NWFP 103

NWFP Based Industries

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CONTENTS

BLOCK 1: PAPER AND PULP

Paper contributes an important role in civilization and the modern society. The writing and printing papers have been considered as the important media to spread the message to masses; equally important as a packaging material and other uses.

Paper is categorized into two categories-cultural (printing and writing paper) and industrial (packing and wrapping paper and boards). Cultural paper accounts for 60 per cent of the total societal demand and 40 per cent as industrial. The greater part of the industrial papers and paperboards is used in packaging. Rising economic activity stimulates the use of all types of packaging. The industrial papers are much in demand to feed the diversifying demand of industries.

Three major factors, viz., the degree of literacy, the growth of the industrial sector and the role of mass media, influence the demand for paper and paperboards, and account for its wide varieties.

Pulp is a dry fibrous material prepared chemically or mechanically by separating fibres from wood, fibre crops or waste paper. Pulp can be either fluffy or formed into thick sheets. The latter form is used if the pulp is to be transported from the pulp mill to a paper mill. Pulp shipped and sold as pulp (not processed into paper in the same facility) is referred to as **market pulp**. When suspended in water the fibres disperse and become more pliable. This pulp suspension can be laid down on a screen to form a sheet of paper, and this is the primary use for wood pulp. Wood pulp is the most common material used to make paper. The timber resources used to make wood pulp are referred to as pulpwood. Wood pulp is obtained from softwood trees such as spruce, pine, fir, larch and hemlock, and hardwoods, such as, eucalypt, aspen and birch.

UNIT 1. MATERIAL

Course Structure

1.1 INTRODUCTION

The earliest information on the use of non-woody plant species as surfaces for writing dates back to 3000 BC in Egypt, where the pressed pith tissue of papyrus sedge (*Cyperus papyrus* L.) was the most widely used writing material . Actual paper making was discovered by a chinese. Ts'ai Lun,in AD 105, when he found a way of making sheets using fibres from hemp rags and mulberry (*Morus alba* L.). Straw was used for the first time as a raw material for paper in 1800, and in 1827 the first commercial pulp mill began operations in the USA using straw (Atchison and McGovern 1987).

The pulp and paper industry is a vital part in Indian economy. As you are well aware of the facts that this included newspapers and magazines, toilet paper, printer and copier paper, tickets, receipts, pictures, stamps, packaging paper, and various other products Paper industry in India is the 15th largest paper industry in the world. It provides employment to nearly 1.5 million people and contributes around Rs 25 billion as reven ue to the government. The government regards the paper industry as one of the 35 high priority industries of the country.

Paper industry is primarily dependent upon forest-based raw materials. The first paper mill in India was set up at Sreerampur, West Bengal, in the year 1812. It was based on grasses and jute as raw material. Large scale mechanized technology of papermaking

was introduced in India in early 1905. Since then the raw material for the paper industry underwent a number of changes and over a period of time, besides wood and bamboo, other non-conventional raw materials have been developed for use in the papermaking. The Indian pulp and paper industry at present is very well developed and established. Now, the paper industry is categorized as forest-based, agro-based and others (waste paper, secondary fibre, bast fibers and market pulp).

Growth of paper industry in India has been constrained due to high cost of production caused by inadequate availability and high cost of raw materials, power cost and concentration of mills in one particular area. Government has taken several policy measures to remove the bottlenecks of availability of raw materials and infrastructure development. For example, to overcome short supply of raw materials, duty on pulp and waste paper and wood logs/chips has been reduced.

1.2 OBJECTIVES

After reading this unit you would be able to:

1 identify the raw material used in pulp and paper industry

2. Explain the importance of non- wood resources for paper making

3. Identify various species of bamboos and grasses used for making paper

1.3 PULP MILL

A **pulp mill** is a manufacturing facility that converts wood chips or other plant fibre source into a thick fibre board which can be shipped to a paper mill for further processing. Pulp can be manufactured using mechanical, semi-chemical or fully chemical methods (kraft and sulfite processes). The finished product may be either bleached or non-bleached, depending on the customer requirements.

Wood and other plant materials used to make pulp contain three main components (apart from water): cellulose fibres (desired for papermaking), lignin (a three-dimensional polymer that binds the cellulose fibres together) and hemicelluloses, (shorter branched carbohydrate polymers). The aim of pulping is to break down the bulk structure of the fibre source, be it chips, stems or other plant parts, into the constituent fibres.

Chemical pulping achieves this by degrading the lignin and hemicellulose into small, water-soluble molecules which can be washed away from the cellulose fibers without depolymerizing the cellulose fibres (chemically depolymerizing the cellulose weakens the fibres). The various mechanical pulping methods, such as groundwood (GW) and refiner mechanical (RMP) pulping, physically tear the cellulose fibres one from another. Much of the lignin remains adhering to the fibres. Strength is impaired because the fibres may be cut. There are a number of related hybrid pulping methods that use a combination of chemical and thermal treatment to begin an abbreviated chemical pulping process, followed immediately by a mechanical treatment to separate the fibres. These hybrid methods include thermomechanical pulping (TMP) and chemithermomechanical pulping (CTMP). The chemical and thermal treatments reduce the amount of energy subsequently required by the mechanical treatment, and also reduce the amount of strength loss suffered by the fibres.

1.3.1 Preparation of fibre source

The most common fibre source for pulp mills is pulpwood. Other common sources are bagasse and fibre crops. The first step in all mills using wood (trees) as the fibre source is to remove the bark. Bark contains relatively few usable fibers and darkens the pulp. The removed bark is burned, along with other unusable plant material, to generate steam to run the mill. Almost all wood is then chipped before it processed further to free the fibers. Removal of the bark is done in a *barker* (or *debarker*). The bark adhesion is about 3-5 kg/cm^2 in the growing season (summer) and 2-3 times higher in the dormant season (winter). The bark of frozen logs is even more difficult to remove.

In chemical pulp mills the bark is introducing unwanted contaminants as calcium, silica and aluminum that are causing scaling and gives an extra load for the chemical recovery system. Birch bark contains betulin, a terpenoid that easily makes deposits in a pulp mill.

1.4 PAPER FROM NON-WOOD FIBRES

Non-wood fibers have a long history as a raw material for papermaking. Hemp, ramie, cotton and rag fibers have been used for almost 2,000 years and wood only started to

replace them when paper usage began accelerating about 200 years ago and textile fibers out-priced themselves. Paper was first made in China in as early as 105 AD. It was produced from old rags, fishing nets, mulberry bark and grass. For the following 1700 years paper was made exclusively from non wood fiber. It was in 1857 that the process for pulping wood fibers and forming them into a paper web was invented. Wood was quickly established as the primary source of fiber for papermaking, and today provides some 90% of the fibrous raw material used in the process.
In 1970, the total worldwide capacity for production of non-wood plant fiber papermaking pulp was only 76,22,000 metric tones out of a total papermaking pulp capacity amounting to 11,35,32,000 metric tones. This amount represented only 6.7% of the total. However, since that time, there has been a dramatic increase in non-wood plant fiber pulping capacity. In 1993, total papermaking pulp capacity based on utilizing non-wood plant fibers amounted to 2,07,36,000 metric tones, or 10.6 per cent of the total. By 1998, it is projected that non-wood papermaking pulp capacity will reach 2,33,71,000 metric tones, or 11.2 per cent of the total. During the period from 1988-93, non-wood papermaking pulp capacity gained an average of 6% annually, or three times as fast as papermaking wood pulp capacity at 2% annually.
China currently produces half of the world's non-wood pulp, while Europe, Latin America and North America are still relatively small players. Nonwood sources for pulping are rags, bagasse, hemp, esparto grass, rye grass, ramie, bamboo, flax, wheat straw, kenaf, reed, rice straw and cotton linters. There is a lot of potential to upgrade what is presently considered state-of-art technology in straw pulping. It is now known that the raw material must be as clean and uniform as possible and the residue should be used to generate energy. For medium and linerboard production, an alkaline process, sodium hydroxide possibly with oxygen to improve yield, seems feasible. A mixture of recycled fiber and straw will most certainly be the main raw material for all corrugated medium production in future. For high quality linerboard up to 25% straw pulp, has proved to be acceptable.

Bleached non-wood fibers are an excellent raw material for printing papers, providing up to 50% of the fiber furnish, and can also be used for tissue and board production. Since wheat straw or similar crops do not have an ideal fiber composition compared to wood

fibers for papermaking, these fibers are still regarded as filler pulp. Other annual fibers are superior for yielding differing qualities. In Central Europe, elephant grass has a high yield when planted on agricultural land, and elephant grass and popular plantations are being seen as a future raw material for pulp & paper production. Professor Rudolf Patt at the University of Hamburg has clearly shown that elephant grass is the best nonwood raw material known today for papermaking fiber. Its pulping response is found to be excellent and its papermaking properties match those of fast-growing hybrid aspen. Researchers have proved that any grade of paper, paperboard or reconstituted panel board can be produced by properly selecting the appropriate mixture of non-wood plant fibers and the appropriate pulping processes. If circumstances demand, all grades can be produced without any addition of wood pulp. In fact, some grades are already being produced with 100% non-wood plant fibers. On a global basis, the future use of renewable non-wood plant fibers for production of papermaking is a reality indeed. With more than 90 million metric tones of cereal straw being available, more than 4 million tones of bagasse, 1 million tones of seed grass straw, 28 million tonne of grain sorghum stalks, and the exciting potential for kenaf, certainly these raw materials should be considered, at least as supplementary raw materials for paper-making pulp, especially in such areas where the cost of wood has seen a rather steep escalation. By a wide margin, the leading non-wood plant fiber presently in use is straw, followed by bagasse and bamboo. During 1993, total capacity of producing straw pulp worldwide was 9.566 million tones, with China having a share 88 per cent, followed by India with 3 per cent share. In the same year, worldwide bagasse pulping capacity was 2.984 million tones. China was again leading the table with 18.9% share, followed by Indian share of 12.16%. The worldwide bamboo pulping capacity in 1993 were 1.483 million tones, India being the leading country with 44.76% share, pushing China to second place with 27.74% share. However, both China and Thailand are increasing their bamboo pulp production at a rapid rate. Perhaps the greatest relative untapped bamboo forests are in Myanmar, but presently only 20,000 tonnes of bamboo pulp are being made there annually. Therefore, the potential for long fiber pulp production in Myanmar is very great. Since the country is opening to foreign investment, we may see some major activities there in the future. The largest capacity for producing pulp from miscellaneous

non-wood plant fibers is also concentrated in China with more than 85% of total world capacity.

Major World Producers of Non-wood Pulp

Country	Capacity (Million tones)	% of total
China	15.2	71%
India	2.0	9%
Mexico	0.3	1%
Peru	0.3	1%
Philippines	0.3	1%
Indonesia	0.3	1%
USA	0.2	1%
Thailand	0.2	1%
Colombia	0.2	1%
Brazil	0.2	1%
10- Country Total	**19.2**	**90%**
Total World	**21.3**	**100%**

Although, India was not the first to use bagasse as a source of paper-making raw materials, the Tamil Nadu Newsprint and Papers Limited (TNPL) is held up as an example to the world, as to what can be achieved using 80-100 % annual fibers to make commercial grades of paper. Earlier last year, TNPL succeeded in making 100% bagasse based newsprint. The most common non-wood fiber used in papermaking is straw accounting for some 47% of total production in 1993. Next largest source was bagasse at 12% and bamboo at 6%.

1.5 RAW MATERIALS

Probably half of the fiber used for paper today is obtained from wood that has been purposely harvested. The remaining material is gathered from wood fiber from sawmills, recycled **newspaper,** some vegetable matter, and recycled cloth. Coniferous trees, such as, spruce and fir, used to be preferred for papermaking because the cellulose fibers in the pulp of these species are longer than the hardwood species, therefore used for stronger paper. These trees are called "softwood" by the paper industry. Deciduous trees (such as, poplar and elm) are called "hardwood." Because of increasing demand for

paper, and improvements in pulp processing technology, almost any species of tree can now be harvested for paper.

Some plant species other than trees are also used suitably for paper-making. In areas where significant forests are limited in composition and area, bamboo has been used for paper pulp, like straw and sugarcane. Flex, hemp, and jute fibers are commonly used for textiles and **rope** making, but these can also be used for paper. The high-grade **cigarette** paper is made from flax.

Cotton and linen rags are used in fine-grade papers making, such as, letterhead and resume paper, and for currency notes and security certificates. The rags are usually cuttings and waste from textile and garment mills. The rags must be cut and cleaned, boiled, and beaten before these are used by the paper mill.

Other materials used in paper manufacturing include bleaches and dyes, fillers, such as chalk, clay, or titanium oxide, and sizings, such as resin, gum, and starch.

1.5.1 Wood Resources

The paper and pulp industry draws its raw material requirements mostly from the natural and planted forests. Wood occupies a position of pre-eminence as a raw material for paper making. In the past, the paper and pulp industry used softwood conifers, which have been most economical and ideal species for paper making.

Non-wood fibres. Agricultural residues (bamboo, bagasse, straw,etc.) form another source of raw materials for pulp as subsidiary source of waste paper. The use of waste paper is quite substantial in the major producing areas of the world. It is the principal raw material, particularly in some packaging grades of paper and paperboards. The material furnishes about 25 per cent of the total requirements of the paper and pulp industry in the developed countries. In the developing countries the amount of waste paper available for pulp manufacturing is relatively insignificant

Leader corporates in the paper industry are "Birlas, Thapars, Somanis and Bangurs". These four groups account for nearly half of the organized sector's production. of paper in India. These corporate plants paper-manufacturing plant species with fully indigenous know-how and machinery. They are expected to ease the burden on the conventional raw materials as they will be using waste paper, rags, agricultural residues, etc.

Utilization:

The non-wood fibres are by far the most important raw materials for paper making in India. The present pattern of utilization of various pulpable raw materials reflects to great extent the peculiar endowment of natural resources in the country. While wood is the principal fibrous raw material in all the leading paper manufacturing countries, the non-wood fibres constitute the principal source of supply to the Indian paper industry. Bamboo alone meets over 80 per cent of the total requirements of the raw material for paper and pulp. The consumption of bagasse, grass, jute, straw, waste paper and rags is also expanding with about 20 percent contribution. Sticks, waste paper, rags, eucalypt and other hard woods are also in use.

1.6 PULP AND PAPER YIELDING PLANTS

Ironically, the computer revolution has not decreased our use of paper as was predicted when computers began to appear in our homes and businesses. Instead, the demand for paper products has skyrocketed over the last 20 years. In the U.S. alone, per capita consumption of paper and paperboard exceeds 800 pounds each year which places enormous strain on forests that take decades to recover. The increasing popularity of bamboo paper may help to decrease reliance on wood pulp in papermaking and offer some relief to our remaining woodlands.

The Chinese have been making paper from bamboo for over 1,500 years but recent demand has grown considerably as consumers look for environmentally friendly products from renewable resources. Responding to the demand, paper manufacturers are introducing new bamboo paper products to the market that are comparable in strength, brightness, and printability to paper made from wood pulp.

There are numerous verities of trees and grasses in the region , which can yield material for paper and pulp. The babar grass found in sufficient quantities in the region and is a suitable material for making coarse cordage and paper. Dendrocalamus spp. Can be utilized in the same manner. The pulp manufactured from *Daphne papyraceae* yields material for a paper that gives the engraver finer impressions that any English - made paper and nearly as good as the fine Chinese paper that is employed for what are called India-paper proofs. The paper made from this shrub in Kumaun is almost as

strong and durable as leather and was largely used for village records and court proceedings. It is exported to Tibet in the north and to the plains in the south for manuscripts and account-books. Apart from this many other plants have paper value. Some important plants are Daphne papyraceae (Satpura), Dendrocalamus strictus(Bans.), dendrocalamus hamiltonii(Bans), *Eulaliopsis binata*(Babar), *Wikistroemia canescens* (Chameliya), *Desmodium tiliaefolium*

1.6.1 Bamboo

Over 100 species of bamboo occur naturally in India. Bambusa arundinacea, B. tulda, B polymorpha. Dendrocalamus strictus, D. hamil-tonii, Melocanna baccifera and Ochlandra travancorica are the most important species because of their wide availability. Dendrocalamus strictus and Bambusa arundinacea are the two principal economic species.

Because of its fast growth, easy propagation, early maturity and long and fine fibre quality , bamboo is an ideal species for paper industry. Bamboo is strong, straight and light. It is hard and hollow and easy to work. It comes in many sizes and has long fibres. Such characteristics make bamboo highly versatile.

Bamboo is the world's largest plant in the grass family and is the long fibre raw material which has been in use since the twenties.. Drawing on a long history of use, it has been integrated into modern technological world, with many types of goods produced particularly high quality paper. It grows abundantly throughout tropical and sub-tropical regions. The indispensability of this raw material can be gauged from the fact that all the available cellulosic raw materials like hardwoods, bagasse, straw, etc., are short fibred materials, the pulp from which will have to be blended with 25 percent of long-fibred pulp to make paper of good quality and adequate strength.

Bamboo has been used for papermaking for hundreds of years. Bamboo canes are used in commercial papermaking, but the fibers are very tough and need a lot of processing, which includes fermenting the canes for months. Bamboo sheaths are easier to use for making pulp for paper and they are the material used by crafters. Bamboo sheaths are the outer covering of the young bamboo, and they fall off as the bamboo grows. They are used often for paper making and require less time and effort than bamboo canes

1.6.2 Why should we use Bamboo Paper?

Listed below are several reasons to purchase and use bamboo paper products including:

- **Bamboo is a quickly renewable resource.** Bamboo is the single fastest growing species of plant on the planet with some species growing more than a meter a day. In sharp contrast to trees which require decades to recover from harvesting, bamboo reaches maturity in 3 to 5 years or less and when it is cut, the stem is left in the soil to sprout a new shoot and start the growing process again.
- **Bamboo thrives in depleted soil.** In environmentally stressed areas where rainforests have been clear-cut and burned, bamboo is one of the few plants that can grow easily and begin the process of returning nutrients to the soil. Bamboo also grows on mountainsides and on steep slopes where few other cash crops can.
- **Bamboo paper is recyclable.** Just like paper made from wood pulp, bamboo paper can be recycled to lessen our impact on the environment and further reduce our reliance on trees.
- **Bamboo helps to reduce soil erosion.** The rhizomes (roots) of the bamboo plant branch out from the stalk which helps to secure soil from erosion and retain precious soil moisture. This also helps to prevent silt from choking rivers and streams and affecting aquatic life.
- **Bamboo provides jobs and economic development.** In economically depressed areas where unemployment and lack of income foster civic unrest, bamboo offers farmers a viable cash crop and jobs in bamboo paper mills give residents a chance to provide a higher standard of living for their families. The exportation of bamboo paper products also allows poor countries a chance to build their economies and provide better roads and services.

As more and more consumers look for everyday products that are environmentally responsible, the emergence of bamboo paper products on the world's markets offers us a chance to save our remaining hardwood forests and reduce the catastrophic environmental effects of clear-cutting and deforestation. The impact of bamboo paper on the worldwide paper industry is still being determined but the largest

manufacturers are taking notice of this trend in the marketplace and introducing innovative uses for bamboo paper every day.

Various species of bamboo and their distribution

	Specise	Distribution	Fl. & fr.
1	*Arundinaria callosa*	Munro(Assa, Meghlaya, Arunachal Pradesh, Nagaland)	Mar.-May
2	*Arundinaria falcorneri*	Benth. Et Hook.f.(Himchal Pradesh,UttarPradesh, Sikkim,and West Bengal)	May- Oct.
3	*Arundinaria khasiana*	Munro(Assam & Meghalaya)	Aug.- Nov.
4	*Arundinaria mannii*	Gamble(Meghalaya, Assam, Arunchal Pradesh)	April- Oct.
5	*Arundinaria racemosa*	Munro(Sikkim, Arunachal Pradesh and West Bengal)	May- Oct.
6	*Arundinaria suberecta*	Munro(Khasi hills)	Not seen
7	*Bambusa arundinacea*	(Retz.) Willd.(Uttar Pradesh, Jammu Kashmir, Maharashtra, West Bengal, Meghalaya, Assam, Orissa, Bihar,Andhra Pradesh and Tamil Nadu)	Mar.- Aug.
8	*Bambusa balcooa*	Roxb. (Assam and West Bengal) • In Assam it is known as Balkua Bans and in in easter part of Bengal it is known as Teli Banss	Jun.-Dec.
9	*Bambusa khasiana*	Munro (Manipur and Meghalaya: Khasi hills)	Mar.-Dec.
10	*Bambusa nastersii*	Munro(Assam) • In Assam it is known as Beti Bans.	Not seen
11	*Bambusa nana*	Roxb. (West Bengal, Himachal Pradesh, Assam) • This bamboo is used as hedge plant in tea garden	Dec. – Feb.
12	*Bambusa nutans*	Wall. Ex Munro (Uttar Pradesh, Sikkim, Assam and Orissa)	May- Dec.
13	*Bambusa pallid*	Munro(Sikkim, Meghalaya, Assam, Arunachal Pradesh, Nagaland, Tripura)	Oct.-Jan.
14	*Bambusa polymorpha*	Munro(Meghalaya) • In Bangladesh it it is known as " Jama bans"	Aug.-Jan.
15	*Bambusa teres*	Ham. Ex Wall. (West Bengal and Assam)	Jan.
16	*Bambusa tulda*	Roxb.(Madhya Pradesh, Meghalaya, Assam) • Locally known as " Mulya Bans"	Dec.- Jun.
17	*Bambusa vulgaris*	Schroder(Uttar Pradesh, Sikkim, West Bengal and Andaman)	Ap.-Dec.
18	*Bambusa jaintiana*	R. B. Majumdar(Meghalaya)	Not seen

19	*Chimonobambusa callosa*	Nakai(Meghalaya,Manipur,and Mizoram)	Not seen
20	*Chimonobambusa griffIthiana*	Nakai(Meghalaya and Nagaland)	Not seen
21	*Chimonobambusa hookeriana*	Nakai(Arunachal Pradesh)	Not seen
22	*Chimonobambusa intermedia*	Nakai(Arunachal Pradesh)	Not seen
23	*Chimonobambusa jainiana*	Das et Pal (Sikkim)	Dec.-May
24	*Dendrocalamus giganteus*	Munro(Malay peninsula)	Not seen
25	*Dendrocalamus hamiltonii*	Nees et Am.ex Munro(Uttar Pradesh, Assam, Meghalaya and West Bengal)	Not seen
26	*Dendrocalamus hookeri*	Munro(Uttar Pradesh, Assam,Meghalaya)	Mar.-Sep.
27	*Dendrocalamus longispathus*	Kurz.(West Bengal)	Not seen
28	*Dendrocalamus patellaris*	Gamble(West Bengal, Assam and Nagaland)	Not seen
29	*Dendrocalamus sikkimensis*	Gamble ex Oliver(Sikkim, Meghalaya, Naga hills)	Not seen
30	*Dendrocalamus strictus*	Ness(throughout India)	Mar.-Oct.
31	*Dinochola compactiflora*	(Kurz)Mc Clure (West Bengal)	Not seen
32	*Dinochola nicobariana*	R. Majumdar(North Nicobar Island) * Culm used in house building	Not seen
33	*Melocalmus compactiflorus*	Benth.& Hook. f.(Assam, Meghalaya)	Mar.- Dec.
34	*Melocalmus gracilis*	R. Majumdar(Meghalaya)	April-Dec.
35	*Melocanna baccifera*	(Roxb.) Kurz. (West Bengal and Meghalaya) • Culm used in thatching	Not seen
36	*Ochlandra beddomei*	Gamble(South India)	Not seen
37	*Ochlandra brandisii*	Gamble(South India)	May- Aug.
38	*Ochlandra ebracteata*	Raizada et Chatterjee(Kerla)	Jun. – Oct.
39	*Ochlandra setigera*	Gamble(Tamil Nadu)	Not seen
40	*Ochlandra travancoria*	Benth(South India)	Not seen
41	*Oxytenanthera nigrociliata*	Munro(Garo hills, Orissa, Andaman)	Mar.- Jun.
42	*Phyllostachys assamica*	Gamble ex Brandi(Assam and West Bengal)	Jun.- Sep.
43	*Phyllostachys mannii*	Gamble(Assam,Meghalaya, Arunachal Pradesh, Nagaland)	Jun.-Sep.
44	*Racemobambos prainii*	(Gamble)keng f. et Wen(Assam, Naga Hills)	Not seen
45	*Schizostachyum capitatum*	(Munro)R.Majumdar (EasternHimalaya)	Not seen
46	*Schizostachyum dullooa*	(Gamble) R. Majumdar (Eastern Himalaya)	Not seen
47	*Schizostachyum grifilthii*	(Munro)R.Majumdar (EasternHimalaya)	Not seen
48	*Schizostachyum helferi*	(Munro)R.Majumdar (Valleys of North East Himalaya)	Not seen
49	*Schizostachyum kurzii*	(Munro) R. Majumdar (South Andman)	Not seen
50	*Semiarundinaria pantlingii*	Nakai(Arunachal Pradesh)	Not seen
51	*Sinarundinaria grffithiana*	(Munro) Chao et Renv. (Meghalaya, Khasia and Jaintia hills, Darjeeling, assam, Mizoram)	Not seen
52	*Sinarundinaria*	Chao et Renvoize (Assam)	Mar.- Jun.

	longispiculata		
53	*Sinarundinaria densifolia*	(Munro)Chao et Renv.(Kerala)	April-Nov.
54	*Sinarundinaria elegans*	(Kurz) Chao.et Renv.(Nagaland, Sikkim)	Mar.-Nov.
55	*Sinarundinaria falcate*	(Nees) Chao et Renv (Himachal Pradesh. Uttar Pradesh, Darjeeling, Nilgiri hills)	April- Jun.
56	*Sinarundinaria hirsute*	(Munro) Chao et Renv. (Manipur, Khasi hill. Naga hills)	Not seen
57	*Sinarundinaria hookeriana*	(Munro) Chao et Renv.(Darjeeling,Sikkim, Arunachal Pradesh)	Not seen
58	*Sinarundinaria maling*	(Gamble)Chao et Renv. (Darjeeling , Sikkim, Meghalaya)	May- Aug.
59	*Sinarundinaria pautlingii*	(Gamble)Chao et Renv. (Darjeeling, Sikkim)	Not seen
60	*Sinarundinaria polystachya*	(Kurz ex Gamble) Chao et Renv. (Darjeeling , Khasi hills. Uttar Pradesh)	Jul.- Sep.
61	*Sinarundinaria rolloana*	(Gamble) Chao et Renv. (Naga hills)	May- Oct.
62	*Sinarundinaria walkeriana*	(Munro) Chao et Renv.(Travancore)	Not seen
63	*Sinarundinaria wightiana*	(Nees) Chao et Renv.(Nilgiri hills)	Not seen
64	*Sinobambusa elegans*	Nakai(Nagaland)	Not seen
65	*Thamnocalamus aristatus*	(Gamble) E.G. Camus(Sikkim and Arunchal Pradesh)	Not seen
66	*Thamnocalamus falconeri*	Hook. f.apud Munro (Uttar Pradesh, Sikkim, and Arunchal Pradesh)	Not seen
67	*Thamnocalamus prijnii*	(Gamble) E.G. Camus (Meghalaya and Nagaland)	Not seen
68	*Thamnocalamus spathiflorus*	(trin)Munro (Arunachal Pradesh and Uttar Pradesh)	Oct.- May
69	*Thyrsostachys siamensis*	Gamble(Arunachal Pradesh)	Mar.- Jun.

1.6.3 Grasses

Sabai grass (*Eulaligpsis binata*) grows abundantly in Northern India i.e. the foot hills and possesses qualities closely resembling esparto grass. It is collected from sub-Himalayar tracts, mostly Nepal terai and Sahibganj (Bihar). The other grasses which are suitable for paper manufacture are- spear grass and elephant grass.

Grass Species and their distribution

Species	**Distribution**	**Fl. & Fr.**
Acrocra munroanum	Hem.(Assam, Meghalaya, Kerala)	Oct.-Nov.
Acroceras zizanioides	Dandy.(West Bengal, Assam, Nagaland)	April-Jan.
Acroceras tonl inense	C.E.Hubb.ex Bor.(Assam)	Sep- Nov.
Aristida adscensionis	L.(throughout India)	Aug.- Dec.

Aristida setacea	Retz(throughout India)	Jun.- Feb.
Aristida redacta	Stapf(Madhya Pradesh, Maharashtra, Rajasthan, West Bengal, Karnataka, Tamil NAdu)	Aug.- Dec.
Arundo donax	L.(throughout India)	April- Dec.
Arundinaria khasiana	Munro(Assam and Meghalaya)	Aug.- Nov.
Bothriochloa intermedia	(R. Br.) A. Camus(West Bengal, Bihar, Orissa and Assam)	May- Dec.
Capilipedium assimile	(Steud) A. Camus (throughout India)	Mar.- Dec.
Capilipedium parviflorum	(R.Br.) Stapf,(Northwest and Eastern India)	Aug.-Nov.
Cenchrus ciliaris	L.(Drier parts of India)	July- Dec.
Centotheca lappacea	Desv.(throughout India in forest margin)	May- Sep.
Chloris dolichostachya	Lagasca(South India)	Oct.- Dec.
Chrysopogon verticillatus	(Roxb.) Trin exSteud (West Bengal, Orissa , Bihar, Tamil Nadu)	Feb.- Mar.
Chrysopogon verticillatus	(Roxb.) Trinex Steud(West Bengal, Orissa, Bihar, Tamil Nadu)	Feb.- Mar.
Cybbopogon flexuosus	(Nees) Wats. (South India)	Aug.- Nov.
Cymbopogon nardus	(L.)Rendle (Central and Eastern India)	May- Feb.
Cyrtococcum oxyphyllum	Stapf.(throughout India in damp slops in forest)	Feb. – April
Eragrostiella bifaria	(Vahl.)Bar.(Madhya Pradesh, uttar Pradesh, West Bengal, Bihar, Orissa, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala)	Jul- Dec.
Erianthus ravennae	(L.) P. Beauv.(Uttar Pradesh, West Bengal, Orissa, Bihar, Assam , Meghalaya)	Mar.- Dec.
Eulalia leschenaultiana	(Decne)Ohwi (Uttar Pradesh, West Bengal, Bihar, Karnataka)	-
Hackelochlca granularis	(L.)O. Ktze.(Deciduous forest)	May- Jan.

Hystrix duthiei	Bar(Uttar Pradesh,)	Mar.- Sep.
Leptaspis urocolata	R. Br.(Kerala)	Oct.- Jan.
Lophatherum gracile	Brongn(Assam)	Oct.- Jan.
Microstegium ciliatum	A.Camus (Uuttar Pradesh, Madhya Pradesh,Maharashtra, Bihar, West Bengal, assam, meghalalaya, Andhra Pradesh, Nagaland, kerala)	Oct.- Feb.
Myriostachya wightiana	Hook.f. Sporobolus tremulus(Willd.)Kunth, Proteresia coarctata(Roxb.) tateckao, *Spinifex littoreus* (Burm. f.) Merr., are the principal grasses in mangrove forests.	Mar.- Nov.
Narenga porphyrocoma	(Hance) Bor. (Uttar Pradesh, West Bengal, Madhya Pradesh, Bihar, Sikkim, assam, Meghalaya)	Nov.- Feb.
Oplimenus composites	P. Beauv.(yhroughout India)	May- Feb.
Oplimenus Undulatifolius	P.beauv.(Punjab and Uttar Pradesh)	May- Oct.
Ottochloa nodosa	Dandy(Assam,Lushai hills)	Oct.-Feb.
Panicum brevifolium L.	(Sikkim.Assam, Meghalaya, Arunachal Pradesh, Nagaland.Orissa, Andhra Pradesh, Tamil Nadu, Kerala)	Aug.- Feb.
Panicum montanum	Roxb.(throughout India)	Oct.- Jan.
Panicum sarmentosum	Roxb.(Maharashtra.Bihar, West Bengal.Sikkim, Assam, Meghalaya, Arunachal Pradesh, Tripura)	Aug. –Nov.
Pennisetum pedicellatum	Trin.(throughout India)	Sep.-Dec.
Pennisetum purpureum	Schumach(Gujarat, West Bengal, Andhra Pradesh, Maharashtra, Kerala)	Aug.- Dec.
Pennisetum setosum	L.C. Rich. (Bihar, Madhya Pradesh, Nagaland, Orissa, Andhra Pradesh, Kerala)	May- Dec.
Phragmites karka	(Retz.) Trin.(throughout India)	Mar.- Dec.

	• Principal grasses of the deciduous forest with special reference to *Sal* forest	
Pogonatherum contortum	Brongn(Hill slopes)	Mar.- Dec
Pseudechinolaena polystachya	Stapf. (Eastern Himalaya-Khasi hills, Nagaland, Tamil Nadu,)	May- Nov.
Schizachyrium exile	(Hochst.)Staff.(uttar Pradesh, Madhya Pradesh, West Bengal, Bihar Meghalaya, Tamil Nadu, Kerala)	Aug.- Dec.
Setaria palmifolia	Stapf. (West Bengal, Assam, Meghalaya, Arunachal Pradesh, Andhra Pradesh, kerala)	Aug.- Nov.
Sorghum halepense	(L.) Pers. (Different parts of India)	May – Sep.
Streptogyna crinite	P. Beauv.(Kerala)	Not seen
Stipa sibririca	Lamk(Kashmir) • Principal grass in pine forest	Aug.- Dec.
Themeda anathera	Hack.(Kashmir, Uttar Pradesh) • Principal undergrowth of chir pine forest	Jun.-Sep.
Thysanolaena maxima	(Roxb.) O. Ktze.(throughout India)	April – Jan.
Themeda quadrivalais	(L.) O. Ktze.(Uttar Pradesh, Maharashtra, Rajasthan, Bihar, West Bengal, Sikkim, Nagaland, Manipur)	April- Nov.
Themeda triandra	Forssk.(throughout India)	March- Oct.
Themeda villosa	(Poir) A. Camus(Eastern India)	Aug.- Nov.

Source : Rawat S. P. 2008. Non-Timber Forest Products of India. Gene- Tech Books, New Delhi.

Straw is also used frequently for paper making.

Bagasse: India, which grows 100 million tonne of sugarcane, offers a large potential of bagasse, as by-product of sugarcane processing. The current supplies of bagasse to the

paper industry is obtained from large and modern sugar mills .However, in relation to the total availability of bagasse, its consumption in the paper industry is still negligible, i.e. about 1.5 percent of total raw material use

1.7 SUMMARY

* Non-wood forest produces are the produces from various forest-based species, such as, fruits, seeds, leaves, barks, roots, flowers and grasses, etc. including entire plant of medicinal importance. The forest ecosystems are very rich in regard to non-wood forest products. The animal produces like lac, honey,etc. are also non-wood forest products but generally the plant based produces are included as NWFPs.

* Paper contributes an important role in civilization and the modern society. The writing and printing papers have been considered as the important media to spread the message to masses; equally important as a packaging material and other uses.

*Paper is categorized into two categories-cultural (printing and writing paper) and industrial (packing and wrapping paper and boards). Cultural paper accounts for 60 per cent of the total societal demand and 40 per cent as industrial. The greater part of the industrial papers and paperboards is used in packaging. Rising economic activity stimulates the use of all types of packaging. The industrial papers are much in demand to feed the diversifying demand of industries.

* Non-wood fibers have a long history as a raw material for papermaking. Hemp, ramie, cotton and rag fibers have been used for almost 2,000 years and wood only started to replace them when paper usage began accelerating about 200 years ago and textile fibers out-priced themselves.

*Paper was first made in China in as early as 105 AD. It was produced from old rags, fishing nets, mulberry bark and grass.

1.8 REFERENCES

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1.9 TERMINAL QUESTIONS:

Q.1. Fill in the blanks:

(i). Some high-grade cigarette paper is made from.....

(ii). .....trees are called "softwood" by the paper industry.

(iii). .....grass grows abundantly in Northern India for manufacturing of paper.

(iv). Flex, hemp, and jute fibers are commonly used for textiles and ..... making

(i. flax. ii. Coniferous, iii. *Sabai,iv* . rope)

Q2 Discuss the non-wood fibre plants used for paper production.

Q3. List out various countries producing non-wood pulp.

Q4 Discuss the raw material used in paper production

Q5 Discuss various reasons to use bamboo as raw material for paper production.

Q6. List out various species of bamboos found in India. Mention their locality also.

Q7 List out various species of grasses found in India.

UNIT 2. PROCESS OF PAPER MAKING

Course structure

2.1 INTRODUCTION

Formed from wood pulp or plant fiber, paper is chiefly used for written communication. The earliest paper was papyrus, made from reeds by the ancient Egyptians. Paper was made by the Chinese in the second century, probably by a Chinese court official named Cai Lun. His paper was made from such things as tree bark and old fish netting. Recognized almost immediately as a valuable secret, it was 500 years before the Japanese acquired knowledge of the method. Papermaking was known in the Islamic world from the end of the eighth century A.D.

Paper, whether produced in the modern factory or by the most careful, delicate hand methods, is made up of connected fibers. The fibers can come from a number of sources

including cloth rags, cellulose fibers from plants, and, most notably, trees. The use of cloth in the process has always produced high-quality paper. Today, a large proportion of cotton and linen fibers in the mix create many excellent papers for special uses, from wedding invitation paper stock to special paper for pen and ink drawings.

The method of making paper is essentially a simple one mix up vegetable fibers, and cook them in hot water until the fibers are soft but not dissolved. The hot water also contains a base chemical such as lye, which softens the fibers as they are cooking. Then, pass a screen-like material through the mixture, let the water drip off and/or evaporate, and then squeeze or blot out additional water. A layer of paper is left behind. Essential to the process are the fibers, which are never totally destroyed, and, when mixed and softened, form an interlaced pattern within the paper itself. Modern papermaking methods, although significantly more complicated than the older ways, are developmental improvements rather than entirely new methods of making paper.

2.2 OBJECTIVES

After reading this unit you would be able to

1. Explain the history of paper making
2. Discuss tha manual and industrial paper making
3. Discus the process of paper making
4. Explain various categories of pulp

2.3 HISTORY OF PAPER MAKING

Papermaking is known to have been traced back to China about 105 CE, when Cai Lun, an official attached to the Imperial court during the Han Dynasty (202 BCE-220 CE), created a sheet of paper using mulberry and other bast fibres along with fishnets, old rags, and hemp waste(Herbert Holik 2006). However a recent archaeological discovery has been reported from Gansu province of paper with legible Chinese writings on it dating from 8 BCE, while paper had been used in China for wrapping and padding since the 2nd century BCE (Joseph 1986). Paper used as a writing medium became widespread by the

3rd century, and by the 6th century toilet paper was starting to be used in China as well. During the Tang Dynasty (618-907 CE) paper was folded and sewn into square bags to preserve the flavor of tea (Joseph (1986), while the later Song Dynasty (960-1279 CE) was the first government on Earth to issue paper-printed money.

In the 8th century, paper spread to the Islamic world, where the rudimentary and laborious process of papermaking was refined and machinery was designed for bulk manufacturing of paper. Production began in Baghdad and they invented a method to make a thicker sheet of paper. This helped transform papermaking from an art into a major industry. The earliest use of water-powered mills in paper production, specifically the use of pulp mills for preparing the pulp for papermaking, dates back to Samarkand in the 8th century. The earliest references to paper mills also come from the medieval Islamic world, where they were first noted in the 9th century by Arabic geographers in Damascus. Papermaking was diffused across the Islamic world, from where it was diffused further west into Europe.

Paper is recorded as being manufactured in both Italy and Germany by 1400, just about the time when the woodcut printmaking technique was transferred from fabric to paper in the old master print and popular prints. Modern papermaking began in the early 19th century in Europe with the development of the Fourdrinier machine, which produces a continuous roll of paper rather than individual sheets. These machines have become very large, up to 500 feet (~150 m) in length, producing a sheet 400 inches (~10 m) wide, and operating at speeds of over 60 mph (100 km/h). In 1844, both Canadian inventor Charles Fenerty and German inventor F.G. Keller had invented the machine and process for pulping wood for the use in papermaking. This would end the nearly 2000-year use of pulped rags and start a new era for the production of newsprint and eventually almost all paper out of pulped wood.

2.4 MANNUAL PAPER MAKING

Papermaking, regardless of the scale on which it is done, involves making a dilute suspension of fibers in water and allowing this suspension to drain through a screen so

that a mat of randomly interwoven fibers is laid down. Water is removed from this mat of fibers by pressing and drying to make paper.

First the fibers are suspended in water to form a slurry in a large vat. The mold is a wire screen in a wooden frame (somewhat similar to an old window screen), which is used to scoop some of the slurry out of the vat. The slurry in the screen mold is sloshed around the mold until it forms a uniform thin coating. The fibers are allowed to settle and the water to drain. When the fibers have stabilized in place but are still damp, they are turned out onto a felt sheet which was generally made of an animal product such as wool or rabbit fur, and the screen mold immediately reused. Layers of paper and felt build up in a pile (called a 'post') then a weight is placed on top to press out excess water and keep the paper fibers flat and tight. The sheets are then removed from the post and hung or laid out to dry. A step-by-step procedure for making paper with readily available materials can be found online.

When the paper pages are dry, they are frequently run between rollers (calendered) to produce a harder writing surface. Papers may be sized with gelatin or similar to bind the fibres into the sheet. Papers can be made with different surfaces depending on their intended purpose. Paper intended for printing or writing with ink is fairly hard, while paper to be used for water color, for instance, is heavily sized, and can be fairly soft.

The wooden frame is called a "deckle". The deckle leaves the edges of the paper slightly irregular and wavy, called "deckle edges", one of the indications that the paper was made by hand. Deckle-edged paper is occasionally mechanically imitated today to create the impression of old-fashioned luxury. The impressions in paper caused by the wires in the screen that run sideways are called "laid lines" and the impressions made, usually from top to bottom, by the wires holding the sideways wires together are called "chain lines". Watermarks are created by weaving a design into the wires in the mold. This is essentially true of Oriental molds made of other substances, such as bamboo. Hand-made paper generally folds and tears more evenly along the laid lines.

Hand-made paper is also prepared in laboratories to study papermaking and to check in paper mills the quality of the production process. The "handsheets" made

according to TAPPI Standard T 205 are circular sheets 15.9 cm (6.25 in) in diameter and are tested on paper characteristics as paper brightness, strength, degree of sizing.

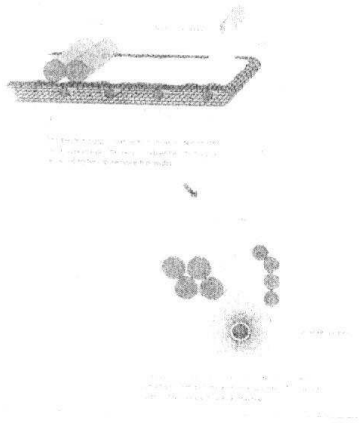
2.5 INDUSTRIAL PAPERMAKING

A modern paper mill is divided into several sections, roughly corresponding to the processes involved in making hand-made paper. Pulp is refined and mixed in water with other additives to make a pulp slurry, the headbox of the papermachine (Fourdrinier machine) distributes the slurry onto a moving continuous screen, water drains from the slurry (by gravity or under vacuum), the wet paper sheet goes through presses and dries and is finally rolled into large rolls, often weighing several tons.

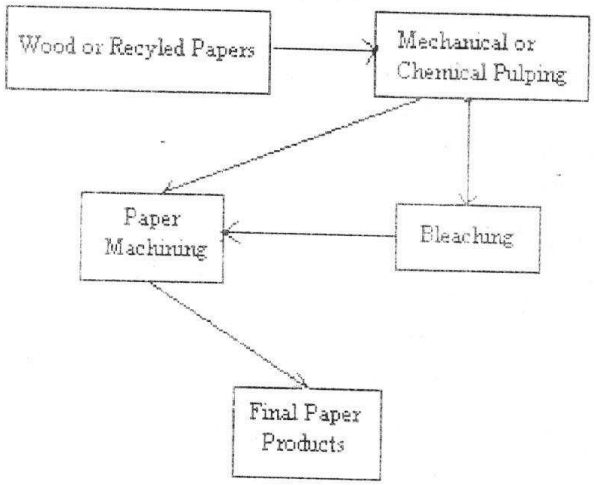
Another type of papermachine makes use of a cylinder mold that rotates while partially immersed in a vat of dilute pulp. The pulp is picked up by the wire and covers the mold as it rises out of the vat. A couch roller is pressed against the mold to smooth out the pulp, and picks the wet sheet off of the mold.

2.6 MANUFACTURE OF PULP

The first step in the manufacture of paper is conversion of the fibrous material into pulp. Several processes are commonly used to convert logs to wood pulp. In the mechanical process, logs are first tumbled in drums to remove the bark. The logs are then sent to grinders, which break the wood down into pulp by pressing it between huge revolving slabs. The pulp is filtered to remove foreign objects. In the chemical process, wood chips from de-barked logs are cooked in a chemical solution. This is done in huge vats called digesters. The chips are fed into the digester, and then boiled at high pressure in a solution of sodium hydroxide and sodium sulfide. The chips dissolve into pulp in the solution. Next the pulp is sent through filters. **Bleach** may be added at this stage, or colorings. The pulp is sent to the paper plant.



2.6.1 Mechanical process: Mechanical pulp is obtained from relatively soft wood like pine. The short, unbarked logs are subjected to mechanical grinding in presence of water. The pulpy material, thus, produced contains all the matter (lingo-cellulose) present in the original wood. Mechanical pulp is difficult to bleach and is used for manufacturing inferior paper, such as, newsprint, wall paper, etc. This paper turns yellow with age and cannot, therefore, be used for printing books, etc.



2.6.2 Chemical process:

In this process the material is cut into chips digested under pressure (cooked) with either (i) a solution of calcium bisulphate $Ca(HSO_3)_2$ (sulphite process) or (ii) a solution of caustic soda (soda process). This dissolves out the lignin which together with cellulose makes up the solid part of its structure. The pulpy material so obtained is washed and screened. It is then bleached by adding chlorine and water or with "bleach liquor". The bleached pulp is beaten with water in a "pulp beater". Beating is the process of reducing the fibres to minute shreds

and causing them to absorb and hold more water-an operation often referred to as "hydration"

2.6.3 Beating

The pulp is next put through a pounding and squeezing process called, appropriately enough, beating. Inside a large tub, the pulp is subjected to the effect of machine beaters. At this point, various filler materials can be added such as chalks, clays, or chemicals such as titanium oxide. These additives will influence the opacity and other qualities of the final product. Sizings are also added at this point. Sizing affects the way the paper will react with various inks. Without any sizing at all, a paper will be too absorbent for most uses except as a desk blotter. A sizing such as starch makes the paper resistant to water-based ink (inks actually sit on top of a sheet of paper, rather than sinking in). A variety of sizings, generally rosins and gums, is available depending on the eventual use of the paper. Paper that will receive a printed design, such as gift wrapping, requires a particular formula of sizing that will make the paper accept the printing properly.

2.6.4 Filling and sizing:

The paper is used as a convenient place to mix filling materials, colouring matter and sizing. Fillers and loading materials are various inorganic substances like clay, calcium carbonate, calcium sulphate, talc, titanium and zinc sulphide. These give the proper body to paper, improve the appearance, make better printing surface, increase the capacity and reduce the costs. Some ultramarine is added to give it the desired shade. Some other colouring materials may be added to give it the desired shade of colour. To prevent spreading of ink as on a blotting paper, the paper requires "sizing". For this purpose some sizing materials like resin, starch, glue or casein are either added to the better or applied to the sheet of paper during its manufacture.

2.7 PULPING

Most pulp mills use good forest management practices in harvesting trees to ensure that they have a sustainable source of raw materials. One of the major complaints about harvesting wood for pulp mills is that it reduces the biodiversity of the harvested forest.

Trees raised specifically for pulp production account for 16 percent of world pulp production, old growth forests account for 9 percent, and second- and third- and more generation forests account for the rest. Reforestation is practiced in most areas, so trees are a renewable resource. The FSC (Forest Stewardship Council) certifies paper made from trees harvested according to guidelines meant to ensure good forestry practices.

The number of trees utilized depends whether mechanical processes or chemical processes are used. It has been estimated that based on a mixture of softwoods and hardwoods 12 metres (40 ft) tall and 15-20 centimetres (6–8 in) in diameter, it would take an average of 24 trees to produce 0.9 tonne (1 ton) of printing and writing paper, using the kraft process (chemical pulping). Mechanical pulping is about twice as efficient in using trees since almost all of the wood is used to make fibre, therefore, it takes about 12 trees to make 0.9 tonne (1 tonne) of mechanical pulp or newsprint.

Preparation for pulping

Only the heartwood and sapwood are useful for making pulp. Bark contains relatively few useful fibres and is removed and used as fuel to provide steam for use in the pulp mill. Most pulping processes require that the wood be chipped and screened to provide uniform size.

There are a number of different processes which can be used to separate the wood fibres:

2.7.1 Mechanical pulp

Manufactured grindstones with embedded silicon carbide or aluminum oxide can be used to grind small wood logs called "bolts" to make stone groundwood pulp (SGW). If the wood is steamed prior to grinding, it is known as pressure groundwood pulp (PGW). Most modern mills use chips rather than logs and ridged metal discs called refiner plates instead of grindstones. If the chips are just ground up with the plates, the pulp is called refiner mechanical pulp (RMP) and if the chips are steamed while being refined the pulp is called thermomechanical pulp (TMP). Steam treatment significantly reduces the total energy needed to make the pulp and decreases the damage (cutting) to fibres. Mechanical pulps are used for products that require less strength, such as newsprint and paperboards.

2.7.2 Thermo mechanical pulp

Thermo-mechanical pulp is pulp produced by processing wood chips using heat (thus, thermo) and a mechanical refining movement (thus mechanical). It is a two stage process where the logs are first stripped of their bark and then converted into small chips. These chips have moisture content of around 25-30 percent and a mechanical force is applied to the wood chips in a crushing or grinding action which generates heat and water vapour and softens the lignin, thus, separating the individual fibres. The pulp is then screened and cleaned, any clumps of fibre are reprocessed. This process gives a high yield of fibre from the timber (around 95percent) and as the lignin has not been removed, the fibres are hard and rigid.

2.7.3 Chemi-thermo-mechanical pulp

Wood chips can be pretreated with sodium carbonate, sodium hydroxide, sodium sulfite and other chemicals prior to refining with equipment similar to a mechanical mill. The conditions of the chemical treatment are much less vigorous (lower temperature, shorter time, less extreme pH) than in a chemical pulping process since the goal is to make the fibres easier to refine, not to remove lignin as in a fully chemical process. Pulps made using these hybrid processes are known as chemi-thermo-mechanical pulps (CTMP).

2.7.4 Chemical pulp

Chemical pulp is produced by combining wood chips and chemicals in large vessels known as digesters where heat and chemicals break down the lignin, which binds the cellulose fibres together, without seriously degrading the cellulose fibres. Chemical pulp is used for materials that need to be stronger or combined with mechanical pulp to give a product different characteristic. The Kraft process is the dominant chemical pulping method, with sulfite process being second. Historically, soda pulping was the first successful chemical pulping method.

2.7.5 Recycled pulp

Recycled pulp is also called **deinked pulp** (DIP). DIP is recycled paper which has been processed by chemicals, thus, removing printing inks and other unwanted elements and freed the paper fibres. The process is called deinking.

DIP is used as raw material in papermaking. Many newsprint, toilet paper and facial tissue grades commonly contain cent-per-cent deinked pulp, and in many other grades, such as lightweight coated for offset and printing and writing papers for office and home use, DIP makes up a substantial proportion of the furnish.

2.8 BLEACHING

The pulp produced up to this point in the process can be bleached to produce a white paper product. The chemicals used to bleach pulp have been a source of environmental concern, and recently the pulp industry has been using alternatives to chlorine, such as, chlorine dioxide, oxygen, ozone and hydrogen peroxide.

Bleaching mechanical pulps

Mechanical pulps retain most of the lignin present in the wood used to make the pulp and thus contain almost as much lignin as they do cellulose and hemicellulose. It would be impractical to remove this much lignin by bleaching, and undesirable since one of the big advantages of mechanical pulp is the high yield of pulp based on wood used. Therefore the objective of bleaching mechanical pulp (also referred to as brightening) is to remove only the chromophores (color-causing groups). This is possible because the structures responsible for color are also more susceptible to oxidation or reduction

Alkaline hydrogen peroxide is the most commonly used bleaching agent for mechanical pulp. The amount of base such as sodium hydroxide is less than that used in bleaching chemical pulps and the temperatures are lower. These conditions allow alkaline peroxide to selectively oxidize non-aromatic conjugated groups responsible for absorbing visible light. The decomposition of hydrogen peroxide is catalyzed by transition metal , and iron, manganese and copper are of particular importance in pulp bleaching. The use of chelating agent like EDTA to remove some of these metal ions from the pulp prior to adding peroxide allows the peroxide to be used more efficiently. Magnesium salts and sodium silicate are also added to improve bleaching with alkaline peroxide (Biermann, Christopher J. 1993)

Sodium dithionite ($Na_2S_2O_4$), also known as sodium hydrosulfite, is the other main reagent used to brighten mechanical pulps. In contrast to hydrogen peroxide, which

oxidizes the chromophores, dithionite reduces these color-causing groups. Dithionite reacts with oxygen, so efficient use of dithionite requires that oxygen exposure be minimized during its use.(Biermann and Christopher 1993).

Chelating agents can contribute to brightness gain by sequestering iron ions, for example as EDTA complexes, which are less colored than the complexes formed between iron and lignin (Biermann and Christopher J. 1993).

The brightness gains achieved in bleaching mechanical pulps are temporary since almost all of the lignin present in the wood is still present in the pulp. Exposure to air and light can produce new chromophores from this residual lignin (Sjostrom 1993). This is why newspaper yellows as it ages. yellowing also occurs due to the acidic sizing

Bleaching of recycled pulp

Hydrogen peroxide and sodium dithionite are used to increase the brightess of deinked pulp. The bleaching methods are similar for mechanical pulp in which the goal is to make the fibers brighter.

Bleaching chemical pulps

Chemical pulps, such as those from the kraft process or sulfite pulping, contain much less lignin than mechanical pulps, (<5% compared to approximately 40%). The goal in bleaching chemical pulps is to remove essentially all of the residual lignin, hence the process is often referred to as delignification. Sodium hypochroride (household bleach) was initially used to bleach chemical pulps, but was largely replaced in the 1930s by chlorine. Concerns about the release of organochlorine compounds into the environment prompted the development of Elemental Chlorine Free (ECF) and Totally Chlorine Free (TCF) bleaching processes.

Delignification of chemical pulps is rarely a single step process and is frequently composed of four or more discrete steps. These steps are given a letter designation and these are given in the following table:

Chemical or process used	Letter designation

Chlorine	C
Sodium hypochlorite	H
Chlorine dioxide	D
Extraction with sodium hydroxide	E
Oxygen	O
Alkaline hydrogen peroxide	P
Ozone	Z
Chelation to remove metals	Q
Enzymes (especially xylanase)	X
Peracids (peroxy acids)	Paa
Sodium dithionite (sodium hydrosulfite)	Y

A bleaching sequence from the 1950s could look like: **CEHEH** . The pulp would have been exposed to chlorine, extracted (washed) with a sodium hydroxide solution to remove lignin fragmented by the chlorination, treated with sodium hypochlorite, washed with sodium hydroxide again and given a final treatment with hypochlorite. An example of a modern totally chlorine-free (TCF) sequence is **OZEPY** where the pulp would be treated with oxygen, then ozone, washed with sodium hydroxide then treated in sequence with alkaline peroxide and sodium dithionite.

Chlorine and hypochlorite

Chlorine replaces hydrogen on the aromatic rings of lignin via aromatic substitution, oxidizes pendant groups to carboxylic acid and adds across carbon carbon double bonds in the lignin sidechains. Chlorine also attacks cellulose, but this reaction occurs predominantely at pH 7, where un-ionized hypochlorous acid, HClO, is the main chlorine species in solution. To avoid excessive cellulose degradation, chlorination is carried out at pH <1.5.

$$Cl_2 + H_2O \rightleftharpoons H^+ + Cl^- + HClO$$

At pH >8 the dominant species is hypochlorite, ClO^-, which is also useful for lignin removal. Sodium hypochlorite can be purchased or generated *in situ* by reacting chlorine with sodium hydroxide.

$$2\ NaOH + Cl_2 \rightleftharpoons NaOCl + NaCl + H_2O$$

The main objection to the use of chlorine for bleaching pulp is the large amounts of soluble organochlorine compounds produced and released into the environment.

Chlorine dioxide

Chlorine dioxide, ClO_2 is an unstable gas with moderate solubility in water. It is usually generated in an aqueous solution and used immediately because it decomposes and is explosive in higher concentrations. It is produced by reacting sodium chlorate with a reducing agent like sulfur dioxide.

$$2\ NaClO_3 + H_2SO_4 + SO_2 \rightarrow 2\ ClO_2 + 2\ NaHSO_4$$

Chlorine dioxide is sometimes used in combination with chlorine, but it is used alone in ECF (elemental chlorine-free) bleaching sequences. It is used at moderately acidic pH (3.5 to 6). The use of chlorine dioxide minimizes the amount of organochlorine compounds produced.

Extraction or washing

All bleaching agents used to delignify chemical pulp, with the exception of sodium dithionite, break lignin down into smaller, oxygen-containing molecules. These breakdown products are generally soluble in water, especially if the pH is greater than 7 (many of the products are carboxylic acids). These materials must be removed between bleaching stages to avoid excessive use of bleaching chemicals since many of these smaller molecules are still susceptible to oxidation. The need to minimize water use in modern pulp mills has driven the development of equipment and techniques for the efficient use of available water.

Oxygen

Oxygen exists as a ground state triplet state which is relatively unreactive and needs free radicals or very electron-rich substrates such as deprotonated lignin phenolic groups. The production of these phenoxide groups requires that delignification with oxygen be carried out under very basic conditions (pH >12). The reactions involved are primarily single electron (radical) reactions. Oxygen opens rings and cleaves sidechains giving a complex

mixture of small oxygenated molecules. Transition metal compounds, particularly those of iron, manganese and copper, which have multiple oxidation states, facilitate many radical reactions and impact oxygen delignification. While the radical reactions are largely responsible for delignification, they are detrimental to cellulose. Oxygen-based radicals, especially hydroxyl radicals, HO•, can oxidize hydroxyl groups in the cellulose chains to ketones, and under the strongly basic conditions used in oxygen delignification, these compounds undergo reverse aldol reactions leading to cleavage of cellulose chains. Magnesium salts are added to oxygen delignification to help preserve the cellulose chains, but mechanism of this protection has not been confirmed.

Hydrogen peroxide

Using hydrogen peroxide to delignify chemical pulp requires more vigorous conditions than for brightening mechanical pulp. Both pH and temperature are higher when treating chemical pulp. The chemistry is very similar to that involved in oxygen delignification, in terms of the radical species involved and the products produced. Hydrogen peroxide is sometimes used with oxygen in the same bleaching stage and this is give the letter designation **Op** in bleaching sequences. Metal ions, particularly manganese catalyze the decomposition of hydrogen peroxide, so some improvement in the efficiency of peroxide bleaching can be achieved if the metal levels are controlled.

Ozone

Ozone is a very powerful oxidizing agent and the biggest challenge in using it to bleach wood pulp is to get sufficient selectivity so that the desirable cellulose is not degraded. Ozone reacts with the carbon carbon double bonds in lignin, including those within aromatic rings. In the 1990s ozone was touted as good reagent to allow pulp to be bleached without any chlorine-containing chemicals (totally chlorine-free, TCF). The emphasis has changed and ozone is seen as an adjunct to chlorine dioxide in bleaching sequences not using any elemental chlorine (elemental chlorine-free, ECF). Over twenty-five pulp mills worldwide have installed equipment to generate and use ozone.

Chelant wash

The effect of transition metals on some of the bleaching stages has already been mentioned. Sometimes it is beneficial to remove some of these metal ions from the pulp by washing the pulp with a chelating agent such as EDTA or DTPA. This is more

common in TCF bleaching sequences for two reasons: the acidic chlorine or chlorine dioxide stages tend to remove metal ions (metal ions usually being more soluble at lower pH) and TCF stages rely more heavily on oxygen-based bleaching agents which are more susceptible to the detrimental effects of these metal ions. Chelant washes are usually carried out at or near pH 7. Lower pH solutions are more effective at removing transition metals, but also remove more of the beneficial metal ions, especially magnesium

Other bleaching agents

A variety of more exotic bleaching agents have been used on chemical pulps. They include peroxyacetic acid peroxyformic acid, potassium peroxymonosulfate (Oxone), dimethyldioxirane , which is generated *in situ* from acetone and potassium peroxymonosulfate, and peroxymonophosphoric acid (Springer 1997).

Enzymes like xylanase have been used in pulp bleaching to increase the efficiency of other bleaching chemicals. It is believed that xylanase does this by cleaving lignin-xylan bonds to make lignin more accessible to other reagents (Biermann and Christopher 1993). *Essentials of Pulping and Papermaking*. San Diego: Academic Press. Inc. It is possible that other enzymes such as those found in fungi that degrade lignin may be useful in pulp bleaching.

Environmental considerations

Bleaching mechanical pulp is not a major cause for environmental concern since most of the organic material is retained in the pulp, and the chemicals used (hydrogen peroxide and sodium dithionite) produce benign byproducts (water and sodium sulfate (finally), respectively).

However, the bleaching of chemical pulps has the potential to cause significant environmental damage, primarily through the release of organic materials into waterways. Pulp mills are almost always located near large bodies of water because they require substantial quantities of water for their processes. An increased public awareness of environmental issues from the 1970s and 1980s, as evidenced by the formation of organizations like Greenpeace, influenced the pulping industry and governments to address the release of these materials into the environment.

Conventional bleaching using elemental chlorine produces and releases into the environment large amounts of chlorinated organic compounds, including chlorinated dioxins. Dioxins are recognized as a persistent environmental pollutant, regulated internationally by the Stockholm Convention on Persistent Organic Pollutants.

Dioxins are highly toxic, and health effects on humans include reproductive, developmental, immune and hormonal problems. They are known to be carcinogenic. Over 90% of human exposure is through food, primarily meat, dairy, fish and shellfish, as dioxins accumulate in the food chain in the fatty tissue of animals.

As a result, from the 1990 onwards the use of elemental chlorine in the delignification process was substantially reduced and replaced with ECF (Elemental Chlorine Free) and TCF (Totally Chlorine Free) bleaching processes. In 2005, elemental chlorine was used in 19-20% of kraft pulp production globally, down from over 90% in 1990. 75% of kraft pulp used ECF, with the remaining 5-6% using TCF.Most TCF pulp is produced in Sweden and Finland for sale in Germany, all markets with a high level of environmental awareness. In 1999, TCF pulp represented 25% of the European market.

TCF bleaching, by removing chlorine from the process, reduces chlorinated organic compounds to background levels in pulp mill effluent.ECF bleaching can substantially reduce but not fully eliminate chlorinated organic compounds, including dioxins, from effluent. While modern ECF plants can achieve chlorinated organic compounds (AOX) emissions of less than 0.05 kg per tonne of pulp produced, most do not achieve this level of emissions. Within the EU, the average chlorinated organic compound emissions for ECF plants is 0.15 kg per tonne.

However, there has been disagreement about the comparative environmental effects of ECF and TCF bleaching. On the one hand, paper and chemical industry-funded studies have generally found that there is no environmental difference between ECF and TCF effluents. On the other hand, independent peer-reviewed study has found that, comparing conventional, ECF and TCF effluents before and after secondary treatment, "TCF effluents are the least toxic".

2.9 MANUFACTURE OF PAPER

The thin suspension obtained from the beater is called 'soup' by the paper maker. It is taken to a tank called the 'stock box'. The soup is forced through a thin slit in the bottom of the stock box. It falls on an endless band of fine wire gauge screen in motion. As the screen moves forward, the water present in soup drains through it and the fibres mat together. The process of draining is assisted by vacuum from the suction boxes over which the wire gauge screen travels. The fibrous sheet next passes between heavy press rolls covered with felt. Here the excess of water is removed. The sheet is then passed between drying cylinders which are steam heated. In some cases when sizing materials have not been added in the beater, these are applied here in the drier section or even after the driers. Sizing materials are made into a paste and applied to one or both sides of the paper sheet. The excess material is removed as the sheet passes between squeeze rolls.

2.9.1Calendaring:

The surface of the dried sheet is generally rough and irregular. It is passed through a series of very hot and polished rolls. As a result of it surface becomes compact and smooth and it takes a fine glaze. The process is known as *calendaring*. After calendaring the sheet goes to the reel where it is wound into large rolls of finished paper. The roll when full is sent to the slitting machine for cutting paper into rolls of proper width and diameter.

2.9.2 Finishing

Finally, the dried paper is wound onto large reels, where it will be further processed depending on its ultimate use. The paper may be further finished by passing through a vat of sizing material. It may also receive a coating, which is either brushed on or rolled on. Coating adds chemicals or pigments to the paper's surface, supplementing the sizings and fillers from earlier in the process. Fine clay is often used as a coating. The paper may next be supercalendered, that is, run through extremely smooth calendar rollers, for a final time. Then the paper is cut to the desired size.

2.9.3 Environmental Concerns

The number of trees and other vegetation cut down in order to make paper is enormous. Paper companies insist that they plant as many new seedlings of trees as they cut down. Environmentalists contend that the new growth trees, so much younger and smaller than

what was removed, cannot replace the value of older trees. Efforts to recycle used paper (especially newspapers) have been effective in at least partially mitigating the need for destruction of woodlands, and recycled paper is now an important ingredient in many types of paper production.

The chemicals used in paper manufacture, including dyes, inks, bleach, and sizing, can also be harmful to the environment when they are released into water supplies and nearby land after use. The industry has, sometimes with government prompting, cleared up a large amount of pollution, and federal requirements now demand pollution-free paper production. The cost of such clean-up efforts is passed on to the consumer.

2.10 PAPER INDUSTRY IN INDIA

The manufacture of machine-made paper in India dates back to 1867 when the first mill was established on the Hooghly. There were 58 paper mills in 1967-70, 10 in West Bengal; 3 in Orissa; 2 in Uttar Pradesh; 2 in Bihar; 4 in Punjab; 5 in Madhya Pradesh; 6 in Gujarat; 14 in Maharashtra; 2 in Andhra Pradesh; 5 in Karnataka; 2 in Kerala and 3 in Chennai (Tamil Nadu). Some important paper mills are listed below:

S.No.	Name of mill	Location
1	Titaghur Paper Mills Ltd.	West Bengal
2	Bengal Paper Mills Ltd.	West Bengal
3	Orient Paper Mills Ltd.	Orissa
4	Straw Products Ltd.	Orissa
5	Star Paper Mills Ltd.	Uttar Pradesh
6	Rohtas Industries Ltd.	Bihar
7	Shree Gopal Paper Mills Ltd.	Punjab
8	Orient Paper Mill Ltd.	Madhya Pradesh
9	National News Print and Paper Mill Ltd.	Madhya Pradesh
10	Ballarpur Paper and Straw Board Mills Ltd	Maharashtra
11	Sirpur Paper Mills Ltd.	Ahdhra Pradesh
12	Andhra Pradesh Paper Mills	Ahdhra Pradesh
13	West Coast Paper Mills	Karnataka

14	Centuary Pulp and Paper Mill ,Lalkuan,Nainital	Uttarakhand

2.11 SUMMARY

- Papermaking is known to have been traced back to China about 105 CE, when Cai Lun, an official attached to the Imperial court during the Han Dynasty (202 BCE-220 CE), created a sheet of paper using mulberry and other bast fibres along with fishnets, old rags, and hemp waste(Herbert Holik 2006).
- The first step in manufacturing of paper is conversion of the fibrous material into pulp. Two processes used for this purpose: Mechanical process and chemical process.
- There are number of different processes which can be used to separate the wood fibre: Mechanical, thermomechanical, Chemo-thermomechanical Chemical and Recycling

2.12 REFERENCES

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2.13 TERMINAL QUESTIONS

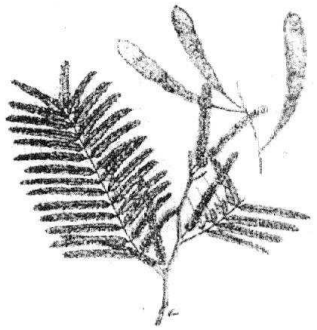
Fill in the blank spaces given below:

1. The largest single energy user at a paper mill is .....
2. If the pulp will not be used on-site it becomes .....
3. The pulping process produces a liquid bioproduct called .....

4. Many papers require a ..... to be complete.
5. The first paper mill was established in.....
6. Only the ..... and sapwood are useful for making pulp.

(1. boiler fuel, 2. market pulp, 3. color-liquor, 4. coating, 5. Hooghly, 6. heartwood)

Katha is obtained from the heartwood of khair (*Acacia catechu*). On boiling with water, the heartwood of the tree yields catechu. The two common varieties of Catechu marketed in India are the pale catechu and the dark catechu commonly called as Katha and cutch, respectively. In some of the older trees, a third substance called as Kheersal is also obtained. It is a white powder or crystalline solid material found in the cavities of the wood and occurs in small irregular fragments. It can be readily purified by the crystallisation with hot water. It is valued for its medicinal properties and used for the treatment of cough and sore throat.



Acacia catechu. 1) flowering branch, 2) branchlet with fruits. Source: *Bentley Sec.* 1 "Dye and tanning producing plants"

In the Indian market, katha is sold in irregular pieces or small square blocks grey in colour. On breaking, these pieces show crystalline fracture. Katha is extensively used in pan preparations and medicines. It is an essential ingredient of pan preparation. It is applied in combination with lime. It gives a red colour resulting from the chewing of pan. Katha is considered to be an astringent, cooling and digestive, and useful in relaxed conditions of throat and gums. It is used for the treatment in cough and diarrhoea. It is also used as cooling applicant to ulcers, boils and skin eruptions.

Cutch or dark catechu is used for dyeing cotton and silk fabrics and in calico printing. Cutch brocun is obtained by steeping the material in a boiling solution of cutch and cusoy. The dark catechu or the cutch is marketed in the form of small cubes or blocks. It is rusty brown or dull orange in colour, and has conchoidal fracture. It possesses high tannin content and was earlier used as a tanning material. It is used as dyeing and preserving agent. Cutch is widely used in printing than in dyeing. In printing, it is used for two main classes - one for producing very fast steam brown and drabs, and other for producing brown in combination with red and chocolate. Cutch can be printed on with a starch tragacanth. On mixing cutch with diazo salts, a wide range of bright and attractive shades with moderate fastness to most of the agencies and poor fastness, can be

produced. It is used for dyeing the ship sails based on its excellent fastness and for its preservative action, which prevents the rotting of cotton from sea water. It is also used in Indian pharmacopoeia. It can be used for dyeing paper and pulp.

The chief components of khair heartwood include catechin and catechu tannic acid. The proportion of cutch in heartwood is nearly upto 17 per cent. The highest annual production of Katha from a factory is about 350-450 tonnes and the annual production of cutch is 750-800 tonnes. In many parts of the country, such as, in Gujarat and Orissa, there are communities traditionally engaged in the extraction of cutch and katha. The important centres of production include states, viz:Madhya Pradesh, Maharashtra and Gujarat. Cutch is exported mainly to United Kingdom. It is considered to be a good source for forest revenue.

Catechu also known as **cachou**, **cutch**, **cashoo**, or **Japan earth** is an extract of any of several species of *Acacia*—but especially *Acacia catechu*—produced by boiling the wood in water and evaporating the resulting brew.

Catechu (called *katha* in Hindi, *kachu* in Malay, hence Latin *Acacia catechu* as the type species which provides the extract) is an astringent and has been used since ancient times in Ayurvedic medicine as well as in breath-freshening spice mixtures.

The mixture is high in natural vegetable tannins (which accounts for its astringent effect), and may be used for the tanning of animal hides. Early research by Sir Humphry Davy in the early 19th century first demonstrated the use of catechu in tanning over more expensive and traditional oak extracts. The extract gave its name to the catechin and catechol chemical families first derived from it.

Black Catechu has recently also been utilized by Blavod Drinks Ltd. to dye their vodka black.

UNIT III MATERIAL AND EXTRACTION

Course structure

3.1 INTRODUCTION

Various non-wood forest products have already been discussed in the previous units of NWFP-basics. Non-wood forest products (NWFP) are extensively extracted from Indian forests, and their role in rural and forest economies is immense. However, the long-term ecological sustainability of NWFP extraction with respect to resource populations, dependent animal species and ecosystem functioning has remained largely unexamined. Still there are a number of useful products yielded by forests which could not be included in groups already discussed. These products are grouped under miscellaneous products e.g katha and cutch. In this unit we will discuss about katha and cutch with special reference to material and extraction.

Kattha & cutch are extracted from wood of Khair tree(A). Acacia is the botanical name of this tree and it has different varieties like Acacia Sundra, Acacia Catechuoides & Acacia Catechu. These species of tree are mainly concentrated in Uttarakhand Uttar Pradesh, Bihar, Rajasthan, Gujarat and Himachal Pradesh. The preferred locations are either UP or Bihar.

Manufacture of katha is an important forest based traditional industry in India. The Cetral Forest Research Institute , Dehradun has developed an improved process to manufacture of these products in simple and does not require sophisticated technology or equipment.

3.2 OBJECTIVES

After reading this unit you would be able to

1. Explain the various species of Acacia used for extraction of katha and cutch
2. Discuss about Katha industries

3.3 SPECIES USED FOR EXTRACTION

Acacia catechue (Khair)

Khair (*Acacia catechu*) is a moderate size deciduous tree with rough dark gray brown bark. It belongs to family Leguminoseae-mimoseae. It is said that the name 'catechu' was given to it because its bristles resemble the claws of animals of the cat family or maybe because its heart wood contains cutch. It is also called khoira, koir, kheriya baval, kher babul, kagli, cachu, kugli, kaderi and sandra in local Indian languages (Hindi, Punjabi). Khair grows naturally all over Haryana and the rest of Indian subcontinent areas experiencing average rainfall, in the whole of the Indo Gangetic plain from Assam westwards, right up to Afghanistan. Also from sea coast to Deccan Plateau and then northwards to the lower Himalayan ranges having an altitude up to about 1250 m or so. Khair grows well on all kinds of geological formations and soils, but porous alluvium consisting of sand and shingle suits it best. It grows on granite, gneiss, schist, quartzite, shale, trap, limestone conglomerate, laterite, etc. and also on black cotton soil. Khair grows slowly and matures to a height of about 10 meters in about 55 years. The diameter of the trunk is about 30 to 40 cm, and it is seldom straight. Instead, it generally tends to be crooked with an irregular shaped crown. Its bark is gray in color and nearly 8 mm to 12 mm thick. It tends to come off in small patches of irregular shape. Khair (*Acacia catechu*) is generally leafless during late spring to early summer. Old leaves are generally shed during Jan-Feb and new ones appear during April- May. The species gets full foliage by June-July when it paints the environment and landscape so very beautifully. The leaves of khair are compound. The rachis branching from the mid-rib has 4 to 5 round prickle. The rachis is nearly 10 to 20 cm long and bears 20 to 60 pinnae each about 3 to 4 cm long. The khair tree flowers during June to October. Its inflorescence is pale yellow to cream colored. The fruit of khair is pod shaped. It is 5 to 7 cm long and 1 to 1.5

cm wide and shining brown in color. The sap wood of khair is large and yellowish white and heart wood is small and red in color. The wood darkens on exposure. Sap wood weighs about 20 kilogram and heart wood weighs 25 to 28 kilogram per cubic foot. While the sap wood is liable to be attacked by a variety of insects, the heart wood is too hard to be attacked by any of such insects. The wood being hard is used for making rice pestles, hookah stems, rollers for crushing sugar cane and oilseeds, ploughs , handles for knife, daggers and swords. The wood is also used for making quality charcoal which is eagerly sought by gold, silver and blacksmiths. While the wood is smooth and lustrous, and takes good polishing, it is not used in house construction because of superstition. The khair tree is very useful in a number of ways. A pale yellow mucilaginous gum exudes from the tree, yielding one of the best substitutes for true gum arabic. Its wood contains catechin, catechutanic acid and tannin. The wood extracts are used for tanning and dyeing khaki. The bark and roots of khair are used in treating sore mouth, body pains, gravel, bronchial asthma and indigestion. The bark is especially useful as astringent, and a cure in cough, diarrhea and indigestion, cancer, piles, sore throat, ulceration, eczema and certain forms of leprosy. Katha is a white substance found in Khair wood. It is obtained by boiling small chips of the heart wood in specially designed earthen pitchers and allowing the concentrate to cool and crystallize. Katha is not only used as a remedy for body pain but also in medicines for other human ailments. Katha is also used extensively in 'pan'. It forms an important ingredient of adhesives for plywood and is also extensively used in drying canvas and sizing of fishing nets and ropes. Because of their various uses, Khair tree wood, bark and roots are in great demand. While the going price of a standing khair tree of approximately one-foot diameter is about Rs 2000, the Katha sells at nearly Rs 600 per kg. The bark fetches nearly Rs 20 per kg. The tree has always been subjected to extensive exploitation- both legal as well as illegal. Khair tree regenerates quite abundantly in suitable soil and moisture conditions, the growers tend to assist the nature artificially to stock the vacant areas with this species at a quick pace. For that its seeds are collected during winter and sown in polythene bags during spring. The

transplanting of the seedling is best done during the rainy season. In natural habitat it can

be raised easily by direct sowing as well.*Acacia catechu* is a deciduous tree with a light feathery crown and dark brown, glabrous, slender, thorny, shining branchlets, usually crooked. Bark dark brown or dark grey, brown or red inside, nearly 12-15 mm in thickness, rough, exfoliating in long narrow rectangular flakes which often remain hanging. Blaze very hard, colour brown and then deep pink.

Branchlets armed with pseudo-stipular spines in pairs below the petioles. Pod 10-15 cm by 2-3 cm, thin, straight, flat, glabrous dark-brown and shining when mature. Seeds 3-8, about 5 mm in diameter.

(b) Natural Habitat and Classification

Acacia catechu is widely distributed throughout the greater part of India except the most humid, cold and the driest regions. It is common in the sub-Himalayan tract and outer Himalayas ascending from 900 to 1,200 m from Jammu to Assam. The record distribution of khair shows that the various forms of it, rather than overlapping, appear representative of none or another tolerably well defined areas.

Var. catechu – Found chiefly in Punjab, Garhwal and Kumaon, Bihar and Orissa. In the sub-Himalayan tract and the outer Himalayas, it ascends upto 900-1200 m elevation.

Var. catechuoides – Found chiefly in Sikkim terai, West Bengal and Assam. This is the Burmese form.

Var. sundra – Found chiefly in the Indian Peninsula. This is southern and western form occurring in the Deccan, Maharashtra, Gujarat and Rajasthan.

Thus the var. catechu has never been found in Eastern Himalayas nor in Assam. The var. catechuoides is apparently absent from the Western peninsula. The var. sundra which is now given specific rank *Acacia chundra*, is confined to Deccan, Gujarat, Rajasthan, Southern Maharashtra only.

Classification

Acacia catechu occurs in tropical moist deciduous forests, dry tropical forests and tropical thorn forests in the following sub-types as given by Champion and Seth (1968).

In low alluvial savannah wood land (3/1S1) associated with *Bombax ceiba, Butea monosperma, Dalbergia sissoo* etc. In Southern tropical dry deciduous forests (5 A), Khair occurs in very dry teak forests (5 A/C1a) and dry teak forest (5A/C1b), associated with associates of teak. It also occurs in southern dry mixed deciduous forests (5A/C3). Common associates are *Terminalia alata, Boswellia serrata, Azadirachta indica* etc.

In northern tropical dry deciduous forest (5B), khair occurs in dry sal bearing forests (5B/C1), dry Siwalik sal forest (5B/C1a), dry peninsular sal forests (5B/C1c) and northern dry mixed deciduous forests (5B/C2). Common associates are *Shorea robusta, Terminalia alata, Terminalia bellirica, Boswellia serrata* etc. Khair occurs in dry deciduous scrub (5/DS1), associated with *Nyctanthes arbortristis, Dodonaea viscosa, Woodfordia fruticosa, Carissa opaca, Flacourtia indica, Lannea coromandelica* etc. It occurs in edaphic climax types of dry deciduous forests as in Anogeissus forest (5/E1) m and Aegle forest (5/E6). It is also found in the seral type of dry deciduous forests as in Khair-Sisam forests (5/1S2).

In southern tropical thorn forests (6A/C1), Acacia catechu occurs associated with *Acacia leucophloea, Anogeissus latifolia, Azadirachta indica*, etc. Climate In the natural habitat of khair, the absolute maximum shade temperature varies from 40oC to 50oC and the absolute minimum from 2.5oC to 7.5oC. The mean daily maximum temperature in May which is generally the hottest month in the hot weather varies from 37.5oC to 43.5oC. The mean daily minimum temperature in January which is the coldest month of the year varies from 1.0oC to 2.1oC.

Acacia catechu is essentially a tree of comparatively dry regions though in its alluvial form, it extends into regions of heavy rainfall as in the Eastern sub-Himalayan tract, where it is found in places with rainfall as high as 3,800 mm. Away from riverain tracts it occurs in localities where the normal rainfall varies from 500 to 2160 mm. Khair develops to its maximum size in localities with heavy rainfall but it is decidedly xerophilous and grows in dry situations where few other species survive.

Topography It is found on flat or gently undulating ground and ravine country as well as in hilly region but seldom extends in areas above 1200 m in elevation above the sea level.

Geology and Soil

Khair occurs on a variety of geological formations and soil, though it undoubtedly thrives best on porous alluvium, composed of sand and shingle and on well drained sandstone. It is known to occur on granite, gneiss, schist, quartzite, shale, basalt, limestone, conglomerate and laterite.

Taxonomy

Ecology and distribution

History of cultivation

The use of A. catechu tanning agent (cutch) in India is believed to go back as far as history relates. A European writer first mentioned A. catechu in AD 1514, referring to it as 'cacho' and mentioning it as being exported from Cambay to Malacca. It became known in Europe in the 17th century. By the early 19th century, it was of some commercial importance and was much used in France. The first A. catechu to reach European countries had been re-exported from Japan and was called 'terra japonica', being thought at that time to be a natural earth or of mineral origin.

Natural Habitat

A. catechu occurs naturally in mixed deciduous forests and savannas of lower mountains and hills. It is especially common in the drier regions on sandy soils of riverbanks and watersheds.

Geographic distribution

Native : India, Myanmar, Nepal, Pakistan, Thailand

Exotic : Indonesia, Kenya, Mozambique

Biophysical limits

Altitude: 0-1500 m, Mean annual temperature: 32-39 deg. C, Mean annual rainfall: 500-2000 mm. Soil type: The species grows in a wide range of soils, such as sandy, gravelly alluvium, loam with varying proportions of sand, and clay and black cotton soils. It is capable of growing in shallow soils.

Reproductive Biology

A. catechu is leafless for a time during the hot season. In northern India, leaves are shed about February, new leaves appearing towards the end of April or during May. The flowers appear at the same time as new leaves. Trees continue in flower until July or August. Pods develop rapidly, becoming full size by September or October and turning from green to reddish-green, and then brown; they begin to ripen by the end of November through to early January. Pods dehisce not long after ripening and commence falling in January, continuing to fall in the succeeding months. Some pods remain on the tree until the following October, by which time, however, the seed has become extremely damaged by insects. The wind- dispersed seeds germinate with the onset of rains.

Katha Industries

Khair wood (*Acacia catechu*) in India is annually consumed for manufacture of cutch and catechu. Chemically, the products are catechin (Katha) and catechutannicacid (cutch). A third article of commerce is also obtained in the shape of a white powder, known as kheersal, which appears as a deposit in the wood. It is used for medicinal purposes, especially for cough and sore throat. The yield of katha and cutch varies considerably with the season in which the trees are felled and their girth, age and condition. The maximum yield of katha is obtained from trees felled in autumn and winter. Freshly felled trees also give higher yields than dried ones. Dead trees are unsuitable for extraction. Katha is marketed in the form of irregular pieces and small square tablets or blocks of grayish brown colour, which when fairly pure, exhibit crystalline feature. There are eight katha factories in Uttar Pradesh located at Izatnagar; the other locations are Bareilly Haldwani and Najibabad. These are in existence for past 50 years or so, while the other are of present origin. The factory at Izatnagar processes about 10,000 tonne of katha wood and produces about 500 tonne of katha and 1,000 tonne of cutch.

3.4 PROCESSING

The dark heartwood of the trunk and of branches greater than 2.5 cm diameter are employed for extraction. Freshly cut material is to be employed to optimise extraction yields. Modern village-scale processing in India involves a number of distinct operations. Heartwood is mechanically chipped prior to the first extraction which is undertaken in metal, open-topped pots of 40 litres capacity. Approximately 10 kg of chips, supported in a wire basket, are boiled with 25 litres of water for 2 hours. The extract is removed and the chips are subjected to a second extraction. The combined extracts are filtered and then concentrated by boiling in the metal pots until the specific gravity attains approximately 1.05 Katha crystallizes out over a period of several days from the concentrate, and this is removed with the aid of a filter press; final preparation of the katha prior to sale involves maceration in clean water, filtering, pressing and drying to around 10 percent moisture content. The filtrate obtained after removal of the katha is concentrated by evaporation to a viscous state, and is then allowed to solidify as cutch.

Multiple borehold method for extraction

Factory-scale processing is basically similar but on a larger scale (typically 2.5 tonnes of heartwood per batch extraction) with additional mechanical aids. The extraction may be carried out both at atmospheric pressure or in

autoclaves at 100-110°C; the process is repeated on the chips six times with the complete operation taking about 12 hours per batch. The extracts are concentrated in a steam-heated vacuum evaporator, and the product is then stored at 0°C for 12 days to crystallize out the katha. The cutch residue is subjected to vacuum concentration and is finally poured into wooden boxes (holding 25 kg) to solidify. Cutch and katha may be cut into pieces for sale, if required by the buyer, and the katha is sometimes reduced to a powder.

Yields

Heartwood yields vary considerably according to the size of the trees at felling and the planting density. Processing yields based on heartwood feedstock average 4 percent for katha and 8 percent for cutch.

Applications

- Katha is commonly used in ayurvedic preparations. Besides this, it serves as one of the major components in masticatory, i.e., chewing of betel leaf (pan) in India.
- Katha after drying is applied on lemon slice and taken regularly with empty stomach to cure piles.

3.5 MARKETING OF KATHA NAD CUTCH

Katha is marketed in the form of irregular pieces and small square tablets or blocks of grayish brown colour, which when fairly pure, exhibit crystalline feature. No regular statistics are however, available for the widely scattered production of katha and cutch by the cottage scale manufacturers whose total production may safely be placed at least as equal to the factory production, if not more.

The factory at Izatnagar processes about 10,000 tonne of katha wood and produces about 500 tonne of katha and 1,000 tons of cutch. The remaining factories utilize about 15,000 tons of heartwood and produce about 400 tonne of katha and 1,000 tonne of cutch. Their annual capacity varies from 1,000 to 3,000 tonne of heartwood.

3.6 SUMMARY

- Non-wood forest products (NWFP) are extensively extracted from Indian forests, and their role in rural and forest economies is immense. However, the long-term ecological sustainability of NWFP extraction with respect to resource populations, dependent animal species and ecosystem functioning has remained largely unexamined. Still there are a number of useful products yielded by forests, e.g katha and cutch etc.
- Kattha & cutch are extracted from wood of Khair tree(A). Acacia is the botanical name of this tree and it has different varieties like Acacia Sundra, Acacia Catechuoides & Acacia Catechu. These species of tree are mainly concentrated in Uttarakhand Uttar Pradesh, Bihar, Rajasthan, Gujarat and Himachal Pradesh. The preferred locations are either UP or Bihar.
- *Acacia catechu* is a deciduous tree with a light feathery crown and dark brown, glabrous, slender, thorny, shining branchlets, usually crooked. Bark dark brown or dark grey, brown or red inside, nearly 12-15 mm in thickness, rough, exfoliating in long narrow rectangular flakes which often remain hanging. Blaze very hard, colour brown and then deep pink.
- *Acacia catechu* is widely distributed throughout the greater part of India except the most humid, cold and the driest regions. It is common in the sub-Himalayan tract and outer Himalayas ascending from 900 to 1,200 m from Jammu to Assam. The record distribution of khair shows that the various forms of it, rather than overlapping, appear representative of none or another tolerably well defined areas.
- The dark heartwood of the trunk and of branches greater than 2.5 cm diameter are employed for extraction. Freshly cut material is to be employed to optimise extraction yields. Modern village-scale processing in India involves a number of distinct operations. Heartwood is mechanically chipped prior to the first extraction which is undertaken in metal, open-topped pots of 40 litres capacity.
- Katha is marketed in the form of irregular pieces and small square tablets or blocks of grayish brown colour, which when fairly pure, exhibit crystalline feature.

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3.8 TERMINAL QUESTIONS

Q.1Discuss the species used for the extraction of katha and cutch

Q2.Define katha and cutch

Q3. Discuss about processing of KAtha

Q 4 Fill in the gaps:

(i) Katha or catechu product obtained from .....

(ii)The **major producer** of cutch and katha is.....

(iii) The ..... of the trunk and of branches are employed for extraction.

(iv) Pale catechu and the dark catechu commonly called as..... and ..... respectively.

(i. Acacia catechu var., ii. India, iii. dark heartwood, iv. katha, cutch)

UNIT IV USES

Course structure

4.1 INTRODUCTION

In previous unit you have studied about the tree species used extraction of katha and cutch. You have also studied the process regarding the extraction.Katha and cutch are products made from the heartwood of *Acacia catechue* tree.

Katha is used as an ingredient of paan (betel) and paan masala chewing confectionary in India. Cutch is used for dying canvas and tanning leather. According to an estimate made a few years ago, 3000 tonnes of leather was produced annually in India. Of which 2,000 tonnes was produced in the forestry sector, which also produced 4,500 tonnes of cutch. The total consumption of wood was estimated to be around 2000, 000m^3 (Tewari 1995)

4.2 OBJECTIVES

After reading this unit you would be able to

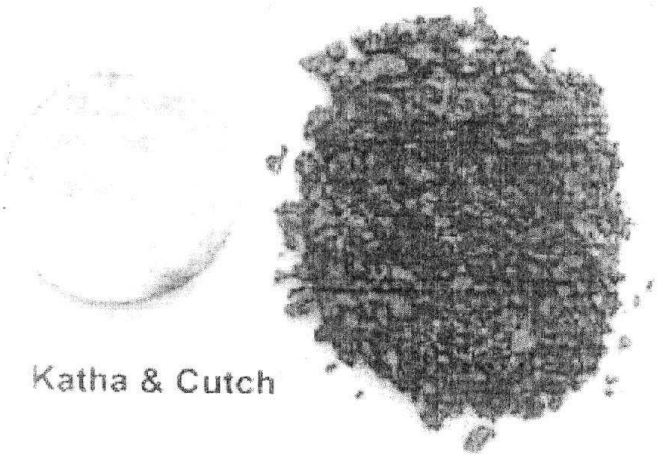
1 emphasize the properties of katha wood

2 Uses of katha and cutch

4.3 PROPERTIES OF WOOD

4.3.1 Physical Properties of the Wood

Sapwood sharply distinct from heartwood, light yellowish-white or yellow. Heartwood deep red or reddish brown, darkening on exposure; somewhat lustrous. The wood is hard to very hard, heavy to very heavy, average weight 1010 kg/m^3 at 12 percent moisture content; somewhat coarse and even-textured and straight to interlocked grained. The wood has no characteristic smell or taste



Katha & Cutch

4.3.2 Mechanical Properties

The timber is very strong, very hard, very steady and moderately tough. The figures for its suitability as a timber for various purposes, expressed as percentages of the same properties of teak, for specimens from western U.P., are – weight, 147; strength as a beam, 128; stiffness as beam, 119; suitability as a post or strut, 127; shock resisting ability, 111; retention of shape, 116; shear, 155; surface hardness, 178; refractoriness (splitting co-efficient), 100; nail or screw holding property, 148.

4.3.3 Seasoning Properties

The timber is highly refractory and liable to end-splitting and surface cracking during seasoning. It seasons very slowly. It should, therefore, be converted soon after the rains and stacked properly under shade, well- protected from rapid drying. Seasoning of thick boards or planks should be avoided wherever the timber is intended to be further converted into thinner sections.

The sapwood is not durable. The heartwood is very durable and is described by Pearson as "one of the most durable Indian woods, which is seldom, if ever, attacked by white ants and fungi". There are several records of its having lasted for centuries in temples and it has also done well in harbour works. Natural durability 'graveyard' tests carried out at the Forest Research Institute(FRI), Dehra Dun, have shown an average life of over 20 years.

4.3.4 Working Qualities

The timber is hard to saw and machine, especially if the wood is old and dry after seasoning. A heavy gauge plate saw with closely spaced teeth and shallow gullets gives the best results and stiff tools should be used in machining and turning. The timber can be turned well. The wood can, however, be finished to an extremely smooth surface and takes polish well.

4.4 USES OF KHAIR

Though Khair is chiefly used as a source of katha and cutch, it is also a useful timber. It is much priazed for posts in house construction and also for making rice pestles, oil and sugar-cane crushers, ploughs, tent-pegs, sword handles and keels and knees of boats. There is, however, a local superstition against it in parts of Uttar Pradesh on account of which it is not used in house construction.

Khair is a valuable economic structural timber, the heartwood being naturally durable. This species has been classified as "Super Group" timber suitable for large spans more than 12 m and is placed as the first choice of selection for permanent structures (I.S.I.,

1962). It is eminently suitable for tools and tool handles, particularly for mallets and plane bodies. It is excellent for making spokes and hubs of wheels.Sapwood of khair is a waste product in katha industry as it does not find at present any use except as a fuel. Since the katha manufacturers use the spent heartwood chips as a fuel in their boilers and bhattis, considerable quantity of the sapwood is literally wasted.

It can be seen from the results of chemical composition of the wood obtained at the Forest Research Institute (FRI) Dehra Dun, that the sapwood of khair trees, if collected economically, can be profitably utilized for producing bleached cellulose which will find use in multifarious cellulose based industries like CMC, cellulose acetate, ethers, and even for paper and paper boards if made available in large quantities.

4.4.1 Use as Fodder:

It is considered to be a good fodder tree and is extensively lopped to feed goats and at time cattle also. The plants are also browsed by cattle, rhinoceros, deer and elephant. The leaves contain 13.0-18.7 percent crude protein, 46.7-51.0 percent N free extract and 0.14-0.17 percent phosphorus. Total digestible nutrients are 46.3 kg. of dry material. The nutritive ratio is 15.0. The digestibility values are moderately high which shows that the leaves are feed for cattle on the basis of crude protein, crude fibre and tannin content. The leaf fodder of *Acacia catechu* is rated as good.

4.4.2 Use as Fuel :

It is also used as fuel and furnishes charcoal of good quality, the calorific value of moisture free sapwood being 5142 calories (9256 B.T.U.) and that of heartwood 4946 calories (8915 B.T.U.).

4.4.3 Medicinal Uses:

The different parts of the tree have a variety of medicinal uses, which in haemoptysis (spitting of blood). A paste of the bark is useful in conjunctivitis. The bark is reported to be useful in the treatment of snake bites.

Flowers: A mixture of flower tops, cumic, milk and sugar is useful in gonorrhea.

Wood: Cutch and katha obtained from the heartwood have great medicinal value. It is cooling, digestive and a very valuable astringent, especially in chronic diarrhoea and dysentery, bleeding piles, uterine haemorrhages, leucorrhoea, gleet, atonic dyspepsia,

chronic bronchitis, etc. It is also useful in cases of mercurial salivation, bleeding or ulcerated or spongy gums, hypertrophy of the tonsils, relaxation of the uvula, aphthous ulceration of the month, etc.

A mixture of catechu and myrrh (Kathol) is usually prescribed as a tonic and as a galactagogue to women after confinement.

Kheersal is used as a remedy for chest diseases, especially for the treatment of asthama, cough and sore throat.

4.4.4 Katha (Catechu)

Good quality of Khair Tree (Acacia Catechu) is procured from various parts of India. Each log is manually stripped & made free from Sapwood. The heartwood is mechanically chipped into small pieces and cooked under pressure. The liquor obtained contains Catechu which is concentrated in multistage evaporator. On chilling the concentrated liquor crystals of Catechu are produced. Crystals are carefully filtered in controlled conditions. The filtered mass is mashed and cut into Biscuits and slowly dried at low temperatures.

Commercially the catechue is valued on the basis of its texture, paste value(8-10 times) and smell. However, detailed analysis of a typical sample is as following

1	Loss on drying	14-16% by weight
2	Matter insoluble in rectified spirit	10-15% by weight
3	Total ash	20% by weight
4	Acid insoluble ash	Max. 0.5% by weight
5	Paste value	9 times(in terms of water retention)

The most important product obtained from *Acacia catechu* var. catechu proper is katha or catechu. This is obtained by boiling chips of heartwood with water. In India two varieties are marketed katha or pale catechu and cutch or dark catechu. As sold in the market, katha is found in irregular pieces or small square blocks of grayish colour, which on breaking show a crystalline fracture.

There is a very large internal demand for it for masticatory use in pan preparations and in medicine. Katha is regarded as astringent, cooling and digestive, and useful in sore throat, cough and diarrhoea. Externally it is employed as an astringent and as cooling application to ulcers, boils and eruptions on the skin. It is an indispensable ingredient of pan

preparations. In combination with lime, it gives the characteristic red colouration resulting from the chewing of pan.

It is traditionally being used as mouth freshener with Betel quid in India. The new generation of mouth fresheners, like Pan Masala deploys Catechu as chief ingredient with Areca nuts and sometimes with chewing tobacco. Catechu is an astringent and has distinct bitterness followed by cool-sweetness. It also finds use as flavoring agent in condiments, ice-creams, candy, beverages etc. Since ages, the medicinal uses of catechu are well known. It finds major use in treatment of diarrhea, dysentery, ailments of mouth, gums, tonsils etc. Many new uses of catechins (which are the natural chief ingredients of catechu) like antioxidant, skin care, anti-diabetic, anti-inflamatory are reported.

4.4.5 Cutch:

The supernatant liquor obtained on filtration of catechu is concentrated in multiple effect evaporator till the semi solid condition is achieved. It is directly packed in suitable packing. The cutch has dark colour and rich in Vegetable Tannins. A typical analysis is given below:

	Moisture, max	12
	Tannins, min	60
	Catechins, min	30
	Insoluble in boiling water, max	5

Cutch is natural source of tannins (for tanning leather). It creates variety of colours with metals are useful as dyeing agent for natural fibre . It is also used as amouth freshner. Medicinal uses are similar to that of catechue are also known. It has application in oil drilling , printing , pigment , adhesive etc.

Packings	Primary	Secondary
Block	50 kgs	50 kgs in Wooden Case wrapped in hessian bag
Slab	3.125 kgs	25 kgs in wooden case wrapped in hessian bag

4.4.6 Other Uses

Lac: Khair is a very good host plant for growing the Katki or Aghani crop in alternation with the normal Rangeeni or Kusumi hosts. This species is unsuitable for the Baisakhi or

fethwi crops due to non-possession of sufficient vitality during the late winter and early hot weather months to bear a lac crop. This species is best used for raising the Aghani crop and produces an encrustation equal in quality and quantity to that produced on kusum (*Schleichera oleosa*). The brood from the infestation of khair with kusum brood takes very well when used to infect kusum again in January-February. The resulting lac is of good quality.

Gum: The gum from khair is said to be of very good quality and is regarded as the best substitute for true gum arabic. The tears may be as large as 3 cm in diameter and pale yellow to dark amber in colour. It is not collected separately and is generally mixed up with other *Acacia* gums.

4.5 M ARKET AND MARKETABLE PRODUCTS USED AS RAW MATERIAL IN FOREST BASED INDUSTRIES

In India. State Forest departments are the major producers of Khair wood. The wood is generally disposed off by the respective State Forest Departments/Forest development corporations at their sale depots.

Wholesale markets are mostly located in towns. These are permanent in nature where transaction take place daily throughout the year. In these markets (Mandis) the wholesalers and commission agents play an important role in the sale of produce. During recent years, with the development roads, communication and transport, there has been a marked increase in the sales of Khair wood at these markets (mandis).

In M.P., marked Khair trees are cut in the coupe and if the trees are big then logged into pieces and numbered. Cut Khair wood is transported to depot where it is transferred to one of the following agencies.

(i) Given to advance purchaser who has tendered the highest rate on log basis for a particular coupe.

(ii) Given to cooperative societies or cottage industry for making Katha by country method.

(iii) Supply of Khair wood to Katha factories under contractual obligation.

(iv) In case of default by any of the above agencies Khair wood is auctioned from the depot.

4.5.1 Khair Wood Used as Raw Material in Katha Industries

About 63,000 tonnes of khair wood (*Acacia catechu*) in India is annually consumed for manufacture of cutch & catechu. Chemically the products are catechin (Katha) and catechutanmicacid (cutch). A third article of commerce is also obtained in the shape of a white powder, known as kheersal, which appears as a deposit in the wood. It is used for medicinal purposes specially for cough and sore throat.

4.5.2 Yield of Katha (Cutch)

The yield of katha and cutch varies considerably with the season in which the trees are felled and their girth, age and condition. The maximum yield of katha is obtained from trees felled in autumn and winter. Trees that are gnarled and crooked are reported to give higher yields than straight one. Trees of higher girth having white lines on them are preferred. Freshly felled trees also give higher yields than dried ones. Dead trees are unsuitable for extraction. Following table depicts yield of katha & cutch from 100 kg. of khair heartwood in different parts of the country.

State	Factories		Small scale units	
	Katha	Cutch	Katha	Cutch
Andhra Pradesh	-	--	2	3
Mumbai (Inc. Maharashtra & Gujarat)	4.5	12	3-4	10
Madhya Pradesh	1.5-1.7	10-12	3	--
Uttar Pradesh	4.5	10.5	--	--
West Bengal	-	10.5	6.3	--

Average katha yield per trees by the country method (Handi method) is estimated as under –

Tree size girth(cm)	Average yield
31-38	0.210
39-45	0.455
Over 45	0.900

4.5.3 Marketing of Katha and Cutch:

Katha is marketed in the form of irregular pieces and small square tablets or blocks of grayish brown colour, which when fairly pure, exhibit crystalline feature. No regular statistics are however, available for the widely scattered production of katha and cutch by the cottage scale manufacturers whose total production may safely be placed at least as equal to the factory production, if not more.

There are eight katha factories in U.P. located at Izzatnagar, Bareilly Haldwani and Najibabad. It is in existence for past 50 years or so, while the other are of present origin. The factory at Izzatnagar processes about 10,000 tons of katha wood and produces about 500 tons of katha and 1,000 tons of cutch. The remaining factories utilize about 15,000 tons of heartwood and produce about 400 tons of katha and 1,000 tons of cutch. Their annual capacity varies from 1,000 to 3,000 tons of heartwood.

4.5.4Markets and depots

Following are some of the important Khair wood markets and depots in Northern India.

Haryana - Sonepat, Chachrauli, etc.

Punjab - Roopnagar, Hoshiarpur, Pathankot, Dausya, etc.

Uttar Pradesh - Kishanpur, Gorakhpur, Tulsipur, Najibabad, Gonda, Bareilly, Lakhimpur, Bahraich,Bijnore, etc.

Uttaranchal – Raiwala

Maharashtra - Chanda, Mhasrul, Kasa, Thane, etc.

Gujarat - Waghai, Songarh, etc.

Bihar - Hazaribagh, Monghyr, etc.

Madhya Pradesh - Sidhi, Panna, Damoh, Sarguja, Sagar, Jabalpur, Sheopur, etc.

4.6 NATURAL REGENERATION

Under natural conditions, the seeds are disseminated by wind. The seeds adhere to the light pod valves after the pods dehisce and are often blown to a considerable distance from the trees. In alluvial tracts, dissemination of the seed is further effected by water. Though the seed itself is rather heavy, the pod with seeds get washed down and the seeds rubbed off among the sand and boulders of newly thrown up islands and banks.

Germination takes place in the beginning of the rainy season, and the early development of the seedling is greatly favoured on loose soil free from weeds. Thus, on alluvial sand or gravel, countless number of small seedlings may be found in the early part of the rainy season not only in the open but also under a comparatively dense cover. In the latter case, they die rapidly owing mainly to shade and to damping off ; and by the end of the season, most of the seedlings disappear. In the open, a fair proportion survives provided the seedlings are protected from grazing.

The cattle are very fond of young shoots and closure of areas under regeneration has strikingly beneficial results. Frequently, there is a high mortality from drought, particularly if the soil is stiff or shallow and the roots have difficulty in penetrating it. The seed germinates readily with heavy rain and although germination takes place ordinarily at the commencement of the monsoon, it may begin earlier in the season in case of early heavy showers of rain: when this happens the seedlings generally die off or the germinating seed perishes in the ensuring spell or dry weather. Such mortality is particularly marked in the case of seeds germinating on the surface of the ground.

In wet season the seedlings damp off is a common diseases. Khair seed is very delicate and is at once killed by the slightest damage from fire. As the seed falls in January and February, that is to say, just before the fire season commences, fires must be rigidly kept out from the areas under natural regeneration. The slightest carelessness in this respect may jeopardise a whole year's natural regeneration.

The freedom with which natural reproduction of khair springs up in alluvial riverain tracts is remarkable. The chief factors favouring it in such localities are the new loose soil

(alluvial soil) free from heavy weeds and the abundance of light while the soil moisture obtained by percolation no doubt also assists the development of the seedlings.

As the crops become older and elevated above the river bed through changes in the course of the river, the conditions for natural regeneration change. The ground becomes harder and a dense undergrowth of *Adhatoda vasica* or other plants frequently makes its appearance. Under such conditions, natural regeneration is no longer possible and although it continues to take place where new alluvium is thrown up, it ceases under the old crops.

4.7 SUMMARY

- Sapwood sharply distinct from heartwood, light yellowish-white or yellow. Heartwood deep red or reddish brown, darkening on exposure; somewhat lustrous.
- The timber is highly refractory and liable to end-splitting and surface cracking during seasoning. It seasons very slowly. It should, therefore, be converted soon after the rains and stacked properly under shade, well- protected from rapid drying.
- The sapwood is not durable. The heartwood is very durable and is described by Pearson as "one of the most durable Indian woods, which is seldom, if ever, attacked by white ants and fungi".
- Though Khair is chiefly used as a source of katha and cutch, it is also a useful timber. It is much priazed for posts in house construction and also for making rice pestles, oil and sugar-cane crushers, ploughs, tent-pegs, sword handles and keels and knees of boats. There is, however, a local superstition against it in parts of Uttar Pradesh on account of which it is not used in house construction.

4.8 REFERENCES

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Google Search, http://en.wikipedia org/wiki/Bamboo

4.9 TERMINAL QUESTIONS

Q1. Write a concept note on natural regeneration of khair

Q2. Disccuss the uses of khair and katha .

Q3. Write a short note on properties of khair wood.

Q. 4. Fill in the blanks:

(i).....of khair is a waste product in katha industry as it does not find at present any use except as a fuel.

(ii) A mixture of flower tops, cumic, milk and sugar is useful in .....

(iii) Katha or catechu is obtained by boiling chips of .....with water.

(i. Sapwood, ii. gonorrhea, iii. heartwood)

UNIT V BAMBOO AND CANES

Course structure

5.1 INTRODUCTION

Bamboo and canes are one of the most important group of forest produce utilized for a variety of purposes. They resemble the woody timber trees in their form and strength and therefore, they are largely used as a substitute for timber.

Bamboos are multipurpose woody species. They play a dominant role as woody raw material for a variety of products in the tropical regions and is considered as 'poor man's timber'. India ranks second in bamboo production with an annual production of 3.2 million tonnes. Bamboo provides raw materials for cottage industries and employment for millions. It is estimated that harvesting of bamboos in India itself requires about 71.25 million man-days every year.

Small Scale Industries are providing large-scale employment next to Agriculture. It have played a vital role in the districts economy by providing large scale employment opportunities at relatively low capital cost, a wide entrepreneurial base, easy dispersal of industries in rural areas and concentration of certain industrial groups at specific areas.

5.2 OBJECTIVES

After reading this unit you would be able to

1. Explain tme importance of bamboosand canes in small scale industries
2. To list out various usue of bamboos and canes

5.3 BAMBOO

Bamboo is woody grass belonging to the sub-family *Bambusoideae* of the family *Poacae*. Worldwide there are more than 1,250 species under 75 genera of bamboo, which are unevenly distributed in the various parts of the humid tropical, sub-tropical and temperate regions of the earth (Subramaniam, 1998). This natural resource plays a major role in the livelihood of rural people and in rural industry. This green gold is sufficiently cheap and plentiful to meet the vast needs of human.Bamboos has versatile uses as building material, paper pulp resource, scaffolding, food, agriculture implements, fishing rods, weaving material, substitute for rattan, plywood and particle board manufacture. Pickled or stewed bamboo shoots are regarded as delicacies in many parts of the country. The major user of bamboo in India is paper industry, which consumes sizeable proportion of the total annual bamboo production.

Bamboos are a group of perennial woody evergreen (except for certain temperate species) plants in the true grass family **Poaceae**, sub-family Bambusoideae, tribe **Bambuseae**.

In bamboo, the internodal regions of the plant stem are hollow, but the vascular bundles, as seen in cross section, are scattered throughout the stem instead of in a cylindrical arrangement. Also, the dicotyledonous woody xylem is absent. The absence of secondary growth, wood, causes the stems of monocots, even of palms and large bamboos, to be columnar rather than tapering.

Bamboos are also the fastest growing plants in the world. They are capable of growing up to 60 centimeters (24 in.) or more per day due to a unique rhizome-dependent system. However, this astounding growth rate is highly dependent on local soil and climatic conditions. Bamboos are of notable economic and cultural significance in East Asia and South East Asia where they are used extensively in everyday life as building materials, as a food source and as a highly versatile raw product.

Over 100 species of bamboo occur naturally in India. Bambusa arundinaria B. tulda, B. polymorpha , Dendrocalamus strictus , D. hamil-tonii, Melocanna baccifera and Ochlandra travancorica are the most important species because of their wide availability. Dendrocalamus strictus and bambusa arundinacea are the two most principal economic species.

5.3.1Morphology:

Bamboos are perennial grasses of extremely gregarious habit. The stems of bamboos are known as culms arise from woody rhizomes. The culms generally grow in a group which is termed as a clump. The point on a stem from which a leaf grows are known as nodes. The portion between two nodes is known as internode. Bamboos can be classified into three broad groups: (i) sympodial or clump forming bamboos as in *Dendrocalamus* and *Bambusa* (ii) monopodial i.e. erect and non clump forming bamboos as in *Melocanna* and *Phyllstachys* and(iii)climbing as in *Dinochloa*.

5.3.2 Distribution:

Bamboos are widely distributed almost throughout the country, almost in every state Its distribution is governed largely by rainfall temperature, altitude and soli conditions. Most bamboo requires a temperature of 8° to 36° C, a minimum of 1,000 mm of rainfall annually and high humidity for good growth. Bamboo is an important constituent of many deciduous and evergreen forests and extends from tropical to mild temperate regions. It grows on flat alluvial plains upto altitude s of 3,050 m above mean sea level.

Generally, in forests bamboo occupy the place where tree canopy is broken. The gaps or clear space which exists in the canopy are occupied by different species of bamboos. Most of the bamboos are light demander. Wherever,bamboo is found as an understorey crop , the growth is poor. Most of the species of bamboos are susceptible to fire and and grazing.

	State	Area(sq km)	Actual production in 1985(lakh tonnes)	Potential annual cut (lakh tonnes)
1	Andhra Pradesh	19,7991	3.07	2.55

2	Arunchal Pradesh	7,779	1.50	2.00
3	Assam	10,000	2.20	12.10
4	Bihar	5294	0.80	2.00
5	Gujarat	1936	0.65	0.46
6	Himachal Pradesh	104	0.03	0.03
7	Karnataka	6000	0.86	4.75
8	Kerala	631	2.00	1.08
9	Madhya Pradesh	14864	4.15	8.00
10	Maharashtra	8500	3.76	3.00
11	Manipur	2500	0.01	2.00
12	Orissa	10500	3.82	4.89
13	Punjab	NA	0.12	0.09
14	Tamil Nadu	5388	0.15	NA
15	Tripura	2894	0.28	2.15
16	Uttar Pradesh	4000	1.80	0.41
17	West Bengal	164	0.18	0.08
	Total	**1,00,299**	**25.38**	**45.59**

5.4 USES OF BAMBOOS

Bamboos have multiple uses.Bamboo is utilized for various purposes depending upon its properties. It plays an important role in the daily life of people; for house construction, agricultural tools and implements, as food material and weaponry etc. Besides being a convenient source of cellulose for paper manufacture and rayon, it supports a number of traditional cottage industries. Bamboo craft is one of the oldest of traditional cottage industries in India. The origin of this rural craft is traced from the beginning of the civilisation when man started cultivation of food crops thousands of years back. People started making baskets, mats and many other products of household use with bamboo that was abundantly available in nearby forests. Later, tribal and rural people in the vicinity of bamboo forest took up this as a means of livelihood. Now bamboo craft is spread in all rural areas of the country and it feeds millions of traditional workers.

Bamboo is emerging as a major source of raw material for several processed products primarily due to its fast growth, wide spread occurrence and its multiple uses. The ten major species used in India for commercial purposes are *Bambusa bambos, B. balcoa, B. nutans, B. tulda, Dendrocalamus strictus, D. hamiltonii, Melocanna baccifera, Ochlandra ebracteata, O. scriptoria and O. travancorica.*

The consumption pattern of bamboo (Tewari, 1992) is given below

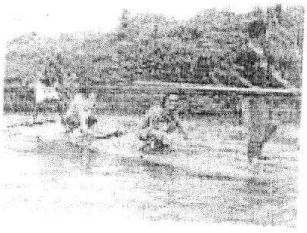
Table: Consumption pattern of bamboos in India.

Uses	Percentage consumption (%)
Pulp	35.0
Housing	20.0
Non-residential	5.0
Rural uses	20.0
Fuel	8.5
Packing, including basket	5.0
Transport	1.5
Furniture	1.0
Others, wood working industries	1.0
Others, including ladders, mats etc.	3.0

5.4.1 Structural uses:

As compared to other constructional timber, bamboos possess better strength to weight ratio and can suitably be used for structural purposes.Due to its physical form with nodes and cross partition walls, bamboo results in light weight but stronger structural component for low cost house construction. Bamboos can easily cut and split.

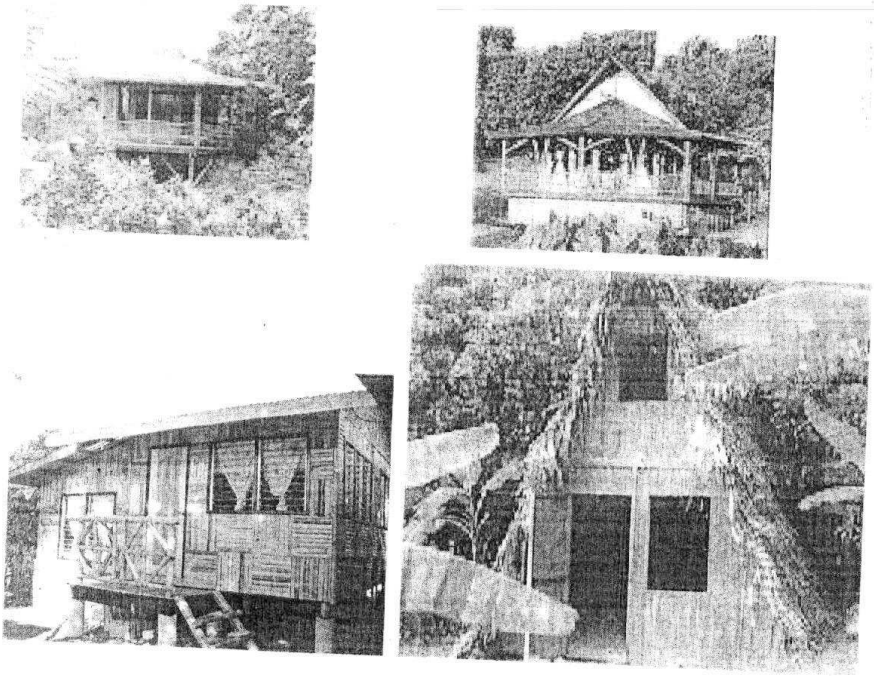
Bamboos are extensively used in rural housing. They are used in the construction of houses and huts. They are used as rafters , ridges, posts, trusses, purlins, roof coverings, walls, floorings, doors and windows etc. the outer surface of bamboo is smooth , clean and hard enabling its easy use for specific purpose. There is no wastabe as there is no bark. Most of the bamboo species posses high tensile strength and elasticity(Dwivedi 2007)



Bamboo raft

5.4.2Construction purpose:

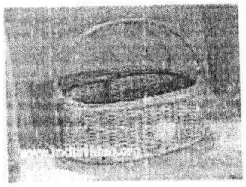
Bamboos are largely used as a substitute for timber . Due to its good strength proprties, straightness and lightness combined with hardness , bamboos are extensively used for construction purposes.

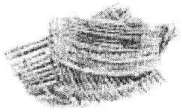


Bamboo houses and huts

Traditional and handicraft items

Bamboo is largely used by handicraft industries due to its strength properties, light weight , straightness combined with hardness. Almost all the species of bamboo are easy to work and take a good polish and finish. There are a large number of traditional and fancy items which can be easily made out of bamboo. These items include agricultural implements, anchors, arrows, back scratches, baskets, beds. Binds, boats, bottles, bows, bridges, brooms, brushes, buildings, caps, carts-yokes, caulking material, chairs, chicks, chopsticks, combs, containers, cooking utensils, cordages, fish traps, fishing nets, fishing rods, flag poles, floats for timber, fluets, flower pots, food baskets, fuel, furniture, hats, handicrafts,haystacklamps lance staves, fences, ladders, lanterns, liningg of hats and sandles, loading vessels, masts, match-sticks, mats, milk-vessels, musical instruments, nails , pens, net floats, ornaments, shoes, sprayers,sport goods, sticks , trays tubs,traps umbrella-handles, wrappers, tables, roofings etc.(Dwivedi 2007)





bamboo baskets and stick tray

Pulp and paper :

Most of the bamboo species yield high grade chemical pulp suitable for making writing , printing and different kinds of quality paper. It is known that bamboo is composed of two main two types of tissues, namely fibres and vessels (parenchyma tissues). The fibre filaments constitute about 60-70% percent(on weigt basis). The parenchyma tissue plays a negative role in the pulping process. More recently, a process has been developed through which parenchyma can also pulped to increase the total yield of pulp. Fibre length length and diameter of some of the species of the bamboo is given table below:

Species	Fibre length(mm)	Fibre diameter(m)
Bambusa bambos	2.52	18.14
B. nutans	2.49	15.43
B. polymorpha	2.41	17.27

B. tulda	2.07	16.07
Schizostachymus pergracile	2.48	16.46
Dendrocalamus hamiltonii	2.66	14.20
D longispathus	2.38	16.25
D. strictus	2.32	16.07
Melocanna baccifera	2.68	14.37
Gigantochloa rostrata	2.54	15.68

Most of the bamboo species provide, long fibre material commonly used in india for paper and pulp industries depend on bamboo species for the supply of long fibre material.

Bamboo parquet:

The term parquet is applied to the flooring, in which strips,3.81cmx6.71cm ,are cut and laid out in geometric pattern.

Laminated bamboo:

The bamboo culms are cracked or split,spread out and flattened into sheets with suitable binding and filling material. These sheets are then combined , lapped,arranged ,glued, treared and pressed to the desired form. These are then cut and trimmed to different size and shape

Artificially shaped bamboo

Bamboo can be made to grow into different shapes. It can be shaped into square , rectangular and triangular shapes for low cost housing , handicrafts, decoration items and cottage industries. Japan has successfully grown artificially shaped bamboos. Production of such bamboos is simple like moulding hollow blocks, but needs practice. The artificially shaped bamboos are expected to be stronger than the round ones.

Culinary: The shoots (new bamboo culms that come out of the ground) of bamboo are edible. They are used in numerous Asian dishes and broths, and are available in supermarkets in various sliced forms, both fresh and canned version. The shoots of the

giant bamboo contain cyanide. Despite this, the Golden Bamboo Lemur ingests many times the quantity of toxin that would kill a human.

The bamboo shoot in its fermented state forms an important ingredient in cuisines across the Himalayas. In Assam, for example, it is called *khorisa*. In Nepal, a delicacy popular across ethnic boundaries consists of bamboo shoots fermented with turmeric and oil, and cooked with potatoes into a dish that usually accompanies rice (*alu tama* in Nepali). Pickled bamboo, used as a condiment, may also be made from the pith of the young shoots.

Tender shoots of several bamboo species are used in curries and pickles. They are considered delicacy by local popultion. The tender shoots are soaked in water, boiled and made into curries. Important species yielding edible shoots are *Bambusa tulda, B. bambos, B. multiplex, B. polymorpha, b. vulgaris, Dendrocalamus hamiltonii, D. strictus, D.Giganteus,D. longispathus Dinochloa andamanica, Gigantochloa rostrata, G. pseudoarundinacea, Melocanna baccifera, Schizostachyum,*spp. *etc.* These shoots are sometimes marteded also. Flowering culms in dry localities exude a sweet brittle gum, which is edible and contains saccharine.

Bamboo shoots contain cyanogenic or glucosides which on hydrolysis yield hydochloric acid. Tips of immature shoots contain hydrochloric acid to the extent of 0.05 to 0.50 percent. Cooking destroys the enzymes responsible for hydrolysis. While cooking, if water is changed several times, the toxicity is removed . in several countries bamboo is cultivated for edible shoots and about 10 tonnes of edible shoots per ha can be obtained.

Bamboo shoots are not highly nutritious, but are a good source of thiamine and niacin, which are the members of vitamin B complex. Tender shoots of *Bambusa bambos* contain 88.8 percent water, 3.9 percent protein ,0.5% fat, 5.7% carbohydrate and 1.1 percent mineral. They also contain thiamine, riboflavin,niacin and vitamin C.

Bamboo seeds are consumed by poors during famine. Seeds of *Bambusa bambos* contain protein content comparable with wheat in quality and with rice comparable in quantity. Seeds of several species of bamboo can be eaten without any adverse effect on human health. In rats, a complete replacement of rice by bamboo seeds in diet enhanced the rate of growth in rats by 50 percent.

Medicine

Bamboo is used in Chinese medicine for treating infections and healing. It is a low-calorie source of potassium. It is known for its sweet taste and as a good source of nutrients and protein.

In Ayurveda, the Indian system of traditional medicine, the silicious concretion found in the culms of the bamboo stem is called *banslochan*. It is known as *tabashir* or *tawashir* in *Unani-Tibb* the Indo-Persian system of medicine. In English it is called "bamboo manna". This concretion is said to be a tonic for the respiratory diseases. It was earlier obtained from *Melocanna bambusoides* and is very hard to get; it has been largely replaced by synthetic silicic acid. In most Indian literature, *Bambusa arundinacea* is described as the source of bamboo manna.

Some of the species of bamboo produce abundant white power on the surface of young culms. This power is used for making sex hormones. Bamboo leaves also possess medicinal properties. Decoction of leaves is fermented and used in the treatment of fever and for blood purification. Leaves of *Bambusa bambos* are used for blood purification leucoderma and for the treatment of inflamatory conditions.Leaves are also used intreatment of bronchitis,gonorrhoea and fever

As fodder

Leaves of several bamboo species are used as fodder. Young leaves and twigs are relished by elephants. Leaves of *Dendrocalamus strictus*, the most common bamboo are widely used as fodder. Leaves of this species on dry matter basis contain crude protein 15 percent , crude fibre 23 percent, ether extract 1.43 percent and ash 18 percent. The digestible nutrient content are 93 percent and 48.9 percent recpectively indicating very high digestibility.

Musical instruments

Bamboo's natural hollow form makes it an obvious choice for many instruments, particularly wind and percussion. There are numerous types of bamboo flute made all over the world, such as the dizi, xiao, shakuhachi, palendag, jinghu, angklung. In India it is a very popular and highly respected musical instrument, available even to the poorest and the choice of many highly venerated maestros of classical music. It is known and

revered above all as the divine flute forever associated with Lord Krishna, who is always portrayed holding a bansuri (flute) in sculptures and paintings.

Water processing

Bamboo as a versatile material is demonstrated by its use in water desalination. A Bamboo filter is used to remove the salt from saltwater.Bamboo is also used in construction and textiles.

5.5 CANE

Cane is either of two genera of tall, perennial grasses with flexible, woody stalks from the family Poaceae that grow throughout the world in wet soils. They are related to and may include species of bamboo. Depending on how flexible they are, different kinds of canes may be fashioned for a variety of purposes, such as tools, walking sticks, crutches, weapons, and in corporal punishment. Judicial canes or school canes, used in some countries for legal corporal punishment, must meet particular specifications, such as, a high degree of flexibility.Similar to bamboo, cane has been used historically for many other purposes as well, such as baskets, furniture, boats, roofs and wherever stiff, withy sticks can be used to advantage.

5.5.1Uses:

Canes are used for variety of purposes on account of their remarkable strength, elasticity and length, they are used for various purposes. Most of the canes are very strong and can be used as a substitute for ropes as cable for suspension bridges and other purposes. Canes are also used for wickerworks,making baskets and different types of containers. Cane industry is developed in Bengal, Bihar, Karnataka and Kerala.

Cane Baskets: Cane baskets of various types are produced in different parts of the State. Cane baskets are used for various purposes. These are used mainly for carrying goods, storing grains and keeping valuables. The tribes, viz: Kukis, Mikirs and Mizos especially use the baskets for keeping ornaments and clothes with locking arrangements. In the plain districts, also a few persons keep their clothes, etc., in cane suitcases. Extensive manufacture of 'plucking baskets' is found in all the plain districts on a commercial basis. Generally, the tea planters purchase these baskets in big lots from time to time.

Therefore, the manufacture of plucking baskets is a monopoly of a few big firms with substantial financial backing. These firms also manufacture various types of baskets used in the carrying of earth, coal, etc. It is seen that these bigger firms obtain their supply of raw materials at much lower costs than the others do.

Cane furniture:

The manufacture of cane furniture, however, calls for a high degree of skill on the part of the workers. Such skill is found to be traditional. In the manufacture of cane furniture, Cachar district of Assam enjoys a special advantage over the other districts of the State as far as skilled artisans are concerned. The craft has commercial production in almost all the important urban areas of the State.

The manufacture of cane furniture starts with the preparation of requisite amount of bamboo slips. Canes of various diameters are also reduced into slips of various sizes according to adaptability. The artisans then prepare a rough structure of the furniture by joining the different bamboo parts (previously sized) with the help of nails. In case of round-cane furniture, thin iron rods are used to get the round cane bend to the required shape. The actual weaving or coiling of the structure so made is done with fine slips of flexible cane. The more skilful an artisan is the finer slips of cane he can use in coiling and plaiting.Cane is a length of colored and/or patterned glass rod used in cane working, a style of glassblowing.

Medicinal use

The roots and leaves are used for medicinal purpose. The seeds of *Calamus rheedei* are powered and applied in ulcer. The roots of *Calamus rotang* are remedy for dysentry,biliousness and febrifuge and also used as tonic. It is used in veterinary as aperient. The tender leaves of *Calamus travan-coricus* are used in dyspepsia, biliousness and as antthelmintic (Dwivedi 2002).

Edible

The fruits of some species of *Calamus* such as *Calamus rotang* are fleshy, mucilaginous, sweet-bitter and edible . The seeds of *Calamus extensus* and *C. erectus* are used as a substitute for betel nut(areca nut). The young and tender shoots of some species are eaten boiled or made into curries and also pickled (Dwivedi2002).

5.6 SUMMARY

- Bamboos and canes are one of the most important group of forest produce utilised for a variety of purposes.
- Once considered as weed in forest, these species are now regarded as the most versatile and useful forest plant species.
- As compared to other constructional timbers bamboos better strength to weight ratio and can suitably be used for structural purposes.
- Bamboos are largely used by handicraft industries.
- Almost all the species of bamboo are easy to work and take a good polish.
- Most of the bamboo species yield high grade chemical pulp suitable for making, writing, printing and different quality kind of quality paper.
- Canes (Rattans) are referred to as plants belonging to the genus *Calamus*.
- Canes rae used for variety of purposes.
- The most extensive use of canes is in furtiniture industry.

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5.8 TERMINAL QUESTIONS

Q1. Write a concept note on morphology and distribution of bamboos

Q2. What are the uses of bamboos

Q3 Write a concept note on uses of canes

Q4 Fill in the blanks:

i..... are the fastest growing plants in the world.

ii. The siliceous concretion found in the culms of the bamboo stem is called.....

iii. In English, *banslochan*, is called .....

iv.Bamboos are the members of grass family .....

(i. bamboos, ii *banslochan*, *iii*. "bamboo manna, iv. Poaceae)

UNIT VI: PENCIL/AGGARBATTI/SPORT GOODS/SPICES

Course structure

6.1 INTRODUCTION

In previous unit you have studied regarding small scale industries with particular reference to bamboo and canes. The present unit also focuses on the role of small scale industries in the context of the aggarbatti , spices. **Small Scale Industries** may sound small but actually plays a very important part in the overall growth of an economy. **Small Scale Industries** help the economy in promoting balanced development of industries across all the regions of the economy. This industry helps the various sections of the society to hone their skills required for entrepreneurship.

India has traditionally been known for small scale industries.Its spice and culinary herb production is one of the largest spice producing and consuming country. Similarly Agarbatti market is huge in rural and metros of India. Agarbatti market is driven by tradition and religion. Its a cottage industry.Rural women are employed in all stages of Agarbatti manufacturing. Availability of cheap labour makes it advantageous for the

producers to ensure large scale production of quality products based on forest , agriculture etc.

Himalayan handicraft, small scale industries based on local produces, artifacts, agriculture, and herbal based industries are some potential entrepreneurships found in scattered form across the different altitudes in Uttarkahand.

6.2 OBJECTIVES

After reading this unit you would be able to

1.List out various species used in small scale industry

2. Discuss uses of plant species for making obtaining spices and other small scale industry products.

2. Discuss various types of spices etc.

6.3 AFRICAN PENCIL CEDAR *(Juniperus procera)*

Habitat: The African pencil cedar is found in mountainous areas and highlands, on rocky ground. In Africa, it occurs at altitudes between 1,050 and 3,600 metres, but is most common between 1,800 and 2,700 metres.

Range: The African pencil cedar has a wide distribution, ranging from the Arabian Penisula, through East Africa, to Zimbabwe. However, whilst widespread, many populations of the African pencil cedar are extremely small and threatened.

Description

The African pencil cedar, the tallest of all juniper species in the world, acquired its name from its extensive use in the manufacturing of pencils. The trunk is straight and sharply tapered, covered with bark varying in colour from pale brown to reddish brown. Young African pencil cedars have needle-like leaves, one to two centimetres long, and as the plant ages, the foliage gradually changes to the scale-like adult leaves, which are light-green or yellowish-green and only up to six millimetres long. Male African pencil cedars bear numerous, tiny male cones at the ends of branches. These greenish to orangey-brown structures are composed of scales, each containing two to three pollen sacs.

Female plants bear the female cones; reddish-brown to blue-black, berry-like structures made of fleshy scales, each one containing a single ovule.

Uses: The wood is of medium hardness, is very resistant to termites, and durable against rotting. It is apt to split when nailed (Dale and Greenway 1961). Main uses include house construction, fence posts, shingles, transmission and other poles, flooring, and wooden structures exposed to the weather where durability is required, for example beehives, and pencils.

6.4 SPECIES USED FOR MAKING AGGARBATTI AND SPORT GOODS

6.4.1 Jamrosa:

Scientifically known as *Cymbopogon khasans*, jamrosa refers to a grass hybrid, which is generally of a pale yellowish color. The origin of jamrosa grass is in India and it is widely grown in areas like Chhattisgarh, Maharashtra, Madhya Pradesh and also in the southern parts of the country. The jamrosa oil is extracted from the highly aromatic jamrosa grass. This medium-sized grass is of hybrid origin, being a cross between the palmarosa and citronella. It is a plant which generally grows in the wild. The high quantities of ocimene and geraniol present in jamrosa impart it with the scents of mangoes and roses and this is how it differs from the palmarosa. Recently, the jamrosa products have seen a rise in demand and commercial cultivation of the grass on a larger- scale is required. The Regional Research Laboratory (RRL), Jammu has developed a new variety of the jamrosa, which is called CN-5.

Uses: The spent grass of jamrosa is used in the making of cattle feed and organic manure. Handmade papers are also made from jamrosa products and also for making **dhoop, agarbatti/ masala agarbatti** and **raw agarbatti**. The spent water of the plant is used to make natural insect repellent. The spent water of the plant is highly pure in quality and has many chemical agents which can be dissolved easily in water. It is considered good for health reasons. Jamrosa is also used for creating fragrances like rose fragrances.

These grasses are ecologically- important as they have the ability to prevent soil erosion, recharge the ground water and to detoxify environmental contamination.

6.4.2 Mulberry *(Morus alba)*:

Morus is a genus of flowering plants in the family Moraceae. The 10-16 species of deciduous trees it contains are commonly known as **Mulberries.** They are native to warm temperate and subtropical regions of Asia, Africa, Europe, and the Americas, with the majority of the species native to Asia.The closely related genus *Broussonetia* is also commonly known as mulberry, notably the Paper Mulberry, *Broussonetia papyrifera*.Mulberries are swift-growing when young, but soon become slow-growing and rarely exceed 10–15 m (33–49 ft) tall. The leaves are alternately arranged, simple, often lobed, more often lobed on juvenile shoots than on mature trees, and serrated on the margin.

Uses: It is strong, tough and elastic. It takes up a clean finish. It can be well seasoned. It is turned and carved easily. Mulberry is typically used for **baskets** and **sports goods** like **hockey sticks, tennis rackets and cricket bats**. The fruits are edible and tasty

6.4.3 Dalbergia *sissoo*

Common names

(English): Bombay blackwood, Indian rosewood,

(Hindi): shisham, sisam, sissai, sissoo, sissu

Dalbergia *sissoo* is a medium-to large-sized deciduous tree, growing up to 30 m in height and 80 cm dbh under favourable conditions. The crown is wide spreading and thin. Bark thin, grey, longitudinally furrowed, exfoliating in narrow strips. It develops a long taproot from an early age, and numerous lateral ramifying roots. The leaves are imparipinate; leaflets 3-5, alternate, 2.5-3.6 cm in diameter, broad ovate, acuminate, glabrescent, petiolules 3-5 mm long. Flowers 5-8 mm long, pale white to dull yellow, racemes 2.5-3.7 cm long in short axillary panicles. Pods 5-7.5 cm x 8-13 mm, narrowed at the base, indehiscent, glabrous, with 1-4 seeds. Seeds 6-8 x 4-5 mm, kidney-shaped, thin and flat, light brown. The generic name *Dalbergia* honours the Swedish brothers Nils and Carl Dalberg, who lived in the 18th century. The former was a botanist and the latter explored Surinam.

In its native countries of India and Pakistan, D. sissoo has been widely planted outside its natural range. It has been established in irrigated plantations, along roadsides and canals, and around farms and orchards as windbreaks. It has been introduced in many countries, including Nepal, Sri Lanka, Indonesia, Mauritius, Ghana, Kenya, Sudan, Nigeria, Zimbabwe, Cyprus, Iraq, the USA, the Gaza strip, South Africa and Tanzania. The tree has shown promising results in the Khartoum greenbelt (Sudan) with irrigation, but has been less successful in Ghana, N. Nigeria, N. Cameroon and Togo. It is increasingly planted as a street tree in southern Florida and is becoming invasive. In other locations, the plantations are experimental.

Uses: *Dalbergia sissoo* is one of the most useful timber species of India. The heartwood is very hard and close grained with a specific gravity of 0.62-0.82. It seasons well and does not warp or split; it is extremely durable and is one of the timbers least susceptible to dry-wood termites in India. Wood offers resistance to sawing and cutting but is excellent for turnery, takes a good polish and finishes to a smooth surface. It is used for high-quality furniture, cabinets, decorative veneer, marine and aircraft grade plywood, ornamental turnery, carving, engraving, tool handles and sporting goods.

6.5 SPICES

6.5.1 Spices and Condiments Obtained From Roots:

Horse-radish

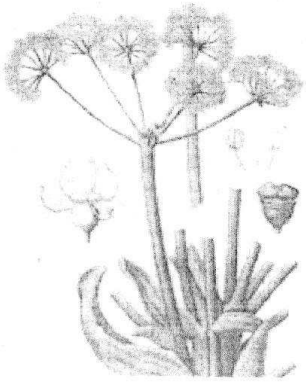
Armoracia lapathifolia Gilib.; Syn. *Roripa armoracia* (Linn.) Hitch.; *Cochlearia armoracia* Linn.: Eng.- Horse-radish. Family- Crucifeare (Brassicaceae).

It is a tall hardy herb with glossy green toothed leaves and masses of small white flowers. The roots are large, fleshy and cylindrical. It is native of Europe. In India, it is grown in Northern region and the hill stations of Southern India.

Uses: The roots are scraped or grated, and used as condiment, either fresh or preserved in vinegar. The pungent taste is due to glucoside-sinigrin. It makes a valuable condiment. It aids digestion and prevents scurvy. The roots are used also for flavouring food products. It is credited with digestive and anti-scorbutic properties because of its high vitamin C content. It is highly priazed as condiment especially with oysters and

cold meats. When mixed with ketchup, the grated roots are imparts a refreshing taste to sea-foods, especially shrimp, cocktail and oysters.

Asafetida



Ferula Linn.; English-Asafetida; Hindi-*Hing*; Family-Umbelliferae (Apiaceae).

This is genus of perennial herbs commonly distributed from the Mediterranean region to central Asia. Some of the species are important as source of oleogum-resins, used as condiment and in medicine. Three species of this genus are found in India. The main bulk of asafetida and other ferula gum-resins are being imported in India from Afghanistan.

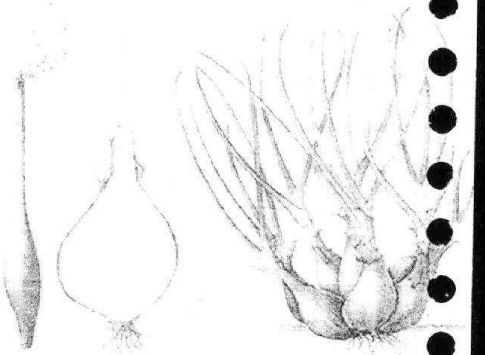
Asafetida the dried latex obtained mainly from living root stocks or taproots of several species of *Ferula*, such as: *F. foetida* Regel. *F. alliacea* Boiss., *F. rubricaulis* Boiss., *F. assafoetida* Linn. and *F. narthex* Boiss., found in Central Asia and *F. narthex* and *F. assafoetida* found in Himachal Pradesh and Kashmir.

Uses: Asafetida is bitter and acrid in taste and emits a strong and peculiar odour. In India, it is used for flavouring curries, sauces and pickles. It is also used in Ayurvedic medicines. It stimulates the intestinal and respiratory tracts and the nervous system. It is useful in Asthma, whooping cough in epileptic and hysterical affections and in cholera. It is also used in veterinary medicine.

6.5.2 Spices and Condiments obtained from Underground stems Shallot :

Allium ascalonicum Linn.; English- Shallot; Hindi- *Gandana*; Family- Liliaceae.

It is native of Israel. This has been cultivated from the ancient times by all the nations of Asia and Middle East. It is regarded as much milder than garlic. The flowers are greenish-white or purplish white, the bulbs are white. It is mainly found in Tamil Nadu.



Cultivation: Cloves or small bulbs are to be planted in October about 6 inches apart, and that by beginning of the hot season, the crop will be ready for use.

Uses: The bulbs (rhizomes) are used as condiment. The bulbs separate into cloves, like those of garlic and are used for culinary purposes, being of milder flavor than onion. They also make excellent pickle.

Onion

Allium cepa Linn.; English- Onion; Hindi- *Piyaz*. It is cultivated all over India. Onion seeds (bulb) are not left for certain more than one year. The selected bulbs are planted, and seeds are obtained from these. If the bulbs are planted in the cold season, these will produce seeds in the beginning of the hot season, and if carefully preserved, after being well-ripened and dry, the seed obtained in this way are reported found to yield a good crop in the following cold season, from October to February.

Uses: The bulbs (rhizomes) are used as food and condiment.

Leek

Allium porrum Linn.; English- Leek; Hindi- *Kirath*; Family- Liliaceae.

This succulent plant has been known from time immemorial. It is thought to be a native of Switzerland. It is also probably, like the onion, came from the Middle East. It was cultivated by Egyptians in the time of Pharaoh.

It is best propagated in India by sowing the seed broadcast on a small bed immediately the rains stop. When the seedlings are about 6 inches high, they need be carefully transplanted. They should then be planted in rows six inches apart. They require plenty of water and should be earthed up once or twice.

Uses: The bulbs are used as food and condiment.

Garlic

Allium sativum Linn. ; English- Garlic; Hindi- *Lasan, lashun*; Family- Liliaceae

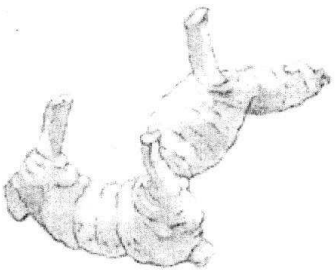
Numerous bulbs remain enclosed in a common membranous covering. Stem simple, about 2 feet high; scape is smooth and shining, solid terminated by a membranous

pointed spathe enclosing a mass of flowers and solid bulbils prolonged into leafy points; leaves long, flat, acute, sheathing the lower half of the stem; flowers small, white.

Uses: The bulbs (rhizomes) are used as condiment and flavouring substances. Garlic powder is used as condiment. It is carminative, diuretic, stomachic, alterative, emmenagouge, and tonic. It serves as the best medicine for gastric trouble(gas formation). In market, it is available as garlic tablet.

Greater Galangal

Alpinia galanga (Linn.) Willd.; Syn. *Languas galanga* (Linn.) Stuntz.; English- Greater galangal; Hindi and Bengali- *Kulinjan, kulanjan, bara-kulanjan*; Family- Zingiberaceae.



A perennial herb: native of Indonesia and Malaya, now cultivated in Bengal and South India. A perennial with broad, lanceolate, sessile, sheathing leaves, having a short, rounded, ciliate ligules, 12-24 inches long and 4-6 inches broad; stem when in flower, 6 feet high, the lower half ensheathed by the smooth leaf-sheaths. *Panicle* terminal, erect, oblong composed of numerous, dichotomous branches, each supporting 2-3-6 pale-greenish white faintly fragrant flowers. *Calyx* scarcely the length of the corolla-tube, *Labellum* oblong, stalked, arching towards the stamens, lip bifid. *Capsule* the size of a cherry, deep orange-red, *seeds* often only one in each cell.

Uses: The reddish brown rhizomes are used as condiment and the source of an essential oil. It gives a pungent taste, like a mixture of pepper and ginger. The seeds are also used as spice.

Lesser Galangal

Alpinia officinarum Hance.; English- Lesser galangal; Hindi and Mumbai- *Kulinjan, kolijana, chandapuhspi, chhota-pan-ki-jar*; Family- Zingiberaceae.

It is native of Southern China. It is perennial herb with a raceme of showy flowers and ornamental foliage.

Uses: The rhizomes possess an aromatic, spicy odour and a pungent taste, like a mixture of pepper and ginger. It is used to some extent in cooking, in medicine, and for flavouring liqueurs and bitters. It is also used to impart a pungent flavour to vinegar.

Turmeric

Curcuma domestica Valet; Syn. *C. longa Auct.* Non Linn.; English- Turmeric; Hindi- *Haldi*; Family- Zingiberaceae.

Turmeric has been cultivated in India from very ancient times. It prefers sandy and clayey loams for its cultivation. The crop cannot stand water-logging or alkalinity in the soils. The largest supplies of turmeric are obtained from Guntur district of Andhra Pradesh. Orissa is the next important growing area for turmeric where production is concentrated in the districts of Ganjam, Phulbani, and Koraput, in Maharashtra. The main centers of turmeric production are in Gujarat, Thane and Kahndesh districts. Tiruchirapally, Salem and Coimbatore districts of Tamil Nadu are also important turmeric growing areas. Other important states for this crop are- Uttar Pradesh, Madhya Pradesh, Karnataka, West Bengal, Rajasthan and the Punjab. The total average under turmeric in India has been estimated variously from 60,000 to 100,000 acres, and the production is nearly 100,000 tonnes of rhizomes per annum. A large part is consumed within the country, but a portion is exported to the U.K., Pakistan, Sri Lanka and U.S.A.

Uses: It is used as a condiment. It is used to flavour and colour pickles, and foodstuffs. It is one of the principal ingredients of curry.

Ginger

Zingiber officinale Rosc.; English- Ginger; Hindi- Plant = *adrak*; Family- Zingiberaceae.

Ginger of commerce is a dry product prepared from the green underground stems or rhizomes. The most important producers of commercial dry ginger are India, Jamaica and Sierra Leone. The most important ginger growing area in India is Kerala State. The preparation of the dry ginger (sonth) of commerce is also exclusively confined to this area. In Kerala, the main producing centres lie in the Kottayam division. The other main producing areas in the West Coast are in the Malabar district.

Ginger is grown generally in areas of heavy rainfall. It requires a rich and well drained soil for its cultivation. The most suited soils are sandy or clayey loams and laterites of the Malabar Coast. Ginger is cultivated usually in small home gardens.

Uses: Ginger is used more as a condiment than as a spice. The aroma of ginger is due to essential oil, whereas the pungent taste is due to the presence of carminative and digestive stimulant. The essential oil, obtained from the rhizomes is used for flavouring food stuffs. Ginger is exceedingly popular for flavouring beverages, such as, ginger bear and ginger malt.

Zerumbet Ginger

Zingiber zerumbet (Linn.). Rosc. ex Smith; English- Zerumbet ginger; Hindi- *Mahabari bach, nar kachur*; Family Zingiberaceae.

A perennial herb found throughout India.

Uses: The rhizomes are used as spice and condiment. The rhizome has a slightly aromatic odour and possesses similar properties to those of *Zingiber officinale*, but in a minor degree.

6.5.3 Spices and Condiments obtained from bark:

Cassia China

Cinnamomum aromaticum Nees.; English- Cassia China; Family- Lauraceae.

Cassia China is obtained from *C. aromaticum* Nees cultivated in China. The bark is the regular Cassia China of commerce. Because of its brittle nature, much of the bark is broken, thus, yielding the '*broken grade*'. The main grades are: 1. Whole Quills or China Rolls. 2. Selected Brokens or Canton Rolls, and 3. Extra selected brokens. Trees growing at higher altitude (180-300 meters) yield better quality bark with higher volatile oil content. The bark has been known from the earliest times. The dried immature fruits constitute the well known '*Cassia buds*', known in India as *Kala Nagkesar*. This species of Cassia is not grown in India but considerable quantities of it are imported into the country.

Uses: It is used as a spice or condiment in curries and similar preparations. The important constituent of commercial importance is the volatile oil which finds numerous uses in the various culinary preparations, perfumery and cosmetics as well as pharmaceutical preparations.

Cassia

Cinnamomum inners Reinw.; English- Cassia; Hindi- *Jangli darchini*; Family- Lauraceae

Cassia is a popular spice commonly used in the Indian dietary. The name *Darchini* is derived from the Arabic term *Dar-al-chini* which means the wood or bark of China. European and Arabian travelers wrote about the trade in cassia from Sri Lanka, Seynchelles, China, Indonesia and West Coast of India to other countries. The demand for cassia has been so considerable that during the fifties, India used to be the second largest importer of cassia in the world, being next to the United States.

The cassia of commerce consists of layers of dried inner barks of branches of tropical trees belonging to the genus Cinnamomum.

Uses: The bark is utilized in the similar way as that of true cinnamon (dalchini). It is used as a spice or condiment in curries and similar preparations. The bark contains 0.5 per cent volatile oil with the odour of cloves and musk.

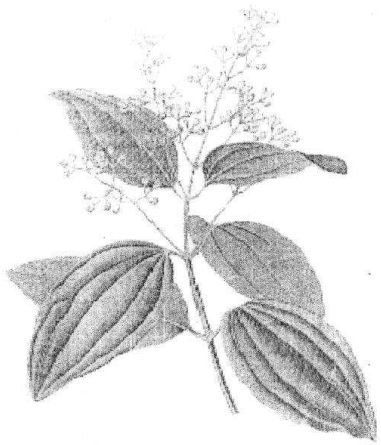
Indian Cassia

Cinnamomum tamala Nees. & Eberm.; English- Indian Cassia; Hindi- *Tejpat, tejput*; Family- Lauraceae

A moderate-sized evergreen tree, distributed in tropical and subtropical Himalayas (915 to 2440 meters altitude), Khasi and Jintia hills (915-1220 meters altitude).

The bark of the tree, known in trade as Indian Cassia or Indian Cassia Lignea, is collected from trees growing at the foot of the Sikkim Himalayas. Regular plantations of *C. tamala* are grown in Khasi and Jaintia Hills of Meghalaya, Manipur and Arunachal Pradesh.

Uses: The bark is aromatic. It is coarser than the bark of true cinnamon and is one of the common adulterants of true cinnamon. The essential oil from the bark is pale yellow and contains 70-85 per cent cinnamic aldehyde.



Cinnamon

Cinnamomum zeylanicum Bl.; English- Cinnmon; Hindi- *Dalchini*, Family- Lauraceae.

Cinnamon is one of the oldest known species. The true cinnamon, also called as Ceylon Cinnamon is the dried bark of *Cinnamomum zeylancium* Bl.

It is native of Sri Lanka. In India, it is grown in the Nilgiris, South Kanara, Malabar, Assam and Kumaun. It is an evergreen tree. The tree attains a height of 8 to 12 meters, but in cultivation it is coppiced or cut back to a height of about 2 meters. Its highly aromatic leaves are 12 to 17 cm. long, dark glossy green above and lighter beneath. The flowers are small, yellow and inconspicuous developing into dark purple ovoid and one seeded berries, about 1.5 to 2.5 cm. long.

Uses: Cinnamon is generally used as spice or ingredients of curry powder. It is used as spice or condiment in curries and similar preparations. It is also used in medicine as cordial stimulant. It is also used in bowel complaints, such as, dyspepsia, diarrohea and vomiting. Powder cinnamon is a reputed remedy for diarrhoea and dysentery. The bark also yields oil of which the chief constituent is cinnamic aldehyde.

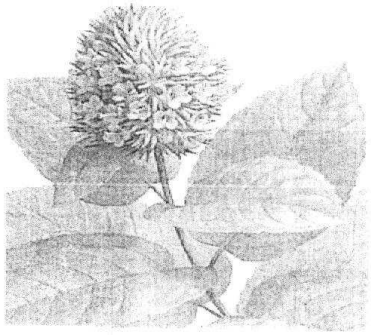
6.5.4 Spices and Condiments obtained from leaves and twigs

Mint

Mentha longifolia (Linn.) Huds.; English- Mint; Hindi- *Pudina, jungle pudina*; Family- Labiatae (Lamiaceae)

This is an aromatic herb, found in temperate Himalaya and in Kashmir, Garhwal, Kumaun, Punjab, Maharashtra and Uttar-Pradesh.

Uses: The leaves are used as flavouring agent. The dried leaves are used as carminative and stimulant. The essential oil obtained from the plant on stem distillation can be used as a substitute for peppermint oil to flavour confectionery.



Peppermint

Mentha piperita Linn.; English- Peppermint; Hindi- *Vilaiti pudina, paparaminta, gamathi phudina;* Family- Labiatae.

This is an aromatic herb. It is native of Europe. It is grown in Indian gardens and also cultivated in Kashmir, Nilgiris, Mysore, Delhi and Dehradun. *M. piperita* is considered to be hybrid between *M. spicata* and *M. aquatica.*

Uses: The leaves and flavouring tops are used for flavouring food stuffs. The herb is aromatic, stimulant, stomachic and carminative and used medicinally. The herb yields a true peppermint oil on stem distillation. The oil is extensively used for flavouring food stuffs and in pharmacy. Peppermint oil is one of the most popular and widely used essential oils. It is employed for flavouring chewing gums, candies, ice creams, confectionary, mouth washes, pharmaceutical, dental preparations and alcoholic liqueurs. It is widely employed for nausea, flatulence and vomiting. It has a refreshing odour and a persistent cooling taste. It may be taken with sugar or in the form of tablets or lozenges.

Spearmint

Mentha spicata Linn.; English- Spearmint; Hindi- *Pahari pudina*; Family- Labiateae (Lamiaceae)

A perennial aromatic herb, 1 to 3 feet high, with creeping rhizomes. It is native of temperate Europe and Asia. In India, it is cultivated in the Punjab, Uttar Pradesh and Maharashtra.

Uses: Both fresh and dried leaves are used for mint sauce and jelly and to flavour soups, stews, sauces and beverages. The leaves are the source of spearmint oil, which is used for flavouring food products. Spearmint oil is used in U.S.A. for flavouring chewing gums, confectionary and pharmaceuticals. In India, green leaves are used for making chutney and for flavouring culinary preparations, vinegars, jellies and iced drinks. The herb is considered stimulant and carminative. A soothing tea is brewed from the leaves.

Curry Leaf Tree

Murraya koenigii (Linn.) Spreng.; English- Curry leaf tree; Hindi- *Kathnim, mintha nim*; Family- Rutaceae.

A large aromatic shrub or a small tree, upto 6 m. in height and 15-40 cm in diameter, found throughout India and the

Andaman Islands upto an altitude of 1500 m Bark dark-brown or almost black; leaves imparipinnate; leaflets 9-25, ovate, lanceolate, crenate-dentate, obtuse or acute, glabrous above, pubescent beneath, gland dotted, strongly aromatic; flowers in terminal corymbose cymes, white, fragrant, berries sub-globose or ellipsoid, purplish black when ripe, 2-seeded. The plant is much cultivated for its aromatic leaves. It is propagated by seeds.

Uses: The leaves of the plant are extensively employed as flavouring agent in curries and chutneys. The leaves, root and bark are used also as tonic, stomachic and carminative.

Common Basil

Ocimum basilicum Linn.; English- Common basil, sweet basil; Hindi- *Babuitulsi, kalitulsi, sabzah, marua*; Family- Labiateae (Lamiaceae).

An erect, herbaceous, glabrous or pubescent annual, 1-3 feet high, native of Central Asia and North-West Asia, growing throughout India. Leaves ovate-lanceolate, gland dotted; flowers white or pale purple. It is cultivated throughout tropical India from the Punjab to West Bengal.

Uses: Common basil or sweet basil possesses a clove like scent and saline taste. It yields an essential oil known as oil of basil, which is used as flavouring agent. Oil of basil is commonly used for flavouring confectionery, baked goods, sauces, ketchups, tomato pastes, pickles, vinegars, spiced meats, sausages and beverages.

Rosemary

Rosmarinus officinalis Linn.; English- Rosemary; Hindi- *Rusmary*; Family- Labiateae (Lamiaceae).

A small shrub, native of Mediterranean region. It is found wild on dry rocky hill in the Mediterranean region. In India, it is cultivated to some extent in the temperate Himalaya and Nilgiri hills in dry to moderately mist climate.

Leaves of rosemary possess an agreeable aromatic odour and a pungent, bitter and camphoraceous taste. It yields a volatile oil known as oil of rosemary. The volatile oil is obtained by stem distillation of leaves, flavouring tops and twigs. The finest produce is being obtained from the dried leaves

freed of stalks. The oil is pale-yellow or colourless liquid with the characteristics odour of the leaves and a warm camphor, borneol and bornyl acetate.

Uses: The leaves are employed as a condiment dried and powdered. They are added to cooked meats, fish, eggs, soups, stews, sauces, dressings, preserves and jams. The oil is mainly used in perfumery. It also used in medicinal preparations.

Garden Sage

Salvia officinalis Linn.; English- Sage, Garden sage; Hindi- *Salvia sefakuss*; Family- Labiateae (Lamiaceae)

It is a small shrub. It is native of Mediterranean region, cultivated as a spice and for medicinal purpose. Stems are shrubby white wholly; flowering branches tomentose-pubscent; leaves aromatic, petiolate, entire, oblong, base narrowed; flowers purple, blue or white, in racemes. The grayish-green hairy leaves are very aromatic.

Uses: The leaves and tender twigs are used for flavouring food products. Sage has been extensively employed in the food industry as a standard spice in making stuffing for fowl, meats and sausage. Dried and powdered aromatic leaves are mixed with cooked vegetables and sprinkled on cheese dishes, cooked meats and other curries. Fresh sage leaves are used in salads, vegetable sandwiches.

Thyme

Thymus vulgaris Linn.: English- Thyme; Family- Labiateae (Lamiaceae)

It is a flowering plant. It is perennial in gardens. It is native of Mediterranean region. In India, it is found in Himalaya from Kashmir to Kumaun.

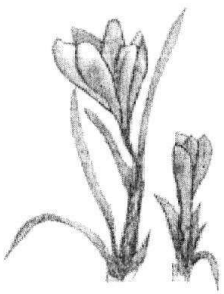
The dried leaves and tender tops make "thyme" of commerce. A volatile oil of pleasant odour is obtained on stem distillation of herb.

6.5.5 Spices and Condiments obtained from Flower buds, Flowers and Inflorescence:

Saffron

Crocus sativus Linn.: English- Saffron; Hindi- *Kesar, zafran*; Family- Iridaceae

A rhizomatous herb. It is cultivated in Kashmir at Pampur near Srinagar. To a small extent it is cultivated also at Bharsar and Chaubattia in

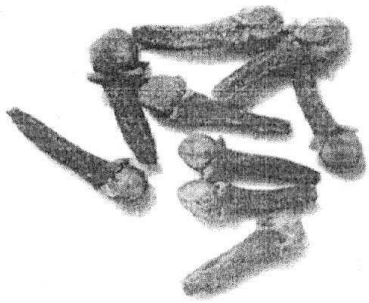


Uttarakhand. The dried stigmas and tops of the styles make the saffron of commerce. The product is obtained from the stigmas of the flowers, 4,000 of which are required to produce 25 gms. of saffron.

Uses: The saffron is used as spice and dyestuff. It possesses a pleasant aroma. Saffron is an ingredient of many Indian dishes, particularly cooked rice and sweet rice (*Kesaria chaval*) and *pulao*.

Clove

Syzygium aromaticum (Linn.) Merr. & Perry; Syn. *Eugenia aromatica* O. Kunteze; *E. caryophyllata* Thumb; English- Clove; Hindi- *Laung*; Family- Myrtaceae.



Clove is one of the most ancient and valuable spices of the orient and holds a unique position in the international spice trade. Native to Moluccas, the so called 'Spice Islands' in the East Indian Archipelago, this spice was first introduced in India around 1800 A.D. by the East India company. The company's spice garden in Courtallam in Tamil Nadu was then established to cultivate clove and nutmeg as the principal spice crops. Induced by the success of the cultivation in Courtallam, cultivation of clove was extended during the period after 1850 A.D. to Nilgiris (Burliar) in Tamil Nadu, Southern regions of Travancore and also to Cochin State on the slope of Western Ghats. The important clove growing regions in India now are Nilgiris, Tenkasi hills, and Kanyakumari districts of Tamil Nadu and Kottayam and Quilon districts of Kerala.

Although clove has been under cultivation in India for over about 170 years, its development has been very slow owing probably to its long pre-bearing period and lack of knowledge regarding the method and economics of its cultivation.

Clove is the dried unopened flower bud of *Syzygium aromaticum*, a medium-statured, cone shaped evergreen tree belonging to the family- Myrtaceae. Clove tree attains a height of 10 to 12 meters. The stem is usually forked near its base with two or three main branches. Smaller branches are slender, rather brittle and covered with grey bark. The leaves appearing in pairs, are lanceolate, acute at both ends and are dark

shining green colour. The aromatic nature of the leaves is due to numerous oil glands found on their under-surfaces. The flower buds are greenish when fresh and are borne on ends, which are picked green and dried in the sun till they become dark brown, from the 'clove' of commerce. The buds have slightly cylindrical base and are surmounted by the plump ball like unopened corolla which is surmounted by the four toothed calyx. If the bud is left unpicked, the flower develops after fertilization into a fleshy, purple and one-seeded oval fruit as 'Mother of clove'. The fruit is about 2.5 cm. long and 1.25 cm. in width. The seed is oblong, rather soft in texture and grooved on one side. The leaves, unripe fruit and broken clove, including the stalk are all aromatic and yield an essential oil.

Uses: Clove is very aromatic and fine-flavoured and imparts warming qualities. It is used as culinary spice as the flavour blends well with both sweet and savoury dishes. Clove is used for flavouring pickle, curries, ketchup and sauces. It is highly valued in medicine as a carminative, aromatic and stimulant. Clove has stimulating properties and is one of the ingredients of betel chewing. In Jawa, clove is used in preparation of special brand of cigarette for smoking. The essential oil which is obtained by distilling clove with water or stem has even more uses. It is used medicinally in several ways. The chief constituent of the oil, eugenol is extracted and used as an imitation carnation in perfumes.

6.5.6 Spices and Condiments obtained from Fruits:

Sweet Pepper

Capsicum annuum Linn.; English- Sweet pepper, paparika, Hungarian paprika, Spanish pimento; Family- Solanaceae

This is non-pungent variety of chilli. The red paprikas are famous for their brilliant red colour and mild flavour. Several varieties of paprika have been successfully grown at Indian Agriculture research Institute (IARI), New Delhi and Central Food Technology Research Institute (CFTRI), Mysore. Since several varieties of *Capsicum annuum* Linn. are used to produce paprika, pods are round in shape with pointed end whereas, the others are elongated. They are medium to small and quite fleshy. They are produced on small, bushy plants. When ripe, the pods are picked and dried in the sun. It is processed into

powder where it is grown. The paprika pods are supposed to be one of richest source of ascorbic acid (vitamin C).

Uses: Paprika is used for its colouring and flavouring properties. It is used largely as a garnish for light coloured foods, such as eggs, fish, potatoes, salads and salad dressings. In food manufacturing, flavour is important, as this spice becomes a vital ingredient of sausages, soups, salad, salad dressings and many ready prepared foods.

Red pepper, Chillies

Capsicum frutescens Linn.; Syn. *C. annuum* Linn.; English- Red pepper; Hindi- *Lal mirch, marcha, mirch*; Family- Solanaceae

It is native of the West Indies and tropical America, most probably of Brazil. Commonly cultivated for its fruit throughout the plains of India, and on the lower hills, such as, Kashmir, and in the Chenab Valley upto altitude 6,500 feet. When grown on the hills, it is said to be very pungent. There are several varieties, differing chiefly in the length, shape, and colour of the fruit, some being round, others, oblong, obtuse, pointed and bifid, smooth or rugose, and red, white, yellow or variegated. The very pungent principles are present in the flesh and rind as well as seeds. The ripe fruits are dried in the sun and used whole or powdered.

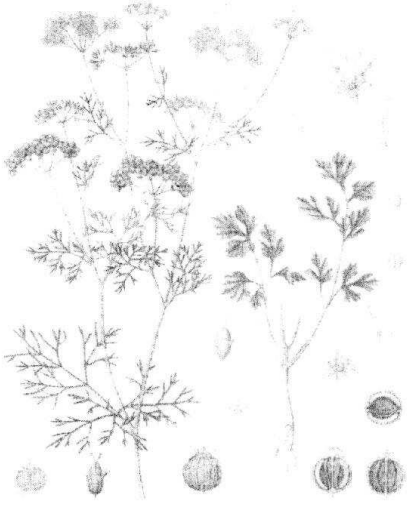
It is a herb, 2 to 3 feet in height, with entire ovate leaves, white flowers with a rotate corolla, and many-seeded fruits, which are technically berries.

Uses: The fruit when green is used for pickling and when ripe is mixed with tomatoes to make sauces. It is also dried and ground for use. The consumption of chillies is very great, and both rich and poor daily use them. The chillies from the principal ingredient in all chutneys and curries. They are ground into a paste traditionally between two stones (Silabatta), with a little mustard oil, ginger and salt, they from the only seasoning which the millions of poor can obtain to eat with rice.

Coriander

Coriandrum sativum Linn.; English- Coriander; Hindi- *Dhaniya*; Family- Umbelliferae (Apiaceae).

It is native of the Mediterranean region. It is grown extensively in India, Russia, Central Europe, Asia Minor and Morocco. In India, it is cultivated in all the



states. The more important states for its cultivation are- Andhra Pradesh, Assam, Maharashtra, Tamil Nadu, Uttar Pradesh, Karnataka, Himachal Pradesh and Madhya Pradesh.

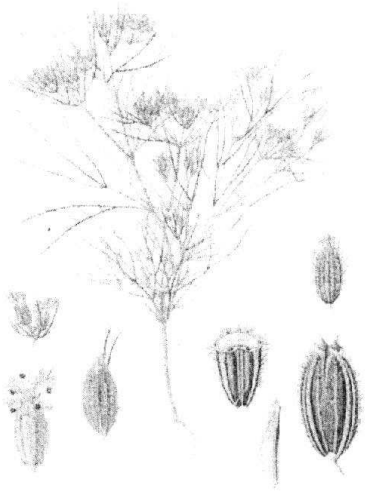
The plant is generally 2-3 feet in height, with white or pinkish flowers. The lower leaves have broad segments, while the upper are very narrow. The fruits are small, oval and aromatic. Technically the fruit is known as "cremocarp". Each fruit consists of two one-seeded carpels, or mericarps with numerous oil ducts (vittae).

Uses: The fruits and leaves are aromatic and used as flavouring materials. The fruits are used extensively in the preparation of curry powder, pickles, sauces, soups, sausages and seasonings. They are also employed for flavouring pastries, cookies, buns and cakes and tobacco products. It is also used for flavouring liqueurs, particularly gain. The fruits are used both as spice and condiment. It is an important condiment used widely in all parts of India. A major part of the produce is used within the country. The fruits are also used as stimulant, carminative, stomachic, diuretic, antibilous, refrigerant, aphrodisiac and tonic. Oil of coriander is used in medicine and for flavouring beverages. The coriander leaves make one of the richest sources of vitamin C (*i.e.*, 250 mg/100 g.) and vitamin A (*i.e.*, 5200 I.U./100g.).

Cumin

Cuminum cyminum linn.; English- Cumin; Hindi- *Zira*; Family- Umbelliferae (Apiaceae)

It is native of Mediterranean region. In India, it is cultivated mainly in the Punjab, Rajasthan, Haryana and Uttar Pradesh. The plant is a little annual herb with small pinkish flowers. The elongated oval fruits are aromatic and light brown in colour.

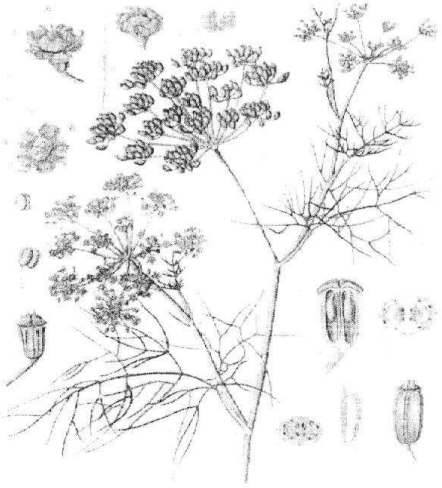


Cumin is a very old spice. It would appear to have been known to the ancients; at least there are names for it in most of the classical languages. During middle age, it was one of the most favoured of spices. It was in frequent use, for example, in England in the thirteenth century.

Uses: The aromatic fruits are used as spice and condiment. The fruits are used in soup, curries, cake, bread, cheese and pickes. They from an ingredient of some curry powders and pickles. The fruit contains an essential oil, which is mixture of cymol and cuminol and other hydrocarbons. Both fruit and oil possess carminative properties. They are also aromatic, stimulant, stomachic and astringent. Their warm bitterish taste and aromatic odour reside in the volatile oil.

Fennel

Foeniculum vulgare Mill.; English- Fennel; Hindi- *Saunf;* Family- Umbelliferae



It is a stout, glabrous, aromatic herb, 5-6 feet high; leaves pinnately decompound; flowers small, yellow, in compound terminal umbels; fruit oblong, ellipsoid or cylindrical, 6-7 mm. in length, straight or slightly curved, greenish or yellowish born; mericarp 5-ridged with prominent vittae.

Fennel is a very old flavouring substance. It was known to the ancient Hindus, Chinese and Egyptians as a culinary spice. It is native of Mediterranean region. In India, it is cultivated mainly in the Punjab, Uttar Pradesh, Assam, Maharashtra and Baroda. It is cultivated mostly as a garden or homeyard crop throughout India at all altitudes upto 6,000 feet. It requires a fairly mild climate and is cultivated as a cold whether crop in parts of Northern India.

Uses: The leaves are used in fish sauce and for garnishing. Leaf stalks are used in salad. The leaf stalks are also used as vegetable. The leaves also possess diuretic properties. The roots are used as purgative and they possess n aromatic odour and taste.

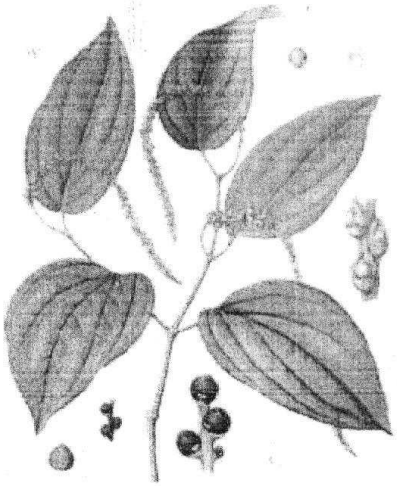
Dried fruits of fennel have a fragrant odour and a pleasant aromatic taste. They are used for flavouring curries, soups, meat dishes, sauces, bread rolls, pastries and confectionery. They are also used for flavouring liqueurs and in the manufacturing of pickles.

The fruits are aromatic, stimulant and carminative. They are useful in the diseases of chest, spleen and kidney. It is used as one of the condiments in liquorice powder. A hot infusion of the fruits is used to increase lacteal secretion and to stimulate sweating.

Fennel fruits from Lucknow are considered to be the best and are priced higher than those from other areas.

Black Pepper

Piper nigrum Linn.; English- Black Pepper; Hindi- *Kalimirch, golmirch, choca mircha*; Family- Piperaceae.



A branching, climbing perennial shrub, mostly found cultivated in the hot and moist parts of India, Sri Lanka and other tropical countries. Branches stout, trailing and rooting at the nodes; leaves entire, 12.5-17.5 by 5.0-12.5 cm., very variable in breadth, sometimes glaucous beneath, base acute rounded or cordate, equal or unequal; flowers minute in spikes, usually dioecious; fruiting spikes very variable in length and robustness, rachis glabrous; fruits ovoid or globose, bright red when ripe; seeds usually globose, testa thin, albumin hard.

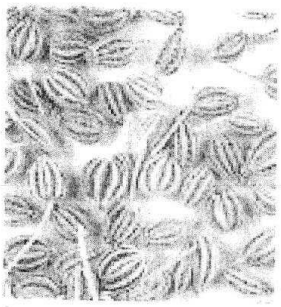
Pepper is one of the most ancient crops cultivated in India and has probably originated in the hills of south-western India, where it is met with in a wild state in the rain forests from North Kanara to Kanyakumari. The pepper vine in its wild state is mostly dioecious and consequently rarely sets fruit. Under cultivated condition, however, the fruiting is very much better, since most of the cultivated types are bisexual. Almost all the types cultivated at present are selections from wild plants. Some crosses have already been evolved at the Pepper Research Station, Panniyur (Kerala). Of these, the hybrid, *Panniyur* I, noted for its high yield. *Panniyur* I is a good hardy climber and has long spikes with close set, large fruits.

Uses: Pepper fruits are used as spice or condiment. In Kerala, fresh green pepper is sometimes used for preparing pickles. Black and white pepper make the major condiment employed for seasoning freshly cooked and prepared foods. In U.S.A. and other European countries, they are used mainly for preserving meat. The whole fruits are added to pickles, certain types of sausages, etc., but the bulk of the product is generally ground before use. Black pepper is mostly used for its characteristics aroma and pungent taste.

White pepper is less pungent. The aromatic odour is also present. Pepper stimulates the flow of salvia and the gastric juices and has a cooling effect. In modern Indian medicine, it is much employed as an aromatic stimulant in cholera, weakness following fevers, coma, etc., as a stomachic in dyspepsia, as an antiperiodic in malarial fever.

Ammi

Trachyspermum ammi (Linn.) Sprague; English- Ammi, Lovage; Hindi- *Ajwain, ajowan;* Family- Umbelliferae



This is an aromatic herb and cultivated extensively in India for its fruits (seeds) from the Punjab and Bengal to the South Deccan. It is first mentioned in Europe as brought from Egypt about 1549 A.D.

Uses: The fruits are used as spice. They yield an oil of distillation with water, which is used medicinally. The fruits (seeds) are much valued for their antispasmodic, stimulant, tonic and carminative properties. They are considered to combine the stimulant quality of capsicum or mustard with the bitter property of chiretta, and the antispasmodic virtues of asafoetida.

6.5.7 Spices and Condiments obtained from Seeds

Bengal Cardamom

Amomum aromaticum Roxb; English- Bengal cardamom; Hindi- *Bari elaichi*; Family- Zingiberaceae

It is a perennial herb, grown in North Bengal and Khasia hills. The fruit ripens in September; the capsules are then carefully gathered by the natives and sold to the druggists.

Uses: The fruits and seeds are used as condiment. It is one of the chief ingredients of '*garam masala*'.

Greater Cardamom

Amomum subulatum Roxb; English- Greater or Nepal cardamom; Hindi- *Bari elaichi*; Family- Zingiberaceae

It is native of Nepal. A perennial herb,it is grown in swampy places in Bengal, Sikkim, Assam and Tamil Nadu. The fruit of greater cardamom is irregularly obcordate, flattened anteroposteriorly, having 15-20 irregular dentate-undulate wings, which extend from the apex downwards for two-thirds of the length of the cardamom.

Uses: The seeds are used in the preparation of sweet meats and for flavouring beverages. They are cheaper but inferior substitute for the true cardamom.

The oil of greater cardamom is an agreeable aromatic stimulant, pale yellow in colour, having the odour and flavour of the seeds.

Lesser cardamom

Elettaria cardamomum Maton; English- Lesser cardamom, cardamom; Hindi- *Chhoti elaichi*; Family- Zingiberaceae

This is tall herbaceous perennial, with branching subterranean rootstock, from which arise a number of upright leafy shoots, 5-18 feet high, alternate, elliptical or lanceolate sheathing leaves, 1-3 feet long. Flowers borne in panicles 2-4 feet long, arising from the base of vegetative shoots; panicle upright throughout their length or upright at first and ultimately pendent or prostrate; flowers about 1.5 inches long, white or pale green in colour with a central lip streaked with violet, borne in a close series on the rachis; bisexual. Fruits trilocular capsule, fusiform to ovoid, pale green to yellow in colour, containing 15-20 hard, brownish black, angled and rugose seeds, covered by thin mucilaginous membrane.

It is native of the moist evergreen forests of South India, growing wild in the Western Ghats, between 2,500 and 5,000 feet. It is found wherever the overhead canopy has been thinned. It is also found along stream banks, where the overhead shade is less dense.

Uses: Cardamom is used as a spice and masticatory, and in medicine. The seeds possess a pleasant aroma and a characteristic, warm, slightly pungent taste. It is used for flavouring curries, cakes, bread and for other culinary purposes. It is also used for flavouring liqueurs. In the Arab countries, cardamom is used for flavouring coffee and tea. In medicine, it is used as an aromatic, stimulant and flavouring agent.

Cardamom oil of commerce is obtained by the distillation of the whole fruits of *E. cardamomum*. The cardamom oil is a colourless or pale yellow liquid with penetrating, camphoraceous odour and a strong pungent taste. The main constituents of the oil are-

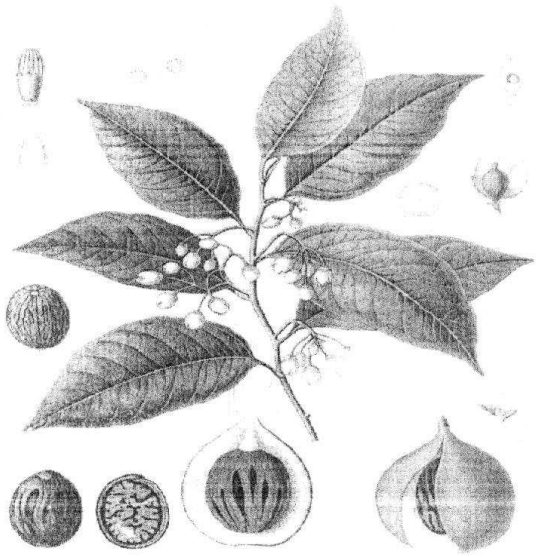
cineol, terpinene, limonene, sabinene and terpineol in the form of formic and acetic esters. Cardamom oil is used in flavouring beverages.

The chief importing countries of Indian cardamom are- Arabia, Sweden, U.K., U.S.A., Germany and Middle East countries.

Nutmeg and Mace

Myristica fragrans Houtt.; English- Nutmeg tree; Hindi- *Jaiphal (fruit kernel), japatri (aril)*; Family- Myristicaceae.

It is native of the Moluccas Islands. In India, it is grown in the Nilgiris, Kerala, Mysore, Andhra Pradesh, Assam and West Bengal.



This is dioecious or rarely monoecious evergreen aromatic tree, usually 30-40 feet high. The bark is grayish and longitudinally fissured in old trees. The leave are elliphatic or oblong-lanceolate and fragrant. The fruits are yellow, broadly pyriform or globose, 6-9 cm. long, glabrous often drooping. The pericarp is fleshy, 1.25 cm. thick, splitting into two halves at maturity. The seeds are broadly ovoid, arillate, albuminous, with a shell like purplish brown testa. The arial is red and fleshy.

Uses: Both nutmeg and mace are used as condiment and in medicine. They are commonly used more as a drug than as condiment. Nutmeg is stimulant, carminative, astringent and aphrodisiac. It is used in tonics and forms a constituent of preparations prescribed for dysentery, flatulence, nausea, vomiting, malaria, rheumatism, sciatica and leprosy.

Nutmeg oil and mace are used for flavouring food products and liqueurs. Nutmeg butter is used as mild external stimulant in ointments, hair lotions and plasters, and forms a useful application in case of rheumatism.

Black Cumin

Nigella sativa Linn; English-Black cumin, small fennel; Hindi- *Kalonji, kalajira*; Family-Ranunculaceae

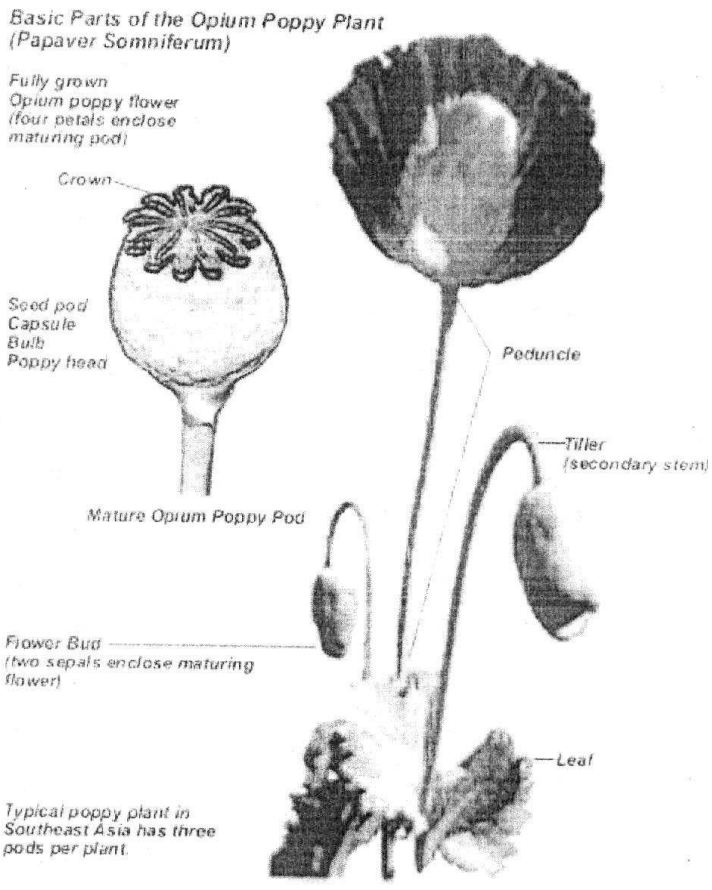
It is a herb and native of Southern Europe. In India, it is cultivated in the Punjab, Bengal, Assam and Bihar for its seeds. Its Sanskirt names indicate its introduction at a very early period.

Uses: The seeds possess a strong, pungent, aromatic taste, therefore, are much use in curries, pickles and other dishes. They are also frequently sprinkled over the surface of bread along with sesamum seed. French cooks employ the seeds of this plant under the name of *Quatre epices* or *toute epices*, and they were formerly used as a substitute for pepper.

Poppy seeds

Papaver somniferum Linn. var. album; English- Poppy seeds; Hindi-*Post*; Family-Papaveraceae

It is native of west Asia. In India, it is cultivated in the East Punjab, Uttar Pradesh, Rajasthan and Madhya Pradesh. The plant is an erect, rarely branched, usually glaucous annual herb, 60-120 cm. in height. Leaves ovate-oblong or linear-oblong, amplexicaul, lobed, dentate or serrate; flowers large, usually bluish white with a purplish base or white, purple or varie- gated; capsules large, 2.5 cm. diameter, globose, stalked; seeds white or black, very minute, reniform.



As we know poppy is cultivated also for its seeds. In India, *var. album*, with white seeds has been cultivated for many years for the production of seeds (*post*) under licence in Dehradun and Tehri Garhwal districts of Uttarakhand, and in Jalandhar, Kapurthala, Hoshiarpur and Patiala

districts of the Punjab. In India, best seeds are obtained when the capsules have not been incised for extraction of opium. The crop yields 220-275 kg. of seeds per hectare.

Uses: Poppy seeds are considered nutritive and are used in breads, curries, sweets and confectionery. Poppy seeds contain upto 50 per cent of an edible oil. The oil is odourless and possesses a pleasant almond-like taste. In India, the oil is extracted by cold –pressing the seed in small presses. The oil is widely used for culinary purposes. It is free from narcotic properties and used as a salad oil. The cake or the meal left after extraction of the oil from the seeds is sweet and nutritious and is eaten by poor people.

Fenugreek

Trigonella foenum-graecum Linn; English- Fenugreek; Hindi- *Methi*, Family- Papilionaceae

It is a native of Southern Europe and Asia. It is grown mainly in Northern India. It is an annual legume with white flowers and long slender pods with a pronounced beak. The crop is sown in October-November. It is ready to harvest in April.

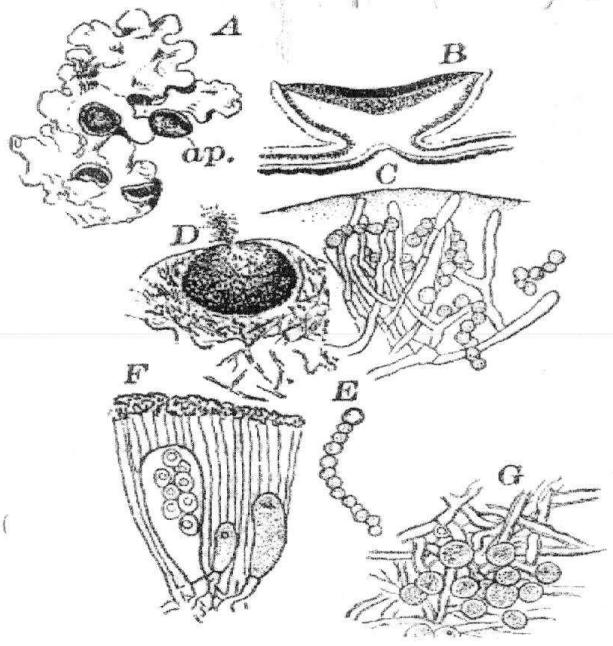
Uses: The seeds are chiefly used as a condiment to flavour curries made of rice, pulse, flour and meat, or as a relish with unleavened bread. The aromatic leaves are used as vegetable. The seeds are carminative, tonic and aphrodisiac.

6.5.8 Spices and Condiments obtained from Lichens

Parmelia

Parmelia abessinica Kremp; Telugh- *Rathipooveu*; Family- Parmeliaceae.

This is crustaceous lichen in rocky areas of Bellary, Anantpur and Guddapah districts of Andhra Pradesh. The lichen is available in large quantities in the market and used



as food material and condiment. It contains atranorin (1.1%), lecanoric (3.3%), salazinic acid (0.1-0.5 %) and isolichenin (3.4%).

Parmelia tinctorum Despr. is foliose lichen commonly found in the plains of India and in the Himalaya on tree bark and rocks. It is commonly used in certain parts of South India as a component of various food preparations. It contains-crude protein, 13.8; ether extract, 6.0; isolichenin, 25.0; crude fibre, 13.4; and ash, 12.6%; calcium1, 728 mg; ascorbic acid. 5.5mg and riboflavin 100 mg./100g.

Uses: The above mentioned lichens are used as spice and condiment.

6.6 SUMMARY

- India has traditionally been known for small scale industries.
- The African pencil cedar is found in mountainous areas and highlands, on rocky ground. In Africa, it occurs at altitudes between 1,050 and 3,600 metres, but is most common between 1,800 and 2,700 metres.
- The jamrosa oil is extracted from the highly aromatic jamrosa grass and used in dhoop and aggarbatti.
- *Morus* is a genus of flowering plants in the family Moraceae. The 10-16 species of deciduous trees it contains are commonly known as Mulberries and used in making sport goods.
- Roots of horse-radish and Asfafetida are used as spices and condiments
- Shallot , onion , garlic turmeric , ginger etc are under ground stems used as spices and condiments
- Bark of Cassia used as one of the most important and demanding spices obtained from the bark.

6.7 REFERENCES

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6.8 TERMINAL QUESTIONS

Q1 Write a concept note on African pencil cedar

Q2. Discuss the species used for aggarbatti and sport goods

Q3. Write a short note on *DAlbergia sissoo*

Q4. Explain the spices and condiments obtained from roots

Q5. Write down the spices and condiments obtained from bark.

Q6 Write a concept note on the spices and condiments obtained from leaves and twigs of the plants.

Q7 Discuss the spices and condiments obtained from inflorescence and flower buds.

Q8 Write a short note on Cardomom

Q9Write short note on spices and condiments obtained from lichens

Q10. Fill in the blanks

i. ..... used in the manufacturing of pencils.

ii. The Regional Research Laboratory (RRL) in Jammu has developed a new variety of the jamrosa which is called.....

iii. .....products are used for making dhoop, agarbatti .

iv. .....lichens are used as spice and condiment.

(i. *Juniperus procera*, ii. CN-5, iii. Jamrosa, iv. . *Parmelia tinctorum*)

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