Chapter-1

INTRODUCTION

The word “Textile” comes from the Latin verb “texere”, meaning to weave. Traditionally textiles are made from yarn, which is developed by processing fibres although many textiles can be made by the direct conversion of fibres. The term ‘textile fibres’ refers to any product capable of being woven or otherwise made into fabrics.

The quality of the finished textile is determined by the length, strength, and nature of its constituent fibres. Fibres used for textiles are usually described as being filaments or staples. A filament is a continuous-length fibre and staples are limited-length fibres requiring twisting together to make them usable.

Textile fibers are broadly classified into two categories -Natural fibres, and manmade fibers. Natural fibers that occur in nature are classified as vegetable fibres, animal fibres, and mineral fibres. Vegetable fibers found in the vegetative matter are basically cellulose in composition. Animal fibers produced by animals or insects, are proteinic in composition. Mineral fibre is mined from certain types of rock. Man-made fibres are divided into two categories regenerated and synthetic fibres.

Textile fabrics are produced by interlacing or entangling yarns or fibres in some manner. In turn textiles yarns are continuous strands made up of textile products. Each individual fibre is made up of millions of individual long molecular chains of discrete chemical structure. The arrangement and orientation of these molecules within the individual fibers will affect fibre properties but by far the molecular structure of the long molecular chains, which make up the fibre, will determine its basic physical and chemical nature.

Textile fibers both natural and man-made are mainly composed of compounds belonging to the class of high molecular compounds i.e. high polymers.
Compounds with molecules consisting of hundreds of thousands of atoms joined together by the forces of primary valencies are called high molecular compounds, and such molecules because of their large size and high molecular weight are called as macromolecules.

In most high molecular compounds, the molecules are built up of a great number of small elementary units called monomers and therefore are often referred to as higher polymers or simply polymers. Natural rubber and the various synthetic rubbers, natural and synthetic resins, cellulose, and protein are high polymer based substances.

The properties of high molecular compounds are mainly determined by their chemical nature, molecular weight and the structure of the macromolecules.

In India cotton ranks first in respect of area under cultivation. Cotton is the principal clothing fibre not only of India, but also of five continents of the world and accounts for more than 50% of clothing, household, and industrial application. Considering textiles from natural resources point of view, the consumption is increasing in such a galloping rate, further even the changing lifestyles have created a need to blend cotton with various other fibers, that the king of fibers for 5000 centuries is still reigning supreme.

Apart from cotton India has a large variety of other cellulosic fibre like pineapple, ramie, jute, coir and banana. Although banana is largest horticultural crop in India, it is the second largest fruit crop in the world and the fourth most important commodity, the first three being rice, wheat and dairy products. The trunk (pseudostem) of banana plant is used to some extent in pulping and paper manufacturing and also for making pressed boards.

1.1. **BANANA FIBRE:**

1.1.1. **Origin and history**
They are essentially hot climate plants. Their origin or home is said to be the tropical forests of Asia. In addition to this, now a day, it is also gaining importance as a source of fibres.

Banana has important place in our mythology. It is said Manu or Noah (according to western mythology) or Hazrat Nuh (according to muslims) when started implanting new life on our planet after the great flood, sought help from God for a multipurpose plant that serve as food, fruit and fodder crop. It is said that god gave him banana tree which meets most of our want since besides fruit and vegetable, flowers and stems are cooked, plant gives fibre for manufacturing dresses, its leaves are used as plates to serve food besides of course various medicinal virtues. The plant grows easily of its own as it sets young shoots. There are references of this plant and fruit in a number of places in our epics Ramayana and Mahabharata.

There is a wide variety of historic references to bananas. They are mentioned in ancient Hindu, Chinese, Greek and Roman texts. It is believed that the earliest written reference to banana is in Sanskrit and dates back to around 500 BC. Bananas are suspected to be the first fruit in the earth by some horticulturists.

The origin of bananas is placed in Southeast Asia, in the jungles of Malaysia, Indonesia or Philippines, where so many varieties of wild bananas still grow at present. Bananas have later travelled with human population. The first Europeans to know about bananas were the armies of Alexander the Great, while they were campaigning in India in 327 BC. In the middle Ages, the banana was thought to be the forbidden fruit of paradise by both Muslims and Christians. The Arabs brought them to Africa. Africans are credited to have given the present name, since the word banana would be derived from the Arab finger. The Portuguese brought them to the Canary Islands. Bananas changed during all these trips, gradually losing its seeds, filling out with flesh and diversifying.

When Spaniards and Portuguese explorers went to the New World, the banana travelled with them. In 1516, when Fiar Tomas de Berlanga sailed to
Santo Domingo, he brought banana roots with him. From there, bananas spread to the Caribbean and Latin American countries.

Bananas started to be traded internationally by the end of XIX century. Before that date, Europeans and North Americans could not enjoy them because of the lack of appropriate transport for bananas. The development of railroads and technological advances in refrigerated maritime transport allowed for bananas to become the most important world traded fruit. Members of the genus *Musa* (part of the family *Musaceae*); they are considered to be derived from the wild species *Musa acuminata* (AA) and *Musa balbisiana* (BB). It is believed that there are almost 1000 varieties of bananas in the world, subdivided in 50 groups. The most commonly known banana is the *Cavendish* variety, which is the one produced for export markets.

![Plate 1: The banana crop](image)
1.1.2. Crop

The banana is not a tree but a high herb that can attain up to 15 feet of height. It is a perennial plant that replaces itself. Bananas do not grow from a seed but from a bulb or rhizome. The time between planting a banana plant and the harvest of the banana bunch goes from 9 to 12 months. The flower appears in the sixth or seventh month. Bananas are available all year long.

Bananas are grown in tropical regions where the average temperature is 80° F (27° C) and the yearly rainfall is 78-98 inches (200-250 centimeters). They require moist soil with good drainage. In fact, most bananas exported are grown within 30 degrees either side of the equator.

Banana growing is, in general, labour intensive because banana plants require intensive, individual care in order to obtain the required quality fruit: clearing away of jungle growth, propping to counter bending from the weight of the growing fruit and irrigation during the dry season.
Banana is cultivated in over 120 countries throughout the tropical and subtropical regions of the world. The ten largest banana-producing countries are India, Uganda, Ecuador, Brazil, Colombia, Philippines, China, Indonesia, Democratic republic of Congo, and Costa Rica. About 17% of world's bananas are produced in India. India is the largest producer of Bananas in the world with an estimated annual output of 13.5 million tons. It is cultivated in the tropics; in about 1, 86,000 hectares of land and the fiber yield is around 7.5 lakh tones per annum. In India, banana is cultivated on 5.65 lakh ha area and the leading major banana growing states are Maharashtra (0.54 lakh ha), Gujarat (0.49 lakh ha), Tamil Nadu (0.82 lakh ha), Andhra Pradesh (0.56 lakh ha), Karnataka (0.42 lakh ha) and Kerala (0.59 lakh ha). After the fruit production, the trunk of the banana plant i.e.: the pseudostem is thrown as agricultural waste to a great extent. These pseudostems can be effectively utilized in production of the banana fibres as, annually, about 1.5 million tons of dry banana fibres can be produced from the outer sheath of pseudostem. With the increasing demand for Banana in both the Indian and International markets, the acreage and production are expected to increase in the coming years, thus generating more of the pseudostem biomass waste. Being a rich source of natural fibres, the pseudostem can be profitably utilized for numerous applications and preparation of various products.
Plate 3: The Banana Plant
Banana fibre is obtained from the pseudostem of the banana plant by decortication i.e. stem is generally scrapped with the help of a blunt knife. Banana plant cannot be grown except under tropical conditions, as it bears
numerous leaves and only very short roots, it requires humidity both in the atmosphere and in the soil, and is only able to thrive in areas which have rainfall more or less evenly distributed throughout the year. It is essential that the rainfall should be evenly distributed throughout the year as a rainless period of as long as 6 weeks may harm the plant. While a prolonged draught is usually fatal, banana will not withstand flooding. So a warm humid climate is essential. The soil should be loose, rich in humus, and properly drained. A moderate amount of minerals in soil is stated to be necessary.

All varieties of banana trees abound in fibres. In fact almost each and every part of the banana plant gives fibres of various strength, colour and beauty and staple length which can be used for various purposes.

Out of the 14-18 sheaths available in a stem, the outermost 4-6 sheaths yield course fibre, the outer 6-8 sheath soft lustrous fibre and the rest middle sheath excluding the innermost 4-6 sheaths yield very soft fibers. In each sheath, there are 3 distinct layers, the outer layer including the epidermis, contain the bundles of fibres dispersed in a soft tissue matrix. The middle layer consists of water transporting fibre vascular tissue. And the inner layer consists of soft, cellular tissue. The quantity of fibre in each sheath depends upon its width and its location in the stem, as does its quality. In addition to fruit production, huge quantity of biomass (pseudostem, leaves, suckers etc.) is generated. Presently, this biomass is discarded as waste. In past, some researchers have successfully demonstrated use of banana pseudostem and leaves for extraction of fibres on a small scale. In India, the fibres are being used for preparing handicrafts, ropes etc., which otherwise can be used for making fabrics, home furnishings and good quality papers. The major problem of non-adoption of fibre extraction technology is low recovery of fibres leading to high transport cost.
1.1.3. EXTRACTION OF BANANA FIBRE: -

Banana fibre is extracted, not on a commercial worthwhile scale anywhere in the country. For extraction of fibres from the pseudostem, the most common method followed in Indian villages is hand scrapping, i.e. to scrap the stem with blunt metal edge. The drawback of hand scrapping is that the fibre output is very low.

The essentially hand driven process of extracting banana fiber is now set to change with the invention of the Banana Fiber Separator Machine. An easier and quicker way of extracting fibres is to use a machine extractor, called Raspador, Banana Fiber is extracted from Banana pseudostem sheaths. Some efforts to extract the fibre by conventional methods like Hand extraction are being made in state of Kerala but the quantity of fibre produced is quite small. In some banana growing countries of the world like Philippines, Uganda, China, and Indonesia systematic extraction of banana fibre is being carried out.

The plants are cut down as soon as the fruits are harvested. The trunk is peeled. Brown-green skin is thrown away retaining the cleaner or white
portion which will be processed into knotted fibers. To extract the fibre, the pseudostem is cut at the bottom at an angle, and its sheaths are removed, as each series of leaf sheaths produces different grades of fibers. It would be desirable to separate them according to the classification mentioned above prior to the cleaning or stripping that would enable the artisans to market the fibres advantageously. The fibers are extracted through hand extraction machine composed of either serrated or non serrated knives. The peel is clamped between the wood plank and knife and hand-pulled through, removing the non-fibrous material. The extracted fibers are sun-dried which whitens the fiber.

Once dried, the fibers are ready for knotting. A bunch of fibers are mounted or clamped on a stick to facilitate segregation. Each fiber is separated according to fiber sizes and grouped accordingly. To knot the fiber, each fiber is separated and knotted to the end of another fiber manually. The separation and knotting is repeated until bunches of unknotted fibers are finished to form a long continuous strand. This fiber can now be used for making various products. One more interesting fact associated with the development of this machine is that it uses the agriculture waste of banana harvests to produce silk grade fiber. These silk grade fibers are of immense help to the handicrafts and textile industry. What was previously considered an agricultural waste is now converted to a raw material for good quality silk like yarn.
Plate 6: Banana plants laden with fruit bunches

Plate 7: The Banana pseudostem
Plate 8: Banana Pseudostems are separated manually before fibre extraction
Plate 9: Separation of the pseudostems before fibre extraction
Plate 10: Fibre extractor
Plate 11: Banana Fibre Extractor
Plate 12: Fibres being extracted
Plate 13(a): The banana fibres kept for drying after extraction.
Plate 13(b): Banana Fibres kept for drying after extraction
Plate 14: Dried Banana fibres
1.1.4. Characteristics of Banana Fiber

In most part of India, these banana trunks are thrown as agricultural waste because most of the people are ignorant about the extraction of the fibre and its utilization except Kerala where this fibre is partly used for manufacturing household articles. This present portion of article gives an evaluation of yield, structure and properties of banana fibres gathered from a few commercially cultivated varieties. Results indicate that variation exists in both structure and properties of fibres from different regions along the length and across the thickness of the trunk.

Banana fiber is a natural leaf fiber. It has its own physical and chemical characteristics and many other properties that make it a fine quality fiber.

- Appearance of banana fiber is similar to that of bamboo fiber and ramie fiber.
- The chemical composition of banana fiber is cellulose, hemicelluloses, and lignin.
- It is a strong fiber.
- It has smaller elongation.
- It has somewhat shiny appearance depending upon the extraction.
- It is light weight.
- It has strong moisture absorption quality. It absorbs as well as releases moisture very fast.
- It is bio-degradable and has no negative effect on environment and thus can be categorized as eco-friendly fiber.
- Its average fineness is 4 to 15 tex.
- Currently the specification of banana fiber as followings:

**Table 1.1: Specification of Banana fibres**

<table>
<thead>
<tr>
<th>Linear Density (D)</th>
<th>Average Strength (cN(tex))</th>
<th>Strength Unevenness (%)</th>
<th>Average Elongation at Break (%)</th>
<th>Elongation Unevenness (%)</th>
<th>Break Strength (cN(tex))</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.03</td>
<td>39.3</td>
<td>34.3</td>
<td>5.4</td>
<td>19.7</td>
<td>2.3</td>
</tr>
</tbody>
</table>

**Table 1.2.: Physical properties of banana fiber**

<table>
<thead>
<tr>
<th></th>
<th>Single cell</th>
<th>Bundle fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length (mm)</td>
<td>Diameter (um)</td>
</tr>
<tr>
<td></td>
<td>Fineness (tex)</td>
<td>Length (mm)</td>
</tr>
<tr>
<td>Banana</td>
<td>2-4</td>
<td>10-35</td>
</tr>
</tbody>
</table>

Banana fiber is short, before spinning, must be made Technical fiber (length is 50~60mm)
Table 1.3.: Properties of modified fibers

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Observed value</th>
<th>Reported value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Average</td>
</tr>
<tr>
<td>Diameter (micro M)</td>
<td>11-34</td>
<td>21.28</td>
</tr>
<tr>
<td>Length(Cms)</td>
<td>80-200</td>
<td>115.0</td>
</tr>
<tr>
<td>Strength(gms)</td>
<td>120-670</td>
<td>402.33</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>2.2-4.3</td>
<td>3.18</td>
</tr>
<tr>
<td>Fineness (denier)</td>
<td>54-68.4</td>
<td>62.64</td>
</tr>
<tr>
<td>Tex</td>
<td>6-7.6</td>
<td>6.69</td>
</tr>
</tbody>
</table>

Table 1.4.: Physical properties of banana fibre

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Observed value</th>
<th>Reported value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Average</td>
</tr>
<tr>
<td>Diameter (micro M)</td>
<td>11-34</td>
<td>21.28</td>
</tr>
<tr>
<td>Length(Cms)</td>
<td>80-200</td>
<td>115.0</td>
</tr>
<tr>
<td>Strength(gms)</td>
<td>120-670</td>
<td>402.33</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>2.2-4.3</td>
<td>3.18</td>
</tr>
<tr>
<td>Fineness (denier)</td>
<td>54-68.4</td>
<td>62.64</td>
</tr>
<tr>
<td>Tex</td>
<td>6-7.6</td>
<td>6.69</td>
</tr>
<tr>
<td>Tenacity(gms/tex)</td>
<td>20-88.15</td>
<td>50.75</td>
</tr>
</tbody>
</table>
### Table 1.5.: Mechanical property of banana fibre for different varieties

<table>
<thead>
<tr>
<th>varieties</th>
<th>BL (N)</th>
<th>Tex (G)</th>
<th>Extn (%)</th>
<th>Tenacity (MN/dtex)</th>
<th>Spl. work of rupture (J/G)</th>
<th>Modulus (MN/dtex)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Initial</td>
</tr>
<tr>
<td>Nendran</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thin</td>
<td>2.54</td>
<td>3.04</td>
<td>3.05</td>
<td>76.50</td>
<td>13.45</td>
<td>2724</td>
</tr>
<tr>
<td>Thick</td>
<td>5.14</td>
<td>7.54</td>
<td>2.69</td>
<td>68.17</td>
<td>9.24</td>
<td>2185</td>
</tr>
<tr>
<td>Safed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thin</td>
<td>2.30</td>
<td>4.28</td>
<td>2.55</td>
<td>53.74</td>
<td>6.80</td>
<td>1737</td>
</tr>
<tr>
<td>Thick</td>
<td>4.50</td>
<td>10.56</td>
<td>2.37</td>
<td>44.40</td>
<td>4.57</td>
<td>1547</td>
</tr>
<tr>
<td>Velchi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thin</td>
<td>1.30</td>
<td>3.20</td>
<td>4.63</td>
<td>40.62</td>
<td>10.47</td>
<td>1093</td>
</tr>
<tr>
<td>Thick</td>
<td>5.27</td>
<td>12.08</td>
<td>4.38</td>
<td>43.62</td>
<td>10.60</td>
<td>838</td>
</tr>
<tr>
<td>Padalse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thin</td>
<td>2.55</td>
<td>5.40</td>
<td>4.06</td>
<td>47.22</td>
<td>10.71</td>
<td>1613</td>
</tr>
<tr>
<td>thick</td>
<td>6.00</td>
<td>11.77</td>
<td>4.33</td>
<td>50.98</td>
<td>11.09</td>
<td>1130</td>
</tr>
</tbody>
</table>

### Table 1.6.: Chemical Constituents of Banana Fibres

<table>
<thead>
<tr>
<th>Constituents:</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulose:</td>
<td>67.4</td>
</tr>
<tr>
<td>Lignin:</td>
<td>4.8</td>
</tr>
<tr>
<td>Ash:</td>
<td>1.0</td>
</tr>
<tr>
<td>Moisture:</td>
<td>7.5</td>
</tr>
<tr>
<td>Cold water Soluble Compounds:</td>
<td>1.9</td>
</tr>
<tr>
<td>1% NAOH Soluble Compounds:</td>
<td>28.5</td>
</tr>
</tbody>
</table>
The chemical composition of banana fiber is mainly cellulose, hemicelluloses, and lignin.

The banana fibre is resistant to the action of alkali, phenol, formic acid, chloroform acetone and petroleum ether. It is soluble in hot concentrated sulphuric acid. The lignin content of banana fibre is less than jute fibre.

Table 1.7.: Effect of Various Chemicals

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dilute NaOH (1%)</td>
<td>No reaction even on heating</td>
</tr>
<tr>
<td>Conc. NaOH (20%)</td>
<td>No reaction in cold but on heating and boiling for several minute, the fibre swells.</td>
</tr>
<tr>
<td>Dilute HCL</td>
<td>No effect</td>
</tr>
<tr>
<td>Conc. HCL</td>
<td>No effect</td>
</tr>
<tr>
<td>Dilute HNO3</td>
<td>No reaction</td>
</tr>
<tr>
<td>Conc. HNO3</td>
<td>On heating color changes to yellow and fibre disintegrates</td>
</tr>
<tr>
<td>Dilute H2SO4</td>
<td>On heating slight swelling and disintegrates of fibre</td>
</tr>
<tr>
<td>Conc. H2SO4</td>
<td>Dissolves fibre completely</td>
</tr>
<tr>
<td>Phenol</td>
<td>No effect</td>
</tr>
<tr>
<td>Formic acid</td>
<td>No effect</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>Fibre become soft</td>
</tr>
<tr>
<td>Petroleum ether</td>
<td>No effect</td>
</tr>
<tr>
<td>Chloroform</td>
<td>No effect</td>
</tr>
<tr>
<td>Cuprammonium</td>
<td>No effect</td>
</tr>
<tr>
<td>Acetone</td>
<td>No effect</td>
</tr>
</tbody>
</table>
Table 1.8.: Colour Reaction Of Fibre

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zink chloride &amp; iodine reagent</td>
<td>Golden yellow</td>
</tr>
<tr>
<td>Para – Nitro aniline reagent</td>
<td>Bright orange</td>
</tr>
<tr>
<td>Potassium permanganate</td>
<td>Pink</td>
</tr>
<tr>
<td>Meliorate green</td>
<td>Green</td>
</tr>
<tr>
<td>Iodine and sulphuric acid reagent</td>
<td>yellow</td>
</tr>
</tbody>
</table>

There are characteristics with high strength, small elongation, good luster, light weight, strong moisture absorption, fast moisture absorption and release, easy degradation as well as environmental protection etc. Banana fiber can be made into garment, curtain, towel, bed sheet etc due to it's characteristics with good luster and moisture absorption.

Before discussing further on the utility of the banana fibre two reports may be quoted here to elaborate its versatile uses. The Times of India representative in Federal Republic of Germany, Sri. M. V. kamath wrote in the course of an article on the subject on 29.1.1961 that:

“The banana fibre according to very high authorities, is not only suitable for manufacturing strings, ropes, cords, cables and ship building thread, but can also be used to make sacks and packing fabrics as well as mats and rugs. Expert opinion submitted by the institute as Reutilgen reveals that it is in many ways superior from the point of view of quality to jute fibres. It is not only lighter but also sturdier than a comparable jute sack. The initial expectations, according to the report, were even surpassed when it was finally found that the banana fibre is even equal to Manila hemp and is alkali proof, and had good receptivity for dyes.”

The author had referred the matter to Dr. A. Blumoke, Professor for the Fibre Spinning at the Government College for Technical Textile Industries, Reutlingen, F. R. Germany. The learned Professor replied (Translation of the original letter written in Germany).
“The bundles of fibres, extracted out of banana leaves which were given at my disposal, were first tested by me and then gave them for spinning and weaving. I came to the following results:

Banana fibres can be spun into yarns, whose solidity is suitable for packing textures. The solidity is sufficient and is better then comparable jute textures, when their readiness to not be concerned, textures of banana fibres, as the earth-rotting test showed, are to be declared good.

It may be pointed out that the above experiments were made and suggestions and findings thus recorded during early part of decade of sixties when even jute was not thought suitable for garment industry. Situation has now changed considerably and as on date jute has already entered into the garment sector, a domain considered exclusive for cotton, silk, woolens and synthetics.

Therefore, if quality and fineness besides spinnable quality is considered in comparison at least with jute, banana fibres is certainly superior. Considering the colour of the inner fibres it is certainly suitable for value added fashion garments. Fact that Hindu mythology described it as "Kalpa Brikshya" a plant that gives us food, medicines, shelter and clothing's, it is natural that it was considered as a plant that gave us garments. Therefore during ancient India use of its fibres for garment industry was fairly known. Perhaps it was discarded due to its later discoveries.

Thus this neglected fibre available all over India in abundance can give us garments of high fashion. Even coarse fibres can be used for winter garments. It can thus be answer to future textile crisis not only in India but also entire tropical world.
1.1.5. USES/ APPLICATIONS: -

Banana is cultivated in about 2, 30,000 hectares of land and the fibre yield is around 8.7 lakh toned. Though fibre extraction is not done on any large scale at present, banana fibres are reported to have been spun on the jute spinning machinery and used hand bags and other fancy articles.

Most of the Banana fibers produced today is used for ropes and cordage. The resistance of the fibre to the sea-water and its natural buoyancy has created a ready market for it in the manufacture of shipping cables. It is also widely used for making power transmission ropes and cordage, wall drilling cables, fishing nets, lines and other types of cordage. Bast fibers such as flax, jute, hemp, and pineapple etc plant fibers are all made up of thick walled cell tissue and they are bonded together by natural gums and support the branches, stems, leaves and fruits. Although banana plants and fibers are available in tropical regions in abundance, their application potential has not been exploited fully. At present, other companies make the limited application of banana fiber, for example, in making ropes, mats, and some other fields such as the composite materials. In recent years, more and more plant fibers were considered to be "environmentally friendly" fiber sources, and many countries
are emphasizing the utilizing of these fibers. The best thing about these fabrics is that they are biodegradable, finally broken down into water and carbon dioxide by microorganisms in the soil.

Innovation sees no limit and Indian consumers can expect something big coming up in the textile industry like fabrics and textiles woven from fine quality banana fibre. Several studies carried out on blending revealed that the studies were carried out on cotton with various natural and synthetic fibers with a view to impart value addition. In the present investigation banana fibres were blended with cotton and jute fibres to make banana blended fabrics and further evaluation of the fabric properties are also carried out.

In the recent past, banana fiber had a very limited application and was primarily used for making items like ropes, mats, and some other composite materials. With the increasing environmental awareness and growing importance of eco-friendly fabrics, banana fiber has also been recognized for all its good qualities and now its application is increasing in other fields too such as apparel garments and home furnishings. However, in Japan, it is being used for making traditional dresses like kimono, and kamishimo since the Edo period (1600-1868). Due to its being lightweight and comfortable to wear, it is still preferred by people there as summer wear. Banana fiber is also used to make fine cushion covers, Neckties, bags, table cloths, curtains etc. Rugs made from banana silk yarn fibers are also very popular world over.
1.1.6. Research work done in India:

The fibre portion of the pseudostem left over after extraction of starch was utilized for the preparation of paper pulp by Subrahmanyam et al., (1963). Banana fibres are reported to have been spun on the jute spinning machinery (Sinha, 1974a, 1974b) and used in making ropes and sacks. Hand extracted fibres have been used to produce handbags and other fancy articles (KVIC, Bombay). However, Kulkarni et al., (1983) were the first to report on the fibre yield, structure and properties of banana fibres. Subsequently, Bhama Iyer et al., (1995) evaluated yield, structure and properties of banana fibres gathered from a few commercially cultivated varieties and observed that variations exist in both structure and properties of fibres from different regions along the length and across the thickness of the pseudostem. They also reported differences in tensile and structural properties among fibres belonging to different varieties and showed that the matrix in which the cells are embedded in the fibre had a role in deciding the tensile strength of the fibre.
Visvesvaraya Industrial Research and Development Centre, Mumbai, have carried out a techno economic research study on extraction and utilization of banana stem fibre. According to them, handmade paper industry can effectively and competitively use banana fibre as its raw material.

It has been stated that banana fibre possess lot of advantageous physical and chemical properties which promotes it’s use in textile applications (Mishra and Goel, 1999). Enzyme application increases tensile energy, extensibility and improves the surface characteristics of the cotton-banana union fabric. Detailed study was undertaken to explore the sewability of cotton-banana blended fabrics and it is concluded that they give higher/better seam pucker but higher bending rigidity than 100% cotton (Behera et. al., 2000, 2001).

Plate 18: Footwear made of banana fibres.
Plate 19: Fibre bundles for processing.

Plate 20: Fruit and other value-added products
Plate 21: Blended products from banana fibres
Plate 22: Banana fibre pot holder
Plate 23: Banana fibre products
1.1.7. Research work done Abroad:

Tenacity of 33 cultivars of banana grown in Philippines was reported to range from 22.4–44.8 g/tex (gkm/g). Saba cultivar showed maximum strength while cv. Inarmibal had a low strength of 22.4g/tex. These values were lower in comparison with those of abaca, which was 55.3 g/tex (kmg/g). The fibre, however, was extracted by hand stripping by using a stripping device applying low pressure to prevent the fibres from breaking (PCARRD, 1992).

Several products have been made from banana fibres in the Philippines. The banana fibres were reported to be elegant and highly versatile. As they did not easily crumple, these fibres have been used in the manufacture of dress materials. The fineness of texture was found to depend on the quality of fibres used. The material had beautiful sheen and so has been used to prepare wedding gowns and barongs. When used in layers and flourlike, the fibre made beautiful dresses. Banana fibre dyed from its natural beige to bright colours was used to make chic blouses and outfits with plenty of ruffles and laces. Napkins and placemats have also been made. The fibre of Cavendish variety has been used as a potential source for specialty pulp manufacture. Pulped through sulphate process, it has been used as a raw material for the manufacture of good quality wrapping papers.

Banana fibres spun with other fibres make excellent ropes suitable for agricultural purposes. In Costa Rica, Industrial production of paper from banana pseudostem is going on and a whole range of products labeled “Earth” which includes paper, cardboard, notepads, letter paper, envelopes, post card and notebooks have been launched. The banana fibre paper is reported to be of high strength and it is used to make tea bags and currency notes. In Germany, work is in progress to develop banana fibre lining for car interiors.
1.2. COTTON FIBRE:

1.2.1. ORIGIN AND HISTORY

The cotton plant has always thrived in the wild. By contrast, the historical origin of its commercial exploitation, particularly with regard to textile uses, is fuzzier. Relevant literary references point to two distinct geographical origins of cultivated cotton, namely, Asia and pre-Columbian America. The first cotton fabric would date back to approximately as early as 3,200 BC, as revealed by fragments of cloth found at the Mohenjo-Daro archaeological site on the banks of the River Indus. From India, cotton textiles probably passed to Mesopotamia, where the trade started around 600 years BC. There is evidence to suggest that trade in cotton started around Rome at the time of Alexander the Great, in the 4th century BC. The trade flourished after the discovery of the maritime route passing by the Cape of Good Hope and the establishment of trading posts in India. Portuguese trading prominence in this part of the world had been challenged by other European countries (notably, France and England) since 1698. The Arab conquests introduced the first cotton manufacturing facilities into Spain (Granada), Venice, and Milan. In England, the first cotton-spinning factory opened its doors in Manchester in 1641. This date marked the beginning of the cotton industry in Europe. The industrial revolution of eighteenth century Europe paved the way for the most far-reaching, influential transformation of cotton textile manufacturing. In this connection, the major technological innovations were the following:

According to Stout (1970), the name cotton is derived from the Arabic word ‘quth’ (or Katan). Cotton is a soft, staple fiber that grows in a form known as a ball around the seeds of the cotton plant, a shrub native to tropical and subtropical regions around the world, including the Americas, India and Africa. The fiber most often is spun into yarn or thread and used to make a soft, breathable textile, which is the most widely used natural-fiber cloth in clothing today. Cotton plants are found growing in almost all subtropical areas of the world although relatively few varieties have attained commercial importance.
References of cotton are found in Greek and Roman literature. In India, cotton has been grown for more than three thousand years and it is referred to in Rig Veda, written in 1,500 BC. A thousand years later the great Greek historian Herodotus wrote about Indian Cotton “There are trees which grow wild there, the fruit of which is a wool exceeding in beauty and goodness that of sheep”. The Indians make their clothes of this tree wool”

Cotton is obtained from quite a number of species of Gossypium; it belongs to the family Malvaceae. The fine fibre hairs on the seed surface constitute the raw material. The length of the staple depends on the quality, which varies from species to species. The common commercial varieties are:

<table>
<thead>
<tr>
<th></th>
<th>Varieties of cotton fibres</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>True cotton</td>
</tr>
<tr>
<td>B</td>
<td>Creole cotton</td>
</tr>
<tr>
<td>C</td>
<td>Levent cotton</td>
</tr>
<tr>
<td>D</td>
<td>Upland cotton</td>
</tr>
</tbody>
</table>

1.2.2. STRUCTURE AND CRYSTALLINITY

Cotton is the generic name of a fibre that grows from the seed of the cotton plant as seed hair. When cotton is blended with other fibers; the cotton look is maintained because consumer likes the clean, fresh, somewhat dull appearance of cotton fabrics. Cotton has been of service to mankind for so long that its versatility is almost unlimited and new uses are constantly being discovered. Cotton is the most abundant and technically most important natural textile fibre.
Plate 24: Cross-sectional and Longitudinal view of Cotton fibre

As seen in Plate 24, under a microscope, the longitudinal view of the cotton fibre appears as a very fine, regular fibre, looking like a twisted ribbon or a collapsed and twisted tube. These twists are called convolutions. In the cross-sectional view the fibre appears as bean shaped with a central hollow canal called as lumen. The many varieties of cotton are broadly classified into four groups viz. Sea Island Cotton, Egyptian cotton, American Pima Cotton and Asiatic Cotton.

Table 1.10: The approximate composition of raw cotton is as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulose</td>
<td>85.5%</td>
</tr>
<tr>
<td>Oils &amp; Waxes</td>
<td>0.5%</td>
</tr>
<tr>
<td>Proteins, Pectoses &amp; Colouring matter</td>
<td>5.0%</td>
</tr>
<tr>
<td>Mineral matter</td>
<td>1.0%</td>
</tr>
<tr>
<td>Moisture</td>
<td>8.0%</td>
</tr>
</tbody>
</table>

After removal of the unwanted natural impurities in cotton, it becomes almost fully cellulose. Cellulose is water insoluble polysaccharides with an empirical formula \( (C_6H_{10}O_5)_n \). Cellulose is a homopolymer that has been polymerized by condensation, with a molecule of water \( (\text{HOH}) \) split off where two units join. In case of cotton, the molecular chain involves perhaps 10,000 glucose units. Cellulose is essentially a poly (1, 4) \( \beta \)-D glucopyranose.
1.2.3. Cultivation

Successful cultivation of cotton requires a long frost-free period, plenty of sunshine, and a moderate rainfall, usually from 600 to 1200 mm (24 to 48 inches). Soils usually need to be fairly heavy, although the level of nutrients does not need to be exceptional. In general, these conditions are met within the seasonally dry tropics and subtropics in the Northern and Southern hemispheres, but a large proportion of the cotton grown today is cultivated in areas with less rainfall that obtain the water from irrigation. Production of the crop for a given year usually starts soon after harvesting the preceding autumn. Planting time in spring in the Northern hemisphere varies from the beginning of February to the beginning of June. The area of the United States known as the South Plains is the largest contiguous cotton-growing region in the world. It is heavily dependent on irrigation water drawn from the Ogallala Aquifer.

Cotton is a thirsty crop, and as water resources get tighter around the world, economies that rely on it face difficulties and conflict, as well as potential environmental problems. For example, the cultivation of cotton has led to desertification in areas of Uzbekistan, where it is a major export. In the days of the Soviet Union, the Aral Sea was tapped for agricultural irrigation, largely of cotton, and now salination is widespread.

1.2.4. DESCRIPTION AND TECHNICAL FEATURES

Cotton is a natural fibre of vegetable origin, like linen, jute or hemp. Mostly composed of cellulose and formed by twisted, ribbon-like fibres. Cotton is the fruit of a shrubby plant commonly referred to as the "cotton plant". The cotton plant, a variety of plants of the genus Gossypium, belongs to the Malvacae family, which comprises approximately 1,500 species, also including the baobab tree, the bombax or the mallow. The plant, growing up to 10 metres high in the wild, has been domesticated to range between 1 to 2 metres under commercial cultivation in order to facilitate picking. Either herbaceous or ligneous, it thrives in dry tropical and subtropical areas. Whereas by nature the plant is a perennial tree (lasting about 10 years), under extensive
cultivation it is mostly grown as an annual shrub. The cotton flower has five large petals (showy, white, white-creamy, or even rose in colour), which soon fall off, leaving capsules, or "cotton bolls", having a thick and rigid external layer. The capsule bursts open upon maturity, revealing the seeds and masses of white/creamy and downy fibres. Cotton fibres of the *Gossypium hirsutum* species range from about 2 to 3 centimeters in length, whereas *Gossypium barbadense* cotton produces long-staple fibres up to 5 centimeters length. Their surface is finely indented, and they become kinked together and interlocked. The cotton plant is almost exclusively cultivated for its oleaginous seeds and for the seminal fibres growing from them (i.e. cotton, strictly speaking). In ordinary usage, the term "cotton" also makes reference to fibres that are made into fabric wires suitable for use in the textile industry.

Although the cotton plant is native to tropical countries, cotton production is not limited to the tropics. Indeed, the emergence of new varieties, as well as advances in cultivation techniques led to the expansion of its culture within an area straddling from approximately 47 degrees North latitude (Ukraine) to 32 degrees South (Australia). Although cotton is widely planted in both hemispheres, it remains a sun-loving plant highly vulnerable to freezing temperatures. Cotton is crucially important to several developing countries.

Besides traditional uses and as a result of different finishing processes that have been applied to the cotton fibre, cotton is made into specialty materials suitable for a great variety of uses. Cotton also finds speciality applications in medical and hygienic uses. Most notably, the fibre is used to manufacture cotton (cotton wool), compress, gauze bandages, tampons or sanitary towels, and cotton swabs. In this field, the most suitable cotton variety is the species *Gossypium herbaceum* with short-staple thick fibres.

From the beginning of the 20th century until the end of the Second World War (WWII) cotton had accounted for 81% of world total fibre consumption. A shift occurred in the 1940s, when man-made fibres first appeared in the market (accounting for 12% of the world's total fibre consumption over the 1940s). As from the 1960s, with a deepening of the trend since 1970, decline in cotton consumption has become more prominent. The ratio of cotton in the fibre
market decreased from 75% in 1940 to 68% in 1960. In 1970 cotton accounted for 57% of textile fibres. Since the early 2000s, cotton has accounted for roughly 39% of world fibre consumption. By contrast, the share of synthetic fibres rose to 58%, up from 5% in 1960.

The major end uses for cotton fibre include wearing apparel, home furnishings, and other industrial uses (such as medical supplies). The cotton fibre is made primarily into yarns and threads for use in the textile and apparel sectors (wearing apparel would account for approximately 60% of cotton consumption). Cotton is also used to make home furnishings, such as draperies (eventually the third major end use) or professional garments (about 5% of cotton fibre demand).

Cotton has very little natural elasticity. The elasticity in certain cotton fabric is added by special processing such as slack mercerization. But, it lacks appreciable resilience, while special finishes reduce this disadvantage; the durability of the fibre also reduces.

Cotton has poor draping quality, shrinks considerably when wet, and it is a good conductor of heat, absorbs water rather well, but does not dry quickly. Cotton may be safely bleached by with ordinary household bleaches containing sodium hypochlorite.

Sunlight tends to weaken cotton; it also has a tendency to yellow. Cotton is liable to be attacked by mildew & bacteria provided sufficient moisture is present, but is not attacked by moth or carpet beetle. Cotton is destroyed by concentrated inorganic acid, even in dilute solutions. It is not affected by alkalies even in hot, strong solutions. Heavy-duty detergents may also be used in washing cottons. Perspiration degrades Cotton fibers. Cotton has affinity for direct, reactive, certain azoic, sulphur, vat and natural dyes.

1.2.5. Uses

Cotton is used to make a number of textile products. These include terrycloth, used to make highly absorbent bath towels and robes; denim, used to make
blue jeans; chambray, popularly used in the manufacture of blue work shirts (from which we get the term "blue-collar"); and corduroy, seersucker, and cotton twill. Socks, underwear, and most T-shirts are made from cotton. Bed sheets often are made from cotton. Cotton is also used to make yarn used in crochet and knitting. Fabric also can be made from recycled or recovered cotton that otherwise would be thrown away during the spinning, weaving, or cutting process. While many fabrics are made completely of cotton, some other fibers are blended with cotton, including rayon and synthetic fibers such as polyester. It can either be used in knitted or woven fabrics, as it can be blended with elastine to make a stretchier thread for knitted fabrics, and things such as stretch jeans.

In addition to the textile industry, cotton is in fishnets, coffee filters, tents, gunpowder (see Nitrocellulose), cotton paper, and in bookbinding. The first Chinese paper was made of cotton fiber. Fire hoses were once made of cotton.

Cotton linters are fine, silky fibers which adhere to the seeds of the cotton plant after ginning. These curly fibers typically are less than 1/8 in (3 mm) long. The term also may apply to the longer textile fiber staple lint as well as the shorter fuzzy fibers from some upland species. Linters are traditionally used in the manufacture of paper and as a raw material in the manufacture of viscose. In the UK, linters are referred to as "cotton wool". This can also be a refined product (absorbent cotton in U.S. usage) which has medical, cosmetic and many other practical uses. The first medical use of cotton wool was by Dr Joseph Sampson Gamgee at the Queen’s Hospital (later the General Hospital) in Birmingham, England.
1.3. JUTE FIBRES:

Jute is a long, soft, shiny vegetable fiber that can be spun into coarse, strong threads. It is produced from plants in the genus *Corchorus*, family Tiliaceae. Jute is one of the cheapest natural fibres and is second only to cotton in amount produced and variety of uses. Jute fibres are composed primarily of the plant materials cellulose (major component of plant fibre) and lignin (major components of wood fibre). It is thus a ligno-cellulosic fibre that is partially a textile fibre and partially wood. It falls into the bast fibre category (fibre collected from bast or skin of the plant) along with kenaf, industrial hemp, flax (linen), ramie, etc. The industrial term for jute fibre is raw jute. The fibres are off-white to brown, and 1–4 meters (3–12 feet) long. Jute fibre is often called hessian; jute fabrics are also called hessian cloth and jute sacks are called gunny bags in some countries.

1.3.1. Cultivation

Jute needs a plain alluvial soil and standing water. The suitable climate for growing jute (warm and wet climate) is offered by the monsoon climate during the monsoon season. Temperatures ranging 20° C to 40° C and relative humidity of 70%–80% are favorable for successful cultivation. Jute requires 5–8 cm of rainfall weekly with extra needed during the sowing period.

1.3.2. History

For centuries, jute has been an integral part of Bengali culture, which is shared by both Bangladesh and West Bengal of India. In the 19th and early 20th centuries, much of the raw jute fibre of Bengal was exported to the United Kingdom, where it was then processed in mills concentrated in Dundee ("jute weaver" was a recognized trade occupation in the 1901 UK census), but this trade had largely ceased by about 1970 due to the appearance of synthetic fibres.

Margaret Donnelly, a jute mill landowner in Dundee in the 1800s, set up the first jute mills in India. In the 1950s and 1960s, when nylon and polythene
were rarely used, Pakistan, then the world leader in jute products, was earning exchange from jute grown in East Pakistan, now Bangladesh. It was called the “Golden Fibre of Bangladesh,” and it used to bring the major portion of foreign currency reserve for the country. However, as the use of polythene and other synthetic materials as a substitute for jute increasingly captured the market, the jute industry in general experienced a decline.

During some years in the 1980s, farmers in Bangladesh burnt their jute crops when an adequate price could not be obtained. Many exporters that were dealing with jute found other commodities in which to deal. Jute-related organizations and government bodies also experienced closures, change, and fund cutting. The long decline in demand forced the largest jute mill in the world (Adamjee Jute Mills) to close. Latif Bawany Jute Mills, the second largest, is still running but was nationalized by the government from prominent businessman, Yahya Bawany. Farmers in Bangladesh have not completely ceased growing jute, however, mainly due to demand in the internal market. Recently (2004–2009), the jute market began to recover and the price of raw jute increased more than 200%.

Jute has entered many diverse sectors of industry, where natural fibres are gradually becoming better substitutes. Among these industries are paper, celluloid products (films), non-woven textiles, composites (pseudo-wood), and geo-textiles.

In December 2006 the General Assembly of the United Nations proclaimed 2009 to be the International Year of Natural Fibres, so as to raise the profile of jute and other natural fibres.

1.3.3. Uses

Jute is the second most important vegetable fibre after cotton; not only for cultivation, but also for various uses. Jute is used chiefly to make cloth for wrapping bales of raw cotton, and to make sacks and coarse cloth. The fibres are also woven into curtains, chair coverings, carpets, area rugs, hessian cloth, and backing for linoleum.
While jute is being replaced by synthetic materials in many of these uses, some uses take advantage of jute’s biodegradable nature, where synthetics would be unsuitable. Examples of such uses include containers for planting young trees which can be planted directly with the container without disturbing the roots, and land restoration where jute cloth prevents erosion occurring while natural vegetation becomes established.

The fibres are used alone or blended with other types of fibres to make twine and rope. Jute butts, the coarse ends of the plants, are used to make inexpensive cloth. Conversely, very fine threads of jute can be separated out and made into imitation silk. As jute fibres are also being used to make pulp and paper, and with increasing concern over forest destruction for the wood pulp used to make most paper, the importance of jute for this purpose may increase. Jute has a long history of use in the sackings, carpets, wrapping fabrics (cotton bale), and construction fabric manufacturing industry.

Jute can be used to create a number of fabrics such as Hessian cloth, sacking, carpet backing cloth (CBC), and canvas. Hessian, lighter than sacking, is used for bags, wrappers, wall-coverings, upholstery, and home furnishings. Sacking, a fabric made of heavy jute fibres, has its use in the name. CBC made of jute comes in two types. Primary CBC provides a tufting surface, while secondary CBC is bonded onto the primary backing for an overlay. Jute packaging is used as an eco-friendly substitute.

Diversified jute products are becoming more and more valuable to the consumer today. Among these are espadrilles, floor coverings, home textiles, high performance technical textiles, Geo-textiles, composites, and more. Jute has many advantages as a home textile, either replacing cotton or blending with it. It is a strong, durable, colour and light-fast fibre. Its UV protection, sound and heat insulation, low thermal conduction and anti-static properties make it a wise choice in home décor. Also, fabrics made of jute fibres are carbon-dioxide neutral and naturally decomposable. These properties are also why jute can be used in high performance technical textiles.
Thus, jute is the most environment-friendly fibre starting from the seed to expired fibre, as the expired fibres can be recycled more than once. Another diversified jute product is Geo-textiles, which made this agricultural commodity more popular in the agricultural sector. It is a lightly woven fabric made from natural fibres that is used for soil erosion control, seed protection, weed control, and many other agricultural and landscaping uses. Jute fibre is 100% bio-degradable and recyclable and thus environmentally friendly.

- It is a natural fibre with golden and silky shine and hence called The Golden Fibre.
- It is the cheapest vegetable fibre procured from the bast or skin of the plant's stem.
- It is the second most important vegetable fibre after cotton, in terms of usage, global consumption, production, and availability.
- It has high tensile strength, low extensibility, and ensures better breathability of fabrics. Therefore, jute is very suitable in agricultural commodity bulk packaging.
- It helps to make best quality industrial yarn, fabric, net, and sacks. It is one of the most versatile natural fibres that has been used in raw materials for packaging, textiles, non-textile, construction, and agricultural sectors. Bulking of yarn results in a reduced breaking tenacity and an increased breaking extensibility when blended as a ternary blend.
- Unlike the hemp fiber, jute is not a form of cannabis.
- The best source of jute in the world is the Bengal Delta Plain in the Ganges Delta, most of which is occupied by Bangladesh.
- Advantages of jute include good insulating and antistatic properties, as well as having low thermal conductivity and a moderate moisture regain. Other advantages of jute include acoustic insulating properties and manufacture with no skin irritations.
- Jute has the ability to be blended with other fibres, both synthetic and natural, and accepts cellulosic dye classes such as natural, basic, vat, sulfur, reactive, and pigment dyes. As the demand for natural comfort fibres increases, the demand for jute and other natural fibres that can
be blended with cotton will increase. The resulting jute/cotton yarns will produce fabrics with a reduced cost of wet processing treatments. Jute can also be blended with wool. Some noted disadvantages include poor drapability and crease resistance, brittleness, fibre shedding, and yellowing in sunlight. However, preparation of fabrics with castor oil lubricants result in less yellowing and less fabric weight loss, as well as increased dyeing brilliance. Jute has a decreased strength when wet, and also becomes subject to microbial attack in humid climates. Jute can be processed with an enzyme in order to reduce some of its brittleness and stiffness. Once treated with an enzyme, jute shows an affinity to readily accept natural dyes, which can be made from marigold flower extract.

1.4. FINISHING:

Textile processing is one of the important industries related with textile manufacturing operations. Textile processing is a general term that covers right from singeing (protruding fiber removal) to finishing of fabric. Finishing is the final process to impart the required end use finishes to the fabric.

Textile Fabric Finishing is a process used in manufacturing of fiber, fabric, or clothing. Finishing is the final series of operations that produces finished textile fabric from grey goods. Finishing operations are predominantly wet operations requiring large amounts of thermal energy for water heating and drying. The term finishing includes all the mechanical and chemical processes employed commercially to improve the acceptability of the product, except those procedures directly concerned with colouring. The objective of the various finishing processes is to make fabric from the loom or knitting frame more acceptable to the consumer. Finishing processes include preparatory treatments used before additional treatment, such as bleaching prior to dyeing; treatments, such as glazing, to enhance appearance; sizing, affecting touch; and treatments adding properties to enhance performance, such as preshrinking. Newly formed cloth is generally dirty, harsh, and unattractive,
requiring considerable skill for conversion into a desirable product. Before treatment, the unfinished fabrics are referred to as gray goods, or sometimes, in the case of silks, as greige goods.

Finishing formerly involved a limited number of comparatively simple operations evolved over the years from hand methods. The skill of English and Scottish finishers was widely recognized, and much British cloth owed its high reputation to the expertise of the finisher. More sophisticated modern finishing methods have been achieved through intense and imaginative research.

In order to impart the required functional properties to the fiber or fabric, it is customary to subject the material to different type of physical and chemical treatments for example mercerizing, singeing, flame retardant, water repellent, water proof, antistatic finish, peach finish etc are some of the important finishes applied to textile fabric. In textile manufacturing, finishing refers to any process performed on yarn or fabric after weaving to improve the look, performance, or "hand" (feel) of the finished textile.[1] Some finishing techniques, such as fulling, have been in use with hand-weaving for centuries; others such as mercerization are by-products of the Industrial Revolution. It is frequently necessary to carry out some preparatory treatment before the application of other finishing processes to the newly constructed fabric. Any remaining impurities must be removed, and additives used to facilitate the manufacturing process must also be removed. Bleaching may be required to increase whiteness or to prepare for colour application. Some of the most frequently used preparatory processes are discussed below.

1.4.1. SCOURING

When applied to gray goods, scouring removes substances that have adhered to the fibres during production of the yarn or fabric, such as dirt, oils, and any sizing or lint applied to warp yarns to facilitate weaving.
1.4.2. **BLEACHING**

Bleaching, a process of whitening fabric by removal of natural colour, such as the tan of linen, is usually carried out by means of chemicals selected according to the chemical composition of the fibre. Chemical bleaching is usually accomplished by oxidation, destroying colour by the application of oxygen, or by reduction, removing colour by hydrogenation. Cotton and other cellulosic fibres are usually treated with heated alkaline hydrogen peroxide; wool and other animal fibres are subjected to such acidic reducing agents as gaseous sulfur dioxide or to such mildly alkaline oxidizing agents as hydrogen peroxide. Synthetic fibres, when they require bleaching, may be treated with either oxidizing or reducing agents, depending upon their chemical composition. Cottons are frequently scoured and bleached by a continuous system.

1.4.3. **FINISHES ENHANCING APPEARANCE**

These finishes improve the overall appearance of the fabrics.

1.4.3.1. **SHEARING**

Shearing cuts the raised nap to a uniform height and is used for the same purpose on pile fabrics. Shearing machines operate much like rotary lawn mowers, and the amount of shearing depends upon the desired height of the nap or pile, with such fabrics as gabardine receiving very close shearing. Shearing may also be applied to create stripes and other patterns by varying surface height.

1.4.3.2. **OPTICAL BRIGHTENING**

Optical brightening, or optical bleaches, is finishes giving the effect of great whiteness and brightness because of the way in which they reflect light. These compounds contain fluorescent colourless dyes, causing more blue light to be reflected. Changes in colour may occur as the fluorescent material
loses energy, but new optical whiteners can be applied during the laundering process.

1.4.3.3. SOFTENING

Making fabrics softer and sometimes also increasing absorbency involves the addition of such agents as dextrin, glycerin, sulfonated oils, sulfated tallow, and sulfated alcohols.

1.4.4. ENZYMATIC FINISHES

Bio-polishing: This is a process to remove the protruding fibers of a fabric through the action an enzyme. This enzyme selectively acts on the protruding fibers and cease to work after finishing the work by a simple raise in temperature of the treatment bath. Biopolishing improves the fabric smoothness and softness, clears fabric surface, reduces pilling action of the fabrics by preserving more fabric strength and also improves the overall drape of the fabrics.

1.4.5. FUNCTIONAL FINISHES

When textile assumes an additional function over and above the conventional purpose, it may be regarded as specialty or functional textile. The textile industry of the future looks very promising – something to revive our spirits considering the fact that it is considered an obsolete technology. However, the textile industry is required to shift its emphasis from “quantity” to “quality” and adopt itself to the dynamism of the market economy. Functional finishes represent the next generation of finishing industry, which, make textile materials act by themselves. This means that they may keep us warm in cold environments or cool in hot environments or provide us with considerable convenience, support, and even fun in our normal day-to-day activities.

The properties of synthetic fibers, most important among them being polyamide, polyester and polyacrylonitrile, are essentially different from those of natural cellulosic and wool fibres. Hence the sequence of finishing
operations is likely to be different. While cellulosic's require a resin finishing treatment to impart easy-care properties, synthetic fibers already have these easy-care criteria and require only a heat setting operation. The use of open weave has enabled production of lighter, air permeable, fabrics to ensure better wearing comfort. New innovative functional finishes represent the next generation of finishing industry, which, make textile materials act by themselves. As with all emerging technologies, a successful future for Functional Finished Textiles will only be achieved through open sharing of ideas and research findings, a thorough testing of the capability boundaries, and frank discussion of fears and failings. India has a bright future in Functional Finished Textiles.

1.5. PRACTICAL / SCIENTIFIC UTILITY OF BANANA FIBRES:

The textile industry plays an important role in the economy of the country in contributing to employment generation and foreign exchange earning. Today's textile world is expanding fast. The durable textile is being continuously replaced by disposables. With the evolution of industrial era the textile industry has undergone tremendous changes. There are many techniques of producing textiles.

In previous year the use of textile natural fibres were predetermined and restricted to conventional products. It is a well known fact that cotton, silk; wool played a predominant role in textiles. Though there are other materials such as jute, ramie, sisal, banana known to man. Their uses were restricted to non textile material such as packing material, ropes etc. The developments in the use of latest technology in adopting this non apparel fibre have led to introduction of new diversified material. That is why; the present investigation focuses on optimum utilization of banana fibres for best suited end-uses.

From the estimated yield of 1.5 million tons of dry banana fibres annually, a very small quantity is presently being utilized for the preparation of handicraft items. However this pseudostem waste can be very well used for the production of items such as cardboard, paper, tea bags, and fibre linings for car interiors, high quality dress material and also currency notes. With the rise
in urbanization and increasing literacy levels, the paper industry is likely to face the crises of shortage of raw material. In this regard, the banana pseudostem could be used as very good raw material for the paper industry. Because banana is an all season crop, substantial quantity of pseudostem waste is produced throughout the year, ensuring constant supply of raw material for the production units. Recent studies have indicated that banana fibres possesses lot of advantageous physical and chemical properties because of which it can be used a very good raw material for the textile industry. Many applications can be enlisted as follows:

1. As an eco-friendly substitute in textile industry in place of the environmentally hazardous synthetic fibres.
2. To provide livelihood to the rural poor through generation of employment in the fibre producing and processing industry.
3. Being completely biodegradable and naturally occurring, the banana fibre products are expected to be in great demand in the international markets as they pose no toxic effects to man and environment.
4. To make value added products, which would enhance the profitability of banana farming.
5. To minimize deforestation due to various wood/cellulose processing industries, thus protecting our ecology and environment.

Several studies were also reported (in addition to the one reported in the earlier sections of this chapter) on banana fibres carried out abroad wherein several products were made from banana fibres in Philippines, which were reported to be elegant and highly versatile. The fineness of texture was found to depend on quality of the fibres used and the materials had beautiful sheen and were also dyed from its natural beige to bright colours to make napkins, placemats etc. The banana fibres spun with other fibre makes excellent ropes suitable for agricultural purposes. In Costa Rica, Industrial production of paper from banana Pseudostem is going on and a whole range of products labeled ‘Earth’ which includes paper, card-board, note pad letter paper etc has been launched. In Germany, work is in progress to develop banana fibre lining for car interiors. Conversion of Pseudostem and corn starch by fermentation into
wine has been in practice in Ethiopia. Banana starch is used for making glue, which is used in the production of cartons for exporting fresh bananas (Thompson 1995).

The present study reports development of softening processes for the inherently coarse banana fibres making it more suitable for spinning operations, spinning of the softened fibres into yarns, after blending them with suitable natural fibres and testing the physical and mechanical properties of the yarns. The Yarns were further converted to fabrics and again assessed for their physical and mechanical properties. The fabrics were further passed through various finishing processes and then tested for all the mechanical and physical properties. The fabrics were further taken for dyeing with two classes of dyes and then assessed for the various fastness properties.

1.6. NEED OF THE PROPOSED STUDY

Apart from cotton, India has a large variety of other cellulosic fibers like pineapple, ramie, jute, coir, and banana. The method of manufacturing textiles in modern era causes pollution. Manufacturer of synthetics right from the beginning causes pollution, even natural resources in some stage or other causes pollution to considerable extent. With growth of population at galloping rate, the demand for textiles shall increase at equal or faster proportion, more so because consumption for fashion is an added dimension. Keeping in mind the factors such as:

1. The growth of population
2. Urgent need of economical growth of rural areas
3. Future clothing and food demand
4. Raw material resources for polymers
5. Environment safety - urgent need for preservation of forests.

We have to search for alternative renewable sources for textiles to give us an effective eco-friendly solution.
1. This study would impart market value to banana fibres by introducing them for fabric production for home furnishings, upholstery, apparels and make value added products, which would enhance the profitability of banana farming. And also availability of added raw materials for the textile market.

2. To provide livelihood to the rural poor through generation of employment in the fibre industry and also in the rural areas in terms of production i.e.: employment generation.

3. Being completely biodegradable and naturally occurring, the banana fibre products are expected to be in great demand in the international markets as they pose no toxic effects to man and environment thus promoting eco-friendliness.

4. It would also give an idea as to how various finishes behave on the blended fabrics and the manner in which they change the surface characteristics and improve the functional and aesthetic value of the fabrics.

5. Utilization of the waste is effective as tons of banana pseudostems are thrown away and are not utilized effectively.

1.7. OBJECTIVES

1. To develop a softening process for banana fibres with a view to reduce the stiffness of the fibres and to improve their pliability.

2. To assess the Spinning performance of Banana fibres.

3. To blend the softened banana fibres with cotton and/or jute fibres in order to obtain the blended yarns.

4. To study the physical and mechanical properties of the banana fibre blended yarns.

5. Preparation of woven fabrics and evaluation of different mechanical and comfort characteristics of fabrics.


7. To use minimum two dyes for dyeing the above prepared jute/banana fabrics.
8. To determine and analyze the fastness properties of the dyed samples viz: washing fastness, light fastness, rubbing fastness, and the perspiration fastness of the dyed samples.

9. To work out the economics of finished fabric production of the blended fabric.

1.8. SCOPE OF THE STUDY

Several major export houses are looking at India to create a base for the natural fibre such as jute, sisal, banana, ramie, hemp etc. and their blends. Some institutions in India have developed various types of eco friendly fibres blended garments and many such value added diversified product with the intention to catch domestic and export market. Thus the increase in the integrated natural fibre textile sectors for nature friendly produces with diversification into high value, eco-friendly textiles.

The natural color of naturally available fibres like coir, jute, sisal and banana etc is being adorned with such trials and studies and this yarn could be used in making of newer fabrics and products having a new dimension in the fabric appearance and aesthetic properties is achieved and also could be enhanced.

The main advantage with the banana fibres is that it is unlike many other natural fibres, banana fibres are frequently available, very cheap and have a good thermal insulation value and many desirable properties like strength, luster etc.

The study could be extended with many different varieties of banana fibres even thought the basic output would remain the same and is not changed much.

Many wider possibilities of softening could be tried out with different finishing enzymes to make them more pliable, aesthetically appealing and user-friendly.
As no standard method of spinning is till date established for conversion of the banana fibres to yarns, this technique of using the Jute spinning system can be further refined and standardized for spinning of banana fibres.

5.1.9. LIMITATIONS OF THE STUDY

1. This study is restricted only to one variety of cotton fibre, jute fibre and banana fibre. The research could be extended to other types of fibres as well.
2. The number of blends is limited. viz: (80:20), (70:30) & (50:50). The yarn and fabric specification parameters in relation to yarn and fabric count and weave are limited to a few combinations. Various other combinations could be used in further research.
3. The finishes being applied also are limited to a few which could be extended to other formulations.
4. It may not be possible to carry out all the possible finishing treatments due to limited resources and time.
5. The study will be more of an exploratory type indicating the possible applications of banana pseudostem fibers. Since there is hardly any reported work available on use of banana fibres into yarns and fabric available into conversion into ropes of linear density of more than 2000-3000 tex yarns. Large-scale trials would not be possible due to limited resources.

1.10. SIGNIFICANCE OF THE STUDY

Many applications of banana fibres can be enlisted as follows:

1. As an eco-friendly substitute in textile industry in place of the environmentally hazardous synthetic fibres.
2. To provide livelihood to the rural poor through generation of employment in the fibre producing and processing industry.
3. Being completely biodegradable and naturally occurring, the banana fibre products are expected to be in great demand in the international markets as they pose no toxic effects to man and environment.
4. To make value added products, which would enhance the profitability of banana farming.
5. To minimize deforestation due to various wood/cellulose processing industries, thus protecting our ecology and environment.