Chapter-2

REVIEW OF LITERATURE

Banana has long been considered a food, fruit and fodder crop. In addition to this, now a day, it is also gaining importance as a source of fibres. India is the largest producer of banana in the world with an estimated annual output of 13.5 million tons, of which 80% is generated from six states, namely, Tamilnadu, Maharashtra, Karnataka, Kerala Andhra Pradesh and Gujarat. 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. Thus in order to get acquainted with the earlier reported details of banana fibre production and utilization and blending possibilities, an extensive literature review was carried out. In order to have a clear picture of the banana fibre utilization the literature collected has been further classified under three categories.

2.1. Studies related to banana fibres.
2.2. Studies related to natural fibres and its blends.
2.3. Studies related to pre-treatments.
2.4. Studies related to finishing treatments.

2.1. STUDIES RELATED TO BANANA FIBRES:

This consists of studies related to banana fibres and its applications.

Sinha (1973) studied on the use of banana plant fibre as a substitute for Jute. Banana-plant fibre is strong, soft, and coarse and technique developed for processing the fibre on standard jute machinery is reported. In some trials the banana fibre were also blended with Mesta (cellulosic fibre). The banana
fibre spinnability and weaving performance were invested, so that it can be used as a good substitute for jute in making of sacks and packaging materials. The yarn composed of entirely of banana fibre can replace jute on weft, sacking warp yarn and still maintain the standard cloth characteristic Banana. The study also affirmed that sacking fabrics woven with banana-fibre yarn as weft and with jute yarn in the other direction compiled with standard specifications and performed better than corresponding all-jute fabrics.

Jute Technological Research Laboratories, (JTR Lab) Calcutta\textsuperscript{73}, carried out an experiment work, (1974) on rope making with banana plant fibre. It was concluded that banana fibre can replace certain percentage of Mesta, a cellulosic fibre in the composition of agricultural ropes. The Mesta or allied fibers thus saved could be more profitably be used for packaging textiles and other materials fibre yarn makes the cloth brighter, impart better dyeing properties and can also be bleached. This additional outlet for the products of banana plantations would benefit the farmer, but a prerequisite for economic use of banana fibre will be a steady bulk supply, initially at a somewhat lower price than that of the existing comparable fibres.

Kurein (1981)\textsuperscript{87} studied on the dyeing behavior of banana fibre. During this study 4 different classes of dyes were used on unmercerised, mercerized cotton fibre and banana fibre. Their dye-uptake, wash-fastness and light-fastness were determined. The dyes selected were direct dye, vat dye, reactive dye, and azo dye. The following conclusions have been drawn: -

1] Correlating the dye uptake and the fastness properties it may be concluded that the fastness properties may not necessary depend upon the amount of dye present on the fibre. It may be said that this property depends more on the structure of the fibre and the manner in which the dye is present on the fibre.

2] It has been noted that the light fastness of banana fibre is inferior to cotton. This may be attributed to the impurities present in the banana fibre in the form of lignin and the other insoluble matter.
3] Banana and cotton fibers dyed with vat dye have an excellent dye uptake, wash-fastness, and light–fastness and the fibers dyed with direct dyes showed inferior properties in all respects.

4] Banana and cotton fibers dyed with reactive and azo dyes show similar properties.

5] Cotton show better properties than banana fibre in all respect after mercerization the dye uptake and that luster of the cotton fibre has considerably increased.

Baruch. et al (1997) carried out Research on “Micro structural study of fibre extracted from wild banana (musa velutina) by X-ray line broadening analysis”. During the study crystallinity, crystallite size and lattice distortion of wild banana (musa vetuling) cellulose were studied using X-ray line broadening analysis (Diffraction data obtained using computer controlled X-ray diffractometer). The degree of crystallinity of banana cellulose has been found to be 45% and the results indicate that the banana species is suitable for use as raw material for textile and pulp paper industries.

Kulkarni et. al (1982) had discussed about the mechanical properties of banana fibres (Musa sepientum). The stress–strain curve for banana fibre is determined. Properties such as the initial modulus (YM), ultimate tensile strength (UTS) and percentage elongation are evaluated as a function of fibre diameter, test length and speed of testing. It is found that YM, UTS and % elongation show little variation in their values for fibres of diameter ranging from 50 to 250 μm. The UTS and breaking strain are found to decrease with an increase in the test length while both breaking strength and breaking strain remain constant with the increase of speed of testing from 0.5 to 100 × 10^{-3} m and thereafter they both decrease. These observed properties are explained on the basis of the internal structure of the fibre, namely, the number of cells, spiral angle and the number of defects. Scanning electron microscopic (SEM) studies of the fractured surfaces of these fibres indicate that the failure is due
to pull-out of microfibrils accompanied by tearing of cell walls; the tendency for fibre pull-out seems to decrease with increasing speed of testing.

Pothan and co workers (1985) had carried out an experimental work on short banana fiber reinforced polyester composites: mechanical, failure and aging characteristics. This paper describes the tensile, impact, flexural properties and aging behavior of short banana fiber reinforced polyester composites with special reference to the effect of fiber length and fiber content. Maximum tensile strength was observed at 30 mm fiber length while impact strength gave the maximum value for 40 mm fiber length. Incorporation of 40% untreated fibers gave a 20% increase in the tensile strength and a 341% increase in impact strength. On treatment with silane coupling agent, composites showed a 28% increase in tensile strength and a 13% increase in flexural strength. Aging studies showed a decrease in tensile strength of the composites. The experimental tensile strength values were compared with theoretical predictions according to Piggot equation. Scanning electron microscopy studies were carried out to understand the morphology of the fiber surface, fiber pullout and interface bonding. Water absorption studies showed an increase in water uptake with increase in fiber content. Finally, the properties of banana fiber reinforced polyester composites have been compared with other natural fiber reinforced composites.

Hendrickx (1989) in his editorial review on natural fibre product description has discussed about the Japanese word bashôfu literally means "banana-fiber cloth." Both the cloth and the clothing made from it are now considered important constituents of Okinawan identity. The Japanese Folk Craft Movement in the 1930s brought attention to this special trait of Okinawan material culture. After years of decline following World War II, the weaving and use of bashôfu saw a revival that accelerated after the return of Okinawa to Japan in 1972 and still continues. Although today bashôfu receives considerable attention because of its status since 1974 as one of Japan's important intangible cultural properties, its origins and history had remained hidden. In this book Katrien Hendrickx searches for the origins of bashôfu in the Ryukyus, including the origins of ito bashô, the plant that provides the raw
material, and studies the yarn-making methods and weaving techniques. She also focuses on why and how the Ryukyuan people adopted those techniques and introduced them into their own society. By careful analysis of all available sources, considered from viewpoints from fields as various as pure history, phytohistory, philology, ethnography, and folklore, Hendrickx convincingly proves that bashôfu was introduced in the Ryukyus from Southern China, and not from Southeast Asia as is commonly argued. Her overview of present-day bashôfu-weaving and its use also provides valuable insights into the situation of folk-craft within Okinawan society during the second half of the twentieth century and up to the present day.

Mani and co workers (1990) studied the effects of the surface treatments of lignocellulosic fibers on their debonding stress. This paper presents some results on the surface treatments given to natural fibers, namely coir, banana, and sisal fibers, using γ-methacryloxypropyltrimethoxysilane (MEMO), γ-aminopropyltriethoxysilane (AMEO), sodium alginate (NaAl), and sodium hydroxide (NaOH) solutions. The cleaned, washed, and dried fibers were dipped in these solutions separately for a given time and dried. Treated and untreated fibers were tested for strength properties, including debonding stress, and structural analysis of the fibers was carried out. It was found that a 3-11% increase in debonding stress was observed for all the treated fibers; and about 30% increase in the ultimate tensile strength (UTS), 9% in initial modulus for silane-treated coir, and only 18% increase in UTS for NaAl-treated coir and sisal fibers were also observed. No significant improvement was observed in the case of surface-treated banana fibers.

Nair (1990) has reported in the article on the women’s society which makes good money from banana fibre. Puthenvelikkara, a village in Chendamangalam Panchayat in Ernakulum district, has set an example for others to emulate by introducing a "new" concept of processing banana fibres for making attractive and inexpensive handicraft items. The significance is that a group of women has set up a unit here to manufacture handicrafts with banana fibre. It is run exclusively by women. These women are members of the Vegetable and Fruit Promotion Council Keralam (VFPCK). The women's
society known as `Janani' has set up a small manufacturing unit where handbags, dolls, flower vase, wallets, tablemats and doormats etc. "We are using the banana stems which were hitherto disposed of as waste material," said a member of the society. From 12-14 stems, 1 kg of fibre could be extracted using the conventional method. The extracted fibre is dried in the sun under a shade and then used for spinning. The members are divided into several units, with each group having three farmers headed by a convenor. `Janani' was formed by Ms N.B. Snehalettha, a teacher, along with 12 members. Today it has grown to six units having a total membership of 60, a VFPCK official said. Each unit produces fibre from banana stems and then transports it to the spinning unit where the products are manufactured. In addition, now two members of each unit are given training on a nominal fee. A common corpus is also created by collecting a fixed amount from the members every month. Mr. K.R. Vishwambharan, VFPCK Director, said that the council would assist Janani by providing expert advice in production, sales and exports. A senior member of the group said that self-help groups, through its joint efforts, could take up such new ventures utilizing the available resources that are either wasted or not commercially exploited for want of technical know-how. According to her, it would provide the housewives with a source of income apart from helping them utilize their spare time gainfully.

Okinawa (1992) [116] had discussed about the Kijoka banana fiber cloth.

It seems that banana fiber cloth was already being made around the 13th century but it was much later that it became popular. In the old days banana trees were planted in gardens and fields, and the womenfolk of a family wove it into fabric for home use. Silk and cotton became much more readily available during the 19th century but people still enjoyed wearing banana fiber cloth. Kijoka Banana Fiber Cloth, which carries on these traditions, was designated as a cultural property by the Prefecture in 1972 and two years later in 1974 it was made an important intangible cultural property by the nation.

Woven from fibers taken from the banana tree, banana fiber cloth is highly representative of the weaving of Okinawa. It was very popular for making a
piece of summer-weight formal dress called kamishimo in the Edo period (1600-1868) and being light and comfortable to wear, it is still a great favorite with many people today for kimono in the height of summer. But kimonos are not its only use. Some is made into obi, while other pieces make fine cushion covers. Ties, bags and table centers are also made of this engaging cloth, which also makes fine split curtains or noren. There are 52 people employed by the 27 firms producing one of Okinawa’s finest cloths.

A review article by an Agricultural correspondent (1994) had briefed about the low-cost banana fibre extractor, which is an eco-friendly and user-friendly device for extracting fibres from the psuedostem of banana has been developed through an inter-institutional project by the scientists from the Central Tobacco Research Institute (CTRI), Rajahmundry and the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad. "It is a simple mechanical contraption, and it can extract 15 to 20 kg fibres from the banana wastes in a day as compared to 500 g a day through the laborious manual process," says Dr. V. Venkatasubramanian, one of the inventors of the machine and a Senior Training Organizer at the Krishi Vigyan Kendra (KVK), Kalavacherla in AP. The machine consists of a rigid frame on the roller rotates. The roller is made of horizontal bars with blunt edges, and it is driven by a one hp single-phase electric motor. For feeding the banana psuedostems, adjustable guiding rollers are provided. All safety provisions are incorporated to make a "user-friendly" machine with high efficiency, according to Dr. Venkatasubramanian. The cost of the machine is Rs. 15,000. The department of Agriculture, AP, has offered a 33 per cent subsidy to popularize the machine, according to him. "The machine reduces the drudgery, and provides a clean working environment for the labourers. It increases the fibre production by fifty times. The machine-extracted fibre is of superior quality in terms of length, softness, strength and colour," explains Dr. Venkatasubramanian. The fibre fetches up to Rs. 50 per kg and it is extensively used for making high quality special paper and decorative papers. Special fabric woven using banana fibres is popular in the Philippines, Malaysia, Japan and Korea. It can be easily blended with other fibres such as jute and mesta. Banana fibres are generally extracted through a cumbersome
process. In the existing manual process, the pseudostems are cut into bits 60 cm long and 7.5 cm wide. By using a metal scraper (flat and blunt blade), the pseudostems are scraped and the fibre is removed. An expert worker can extract between 500-600 g of the fibres in a day of eight hours. The process is also messy, as it will blacken the hands of the workers, and result in mail ulcers. The spillage of the juice and the waste pith will also pollute the working environment. The new machine will offer a clean atmosphere for work, and it will help the workers to produce more fibres as well as get increased income. The machine will provide excellent opportunity in by-product utilization in banana, and it will come in handy when the crop gets damaged due to cyclones and floods. It will ensure an additional income of Rs. 7500-Rs. 12,500 per hectare for the banana growers, according to Dr. Venkatasubramanian.

Padmanabhan (1995) had reported about the low-cost machine to extract banana fibre. The Krishi Vigyan Kendra (KVK) of the Central Tobacco Research Institute (CTRI), Rahajmundry, Andhra Pradesh, in a bid to empower women workers engaged in manual extraction of banana fibre (from the pseudostems) in all growing areas, has designed, developed and commercialized a novel "Banana Fibre Extractor (BFE)" machine. Dr V. Krishnamurthy, Director, CTRI (under the Indian Council of Agricultural Research), told Business Line recently in Rajahmundry (Andhra Pradesh) that a team of senior scientists and technicians attached to KVK had developed this machine, enabling small entrepreneurs in the State to take up banana fibre extraction as an enterprise for value addition and income generation. Dr Krishnamurthy said banana fibre was extensively used as blending material in textile industries in countries such as the Philippines, Malaysia, Japan and Korea. Being a natural fibre, it easily blends with other fibres such as jute and mesta. He said the fibre can also be a good raw material in manufacture of items such as tissue paper, filter paper and decorative kraft paper. Banana fibre-based products, being chemical-free, also have large export potential to countries such as the US, UK, Australia, Malaysia, Japan and Thailand. Pointing out that the BFE machine has revolutionized the living conditions of banana farmers and workers in the region, Dr Krishnamurthy said extraction
of fibre and preparation of organic manure from banana stems have been found to be highly useful and economical to the farmers. He said banana is grown, largely by small and marginal farmers, in an area of 0.68 million hectares, spread over 10 States of the country, and only the fruits and leaves are used while the pseudostems and petioles of the plant are thrown away as waste material. It is estimated that 17,000 tonnes of fibre can be extracted from this waste portion of the banana plant, valued at roughly Rs 85 crore (Rs 50,000 per tonne).

Iyer and co workers (1995)\textsuperscript{68} had carried out a study on properties of some varieties of banana fibres. This article presents an evaluation of yield, structure and properties of banana fibres gathered from a few commercial cultivated varieties. Results indicate that variations exist in both structure and properties of fibres from different regions along the length and across the thickness of the trunk. Further, differences in tensile and structural properties are noticed among fibres belonging to different varieties as well. However, structure and properties among the varieties could be correlated. The matrix in which the ultimate cells are embedded in the fibre also seems to have role in deciding the tensile strength of the technical fibre.

Baruch. et al (1997)\textsuperscript{9} carried out Research on “Micro structural study of fibre extracted from wild banana (musa velutina) by X-ray line broadening analysis”. During the study crystallinity, crystallite size and lattice distortion of wild banana (musa vetuling) cellulose were studied using X-ray line broadening analysis (Diffraction data obtained using computer controlled X-ray diffractometer). The degree of crystallinity of banana cellulose has been found to be 45% and the results indicate that the banana species is suitable for use as raw material for textile and pulp paper industries.

Shukla (1998)\textsuperscript{164} carried out an experimental study on printing of cotton/banana union fabric with reactive dyes and to test its fastness properties. In this study, the cotton/banana union fabric was bleached in solution containing 1% hydrogen peroxide. After pre-treatment the samples were washed thoroughly with water and air-dried. The screens were prepared by the photochemical method. The dyes used were cold brand reactive dye
i.e. Dichloratriazine-procion golden yellow MEZRL. It was concluded that the pre-treatment could be effectively used to induce desirable qualities in the cotton/banana union fabric to make it more durable and to increase the aesthetic appeal. Banana has a bright future as a raw material in the textile market. The present research was undertaken and was focused on ways and means to strengthen its qualities like light and wash fastness by chemically pre-treating them and then dyeing the fabric with reactive dyes to increase its versatility as a product for varying end uses.

Bhandari (1999)\textsuperscript{13} studied dyeing behavior of banana fibers with natural dye, mordant and their various combinations. In this study Banana fibre was dyed with Ratanjot and Eucalyptus dyes. Bundle tenacity, percentage reflectance, and color fastnesses were measured for each dye. It was reported that, eucalyptus dye gives better result in terms of wash-fastness, light-fastness and bundle-tenacity compared to ratanjot. Among mordants, both alum, and ferrous sulphate, gives good result except bundle tenacity. With use of synthetic mordant all give good result except bundle tenacity.

Rawal (1999)\textsuperscript{141} carried out an experimental study on color fastness properties of eco friendly pigment printed, chemically pre treated cotton, banana and jute fabrics. In this study it was concluded that bleaching with hydrogen peroxide was effective for cotton, cotton/banana union fabric and jute/cotton because the impurities whitened and reduced the yellowness of the fabrics. Pretreatment with polyurethane glycol increased the yarn diameter for cotton showing that it created sufficient space for other processes to follow. The color yield of kerosene free pigment prints was compared to conventional kerosene pigment prints. Addition of silicone softener in the printing paste reduced the bending rigidity to all the fabrics improving the feel of the fabric. It also improved the color retention after laundering. Light fastness properties were found satisfactory however crocking of pigment was showing poor rub fastness.

Arora and Phadke (1999)\textsuperscript{24} carried out an experiment of using banana fibers as weft and cotton rayon as warp and their suitability. The apparels made were highly appreciated for their uniqueness by the experts stating that the
apparels were esthetically appealing possessing a rich natural luster. The cotton-rayon/banana fibre apparels were possessed good strength characteristics, were wearable with lining, and are suitable for top garments. The fibers take up dyes quite evenly. Designed colorful garment look beautiful and have great market-appeal.

Vinita and Alka (1999)\textsuperscript{98} carried out a study on the softening of banana fibers. Major obstacles limiting full market development for banana fibres include the difficulties and expense of softening the fibre. These factors have led to regular and relatively small production levels and supplies, unevenness in quality and high prices in comparison to other fibers like cotton, wool, flax and ramie. Banana fibers were extracted and softened with 20% acetic acid. The results show that treatment with acetic acid causes a reduction of diameter of the banana fibre but at the same time this treatment with acetic acid solution enhances the properties of banana fibers to a great extent, which will further improve the bending capacity of banana fibres for apparel use.

Arun (2000)\textsuperscript{4} carried out an experiment work to study few properties-Banana fibres. Few different varieties of banana fibers like Nendran, Padalse, Safed vekhi, Basrai etc were used for the study. It was concluded that the breaking extension shows good correlation indicating that despiralling (untwisting in the fibre molecular structure) occurs during tensile loading. Tensile strength of the banana fibers showed significant differences among different varieties and could be related to their structural properties.

The determination of chemical constituents such as moisture, cellulose, lignin, and ash content, solubility in 1\% NaOH and cold water was done and the mean values were found out and it showed that banana fibres are resistant to the action of alkali, phenol, formic acid, chloroform, acetone and petroleum ether. It is soluble in hot concentrated sulphuric acid.

Behra et al \textsuperscript{11}, studied on “Hand value of cotton-banana union fabric” Two types of fabric samples were produced for the study 100\% cotton fabric and cotton-banana union fabric where cotton yarn were used as warp and banana filament as weft. It was concluded that banana fibre is a stiff filament,
coarser, thicker, stronger and possesses high moisture regain than cotton fibre. The cotton banana union fabric is less extensible, less compressible with high bending modulus and flexural rigidity than pure cotton fabric. The cotton banana union fabric is stronger than cotton fabric in weft (banana fibre) direction. Tensile strength decreased due to enzyme application for all the fabrics. Cotton/banana union fabric appears to have some potential for ladies wear & men’s summer wear before and after enzyme application, as the enzyme treatment endures improved surface characteristic (smooth surface) and also contributes to the appearance of the fabric. Cotton/banana union fabric possesses certain properties, particularly higher Shari (crispness) value, which makes the fabric useful as a summer wear.

Iyer et al (2001)\textsuperscript{68} studied the properties of some varieties of banana fibre. This article presents an evaluation of yield, structure and properties of banana fibers gathered from a few commercially cultivated varieties like French Plantain, Ney Poovan, Dwarf Cavendish, Giant Cavendish, Safed Velchi, Padalse, Basrai. Results indicate that variations exist in both structure and properties of fibers from different regions along the length, and across the thickness of the trunk. Further differences in tensile and structural properties are noticed among fibers belonging to different varieties as well. However, structure and properties among the varieties could be correlated. The matrix, in which the ultimate cells are embedded in the fibre, also seems to have a role in deciding the tensile strength of the technical fibre.

Joseph et. al (2002)\textsuperscript{72} carried out a comparative study of the mechanical properties of phenol formaldehyde composites reinforced with banana fibres and glass fibres. In this study composites were fabricated using banana fibre and glass fibre with varying fibre length and fibre loading. The analysis of tensile, flexural and impact properties of the composites revealed that the optimum length of fibre required for banana fibre and glass fibre are different in phenol formaldehyde resole matrix. Both fibres show a regular trend of increase in properties with fibre loading, interfacial shear strength values obtained from single fibre pull out test, which also revealed that the banana
fibre and phenol formaldehyde resin is much higher than that between glass and phenol formaldehyde resin.

Katrien (2002) has reported on the banana Stem fibre bags from Etikoppaka and about the hand-made paper and textile dyeing methods. After the fruit is harvested, the banana trunk is cut into slices manually. The slices are put in a depithether - the pith is separated from the fibre. The pith has high quantities of lignin which is taken into a compost pit. The fibre is thoroughly washed and put in a beater, adding adequate water. The sizing material is added in the beater just before the completion of beating. After beating, filler is added. Then water is added to the pulp and the pulp is laid out into sheets. The sizing material and the filler are natural non-toxic organic products. The bag handles are made of sisal fibre. The colours used for the bags are also eco-friendly. The bags are totally eco-friendly and completely biodegradable.

Sapuan and Maleque (2003) have explained about the design and fabrication of natural woven fabric reinforced epoxy composite for household telephone stand. In the recent era there has been an increasing interest in composite materials for its applications in the field of aerospace, sports, industries, medical, and in many other fields of engineering including household furniture. This paper deals with the design and fabrication of banana woven fabric reinforcement epoxy composite for household telephone stand. A systematic approach of total design process is presented for better understanding of the best design concept for the product. The fabrication process of composite telephone stand using banana woven fabric is also described in this paper.

Hazra (2004) made an attempt to study the diversified uses of Jute and allied fibre crops, which speaks about the varied uses of textiles from apparel grade lingo-cellulosic fibres like jute, mesta, roselle, sun hemp, flax, ramie, banana etc, blending them between each other, or with any one fibre like cotton, viscose, rayon and its modified forms have high potential for various value added product manufacturers. Processing technologies are well developed for certain n items. What is needed is availability of these fibres in sufficient quantities in pre-cleaned and ready to use form on cost competitive
basis. However, for certain other items, modifications in existing processing technologies and machineries are needed.

Karolia (2005)\textsuperscript{78} reported in the article on Daimer Chrysler to use banana fibre reinforced plastics. Daimer Chrysler AG, Germany, is using composites made of polypropylene reinforced with banana fibres to make under floor protection panels, for manufacture of its Mercedes automobiles. It is the first time a natural fibre component has been used on the exterior of a passenger automobile, specifically as a covering for the spare wheel recess for the Mercedes-Benz-E-Class coupe. The composite meets the stringent quality requirements for components used on the exterior of road vehicles, especially resistance to influences such as stone strike, exposure to elements, and dampness. Manila Cordage supplies the fibres, from the banana variety ‘Musa textilis’, which is commonly known as abaca. The fibres are 1.5-2.7m long have a tensile strength and are traditionally used for making ropes. The use of Abaca fibres can bring about energy savings of 60\% or more, compared with standard glass fibre production. Reiter Automotive developed the manufacturing process used to make the composite part by adapting the long glass fibre reinforced thermoplastic (LFT) technique.

An article by Tree hugger (2005)\textsuperscript{187} on Papyrus Australia Makes Banana Paper, explains about a technology that turns banana waste into paper. Banana trees produce fruit once year, and are then cut down, so banana fiber is an abundant waste product. Papyrus makes the banana paper using an economical process that uses no chemicals, no water, and about 1\% of the energy conventionally used. The company is preparing to tap into what it believes is a potential multi-industry global empire. Others have produced paper with banana fiber content, like Costa Rica Natural, but their paper only contains 5\% banana fiber. The founder of Papyrus Australia, Ramy Azer, learnt the ancient technique of developing paper from papyrus reeds in his native Egypt. Azer says: “What have caught the eye of international markets are not banana papers’ ingredients, but its versatility. It is waterproof and believed to be up to 3,000 times stronger than wood-pulp paper, meaning it
can be used in packaging and even as a basis for building materials. Wallets, hats, bags, clothes and even furniture are also in the pipeline.

Karolia and Malhan (2005) carried out eco-friendly printing on minor fibre fabrics (jute and banana). Minor fibre fabric’s offers a lot of potential for diversified end-uses, and printing has been proved to be a one successful method for value addition to provide product diversification. A study was carried out by the Dept of clothing and textiles, M S University of Baroda, Baroda, India, to develop a diversified line of products for cotton banana union fabrics (CBUF) and 100% jute fabrics by printing them with hand blocks using eco-friendly pigment dyeing recipe. Another research was carried out with the objective of producing diversified value added products by printing with eco-friendly pigment dyes. The study included preliminary market surveys, preparation of print paste, designing print layouts, and preparation of tool for data collection. The results reveal that these products are acceptable among upper middle and upper-economic class of the society, and have greater scope of commercial viability.

An article (2005) on “Kendra plans to popularize banana fibre extraction” explains about the Saraswathi Krishi Vigyan Kendra, Puzhutheri, has chalked out a special programme to propagate banana fibre extraction and production of value added banana fibre products in the region. Since the areas bordering Karur and Tiruchi districts have vast stretches under banana cultivation, rural economy could get a fillip if individuals take up manufacturing of banana fibre products that are finding increasing use, SKVK Programme Coordinator S. Vallal Kannan said here recently. The SKVK is propagating the idea that “even the waste should not be wasted.” The recent workshops conducted for the benefit of self-help group women, especially from the intense banana cultivating regions such as Kulithalai and Krishnarayapuram areas, have given hope that a sustained programme will lead to creation of awareness on the economic advantages of the banana fibre extraction and value addition, he said. “We want to create a situation similar to that in the Marthandam area bordering Kerala, where almost every household is engaged in banana fibre extraction and value addition works. The banana fibre, blended with natural
dyes, is used in making a wide range of goods such as hand bags, tablemats, doormats, purse, hangings, papers and attractively patterned cloth. It is greaseproof, water and fire resistant and totally bio-degradable,” said Dr. Vallal Kannan. The maximum quantity of fibre that an individual can extract by manual process will be just 500 gram a day. For manual extraction, only wooden boards and metal scrapper are required. A fibre-extracting machine, with the capacity to extract 15 to 20 kg a day, has been bought at a cost of Rs.30, 000 from Rajamundhry in Andhra Pradesh. The machinery uses very little power and can be operated by using solar and wind energy. The KVK has so far trained over 500 people, especially women self help group members, in fibre extraction and is ready to help trainees and banana cultivators purchase machines by arranging for bank credit tie-up. The KVK has also opened a procurement centre, where a machine has been installed for training purpose. The banana fibre is bought from farmers at prices ranging between Rs.50 and Rs.100 per kg depending on the quality.

Singh (2005)\textsuperscript{167} had reported in the article on the scope of making money from banana fibres Even the waste should not be wasted. This seems to be the motto of a large number of people, mostly women, of Bihar's Vaishali district who are making a living out of the trunks of banana trees. A handful of women of Sughai Jamalpur, Siduari, Panapur Langa and Dighi villages in Vaishali district, known for producing a wide variety of bananas, hit upon the idea of producing household items from banana trunks. These women are making a variety of household items from the fibre extracted from banana trunks, from flower baskets, wall hangings, tablemats, chappals, handbags and rakhis. "Their enterprise has not only brought kudos to these women but also transformed the living standards of their families. Says the banana growers were a happy lot as apart from the fruit, which fetches them Rs 50 a bunch, they were also selling the felled trees for Rs 5 a piece. "Earlier, even dumping the banana trees was a major problem for them, but now, the farmers are making the most of the situation by selling those to the women engaged in extracting fibre," he says. A fibre-extracting machine with the capacity to extract 25 kgs of fibre a day was bought at a cost of Rs 25,000 from Hyderabad and some women were imparted training. During the past
one year the institute trained over 1500 people in banana fibre extraction, Singh says adding the institute helped some cultivators in purchasing such machines with financing from banks. He said the institute has opened a procurement centre at Hajipur where banana fibre was being bought from the farmers at prices ranging between Rs 60 and Rs 100 per kg depending on the quality of the product. Singh said the fibre was being sold to silk manufacturers of Varanasi, Jaipur and Bhagalpur where the banana fibre was mixed with silk fibre to produce high quality cloth, which was even exported to foreign countries. Singh said a Horticulture and Agriculture Technology Transfer Extension Core Committee has been constituted with the Vaishali district magistrate as its chairman to propagate efforts of the people of Vaishali, particularly women."If all goes well we will succeed in our endeavour to provide the fibre extraction business the status of an industry," he said.

Goswami et. al (2006)48 Utilized banana fibre for making certain specialty paperboards using eco-friendly processes" Banana fibres used for the present investigation was extracted mechanically in a fibre raspador. Bleaching of the fibres was carried out using hydrogen peroxide. An enzymatic treatment was given to the fibres prior to the bleaching in order to remove the gummy materials and lignin. The fibres were beaten in laboratory valley beater up to 45º SR freeness. The waste paper was also beaten at the same freeness. Wax emulsion, natural latex and cationic starch solution was added to the pulp at stock during the time of beating. Multilayer boards were made in the laboratory hand sheet-forming machine using banana fibre and waste paper pulp at different blend ratios viz: 20:80, 40:60, and 50:50.Boards of different thickness varies from 2-5mm were prepared and pressed in a hydraulic press and then dried in an air- circulating oven at 100±2ºC temperature. Thus the process involves no hazards effect. No harmful chemicals were used during the processing of fibres and manufacturing of the boards. It may be concluded that mechanically extracted banana fibres can be easily utilized for making special paperboard products like cellulosic leather board. There is substantial scope for using this type of paperboards in packaging and footwear industries.
Behara and co workers (2006) had carried out a comparative assessment of low stress mechanical properties and sewability of cotton and cotton-banana union fabric. Sewability is that characteristic of the fabric that allows it to be seamed at the full limit of performance of high speed sewing machinery, without the fabric suffering perceptible mechanical degradation. In this study all the mechanical parameters such as machine speed, stitch geometry, needle size etc are kept constant in order to see the influence of the fabric and sewing thread effect on sew ability. The apparel production system from conventional to high tech computerized production system, the inter-relationship between the fabric dimensional, mechanical and low stress mechanical properties and their processability in tailoring and easy in making a garment have become more important. It is therefore imperative that the optimization of sewing process of a new fabric must be carried out before the fabric is introduced to making up process. Banana fibre is one such product being introduced recently in textile apparel sector. It was therefore felt worth undertaking to conduct a detailed study to explore the sewability of cotton banana union fabric. The study clearly revealed that the cotton banana union fabric does not pose any unavoidable obstacle for sewing the fabric. It also confirmed that the 100% cotton fabric has smaller Linearity of load extension curve, so the fabric extensibility in initial strain range is high so as to give comfort in wearing but there are problems in overfeed operations, steam pressing and sewing. The seam damage is found to be higher in weft direction of cotton banana union fabric as cotton being a spun yarn is bulky so it is more prone to be cut under the needle action.

Naik and Mishra (2006) studied on electrical properties of natural fibre. The composites of banana, hemp and agave with HDPE resin were separately prepared in different ratios, 60:40, 55:45, 50:50 and 45:55 (wt/wt). These fibres were treated with maleic anhydride and the effect was studied on the surface resistivity and volume resistivity of wood polymer composites. The Young’s modulus, flexural modulus, impact strength and Shore-D hardness all decreased with increasing amounts of fibres in the natural fibre: polystyrene composites. The sisal fibre composites showed the greatest mechanical strength of all the other ratios. A maleic anhydride treatment shows significant
improvement in Young’s modulus, flexural modulus, impact strength, and Shore-D hardness compared with the untreated fibre composites.

Walker (2006) suggested about the envelopes made from bananas are the latest green products to be launched by UK company The Consortium. The envelopes, produced from banana and other plant fibres from north-east India, are due to go on sale in Britain this summer. The firm, which also makes mouse mats from car tyres and garden furniture from egg boxes, says the envelopes will cost no more than standard ones. The True Green envelope, aimed at replacing the bulky ones made of plastic padding and paper, will be biodegradable and will save on oil. Although it is currently manufactured abroad, The Consortium’s boss Mark Barnett says there is potential to work with UK farmers on the product.

Maleque and co workers (2006) had discussed about the mechanical properties-study of pseudo-stem banana fiber reinforced epoxy composite. Composite materials were known to mankind in the Paleolithic age (also known as Old Stone age). The 300 ft high ziggurat or temple tower built in the city center of Babylon was made with clay mixed with finely chopped straw. In recent years, polymeric based composite materials are being used in many applications, such as automotive, sporting goods, marine, electrical, industrial, construction, household appliances, etc. Polymeric composites have high strength and stiffness, light weight, and high corrosion résistance. In the past decade, extensive research work has been carried out on the natural fiber reinforced composite materials in many applications. Natural fibers are available in abundance in nature and can be used to reinforce polymers to obtain light and strong materials. Natural fibers from plants are beginning to find their way into commercial applications such as automotive industries, household applications, etc. A number of investigations have been conducted on several types of natural fibers such as kenaf, hemp, flax, bamboo, and jute to study the effect of these fibers on the mechanical properties of composite materials. On the other hand, jute fabric-reinforced polyester composites were tested for the evaluation of mechanical properties and compared with wood composite, and it was found that the jute fiber composite has better strengths.
than wood composites. A pulp fiber reinforced thermoplastic composite was investigated and found to have a combination of stiffness increased by a factor of 5.2 and strength increased by a factor of 2.3 relative to the virgin polymer. Information on the usage of banana fibers in reinforcing polymers is limited in the literature. In dynamic mechanical analysis, have investigated banana fiber reinforced polyester composites and found that the optimum content of banana fiber is 40%. Mechanical properties of banana–fiber–cement composites were investigated physically and mechanically. It was reported that kraft pulped banana fiber composite has good flexural strength. In addition, short banana fiber reinforced polyester composite. This study concentrated on the effect of fiber length and fiber content. The maximum tensile strength was observed at 30 mm fiber length while maximum impact strength was observed at 40 mm fiber length. Incorporation of 40% untreated fibers provides a 20% increase in the tensile strength and a 34% increase in impact strength. Banana fiber and glass fiber were tested with varying fiber length and fiber content as well. The analysis of tensile, flexural, and impact properties of these composites revealed that composites with good strength could be successfully developed using banana fiber as the reinforcing agent. The source of banana fiber is the waste banana trunks or stems which are abundant in many places in the world. Therefore, composites of high–strength pseudo-stem banana woven fabric reinforcement polymer can be used in a broad range of applications. The objective of this paper is to study the tensile, flexural, and impact properties of pseudostem banana fiber reinforced epoxy composites. The tensile test results depict that UTS of virgin epoxy resin was in the range of 22–26 MPa, and the mean is 23.98 MPa. The UTS of banana fibers reinforced epoxy resin was in the range of 44–50 MPa, and the mean was 45.57 MPa. The UTS of banana fiber reinforced epoxy composite increased by 90% as compared to the unreinforced epoxy. The epoxy matrix transmits and distributes the applied stress to the banana fiber resulting in higher strength. Therefore, the composite can sustain higher load before failure compared to the unreinforced epoxy. In addition, higher ultimate tensile strength and higher elongation leads to higher toughness of the material. Figure 5 shows the result of the Young’s modulus of the virgin. The following conclusions can be drawn from the present study. The tensile strength on the
pseudo-stem banana woven fabric reinforced epoxy composite is increased by 90% compared to virgin epoxy. The flexural strength increased when banana woven fabric was used with epoxy material. The results of the impact strength test showed that the pseudo-stem banana fiber improved the impact strength properties of the virgin epoxy material by approximately 40%. Higher impact strength value leads to higher toughness properties of the material. The banana fiber composite exhibits a ductile appearance with minimum plastic deformation.

In the article by Jin (2006)\textsuperscript{203} on Paper making from banana fibres various types of papers like security paper, insulating paper or carbon paper is made from the banana fibres from the stem, trunk and leaves of the plant by cutting into chips, pithing and degumming by mechanical and chemical means, followed by washing and pressing, digesting, cleaning, bleaching, and making the paper.

Sudha et.al (2006)\textsuperscript{178} have discussed about natural fibre composites, which are to be used as a substitute for the glass fibres in composite components have gained interests, as these fibres are cheap, have better stiffness per unit weight, and low impact on the environment. Jute, sisal, banana and coir are some of the major source of natural fibres that are grown mainly in parts of India. Jute has a superior specific modulus than that of glass and jute fibres can be used in place of traditional glass fibres. Coir fibre has an advantage of stretching beyond its elastic limit without rupturing as well as to take up the permanent stretch. Various processes are available for the fabrication of composites and the selection of the right technique to match the application is critical for the successful production. Natural fibre reinforced composites can be used for a number of household applications and has the potential to reduces the costs of these products.

Mishra (2006)\textsuperscript{100} A made a “Comparative study of pure cotton and banana fibre blended fabric”. Banana fibre possesses a lot of advantageous physical and chemical properties, which promote its use in textile applications. This also reduces the disposal problem, the pseudostems being taken care of. The
fibre can also be blended with cellulosic fibres like cotton to produce apparels and fancy items. This will help bringing down the overall cost of cotton.

Naik and Mishra (2006) examined the compatibilizing effect of maleic anhydride on swelling properties of plant fibre-reinforced polysterene composites. In this work the fibres of banana, hemp and sisal are employed as fillers for the formation of wood polymer composites with polystyrene in the different ratios of 40\60 and 45:55 (wt/wt), respectively. These fibres were esterified with maleic anhydride, and the effect of maleic anhydride was studied on absorption of steam and water at ambient temperature in wood polymer composites. Untreated fibre composites show more absorption of steam in comparison to maleic anhydride (MA)-treated fibre composites. The absorption of water increases with the increase in time from 2-30 h in all untreated fibre composites. The maximum absorption of water was found in hemp fibre composites and the minimum in sisal fibre composites. The maleic anhydride esterified fibre composites showed less absorption of water than the untreated fibre composites. Steam absorption in MA treated and untreated fibre composites containing low amount of fibre shows less absorption of steam and water at ambient temperature than the composites containing a greater amount of fibre in respective fibre composites.

Zawawy (2006) have explained about the blended graft copolymer of carboxymethyl cellulose and poly (vinyl alcohol) with banana fibre. Conducting hydrogel copolymer was prepared by graft polymerization of carboxymethyl cellulose (CMC) and boric acid onto poly (vinyl alcohol) (PVA). The dielectric properties of CMC-g-PVA/pre-hydrolyzed banana blend had been investigated as a function of frequency, with special reference to pure pre-hydrolyzed banana. Also, the static bending for the blend was determined and no abrupt failure was observed. The dielectric properties measured were dielectric constant, dissipation factor and loss factor. At high frequencies, a transition in the relaxation behavior was observed, whereby the dielectric constant, loss tangent, and loss factor decreased with frequency behavior depends greatly on the nature of the present group. The crystallinity of the system and the degree of hydrogen bonding between the different chains.
The variations of the dielectric properties were correlated with blend morphology and also to the possibility for interfacial polarization that arises because of the differences in the conductivity of the two phases. It was found from the infrared spectra that the incorporation of CMC-g-PVA copolymer decreases the crystallinity of the blend and also decreases the degree of hydrogen bonding, which results in a high dielectric constant.

Ratanakamnuan and Ong (2006) explained the photobiodegradation of low density polyethylene/banana starch films. The effects of the starch content, photosensitizer content and compatibilizer on the photobiodegradability of low density polyethylene (LDPE) and banana starch polymer blend films were investigated. The compatibilizer and photosensitizers used in the films were PE-graft-maleic anhydride and benzophenone respectively. Dried banana starches at 0-20% (w/w) of LDPE, benzophenone at 0-1% (w/w) of LDPE and PE-graft-maleic at 10% (w/w) of banana starch were added to LDPE. The photodegradation of the blend films were performed with outdoor exposure. The progress of the photodegradation was followed by determining the carbonyl index derived from Fourier transform IR measurements and the changes in tensile properties. Biodegradation of the blend films was investigated by soil burial test. The biodegradation process was followed by measuring the changes in the physical appearance, weight loss and tensile properties of the films. The results showed that both photo- and biodegradation rates increased with increasing amounts of banana starch, whereas the tensile properties in the films decreased. The blends with higher amounts of benzophenone showed higher rates of photodegradation, although their biodegradation rates were reduced with an increase in benzophenone content. The addition of PE-g-MA into polymer blends led to an increase in the tensile properties whereas the photobiodegradation was slightly decreased compared to the films without PE-g-MA.

Oliveira and co-workers (2006) have explained about the lipophilic extractives from different morphological parts of banana plant “Drawf Cavendish”. The chemical composition of the dichloromethane extracts of different morphological parts of banana plant “Drawf Cavendish”, cultivated in
Madeira Island (Portugal), were studied by gas chromatography-mass spectrometry. The five different morphological fractions in study have a similar qualitative chemical composition. Fatty acids and sterols are major families present in the lipophilic extract of “Drawf Cavendish”, representing ca. 33-66% and 12-43%, respectively, of the total amount of lipophilic components. Among all the identified compounds, campesterol, stigmasterol ad fatty acids, such as palmitic, stearic, linoleic, linolenic, 22-hydroxydocosanoic and 26-hydroxyhexacosanoic acids, were the major components found in all morphological zones. Other families of compounds such as aromatic compounds, fatty alcohols and alkanes were also identified. The high increase in some components after alkaline hydrolysis, particularly, ferulic and fatty acids, indicates the presence of a considerable fraction of such components in esterified structures.

Bryan lee (2007) studied the Use of Banana stain to decorate fabrics or for other aesthetic purposes, It is claimed that the banana stain can be used to ornament, label or outline many objects for aesthetic purposes. Ways of extracting and treating the stain are also claimed, including collecting drippings from the fruit, leaves, or the bark of the plant and/ or grating the skin.

Mitra et .al (2007) investigated the use of natural lingo-cellulosic fibres and their blends for textile application. Ligno-cellulosic long vegetable fibres like jute, mesta, Roselle, flax, banana, pineapple, ramie, sisal, manila etc have wide textile use. Jute is traditionally used as packaging material like the Hessian and sacking. Mesta and Roselle fibres are used as substitutes for the jute to produce coarse type of twines or bags. Flax fibre is mainly used in production of industrial (i.e.: -hose pipe, shoe twin etc) and apparel (i.e. linen cloth) textiles. Banana fibre is available from the pseudostem of the banana plant. The fibre is very coarse, but bright in appearance and at NIRJAF (Calcutta) the fibre has been utilized in blends with jute, Mesta to produce packaging materials and ropes. Pineapple leaf fibre is very silky and strong and is blended with jute and other fibres. Ramie is fine strong and silky fibre.
after degumming. Higher density and wet strength along with high flexural and torsional rigidity restrict their application to cordage industry.

Sugiura et al. (2007) had explained the “Analysis of fine structure of subtropical plant fibres treated with sodium hydroxide or liquid ammonia by microscope observation and X-ray diffraction measurement”. For this study six kinds of subtropical plant fibres taken from the hibiscus, Pineapple, Okra, Plantain, Banana and Agave were treated with sodium hydroxide aqueous solution and liquid ammonia using a commercial plant. Cross sections of the fibres were observed with microscope. Furthermore, in order to investigate the internal structure, X-ray diffraction measurement was carried out and crystallinity of the treated fibres was obtained. From the observation of the cross section, it is clear that every fibre forms honey comb structure which consists of several to many cells, and each cell has a void in the cell. The void is comparably larger than that of the cotton lumen, and the void generally became smaller by the NaOH treatment. Furthermore X-ray diffraction profile was measured for each of the fibre. Most of the fibres were changed from, cellulose I to cellulose II by the NaOH treatment, whereas the fibres unchanged to cellulose III. After the three treatments, the cellulose III intensity increased comparably, although the cellulose I remains not a little for all samples. On the other hand, cotton fibre completely changed to the cellulose III structure by the above treatment. Hereafter, it is necessary to investigate the void structure including the effect of lignin and cell wall as a multicellular plant fibre.

Torres (2007) carried out the morphological, thermal and mechanical studies of film elaborated with the blend low-density polyethylene and chemical modified banana starch. Films were prepared by extrusion acetylated and oxidized banana starches at different concentration mixed with low density polyethylene. Morphological, mechanical, and thermal characteristics of the films were tested. Irregularities in the films prepared with native and oxidized banana starches were observed by scanning electron microscopy. This pattern is maybe due to the incompatibility between both polymers. However, films elaborated with acetylated banana starch showed a
smooth surface. The tensile strength and elongation at break decreased when starch level in the blend increased. An inverse pattern was showed for elastic module. The effect on mechanical properties was more notorious in those films elaborated with the acetylated and oxidized banana starches. Two thermal transitions were observed by differential scanning calorimetry, the principal transition at similar to 111° C was due to disorganization of the low density polyethylene. Enthalpy value associated to that principal transition was higher in the films elaborated with acetylated banana starch, showing higher compatibility between both polymers. The use of biodegradable polymers such as chemically modified banana starch might be feasible for elaboration of films with adequate mechanical properties.

Zuluaga and co-workers (2007)²⁰¹ have explained about the cellulose microfibrils from banana farming residues. Cellulose microfibrils have been prepared from banana rachis using a combination of chemical and mechanical treatments. The morphology and structure of the samples were characterized using transmission electron microscopy, atomic force microscopy, and X-ray diffraction. Fourier-transformed infrared spectroscopy was used to characterize the chemical modifications of the samples after each treatment. Suspensions of bundled or individualized 5nm wide microfibrils were obtained after homogenization (PH) whereas an organosolv (PO) treatment resulted in shorter aggregates of parallel cellulose microcrystallites. The sharper rings in the X-ray diffraction pattern of the PO-treated sample suggest a higher crystalline due to a more efficient removal of hemicelluloses and dissolution of amorphous zones by the acid treatment. Both microfibrils and microcrystals prepared by both methods can be used as reinforcing filler in nanocomposite materials.

Jahan et.al. (2007)²⁰³ explained about the atmospheric formic acid pulping and TCF bleaching of dhaincha (sesbania aculeate), Kash (Saccharum spontaneum) and banana stem (Musa Cavendish).Fractionation of dhaincha, kash and banana stem was investigated by atmospheric formic acid pulping. Pulping of dhaincha, banana stem and kash was not satisfactorily delignified when the formic acid concentration was limited to 70%; even longer cooking
time (120min) at this concentration did not produce pulp of lower lignin content. The marked effect of delignification was observed in case of 90% formic acid concentration. Peroxyformic acid effectively reduced the residual lignin of the formic acid pulp. In alkaline peroxide bleaching, formic acid pulp was bleached to 75-83% brightness depending on the nonwood. The strength properties were almost comparable to conventional pulp. The dhaincha pulp was stronger than the banana stem and kash pulp. The bleaching improved the strength properties of the pulp. The major devoilatization of formic acid lignin was occurred between 200 and 550°C as shown by the TG graph. The xylose was the main sugar in water soluble fractions of formic acid spent liquor that represented 50-60% of the content in original raw materials.

Finnie and Azer (2007) have discussed about the method and apparatus for removing sheets of fibres from banana plants for the production of paper products. A method and apparatus for producing sheets from the pseudostems of banana plants in the family Musaceae into a work station, and contacting the rotating pseudostem along substantially its entire length with a fibre separating device, whereby a continuous sheet of fibre is removed from the pseudostem by the fibre separating device during rotation. Raw paper may also be made by laminating two or more of these sheets together such that the direction of the generally parallel fibres in at least two adjacent sheets is not aligned and then curing the sheets to form raw paper.

Oliveira et al (2007) explained the “Chemical composition of different morphological parts from ‘Drawf Cavendish’ banana plant and their potential as a non-woven renewable source of natural products”. The study on chemical composition and structure of components from different morphological parts of ‘Drawf Cavendish’ banana plant had been carried out aiming to evaluate their potential as eventual raw material for the chemical processing. Macromolecular components were analyzed using solid state NMR, ATR-FTIR and wet chemistry methods. Mineral components were assessed by ICP analysis of ashes obtained after raw material calcinations. It was verified that chemical composition of the studied fractions of banana plant varies significantly. The major extremes were found in the contents of
cellulose, starch, lignin and lipophilic extractives. All morphological parts of banana plant contained considerable amounts of ashes composed mainly by potassium, calcium and silicium salts. The hemicelluloses in banana plant are proposed to be mainly glucuronoxylan and xyloglucan. Rather significant amounts of proteins were found in the leaf blades. Lignin analysis revealed that it is of HGS type with H:G:S proportion ranged of (5-17):8-54):(35-71). The significant variation of lignin structure among the different morphological parts of banana plant was highlighted. Results of this study allowed some propositions about possible applications of banana plant residues as non-wood renewable source of natural products.

Khan and co-workers (2007)\textsuperscript{205} carried out a study on graft copolymerization of catalytic urea formaldehyde resin onto banana plant fibre and its physico-chemical properties. The physico-chemical properties of bleached banana plant fibre and modified banana plant fibre with catalytic urea formaldehyde resin had been studied. The bleached banana fibre plant was modified with urea formaldehyde resin in presence of magnesium chloride and COOH as catalyst. The optimum modification conditions, viz. modifier concentration, catalyst concentration, modification time and temperature were determined on the basis of maximum weight gain of the fibre. Weight gain of the fibre increases with the increases with the increase of modifier concentration from 10-90\% and catalyst concentration from 0.25-1.75\% and there after it remains almost constant. Modification time and modification temperature also influence the rate of reaction and maximum weight gain was obtained at 20-30 °C for 45 mins. The degree of grafting was evaluated by means of moisture content and infrared spectroscopy measurements. From the experimental results, it was observed that the modification had positive effect on tenacity, colorfastness and other physico-chemical properties of banana plant fibre.

Osma et.al. (2007)\textsuperscript{117} explained about the uses of banana skin-a novel waste for laccase production by Trametes pubescens under solid state conditions. Application to synthetic dye colouration”. In this paper, investigations of the potentials of banana skin as a support-substrate for the production of
extracellular laccase by the white-rot fungus Trametes pubescens. Laccase showed a maximum activity of 1570U/I. In addition, the assessment of the degrading ability of the extracellular liquid is obtained. For this the invitro decolouration of the two structurally different dyes such as the anthraquinonic dye Remazol Blue R and Triphenylmethane dye methyl green. The former was decolourised about 57% in 4hr. whereas the latter presented a lower decolouration rate of 40.9% in 4h. Interestingly the RBBR decolouration was considerably higher than that attained by a commercial laccase, whereas MG decolouration was very similar for both laccases. This shows the high potential of T.pubescens laccase for synthetic dye colouration, especially for anthraquinonic dyes.

Pothan and co-workers (2007) explained the effect of layering on the water adsorption of banana glass hybrid composites. Hybridization of banana fibres with glass fibres had been found to reduce the water adsorption behavior of the composites. Banana fibres were hybridized with glass and different layering patterns were followed in the preparation of the composites. The effect of the various layering patterns on the water absorption of the composites was studied. It was found that water diffusion occurs in the composite depending upon the layering pattern as well as the temperature. In all the experiments, it has been found that the composites with an intimate mixture of glass and banana show the maximum water uptake except for temperature of 90°C. At 90°C the maximum water uptake is found to be for composites where there is one layer of banana and another layer of glass. The water uptake follows the same trend as that in all other temperature till a time span of 4900 min is reached. The kinetics of diffusion was found to be Fickian in nature. The various thermodynamic parameters like sorption coefficient, diffusion coefficient, and enthalpy change entropy change and activation energy of the various composites were calculated. From all the calculations, it has been concluded that layering pattern is an important parameter, which controls the water absorption of the composites. The layering pattern Cg-b-g was found to have the lowest water uptake.
In an Editorial article (2007) on “Growing Banana Fibre Becoming Popular in Tamil Nadu” a group of weavers in Anakaputhur, a small town in Tamil Nadu, have successfully taken to weaving banana fibre. It was a chance discovery on the part of Padma Shekhar, the owner of a weaving unit, which led to the usage of ‘Vazhai Naaru’ or the banana fibre as dress material. Raw fibre is cleaned by artisans through a simple bleaching method. Its fat content is then removed. Each strand of the fibre is taken out and woven into fabrics after being dyed in various colours. Banana fibre has an affinity to colours that makes it easier to weave attractive designs from it. The process maybe cumbersome but the six yard wonders fabricated from this fibre is very comfortable and in much demand. "These saris are woven in natural fabrics like banana fibre. It is very comfortable to wear and relieves off the scorching heat as they have a cooling effect. It is really nice to wear," said Shekhar. A sari made with an investment of mere 100 rupees is sold at five times the production cost at 500 rupees in the market. These saris are supplied to both national and international markets. Although the returns are good, the work is restricted to only one weaving unit. The unit is small scale with hardly ten workers accounting for the entire work force. "We have benefited a lot from these natural fibre clothes. There is a huge demand for them in both national and international markets. We earn good wages by weaving these clothes. Initially we started off with 30 workers but now only ten workers are employed," said Uma, a weaver. The looms used for weaving are 1.2 meters and weaving on them is a painstaking process. It takes a month to weave one sari. With 750 handloom weavers in the entire Anakaputhur, Shekhar is single handedly attempting to popularize the cause of banana fabric. The State Government is yet to take notice. Though popular for its fruit, the banana plant has long been a source of fibre for high quality textiles. Banana fibre was used in Philippines for making shirts and other dresses. In Japan, the cultivation of banana for clothing and household use dates back to at least the 13th century mentions the article.

Revathy (2007) had reported about the NRCB plans for large-scale banana fibre extraction. The National Research Centre for Banana (NRCB) plans to extract banana fibre on a large scale for commercial purposes. Banana fibre
is used in textiles in Japan and Philippines, but in India, fibre extraction was until now carried out only on a modest scale at the NRCB farm at Podavur to educate the farmers about its potential. Though only about one per cent of the banana plant's bio-mass is available for extraction, researchers sight immense potential for this fibre. About 1,200 plants were being raised in an acre and over 40,000 acres are under banana cultivation in Tiruchi district alone. The fibre was extracted from the stem, which weighs about 50 kegs on an average (per plant). Considering the availability and immense potential for extraction and use of the banana fibre, the Tiruchi-based NRCB plans to extract this fibre on a commercial scale. Value-added products like chappals and handicraft items were made from banana plant. "The extract is powdered, coloured and put to use," he added. The NRCB had participated in an exhibition in Bangkok last year, where it had bagged the first prize for its exhibit under the `non-food banana item` category, he said. The Centre had developed value-added products like banana figs, juice, jam, biscuits, health supplement and a baby cereal and imparted a week long training course to the farmers. Though the scientific process was available, the major hurdle was the lack of technical knowledge and marketing expertise, he said. Emphasizing the enormous market potential for the banana fibre extract, Dr Sathyamoorthy said `if the process worked out well, it will be a boon for the banana growers, who are now facing a severe economic crisis due to glut in the market'.

Saupan and co workers (2007) had explained about the design and fabrication of a multipurpose table using a composite of epoxy and banana pseudostem fibres. This paper describes the fabrication of a multipurpose table using banana trunk fibre-woven fabric-reinforced composite material. The aesthetic value coupled with strength and mechanical properties make banana trunk fibre-woven fabric-reinforced composites, a suitable material for furniture making. Design and fabrication details using hand lay up process are described. The item (Fig. 3) so made was lightweight (4.25 kg), compact, stable, and easy to transport with an aesthetically pleasing golden brown colour. Banana fibre, which otherwise is considered a waste product, could thus become a useful raw material for producing reinforced composites with
household furniture applications and may replace the conventional metallic, non-metallic, wood, and plastic materials to some extent.

Shetti and Karolia (2008) evaluated resin finished CBUF using Kawabata system. Hike in cotton prices and decreasing demand for synthetics motivated the global textile-scenario to be in search for new eco-friendly products to hold the consumers attention. Hence, with a view to widen the scope for end-use of eco-friendly CBUF, the pre-treated and bleached fabric was treated with a combination of DMDHEU resin and two selected softeners namely silicone softener and cationic softener. Results showed that better strength retention and improved wrinkle recovery and drape could be obtained by silicone softener treated fabric, thus reducing the cost of expensive resin. However, the most important criteria that determines consumers acceptance to a fabric is its hand or feel. Thus, Kawabata evaluation system was used for objective evaluation of the feel of the fabric. The best result for the fabric feel was obtained by the silicone softener treated fabric.

Singh et al (2008) had carried out an extensive research & development in banana and plantain – national and international scenario. Banana and plantain are playing a pivotal role in human welfare since their domestication. Banana as a desert has a unique role, while plantain fulfils as the food for masses globally. Both banana and plantain are grown in more than 130 countries the world over, producing 97.38 million tones from 8.25 million ha. India is the largest banana producer, accounting 24% of the total banana production, followed by Brazil, the Philippines, Indonesia, China and Ecuador. With a sound R & D system in our country, still there is a region specific banana production constraint. To meet the challenge and to make banana and plantain competitive internationally, there is still a gap to be fulfilled, emphasized the authors.

Uma and co workers (2008) have explained that quality-planting material is the key for successful production of banana and for its propagation as a farmer friendly technology. India has largest area of 5.5 lakh ha under banana requiring 0.125 billion plants per annum. This requirement is reduced by 50 and 33% in two subsequent years depending on replanting of plantation after
1+1 crop or 1+2 crops respectively. This is an enormous requirement in a vegetatively propagated crop like banana. Presently 15-20 viable companies are involved in production of tissue-cultured banana with an annual production of 2-5 million plantlets. Thus only 4.0% is being produced through tissue culture, while the rest 96% of the planting material requirement is being catered as suckers. Hence, the quality planting material applies both to suckers and tissue cultured plants.

Uma et al (2008) had tried exploring plantain for welfare of masses, as there exists a great scope for effectively utilizing the pseudostem waste for the preparation of a whole range of products like marine cordages, high quality paper card boards, tea bags, string thread, high quality fabric materials and paper. With the dwindling resources paper industry is facing an acute shortage of raw material for the industry. This is catalyzed by the fast urbanization and rise in literacy levels. There is an urgent need to look for bio-renewable and biodegradable raw material. Banana satisfying both these primary requirements forms a major alternative to polythene bags, which are fast becoming an environmental pollutant. Fibres in their raw state produce a highly sorbent material, which allows a more expedient and therefore more expensive cleanup. Banana fibres can be used in sorbent socks, pillow and brooms etc. Banana fibres are flame resistant in its natural form and petroleum products can be recovered from the material thus allowing recycling of recovered oil. Fibres have been already tested or use as a filtration agent in the wastewater treatment industry. The fibres were reported to be elegant and highly versatile. The fibres can be powdered and different colours of fibres can be obtained using natural dyes, which can be made into beautiful pictures.

Narayana and Mustaffa (2008) had tried to explain about the value added products of banana. Quality is the basic criterion on which the banana trade is dependent besides the price in the international market. Though India is the largest producer of bananas in the world, it has not been able to make its presence felt in the international market, as the fruits produced are not of the international quality and the prices to produce the high quality fruits are
essential for sustaining in export trade of banana. Maturity is an important
criterion to be taken into consideration in harvesting, while improved handling
practices, suitable packaging and storage methods are some post harvest
factors to be given utmost priority in post harvest management.

Sundararaju (2008)\textsuperscript{180} reported about the evaluation of banana (Musa spp)
germlasm against root-knot nematode (Meloidogyne incognita). Banana
(Musa spp) in India is attacked by 71 species of nematodes belonging to 33
genera. Among them, the root-knot nematode Meloidogyne incognita (Kofoid
and White 1919, Chitwood 1949) is considered to be the economically
important nematode pests of banana. Root-knot nematodes can be controlled
with chemicals but they have adverse environmental effects and the use of
nematicides is too expensive and the products are too dangerous for
subsistence farmers. Breeding for host plant resistance is a promising
strategy for controlling nematodes. As root-knot nematode has been well
documented to cause considerable yield loss to banana, the present study
was undertaken to evaluate the 72 banana germplasms in pots under green
house conditions for locating the resistant/tolerant reaction to root-knot
t nematode. A pot culture experiment was conducted to evaluate 72
varieties/cultivars of banana for the tolerance/resistance against root-knot
nematode, Meloidogyne incognita. The results indicated that none of the
varieties/cultivars was resistant to root-knot nematode.

Mukhopadhyay et al (2008)\textsuperscript{105} investigated the variability of tensile properties
in fibres extracted from pseudostem of the banana plant. This paper highlights
the variability of mechanical and thermal properties of banana fibres with
respect to aging and an analysis of the difference from the polymeric
viewpoint. The banana fibres were found to be good reinforcement in
polyester resin. It was found that the mechanical properties of the banana/
phenyl formaldehyde composites are comparable to those of the glass
fibre/PF composites. The effects of chemical modification on the physical
properties of banana fibres were analyzed. The behavior of fresh and aged
fibres and their reaction to alkali at different concentrations was investigated.
The results can be explained in terms of the internal structure of the fibre,
such as cell structure, microfibrillar angle, defects etc. In rapid mechanical testing, the fibre behaves like an elastic body i.e.: the crystalline region shares the major applied load resulting in the high tenacity values. When the testing speed decreases, the applied load will be borne increasingly by the amorphous region. The amorphous region takes up the major portion of the applied load giving a low fibre modulus and a low tensile strength.

Desai (2008)\textsuperscript{32} reported about the conventional textiles in India-Banana fibres. The banana fibres were reported to be elegant and highly versatile. The hand extracted fibres were used in manufacturing of handicraft articles, bags, table mats wall hangings, etc. The fibres can be powdered and different colours may be applied using natural dyes foe making beautiful pictures. The banana fibres were also blended with many natural and synthetic fibres to male varieties of fabrics. However, the inherent drawback of the banana fibre is its poor quality and higher irregularity owing to its multicellular nature of the fibres. The fibre has not been exploited much commercially hitherto, as it was considered inferior to abaca and other available hard fibres. Banana fibre is classified as medium quality fibres and performs very well in combination with other fibres for making fine articles like handicrafts, currency etc. Over the years, there has been considerable interest in exploiting it for variety of household and industrial uses on a larger scale.

Vasatwiki (2008)\textsuperscript{207} discussed about the cultivation and the properties of banana fibres. According the author the banana fibres has long been a source of fibre for high quality textiles. The banana shoots produce fibres of varying degrees of softness, yielding yarns and textiles with differing qualities for specific uses. For example, the outermost fibres of the shoots are the coarsest, while the innermost fibres are the finest. In another system employed in Nepal, the trunk of the banana plant is harvested instead, small pieces which are subjected to a softening process, mechanical extraction of the fibres, bleaching and drying. After that the fibres are sent to the Kathmandu valley for the making of high end rugs with a textural quality similar to silk. These banana fibre rugs are woven by the traditional Nepalese hand-knotted methods and are sold Rugmark certified. Bananas come in
variety of sizes and colours, most cultivars are yellow when ripe but some are red or purple. Depending on the cultivar and ripeness, the flesh can be starchy to sweet and firm to mushy. In addition to the fruit, the flower of the banana plant is used in many areas, where they are either served raw with dips or cooked in soups or curries. The tender core of the banana plant’s trunk is also used in many regions for cooking purposes. Bananas are also eaten as fritters, with ice-creams, baked in their skin in a split bamboo or steamed in glutinous rice wrapped in a banana leaf. The juice extract prepared from the tender core is used to treat kidney stones. The leaves of banana are large, flexible and water-proof and are used in many ways including surgical bandages, umbrellas, in wrappings etc. Banana chips are a snack produced from dehydrated banana or fried banana. Mashed banana pulp mixed with honey is used to treat jaundice in many countries.

Revathy(2008)\textsuperscript{204}, described about banana fibres which are emerging good business proposition. Banana fibre extraction is emerging as a good business proposition in Tamil Nadu and Kerala following good demand for the fibre. Especially, three hamlets off Marthandam in Tamil Nadu — Thakkalai, Thiruvattaru and Mathur — have become the centre for banana fibre wherein every household of the village is engaged in the fibre extraction activity eking out their livelihood. “Manual fibre extraction from the banana pseudostem is an arduous task,” says Ms Kalpana, a research associate at the National Research Centre for Banana (NRCB) at Tiruchi. Ms Kalpana, who is engaged in a project on physiochemical and structural characteristic of banana pseudostem told Business Line that there was huge demand for the banana fibre, which was (blended with other natural fibres) used in making a wide range of goods as cordage, yarns, paper and paper cups, tea cups and tea bags, attractively patterned cloth, handbags/purses and shoes. A tribute to the tear and tensile strength of banana fibre were the Japanese yen notes printed on paper from the fibre of the banana variety — abaca, she added. “Because of the huge demand in the markets abroad, the pseudostem is not junked anymore,” she said and pointed out that a kg of the fibre was bought locally only for about Rs 50. “However, the maximum quantity of fibre that an individual can extract in a day would be just 500 g whereas in the mechanical
process the same quantity could be extracted in an hour," she said. Only wooden boards and metal scrapper are used in the manual fibre extraction process, Ms Kalpana said. NRCB had collaborated with a Mumbai-based research institute for developing a low cost mechanical device for the purpose. According to her, over 5 lakh hectares of area were under banana in India, and the pseudostem alone would account for 28 million tonnes, from which the fibre, if extracted should weigh around 2.2 million tonnes every year. There are at least 117 different banana varieties. The fibre content in the wild varieties is said to be more. She said that a survey conducted in the Nagercoil belt showed that four red banana plants could yield one kg of fibre as against 10 plants of the nendran variety. ``The fibre content is even less in commercial varieties like robusta," she said.

In an article (2008) on “Banana fibre – the next new sensation in textile industry”,

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.

A research study is already being carried out by the National Research Centre for Banana (NRCB) and if the proposition turns out to be viable, the country can very soon expect the domestic market to be flooded with an array of textile and garment products made from banana fibre. In India this fibre is mostly used for making handicraft items but even the US market has a huge demand for this raw material.

As of now, the NRCB has joined hands with the Central Institute of Cotton Technology, Mumbai, with the aim of producing quality fibre by improving the retting process, adding certain non hazardous chemicals to banana fibre to produce lengthy fibre, with adequate strength and lustre. This process will have to be undertaken as banana fibre drawn from the stem of the plants is very brittle which makes drawing-out of long fibre a little difficult. In fact, the NRCB had also brought special varieties of banana plants from the Philippines and the Middle East that does not bear fruits or flower and only
yields fibre. However, crucial tests like long term durability of the fabric, retention of fast color dyeing and stitching capability has to be conducted before the technology can be adopted for commercial production.

In an exclusive interview with Fibre2fashion, Dr C K Narayana, Principal Scientist at NRCB informed saying, “The fibre is essentially made from banana plant stem which is considered as a waste material after harvesting. Although, there are a few available machines to extract banana fibre, there is a lack of adequate methodology to make yarn from the fibre.” While Central Institute of Cotton Technology, Mumbai is working on developing that methodology, the Khadi Village Industry Commission (KVIC) in Trivandrum has already used banana fibres for blending with cotton to produce fabric from it.

Dr Rajan P Nachane, Principle Scientist and Head, Quality Evaluation & Improvement Division of Central Institute for Research on Cotton Technology, also pointed out that, “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 the environment. A number of value added textile products can be made which in turn would enhance the profitability of banana farming. Banana fibres can be made available at cheap rate for preparation of fancy articles as well as textiles. In the past spinning of Banana fibres has been tried on jute spinning machinery for making ropes and sacks. However, spinning performance of Banana fibres for the preparation of yarns and fabrics has not been tried much in India.” He further added that from an estimated yield of one million tons of dry banana fibres annually, a very small quantity is presently being utilized for the preparation of handicraft items. With the increasing demand for banana in 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.
In an article (2008) by Tembo titled “Farmers reap from banana fibres “, the author has briefed about Mr. Njihia, 52, who owns a two-acre farm in Maragua district, 70 kilometres north of the capital, Nairobi, makes a fortune from banana fibre.“We realized that there’s more money in fibre products than in the fruit itself, from a single stem, you can get four times more from the fibre product,” Njihia explained. He said the banana fibre has added to the farmers’ creativity in their quest to earn bit money. From the fibre, farmers weave the traditional baskets (kyondosi), photo albums, table mats, ear rings, wall mats, fruit mats, bible carriers, picture frames, among other products. Farmers also make honey care packaging materials, which are used to wrap honey bottles. These articles sell from Ksh200 each and farmers sell up to Ksh3,000 per day during the peak of the tourism season. During elections, farmers make fly-whisks which are popular with politicians. A former teacher, Mr. Njihia said banana fibre has enabled his family earn decent income besides the sale of the banana fruit. From fibre, he has invested in buildings and tissue culture nursery,” he said. Fibre has also created employment opportunities for the youth in the country. Farmers are very innovative,” Njihia said at his exhibition stand during the Banana 2008 international conference in Mombasa. Njihia who leads the 1,000-member strong Highridge Banana Growers and Marketing Association in the central province, however, bemoaned the fluctuations on the market. He said that tourists were the major clients of the fibre products and business tended to be slow when tourism was off peak. He said that during the recent political stand off in the country, which led to clashes among the rival political groups, tourism was heavily affected, so were the sales of their products. “Global warming also has an effect, when it is too dry, we have difficulties in getting good fibre materials,” Njihia said. He expressed his members’ frustrations at the failure to penetrate the European and United States markets due to stringent procedures. Njihia cites lack of patenting of their products as a drawback in their business because other merchants from other countries and continents easily imitated their products. The utilization of fibre products has added to unity among banana growers, as they are able to share experiences. Mgenzi Byabachwezi, a Ugandan scientist, said utilization of banana fibre was similar in the Eastern African community. Byabachwezi said farmers in Tanzania also make bags,
mats, roofing materials, ropes as well as recycling it to make mulch which kills weeds in the field. Mwenebanda, a Malawian research associate, echoed his sentiments. Stella Mwashumbe, a technical assistant at Kenya Agricultural Research Institute, based at Mtwapa Research Centre, said banana varieties like bokoboko and mzdzavudza produce the best fibre because they are straight and strong. She said while bokoboko was used for wrapping of tobacco, mzdzavudza was used to make ropes for tying animals like goats. With competition emerging, Njihia says farmers should take advantage of tissue culture to plan for the markets. “With tissue culture, you can have many harvests at the same time, get better bunches and good tasting bananas,” he said. He called for the change of eating habits in Kenya to take advantage of the more nutritious banana products.

Kartik in an editorial article (2008)\textsuperscript{204} speaks about the advancements made in terms of the banana fibre utilization. The banana fibre bag, folder, CD case, hotel tariff card and a few other products have sold like hot cakes. “At Union Government-conducted exhibitions, products made of banana fibre have had a good patronage,” says Mr. Karthik, who is basically in to manufacturing jute products. It was also highlighted that the banana fibre extraction is difficult because machines in the market are not good enough. And, processing the fibre is also a tricky issue. The author states that says corporate patronage is important because it will lead to ordinary people using natural fibres, which is environment-friendly.

Saupan et al (2008)\textsuperscript{156} carried out an experimental study on mechanical properties of woven banana fibre reinforced epoxy composites, the experiments of tensile and flexural (three-point bending) tests were carried out using natural fibre with composite materials (Musaceae/epoxy). Three samples prepared from woven banana fibre composites of different geometries were used in this research. From the results obtained, it was found that the maximum value of stress in x-direction is 14.14 MN/m\(^2\), meanwhile the maximum value of stress in y-direction is 3.398 MN/m\(^2\). For the Young’s modulus, the value of 0.976 GN/m\(^2\) in x-direction and 0.863 GN/m\(^2\) in y-direction were computed. As for the case of three-point bending
(flexural), the maximum load applied is 36.25 N to get the deflection of woven banana fibre specimen beam of 0.5 mm. The maximum stress and Young's modulus in x-direction was recorded to be 26.181 MN/m² and 2.685 GN/m², respectively. Statistical analysis using ANOVA-one way has showed that the differences of results obtained from those three samples are not significant, which confirm a very stable mechanical behavior of the composites under different tests. This shows the importance of this product and allows many researchers to develop an adequate system for producing a good quality of woven banana fibre composite which maybe used for household utilities.

Khan (2008) suggested about the pulp and paper making of banana pseudo-stem with the determination of chemical composition and the study of the pulping and paper making potentialities of banana pseudo-stems growing in Thailand. The fiber morphology and chemical compositions of the raw material were studied. The lignin and extractive content was found low. The only discouraging finding was the relative high amounts of ash (approximately 16%) and water solubility (approximately 15%) of raw material. Banana stem was cooked by Kraft process with different chemical charges and a wide range of time and temperature and the optimal pulping conditions were established. The best cooking condition of banana stem fiber was found with a low alkali charge (12 to 14) %, at 1700C temp for 120 minutes to the kappa number around 25, with the yield of around 40 % and with a medium viscosity. Unbleached banana kraft pulp in the kappa number range of 23-28 was not easy to bleach with three stages sequence of D0EPD1. The brightness was achieved 45 % ISO, with a viscosity level at 585 ml/g. Drainage of pulp was extremely slow and paper making properties was characterized by low strength, low bulk, rough surface and extremely poor optical properties.

Mukhopadhyay et al (2008) studied the Banana fibers for their variability and fracture behavior. Natural fibers present important advantages such as low density, appropriate stiffness and mechanical properties and high disposability and renewability. Moreover, they are recyclable and biodegradable. There has been lot of research on use of natural fibers in reinforcements. Banana fiber, a ligno-cellulosic fiber, obtained from the
pseudo-stem of banana plant (Musa sapientum), is a bast fiber with relatively good mechanical properties. The "pseudo-stem" is a clustered, cylindrical aggregation of leaf stalk bases. Banana fiber at present is a waste product of banana cultivation and either not properly utilized or partially done so. The extraction of fiber from the pseudostem is not a common practice and much of the stem is not used for production of fibers. This is reflected from the relatively expensive price of banana fibres (Table I) when compared to other natural fibres. The buyers for banana fibers are erratic and there is no systematic way to extract the fibres regularly. Useful applications of such fibres would regularize the demand which would be reflected in a fall of the prices. Banana fibers obtained from the stem of banana plant (Musa sapientum) have been characterized for their diameter variability and their mechanical properties, with a stress on fracture morphology. The nature of representative stress strain curves and fracture at different strain rates have been analyzed through SEM.

In a review article by Rwanda (2009) on Banana fibre for fabrics, which is making a refreshing innovation. Rwandans are known for their exquisite and truly majestic Imishanana traditional attires. Now the country has decided to venture into the creative world of fabrics, this time on a discovery mission of how to manufacture fabrics from banana fibre. Bananas are a staple food here in Rwanda being consumed by the greater part of the population. While we consume the fruit, cloth will be woven from tree fibres. Now imagine how the local textile industry is set for a major boom, after the announcement today of the seven-member technical team that is set for Japan, to start the process of transferring banana textile technology to Rwanda. This team is going to study this ancient tradition of transforming banana fibre into textiles which dates back to the 13th century, in Japan. It's a no brainer, that perhaps this will be one of the most innovative, income generating and community empowering projects of our time. The initiative that is gaining momentum with the support of Japan's Tama Art University (TAU), who are working with the relevant government institutions and local investors, could revolutionise the local textile industry. This places a huge responsibility on the initiators of the project, in particular UTEXRWA, the country's major textile company, to
ensure that all processes are duly complete for the project to take off. Every bit of the process will impact national development positively in one way or another. Stages that if well coordinated, among the players involved, can actually form a positive cycle. Money accrued from sales can be reinvested in training others on the trade of making textiles out of banana fibre. One of the major criticisms made against developing countries 'is the inability to develop has been the lack of diversification, particularly when it comes to locally produced products. And so as Rwanda gears for more competition, within the East African Community, she will have a definitive competitive edge over the other regional countries, especially in the textile industry, courtesy of this venture.

Indicula and co workers (2009) has discussed about the dynamic mechanical analysis of randomly oriented intimately mixed short banana/sisal hybrid fibre reinforced polyester composites. The dynamic and static mechanical properties of randomly oriented mixed short banana/sisal hybrid fibre reinforced polyester composites were determined. Dynamic properties such as the storage modulus, damping behavior and static mechanical properties such as tensile, flexural and impact properties were investigated as a function of total fibre volume fraction and the relative volume fraction of the two fibres. Keeping the relative volume fraction of banana and sisal 1:1, the volume fraction of the fibre was optimized. The storage modulus was found to increase with fibre volume fraction above glass transition temperature of the matrix and maximum value was obtained at a volume fraction of 0.40. The tensile modulus and flexural strength were found to be the highest at 0.40 volume fraction which indicates effective stress transfer between the fibre and matrix. Amongst the hybrid composites having different volume ratios of the fibres and unhybridised composites, the sisal/polyester composite showed maximum damping behavior and highest impact strength as compared to banana/polyester as well as hybrid composites. However, maximum stress transfer between the fibre and matrix was obtained in composites having volume ratio of banana and sisal as 3:1. The tensile strength and flexural modulus were also the maximum and impact strength was the minimum at this volume ratio. Fractographic evaluations carried out under the scanning
electron microscope (SEM) confirm the quantitative characterization obtained from the static and dynamic mechanical analysis. The Arrhenius relationship has been used to calculate the activation energy of the glass transition of the polyester. The highest activation energy was found in hybrid composite with volume ratio of banana and sisal as 3:1. A master curve was constructed based on time-temperature superposition principle. Finally, the experimental results were compared with the theoretical predictions.

An article published by the division of forestry “Decorative uses of banana” states that the fibres obtained from banana tree Musa textiles Nee which grows chiefly in the Southern Philippines, but also in Costa-Rica, India, Java are examined. These complex fibres have a length of 2-3mm. They have various uses: clothing is one of them, and they also have decorative uses. Additionally they are used in marine textiles, as they are strong and rot-resistant.

An article from the magazine World Textiles (2009) on “Banana leaf dressing proves effective for skin graft donor areas”, reveals that, Researchers at LTMG Hospital in Mumbai, India have carried out a controlled trials to compare the efficacy of banana leaf dressing (BLD) and Vaseline gauze (VG) dressing used by the majority of burn centers for dressing skin graft donor areas. BLD was found to be far more superior, offering a non-adhesive, pain-free, cheap and easily available dressing material.

Ibrahim (2009) carried out a study on Lignocellulosic composites. According to the study, banana pseudostem fibre, which is a ligno-cellulosic material, relatively inexpensive, and abundantly available, was assessed in terms of its fibre-matrix adhesion and dispersion in composites. Different types of adhesives were used. The mechanical and water adsorption properties were investigated. Overall, for the produced composites, the incorporation of sawdust-urea-formaldehyde resin into banana fibre resulted in the best mechanical properties. Good adhesion-fibre interaction is believed to be responsible for the good ultimate performance. The superior reinforcing characteristics of sawdust resin were shown by the scanning electron microscopy (SEM), which revealed better fibre-matrix adhesion. Water
adsorption tests revealed that the presence of the adhesive affected the amount of water absorbed.

The article reported on Fruity clothing with banana fibres (2009) speaks about the prospects of this fibre gaining global spotlight. 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 the environment. A number of value added textile products can be made which in turn would enhance the profitability of banana farming. Banana fibres can be made available at cheap rate for preparation of fancy articles as well as textiles. Application potential of banana fibre is not having optimum utilization. Buyers for these fibres are also inconsistent. Extraction of fibres requires a more systematic way. Government patronage and useful applications of this fibre would regularize the demand and enable a sturdy market for these fibre products. With the increasing demand for banana in the global arena, much focus is required on increasing its production generating more of the pseudo stem biomass waste. Being a rich source of natural fibres, the pseudo stem can be profitably utilized for numerous applications and preparation of various products.

Kanyesigye (2009) had reported on the training carried out in banana fibres in Rwanda. The workshop that was organized by the Workforce Development Authority (WDA), aimed at training artisans to understand the features of banana fibre and review both manual and machine extraction. People were taught appropriate dying and braiding of banana fibres and handicrafts making. The training workshop was organized by the Workforce Development Authority (WDA) and supported by UTEXRWA (a local textile industry) and PPPMER, a body that supports small and medium enterprises. Participants were awarded with certificates at the end of the training and the best performers rewarded. Rajendran Ranganathan, the Managing Director UTEXRWA, urged the participants to disseminate the knowledge and skills to local people who are involved in handicrafts making. Efforts to introduce the technology of converting banana fibre into fabrics started way back in 2008.
when President Paul Kagame invited Japan's Tama Art University (TAU) to help initiate it in the country.

2.2. STUDIES RELATED TO NATURAL FIBRES AND ITS BLENDS:

This consists of studies related to natural fibres and its blends.

Bhattacharya and Thampi (1994)\textsuperscript{14} had discussed about the blending of coconut fibre and jute fibres- two non-similar fibres for production of Home- Textiles. Customer demand calls for value-addition, diversified products and also technology refinement and innovation to ensure the demand both in domestic and export market. The basic problem of the industry had been inadequate and lack of R&D support on the basis of the raw material-coconut fibre similar to jute and cotton in India. Hard fibres like coconut call for basic studies from the very first stage of processing viz: retting, defibering, and grading, softening, physical and chemical properties of the fibre variety wise, production of quality yarns, composite yarns, value added high value products etc. Jute and coconut fibres are different from each other so far as their production, characterization, physical, chemical properties and end-uses are concerned. Coconut fibre have been softened in four ways namely autoclaving, boiling in NaOH, soaking in NaOH solution and passing through mechanical gears. Any one of the methods or in combination with more can be adopted to soften the coconut fibres prior to blending with jute, considering the cost involvement in the process and the product envisaged. The authors have also stressed for the need for further studies in this process.

Sett and Sur (1994)\textsuperscript{159} had carried out an experimental work to determine the effect of twist on mechanical properties of open-end rotor spun jute-viscose blended yarn. The open end rotor spinning system produces yarns with much regularity and bulk maintaining and satisfactory mechanical characteristics. The present study had proved clearly the possibility of producing jute-viscose blended yarn of much finer counts using rotor spinning system at a production rate of 50 meter/min which is considerably higher than the 25 meter/min delivery rate of the conventional flyer spinning system used for the jute.
Visually the yarns showed improved regularity and less hairiness compared to the non-conventional yarn. The present study also reported important information on the effect on the yarn tensile characteristics of twist variation in case of rotor spun jute-viscose blend yarn of finer count. The tensile strength and elongation decreased which helped to obtain improved yarn initial modulus.

Kundu et.al (2005) explained the physical characteristics of Khimp fibre. Physical characteristics of Khimp (Leptadenia pyrotechnia) fibre have been studied and compared with those of the other natural fibres, such as cotton, jute, sunhemp and pineapple. The Khimp fibre is lignocellulosic having high cellulose (75.26%), and low lignin (4.93%) and pentosan (5.15%) measured by X-ray diffractometry technique is lower than that of cotton but higher than that of lignocellulosic fibres like jute or sunhemp. SEM study of the fibre shows that the fibrils are arranged longitudinally. Cross-sectional features studied by SEM reveal that the fibre is multicellular in nature, consisting of 5-6 cells in a fibre. The infrared spectra of Khimp fibre show peaks in the regions as observed for lignocellulosic fibre like jute.

Roy (1995) carried out an experimental study on jute -HSA – blended bulk yarn, which is a novelty high bulk yarn developed from blends of three fibres, viz, jute, high shrink acrylic (HSA) and poly propylene, using steam relaxation treatment. The special characteristics of this new yarn are high bulk and soft feel. A simple and inexpensive wet steam injection method was employed for producing this yarn. This yarn has improved extension, higher diameter and good strength. The yarn has vast scope in the development of various light weight diversified products like the ladies wrapper cloth, warm garments, knitted goods etc and may create a new avenue in the use of jute fibres.

Berger and co-workers (1999) reported on cotton/kenaf fabrics. By blending Kenaf with cotton, new high-end uses for Kenaf have been identified. Kenaf fibres, bast fibres similar to jute are typically separated by mechanical, chemical or bacterial means. Mechanically separated fibres are usually too stiff to be blended with cotton and cannot be made into good yarns. Fibres processed chemically and bacterially were blended with cotton and made into
fabrics and evaluated. The retted kenaf ribbons were carded to produce straightened fibres which were cut into uniform lengths, blended with cotton, converted into yarns which were then made into fabrics to compare the retting treatments effects on fabric hand and appearance. In order to further improve the hand of the retted fabrics, the fabric needed to be softened with routine finishes. The effects of different fabric treatments such as enzymes, bleaching and mercerization on blended light weight and heavy weight cotton/kenaf blend fabrics were compared and measured for softness of hand. This collaborative effort resulted in cotton/kenaf blend fabrics that were aesthetically appealing and had a soft hand. The light weight blend fabrics had a linen look and after treatment, were suitable for use in apparel without any type of lining. Mercerization was an adequate means to improve hand and appearance of the heavy weight fabrics, resulting in excellent examples of upholstery fabrics. Cotton enhanced the Kenaf fibres and resulted in a higher value end product.

Natarajan and co-workers (2000) studied textile applications of unconventional natural cellulosic fibres as fibres for the next millennium. Many study projects have been undertaken in India to study the techno-economic feasibility of extraction and processing of unconventional cellulosic fibres. The present studies covered three fibres, namely, a seed fibre (Kapok), a leaf fibre (Furcrea) and a bast fibre (Hibiscus). This paper was a summary of the results obtained on the above with respect to their extraction, fibre properties, spinning, weaving and related conversion technologies and bleaching and dyeing. The Indian Kapok popularly known as the silk cotton is a fine fibre, short, sufficiently strong and extensible fibre having a Fibre Quality Index of 18.6 (compared to a value from 20 to 140 for cotton). The studies have established that OE rotor yarns of 60 Tex can be produced in blends with cotton and yarns are weavable in handlooms and slow speed power looms. Kapok blended cotton fabrics are softer, show better drape compared to cotton fabrics, the effect being more significant with higher proportion of Kapok fibre. Studies on furcrea fibre extracted from the wild furcrea plants in the Nilgiri Mountains of TamilNadu revealed that the fibre is strong and flexible to suit textile processing but too coarse to be used in apparel.
applications. The furcrea fibre having an average fineness of 21 tex becomes finer with improved spin ability on being treated with Sodium Hydroxide. Furcrea/Jute blended yarns have been produced in long staple jute spinning system and in Dref machine. A fibre like jute improves the spinnability acting as a carrier fibre. Fabrics made from furcrea yarns as weft and cotton as warp exhibited very high tensile and tearing strength. Furcrea needle punched non-woven’s can be used in varied applications. Furcrea juice, a bye-product of furcrea fibre extraction from leaves has found to a very good stain remover. Hibiscus fibre studied under the project, is an agro-waste of the hibiscus plant, whose juice is used to clarify sugar cane juice in the sugar industry. Studies with this medium fineness fibre having an average fineness of 6.9tex showed a very low elongation and high tenacity. Though it contains about 8% lignin, it gets bleached and dyed easily to acceptable levels with hydrogen peroxide and direct dyed respectively. Twisting, braiding, macramé and coiling techniques have also been found useful in producing utility products and home decoratives. As hibiscus fibre is finer than cotton, it has potential as a blend component to cotton.

Pandey and Majumdar (2001) reported on effect of chemical texturization of jute on processibility and properties of Jute-nonwovens. Jute is a lignocellulosic bast fibre which is primarily used for packaging. The fibre contains lignin and cellulose including hemicellulose besides waxes, sugars, minerals etc. Due to stiff competition from synthetic fibres, its uses in packaging have been considerably reduced. In view of this, it has become necessary to develop diversified jute products for new uses. With this aim, attempt is made to study texurisation by chemical treatment such as alkalies like sodium hydroxide and allied chemicals. Its properties undergo a radical change during such modifications. It improves the fineness of the fibre and opens the structure to look like a woolen fibre. Besides, three dimensional crimp is also imparted. Thus the chemical treatment brings forth a sort of ‘texurising effect’ on straight, wire like jute filament. Not only substantial crimp is developed but also the post decrimped extension becomes appreciably higher than the breaking extension of raw jute. Attempts have also been made to utilize such modified fibre for production of needle punched woolenised jute
blended products and to evaluate their various properties including thermal insulation values, tenacities and abrasion resistance.

Kothari and co-workers (2004) studied the Hairiness properties of polyester/cotton blended yarns. Hairiness refers to the number of protruding fibres that can be seen on the fabric surface. EBI-MTH hairiness tester, Shirley hairiness tester, Laserport and Uster 3 were used to observe the relationship between hairiness results obtained when different measuring principles on these instruments are used. The effect of blend ratio and winding on hairiness properties of ring spun yarns had also been assessed. Almost all the measuring instruments reported increase in yarn hairiness after winding. A high correlation was found between the tests results obtained on the instruments.

Doke and Shinde (2006) reported on Dref-III Sunhemp blended yarns for developing multi-use fabrics. The blending potentiality of sunhemp fibre, a bast fibre belonging to mulberry family, with cotton, polyester and viscose fabrics on Dref-III friction spinning system shows various useful properties of these fibres. The yarn forming principle in Dref-III is based on aerodynamic collection of fibres on the perforated rotating spinning drums, rotating in the same direction. Fibres of different physical properties can be fed in the sliver form as core to one of the drafting units at right angles to the other drafting unit of the machine. Fibres of any combination of maximum six slivers at sheath can be fed to produce core-sheath type of yarn. This way the spinning system can develop the yarn structures by preferential placement of different types of fibres in layers according to end use requirements of the fabrics. These fabrics can be used for apparel, upholstery and dress material or coated fabrics.

Dhandapani (2007) investigated the Structural aspects of Borassus flabellifer L (palmyrah palm) fruit fibres. Natural cellulosic fibres such as coir, sisal, cotton, jute and ramie have been widely used in fibrous forms and the reinforcements in the composites due to their low density and bio-degradable nature. Fibres from date palm leaves and oil palm trees have been analyzed and attempts have been made to measure and reduce the sorption
characteristics of oil palm fibers using various treatments. Borassus fibre is a natural cellulosic fibre obtained from fruit extracts of palmyrah (toddy) palm trees. Fibres are available from the covering of the fruits that can be separated by mechanical peeling operation, followed by minor beating. Though synthetic fibres exhibit superior properties and performance compared to many natural fibres, the latter has still strong acceptance in many applications. Unconventional natural fibres are often explored due to their eco-friendliness and availability in many regions. Such fibres are often used in low cost composites, technical applications such as ropes and cordages. The structural properties and the physical properties were studied in detail. It showed some unique properties that are normally observed in other cellulosic fibres. Very low density values and higher moisture regain levels appear to be the distinct aspects of the fibres. Also, the fibres are capable of withstanding high temperatures without any degradation or transitions. The tenacity values remained unchanged even under wet conditions and there is presence of elastic region represented by the yield point, which is absent in many natural cellulosic fibres.

Krishna Kumar and co-workers (1997) reported on pineapple fibre processing. Spinning, weaving and processing of fibres and fabrics made out of leaf fibres is a new concept of recent origin, where pineapple fibre is gaining considerable importance, even though this fibre could not be blended either with cotton or synthetic fibre due to its long length and high fibre weight, it is expected that in the nearer future these fibres will be exclusively used for a specific purpose, along with cotton either in warp or weft to produce carpet type fabrics.

Samanta and Das (1997) have explained the chemical processing of diversified jute products. Different textile and non textile applications of diversified jute products are systematically listed and the present thrust areas are focused. In the jute diversification approaches, the role and importance of chemical processing is highlighted, along with the role of the Institute of Jute Technology covering its activities in offering training services in both the centralized and decentralized jute sectors besides regular courses and
research and development activities. Different refresher and on-site short training course modules in chemical processing of jute products, offered by IJT are reported. Different problems as observed/encountered during these on-site training for chemical processing of jute yarns were also discussed in brief. Change in practice of handloom dyers for using reactive dye instead of vat dye was suggested wherever possible. Some findings of the research activity undertaken on chemical processing (preparatory processing, resin and polymeric finishing and washability etc) of all jute fabric and jute/viscose blended fabric and jute/cotton union fabric are reported, and may be considered as useful information in this field of chemical processing of jute diversified products, before adopting suitable chemical processing for them.

Ghosh and co workers (1998)\(^4\) had explained about the scope for promotion of Jute based products in the cottage industry. As jute is the principal cash crop in the eastern part of the country, about 880 thousand hectares of land in India are now under jute cultivation. The growing of jute, its harvesting, processing and manufacture into textile based products is of major survival and economic importance to the country with some 4.75 million families supported directly by the industry. Various products are identified for jute based cottage industry. Apart from the conventional different types of all jute yarns, the R & D organizations have developed various unconventional products like the furnishing fabric, upholstery fabric blankets, carpets, knitted goods, floppy Ashan, Mufler, Wrapper cloth etc from the Jute-man-made/Synthetic fibre blended yarn. These can be easily manufactured in the hand-loom and create a new avenue of jute products. The J.T.R.L has developed small scale jute spinning plant for manufacturing of all jute and jute synthetic blended yarn using fibres like viscose, polypropylene, acrylic etc. The article gives a brief description of all the yarns along with coat of manufacturing. Thus the growing up of this cottage industry may be of actual help to the jute growers and villagers of jute growing area.

Rawal (1999)\(^1\) carried out an experimental study on color fastness properties of eco friendly pigment printed, chemically pre treated cotton, banana and jute fabrics. In this study it was concluded that bleaching with
hydrogen peroxide was effective for cotton, cotton/banana union fabric and jute/cotton because the impurities whitened and reduced the yellowness of the fabrics. Pretreatment with polyurethane glycol increased the yarn diameter for cotton showing that it created sufficient space for other processes to follow. The color yield of kerosene free pigment prints was compared to conventional kerosene pigment prints. Addition of silicone softener in the printing paste reduced the bending rigidity to all the fabrics improving the feel of the fabric. It also improved the color retention after laundering. Light fastness properties were found satisfactory however crocking of pigment was showing poor rub fastness.

Doke and Garag (2003)\textsuperscript{37} studied the effect of NaOH on structural properties and spinnability of sunhemp fibres. The world has become conscious towards ecology and needs eco-friendly, biodegradable fabrics for daily wear. This keeps natural fibres the main resource for textiles in spite of increasing competition from man-made fibres. Though sun hemp fibres are a natural vegetable bast fibre and also bio-degradable, its potential in textiles is left untapped. This work unfolds the suitability of it for use in textiles by improving basic properties to overcome the inherent drawbacks by treating with NaOH solution. With the basic aim, the Sunhemp fibres were grouped into three parts 1) treated with 6\% NaOH 2) treated with 18\% NaOH and 2) untreated, used for comparison studies. The untreated fibres were blended with V797 cotton variety with equal amount and spun on jute-cotton spinning system to the nominal count of 9’s Ne. The treated samples 1)and 2) were blended with LRA cotton in the ratio 30:70 and spun on cotton system to the same nominal count of 9’sNe. Later fabrics were woven with these yarns as weft and 2/16 cotton yarn as warp with square weave of 30x30 and with 30epi and 26 epi to study fabric properties. Simultaneously, treated and untreated samples of sunhemp fibres were examined for structural properties by electron microscope and X-ray diffraction and also for their physical properties such as fibre fineness, tensile strength etc. After the study of sunhemp fibres from structure to spinnability to formation of fabrics, it was found that NaOH treated fibres were well softened, crimped, increase inter-fibre cohesion improving spinnability to produce better yarns, which can be used to make apparel.
fabric. It is to be emphasized here that the aim of this study is to promote sunhemp fibres in textiles which are otherwise neglected.

Bhattacharya et al (2004)\textsuperscript{16} studied about the mechanical processing of natural fibre blends. Natural fibres either from vegetable origin or from the animal origin, which have wide acceptance in textile application, are cotton, jute, ramie, sisal, coconut (coir), silk, wool etc. Possibility of other fibres like PALF, banana, sisal etc in textile applications has also been explored. Each fibre has its own distinctive positive as well as negative characters. In order to achieve the best utilization of the positive attributes of these fibres and to minimize or to remove the negative characters as far as practicable, blending of different fibres are done. The blending can be conceived at various stages of mechanical processing depending upon the mechanical behavior of the component fibres in the blend and on the desired characteristics of the end products.

Hazra and Karmakar (2004)\textsuperscript{53} have described about the Jute fibre blends and its potentialities. High performance target oriented technical textiles demand special man-made fibres, in general, although natural fibres like jute, sisal, ramie, mesta, sum hemp, flax, coir, etc have excellent scope to be used in the application areas since these are bio-degradable with high moisture absorption efficiency. On the contrary, in application areas where hydroscopicity is a hindrance, hydophobicity can be imparted in jute fibre by well-established processing technologies. The overall picture emerging from the facts make it clear that potential application area of jute/synthetic fibre non-woven's include: gas filtration, liquid filtration, automotive, household, agriculture, soil-savers, civil structures and others. There are areas where great potential exists but remain to be exploited commercially. Huge plant biomass is produced while growing jute ad other allied fibre crops for fibre purpose, wherein the fibre constitutes only 4 - 6\% of total biomass.

Sreenivasan (2004)\textsuperscript{176} have discussed regarding the current scenario and future prospects for diversified utilization of natural fibres other than cotton, looks into the suitability of natural fibres for various applications like: high quality blended apparel grade textiles, technical, industrial and home textiles.
including non-wovens, bio-composites, pulp and paper, fine chemicals, cosmetics, health care products and bio-fuel, its scope for enhanced use and projected demands in terms of quality and quantity. The article also looks into the basic physical, chemical, structural, morphological traits of natural fibres, the blending of cotton with jute, pineapple, flax, ramie etc, in preparation of particle boards, hard-board from crop residues like cotton stalks, craft paper from cotton stalk pulp, making of corrugated boxes etc are outlined. In addition to the current global trends, emerging areas of newer applications for natural fibres are highlighted. Based on the international scenario and increasing governmental thrust for post harvest processing, value addition including packaging of agricultural produce, it is felt that the demand for natural fibre products is bound to increase in years to come.

Doke and Behara (2004) carried out experiments on the cotton/sunhemp blended yarns for diversified uses in textiles. According to the study; Sunhemp fibre is referred in ancient Indian literature as ‘San Pat’ is obtained from the leguminous plant Crotalaria Juncea. It is not used by textile manufacturers and technologists, though it has great potential if diversified textile products are developed. In this paper, the method of spinning sunhemp/cotton blended ring yarns is discussed. Coarse, stiff and long sunhemp fibres after cutting into short length of 32 and 38 m are softened and then opened in the specially designed opener machine for short sunhemp fibres. Then these opened fibres are blended with short staple, flexible natural fibres of cotton fibres in the carded web form with different proportions to produce sunhemp/cotton yarns of 6s Ne and 10s Ne. Two varieties of cotton are used for blending, out of these yarns, after testing, the best samples of 6s count yarn with 20/80, 30/70 and 50/50(SH/C) and another from 10s count are selected to use as weft and cotton as warp to produce fabrics. Then the fabrics are chemically processed to get soft and fuller feel. The success lies in showing that sunhemp fibres can be blended to get course yarns to weave fabrics, which can be used for various applications. The possibility of producing value added fabrics from neglected sunhemp fibre would be definitely helpful for the sunhemp fibre to find a place in the textile world.
Doke and Garag (2003)\textsuperscript{37} studied the effect of NaOH on the structural properties and spinnability of sunhemp fibres. The sunhemp fibre is a natural vegetable bast fibre and also bio-degradable, its potential in textiles are left untapped. This work unfolds the suitability of it for use in textiles by improving basic properties to overcome the inherent drawbacks by treating with NaOH solution. With this basic aim, the sunhemp fibres were grouped into three parts 1) treated with 6% NaOH 2) treated with 18% NaOH 3) untreated, used for comparison studies. The untreated fibres were blended with V797 cotton variety with equal amount and spun on the jute-cotton spinning system to nominal count of 9’s Ne. The treated sample 1) & 2) were blended with LRA cotton in the ratio 30:70 and spun on cotton system to the same nominal count of 9’s Ne. Later the fabrics were woven with these yarns as weft and 2/16 cotton yarns as warp with square weave of 30×30 and with 30epi and 26ppi to study the fabric properties. Simultaneously, treated and untreated samples of Sunhemp fibres were examined for structural properties by electron microscope and X-ray diffraction and also for their physical properties such as fibre fineness, tensile strength etc. After study of sunhemp fibres right from structure, spinnability to formation of fabrics, it is found that NaOH treated fibres are well softened, crumpy, increase inter-fibre cohesion improving spinnability to produce better yarns, which can be used to make apparel fabric. It is to be emphasized here that the aim of this study is to promote sunhemp fibres in textiles otherwise which are neglected ones.

Mitra. et .al (2005)\textsuperscript{102} studied the use of natural lingo-cellulosic fibres and their blends for textile application. Ligno-cellulosic long vegetable fibres like jute, mesta, Roselle, flax, banana, pineapple, ramie, sisal, manila etc have wide textile use. Jute is traditionally used as packaging material like the Hessian and sacking. Mesta and Roselle fibres are used as substitutes for the jute to produce coarse type of twines or bags. Flax fibre is mainly used in production of industrial (i.e.: -hose pipe, shoe twin etc) and apparel (i.e. linen cloth) textiles. Banana fibre is available from the pseudostem of the banana plant. The fibre is very coarse, but bright in appearance and at NIRJAFT (Calcutta) the fibre has been utilized in blends with jute, Mesta to produce packaging materials and ropes. Pineapple leaf fibre is very silky and strong and is
blended with jute and other fibres. Ramie is fine strong and silky fibre after degumming. Higher density and wet strength along with high flexural and torsional rigidity restrict their application to cordage industry. The article also speaks of the different blended yarns like jute-ramie, jute-flax, jute-PALF, jute-viscose covered yarn, texturised jute-polypropylene blended yarn, and high bulk acrylic blended yarn. It also speaks of blended products like curtain cloths, upholstery fabric, furnishing fabric, blankets, carpets, knitted goods and woven garments. Thus the present status of technology of various lingo-cellulosic fibre blended products are developed in existing jute mill processing machinery. Weaving can be commercially performed in corporate and decentralized handloom weaving sector.

Doke. et. al. (2007)\textsuperscript{39} studied the effect of fabric parameters on shear and the mechanical properties of fabrics. In the above study to make the shear testing economical a shear testing attachment is made to Instron-4411 and further to make it very easy, an attempt is made to develop software which works with Instron-4411 and gives shear testing results instantaneously. The results of this instrument were analyzed statistically to investigate the correlation with results of KES-FB system. Further to investigate the effect of weaving parameters on shear and mechanical properties of fabrics, 12 fabric samples (woolen suiting) were woven by changing various fabric parameters and then tested for shear and mechanical properties. The results were then statistically analyzed.

Sarkar (2005)\textsuperscript{151} made an attempt to study the development of blended yarns. According to the study blending of different fibres is primarily adopted for the improvement of technological and or economical properties of the yarn. Fine type of yarn (84 to 207 tex) needed for producing fine and strong fabrics like furnishing, upholstery, industrial fabrics. Long, fine natural fibres like ramie; flax and pineapple fibres were used in making of blended yarns with jute.

Ranganathan and Amsamani (2005)\textsuperscript{139} reported on jute-cotton blend offers adequate scope for making fancy T-shirts. Jute, a cellulosic fibre can be eco-friendly replacement for textile fibres such as cotton and its blends with cotton offers an adequate scope for making fancy apparel. Jute offers advantages
such as agro-renewability, eco-friendliness, bio-degradability, low thermal conductivity and compatibility in blending with other allied natural and man-made fibres. Blending helps in the removal of certain short comings of jute such as variation in fibre length, roughness, brittleness and difficulty to launder. A study was conducted to obtain jute yarns in blended state, converting them to fabric by knitting, improving their eco-friendly nature by dyeing them and evaluating the performance and quality of these fabrics. The study used jute-cotton blends in the proportion of 50:50 and 70:30 and revealed the suitability for knitting fancy fabrics such as T-shirts and double jersey. Lac dye, a by product obtained from the effluent of the lac industry was used in the study for dyeing knitted fabrics, due to its eco-friendly nature. The evaluation revealed that 50:50 jute combinations showed better drapability than other samples. In addition the study also revealed that a new range of eco-friendly knitted fabrics is ready to capture the international market.

Bhattacharya and Shah (2006) in their experimental work on degumming of decorticated ramie: effects of alkalis on gummy compositions vis-à-vis their properties. Ramie fibre contains cellulose as a main structural component like any other vegetable fibres. Decorticated ramie contains about 19-30% of gummy material. Degumming to a certain extent is necessary for its better possibility. Caustic soda is although the most one explored, various alkalis were judiciously selected on the basis of their base dissociation constant, were used for degumming of the ramie fibres. They were graded according to their performance with respect to the removal of individual components of the gummy material. The fibre properties were analyzed in terms of residual gum content, moisture regain, methylene blue exhaustion, whiteness index and tensile strength. Three formulations with three different alkalis were reported with the all round degumming performance. It was concluded by stating that various alkalis other than caustic soda, can be used as an effective degumming agent for decorticated ramie fibre. Hemicellulose and pectin removal increased with the basicity of the alkalis, while lignin removal was higher with calcium salts, which was confirmed by the characteristics of the degummed fibre. Uniformity in removal of each component of the gummy matter was achieved with the incorporation of alkalis. Excellent fibre
properties were obtained with such degummed fibres. SEM micrographs revealed the best surface morphology with calcium hydroxide and mix alkaline degummed samples.

Chattopadhay and co-workers (2006)\textsuperscript{27} carried out an experimental work on reactive dyeing of a pre-treated jute fabric using minimum application technology. To exploit the full potential of a jute fibre, its value addition and diversification are a must apart from its traditional products. For better look, its colouration is a must and hence wet processing has occupied a very important position in modern jute mills. In the present study the grey jute fabrics were given pre-treatment such as scouring followed by enzyme treatment, which were subsequently bleached with hydrogen peroxide. Dyeing of these bleached jute fabrics were carried out with four different classes of reactive dyes namely cold brand, hot brand, vinyl sulphone and HE-brand reactive dyes, following the conventional exhaust method and pad-batch method. With respect to dyeing behavior, it was found the dye-uptake and wash fastness property of a dyed fabric produced by the pad batch method is well comparable with that produced by the conventional exhaust method. Irrespective of the methods of dyeing, scoured-bleached and scoured-enzyme treated-bleached jute fabrics show better dye uptake and fastness property compared to grey-bleached fabrics. Weight loss and strength loss increase while bending length decreases with increase in pre-treatment stages. Enzyme treatment of a scoured jute fabric before bleaching produces the minimum bending length among all the samples. The pre-treatment process is found to have some detrimental effect on the tensile properties of the jute fabric and as the number of pre-treatment steps increases, the tenacity of the fabric decreases. Reactive dyeing of the pre-treated jute fabrics further reduces their tensile strength by around 10% irrespective of the method of dyeing and pre-treatment process. So, minimum application technology can be well adopted for dyeing jute fabric with reactive dyes. The process is simple, cost-effective as it utilizes dye to its maximum extent, requires minimum energy and is suitable for use in cottage and small-scale industries.
Bhatia et. al (2006)\textsuperscript{6} studied polyester blends on new spinning systems with new cost equations in the spinning industry, it is imperative to have a fresh look o open end, air jet and compact spinning systems for polyester and blended yarns. Open end is traditionally looked upon as suitable for spinning course counts using comber noils and other spinning soft wastes rather than virgin fibres for applications in niwars, durries, tyre cord. Air-jet spinning offers an alternative to ring spinning for the fine count range of 30s and 80s. It is unique in that, the front roller delivery speeds can be maintained at the same level of about 300 meters per minute in all the count range. The compact spinning system is based on the elimination of spinning triangle at the front roller nip at ring frame. The system is based on the principle of condensing of the drafted fibre strand by air suction by additional front perforated roller. Thus the New Spinning Systems viz. Open end, Air jet and the Compact spinning are very much relevant and mills should evaluate the Techno Economics, looking to superior quality of Yarn achieved.

Chellamani. et. al. (2006)\textsuperscript{28} reported on the spinning of coir/jute blended yarns in modified jute spinning system. It focuses on a softening process developed by Sitra to soften coir and sisal fibres. After softening coir fibres, the same can be blended with fibres like jute, sisal and hemp fibres. Appropriate machinery modifications have been carried out in jute spinning system; it is possible to produce coir-blended yarns of 25 to 60% finer as compared to 100% coir yarns produced by normal spinning process available in coir industries. Majority of coir yarns spun using mechanized ratts are manufactured with cotton/polyester filament as core. With cotton the cost of resultant coir yarn increases and with polyester as core the eco-friendly nature of the coir product is affected. Sisal fibres are strong, lustrous and easily dyeable to any shade. Blending of sisal with coir therefore, will improve the durability ant the appeal characteristics of the end product. Moreover sisal fibres have higher abrasion resistance.

In the present study on development of coir-cotton composite yarns through friction spinning for the industrial end-uses, Chattopadhay et.al (2001)\textsuperscript{25} have studied the feasibility of production of coir-composite yarn, employing friction
spinning technology has also been attempted. The fibres like cotton, wool, jute, viscose, polyester, acrylic and polypropylene have been used on the surface of a composite yarn having either single or double ply coir rope in the centre using Friction Spinning Technology. The end product intended were composite yarns containing coir ropes in the centre, known as core and the other staple fibres on the outer surface of the yarn Known as sheath.

Kimmel and co-workers (2006) have analyzed the tensile properties of various cotton and DyneemaR blend yarns. A series of ring and rotor spun yarns had been produced from the low level blends of Dyneema R, a gel-spun ultra high molecular weight, high density polyethylene fibre (HDPE) of varied types, with selected white and naturally coloured cottons and the tensile properties of blended yarns studied. The DyneemaR fibre is commonly referred to as high performance polyethylene (HPPE) due to its exceptionally high strength. The addition of small quantities of certain HPPE fibres substantially increases the yarn tenacity and breaking elongation of certain cotton blended yarns, particularly those made from naturally coloured cottons. The resultant yarn tenacity appears to be influenced by the fineness of the constituent fibres and the level of yarn twist. The effect is more pronounced for the coloured cottons than for the HPPE blends with white cotton. Whereas the yarn strength tends to increase for the pure brown and white cottons as the twist increases, it decreases in the green cotton yarns with the increase in twist within the range studied. However, the addition of small quantities of HPPE fibres results in substantial increase in tenacity for all at a constant level of twist. Finer HPPE fibre provides a greater improvement in yarn strength as compared to coarser HPPE fibres. The different frictional properties and geometries of the constituent cottons and synthetic fibres play a role in their blending and associated resultant yarn strength. The use of small quantities of 1-denier HPPE fibre significantly increases the strength and elongation of cotton blended yarns, particularly those made from brown cotton, with the minimum change in observed colour. Such cotton and DyneemaR blends may find application in special purpose denims, where pure cotton yarns or the traditional cotton rich blends with conventional synthetics may not meet the performance requirements for fabric strength.
Gayathri and Bala (2006) reported on the non-traditional natural textile fibres: production and applications. There are various unconventional natural textile fibres that are available and has their own applications. These materials have the advantage of being biodegradable and eco-friendly. Bamboo possesses unique anti-bacterial and bacteriostatic bio-agent, unusual ability to breathe and has coolness and can therefore be used to make underwear, socks, curtains and sweaters. Kenaf is a short day, annual herbaceous plant cultivated for the soft bast fibre in its stem. It is used in making of value added products like paper pulp. Composite materials, textiles and geo-textiles. Milkweeds produce tough fibres in their stems and are used for making cloth or twine and as substitute for wood in pressed panels. Pineapple fibre is soft, extracted from leaves. The strength and elongation is comparable with cotton fibre and are used for making ropes, cloth, mat, hand-bags. Abaca fibres are extracted from the leaves of the monocotyledonous plant banana. The fibre has a large lumen and used for marine ropes, cables and mats. Spider silk is made of protein secreted as a fluid that solidifies and has high strength than steel. The strength and elasticity of spider silk make it a good candidate for a broad range of medical and industrial applications.

Ingle and Doke (2006) have analyzed sunhemp fibres processed using jute spinning system. Sunhemp is coarse, strong and stiff bast fibre similar to jute fibre but not considered by textile technologists for the purpose of spinning into yarn, which can be further woven into fabrics. The objective of this study was to spin 100% Sunhemp fibres into different yarns of same count on a jute spinning system by using different number of passages of carding and drawing to find how the structural changes in the fibre after each stage mechanical processing. To observe structural changes in the fibre, random sampling method was done using microscope. It was found that a lot of changes occur in the fibre structure due to mechanical processing. The structural details about the fibre entity are depicted in the article. Further, correlation was established between various fibre parameters such as fibre length, fibre diameter and fibre number of branches. Finally, an exponential frequency distribution of the fibre lengths for various stages in the spinning process was calculated. This curve explains how the degree of
individualization increases as the fibre length decreases and makes the fibre spinnable into better quality yarn.

Reddy et.al (2006)\textsuperscript{143} examined the processability and properties of yarns produced from cornhusk fibres and their blends with other fibres. Natural cellulose fibres extracted from cornhusks have been blended with cotton and polyester and processed on the ring and rotor spinning machines. The processability of cornhusk fibres on the conventional spinning systems, compatibility with cotton and polyester, and properties of the blended yarns had been studied. The properties of cornhusk fibres blended yarns are also compared with those of the similar yarns produced from unconventional fibres, such as pineapple and banana leaves, milkweed and kenaf. It is observed that the blending of cornhusk fibres with cotton does not adversely affect the properties of yarns while the blending of cornhusk fibres with polyester improves the strength and elongation of the yarns.

Marwaha (2007)\textsuperscript{207} reported on eco-friendly fibres. According to the study, the growing concerns for the degrading environmental conditions have led to the development of eco-friendly and biodegradable fibres. These fibres, being eco-friendly, do not pose the toxicity and waste disposal problems. Eco-friendly fibres are natural fibres, sub-divided into organic (vegetable and animal) and inorganic (mineral) fibres. The fibres discussed in this article are banana, sisal, mesta, hemp, flax, angora rabbit hair, and pineapple leaf fibre.

Dhamija and Chopra (2007)\textsuperscript{33} Carried out and experimental work to determine the tearing strength of cotton fabrics in relation to certain process and loom parameters. Tearing strength of cotton fabrics made of ring- as well as compact spun weft yarns has been studied in relation to certain process and loom parameters. It is observed that the fabrics made of compact spun weft yarns are more tear resistant. The tearing strength further improves particularly in the weft way direction with the increase in the weft yarn linear density and the weft tex twist factor. There is an initial increase in strength followed by a decrease as the number of picks per inch is increased in the cotton fabrics made of compact spun yarns. However for the fabrics made of ring yarns, it shows a general decreasing trend. The 2/2 designs are found to
be superior in warp-way but inferior in weft-way directions. The fabrics woven on air-jet looms show lower tearing strength than those woven on projectile looms. The mechanical finish as well the variation in shed opening do not effect the tearing strength of cotton fabrics produced from compact-spun weft yarns.

Dhandapani (2007)\textsuperscript{34} investigated the structural aspects of Borassus flabellifer L (palmyrah palm) fruit fibres. Natural cellulosic fibres such as coir, sisal, cotton, jute and ramie have been widely used in fibrous forms and the reinforcements in the composites due to their low density and bio-degradable nature. Fibres from date palm leaves and oil palm trees have been analyzed and attempts have been made to measure and reduce the sorption characteristics of oil palm fibers using various treatments. Borassus fibre is a natural cellulosic fibre obtained from fruit extracts of palmyrah (toddy) palm trees. Fibres are available from the covering of the fruits that can be separated by mechanical peeling operation, followed by minor beating. Though synthetic fibres exhibit superior properties and performance compared to many natural fibres, the latter has still strong acceptance in many applications. Unconventional natural fibres are often explored due to their eco-friendliness and availability in many regions. Such fibres are often used in low cost composites, technical applications such as ropes and cordages. The structural properties and the physical properties were studied in detail. It showed some unique properties that are normally observed in other cellulosic fibres. Very low density values and higher moisture regain levels appear to be the distinct aspects of the fibres. Also, the fibres are capable of withstanding high temperatures without any degradation or transitions. The tenacity values remained unchanged even under wet conditions and there is presence of elastic region represented by the yield point, which is absent in many natural cellulosic fibres.

Ramesh (2007)\textsuperscript{136} carried out a study asserting that yarn quality depends upon the settings and spindle speeds. The study has been conducted for five counts like 34s carded, 40s carded, 40s combed, 60s carded and 80s combed. The spindle speed variation was between 13,500 to 19,500 rpm. The
paper also gave the results on the effect of different spindle speed on evenness, imperfections and hairiness then different back-zone setting in ring frames on imperfections. At increase spindle speeds, yarn quality attributes like strength, evenness and thick places do not get high affected. Thin places, strength C.V % and hairiness show a tendency to increase with spindle speed. While increasing back-zone setting of the ring frame thin places fault (measured Uster tester-3) get reduced.

Sivakumar (2007)\textsuperscript{170} studied the economic dyeing of P/C blends with multifunctional property. The multifunctional auxiliaries and energy conservation processes are the prime concern of the textile chemical processing industry. In this study, for the collaboration of P/C blend fabrics, so-called disperse dyes were used, to conserve time and energy, it is desirable to develop an economical process which can dye both the portions of the blend with altering their viz- properties. Therefore in the present investigation, an attempt was made to dye the P/C blends in a single bath with disperse dyes using high boiling swelling agent (PEG). This resulted in the generation of COD and BOD low values, anti-soiling etc. The level of degradation of PET was determined along with the dye exhaustion percentage, the fastness values and the K/S values. The dye exhaustion and colour strength increases by increasing the concentration of Cd up to 30 gpl. The swelling of PET fabric is favoured at steaming temperature, thus facilitating the diffusion of saturated steam inside the fabric. In case of P/C blend, the presence of PEG, the K/S value is more for the cotton component and less for the polyester component and it is possible that the [pore size available in the cotton fibre structure reduces in the presence of PEG thereby making the cotton fibre as dye able with disperse dyes. The effect of such treatments on various properties like fastness, pilling etc has been discussed in part-2.

Sivakumar (2007)\textsuperscript{171} studied the economical dyeing of P/C blends with multifunctional property. This paper deals with different energy conservation processes and multifunctional auxiliaries. To meet this objectiveness, the dyeing of P/C blends is done by using high boiling swelling agents, as compared with conventional processes. Hence the use of different swelling
agents, results in the generation of COD and BOD low values, anti-soiling agents etc. The successful application of disperse dyes on P/C blends with the help of PRG and CD bring out numerous advantages such as dyeing of P/C blend in a single stage process using disperse dyes, saving of water, energy time, replacing conventional surfactants and thickeners using CD, enhancement of functional property of the P/C fabric by means of CD, minimizing of the effluent problem due to shortening processes, replacing of more polluting surfactants etc and makes it economical. Disperse dyes do not possess any affinity for the cotton component, further tone-in-tone affect on such blends cannot be achieved by using only one dye in a single dye bath application. This could be readily achieved by treating with PEG, NaOH, and CD etc, which further improved the dye ability the fastness properties also to some extent.

Arindam and Prakasam (2007)\textsuperscript{5} have reported about the spinning performances of fibres. When the staple fibres are converted to yarn they go through various processes such as opening, cleaning, combing, drafting, etc. These processes cause various deformations such as tension, bending and compression. The behaviors of fibres during the processes are dependent upon the combined effect of inter-fibre cohesion and resiliency. Though there are widespread recognition of the roles of fibre cohesion and resiliency in textile process, reliable measures of their combined effects do not exist. Considering the importance of these parameters an instrument had been developed which can be used to measure the processing propensity of staple fibres which follows the principle of opening roller of rotor spinning unit which was modified to simulate the carding action. Seven varieties of cotton were tested using the instrument and the same cotton was tested for basic fibre properties and cohesive force. They were further tested for unevenness and imperfections using UT4. The results showed higher strength, length and cohesive force values. The instrument developed by SITRA will help mills in assessing the fibre processing propensity, which will in turn produce yarns of optimum quality from a given fibre.
Balasubramanian (2007) have tried to analyze the hairiness of yarns: and its relative merits of various systems, protruding fibres, loops from the surface of the yarns and loosely wrapped wild fibres constitute hairiness, is a unique feature of staple fibres and that distinguishes it from a filament yarns. In spite of the various drawbacks of hairiness like excessive lint droppings, affecting the appearance, performance gets affected, prints look hazy and lack sharpness, in sewing breakages would be high, increased tendency to pilling, increase in air drag etc, it has some beneficial effects as it adds to fabric comfort, liveliness, warmth. The article also discusses in detail about the procedures for measurement of hairiness like microscopic, photoelectric etc. The various tests to measure hairiness and the methods to control hairiness in different spinning systems. Hairiness is lower in air vortex spinning compared to air-jet spinning and while hairiness increases with cotton content in air-jet, no such trend is found in air vortex spinning.

Gautam and Bhattacharya (2007) have explained the blending of jute with other fibres which requires running the spinning machines at lower speeds because most other fibres have lower strength because most of the jute spinning machines are designed for handling only jute. To facilitate control of speed in a manner that does not result in excessive end breakages, when blending jute accessories like infrared sensors and closed loop controlled drive circuitry were tried and have met with limited success. It was observed that very minor slippage takes place due to increment and change of load between the belt contact positions, which can be neglected for any practical purposes and applications. Thus it may be concluded that work done on control and measurement of flyer speed of jute spinning machines using infrared sensor is a unique one and is highly suitable for production of diversified blended jute products. However demand for blended jute products is growing and the importance of improving productivity in blended jute spinning cannot be over emphasized.

Naik and co workers (2007) in their experimental study on handle and comfort properties of Polyester/Viscose suiting fabrics have studied the handle and comfort properties of PV blended fabrics. As consumers today are
becoming quality oriented, stress is on the aesthetic, intrinsic and utility performance of the fabric. In this paper the handle and comfort properties of PV blended suiting fabric is studied on Kawabata Evaluation system for fabrics (KESF). Fabric mechanical properties like tensile, shear, bending, compression, surface roughness and surface friction were also measured. The air-permeability, thermal insulation, moisture vapour resistance tests were also performed. All the above tests are discussed in detail in the study. In the PV blended fabric with the increase in the polyester content, the extensibility and the tensile energy of the fabric decreases and the tensile resiliency of the fabric increases. The bending rigidity, the hysteresis of bending curve, fabric shear rigidity and the hysteresis of the shear increases with the increase in the polyester content. The compressional energy decreases with the increase in the polyester content. The coefficient of friction increases while the geometrical roughness decreases with the increase in polyester content. The THV decreases with the increase in the polyester content. The air-permeability and the moisture vapour transfer decrease while the thermal insulation increases with the increase in polyester content in the PV blended fabrics. The fabrics with higher viscose content give better hand; higher air-permeability and higher moisture vapour transfer but lower thermal insulation.

Shilpa et al (2007)²³ have stated about the growing importance of cotton blends in the apparel market, have explained the term blending, which is the process required to convert two or more kinds of staple fibres into a single yarn composed of an intimate mixture of the component fibres which is necessary to obtain a uniform yarn from different varieties of the same fibrous polymer. The various reasons for development of blends are to make the fabric economically viable, durability of fabrics, improving the physical properties, to create new colour variations, to improve spinning, weaving and finishing efficiency etc. This paper deals with cotton blending with different varieties of fibres and their properties. Thus the textile industry in India contributes lot in foreign exchange earnings of the country. In which garment industry contributes to 6% of the gross domestic product of India. Hence the
growing importance of fibre blends in apparels. Global competition blending of cotton appears to be inevitable.

Chellamani et. al (2007)\textsuperscript{29} in their experimental study on processing of silk/cotton blends in short staple ring spinning system, have explained the technology of production of spun silk yarn from silk waste which involves a long sequence of machines. There has been a great demand for silk blended fabrics in recent years due to increased price of raw silk. Therefore this study was carried out with the objectives of spinning of silk/cotton blended yarns in short staple spinning systems, evaluation of quality attributes of silk/cotton blended yarns and the assessment of handle and performance properties of silk/cotton fabrics. It concluded by stating that 60s and 80s combed yarns were spun and there is a tendency for the silk/cotton blended yarns to show better yarn quality attributes I terms of imperfections and hairiness. The thermal conductivity of silk/cotton blended yarn fabrics is relatively better as there was a marked improvement in the comfort characteristics making it ideal for summer wear. The total hand value as measured by Kawabata Evaluation system was better for the cotton/silk blended yarn fabrics.

Rao (2007)\textsuperscript{137} explored the “Extraction and tensile properties of natural fibres: Vakka, date and bamboo”. This paper aimed at introducing new natural fibres used as fillers in a polymeric matrix enabling production of economical and light weight composites for load carrying structures. An investigation of the extraction procedures of Vakka, date and bamboo fibres had been undertaken. The cross-sectional shape, the density and tensile properties of these fibres, along with established fibres like sisal, banana, coconut and palm were determined experimentally under similar conditions and compared. The fibres introduced in the present study could be used as an effective reinforcement for making composites, which have an added advantage of being light weight.

Edward and Mrinal (2008)\textsuperscript{97} have described blending used by the yarn manufacturer to describe specifically the sequence of processes required to convert two or more kinds of staple fibres into a single yarn composed of an intimate mixture of the component fibres which is necessary to obtain a
uniform yarn from different varieties of the same fibrous polymer. The various reasons for development of fibre blends are the economic, durability, physical properties, colour, appearance etc. here are four major types of coloured effect achieved by blending like the solid, reserve, shadow and the contrast and each of this is discussed in detail.

Sengupta et al (2008) have discussed about the present scenario in mechanical processing of jute. Jute is one of the most important fibre used for industrial applications. Development in jute mechanical processing sector is remarkable in some areas, but industry is reluctant to accept the new technology and products. The wide variation and unique characteristics in jute fibre properties and the meshy structure make this fibre difficult for processing. Hence its processing machineries are quite different than any other fibre processing machine. Most extensive research; intensive production and marketing expertise have to be built into the jute sector to make jute non-woven’s a commercial success for jute diversifications. It seems that there is potential of use of jute in stitch bonded non-woven, which is unexplored till date. Extensive research is required for jute fibre quality improvement for better processing and yarn quality.

Bhattacharya and co workers (2008) have reported on the improvement of the soil-burial property of jute fabric. Jute is a ligno-cellulosic fibre. Biological degradation of the jute takes place due to the fragmentation of the ligno-cellulosic material and the inter-lignin bonds present in the jute fibre, caused by the enzymes of micro-organisms inside the soil. Degradation of the jute fabric can be delayed by extraction of the natural binder and substituting it with synthetic binders. Studies on the tensile properties of the bleached fabrics were carried out and then compared with the enhancement of the tensile property, after applying synthetic binders by a sprayer, followed by curing. Soil burial tests are also carried out. As usages in traditional areas like packaging of food-grains are declining, it is important for the industry to find more effective, efficient and economically viable usage in other areas.

Itagi and co workers (2008) had reported on polyester cotton blended saree of Shigli (Karnataka). In northern part of Karnataka, weaving is part and parcel
of life, as it has given employment opportunity in the rural areas. Central Silk Board, DCTSC dept, has conducted survey of weaving clusters in Gadag district. This paper reports one such area of Shigli as potential for weaving poly cotton saree, which has developed good market in southern areas. Here power loom uses cotton and polyester yarns for production of sarees, where the cotton of about 2/100s count, is used as warp which is 40%. Polyester yarns of 2/80s count id used for border and 80s for the weft, which is around 60%. Both yarns are dyed and converted to hanks in bobbins. Value addition is also provided by hand embroidery (Kasuti) by trained workers. As per survey, a weaver can produce a saree of 6.2 meters in length in a period of just 31/2 hours and 2 sarees in 8 hours of time. The price varies from around 3000- 500 depending upon the amount of work gone into it. The KSPLDC, Bangalore has constructed 16 sheds, which has been given master weavers to help the weaving community and development of power looms. The polyester cotton blended sarees are having good demand among the customers of different states because of the comfort and low price when compared with other sarees in the market with good colour combinations.

Saktivel et. al (2005) in the article unconventional natural textile fibres have highlighted the importance and wide textile applications of natural fibres which are mostly used in different areas namely wearable textiles, household textiles and industrial textiles, based on the advantages obtained from the particular type of fibres. Large numbers of varieties of unconventional natural textile fibres are available, but due to their unavailability, it is not familiar in the field of textiles. Some of the unconventional fibres like milkweed, pineapple, banana, funcraea and spider silk are used in different applications in the field of textiles, because of their own advantages.

The article “Current scenario and future prospects for diversified utilization of natural fibres other than cotton” looks into the suitability of natural fibres for various applications like: high quality blended apparel grade textiles, technical, industrial and home textiles including non-woven’s, bio-composites, pulp and paper, fine chemicals, cosmetics, health care products and bio-fuel, its scope for enhanced use and projected demands in terms of quality and
quantity. The article also looks into the basic physical, chemical, structural, morphological traits of natural fibres, the blending of cotton with jute, pineapple, flax, ramie etc, in preparation of particle boards, hard-board from crop residues like cotton stalks, craft paper from cotton stalk pulp, making of corrugated boxes etc are outlined. In addition to the current global trends, emerging areas of newer applications for natural fibres are highlighted. Based on the international scenario and increasing governmental thrust for post harvest processing, value addition including packaging of agricultural produce, it is felt that the demand for natural fibre products is bound to increase in years to come.

2.3. STUDIES RELATED TO PRE-TREATMENTS:

This consists of studies related to pre-treatments.

Pahwa and coworkers (1997)\textsuperscript{125} had reported on scouring and bleaching. Raw cotton, in addition to cellulose, contains pectoses and pectins, waxes and oils, proteins and similar related nitrogen compounds, organic acids, mineral matters, etc. For the removal of natural impurities, cotton can be subjected to various chemical treatments, which replace the various hydroxyl groups in order to yield different modified properties as electrical resistance, moisture absorption and rot resistance and reduces the likelyhood of creasing and wrinkling in fabric form. The duration of the treatment in scouring and bleaching has a significant effect on the properties of cotton fibres like with the increase in the treatment time, loss in weight also increases, which again follows the increasing trend with severity of the treatment time. The length and fineness of fibres decreases with increase in the treatment time. Maturity coefficient and bundle strength exhibit an increase of up to 2.10 hr treatment time. Results indicated that sample treated for 6 hr shows decreased value of all the tested properties which may be attributed to the prolonged treatment that has affected the fibre properties adversely. Thus it was recommended that scouring of cotton fibres up to 2.10 hr period is safe in terms of fibre properties and their appearance.
Ray et al. (2004) studied the alkali treatment of jute fibres and their application in composites, for the study jute fibres were subjected to an alkali treatment with 5% NaOH solution for 0, 4 and 8 h at 30°C. Composites were prepared with untreated as well as alkali treated jute fibres and vinyl ester resin with a fibre loading of 35% by hand pultrusion method. The modulus of the jute fibres increased by 12% and 79% after 4 and 8 h alkali treatment respectively. For the 4 h treated composites the flexural strength improved by 20% and modulus improved by 23%. However, this was not reflected in their impact fatigue behavior. On the contrary, the composites reinforced with the untreated and the 8 h treated fibres displayed superior impact fatigue resistance. The higher defect concentrations in the untreated and 8 h treated composites lowered their mechanical properties, but acted as shock absorber to the repeated impacts and improved their impact fatigue resistance property. The improved bonding between the alkali treated jute fibres and the vinyl ester resin increased the relative thickness of the bonded interface. Tiny humps were observed at a temperature higher than the primary transition temperature in the loss modulus curves of the composites. The damping parameter of both the transition peaks showed an increasing trend in the treated composites indicating higher viscous dissipation in the treated composites.

Menezes (2007) have reported on Jute processing. Jute is a bast fibre having meshy structure obtained from the bark of jute plant. Retting and extraction processes have a profound effect on the quality of fibre produced, and on the cost of fibre production affects the efficiency of manufacturing, quality of the end products, competitiveness in market and ultimately determining the level of earnings for industry and returns for growers. The article also explores about the options that existed for qualifying and developing improved microbial retting practices, for determining water requirements and for use of low cost bleaching agents. It also concentrated on studies of mixed bacterial cultures which are efficient retting agents and which have a measure of symbiosis within the culture. It further briefs on the various bleaching techniques like reductive bleaching, sodium hypochlorite bleaching, sodium chlorite bleaching, hydrogen peroxide bleaching, one bath
scouring and bleaching, including the chlorine free bleaching, retting in field, and carding, batch, drawing/grilling, spinning, chemical treatment of jute. Various methods of dyeing of jute fibres especially with reactive dyes and the finishes that can be applied on jute fabrics depending on its end use as well as to improve aesthetic and feel properties.

Samanta and coworkers (2005) studied the effect of selective pre-treatments and subsequent mixed enzyme treatment on properties of jute-cotton union fabric. Jute-cotton (75:25) union furnishing fabric had been treated with varying dose of mixed enzyme (cellulose, xylanase and pectinase) system with or without selective pre-treatments and the consequent changes in important textile related properties of the fabric evaluated. For untreated jute-cotton union fabric, 4% (owf) mixed enzyme treatment at 55° C for 2h using pH 4.8-5.0 is found to be optimum. Between cotton (warp) and jute (weft), enzyme action is found to be more pronounced in cotton than in jute. However, the degree of enzymatic hydrolysis and associated weight loss for jute are found to be more pronounced in cotton than in jute. However, the degree of enzymatic hydrolysis and associated weight loss for jute are found to increase if the mixed enzyme treatment is done after selective pre-treatments. 1% NaOH pretreatment at 30 °C for 30 min offers some unique advantages, except browning of surface colour, when subsequently treated with 4% (owf) mixed enzyme, Steaming of wetted jute-cotton union fabric t 130° C for 5 min shows almost negligible weight loss and marginal or no strength loss, although the reduction in stiffness in jute is poor and inadequate. Conventional scouring followed by 2% bleaching with stabilizer AWNI instead of sodium metasilicate makes the fabric most suited for subsequent 4% mixed enzyme treatment. The use of 5 steel balls in the rotating beaker of the launder-o-meter during the enzyme treatment is found to be very useful for removal of surface fuzz. Changes in the functional group pattern and chemical composition of jute have also been analyzed after the treatments. Scanning electron microscopic and X-ray crystallographic studies respectively reveal the changes in the surface morphological features and the fine structure of differently treated jute component of jute-cotton union fabric. There is apparent increase or decrease in X-ray crystallinity due to associated
mass loss from non-crystalline zone/crystalline interface for different pre-treatments and subsequent enzymatic hydrolysis.

Grancaric et al (2006)\textsuperscript{51} evaluated the efficacy of various scouring and bleaching regimes for flax blends by application of a thin layer wicking method. Increasing interest in blends of short staple or cottonised flax with other fibres has led to the development of new scouring, lignin solubilisation and bleaching regimes for the various blends. In this experimental study flax/wool (33/66) and flax/polyester (33/66) blend yarns, spun from short staple flax were scoured using either conventional or enzymatic scouring methods before bleaching under appropriate conditions for the different blends. The efficacy of the various preparation routes was evaluated using a water droplet absorption test, a vertical wicking test and thin layer wicking method. Enzymatic scouring proved to be least as effective as conventional scouring, but addition of ethylenediamine tetraacetic acid (to enhance pectin solubility) resulted in more hydrophobic yarns. Thin layer wicking with n-heptane and formamide, as well as with water, permitted calculation of yarn surface free energy changes associated with scouring and bleaching. It is suggested that when thin layer wicking is applied to yarns, special care is required when winding the yarns onto the support to ensure that the samples of uniform and repeatable porosity are presented to the wicking liquids.

Varshney et. al (2006)\textsuperscript{193} studied the varietal response of jute fibres with varying meshiness to alkali treatment. The study was carried out in two parts, firstly to study the “Effect of alkali concentration and treatment temperature on crimp development in jute fibres” For the above study four different varieties of jute fibres with different levels of meshiness were carried out at three different conditions of concentration and temperature, namely 9% conc./2°C temp (9/2), 18% conc./30°C temp (18/30) and 18% conc./10°C temp (18/10). Crimping behavior in terms of decrimping extension, decrimping stress, decrimping energy and crimp stability has been studied. It has been observed that under the condition 18/10, crimp development is maximum because of its inherent higher shrinkage potential. Decrimping energy is also found to be highest but the parameter crimp energy decay, having considerable practical
importance and the indicator of crimp instability, comes out to be higher. However for all practical purposes, considering other technical aspects, 18/10 conditions gives satisfactory results in the crimp development.

Secondly to study the properties of the alkali treated jute fibres, different varieties of jute fibres each with different levels of meshiness index have been treated under three different conditions of NaOH solution, namely 9% conc./2°C temp. (9/32), 18% conc./10°C temp. (18/10). Loss in weight and amount of shrinkage and their relationship with the change in tenacity and breaking extension of fibres have been studied. It is observed that the concentration and the temperature of the NaOH solution along with the degree of opening have considerable effect on the properties of fibres. Out of the three conditions, 18/10 is found to be more effective in developing desirable characteristics of breaking extension and tenacity with sufficient crimps for better spinning performance and better blend compatibility with other natural fibres as well as man-made fibres.

Alka et al (2007) in their review study on comparison of different bleaching methods on natural fibres have stressed on the potentialities of natural fibres, as are renewable and the need to be improvised in the areas of pre-treatments and processing which is concerned mainly with the removal of natural as well as added impurities and to impart whiteness and absorbency by utilizing minimum time, energy and chemicals as well as water. This study gives a detail understanding of the effect of different bleaching agents on various fibres/fabrics, under various conditions of concentrations, ph, temperatures, time, and activators. It can be concluded from the above study that different bleaching methods were applied on merino wool, cotton fibre, mulberry and tussar silk and were judged on the basis of the whiteness obtained after bleaching. It was observed that the action of the bleaching agent reduces the strength to an acceptable limit with an increase in elongation percentage. The fineness was also improved due to the bleaching finish on different fibres. Therefore to improve the whiteness of fibres or to fade their natural colour bleaching is recommended.
Dhamija and Manisha (2007)\textsuperscript{33} studied the tearing strength of cotton fabrics in relation to certain process and loom parameters. Tearing strength is one of the important aspects of a finished fabric as it is directly involved in the assessment of serviceability of the fabric in use. Three different varieties of cotton were used and it was observed that the fabrics made out of compact spun weft yarns are more tear resistant. The tearing strength further improves particularly in the weft way direction with the increase in the weft yarn linear density and weft tex twist factor. There is an initial increase in strength followed by a decrease as the number of picks/inch is increased in the cotton fabrics made of compact spun yarns. However, for the fabrics made of ring yarns, it showed a general decreasing trend. The 2/2 designs are found to be superior in warp way but inferior in weft way directions. The fabrics woven on air jet looms show lower tearing strength than those woven on projectile looms. The mechanical finish as well as the variation in shed opening does not affect the tearing strength of cotton fabrics produced from compact spun weft yarns.

Hebsiba and Thambidurai (2007)\textsuperscript{55} investigated the tensile properties of cotton yarns after slack swelling and stretching in presence and absence of sodium hydroxide. For the study, cotton yarns of 16s count were made on a ring and rotor spinning frame from a single fibre mix and yarn samples were prepared in lea forms and treated. The properties of ring and rotor spun cotton yarns subjected to combined swelling and stretching at predetermined time intervals have been studied. Yarn stretched in the solution exhibit spectacular changes in their properties. The increments in shrinkage values were found to be more in slack swollen rotor-spun yarns. Crystallinity values showed a decreasing trend with the increase in swelling time. Yarns stretched in solution showed a tremendous increase in packing fraction. Tenacity and elongation values showed significant increase with the solution stretch. The values of packing fraction, tenacity and percent elongation were found to be higher in the case of ring spun yarns. Scanning electron microscopy proved the swellability and packing of fibres in the yarns.
Igor and co-workers (2007) assessed structural changes in cotton yarns during wet processing, mercerization and scouring. Consumer demand for improved cotton quality is on the rise. Yarn properties depend on the spinning and finishing processes used, such as mercerization, scouring and bleaching. Ring-combed (RSc), ring-carded (RSca), and open-end (OE) spun yarns were, mercerized and scoured by conventional alkaline treatment and enzymatic scouring processes (using alkaline pectinase and acid pectinase). The mechanical properties, degree of mercerization, degree of orientation, work of rupture and abrasion resistance were investigated after each stage of finishing. The greatest increase in tensile strength, elongation and work of rupture and the greatest decrease in initial modulus were observed on mercerized, ring spun yarns. The smallest increase in the degree of orientation, tensile strength, elongation and work of rupture, and the greatest decrease in abrasion resistance were observed on mercerized, OE-spun yarns. In summary, a comparison of the results between the differently spun yarns, it can be concluded that the OE spun yarns gave the greatest degree of mercerization and higher abrasion resistance. Alkaline scoured, mercerized RSc yarns gave greatest increase in tensile strength, elongation and abrasion resistance. The type of treatment and type of yarn significantly influenced the measured parameters (except for the influence of yarn type on Young’s modulus).

Perincek et. al (2007) had conducted a study on ozone bleaching of jute fabrics. Jute is a vegetable fibre derived from the bark of an annual plant. Traditionally used for Hessians and sacking, it may commercially viable as a textile fibre because of it good strength, durability, antistatic properties and low thermal conductivity. The demand for jute decorative goods and upholstery materials would increase if its colour instability could be eliminated. For this reason, jute bleaching has received fresh attention. One advanced method for bleaching of jute fibres is ozonation. The whiteness of ozonated fabric was found to be superior to that of fabrics bleached with hydrogen peroxide and calcium hypochlorite. Ozone is a strong oxidizer, capable of participating in many chemical reactions with inorganic and organic substances. Ozone bleaching techniques have shown some promising results.
in delignification. This work demonstrated that ozone gas could provide the same degree of whiteness as traditional methods, with shorter treatment times. For this study the roles of fabric moisture, pH, treatment time and ambient temperature during ozone bleaching had been investigated. The results showed that an acceptable degree of whiteness, hydrophilicity, and strength loss can be obtained by ozonation in a very short time as compared to fabrics bleached using conventional methods. An acceptable degree of whiteness can be achieved by using ozone for a very short time, providing savings of thermal energy, water, chemicals in comparison to conventional bleaching techniques. Moreover ozonated fabrics showed less surface roughness, the lignin content and DP values were also decreased. And as it is carried out in a closed system it is environment-friendly.

Ram (2007)\textsuperscript{132} had reported on moisture management on cotton and its blends. Moisture management often refers to the transport of both moisture vapour and liquid away from the body. It is the controlled movement of water vapour from the surface of the skin to the atmosphere through the fabric. For this the initial property is to evaporate the perspiration from the skin surface and secondly to transfer the moisture to the atmosphere and make the wearer feel comfortable for which the rate of evaporation should be as close to the wicking rate as possible. The article also discusses in detail about wicking, wetting and the methods used in testing of the above properties.

Samanta et al. (2007)\textsuperscript{149} studied the hydrogen peroxide and potassium-per-oxo-disulphate combined room temperature bleaching of jute, cotton and jute-cotton union fabrics - An energy-efficient eco-friendly process. The demand for jute and jute-cotton union fabrics is gradually increasing due to consumer's preference for eco-friendly natural fibres. In the present study, attempts were made to optimize the bleach-bath composition and the process parameters for room temperature bleaching. A tentative mechanism for the effect of K2S2O2 in boosting the action of H2O2 has also been proposed and discussed. The measurement of physical properties like the breaking tenacity, weight loss and surface appearance study indicates that the proposed room temperature bleaching is less damaging to the three types of fabrics studied as compared
to the conventional hot hydrogen peroxide bleaching. The whiteness index is within the acceptable range. The suggested reaction mechanism indicates that $K_2S_2O_8$ acts as a peroxide booster showing a synergistic action. This room temperature bleaching process is energy efficient, eco-friendly and economical, which can easily, adopted by both small scale and large-scale sectors.

Tyagi and coworkers (2007) carried out an experimental study on effect of caustic and enzymatic scouring treatments on dye uptake and mechanical characteristics. Enzymatic treatments have engendered major research efforts. The present work studied the response of cotton ring and OE rotor spun yarns to scouring treatments, and also deals with the changes in the dye uptake and mechanical and surface properties induced by caustic and enzymatic scouring. For both yarn structures, the flexural rigidity, hairiness, yarn to metal friction and dye uptake increased markedly on scouring with enzymes and sodium hydroxide. Conventional scouring with sodium hydroxide renders the yarn strikingly strong and less extensible. However the tenacity of both yarns is considerably reduced on enzymatic scouring. The dye-uptake of the NaOH scoured yarns is higher and increases marginally with the rotor speed. The effect of opening roller speed on uptake of dye is also minimal.

Alam and coworkers (2008) had explained about the dyeing of cotton fabrics with reactive dyes and their physio-chemical properties. The effect of dye concentration, electrolyte concentration, dyeing time and the dyeing temperature on the dyeing performance of the cotton fabric dyed with reactive dyes, viz: Reactive Red 6B and Reactive Yellow I were studied. The dye absorption increases with the increase in the electrolytic concentrations, dyeing time and the dyeing temperature in the dye concentration. Considering the effects of various external influences on the dyed cotton fabrics, it has been observed that the Reactive Yellow RL imparts better physio-chemical properties than the Reactive Red 6B in most cases. The cotton fabric dyed with both the above dyes was very sensitive to strong acids and alkalis. In
case of colour fastness and other physio-chemical tests, both the dyes gave satisfactory results.

Ian in the review article on “Textile bleaching – a modern perspective” have discussed about bleaching, a process with a long complex history and is dominated by the use of hydrogen peroxide and FBAs. The results are faster processing, unprecedented high standards of whiteness and a much reduced load on environment. The major bleaching agents for textiles are hydrogen peroxide, sodium hypochlorite, sodium chlorite and peracetic acid. Are all oxidative bleaching and the reductive bleaching is based on sodium hydrosulphite. Bleaching increases the reflectance across the whole of the visible waveband, but more especially at the blue end of the spectrum. The two methods of increasing the whiteness are by use of tinting (bluing) or by the application of a fluorescent brightening agent or optical whitening. These are colourless substances that strongly absorb energy in the invisible near ultraviolet region and is re emitted, though some energy is lost as heat in this conversion process, so the re-emitted radiation is of lower energy but of a higher wavelength. Thus the energy that is strongly absorbed in the invisible near-UV region id re-emitted by fluorescence as visible violet or blue light. This results in increased blueness, with a small increase in lightness which leads to overall increase in the perceived whiteness of the textile.

Teli and co-workers (2002) et al studied the response of jute to the dyes of synthetic and natural origin. India is the second largest country in jute production in the world and jute is becoming increasingly important in various textile products as well as its blends with other fibres in apparel as well as non-apparel field. Chemical composition of jute and its high absorbency offer promising potential of getting it dyed with different classes of synthetic dyes also natural dyes. At present the information available on jute dyeing is scanty, as the use of jute till now was limited mainly to packaging material, where the coloration of finished goods is not so important. In the present work it was intended to study the response of jute towards the dye ability with different classes of synthetic and natural dyes.
Zahran and co-workers (2008)\textsuperscript{201} carried out an experimental study on the single bath full bleaching of flax fibres using an activation of sodium chlorite/hexamethylene tetramine system. Flax possesses natural impurities in contrast with cotton; it is more sensitive to alkali and oxidizing, bleaching agents. That is why bleaching of flax based textiles is lengthier and requires more care and precautions than cotton based textiles. The present work gives us an appropriate method to bleach flax in one-step process keeping in mind the quality, cost of the bleaching process and its environmental impact. The process was based on activation of sodium chlorite by hexamethylene tetramine in the presence of a nonionic wetting agent. The factors affecting the bleaching such as HMTA concentration, temperature, duration of treatment was studied to optimize the bleaching conditions. The bleached flax fibres were assessed for critical properties like whiteness index, loss in fibre weight, tensile strength, carboxyl groups and carbonyl groups. Based on the results obtained the optimum formulation for bleaching flax was determined. For comparison purposes, different types of flax fibres namely grey, card and waste properties after bleaching were also examined. Furthermore, tentative mechanisms for the reactions involved in bleaching were also suggested. It seems that, when optimum formulation was used, HMTA activates decomposition of NaClO\textsubscript{2} mainly to liberate nascent oxygen rather than chlorine dioxide.

2.2. STUDIES RELATED TO FINISHING TREATMENTS:

This consists of studies related to finishing treatments.

Shailaja and Kulloli (1995)\textsuperscript{160} had explained about resin treated fabrics. Resin is a chemical compound used in various types of fabric finishing, especially in wash and wear treatments. It is applied to enable fabrics to attain desirable qualities like water repellency, wrinkle resistance, dimensional stability and spot and stain resistance. Resins are applied to cloth always in solution form. This solution contains a catalyst, a chemical which stimulates the resin chemical to polymerize. The other ingredients of resin solution are softeners, lubricants and other materials which impart desirable physical properties to
fabrics. As resin finish affects the fibre itself, the finishing depends on the quality of the grey goods, quality of chemicals used for finishing and the care and technique devoted to the application of the fabric. Maintenance of solution of the finish is very important in order to maintain the tearing strength, tensile strength, abrasion resistance, wrinkle resistance, dimensional stability, spot and stain resistance and hand and feel.

Manjrekar (1999) had reported on application of enzymes in wet processing. Enzymes or biocatalysts have been used on a large scale for more than 75 years. There is no more exciting or a vigorous area of textile research than that of enzymatic processing of textiles. This new exploding area of research will continue to have profound impact on our very mature textile industry. Increasing environmental concerns have forced the manufacturers to rethink about the process being carried out in the textile industries. The emphasis is on total elimination of ecologically non-friendly chemicals. This lead to an intensive research in finding out suitable alternatives of which enzymes are found to be most suitable ingredient for textile wet processing. Also, due to the advanced technology enzymes gave better results than some chemicals used for similar purposes. When the possibilities of textile biotechnology today are compared with those just ten years ago, considerable progress is evident. Thus, due to advances in biotechnology we can get production of safe, highly active, efficient e4nzymes capable of performing various specialized functions so as to change the traditional textile processing operations. They are considered to be environment friendly biochemicals due to their ease of inactivation and disposal.

Tao and Chen (1999) explained the preparing and characterizing of kenaf/cotton blended fabrics. Kenaf fibres offer the advantage of being renewable, bio-degradable and environmentally safe, but kenaf is difficult to process and spin because of its coarseness, stiffness and the low cohesion of its fibre bundles. In this research, kenaf fibres are treated by a modified chemical degumming method to improve their properties. The finer and softer kenaf fibre bundles are easier to process than those in earlier studies. Treated
kenaf fibre bundles are blended with Pima cotton and spun on a cotton processing system to yield blended 30/70 kenaf/cotton yarns. For comparison, 100% cotton yarn, 30/70 jute/cotton yarn and 30/70 flax/cotton blended yarns were also prepared. The kenaf/cotton blended yarns are comparable to the jute/cotton and flax/cotton blends. Experimental woven fabrics made from 100% cotton yarn and from the blended yarns revealed that the breaking strength of kenaf/cotton blended fabric is similar to that of other blends, but lower than that of 100% cotton fabric. The kenaf blended fabric displays the greatest air-permeability. When the Kawabata evaluation system is used to evaluate the fabrics, the results showed that the blends are stiffer and less recoverable after deformation than the 100% cotton fabric, but the measured surface properties of the blended fabrics are comparable to those of 100% cotton.

Byrne (1999) reported on easy care wool/cotton blends. The natural lifetime of a new product development is such that, within a few years, the advantages responsible for its success no longer command a price premium, hence the constant drive to produce new ideas, concepts and technologies to maintain market momentum. For cotton products the major developments in recent years have been the easy care finishes, enzyme wash down treatments and latterly, stain resistance utilizing fluorocarbon finishes, but in many product areas it is blends, which have formed the backbone of apparel product development programmes. This concept has also extended to accommodate blends of wool with cotton and in view of the advantages in terms of aesthetics, comfort and warmth associated with such blends; it is perhaps somewhat surprising that the development of such products has not been actively pursued. Apart from the obvious difficulties associated with dyeing wool/cotton blends to solid shades, one of the major disadvantages of this fibre combination is that of the inherent tendency of the wool component to shrink, or felt, when machine washed and/or tumble dried. This property is of course incompatible with the production of garments which exhibit the full range of modern easy care performance criteria, namely washing machine washability, wrinkle resistance, smooth drying and crease stability. However depending on the blend and the fabric structure, and also the level of
performance required, wool specific chemical finishing may not be necessarily
be required and full range of easy care properties may be often readily
achieved by utilizing conventional cotton finishing techniques. If the
performance of a wool cotton fabric processed in this way does not meet the
requires specifications, a number of wool and cotton chemical finishing
techniques may be readily combined in such a way that a full easy care
performance is achieved without compromising the aesthetics or physical
properties of the fabric.

Chattopadhay and co-workers (2000)\textsuperscript{25} have explained about the enzyme
treatment on jute-optimization of parameters. Enzymes used for improvement
of softness and smoothness of jute fabric are lytic in nature, so there will be a
certain weight loss by enzymatic hydrolysis process. This loss in weight
correlates well with enzyme action and the criteria has been used here for the
optimization study of parameters for enzyme treatment on jute. It has been
found that 55° C at a pH of 5 using 1:10 material to liquor ratio and 4% (owf)
enzyme concentration for a duration of 120 min produces the optimum weight
loss in case of enzyme treatment on jute fabric by a proprietary enzyme
Biocellulase ZK.

Deo and Paul (2000)\textsuperscript{205} had reported on the enzymatic treatments as an
alternative to carbonization of disperse/ reactive dyed polyester-cotton blends.
Polyester-cotton fabrics having different blend proportions were dyed with
various disperse, reactive and disperse/reactive combination dyes and then
treated with cellulose enzyme as an alternative to carbonization. This resulted
in the removal of reactive dyed cotton portion of the blends, thereby altering
the lambda (max) towards disperse dye. The trend of the enzymatic action
was almost similar for all the blends irrespective of cotton content. In case of
cotton rich blends, the traces of cotton were found after the normal enzyme
treatment. This was revealed on comparing the results with those of
carbonized samples. The fabrics were therefore given more severe enzymatic
treatment to remove the traces of cellulose. It was found that severe
enzymatic treatment can provide an alternative to carbonization and that it is
fully eco-friendly process. A controlled doze of enzyme can be used in the correction of shades for disperse/reactive dyed polyester-cotton blends.

Dordevic et.al (2001)\textsuperscript{207} had explained the application of enzymes in textile industry. After weaving the yarn into fabric; the greige goods are in an unfinished state. Varieties of processes are available to improve the appearance, handle, performance and durability of the fabric. Before the more specialized finishing processes are applied, fabrics usually require cleaning (scouring) to remove warp sizing, oils and other additives and dirt. Cotton is frequently boiled or may undergo enzymatic desizing, wool is frequently carbonized and scoured and silk is degummed. Finishing includes all processes that a fabric undergoes once it leaves the mill and before final garments or materials reach the consumer. Processes such as desizing, carbonization of wool, degumming of silk, bleaching, stone washing, biopolishing and processing in aqueous solutions. In this paper are provided examples of some finishing processes with enzymes which depend on the ultimate use of the textile.

Sheth and Musale (2001)\textsuperscript{208} reported on application of enzymes in scouring and bio-polishing of cotton. Biotechnology is being pursued in the processing of textiles involving the use of enzymes to reduce chemical effluent pollution. A wide variety of enzyme compositions have been used in processing different fibre fabrics. The application of enzymes in scouring is introduced and carried out in this study with alkaline pectinase enzyme alone and lipase under different conditions. The experimental methods are described in the article and two methods of scouring investigated, measuring absorbency and calculating the whiteness index. Simultaneous dyeing and bio-polishing of cotton fabrics is then studied to save water, time and energy and raise productivity. Three sets of experiments are specified identifying methods and materials used. Four different methods are employed and the results set out, including colour strength measurement. Three different types of operation were carried out using three different types of cellulase enzymes. The conclusions are summarized.
Verma and Nishkam (2002) reported on enzymes in textile wet processing. The need for environmentally friendly chemicals and processing techniques in the textile industry has become much more pressing, and the use of enzymes has revolutionized textile processing as they are safer, more efficient and very specific in nature. The structure and nature of enzymes are explained and seven important properties listed. Factors influencing enzymatic activity include temperature, reaction bath pH, activators and inhibitors. Four differences found in enzymes as catalysts which sets them apart from each other catalysts are listed. Enzyme sources are examined, and the mechanism of enzymes described. The uses of enzymes in textile processing include desizing of fabric, bio-polishing of the fabric and their use in denim washing. They are also employed in other textile processing areas such as scouring, dyeing, bleaching, and degumming of the silk, jute retting and wool scouring etc. Enzyme use is still limited but is expected to increase rapidly to assist in minimizing negative environmental effects.

Pandey and Dayal (2003) have discussed about flax/jute and flax/cotton blended fabric. Characteristics of pure flax and flax blends with jute and cotton are explored in furnishing material applications. Flax types, textile properties and end-uses are reviewed. Developing flax/cotton blends will also extend the use of cotton for other purposes. Fibre and yarn testing was detailed followed by the testing of the fabrics. Microscopic appearances of flax, jute and cotton fibre strands were studied and chemical properties and chemical constituents were determined. Cost issues during the production process for the samples were considered. The physical properties of both fibre and yarn were described, followed by the physical properties of flax/ jute and flax/cotton blended fabrics which included abrasion resistance, tear strength and elongation percent, crease recovery, fabric stiffness, pilling propensity and chemical properties of fibres. The jute/flax blend of 80:20 demonstrated the best characteristics.

Raskovic (2003) reported on bio-scouring of cotton fabric-Structure and quality changes. Bioscouring of cotton with alkaline pectinase, lipase and cellulase has a significant influence on sorption characteristics and initial
migration of dye in the capillary spaces of the cotton substrate. Gray cotton fabrics show a hydrophobic character due to the presence of the cuticle around the fibres. Cellulases are natural catalyst for modification of cellulosic fibres and fabrics. In this work a cotton fabric were treated with some pectinase, lipase and cellulase at acetate buffer, and the effects of the treatments on the technical properties, such as strength, sorption, FTIR, air permeability and weight loss of the fabrics were evaluated. The results show that the treated cotton fabric is cleaner without large damages of own structure.

Karapinar and Sariisik (2004) reported on the scouring of cotton with cellulases, pectinases and proteases. Cotton may contain between 4% and 12% by weight of impurities in the form of waxes, proteins, pectin’s, ash and miscellaneous substances such as pigments, hemicelluloses and reducing sugars. These impurities are removed from the fabric by scouring, since their hydrophobic nature negatively affects the enhancement of the fabric’s wettability and absorbency. In this work, pectinase, protease and cellulase were used in various combinations for different treatment times, either in baths containing one enzyme or different enzyme combinations, in order to evaluate the effects of these enzymes on 100% cotton fabrics wettability and absorbency. At the end of the enzymatic and alkaline scourings, the wettability and absorbency properties of the garments were evaluated in terms of wettability, CIE*L, WI values and pectin analysis by Ruthenium Red dyeing. Furthermore, the effects of bio-scouring on bleaching and dyeing were also investigated. At the end of the evaluation tests, it was found that in order to achieve adequate wettability and absorbency, cellulase + Pectinase and cellulase + pectinase + protease gave better results than other enzymatic combinations.

Murthy (2004) explained the role of enzymes in textile processing. Mr. Edward Menezes, a technocrat of Rossari Biotech (India), presented an audio-visual presentation on ‘enzymes and colours’, at the Society of Dyers and Colorists, Mumbai in association with the Department of the fibres and Textile Processing Technology, on August 29, 2003. Addressing the
conference, Mr. Menezes explained how auxochromes intensify the colour absorption of chromatophores and help in the fixation of dyes on textiles and pigments with the aid of a resin or binder system. Over the years, enzymes have become an important class of bio-chemicals in textile processing, as they are not consumed in reaction and can be used in standing bath too. Further, the enzymes are also used along with sand blasting and bleaching to produce typical fading effects on denim. Besides this, the enzymes are also used in bio-scouring, bio-bleaching, bio-polishing, bio-softening of wool, silk degumming, carbonizing of wool, peroxide removal and print washing.

Yadav and co-workers (2004)\textsuperscript{206} explained the biopolishing of cotton fabrics- Changes in its comfort properties. The present study was conducted to evaluate changes occurring in the comfort properties during the bio-polishing of cotton fabric. The study was carried out on 100% grey cotton fabrics of three different fabric weights viz: light, medium and heavy weight. Grey cloths were given pre-treatments prior to bio-polishing. Pre-treatments included desizing, scouring, and bleaching. Bio-polished fabrics were analyzed for their constructional and comfort properties. Not much variation was shown in all the constructional properties but porosity showed marginal increase. Similarly, comfort properties, only in case of heavy weight fabrics showed higher comfort values.

Parthiban et. al (2003)\textsuperscript{123} studied the effect of fabric softeners on the thermal comfort of cotton and polyester fabrics. The aim of this work was to examine the effect of fabric softeners on the thermal comfort properties like air-permeability, thermal insulation value, wick-ability of cotton after repeated laundering. Three different parameters such as different fabric softener levels, different fabric types and different laundering cycles were chosen and tested for the thermal comfort properties. The respective yarns and fibres were coated with lubricants, humectants and softeners which make the fabric soft and flexible by internal lubrication of the fibres, which further also acts as an antistatic agent by enabling the synthetic fibres to retain moisture to dissipate static charge, thus making it more comfortable.
Kundu and co-workers (1996)\textsuperscript{85} reported on biopolishing of jute-cotton union fabric. The appearance and handle of the jute-cotton union fabric have been significantly improved by treatment with a commercial enzyme preparation, Biocellulase ZK. The treatment leads to the removal of surface hairs from the fabric and induces improvement in soft feeling. The handle of the fabric is improved due to increased drapability and compressibility and reduced stiffness and rigidity. The principal parameters affecting the treatment are concentration of enzyme and mechanical friction. Strength loss of fabric after the treatment is accompanied with a loss in fabric weight and is acceptable if it is kept within a controlled limit.

Fakin (2006)\textsuperscript{205} explained the influence of enzymatic pre-treatment on the colours of bleached and dyed flax fibres. In this paper the effect of enzymatic bio-scouring on the bleaching and dyeing of flax fibres was studied in comparison with conventional alkaline scouring. Enzymatic bioscouring was performed with a commercial multi-enzyme system consisting of pectinases, hemicellulases and cellulases. The enzyme and alkaline scoured flax fibres were subsequently oxidatively bleached with hydrogen peroxide and dyed with direct dye C.I.Direct red 80 under the same conditions. The efficiency of both the scouring and bleaching processes were evaluated by weight loss and the whiteness of the bleached samples was determined according to CIE formula. The exhaustion profile of the used dye was followed on-line during the dyeing process using absorbance measurement. The colours of bleached and dyed samples were evaluated using CIELAB colour values. The residual pretreatment and dyeing baths were ecologically analyzed with COD, degree of whiteness, comparable dyeing properties and is more environmentally friendly.

Ibrahim (2004)\textsuperscript{60} studied on the development of new eco-friendly options for cotton wet processing. A new approach was used to search for the optimal conditions for enzymatic scouring with an alkaline pectinase and to investigate the feasibility of performed combined bioscouring and bleaching and combined bioscouring and reactive dyeing of unsecured cotton fabrics. The possibility of conducting enzymatic desizing, bioscouring and bleaching of
starch sized cotton fabrics in a single bath was also examined. The results indicated that changes in the parameters of the bioscouring process, the types and the concentrations of the treating bath components, and the sequence of the treatment and addition had pronounced effects on certain properties of the treated cotton substrates (e.g., the residual size, weight loss, wettability, yellowness and whiteness and dyeability with reactive dyes). The optimal conditions for efficient bioscouring alone and in combination with bleaching, reactive dyeing and enzymatic desizing and bleaching were determined.

Salaskar and Desai (2005) explained the effect of enzymes and silicone finishing treatments on physical properties of jute/cellulosic blended textiles. The worldwide focus toward use of bio-degradable and environmental friendly materials had lead to natural fibres like jute to find newer applications in diversified end uses like furnishing, automobile seat cover carpets and blankets. Yarn dyed designs using jute/cellulosic blended yarn enhance the aesthetic appeal of the fabric such as stiffness and hairiness when it is to be used for producing value added products. It is difficult to overcome the drawbacks such as hairiness and stiffness of these fabrics by conventional methods of chemical processing as they contain dyed yarn. Recent technological developments have introduced enzymes suitable for dehairing without any adverse effect on colour of the yarn. Similarly, various silicone finishes have been developed for imparting softness to the fabric. Therefore, the effect of enzyme treatment and silicone finishing treatment on certain physical properties of jute/cellulosic blended fabrics were assesses and the detailed findings are presented in the present article.

Teli and Paul (2005) had explained about swelling and bio-polishing of polyester/cotton blends for developing new shades. The repeated swelling and bio-polishing treatments were performed on cotton blends for developing new shades. Bio-polishing is an effective technique for achieving a variety of shades on dyed polyesters/cotton blends by treating them with cellulose enzymes. These enzymes act on the surface of cellulosic fabrics to improve the surface properties by implying brighter luminosity of colours, softer feel
and pilling resistance. The polyester/cotton blend fabric of 67:33 proportion was treated to swelling procedure with disperse or vat dyes. Disperse or vat colours are found to be more responsive in the case of polyester or cotton blend dyeing, since the vat dye is not covalently bonded and the enzyme action is not reduced. The reduction in the \( K/S \) values, used to analyze the samples, with increased enzyme treatments was also evident.

Prabhu and co-workers (2006)\textsuperscript{128} reported on combined bio-polishing and bleaching of cotton. Enzymatic solutions not only allow environmentally sustainable production processes but also create cost-and time-saving as well as other fabric quality advantages for textile manufacturers. Enzymes have three reaction mechanisms which include lock and key mechanism, induced fit model and the ping pong model. To date, several enzymatic approaches have been developed in the textile industry to make fabrics smoother. Such approaches not only transform cellulose into glucose but also use the glucose for the in-situ formation of hydrogen peroxide. One demonstration of these approaches is the bleaching of cotton using a combination of bio-polishing and bleaching. This eco-friendly and economical process allows lighter bleaching of cotton than is achievable with the peroxide bleaching method.

Sujata and Naik (2006)\textsuperscript{205} examined the effect of softening treatment on the physical properties of naturally coloured cotton khadi fabrics. In this work, an attempt was made to study the effect of softeners viz: - cationic and silicone softener on the physical properties of naturally coloured cotton khadi fabric. It was found that there was increase in the yarn fineness and dimensional stability. The bending path. Elongation percent, tensile strength and drapability showed significant improvement. On treatment with softener resistance to abrasion decreased and on the other hand excellent resistance to pilling was noticed. Among two softners cationic softener showed better results with respect to all mechanical and functional properties.

Jegadeesan and Dhanapal (2006)\textsuperscript{70} studied the effect of enzymatic treatment on liquid moisture transmission of P/V blended single jersey fabric. Moisture transmission properties were studied in an effort to understand the physical basis of clothing comfort. In addition an attempt has also been made to
investigate the influence of enzyme treatment on moisture transmission characteristics of the above fabrics. Polyester and viscose staple fibres of different deniers was ring spun with various blend proportions, which were knitted into single jersey fabrics. The fabrics were then dyed and treated with lipase enzymes. The fabrics were tested for their liquid moisture transmission characteristics. The results reveal that moisture transmission characteristics are strongly influenced by the enzymatic treatments. This is mainly due to the molecular reorientation in the surface of the polyester fibre component in the fabrics. The wicking behavior was also improved due to the enzymatic treatments. Liquid moisture transmission had improved by about 175 to 185% in grey stage and 25 to 40% in dyed stage due to enzymatic treatments.

Mehra et. al (2006) studied versatility of silicones in textile processing. Silicones in textiles have seen an almost uninterrupted growth since the last 4-5 decades. Softening and water repellency are almost synonymous with silicone finishing in textiles. Today the basic structure of silicone finishing in textiles is thoroughly manipulated to give rise to series of functional modified silicones and bringing in the family of amino, carboxyl and epoxy modified silicones for processing of textiles. The article takes a look at the versatility of these wonder molecules in textile processing and highlights the usage in newer areas and even explores the synergies in existing applications.

Vishnu and Selvakumar (2006) reported on biopolishing enzymes and their influence on the properties of cotton materials. Various developments have taken place in the eco-friendly processing of textiles involving enzymes. Among the various enzymes, cellulose is extensively used on cellulosic materials. There are two types of cellulose, namely, acid cellulose and neutral cellulose. Acid cellulose is used in bio-polishing, which is a very popular finishing treatment given to cellulosic fabrics. Apart from polishing the fabrics, the treatment offers a number of other benefits such as improvement in pill resistance, cooler feel, and brighter luminosity of strength. All the above effects are influenced by a number of factors like, composition of the acid cellulose, pre-treatments given to the fabrics and process parameters used at the time of treatment. Moreover, the treatment has influence on post
treatments given to the fabrics. This review exclusively deals with all the above mentioned factors in order to bring out the current status of understanding on acid cellulases and its application on cotton fibre and products made from it.

Bhat (2007) has explained about soil/stain release finishing, as the demand for easy care textiles have increased due to lifestyle shift, which has opened new vistas for the textile manufacturers. Some bonus properties like antimicrobial, flame-retardant, UV-protection, moisture and temperature control and skin treatment can be added to textiles along with easy care properties which would be a strong differentiation tool for the marketers for marketing their merchandize in the competitive business scenario. Today soil stain release finishing is imparted by incorporation of low surface energy fluorochemicals, which allow oil and water stains to penetrate the fabric and when laundered the stains easily get removed. The article explains about fluorochemical treatments, which protect against both water and oil based soils and resists wetting by oily and watery liquids. Silicone treatments protect against water based soils and watery liquids only. The repellent products prevent the textile substrate from wetting and soiling, also called the dual effect. Thus the selection of primary soil release finishing chemical and allied silicones and softeners play a very important role in delivering the desired effect in processing, if factors like fibre type, construction, durability desired etc is considered before finalizing the product for achieving the final finish.

Bagyalakshmi and Kokilavani (2007) have carried out a experimental work on herbal antimicrobial finish for cotton fabric. In the past textiles were primarily for economical and functional point of view. But now some end-users and in particular demands on the safety of textiles for the health has gained considerable importance. The odour development resulting from biological growth on textiles exposed to perspiration had not been considered a real need until relatively recently. TO overcome this problem, now days antiperspirants are used, but they shrink sweat glands and block pores causing toxins that are normally eliminated by perspiring, therefore to control sweating and also to avoid use of antiperspirants, herbal antimicrobial finishes
were introduced onto the fabric. The fabric was converted to arm pads, which are mainly used as sweat absorbents. Absorption of sweat by the arm pad alone does not give freshness instead it provides medium for the growth of microbes. It is important to resist the growth of microbes, which is possible, at least to some extent with the use of herbal antimicrobial agents. The herbal sources selected were neem, aloe vera, tulsi, pomegranate and coffee sena. The results of subjective and objective evaluation were satisfactory.

Chellamani et al (2007) have presented a paper on the application of nano finish on fabrics made out of compact and conventional ring spun yarns. Nanotechnology is an emerging inter-disciplinary technology booming in various areas, wherein the properties of substances are drastically changed, when their size is reduced to the nanometric range. A variety of anti-microbial finishes have been developed for textile use, which in addition to effective bacterial control exhibit durability of activity to laundering. The paper also briefly discusses about the studies conducted on anti-microbial and softness properties of fabrics while applying nano as well as conventional finishing chemicals.

Goyal and Prabhu (2007) in this article on finishing of polyester blend fabrics have briefed upon the phenomenal growth of synthetic textiles especially polyester and polyester blended fabrics all over the world, which is primarily due to its ideal properties like high durability, smooth pleasing appearance, good feel and handle, dimensional stability, excellent wash & wear and quick drying properties. The comfort of the fabric is also equally of paramount importance. The inherent characteristics of polyester blend fabrics depending upon the blend composition, durability, dimensional stability, easy care etc are such that they hardly need special finishes to improve their properties, except for improvement in their hydrophilic nature, which causes static charge build-up, pilling tendency, soiling tendency etc for which special finishes need to be applied. The finishes required for the polyester and its blends are broadly classified as a combination of mechanical & chemical finishes since any one of them cannot confer the desired properties to the fabrics. The article also highlights the various factors to be taken into account regarding the
formulation of a particular finish like the customer requirement, fibre type, blend composition, yarn geometry fabric construction, machinery available in the process house, processing sequence, total number of treatments to be given before finishing.

Karolia and Mendapara (2007)\textsuperscript{79} in their experimental work on imparting antimicrobial and fragrance finish on cotton using chitosan with silicone softener” explains the necessity to meet the growing demand of consumers led to the revolution in functional finishes world-wide. Cotton is widely used for apparel due to its comfort property, but it has two main drawbacks, susceptibility to creasing and bacterial degradation. Chemical compounds are used as antimicrobial agents but they also influence the natural flora of the human skin. Studies have shown that Chitosan, a natural biopolymer, is antibacterial, antifungal, antiviral, non-toxic, non-allergic and biocompatible. Chitosan had been used in combination with citric acid and silicone softener to impart anti-, microbial and fragrance finish with two different application techniques. It was observed that the finish provides better functionality to the fabric as it shows good performance and improvement in physical properties. The finish showed good fastness to washing as well as perspiration. The use of carboxylic acid also improves the affinity of chitosan for cellulose. Thus, the overall functionality of the fabric was increased.

Kan et al (2007)\textsuperscript{74} had reported on the enzymatic treatment of linen. Cellulase is today a widely used enzyme for the treatment of celulosic material, most commonly for cotton materials. In this work the effect of cellulase treatment was evaluated by means of phenol-sulphuric acid method. This method was performed by determining sugar liberation in the treatment bath with the amount expressed in glucose equivalence. As compared with the conventional method, the measurement of amount of sugar liberated gave a more reliable and accurate result than the weight loss method. It was found that although weight loss of cellulose became negligible when the treatment was done under agitation free condition, the amount of sugar liberated was still readily measurable.
Krishnaveni (2007)\textsuperscript{81} studied the development of eco-friendly herbal antimicrobial finish on cotton for medical textiles. Textiles being vulnerable to microorganism attack would cause many cross infections and allergic reactions. Antimicrobial finish on fabrics can minimize the transfer of microorganisms onto the wearer by creating a physical barrier. It prevents the skin diseases caused by the microorganisms. The article speaks about a new approach towards making an anti-microbial fabric using natural extracts and herbs, Kuppanimani (Indian Acalypha) and Marigold (Calendula Officinalis), which are available plants in Tamil Nadu, were chosen for the study. The plants were firstly screened by antimicrobial tests for the presence of active principles and applied onto the fabric by optimizing the process conditions-pH, time and temperature. The fabrics were treated with 50\%, 75\% and 100\% concentrations. Methanol were used as a solvent for extraction and applied by pad-dry-cure method with cross-linking agents. Fabric property tests for all treated and untreated fabrics were carried out, which indicates a little change in the properties. 100\% treated fabric was found to be much softer and its washing fastness was found to be better than all the other treated samples. Antimicrobial and antimycotic tests were carried out for all the treated and untreated samples. 100\% Marigold petal treated sample was found to be the best of all exhibiting a good dye shade and antimicrobial activity.

Mishra and Rani (2007)\textsuperscript{101} has given a brief review of the current scenario on the use of enzymes in Indian textile processing industry. Enzyme technology is much older than genetic engineering, and there is a wide scope for newer applications. Using modern techniques of biotechnology, scientists are attempting to improve the yield of an enzyme by transferring the encoding gene to a microorganism capable of producing the enzyme in larger amounts. It also speaks about the biological approaches and their growth in future due to increased pressure from environmentally conscious producers. An option for complete exploitation of enzyme application in textile sector by researches all over the world in regard to biotechnological treatments that will be translated into new industrial processes for the future.
Parthiban and Ramesh (2007)\textsuperscript{124} have explained the effect of fabric softener on the thermal comfort properties such as air-permeability, thermal insulation value and wickability of cotton and polyester fabrics after repeated laundering have been evaluated. The experimental results reveal that fabric softener treatment with different levels significantly decreased the air-permeability and the wickability of cotton fabrics but had no effect on polyester fabrics. Thermal insulation value increases for both cotton and polyester fabrics to a similar degree. The statistical analysis also indicates that the results were significant among the values on air-permeability, thermal insulation value and wickability of the fabrics. The chemical finishing had a significant influence on the thermal comfort properties of cotton and polyester fabrics after repeated laundering cycles.

Prasad (2007)\textsuperscript{131} stated that industry’s new drive towards high value added products are prompted by increased competition from other countries. The world wide chemical consumption in apparel section is around 60\% as it plays an important role in various sectors. The garment industry is developing textiles with smart functioning using chemical products to provide comfort & increased performance. In order to add value to garments, different types of finishes are adopted, to name a few moisture management, wrinkle free, water/oil repellent, UV protection, anti-microbial, flame retardant etc. The application of nano-finishes has also been growing to obtain better level of performance properties, which id further being driven by ecology and fashion.

Ramachandran and Sampat (2007)\textsuperscript{138} had carried out an research work to study moisture management finish on woven fabrics. Moisture management Analysis of four types of woven fabrics like cotton, polyester/cotton blend, nylon and microdenier polyester was done and the comfort properties were also examined. The optimization of comfort level by varying the process parameters of moisture management finish in order to achieve suitability for making sportswear was also done. Based on the test results, microdenier polyester and cotton exhibits good wicking, wetting and water absorbency characteristics than the polyester/cotton blend and nylon. Comparing the three different process parameters, it was found that the combination of
ethoxylated alcohol blend (wetting agent) and the recipe containing amino silicon polyether copolymer and hydrophilic polymer in the ratio of 1:2 with ph of 5.5 at 60°C-70°C temperature is the optimum finishing process than the other two combinations so as to attain better comfort properties for sportswear.

Roda (2007)\textsuperscript{144} explains about the importance of enzymes, which can be used to replace harsh conditions and chemicals thus being eco-friendly, as they are biodegradable and can be easily absorbed back into the nature. Enzymes are proteins, consisting of long chains of amino acids held together by peptide bonds having potential properties like being specific, are efficient catalysts, have a natural source of origin, and they work on only renewable raw materials. The article briefly explains the need for enzymes in the textile industry, the conventional processes involved with enzymes like in desizing, scouring, in denim finishing, in bio-polishing, in wool and silk finishing and in speciality products.

Sivaramakrishnan (2007)\textsuperscript{174} insights into specialty chemicals, where he focuses on flame retardancy, which has witnessed a vigorous development of new technologies, new products and materials to meet the challenge of the needs of the new industries like computer, electronics, telecommunications, in health care settings, intravenous pumps, hospital beds and curtains. The article also gives insight in to the growing awareness of environmental issues and stiffening demands of consumer safety, which has been forwarded by governments and public agencies. With the new fibres/blends rapidly changing the economic situation, companies that adopt the latest technologies will have the edge in providing superior products with the best balance of properties at the lowest possible price.

Shyamsunder and coworkers (2007)\textsuperscript{165} have discussed the importance of enzyme application in textiles, as they have their own merits and limitations and they often shorten the process cycle reducing time, water consumption and wastewater generation. As with all the chemicals and products, enzymes too have their own merits and limitations. They show specific action without undesirable effects on other components and normally operate under mild
temperature and pressure conditions, but at the same time are sensitive to temperature, pH, humidity and contaminants. Thus stating that enzymes are emerging in the field of textile wet processing and can be utilized in a much bigger way if cost management is applied concluded the article.

Sivaramakrishnan (2007)\textsuperscript{173} has expressed the challenges facing the finishing industry that is striving to survive in the competitive market. Along with durability, functionality, the demand for odour control, freshness, high performance and comfort has also increased. Apparel makers and finishing industry are thus faced with a daunting job of producing superior fabrics that are technically advanced. Multifunctional softeners with special effects are slowly replacing conventional softeners, as the consumers insist or tailor made products, with more value added properties.

Tarafdar and Singh (2007)\textsuperscript{181} studied the effect of flame retardant finishes on silk and polyester fabrics. Flammability has become an important concern for consumers, fee technical organizations, manufacturers, fibre producers and government agencies. It is influenced by the inherent characteristics of different types of fibres and their inherent characteristics of different types of fibres and their blends. Flame retardant finishes for textiles materials includes a various chemical compound and polymer that are appropriate for each type fibre, fibre blend, fabric weight and construction. For preventing the textiles from fire, researchers have developed various types of non-durable, semi durable and durable flame proofing products. As silk is a costlier fibre, is self extinguishing, a cheaper flame retardant chemical has been used in the present study to observe the suitability of the finished material. Thus the study was undertaken with a view to study the effectiveness of different flame retardant finishes on different silk and polyester fabrics with varying density, to study the time to propagate appropriate length of fabric before and after washings, to determine the tenacity and crease behavior after two washings. It was seen that the time to propagate certain length of fabric increased with increase in the add-on percentage, which depends on the areal density of the fabrics. It was also observed that antimony oxide is more suitable than lead monoxide for both the substrates. Washing reduces the add on % of polyester
fabrics more than silk. Resin treatment increases the tensile strength and crease recovery of silk fabrics more than polyester.

Periyasamy and Khanna (2007) reported on Silicone finishing, which has become increasingly important in textiles as it imparts a very unique soft handle and enhances smoothness, flexibility, drape and pliability of the fabric. The silicones were firstly utilized as lubricants in fibre and fabric manufacture, they are also used in permanent press finishes to improve durability, for multifunctional finishes, they are also formulated with special polymers to impart a unique leather soft finish, this article therefore discusses the fundamental principles behind silicone finishes, their developments, textile applications, and contribution from Americos in the field of silicone finishing of textiles by producing the silicone nanoemulsions and special silicone softeners for multifunctional finishes with its state of art manufacturing technology.

Ramachandran and coworkers (2008) have discussed the current scenario of textile industry with regards to functional finishes or speciality finishes. Functional/speciality finishes like fragrance release, protective finishes, skin care additives, insect repellent, deodorizing fragrance, antimicrobials, flame retardant finishes, cool finish, thermal insulatory finish, wrinkle free finishes, water proofing finish thermocoat finishing, and UV stabilizers have been discussed in detail in the article. It also claims that only innovative products will open up new markets and new horizons for textile industry, and within the industry, the challenge for companies lies in bringing to market a stream of new and improved, value-added products, in order to strengthen existing product lines, and diversify into newer areas.

Samanta and co workers (2008) carried out an experimental work on enzyme and silicone treatments on jute fibre to study the effect on textile related properties. The present study relates to broad-based assessment of raw jute and selectively pre-treated jute fibres under the action of mixed enzymes (cellulose, xylanase and pectinase) and a textile grade aminosilicone softener and to further assess how such selective treatments finally contribute in enhancing some textile related properties. Application of 4% mixed enzyme on jute fibre at 55 deg C for 2 h at pH 4.8 offers much finer,
softer, cleaner and brighter jute fibre with some lowering of bundle tenacity. However, pre treatment of jute fibre under combined oxidative action of 3% H₂O₂ and 0.75% K₂S₂O₈ for 2 h at 30 deg C (pH 11) followed by subsequent treatment with 1% mixed enzyme offers a better balance of textile related properties covering moisture related properties, covering moisture regain, fineness, bundle tenacity, flexural rigidity, surface reflectance, whiteness index, yellowness index and brightness index. Treatments of jute fibres with 0.5-1% aminosilicone softener under a specified condition also make jute fibre much softer, smoother, and brighter and cause noticeable reduction in coefficient of friction without much change in bundle tenacity. However, keeping all textile related properties in view, a pre-treatment of conventional 3% H₂O₂ bleaching for 2 h at 85 deg C (pH 11) or an oxidative treatment under combined action of 3% H₂O₂ and 0.75% K₂S₂O₈ for 2 h at 30 deg C (pH 11) prior to 1% aminosilicone treatment of jute fibre were found to be much useful for textile purpose.

Nair (2007)¹⁰⁹ has studied on the eco-friendly chemical processing of cotton textiles. The awareness and the necessity of eco-friendly chemical processing of textiles were observed by the author during his chemical processing experience and have made contributions towards making many process eco-friendly in some of India’s leading textile mills and textile process houses right from 1972 onwards. He has applied eco-friendly processing to flame-retardant finishes, reduction in sodium-hydrosulphite, formaldehyde-free finishes, safe napkins for hospitals, an alternate to eco-unfriendly MK (mineral-khaki) dyeing, measures for eco-friendly work place, eco-friendly bleaches, effluent control in textile industries, in areas of printing, finishing, scouring etc.

Kumar and co workers (2008)⁸⁴ have explained about the conservation of enzymes in biopolishing application of cotton fabrics. Immobilization of commercial cellulose enzyme on ion exchange and epoxy resin carriers has been studied under various process parameters and conditions by using methanol to allow reuse of cellulose enzyme that would otherwise be discarded after biopolishing. The activity of immobilized enzyme was determined by measuring the amount of glucose made from carboxy methyl
cellulose by using an assay with reading at 492nm. The retained activity was investigated by cellulose assay for every successive cycle of operations. Under different process parameters and conditions the activity amount of cellulose immobilization has been tried to increase the immobilization efficiency. Epoxy resin shows a greater amount of cellulose immobilization when compared to ion exchange resin. The immobilized epoxy resin with maximum activity was used on cotton fabric for biopolishing instead of free enzyme for successive cycles and the treated fabrics physio-mechanical properties were studied. Results show that immobilized cellulose can be used for biopolishing for successive cycles efficiently.

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