



# “A STUDY ON PLANT FIBERS FOR SUSTAINABLE AND ECOFRIENDLY TEXTILES”

\*V.S. Karpagavalli<sup>1</sup> and M. Sumithra<sup>2</sup>

Assistant Professor and Head, Garment Designing Department, PSGR Krishnammal College for Women, Coimbatore, Tamil Nadu, India<sup>1\*</sup>

Assistant Professor, Textiles and Apparel Design Department, Bharathiar University, Coimbatore, Tamil Nadu, India<sup>2</sup>

**Abstract:** Plant fibres are sustainable substances that might be without issues in nature and have benefits like low value, mild weight, renewability, biodegradability, and moderately specific properties. The sustainability of herbal fibre-based totally composite substances has increased their applications in various manufacturing sectors. The use of plant fibres and fabrics is in greater demand as they pose no toxicity to the environment and may be recyclable and biodegradable.

This review article explores the use of plant fibres in the textile industry, provides an overview of different types of plant fibres, including cotton, hemp, linen, silk, and wool, and discusses their unique properties and applications in textile production. The environmental impacts of plant fibre production and processing are also discussed, along with the challenges and opportunities facing the industry. The article highlights the growing demand for plant fibres in the textile market and the potential for further growth and innovation in this area. Overall, this review emphasises the importance of plant fibres as a sustainable and ethical choice for the textile industry.

**Keywords:** Plant Fibres, Properties, Bamboo, Banana, Flex, Hemp, Lotus.

## I. INTRODUCTION

Chemical pesticides are not used in the cultivation of natural fibres such as cotton, bamboo, hemp, linen, and specialty fibres. With little to no hazardous pesticide use, this natural fibre is grown to meet the natural demands of the nation. Materials that adhere to the standards of plant farming are used to create plant apparel. Natural labelling on fabrics no longer guarantees that they are made entirely of vegetable fibres. Clothing and household textiles are made from plant textiles. As a resource for developing and safeguarding items with minimal environmental impact, plant fabrics are produced. Additionally, plant fibres use less water. One way distinctive manufacturers are beginning to pay more and more attention to eco-style is through plant apparel. People of all ages frequently wear clothes that are environmentally friendly. It takes a while for the soft cloth to become soiled. Natural clothing typically contains no chemicals at all. Sortable plant fabrics can be washed in a machine using cold water. When compared to unique materials, the cost of making natural fabrics is typically relatively high. This is because we start with natural seeds and then go on to processed goods made without chemicals. Natural fibres have a limited supply because they are not manufactured on an industrial scale, and during the past few years, demand for natural fibres has grown significantly. Plant materials are now a mainstay of fashion, having once been seen as an alternative. The fabrics used in plant clothing are breathable, keeping you dry and reducing rashes or skin irritation. Clothing made of plant materials is dependable and enduring.

## II. PLANT FIBRES

### BAMBOO:

Certain inherent properties of bamboo fibre can be higher than those of cotton fibre. Additionally, it has been asserted by the manufacturers that fabrics made from bamboo fibre offer superior dyeability, superior air permeability, increased flexibility, and a softer feel than cotton. Due to a totally unique rhizome-dependent tool, bamboo is one of the fastest-growing plants in the world. Positive species of bamboo may grow 910 mm (36 in) inside a day at a rate of around forty millimetres (1 12 inches) every hour (a growth rate of one millimetre per ninety seconds or one inch per forty minutes). Bamboo is a high-quality, naturally renewable, biodegradable, and environmentally friendly textile fibre. It is no longer merely a green fibre; however, it has additional inherent assets of anti-bacterial and UV-protecting properties, which make it a completely eco-friendly cloth material in the twenty-first century. [1]

**Properties:**

- Dry tensile strength: 2.33 (cN/dtex)
- Wet tensile strength: 1.37 (cN/dtex)
- Dry elongation at break: 23.8%
- Linear density: 1.8%
- Percentage length: 1.8%
- Overlength staple: 0.2%
- Whiteness: 69.6%
- Moisture regain: 13.03
- Oil content: 0.17

**Characteristics:**

- Softer than cotton, it resembles a blend of cashmere and silk in feel.
- The skip phase of the fibre has a remarkable amount of better moisture absorption and air movement since it is filled with numerous micro-gaps and micro-holes. With soil release, moisture absorption is two times greater than that of cotton.
- Bamboo fibre contains natural antibacterial properties that keep microorganisms away from bamboo fabric.
- Bamboo-fibre clothing can quickly absorb and evaporate human perspiration, much like breathing. People who wear such clothing feel incredibly cool, safe, and non-sticky, even during the hottest summer months.
- Yarns made entirely of bamboo have a remarkable degree of elasticity—nearly 20%. It is possible to get a high degree of elasticity in cloth that is 100% bamboo and eliminate the need for elastomeric fibres like elastomer.
- Bamboo fabric requires significantly fewer dyes than cotton, modal, or viscose. Evidently, dyestuffs have a noticeably higher absorption rate. Bamboo absorbs colours more quickly and imparts a deeper colour.
- Because bamboo fibre is anti-ultraviolet, it is ideal for summer clothing, especially to protect children and pregnant women from the damaging effects of UV rays.

**BANANA:**

Banana fibres, which may be concentrated near the outside floor, are removed by hand scraping, chemically using retting, or mechanically using raspadors. Leaf sheaths that have been boiled in a solution of sodium hydroxide can likewise be used to remove them. Fibres that are manually stripped typically have a superior pleasantness than those that are obtained using a raspador. The stalks are often sufficient for the duration of the monsoon. By hand scraping on a soft wood plank with 0.15 m-long blunt blades, the fibre from the stripped leaf sheath that has been reduced to a length of 0.3–0.4 m and 0.07 m wide is extracted. The pith is then continuously removed until the fibres seem effortless. [2]

**Properties:**

- It is also a strong fibre.
- It has a smaller elongation.
- It has a pretty exquisite look based on the extraction and spinning methods.
- It is of moderate weight.
- It has robust moisture absorption, which is exceptional. It absorbs and releases moisture very quickly.
- It is biodegradable, has no horrible impact on the surroundings, and therefore can be categorised as a "green fibre."
- Its average fineness is 2400 nm.
- It can be spun using almost all the techniques of spinning collectively, including ring spinning.

**Characteristics:**

- It is a natural absorbent. Fabrics made from this fibre allow you to breathe well and help keep you cool on hot days.
- Soft, flexible, and shiny Banana fabric is light and flexible, but not as soft as cotton or viscose.
- Almost all plant stem fibres feel stiffer and coarser than cotton or viscose. It has a silky look with a natural sheen.
- Banana fibre clothing is comfortable and non-allergic.
- It is purely biodegradable.
- It has resistance to oil, water, flame, and heat.
- Not always insulated.
- Although banana cloth is made from a hard outer shell, it is not as strong and durable as materials such as hemp, bamboo, or special plant fibres. It has excellent radiation and tensile strength compared to its own natural fibres.

**EUCALYPTUS:**

A woody, blooming tree, eucalyptus includes many species that are mainly found in Australia and Southeast Asia but also come in many varieties that are growing in Europe, America, and Africa. The oil from this relatively small plant, which is useful for cleaning and as a natural pesticide, has generated interest. Lyocell, a type of eucalyptus cloth manufactured from the pulp of the tree, is also known as eucalyptus. The process for creating eucalyptus fibre is similar to that of the easiest to work with semi-synthetic natural fibres, like viscose bamboo fabric: the eucalyptus wood is pulped, reduced down into a viscous solution of cellulose that is forced through spinnerets, and finally spun into a smooth, lightweight, breathable, and hygroscopic fabric. Tencel production technology uses amine oxide, a non-toxic solvent that enables closed-loop processing in which up to 99% of the chemical is typically recycled, minimising the impact on the environment and conserving energy and water. Additionally, the production process generates a small amount of innocuous waste that is released into the air and water.

**Properties:**

- The actual degree of polymerization in the tencel fibres is higher than for standard viscose, modal (HWM), or polynosics.
- Tencel fibres have excellent wet strength and wet modulus. The high wet modulus of the fibre is an important attribute, as it imparts Tencel fabrics with very low potential shrinkage in the wet state.
- The fibre is round in cross-section and has a natural high lustre.
- Tencel is a cellulosic fibre regenerated from eucalyptus wood.
- Standard Tencel fibres have a reduced duration of 38 mm. However, those fibres are available in shorter lengths, beginning at 12-fifty-eight mm, depending on the ends use.
- The linear density of preferred Tencel fibres ranges from 1.3–2.2 dtex. Micro Tencel can also have a linear density of 0.9 dtex, even though a few Tencel fibres used for filling or technical fabric may additionally have a linear density of up to 6.7 dtex. The tenacity of Tencel fibres is around 36–37 g/Tex in the dry state and 29–30 g/Tex in the wet state. [Dr. Tanveer Hussain, 2014]
- Elongation at the wreck of Tencel fibres is 14% in a dry nation and 16% in a wet state.
- The increase of microorganisms on Tencel fibres is enormously low in comparison to synthetic fibres and cotton. This is because no moisture layer has evolved on the fibre floor to keep microorganisms out because of the short transportation of moisture to the fibre.
- Moisture regain in Tencel fibres is around 13%. High moisture retention prevents electrostatic charging.
- Tencel fabrics have amazing abrasion resistance and dimensional balance.
- Tencel fabrics crease much less and are less complicated to iron in comparison to cotton cloth.

**Characteristics:**

- 100% biodegradable.
- Tencel fibres have been claimed to be more absorbent than cotton, softer than silk, and cooler than linen.
- Tencel fibres have incredible moisture-management properties.
- Tencel effortlessly absorbs moisture and quickly releases it.
- Due to the clean fibre floor, textiles crafted from Tencel feel very smooth on the pores and skin.
- Tencel fibres have outstanding dye functionality.
- Unlike wool, tencel isn't always attacked by moths.
- Tencel fabrics are properly draped.
- Tencel waddings offer better thermal insulation in contrast to polyester fabrics.
- Tencel has a very high absorption capability, a unique nano-fibril structure, and a very smooth surface.[3]

**FLAX:**

The interior stem bark of a plant growing in temperate and subtropical regions of the world yields flax fibre. It is a multifunctional, cellulose-based herbal bast fibre. Since the polymers in flax are almost parallel to the fibre axis, flax is stronger than cotton. One of the earliest types of fibre is flax. Linen is a term for cloth made from flax. The Swiss Lake Dwellers, who lived about 8000 BC, left behind remnants of linen, while Egyptian tombs included linen mummy coverings that were more than three thousand years old. Actually, the linen industry was thriving throughout Europe up until the 18th century. But after the invention of strong spinning, cotton replaced flax as the most important and widely used fibre. Flax has become a prestige fibre in recent years because of its low output and relatively high cost. Clothing made of linen is typically intended for appropriate weather use, excessive fashion factors, or professional positioning.

**Physical properties:**

- Colour: yellowish to grey

- Length: 18 to 30 inches
- Tensile strength: tenacity of 5.5 to 6.5 gms/den.
- Elongation at a break: 2.7 to 3.5%
- Elastic recovery: not enough
- Specific gravity: 1.54
- Moisture regain: 10 to 12%
- Effect of heat: excellent resistance, a good conductor of heat
- Effect of sunlight: not affected
- Resiliency: very poor
- Lustre: brighter than cotton, slightly silky
- Abrasion resistance: moderate

**Chemical properties:**

- Bleaching action: Flax (linen) is more difficult to bleach than cotton because of its huge amount of impurities, like pectin and gum.
- Effect of Acids: Flax is not affected by weak acids but is damaged by concentrated acids.
- Effect of alkali: Flax has good resistance to alkaline solutions.
- Effect of plant solvents: high resistance
- Effect of insects: Flax is not attacked by moths, grubs, or beetles.
- Effect of microorganisms: Attacked by fungi and bacteria, mildew feeds on linen fabrics.
- Dye ability: not a good affinity for dyes. Direct and vat dyes are suitable for flax fibre.[4]

**Characteristics:**

- **Garments that are manufactured from linen are secure to use because,** as the linen fibre is a natural vegetable fibre, it has a large amount of air porosity. So, the air can go inside and out even as you sport those linen clothes, which make the garments pretty comfy.
- **Linen fibre is stronger than cotton.** Another reason for the popularity of linen fibre is that you will get the same comfort as cotton inside the linen fibre, but the energy of the linen fibre is two times that of the cotton fibre. Most sports put on wherein the power is an issue, there the Linen fiber made linen clothes is extensively used.
- **Hand-cleanable and dry-washer-friendly:** You cannot only wash the garments linen but also smooth the clothes through drying. So, making linen clothes through the use of linen fibre is a realistic selection for the fabric industry owner.
- Crisp feeling: if you touch the linen fibre, you can sense that it's actually crisp fibre, which has a precise outlook and feels
- **Tailors well:** One textile weaver or cloth knitter can without problems make the linen fabric through the usage of the bendy linen fibre, and the tailors of the garment shop can even without issues make dresses and suits by way of the use of the linen fabric.
- **Absorbent:** The absorbency of linen fibre is quite good, and this is why linen can be dyed nicely.
- **Dyes and prints nicely: Alongside the** best overall performance in dyeing, you'll be capable of effects printing the linen cloth except for any type of issue like print paste saturation, discoloured floors, and so forth.
- **Light-weight Heavyweight:** Any form of linen fabric or linen fibres are to be had within the market, which can be finished in any weight as long as it is consistent with the fabric customers' requirements.
- **No Static and Pilling Troubles:** If any fabric produces static energy for the duration of the put-on, then nothing can be worse than that. Humans want to position themselves on cloth that is flexible and comfortable to place on. Linen is the right fabric in this regard, as it has no static energy or pilling troubles.
- **Right Abrasion Resistant:** Because the linen fibre is strong, it is meant to have good abrasion resistance.

**HEMP:**

Hemp fibres, which can be obtained from the hemp plant, which is a species of cannabis, are regarded as one of the more durable members of the bast natural fibre family. Due to their biodegradability and low density compared to synthetic fibres, those fibres have recently acquired extensive beauty when used as reinforcement in composite materials. These materials also have built-in mechanical, thermal, and acoustic qualities. [5]

**Physical Properties:**

- Colour: The colour of hemp fibre is yellowish-grey to deep brown.
- Length: 4 to 6.5% feet.

- Tensile Strength: Hemp is a very strong fibre.
- Elongation at break: Hemp fibres stress easily.
- Elastic Recovery: Elastic recovery is very poor. It is less dense than linen fibre.
- Moisture Regain (MR%): Standard moisture regain is 12%. It is more than cotton and linen.
- Effect of Heat: Hemp fibre has excellent resistance to degradation by heat.
- Effect of Sunlight: It has enough ability to prevent the bad effects of sunlight.
- Lustre: highly bright, like linen fibre.

**Chemical Properties:**

- Effect of Acid: Hemp is attacked by hot, dilute, or cold, concentrated acids, which disintegrate it. Hemp fibre is destroyed, like cotton fibre, by the action of acid.
- Effects of Alkalis: Hemp fibre has excellent resistance to alkalis.
- The Effect of Plant Solvents: It is not affected by plant solvents.
- Effects of Insects: Hemp fibre is not attacked by moth grubs or beetles.
- Effect of Microorganisms: Hemp fibre is attacked by fungi and bacteria. Mildews will feed on hemp fabric, rotting and weakening the materials. Mildews and bacteria will flourish on hemp under hot and humid conditions. They can be protected by impregnation with certain types of chemicals. Copper naphthalate is one of the chemicals.
- Ability to Dye: It is not suitable for dyeing hemp fibre.[6]

**Characteristics:**

- Hemp is one of the most effective and longest-lasting of all natural fabric fibres.
- You can say it gets higher with age! The more hemp is used, the softer it becomes.
- Hemp is resistant to moderate UV, mildew, and mould.
- Hemp is notably absorbent, making it easy to dye and an incredible canvas for herbal dyes. Depending on the plant and processing techniques, hemp can clearly be creamy white, brown, grey, nearly black, or inexperienced.
- Like linen, hemp has exceptional thermo-regulating properties, making it best for preserving coolness in warm weather or warmth in cool climates.
- Hemp may be gadget washed and dried. It wrinkles less than linen and calls for less ironing.
- Hemp could be very much like flax in appearance. Hemp fibres can be 3 to 15 feet long.
- Hemp's elastic recuperation might be very poor; it stretches much less than another natural fibre.
- Hemp possesses antibacterial properties.
- Hemp fibres may be very long—3 to 15 feet!

**LOTUS:**

Lotus fibre is a unique type of natural cellulose fibre that is narrow, aromatic, smooth, and hygroscopic. It also has remarkable breathability, liveliness, and superior hygroscopicity. Amazingly, they are unquestionably stain-resistant. The home of the lotus fibre is specific. It is without a doubt delicate, light, highly breathable, and wrinkle-free. Compared to cotton fibre, lotus fibre has less moisture. The tensile strength of lotus was discovered to be superior to silk and equivalent to linen in a fascinating research of lotus composite fibres. Lotus fibre can be used in technical fabrics for industries like science, the automobile industry, and aerospace because its inherent modulus has been shown to be higher than that of silk. It is the most environmentally friendly textile in use today, having attained GOTS (Global Plant Textile Standard) accreditation through chemical-free manufacture and growth in muddy water. It is biodegradable and plant. It increases rural residents' employment and is experimental. Fibre is beneficial for the growth of the body's immune system since it contains harmful oxygen ions made by lotus fibre resources.

**Properties:**

- It has resistance to pilling.
- It has the advent of uncooked silk or linen.
- It has a milky yellow colour.
- It has the asset of self-cleansing.
- It is stiff, cool, mild-weight, wrinkle-unfastened, stain-resistant, crease-resistant, water-proof, gentle, easy, finer, sustainable, and environmentally friendly. The period range of lotus fibre is about 31–50 mm.
- The width of lotus fibre ranges from 50 to 90 mm.
- The fineness of single fibre is 3.963 to 4.516 m. [7]
- The initial modulus is 146.81 cn/dtex.
- Breaking tenacity is 3.44 cn/dtex.



- Elongation at break is 2.75%.
- The density of lotus fibre is 1.1848 g/cc.
- The ratio of length to fineness is about 104.
- The linear density of lotus fibre is 1.55 dtex.
- The moisture content of lotus fibre is 12.32%. [8]
- The crystallinity of lotus fibre is 38.50%.
- It is air-permeable and relaxed.
- It has excellent elasticity.
- It dries fast.
- It absorbs moisture.
- It is cool in the summer and hot in the winter.

**Characteristics:**

- It is a cellulosic fibre and the finest aquatic fibre. (Waterproof fibre)
- It is a cool, stiff, breathable, and secure fibre.
- It has a specific elasticity.
- It is a crease-resistant fibre.
- It absorbs moisture however dries rapid.
- Fabric produced with this fibre has excellent properties.
- It doesn't incorporate any chemical or toxic merchandise, so it produces ecological cloth.
- The production approach doesn't require any gasoline, strength, or more water.
- The entire system takes place within the framework of sustainable development.
- It gives pleasant effects when blended with silk, cotton, kapok, and banana fibres in exceptional proportions.

**III. CONCLUSION**

The increased demand for sustainable and ecologically friendly products has led to an increase in the usage of plant fibres in the textile industry in recent years. Numerous advantages of using plant fibres include lowered environmental impact, greater health and safety, and improved product quality. However, there are drawbacks to the use of plant fibres in the textile sector as well, including greater production costs and a dearth of plant materials. Despite these obstacles, the textile industry's drive towards sustainability is likely to continue, and the use of plant fibres will play a bigger part in this movement. In order to satisfy consumer demand for sustainable and environmentally friendly solutions, it is critical for manufacturers to take into account the advantages and limitations of plant fibres and develop creative ways to incorporate them into their goods. In general, using plant fibres is a step in the right direction towards a more sustainable and accountable textile sector.

**REFERENCES**

- [1]. C. Prakash. (2020). Bamboo Fiber. Handbook of textile fibers (Second Edition). Volume 1: Types, Properties and Factors Affecting Breeding and Cultivation, Woodhead Publishing Series in Textiles, Pages 219-229.
- [2]. Navin Chand, Mohammed Fahim. (2021). Tribology of natural fiber polymer composites (second edition). Woodhead Publishing Series in Composites Science and Engineering, Pages 1-59.
- [3]. Q.Dai. *Flax and ramie*. (2006). Biomechanical Engineering of textiles and clothing. Woodhead Publishing Series in Textiles, Pages 403-412.
- [4]. Anna Kicińska-Jakubowska, Edyta Bogacz & Małgorzata Zimmiewska (2012) Review of Natural Fibers. Part I—Vegetable Fibers, Journal of Natural Fibers, 9:3, 150-167, DOI: 10.1080/15440478.2012.703370
- [5]. *What is banana fabric? Properties, How it is made and where*. (2022 November 24). <https://sewport.com/fabrics-directory/banana-fabric>
- [6]. Md. Jasimuddin Mandal. (2013 January 4). *Tencel Fiber: Properties, Manufacturing Process, Uses, Advantages and Disadvantages*. <https://textilelearner.net/tencel-fiber-properties-manufacturing/>
- [7]. *Lotus Fibre*. (2021 May 9). <https://www.textilecoach.net/post/lotus-fibre>
- [8]. Dr. Tanveer Hussain. (2014 October 28). *Important properties of tencel fibers*. <https://thetextilethinktank.org/important-properties-tencel-fibers/>