iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 14 **Issue:** II **Month of publication:** February 2026

**DOI:** https://doi.org/10.22214/ijraset.2026.77665

# Chemical and Mechanical Characterization of Bauhinia Racemosa Fibre and its Potential Textile Applications

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***Abstract: Bauhinia racemosa is an underexplored bast fibre–yielding tree whose bark provides a moderately strong, low-density fibre with promising technical and functional attributes. This review synthesizes current knowledge on the extraction, morphology, chemical composition, and mechanical behaviour of B. racemosa bark fibre, along with its existing and potential textile applications. The fibre exhibits typical lignocellulosic characteristics, with high cellulose and comparatively low lignin and wax content, supporting favourable strength-to-weight ratios and good interfacial bonding in composites. Microstructural studies reveal multicellular fibre bundles with a rough surface conducive to mechanical interlocking, though short, fragile staple length constrains conventional spinning. Mechanical evaluations indicate medium tensile strength and stiffness at the fibre/strand level and significant improvements in tensile, flexural and impact properties when used as reinforcement in polyester and epoxy composites at optimized loadings. Traditional and experimental applications already include ropes, cords, and Ayurvedic sutures, with the latter demonstrating acceptable tensile performance and biocompatibility. The presence of tannins and flavonoid-rich phytochemicals in bark and associated tissues suggests additional scope for bio functional textiles, including antimicrobial or wound-care materials. Limitations such as fibre shortness, processing variability, and limited standardized textile data are highlighted, alongside research needs in retting optimization, yarn development, bio functional finishing and life-cycle assessment. Overall, B. racemosa emerges as a niche, sustainable bast fibre suited for ropes, sutures, agro textiles, geotextiles and composite-based technical textiles, rather than mainstream apparel applications.***
***Keywords: Bauhinia racemosa, bast fibre, mechanical properties, polymer composites, technical textiles***

## I. INTRODUCTION

Bauhinia racemosa is a small deciduous tree in the family Fabaceae (subfamily Caesalpiniaceae) widely distributed in India and other tropical regions. The bark is thin, grey-brown and yields a strong cordage fibre that has long been used locally to make ropes, torches, slow matches, and to tie cattle. Inner bark fibres are also used in Ayurvedic practice as suturing material under the name “Ashman taka”, highlighting their fineness and tissue compatibility.

Bauhinia racemosa is an under-explored bast fibre source whose bark yields a relatively strong fibre already used traditionally for ropes and cords, and more recently studied for composites and sutures.

Beyond its mechanical usefulness, the bark and leaves are rich in tannins and flavonoids, and are described as astringent, antipyretic and wound-healing; the fibre itself is even reported for sewing wounds. This dual role as a bast fibre and as a source of bioactive compounds makes B. racemosa interesting for functional textile and biomedical textile concepts.

## II. FIBRE EXTRACTION AND MORPHOLOGY

### A. Extraction Methods

Most studies extract Bauhinia racemosa bast fibre from the stem bark using simple mechanical and water-based treatments.

1) In composite work on “Indian Bauhinia racemosa (Aati) fibre”, bark is peeled from stems, sun-dried, manually beaten and combed to separate fibre bundles; fibres are then chopped (e.g., 30 mm) for polyester or epoxy composites.
2) In the Ayurvedic suture study (Ashman taka), bark is stripped, fibres are manually teased, cleaned, and sometimes boiled/autoclaved prior to twisting into suture yarns

These low-technology extraction routes align with traditional bast-fibre processing and indicate that retting or mild alkaline treatment could be optimized for more uniform textile-grade fibre.

 

### B. Physical Characteristics and Microstructure

The extracted fibre shows typical bast fibre morphology: multicellular fibre bundles, surface roughness due to adherent hemicellulose and lignin, and lumen-containing individual cells. Important observed features include

1) Length: Individual fibres are short and fragile, with maximum lengths of about 10–12 cm; practical strands of ~30 cm are prepared by twisting several fibres. Thislimits use in long-staple spinning but suits ropes, cords, and short-fibre yarns.
2) Diameter: Suture filaments showed diameters in the range 0.08–0.40 mm before autoclave, reducing slightly to 0.05–0.30 mm after autoclaving. Diameter depends strongly on the number of elementary fibres in the twisted strand.
3) Colour and handle: The raw fibre is described as creamish-white with smooth texture, indicating relatively low surface impurities compared with darker, heavily lignified fibres.

Scanning electron microscopy (SEM) of B. racemosa fibre and its composites reveals fibre pull-out, matrix cracking, fibre breakage and interfacial debonding as dominant failure modes, confirming a rough surface favourable for mechanical interlocking, but also the need for interface tailoring for high-performance composites.

## III. CHEMICAL COMPOSITION AND RELATED PROPERTIES

### A. Lignocellulosic Composition

B. racemosa bark fibre is a typical cellulosic bast fibre composed mainly of cellulose, hemicellulose and lignin, along with minor waxes, pectins and ash. Recent physicochemical studies on Bauhinia racemosa fibre for epoxy composites report

- A high cellulose content with comparatively low lignin, ash and wax fractions, suggesting good potential for mechanical strength and low density.
- The compositional profile is similar to other bast fibres used in textiles and composites, such as those from related Bauhinia and Albizia species, where cellulose contents of ~60–70 wt% and lignin contents around 10–15 wt% are common.

Higher cellulose and lower lignin are generally associated with better tensile properties and dyeability, while low wax content favours adhesion and wetting.

### B. Phytochemical Constituents and Functional Potential

The plant as a whole (bark, leaves, seeds) is rich in flavonoids, tannins and triterpenoids

- Identified constituents include methyl gallate, gallic acid, kaempferol, quercetin and several glycosides (e.g., quercetin 3-O-α-rhamnoside, rutin
- Phytochemical studies on B. racemosa leaves and seeds report phenols, saponins, flavonoids, glycosides and tannins as dominant groups

While most of these studies focus on medicinal extracts, the presence of tannins and phenolics in the bark matrix suggests inherent astringent and antimicrobial tendencies that might persist to some extent in minimally processed fibre. This is relevant for applications such as sutures, wound dressings, or hygienic technical textiles, where mild bioactivity is advantageous.

### C. Thermal and Physicochemical Behaviour

Composite studies using B. racemosa fibre suggest that the fibre exhibits typical bast-fibre thermal behaviour:

- Thermal stability adequate for processing with thermoset matrices (polyester, epoxy) at moderate temperatures.
- In hybrid Bahunia racemosa/glass fibre systems, increased natural fibre content reduced thermal conductivity, indicating porous, low-density fibre architecture useful for insulation and comfort.

Differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) reported in these works show multi-step degradation associated with hemicellulose, cellulose and lignin decomposition, similar to other lignocellulosic fibres, which constrains textile finishing and dyeing temperatures but is adequate for most apparel and interior textile processes.

## IV. MECHANICAL PROPERTIES OF BAUHINIA RACEMOSA FIBRE AND COMPOSITES

### A. Single fibre and strand properties

Direct single-fibre data for B. racemosa are limited, but the available measurements from suture strands and composite studies provide a picture of moderate strength and stiffness.

1) Suture thread ("Ashman taka")
    - Tensile strength of the twisted B. racemosa suture thread was about 8.8 MPa, with a breaking load of 9.8 N, increasing to 10.4 N after autoclaving, while elongation remained around 1.85%.

- These values are below those of high-performance textile fibres, but acceptable for skin closure where moderate strength and pliability are sufficient.

*2)* Comparison to other natural fibres

Composite work comparing "Aati" fibre with banana, coconut and sisal reports that the intrinsic tensile strength of Bauhinia racemosa fibre is higher than that of elephant grass and banana fibre, and the tensile modulus exceeds that of elephant grass and banana. Moreover, B. racemosa fibre has lower density than banana, coconut and sisal, providing a favourable specific strength for lightweight composites and textiles.

Although absolute values depend on test conditions, these findings position B. racemosa as a medium-strength bast fibre, stronger than some agricultural by-product fibres but below classic textile bast fibres like jute and flax, whose single-fibre tensile strengths often range from several hundred to over 800 MPa.

### *B. Short-fibre Polyester and epoxy Composites*

Most mechanical data come from polymer composites reinforced by short B. racemosa fibres:

1) Polyester composites (IAFP – Indian Aati fibre/polyester):
2) Randomly oriented short fibre composites, with fibre lengths around 30 mm, were fabricated by compression moulding and tested per ASTM standards.
3) Tensile strength of Aati fibre/polyester composites reached about 18.8 MPa at an optimum fibre loading around 40 wt%.
4) Flexural strength was approximately 34.1 MPa at similar fibre content.
5) Water absorption increased with fibre content, but optimum performance was observed at lower fibre percentages (around 10 wt%), indicating a trade-off between strength and moisture sensitivity.
6) Epoxy Composites: Newer work on Bauhinia racemosa fibre-reinforced epoxy reported systematic improvements in tensile, flexural and impact properties with increasing fibre loading, up to an optimum beyond which fibre agglomeration and poor wetting degrade properties. SEM images showed fibre pull-out and fibre breakage under load, confirming effective load transfer but also interfacial failure typical of untreated natural fibres.
7) Hybrid and mat Composites: Studies on Bahunia racemosa/glass hybrid composites and fibre mat reinforced polyester composites indicate that B. racemosa fibre mats can produce higher tensile, flexural and impact strength than some competing natural fibres, and that hybridization with glass further improves performance.

These property levels, combined with low density and renewability, support the use of B. racemosa fibre in semi-structural applications such as interiors, panels and casings, overlapping with several technical textile domains.

## V. TEXTILE AND TECHNICAL TEXTILE APPLICATIONS

### *A. Traditional uses: ropes and cords*

Ethnobotanical and forestry sources consistently note that B. racemosa bark produces a strong fibre used for:

1) Durable ropes for general utility, ladder making, and tying cattle.
2) Torches and slow matches, where the fibre acts as a wick and support.

These uses exploit the fibre's moderate strength, abrasion resistance and availability in rural landscapes. The relatively coarse, bast-type fibre suits cordage rather than fine apparel yarns.

### *B. Sutures and biomedical textiles*

Ayurvedic literature and a dedicated textile-style evaluation of "Ashman taka" demonstrate that B. racemosa fibre can be processed into suture thread:

1) The prepared suture, made by twisting four monofilaments, showed acceptable tensile strength, manageable diameter and stable properties even after autoclaving.
2) Authors concluded that Ashman taka suture thread is "only a step behind" standard requirements and can be used as a safe alternative to cotton suture in skin closure, with good knot security and handling.

The combination of adequate mechanical performance, ease of twisting, and the plant's traditional wound-healing reputation suggests potential for:

- Biodegradable sutures and ligatures.
- Traditional-medicine-inspired wound closure materials.
- Future biofunctional dressings, if fibre-based nonwovens or gauzes are developed.

### C. *Apparel and home textiles: potential and limitations*

There is little documentation of B. racemosa as a conventional apparel fibre, largely due to fibre length, coarseness and fragility. Challenges for apparel use include:

1) Short and fragile fibres (10–12 cm) that complicate long-staple spinning.
2) Medium strength and stiffness that may not justify the processing cost compared to established bast fibres.
3) Moisture uptake and dimensional instability typical of lignocellulosic fibres.

Nonetheless, blending short B. racemosa fibres with other bast or cotton fibres in rotor-spun or air-jet yarns could yield rustic yarns for:

- Hand-crafted textiles, rugs, and mats.
- Eco-friendly furnishings and decorative textiles where coarse texture is acceptable.

### D. *Geotextiles and agrotextiles*

The mechanical profile and biodegradability of B. racemosa fibre make it a candidate for low-cost geotextiles and agrotextiles. While specific geotextile trials with this species are not yet widely reported, analogous bast fibres are successfully used in:

1) Erosion-control mats and blankets.
2) Mulch and weed-control fabrics.
3) Biodegradable nets and twines.

The polyester composite study highlights the fibre's adequate tensile and flexural performance and lower density, which are also desirable in woven or nonwoven geotextiles. Using B. racemosa in such applications could provide value addition in regions where the tree is abundant.

### E. *Composite-based technical textiles*

Polymer composites incorporating B. racemosa fibres demonstrate potential for semi-structural applications including:

1) Automobile interior parts, electronic packaging, building components, bonnets and sports goods, as proposed by the polyester composite authors.
2) Panels and laminates based on woven or nonwoven fibre mats that fall within the scope of technical textiles (e.g., automotive textiles, construction textiles).

In these roles, B. racemosa fibres act as reinforcement within a matrix; the final composite may be processed into sheets, moulded parts, or thick technical textile forms.

## VI. ADVANTAGES, LIMITATIONS

### A. *Advantages*

1) Abundance and renewability: B. racemosa is common in many parts of India, and bark fibre is readily harvested as a renewable resource.
2) Moderate mechanical performance at low density: Fibre strength and stiffness are competitive with several non-textile bast fibres and suitable for composites, ropes and sutures.
3) Functional phytochemistry: Presence of tannins and flavonoids, and documented antimicrobial and antioxidant activities in plant extracts, indicate potential for bioactive materials.
4) Traditional acceptance: Longstanding use for cordage and wound sewing supports biocompatibility and rural user acceptance.

### B. *Limitations*

1) Short, fragile fibres that are highly prone to breakage, limiting spinning into fine yarns and making long, continuous filaments difficult to obtain.
2) Limited standardised textile data, such as fineness (tex/denier), bundle tenacity and elongation, which hinders direct comparison with cotton, jute, flax and hemp.
3) Moisture uptake and dimensional instability, inherent to lignocellulosic fibres, affecting durability and comfort if not properly finished.
4) Processing variability, as most studies use manually extracted fibres, leaving scaling-up and process optimisation largely unexplored.

## VII. CONCLUSION

Bauhinia racemosa bark fibre is an emergent bast fibre with documented use in traditional cordage and sutures and growing interest as reinforcement in polymer composites. Chemically, it is a high-cellulose, low-lignin lignocellulosic fibre, structurally similar to other bast fibres but distinguished by its moderate strength, lower density and the presence of tannin-rich, bioactive components. Mechanical studies on short-fibre polyester and epoxy composites demonstrate adequate tensile and flexural properties, particularly at optimised fibre loadings around 40 wt%, supporting its suitability for lightweight technical products.

From a textile perspective, the fibre's coarseness, short length and fragility limit its immediate use in mainstream apparel, but it is well positioned for ropes, cords, sutures, agrotextiles, geotextiles and composite-based technical textiles. With further research into extraction, spinning, finishing and biofunctionalisation, B. racemosa could evolve from a locally used bark fibre to a niche sustainable fibre for specialized textile applications, especially where biodegradability and functional phytochemistry are valued.

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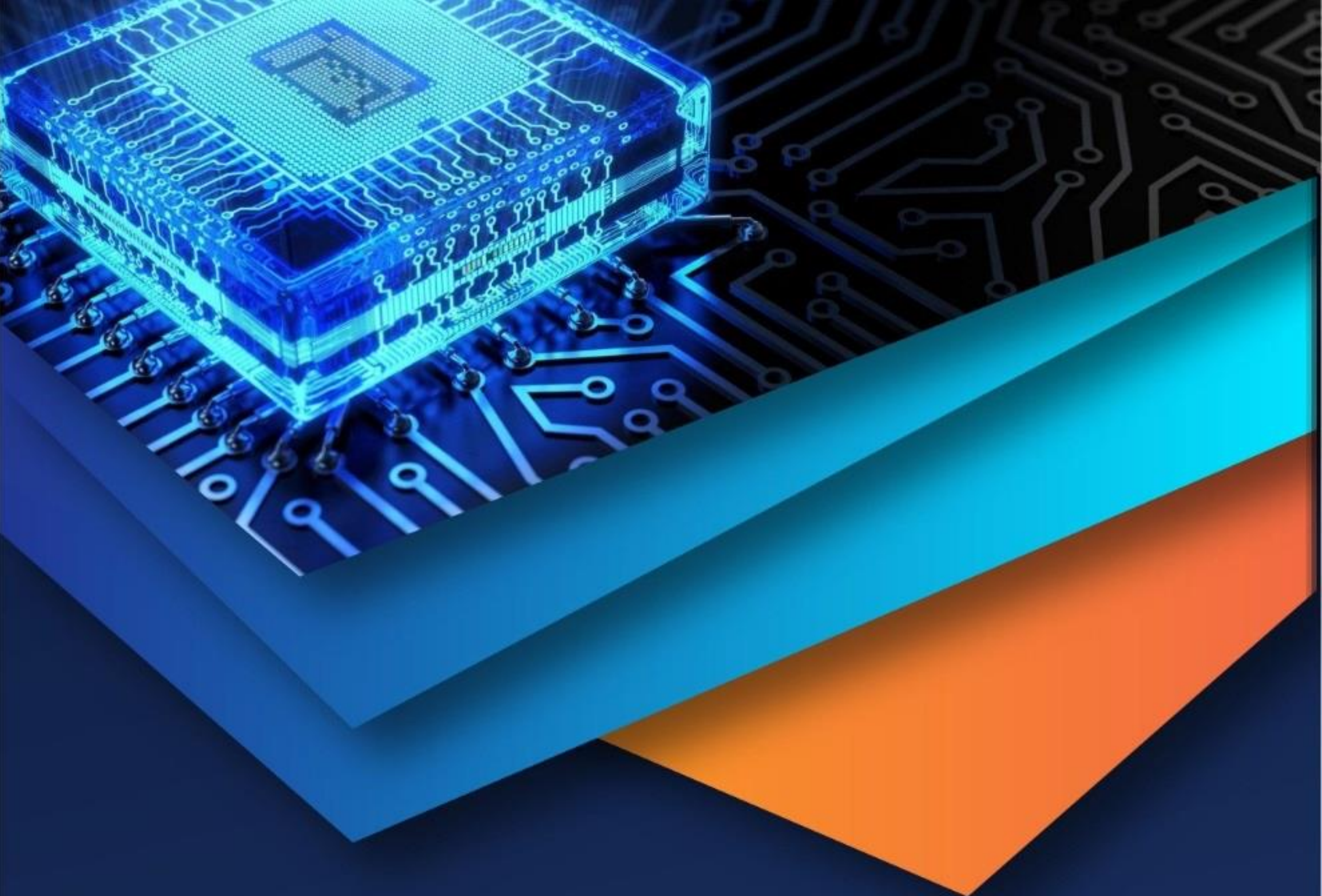


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