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# Development Of Eco-Friendly Fabric Using Banana Fiber And Cotton Yarn.

**Vedha Valli S[1], Dr P Nithya[2]**
[1]M.Sc Student, [2]Assistant Professor, Department of Costume Design & Fashion, PSG College of Arts & Science, Coimbatore.

**Abstract-** This study develops eco-friendly fabrics using banana fiber blended with cotton yarn, utilizing banana pseudostem waste as a renewable textile resource. Today utility of natural fibres is increasing at a global level due to the growing concern on the environment. Manufacturing synthetic fibres from petroleum based products are found to be harmful, non-biodegradable and consume more energy [1]. Banana fiber, known for its strength, moisture absorbency, and biodegradability, was extracted, softened, and degummed to enhance spinnability and fabric performance. The study encompassed various stages of textile production, including fiber processing, yarn spinning, fabric construction, and finishing techniques, to develop sustainable banana-cotton blended fabrics. The developed banana-cotton blended fabrics exhibited satisfactory strength, breathability, and comfort, with a reduced environmental footprint compared to conventional textiles. The findings highlight banana fiber's potential as a sustainable alternative raw material, supporting agricultural waste utilization, rural livelihood generation, and circular economy principles. The blended fabrics are suitable for apparel and home textile applications, contributing to eco-friendly textile innovations.

**Keywork:**Eco-friendly fabric, Banana fiber, Sustainable textiles, Textile innovation, Cotton yarn, Biodegradable, Renewable resource, Agricultural waste.

## I. Introduction

The textile industry's substantial environmental footprint has accelerated the search for sustainable and biodegradable materials. This review examines the potential of banana fiber, an underutilized agricultural waste product, for eco-friendly textile production. Banana fiber's desirable properties, such as high tensile strength, moisture absorbency, and biodegradability, make it an attractive alternative to conventional fibers. However, its limitations in terms of stiffness and coarseness necessitate blending with cotton yarn to enhance comfort, flexibility, and spinnability. This article reviews recent advancements in banana fiber processing, blending strategies, and fabric development, highlighting the potential of banana-cotton blends for sustainable textile production. The review also discusses the environmental benefits of vaporizing agricultural waste and reducing dependence on resource-intensive cotton cultivation, supporting a shift towards environmentally responsible textile production systems. To meet living environment requirements and increasing social perception, the natural material might be greater chances [3].

Cross section of pseudo stem of banana tree (left) and banana leaf (right) [Retrieved from Motalebetal. 2020 [5].

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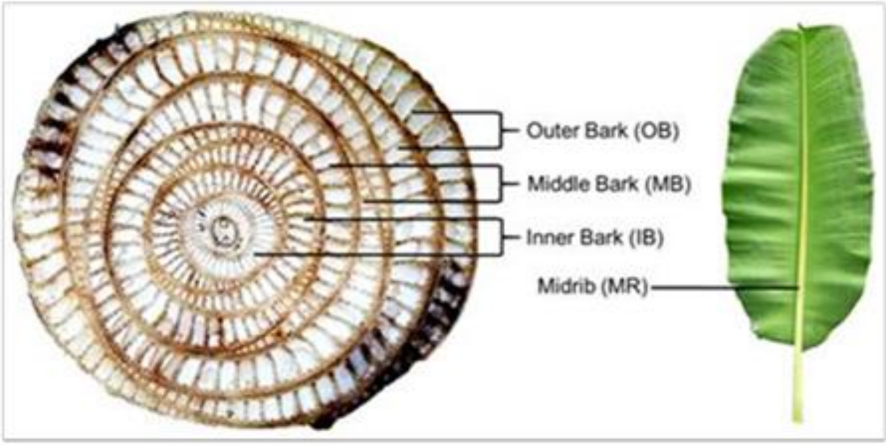


**Objectives:**

- To know about the features of banana & cotton.
- To design the saree with the combination of banana & cotton.
- To assess the mechanical, physical & comfort properties of the material.
- To know about the properties of the natural dyes.

## II. materials

**1.Properties of Banana Fiber:**
Banana Fiber, a lignocellulosic Fiber extracted from banana pseudostems, possesses desirable properties making it suitable for eco-friendly textile applications. Its high tensile strength, low density, and excellent moisture absorbency contribute to its potential as a sustainable alternative to conventional fibers. Additionally, banana fiber exhibits good thermal stability, moderate elasticity, and antimicrobial activity, enhancing its durability and hygiene in textile products. However, its stiffness and surface roughness require chemical or enzymatic softening for apparel applications. The fiber's cellulose-rich composition supports dye uptake, while its biodegradable nature ensures environmental compatibility, aligning with circular economy principles and reducing end-of-life waste.

**Process:**
- Banana Pseudo stem
- Extraction for Fiber
- Washing
- Softening
- Carding
- Spinning
- Winding

## 2. Banana-Cotton Blended Yarns:

Blending banana fiber with cotton yarn addresses the limitations of banana fiber's stiffness and coarseness, enhancing spinnability, softness, and overall fabric performance. The synergy between cotton's flexibility and banana fiber's strength creates a balanced blend with improved tensile properties, reduced hairiness, and better moisture management. Optimized blend ratios yield fabrics suitable for diverse applications, including apparel, home textiles, and technical uses, with enhanced biodegradability and a reduced environmental footprint. This approach leverages the strengths of both fibers, promoting sustainable textile production and expanding the potential uses of banana fiber in mainstream textiles.

## 3. Banana-Cotton Blended Fabric in Saree Application:

Banana-cotton blended fabrics demonstrate promising properties for saree production, offering a unique combination of comfort, durability, and aesthetics. The fabric's soft yet structured drape suits traditional saree designs, with good tensile and tear strength ensuring wearability. Enhanced breathability and sweat absorption make it ideal for warm climates, while its natural sheen and texture add to its aesthetic appeal. The eco-friendly and biodegradable nature of the fabric aligns with sustainable fashion principles. Additionally, the fabric accepts natural and reactive dyes effectively, making it suitable for intricate jacquard designs and traditional border and pallu patterns, offering a balance between traditional handloom look and sustainable innovation. Today utility of natural fibres is increasing at a global level due to the growing concern on the environment. Manufacturing synthetic fibres from petroleum based products are found to be harmful, non-biodegradable and consume more energy. At the same time, banana fiber blends are made up of natural fiber, which not only makes reasonable use of sustainable resources and agricultural waste but also is degradable and friendly to the environment [2] .

Banana – cotton blended fabric

**4. Eco-Friendly Dyeing Process:**

Natural dyes can be classified into different groups based on their application, chemical composition and colour (hue). They can be classified into three major types based on their application: 1- Substantive dyes. 2- Vat dyes. 3- Mordant dyes [4]. Sappan wood (Caesalpinia sappan), a traditional natural dye, yields shades of pink to deep red and reddish-brown on plant-based fibers. Brazilin, the primary coloring compound in sappan wood, undergoes oxidation to form brazilein, yielding the distinctive red coloration characteristic of this natural dye. Its biodegradability and compatibility with cotton and banana fibers make it ideal for eco-friendly textile production, aligning with sustainable development goals.

**Fabric Preparation for Dyeing:**

**Scouring Process**

Scouring is a crucial step in preparing cotton and banana fiber fabrics for dyeing, involving the removal of natural impurities like wax, pectin, oil, and dust. Treatment with a mild alkaline solution or detergent at 60-80°C for 30-45 minutes effectively removes these impurities, enhancing fabric absorbency and ensuring uniform dye uptake. Thorough rinsing and drying follow the scouring process, optimizing the fabric for subsequent dyeing procedures.

**Dye Extraction from Sappan Wood:**

The extraction of dye from sappan wood involves soaking wood chips or powder in water, followed by boiling at 80-100°C for 45-60 minutes to release the colorant compounds. Filtration of the resulting solution yields a reddish dye extract, suitable for textile dyeing applications.

**Mordanting for Enhanced Colour Fastness:**

Mordanting is a critical step in natural dyeing, facilitating dye fixation and improving colour fastness on cotton and banana fabrics. Pre-mordanting involves treating the fabric with a mordant solution at 60-70°C for 30 minutes, followed by light rinsing and transfer to the dye bath. The choice of mordant influences the final shade, producing variations from bright red to darker brownish tones, enhancing the versatility of natural dyeing processes.

**Dyeing Process:**

- Dyeing Temperature: 70-90°C
- Dyeing Time: 45-60 minutes
- Dye Bath Conditions: Slightly acidic pH enhances brightness of red colour
- Fabric Treatment: Continuous stirring ensures uniform dye penetration
- Fiber Characteristics: Banana fiber's higher cellulose content and porous structure facilitate effective dye absorption, producing rich natural shades comparable to cotton.

**Post - Dyeing Treatment:**

After dyeing, fabrics are rinsed thoroughly to remove unfixed dye particles and then shade dried to preserve colour stability and prevent photodegradation-induced fading.

**Dyeing Process:**

- Heat the beetroot dye solution.
- Immerse the saree fully.
- Stir continuously for 45-60 minutes.
- Remove and rinse with cold water.
- Dry in shade.

**Dye Fabric**

**5.Block Printing:**

Block printing is an ancient textile printing method that uses carved wooden blocks to transfer intricate designs onto fabric. This eco-friendly technique is widely practiced on cotton and silk fabrics using natural or synthetic dyes.
Process:

- Fabric Preparation: Cotton or silk fabrics are desized, scoured, and bleached to remove impurities, ensuring optimal dye absorption.
- Block Preparation: Designs are carved onto wooden blocks (typically teak wood), with each colour requiring a separate block.
- Printing Paste: Dyes or pigments are mixed with thickeners, binders, and auxiliaries to create a smooth paste. Natural dyes like indigo, turmeric, or sappan wood are often used.
- Printing: The block is dipped in paste and pressed onto the fabric, repeating the pattern with precision.
- Drying & Finishing: Fabric is air-dried, washed to remove excess dye, and ironed for a crisp finish.

Block Printing 1

Block Printing 2

**6.Testing Process:**

The performance of banana-cotton blended fabrics for saree applications is assessed through various tests, including fabric weight (GSM), tensile strength, tear strength, abrasion resistance, air permeability, moisture absorbency, colour fastness, and shrinkage. These tests evaluate the fabric's suitability for saree drape, durability, comfort, and aesthetic appeal. Key performance indicators include:

- Fabric weight (GSM): influences drape and thickness.
- Tensile and tear strength: ensure durability and resistance to wear.
- Abrasion resistance: evaluates surface durability.
- Air permeability and moisture absorbency: impact breathability and comfort.
- Colour fastness: assesses dye durability and resistance to fading.
- Shrinkage: measures dimensional stability after washing

## III. Results And Discussion

**1.Colour fastness to perspiration:**

Colourfastness to perspiration is an important quality parameter for textiles, especially for garments and other articles which exposed to sweat. Standards tests for color fastness to water wash, soap and chlorinated water and acid wash other unique conditions. Results were findings the cloth is not fading while doing above tests.

| **Assessment (Colour Fastness to Washing)** | **Rating(Fabric )** | |
|---|---|---|
| | Alkaline | Acidic |
| Change in color | 4-5 | 4 |
| Staining on | - | - |
| Wool | 4-5 | 4 |
| Polyester | 4-5 | 4 |
| Acrylic | 4-5 | 4 |
| Nylon | 4-5 | 4 |
| Cotton | 4-5 | 4 |
| Rubbing | | |
| Dry Rubbing(Staining) | 4 | 4 |
| Wed Rubbing(Staining) | 4-5 | 4 |

5 = No change (Excellent), 4 = Slight change, 3 = Noticeable change, 2 = Considerable change, 1 = Severe change

Table 1 Colour Fastness to washing

| **Assessment (Colour Fastness to Light)BW2**<br>**ISO 105 B02: 2014** | **Rating(Fabric) Instrument- Xeno Tester** |
|---|---|
| Light Fading | 5-6 |
| Change in hue | No |

Table 2 Colour Fastness to light

2.Absorption Test:

The measurement of static water absorption of terry fabrics were carried out using Bureau Veritas Consumer Product services BV S1008 internal testing method. The samples were conditioned and cut in to 10 cm x 10 cm and their mass evaluated. The samples were kept in water for five minutes at room temperature. After that the samples were hanged for three minutes to remove excess water. Then, mass of the wet samples were measured. The amount of water absorbed by the terry fabric samples were calculated by taking the difference between the wet and dry mass. The percentage of water absorption was calculated by the following formula.

$$Sw = (m_{mw} - m_d)/m_d \times 100 \ (1)$$

Where: Sw = water absorbed, mw – Product wet mass, md – Product dry mass.

SW= 2.5- 1.0/ 2.5 X 100=60%

| S. No | Sample Code | Size of the Materials | % of Absorption |
|---|---|---|---|
| 1 | Fabric | 10 10 cm | 60.0 |

Table 3 Absorption Test

**3.Air Permeability Test: (ISO 9237TEST SCOPE)**
This international Standard describes a method for measuring the permeability of fabrics to air and is applicable to most types of fabrics, including industrial fabrics for technical purpose, nonwovens and made-up textile articles that are permeable to air.

1. Handle the test specimens carefully to avoid altering the natural state of the material.
2. Place each specimen onto the test head of the test instrument and perform the test as specified in the manufacturer's operating instructions.

3. Place coated test specimens with the coated side down (towards the low-pressure side) to minimize edge leakage.

4. Use a water pressure differential of 100 Pa (12.7 mm or 0.5 in. of water).

5. Read and record the individual test results in SI units as cm3/s/cm2 and in inch-pound units as ft3/min/ft2 rounded to three significant digits.

6. For special applications, the total edge leakage underneath and through the test specimen may be measured in a separate test, with the test specimen covered by an airtight cover, and subtracted from the original test result to obtain the effective air permeability. Remove the tested specimen and continue testing until all the specimens have been tested for each laboratory sampling unit.

| S. No | Sample Code | Size of the Materials | Pressure | Air permeability | Porosity % |
|---|---|---|---|---|---|
| 1 | Product | fabric | 100 pa | 152 mm | 65 |

Table 4 Air Permeability Test

**4.Tensile Strength (ASTM D5034 and D5035):**
The tensile strength of a material is the maximum amount of tensile stress that can be applied to it before it ceases to be elastic. Tensile strength is measured in units of force per unit area. The unit is newton per square meter (N/m^2), kilogram (force) per square centimeter (kg/cm^2) or pounds per square inch (psi)

| Name of the sample | Size | Breaking elongation | % of Tensile Strength |
|---|---|---|---|
| Fabric | 20 x 5 cm | 7.0 % | 50 % |

Table 5 Tensile Strength Test

**Report:**
Under the strength test Breaking elongation and tensile strength shows excellent strength for given fabric sample.

**5.Fabric Shrinkage Test: (ISO 6330 AATCC)**
Testing Procedure:

a. Sample Preparation: Cut 3-5 fabric samples
b. Marking: Mark reference points (e.g., a square within the sample).
c. Washing & Drying: Wash and dry the samples according to standard procedures or specific care instructions.
d. Conditioning: Leave the washed fabric in standard atmospheric conditions to reach moisture equilibrium. Calculate the shrinkage percentage

$$\text{Shrinkage} = \frac{\text{Dimension before wash- Dimension After}}{\text{Dimension before wash x 100}}$$

Shirnkage = 10-09.5/10 x 100=5%

| Name of the sample | Size | % of Tensile strength |
|---|---|---|

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| | | |
|---|---|---|
| Fabric | 10 x 10 cm | 5 % |

Table 6 Fabric Shrinkage Test

**6.Abrasion Test:**
1.At first cut the underarm pad according to the measurement of the instrument.

2.Weigh of the of fabric sample.

3.Now place these samples in the instrument under a certain load as supplied in the instrument.

4.Now start the Abrasion Tester machine for 300 cycles for 5 sec.

5.Now put the weights before and after abrasions in a table and find out their wear index.

| Name of the sample | Sample wt. before abrasion (g) | No. of Cycle | Sample wt. After abrasion (mg) | Weight loss | Wear index |
|---|---|---|---|---|---|
| fabric | 5816 mg | 300 | 5795mg | 21 mg | 72 |

Table 7 Abrasion Test

**Report:**
It is easily understood that the more is number of abrasion cycle the less amount of weight loss for fabric sample. The given fabric sample is not more weight loss, wearing index shows 72 respectively.

**7.Tear Resistance: (ASTM D412)**
The tear resistance test on fabrics or tear strength is measured to check how the material can withstand the effects of tearing or cuts when in tension. The tear strength is measured as per the ASTM D412 standard test method

| Name of the sample | Warp Direction | Weft Direction |
|---|---|---|
| | | |

| | | |
|---|---|---|
| Fabric | 80 | 44 |

Table 8 Tear Resistance Test

**Finish Garment**

## IV. CONCLUSION

The development of banana-cotton blended fabrics offers a promising approach to sustainable textile production, leveraging agricultural waste to create eco-friendly materials. By combining the strengths of banana fiber and cotton, these blends achieve a balance of strength, comfort, and aesthetics while reducing environmental impact. The blended fabrics exhibit acceptable physical, mechanical, and comfort properties, making them suitable for apparel and home textile applications. This innovation supports rural employment, promotes eco-conscious fashion, and aligns with global

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sustainability trends, presenting a viable pathway for environmentally responsible textile production.

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