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Application of tree bark peel-based materials in sustainable product prototype development

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Abstract: *This research explores the application of Grewia tiliifolia (Dhaman tree) bark peels-based material in sustainable product prototype development by transforming natural bark waste into functional and esthetically appealing product. Various experimental samples were developed using techniques such as weaving, dyeing, layering and mesh integration of evaluating their structural, visual and sustainable properties based on the comparative analysis. A bark mesh lampshade prototype was selected and developed to demonstrate the practical applicability of bark-based material in contemporary product design. A survey involving 40 participants was conducted to evaluate the prototype in terms of material quality, durability, esthetics, lighting effect, sustainability and purchase interest. The findings revealed highly positive responses toward the prototype, highlighting its ecofriendly valued handcrafted appearance and market potential. The study concludes that tree bark peel-based material possess significant potential as sustainable alternatives for innovative product development while encouraging environmental consciousness and preservation of traditional craft practices in modern design.*

Keywords*: Tree bark, Grewia tillifolia (Dhaman), Product design, Sustainability.*

1. INTRODUCTION

The growing demand for sustainable and ecofriendly products has encouraged designers and researchers to explore innovative natural materials for product development. In the recent years, waste based and biodegradable materials have gained importance as alternatives to synthetic and environmentally harmful resources. Among these, tree bark possesses unique textural, structural and aesthetic qualities that offer. Potential for sustainable product applications. However, limited research has focused on the practical application of bark peel-based material in product development and design innovation. In this context, the bark of Grewia tiliifolia (Dhaman tree) was explored as sustainable material for developing functional and aesthetically appealing product. This study focuses on the application of tree bark peel-based material in sustainable product development through experimental design, exploration and prototype creation, contributing toward ecofriendly material innovation and sustainable design practices.

The project also includes the development of a **final prototype**, showcasing the practical application and design potential of bark-based materials. Overall, this research contributes to promoting sustainable design approaches by turning natural waste specifically Dhaman tree bark peels into valuable and creative material alternatives.

2.Background of the study

In this context, the bark of Grewia tiliifolia (Dhaman tree) presents unique potential known for its fiber structure, strength and flexibility. Dhaman tree bark can be processed into material suitable for various sustainable applications. By experimenting with this natural resource, designers can develop innovative materials that can combine aesthetic appeal with environmental responsibility.

This Study builds upon these ideas by developing and testing tree park samples using different experimental techniques. The research also extends to evaluating their aesthetic functional and environmental performance leading to the creation of final sustainable product prototype. Through this approach, the project aims to contribute to the field of sustainable design by transforming natural waste into a valuable resource for creative material development.

3.Aim

To explore the application of tree bark peel-based materials in sustainable product development by creating functional and aesthetically appealing prototypes through experimental design techniques.

The research further aims to evaluate the performance and visual quality and feasibility of these developed materials to sample experimentation and prototype development, ultimately contributing to innovative and sustainable material alternatives for contemporary design practice.

4.Objective

To explore the application of tree bark peel-based materials in developing sustainable and aesthetically appealing product prototypes.

5.Scope of the Study

This study focuses on the application of three bar peel-based materials in the sustainable product development through experimental design, exploration and prototype creation. The research includes the development of functional and aesthetically appealing products using bark-based material in different weaving techniques. The study is limited to small scale prototype development and design experimentation emphasizing sustainability, material adaptive adaptability and ecofriendly product applications. However, the research does not include large scale manufacturing and commercial production or market testing.

6.Limitations of the Study

- Scope of the material: The experimental exploration is limited to tree bark peels specifically from the Grewia Tiliifolia (Dhaman)species.
- Scale of testing: Material development and testing were conducted on small scale, which may not accurately reflect results for large-scale production.
- Artisan feedback: Qualitative feedback was restricted to only two artisans experienced in bamboo and bark craft techniques.
- Sample Size: The quantitative survey involved only 40 participants, which may be insufficient to generalize the findings to a broader population.
- Resource Constraints: The extent of experimentation and prototype development was limited by available time, materials, and resources.

7.Significance of the Study

The research promotes resource efficiency and supports sustainable design practices. The findings contribute to the growing field of alternative bio-based materials offering new insights for designers, researchers and industries aiming to reduce environmental impact. The developed samples and the prototype demonstrate how a natural bark can be creatively proposed into functional and aesthetically appealing products.

8. Review of Literature

Sustainable design research increasingly emphasizes the use of natural and biodegradable materials to minimize environmental impact and promote circular design practices. Provide studies has explored plant fibers, bark-based materials and agricultural waste as ecofriendly alternatives in product and material design. However, limited research has focused on the application of tree bark pills as a functional and aesthetically appealing material for sustainable

product development. This review of literature analyses existing studies related to natural and bark-based material and identifies the research gap, the practical utilization of *Grewia tiliifolia* (Dhaman tree) bark peels within contemporary product design practices.

Tree bark as a material

Tree bark has traditionally been used in handicrafts, weaving and indigenous material practices due to its flexibility, texture and natural strength. Recent studies have explored bark as a sustainable material for ecofriendly applications. However, its use in product development remains under Explore the Bark of *Grewia tiliifolia* (Dhaman tree) possesses unique structural and visual qualities that make it suitable for experimental product applications. Therefore, this study investigates the application of tree bark in base materials in sustainable product development through prototype creation and design experimentation.

Studies on bark-based material

Here's a categorized overview of plants whose bark is traditionally used for daily life items:

Textiles & Clothing (Barkcloth)

Denner, A. & Reilly, F. "The Fabric of Life: Early Polynesian Barkcloth in Context." National Museums Scotland, 2017-2018 project.

Fig. 1 Traditional Ugandan barkcloth (source: www.nationalgeographic.com)

Ropes, Mats, and Straps

Fig. 2 Traditional woven mat from bark (source: northhouse.org)

Bark Uses in India (Textiles & Weaving)

Bark Strips (for weaving & mats)

- Sterculia villosa ("Udal tree")
- Bark easily peels into sheets or strips.
- Traditionally used for mats, ropes, coarse weaving, sometimes paper.

Reference: Indian Forester 116(8): 621–627 (1990).

- Grewia tiliifolia (धामण / "Dhāmṇ")
- Inner bark strips used for ropes, mats, coarse textile experiments.
- Fibers are tough and flexible.

Reference: Journal of Natural Fibers (2018): properties of Grewia bast fibers.

- Hibiscus tiliaceus (Coastal / SE India, Andaman–Nicobar)
- Bark strips softened and used for ropes, nets, lashings, mats.
- Common in coastal fishing communities.

Fig. 3 Fiber of bark of hibiscus tiliaceus arrangement (source: reserchgate.net)

Reference: Pacific Science 36(1): 1–17 (1982).

Bark Fibers (retted, separated & woven like thread)

- Grewia spp. (various regions in India)
- Used for cordage, ropes, mats.

About Grewia tiliifolia (*Dhaman*) tree bark

Grewia tiliifolia (*Dhaman*)

Here's a detailed look at *Grewia tiliifolia* (sometimes spelled tilifolia) from the perspective of its bark / bast fibers and their potential for weaving, textile use, and product development. (www.flowersofindia.net)

Fig. 4 Grewia tillifolia tree Fig. 5 tree (bark view) Fig. 6 Tree Bark peel

(Source: taken by researcher, location: Ratnagiri, Maharashtra)

What is Grewia tiliifolia

- *Grewia tiliifolia* Vahl is a tree in the Malvaceae (formerly Tiliaceae) family, distributed in India, Sri Lanka, Indochina etc.
- It is used traditionally for medicine (bark, leaves), fodder, fuel, tool handles, etc.
- The bark is known for being astringent, vulnerary, etc.

Selection of prototype

Taken together, the literature supports the choice of a lampshade as a demonstrated product. Bark materials have a precedent in lighting can be processed into sheets/films/panels and their unique texture produce desirable light diffusion. The documented light sensitivity of some barks means experimental testing of translucent durability and surface treatment is important and novel, especially because *Grewia tiliifolia* has not been extensively studied for material design. The prototype therefore fills both an applied design role and a gap in species-specific material research.

Research Gap

In summary, while the literature acknowledges the sustainability potential of a bark as a natural and renewable resource, this remains a critical research gap in exploring its creative transformation through textile and design techniques. Existing studies have not sufficiently investigated how tree bark pills can be processed combined with other natural residues and aesthetically enhances for application in product design.

Therefore, this research seeks to fill this gap by developing, experimenting with and analysing bark-based material samples, applying various weaving, dyeing and compositing techniques, assessing their design, aesthetic and sustainability performance. The findings will contribute to establishing a new framework for a bark-based material innovation, bridging craft knowledge, sustainable design practice and the material development.

9. Research Methodology

This study follows an exploratory and experimental research methodology aimed at developing and evaluating sustainable materials made from tree bark peels and exploring their potential application in product design. The research process was conducted in four main stages, material experimentation, artisan feedback, prototype development, and prototype analysis by user survey.

Overview

Phase 1 – Material experimentation and Sample Development

- Collection and preparation of *Grewia tiliifolia* (Dhaman) bark peels.
- Development of **seven experimental samples** using different surface and structural design techniques (weaving, dyeing, pressing, etc.).
- Documentation of the visual, textural, and structural qualities of each sample.

Phase 2 – Prototype Development

- Based on sample analysis, selected one most suitable technique for product application.
- Designed and developed a lampshade prototype using bark material to demonstrate its functionality and visual potential in sustainable design.
- The prototype served as a practical example of eco-conscious design using natural waste-derived resources.

Phase 3 – User Evaluation and Data Analysis

- Conducted a survey with 40 participants to assess the prototype in terms of:
  - Aesthetic appeal
  - Material innovation
  - Functionality and usability
  - Environmental consciousness
- Data was analysed to interpret user preferences and acceptance of bark-based sustainable products.

Phase 1 – Material experimentation and Sample Development

Process of extracting the bark from tree is the first primary step for all samples.

Fig. 7 Tree branches Fig. 8 extract bark peels from branches Fig. 9 Bark stripes

All materials were chosen for their biodegradability and low environmental impact**,** aligning with sustainability principles.

Experimentations

This experimental study focuses on exploring various weaving techniques using natural fibers, plant residues, and upcycled materials to understand their structural behavior, aesthetic value, and potential for product development. The experiments combine traditional craft principles with innovative metal combination to create sustainable textile surfaces.

Sample 1 – Plain Basket Weave with Dyed Bark Strips

- Technique: Basic plain weaves, using evenly cut bark strips.

Fig. 10 tree Bark

Fig. 11 Weaving pattern with dye color

- Potential: High potential for use in small lifestyle accessories such as wallets, clutches, or decorative panels due to its durability and clean aesthetic.

Sample 2 – Cross Basket Weave Design

- Technique: Crossed basket weave, with intersecting layers of bark strips.

Fig. 12 Cross Basket Weave Design patterned sample.

- Potential: Moderate potential for decorative surfaces, packaging, or rigid panels, where visual texture is prioritized over flexibility.

Sample 3 and 4 – Traditional Round Basket Weave & the yamabudō — (tight plaited lattice) Basketry technique

Sample 3

- Technique: Spiral or radial weave patterns inspired by traditional basketry.

Fig. 13 Traditional round basket weave sample

Sample4

- Technique: yamabudō — (tight plaited lattice) Basketry technique



Fig. 14 Small piece Fig. 15 small strips cutting Fig. 16 Main sample

- Potential: High potential for 3D forms and container-like products such as coasters, trays, or structural elements in home décor.

Sample 5 – Plain Basket Weave using Corn Peels and Rice Husk

- Technique: Simple over–under basket weave.

Fig. 17 Plain Basket Weave using Corn Peels and Rice Husk sample

- Potential: High potential for upcycled product applications like eco-packaging, lamp covers, or panels due to its sustainable and aesthetic quality.

Sample 6 – Fabric Swatch using Bark Fiber Extract (Plain Weave)

Technique: Plain weave using extracted bark fibers spun into fine threads.




Fig.18 Tree barks Fig.19 soak in water (7 days) Fig. 20 Extract fibres Fig. 21 sunlight dry



Fig. 22 twist the fibres Fig. 23 Weaving on frame Fig. 24 completed sample swatch

- Potential: Very high potential for sustainable textile applications—bags, upholstery, or fashion accessories—if further processed for softness and finishing.

Sample 7 – Bark Strips with Cancan (Hybrid Material)

- Technique: Integration of vertical bark strips woven or attached with black cancan net structure.

Fig. 25 Cutting the tree barks with thin stripes

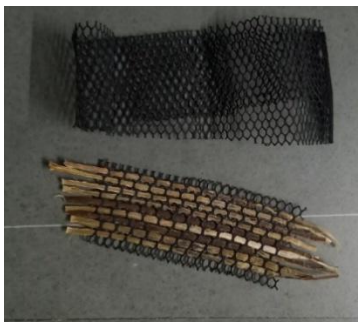

Fig. 26 inserting stripes into net mesh material

- Potential: High potential for innovative material development—ideal for conceptual products, experimental garments, or mixed-media panels.

Phase3: Prototype development

Selection of Technique

The Final Pro. Type was developed using the woven bark and the mesh technique within thin bark strips (7th sample) were interlaced through a flexible synthetic net. This technique was selected for its balance for structure, translucent and flexibility, making it suitable for creating a three-dimensional surface that allows light diffusion.

Among all experimental samples, this combination offered the most versatile and stable construction. The bark strips provided a natural textural appeal and rigidity, while the mesh space contributed flexibility and uniform spacing, allowing light to pass through without compromising structural strength. This dual material interaction represents a successful integration of organic and synthetic systems, aligning with a research aim to explore material innovation through sustainable design experimentation.

Criteria	Description / Observation	Relevance to Lampshade Prototype
Material Composition	Combination of natural bark strips interlaced with a flexible cane or mesh base	Ensures both organic visual quality and stable structural support
Texture Quality	Contrast between rough natural fibers and smooth mesh surface	Creates tactile richness and visual depth when illuminated
Light Interaction	Semi-transparent surface allows filtered, diffused light	Produces a warm, ambient glow ideal for interior lighting
Structural Integrity	Mesh acts as reinforcement while bark adds surface density	Maintains lampshade shape and prevents sagging or deformation
Craftsmanship Value	Integrates traditional basketry weaving with experimental hybrid material use	Represents innovation within sustainable craft practices
Aesthetic Appeal	Blend of natural and modern aesthetics; earthy tone with contemporary pattern	Complements minimal, eco-modern interior styles
Sustainability	Uses renewable bark fibers; partial use of synthetic mesh extends product life	Balances eco-friendliness with durability for long-term use
Functional Efficiency	Lightweight yet sturdy; easy to mold into curved forms	Practical for hanging or table lampshade structures
Design Expression	Symbolic fusion of nature and technology	Reflects design intent of connecting heritage crafts with modern design thinking

Table 1 Summary of Material & Aesthetic Suitability

Design Development

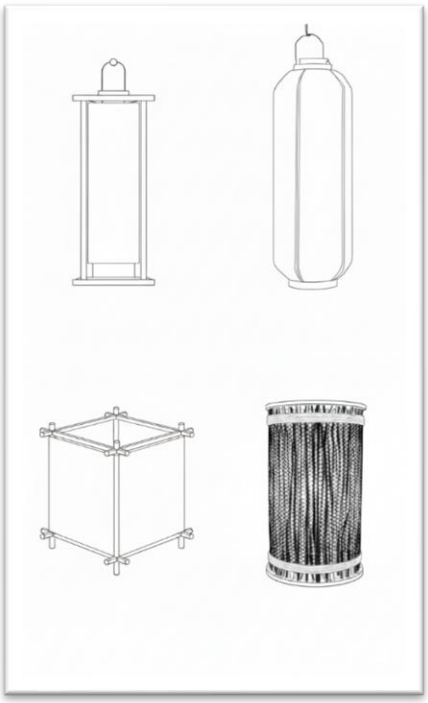

Fig. 27 Design Development

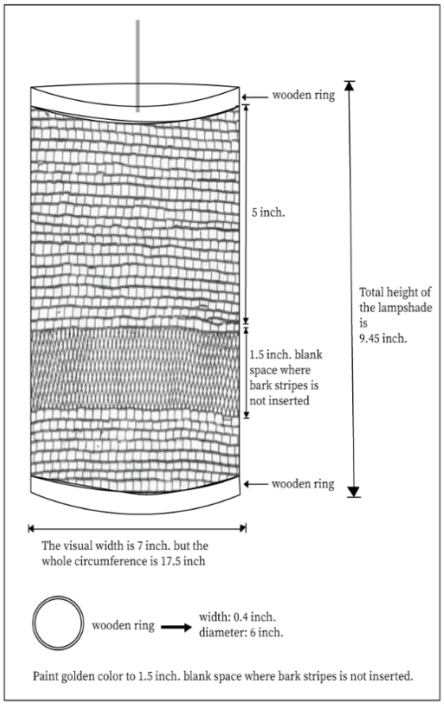

Fig. 28 Final design

Making Process

Step1. Cut the thin strips and cut the cancan Part for require size.

Fig. 29 Cutting the thin stripes

Fig. 30 Cutting the cancan with size 19” by 9.5”

Step2. Insert the strips into cancan through their holes alternatively.

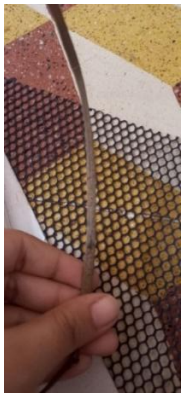

Fig. 31 Cut the strip as per requirement Fig. 32 insert the strip into material

Step3. Insert all the stripes and finish the main part.

Fig. 33 completed the main part with insert all stripes

Step4. Attach both sides with glue and make round shape.

Fig. 34 Attach both sides with glue and make round shape.

Step5. Attach both wooden rings to both ends.

Fig.35 attaching both wooden rings to both side of lampshade

Step6. Color the mid blank space with golden color.

Fig. 36 Color the mid part with golden color

Step7. Add the lacquer to finishing.

Fig. 37 Lacquer finish

Final Product

Fig. 38 Final Product(a)

Fig. 39 Final Product(b)

Fig. 40 Product with light (a)

10. Result and Discussions

Prototype Development

survey

A total of 40 participants were selected as a sample size for this study. This survey method was used to collect feedback for assessing the product prototype. A lampshade made from tree bark and can can mesh. The survey aimed to evaluate the product based on key parameters such as material quality, design, aesthetics, functionality, sustainability and market potential.

This user cantered approach helps in understanding the audience perception of the product and its acceptance as a sustainable design innovation

Analysis

Parameter	Criteria	Response Summary	Interpretation
Material Quality	Excellent – 75% Good – 25% Average – 0% Poor – 0%	Majority rated the material as good to excellent	The bark–mesh combination was appreciated for its natural and innovative quality
Durability	Very Durable-90% Moderately Durable – 10% Not durable-0%	Most participants found the product durable	Very small concern about long-term strength and finish
Shape and Aesthetics	Very Appealing -45% Appealing –52.5% Neutral – 2.5% Unappealing – 0%	High appeal in form and visual balance	The design was praised for its organic and handcrafted look
Lighting Effect	Warm & inviting –57.5% Modern & Minimal – 12.5% Rustic & Natural – 30% Dull – 0%	Warm tone most preferred	The bark texture produced a soothing and diffused glow
Sustainability	Strongly Agree – 42.5% Agree – 57.5% Neutral – 0% Disagree – 0%	88% positive sustainability perception	The lampshade successfully reflected eco-friendly values
Purchase Interest	Definitely – 100% Maybe – 0% No – 0%	100% showed buying interest	Great potential for market acceptance

Table 2 Summary of Survey Results for Bark-Based Lampshade Prototype (n = 40)

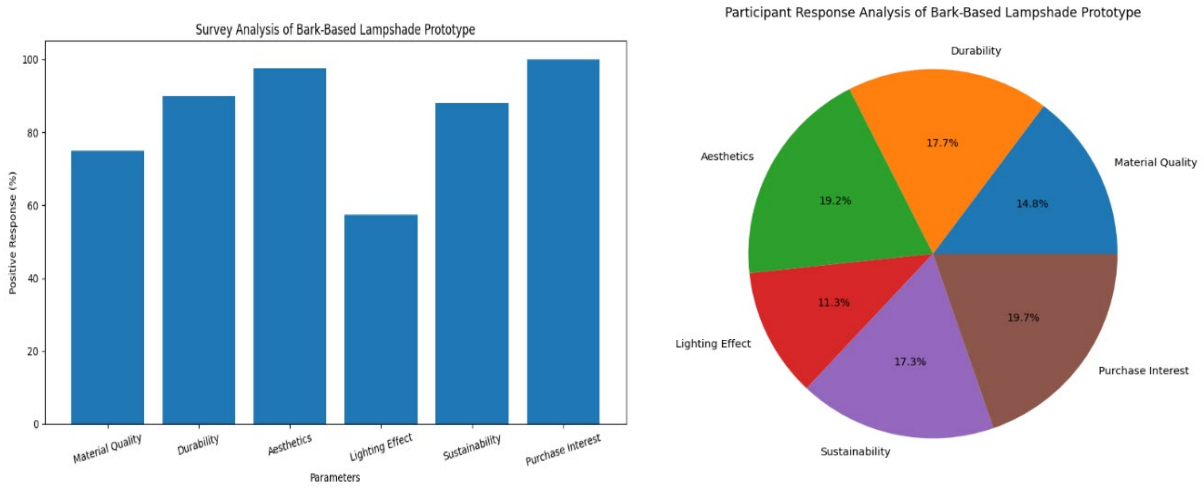

Fig. 41 Bar graph and pie chart for the overall analysis

Overall Interpretation:

The analysis indicates a highly positive response toward the bark-based Lampshade prototype in terms of material quality, durability, aesthetics, sustainability and market acceptance. More participants appreciated the natural texture, handcrafted appearance and warm lighting effect created by the bark material. The high percentage of positive responses for sustainability and purchase interest suggest that tree bark peel-based material have strong potential for sustainable product development and contemporary eco conscious markets. Overall, the findings validate the functional, aesthetic and environmental value of bark-based material as an innovative alternative for sustainable design applications.

11. Findings:

- Majority rated the material quality and visual aesthetics as good to excellent.
- The lighting diffusion created by bark textures was perceived as warm and inviting.

- Over 80% of respondents recognized the sustainable value of the product.
- Around 100% expressed interest in purchasing such a product.

✓ This shows objective is fulfilled.

12. Conclusion

In conclusion, the study demonstrated that tree bark peel-based materials possess significant potential for sustainable product development. The experimental samples and prototype evaluation revealed that material offers desirable aesthetic qualities, satisfactory durability, functional adaptability and strong sustainability value. The positive feedback from the participants further confirms that acceptance and market potential of bark-based products in contemporary design. The research highlights how natural waste materials such as Grewia Tillifolia (Dhaman tree bark) can be transformed into innovative and ecofriendly design solutions, encouraging future exploration in sustainable material innovation and environmentally responsible product design.

13. Future scope and recommendations

- Improve the durability, flexibility and strength of tree bark pail based materials through advanced treatment techniques.
- Explore the combination of bark material with other natural fibers and bio based benders for enhanced functionality.
- Investigate large scale production possibilities and commercial feasibility for sustainable product industries.
- Expand applications of bar based metal in furniture, interior products, passion accessories. Lifestyle products.
- Experiment with innovative weaving, composting, dyeing and surface development techniques.
- Encourage collaborations among designers, artisans, researchers, and local craft communities for sustainable innovation.
- Promote the use of locally available natural waste material in sustainable design, education and contemporary product development.

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