and consumed by animals that disperse seeds, even though the seeds contain toxic alkaloids.

Medicinal Uses:

- Highly poisonous; sedative, narcotic, anodyne, nervine, antispasmodic (used in paralysis); parkinsonism; encephalitis; carcinoma; spastic dysmenorrhoea; whooping cough, spasmodic asthma; colic of intestines, gall bladder or kidney, spasm of bladder and ureters; contraindicated in enlarged prostate.
- Drops prepared from the plant are used to dilate the pupils of the eye.
- Traditionally used in the treatment of headache, menstrual symptoms, peptic ulcer, histamininc reactions, inflamations and motion sickness.
- Also used as sedative, stopping brochial spasm in asthama, whooping cough, also in cold and hey fever

9.3.14. Cinchona (Lojabark)

Botanical Name: *Cinchona officinalis* Linn. Syn. *C. robusta* How.

Family: Rubiaceae

English: CrownorLoxa Bark

Ayurvedic: Quinine

Habitat: Cultivated in West Bengal and Tamil Nadu.

Geographical Distribution:

General Description: It is an evergreen tree with an erect trunk rising up to a height of 15–25 m. Its bark is yellow in colour and the leaves are broad and smooth. The flowers are red, flowering takes place between May to August, and it bears fruit in autumn. The bark is grayish brown, thin, with many shallow fissures; branches flattened to sub-quadrangular, puberulentto hirtellous or glabrescent. Petiole 3– 20(–30) mm, glabrous or hirtellous or puberulent; leaf blade drying papery or thinly leathery, oblong-

lanceolate, elliptic-oblong, or lanceolate, 7–16(–21.5) × 2.5–6(–11) cm, both surfaces glabrous or sparsely puberulent to hirtellous abaxially, base acute to cuneate, apex obtuse to rounded or rarely acute; secondary veins 7–11 pairs, usually with crypt domatia, these best developed in proximal part of blade; stipules 10–20 mm, glabrous to puberulent or hirtellous, obtuse to rounded. Inflorescences 5–23 × 5–18 cm, densely hirtellous to puberulent; bracts triangular, 0.5–3 mm; pedicels 1–8 mm. Calyx densely sericeous; ovary portion ellipsoid, 1.5–2 mm; limb 1–2 mm, sparsely puberulent, partially lobed; lobes ovate-triangular, 0.5– 1 mm. Corolla white, pale yellow, or pale pink, glabrous to puberulent outside; tube cylindrical, 5–9 mm, glabrous inside; lobes lanceolate, 3–4(–6) mm, acute. Capsules 8–30 × 3–8 mm, stiffly papery to woody, puberulent or pilosulous to glabrescent; seeds 3–10 × 1.6–3.7 mm (including wing). Fl. Jun–Feb

Medicinal Uses: Anti malarial, febrifuge, astringent, orexigenic, sapasmolytic. Also prescribed in amoebic dysentery, jaundice, atonic dyspepsia, night cramps. Sometimes causes gastric and intestinalirritation.

9.3.15. Indian Wild Liquorice

Botanical Name: *Abrus precatorius* Linn.

Family: Papilionaceae/Fabaceae

English: Indian Wild Liquorice, Jequirity, Crab's Eye, Precatory Bean

Ayurvedic: Gunjaa, Gunjaka, Chirihintikaa, Raktikaa, Chirmiti, Kakanti, Kabjaka, Tiktikaa, Kaakananti, Kaakchinchi

Habitat: Throughout the country, ascending to an altitude of about 1050 m in the outer Himalayas.

General Description: *Abrus precatorius* is a woody twinning plant with characteristic toxic red seeds with black mark at the base (5). It is native to India, at altitudes up to 1200 m on the outer Himalayas. It is now naturalized in all tropical countries (6). It is a beautiful, much-branched, slender, perennial, deciduous, woody, prickly twining or climbing herb. Stem cylindrical, wrinkled, bark smooth-textured, brown. Leaves stipulate, pinnately compound; leaflets 7-24 pairs, 0.6-2.5 x 0.4-1.2 cm, turgid, oblong, obtuse, truncate at both ends, appressed hairy. They are alternate and glabrous with many paripinnate leaflets arranged in pairs. Flowers in

axillary racemes, shorter than leaves, fascicled on the swollen nodes, pink or pinkish-white; calyx-lobes short, appressed hairy. Pods 1.55.0 x 0.8-1.5 cm, turgid, oblong, appressed hairy, with a sharp deflexed beak, silky-textured, 3 to 5-seeded. Seeds elliptic to sub-globose, 0.5 cm in diam., smooth, glossy, shining red with black blotch around the hilum.

Importance:

- Uterine stimulant, abortifacient, toxic.
- Seeds—teratogenic. A paste of seeds is applied on vitiligo patches. Along with other therapeutic applications, The Ayurvedic Pharmacopoeia of India has indicated the use of seeds in baldness.
- Seeds contain abrin, a toxalbumin, indole derivatives, anthocyanins, sterols, terpenes. Abrin causes agglutination of erythrocytes, haemolysis and enlargement of lymph glands.

9.3.16. Vasaca

Botanical Name: *Adhatoda vasica* Nees. Synonym *A. zeylanica* M

English Name: Malabar Nut

Family: Acanthaceae

Ayurvedic Name: Vaasaa, Vaasaka, Vaasikaa, Simhaasya, Simhaparni, Simhavadanaa, Vaajidanta, Vrisha, Aataruushaka

General description: *Adhatoda vasica* Nees belongs to the medicinal family Acanthaceae. It is an evergreen shrub of 1-3 feet in height with many long opposite branches. Leaves are large and lance-shaped. Stem herbaceous above and woody below. Leaves opposite and exstipulate. Flower spikes or panicles, small irregular zygomorphic, bisexual, and hypogynous (Shinwari et al., 1995). It has capsular four seeded fruits. The flowers are either white or purple in colour. Its trade name Vasaka is based on Sanskrit name (Kumar et al., 2010). Inflorescences in axillary spicate cymes, densely flowered; peduncles short; bracts broadly ovate, foliaceous. The leaves, flowers, fruit and roots are extensively used for treating cold cough,

whooping cough, chronic bronchitis and asthma, as sedative, expectorant and antispasmodic (Pandita et al., 1983).

Medicinal Uses

i) Expectorant (used in bronchial, asthmatic and pulmonary affections), antispasmodic, febrifuge.

ii) As bronchodilator, expectorant (Indian Herbal Pharmacopoeia.)

iii) The Ayurvedic Pharmacopoeia of India indicates its use in dyspnoea. The chief quinazoline alkaloid vasicine is reported in all parts of the plant, the highest being in inflorescence. It is a bitter bronchodilator, respiratory stimulant, hypotensive, cardiac depressant, uterotonic and abortifacient.

9.3.17. Haldu

Botanical Name: *Adina cordifolia* Hook.f.ex Brandis Syn. *Haldina cardifololia* Ridsdale

Family: Rubiaceae

Habitat: Indigenous in deciduous forests all over India

English: Yellow Teak, Saffron Teak

Ayurvedic name: Haridru, Haraduaakadamba, Gaur-kadamba

General description: It is a South East Asian species. It is distributed throughout India, Burma, Sri Lanka, Bangladesh, Nepal, Thailand, South China, Bhutan, Vietnam, Myanmar and Malaysia. It is found scattered in deciduous forests throughout the greater part of India, (except in arid regions of Rajasthan) ascending to an altitude of 900 m in the sub-Himalayan tract. It is also common in the forests of South India (Iqbal et al. 2009). It grows well under 300-1000m altitude and prefers well-drained soil. Suitable soil pH range is 5.5 to 6.5. The annual temperature requirement is within the range of 25^0C-35^0C and prefers a mean annual rainfall between 1000-2000 mm (Tntreepedia, 2018). It is not frost tolerant. The tree grows in various geological formations such as granite, gneiss, schist, quartzite, trap and laterite up to an elevation of 1000 MSL (Kundu, 2018).

It is a large deciduous tree up to 40 m tall and 2.2m in diameter. Bark pale brown, horizontally wrinkled and cracked. Leaves opposite which are broadly oval in shape with heart shaped base and pointed tip (Kulkarni et al. 2015). Flowers are bisexual yellow in color in round heads, seeds many with tail at one end and bifid wings on other end. Generally flowering occurs during June–July and fruits ripen during December-March (Talbot,1976). The seeds are very small and light 0.06 to 0.12 in. long brown with numerous minute longitudinal wrinkles, one end tapering to a point, and the other terminating in a pair of pointed appendages. One gram of seeds contains as many as 11000 seeds (Troup 1921)

Medicinal uses: Antibacterial, antiseptic, antidysenteric, ant bilious (used in biliary colic), febrifuge. Root is astringent.

9.3.18. Bael

Botanical name: *Aegle marmelos* (L.) Correaex Roxb.

Family: Rutaceae

English: Bael tree

Ayurvedic name: Bilva, Shriphala,

Habitat: The plains and sub mountain regions of India, ascending to an altitude of 1200 m in the western Himalayas; cultivated all over India.

General Description: It is a small to medium sized thorny tree about 10-12 m in height. It is recorded growing in wild habitats in foot hills of Himalaya, Chattishgarh, Bihar, West Bengal, Central as well as South India. The fruit is woody, grey or yellowish, round, 5 - 17.5 cm in diameter, containing numerous seeds embedded in a mass of sweet, orange coloured aromatic pulp. The ripe fruit is sweet and cooling. It is used in the form of sherbet or for making jams and preserves.

Medicinal uses: Stomachic, antimicrobial (specific for diarrhoea, colitis, dysentery and enteric infections), digestive, astringent, spasmolytic, hypoglycaemic. Key application As antidiarrhoeal. (Indian Herbal Pharmacopoeia.) Along with other therapeutic applications, The Ayurvedic Pharmacopoeia of India indicates the use of root in dysuria; stembark in diabetes and lipiddis orders. A number of coumarins

(including xanthotoxol and alloimperatorin methyl ether), flavonoids (including rutin and marmesin), alkaloids (including alpha-fagarine), sterols and essential oils have been isolated from plant parts. Pectin is an important constituent of the fruit. Alkaloid aegeline, present in the leaves, is efficacious in asthma. The active principle in aqueous extract of leaf shows hypo glycemic activity similar to insulin. Leaves are also given in jaundice. Alcoholic extract of seeds shows antiallergic activity. Marmin, a coumarin isolated from the roots, shows anti-inflammatory effects experimentally. Marmin also inhibited gastric haemorrhagic lesions in rats and exhibited antiulcer effects. Seed oil showed beneficial effects in regeneration of tumour cells. Aurapten is found to be the most potent inhibitor of heart rate. Root bark is used for palpitation of the heart.

9.3.19. Akarkara

Botanical name: *Anacyclus pyrethrum* DC. syn. *A. officinarum* Hayne

Family: Asteraceae

English: Pellitory

Ayurvedic name: Aakaarakarabha, Aakallaka, Aakulakrit, Agragraahi

Habitat: Native to the Mediterranean region; cultivated in Algeria

General Description: A perennial procumbent herb bearing alternate and pinnate leaves; segments linear; ray florets white, purplish beneath, 3 much like chamomile in habitat and appearance, the root is brown, rough, shriveled surface, with the root bark closely adhering to the wood. They have a slight aromatic smell and persistent pungent test. The plant is native to North Africa, distributed in Mediterranean region, 3 it has been grown on an experimental scale at elevations of 900 m at Katra (Jammu and Kashmir), and Himalayan region from seeds imported from Algeria. The roots of the plant have long been imported into India for medicinal use.

It is a perennial herb with numerous spreading, prostrate or ascending branched stems, 19 more or less hairy in their upper portion, nearly smooth below, and coming from the crown from a long, tapering, vertical, brown, slightly branched root. Leaves alternate, the ones at the root crown long stalked, ovate or oblong in outline,

deep bipinnatisect, segments linear, acute often again 2 or 3 fid, more or less hairy or nearly glabrous. Heads terminal, large, 1-1½ inch or more wide, with a wide disk; involucral scales in several rows, imbricated , ovate- lanceolate, varying in width, blunt or sub acute, smooth, pale green, bordered with an edge of brown; receptacle slightly convex, with large obovate rounded transparent scales beneath the flowers.

Disk flowers bisexual, corolla tubular, contracted below, with 5 equal triangular spreading teeth, yellow; style exerted, stigma bifid, with 2 linear branches. Ray flowers female in a single row, corolla ligulae, the limb broadly oval, trifid at the apex, white above, tinged with bright pink below. 5 The root as found in shops is simple, 3-4 inches long by 3/8 to 4/8 of an inch thick, cylindrical or tapering, some time terminated at the top by bristly remains of leaves and having only a few hair like rootlets, externally it has a brown, rough, shriveled surface, is compact and brittle, the fractured surface being radiate and destitute of pith which is almost obliterated, and internally radiating secondary wood occupying about 2/3 of total thickness particularly in older roots. The root is characterized with an aromatic odor and a persistence pungent test.

Medicinal uses: Stimulant, cordial, rub efficient. A gargle of infusion is prescribed for relaxed vulva. Root— used for toothache, rheumatic and neuralgic affections and rhinitis. Roots, along with the root of *Withania somnifera* and *Vitis vinifera, areusedin epilepsy.* Along with other therapeutic applications, Ayurvedic Pharmacopoeia of India indicates the use of the root in sciatica, paralysis, hemiplegic and amenorrhea. The root contains anacycline, isobutylamide, inulin and *atraceo fessential* oil.

The local anaesthetic activity of the alcoholic extract of the root was found to be comparable to that of xylocaine hydrochloride in dental patients. Use of the drug in patients with insulin-dependent diabetes mellitus reduces the dose of insulin. It decreased the plasma glucose and serum cholesterol levels after oral administration for3-6 weeks. (The plant is mixed with *Helleborus nigar* in a ratio of 1:3).

9.3.20.Kalmegha

Botanical name: *Andrographis panicultata* Wall.exNees

Family: Acanthaceae

Ayurvedic name: Kaalmegha, Bhuunimba, Bhuuminimbaka, Vishwambharaa, Yavtikta, Kalpanaatha, Kiraata-tikta

Habitat: The herb is found in a variety of habitat viz. plains, hill slopes, waste lands, farms, dry or wet lands, and sea shore and even in the road side.

Distribution: Widely found and cultivated in tropical and subtropical Asia, south-east Asia and India. The species is also reported from different phyto-geographical zones throughout India, from Himachal Pradesh to Assam and Mizoram, and all over southern India.

General Description: It is an annual profusely branched, erect herb extremely bitter in taste. It grows to a height of 30-110 cm in moist shady places with glabrous leaves and white flowers with rose purple spots on the petal. The stem dark green, 0.4-1.0 m in height, 2-6 mm in diameter, quadrangular with longitudinal furrows and wings on the angles of the younger parts, slightly enlarged at the nodes; leaves glabrous, up to 8.0 cm long and 2.6 cm broad, lanceolate, pinnate; flowers small and solitary, corolla whitish or light pink in color with hairs, in lax spreading axillary and terminal racemes or icles; capsules linear-oblong, acute at both ends, 1.90.3 cm; seeds numerous, sub quadrate, yellowish brown. It is an annual herb found in Sri Lanka, Pakistan, Java, Malyasia, Indonesia and throughout India, specifically in Maharashtra, Karnataka, Uttar Pradesh, Tamilnadu, Andhra Pradesh and Madhya Pradesh. It is cultivated to some extent in Assam and West Bangal.

Medicinal uses: Hepato-protective, cholinergic, antispasmodic, stomachic, anthelmintic, alterative, blood purifier, febrifuge. It acts well on the liver, promoting secretion of bile. Used in jaundice and torpid liver, flatulence and diarrhoea of children, colic, strangulation of intestines and splenomegaly; also for cold and upperrespiratory tract infections.

Table 1. List of some Important Himalayan Medicinal Plants

Botanical names	Local names	Botanical names	Local names
1. Acacia catechu	Khair	*2. Brassica rapa subsp.*	Sarson
3. Achyranthes aspera	Latjeera	*4. Calotropis procera*	Ak
5. Aconitum heterophyllum	Atis	*6. Cassia fistula*	Amaltas
7. Acorus calamus	Bach	*8. Crocus sativus*	Kesar
9. Aegle marmelos	Bel	*10. Dactylorhiza hatagirea*	Salam-panja
11. Aesculus indica	Pangar	*12. Datura stramonium*	Dhatura
13. Agave Americana	Ram-bansh	*14. Dioscorea bulbifera*	Gethi
15. Ajuga bracteosa	Ratpatti,Ratpatia	*16. Eclipta prostrate*	Bhangru,Bhangri
17. Albizia lebbeck	Siris	*18. Evolvulus alsinoides*	Sankha-pushpi
19. Allium cepa	Pyaj,Pyaz	*20. Ficus palmate*	Beru
21. Allium sativum	lehsan	*22. Ficus religiosa*	Pipal
23. Angelica glauca	Gandhrayan	*24. Glycyrrhiza glabra*	Muleti
25. Artemisia indica	Pati	*26. Grewia optiva*	Bheemal
27. Artemisia nilagirica	Ghari-pati	*28. Juglans regia*	Akhrot
29. Asparagus racemosus	Satavari,Kairua	*30. Mangifera indica*	Aam
31. Azadirachta indica	Neem	*32. Mentha arvensis*	Pudina
33. Bacopa monnieri	Mandookparni, Brahmi	*34. Ocimum canum*	Tulsi
35. Bauhinia vahlii	Malu,Maljhan	*36. Oxalis acetosella*	Chalmori
37. Bauhinia variegata	Kachnar	*38. Phyllanthus emblica*	Amla
39. Berberis aristata	Kilmora,Rasut	*40. Potentilla flugens*	Bajradanti
41. Berginia ciliate	Pashan-bhed	*42. Solanum nigrum*	Makoi
43. Berginia ligulata	Pathar-chatta	*44. Swertia nervosa*	Chirayata
45. Betula utilis	Bhoj-patra	*46. Taxus baccata*	Thuner
47. Boerhavia diffusa	Punernava	*48. Terminalia bellirica*	Behera
49. Bombax ceiba	Semal	*50. Tinospora cordifolia*	Giloy