International Journal of Home Science 2025; 11(2): 580-583

International Journal of Home Science

ISSN: 2395-7476
IJHS 2025; 11(2): 580-583

www.homesciencejournal.com
Received: 27-05-2024
Accepted: 28-06-2024

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Sustainable dyeing of tencel fabric using *Beta vulgaris*

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Abstract
This study explores the sustainable dyeing of 100% Tencel fabric using natural pigments extracted from Beta vulgaris (beetroot peel) and Myrobalan as a natural mordant. The research aimed to evaluate the physical, chemical, and fastness properties of the dyed fabric under various mordanting techniques, ultimately identifying pre-mordanting as the most effective. Objective evaluations, including tensile strength and color fastness to washing, sunlight, perspiration, and rubbing, confirmed the efficiency of the eco-friendly dyeing approach. The dyed fabric was also utilized for the development of end-use products like handkerchiefs. This study supports the broader shift toward sustainable textile practices.

Keywords: Natural dye, tencel, beta vulgaris, eco-friendly textile, mordanting, color fastness, myrobalan

Introduction
In recent years, there has been a growing demand for eco-friendly practices in the textile industry due to the harmful environmental impacts of synthetic dyes and chemicals. Consumers and manufacturers are shifting toward sustainable alternatives that are safe for both human health and the environment. Among various sustainable approaches, the use of natural dyes derived from plant-based sources has gained considerable attention. Natural dyes are biodegradable, renewable, and generally non-toxic, making them an ideal choice for developing environmentally responsible textile processes [1, 8].

Tencel, a regenerated cellulose fiber produced from sustainably harvested wood pulp, is widely recognized for its softness, strength, breathability, and biodegradability. It serves as an excellent substrate for natural dyeing due to its high absorbency and smooth surface [2]. In this project, beetroot peel (Beta vulgaris), a commonly discarded vegetable waste, was selected as the natural dye source. It contains betalain pigments that impart a vibrant reddish hue and possess antioxidant and antimicrobial properties [3, 5].

Myrobalan (Terminalia chebula), a traditional herbal mordant, was used to improve dye fixation and enhance fastness properties [4]. This study aims to investigate the effectiveness of beetroot peel dye on Tencel fabric using three different mordanting methods pre-mordanting, simultaneous, and post-mordanting and to assess the resulting color fastness and strength of the dyed material. By repurposing vegetable waste and adopting herbal treatments, the project contributes to sustainable fashion practices and promotes circularity in textile production.

Materials and Methods
Materials
The primary fabric selected for this study was 100% Tencel, a twill weave fabric with 40 ends per inch and 40 picks per inch. Tencel was chosen for its eco-friendly origin, high moisture absorbency, and smooth texture, making it an ideal substrate for natural dyeing [2, 6]. The dye source used was beetroot peels (Beta vulgaris), a commonly discarded vegetable waste material rich in betalain pigments that provide a natural reddish-purple hue [3, 5].

As a natural mordant, Myrobalan (*Terminalia chebula*) powder was selected for its astringent properties and rich tannin content, which improves dye adherence and enhances fastness properties [4, 7]. Other auxiliaries used during the dyeing process included common salt (sodium chloride) to support dye fixation and tap water for all wet processing steps [8].

Preparation of dye extract

Beetroot peels were collected from fresh beetroot, thoroughly washed to remove dirt and residues, and then dried at room temperature for 2-3 days. The dried peels were ground into a coarse powder using a household grinder. To extract the dye, 100 g of beetroot peel powder was boiled in 1 liter of water for 30 minutes. The solution was then cooled and filtered using a muslin cloth to obtain a clear reddish dye extract, which was used immediately for the dyeing process.

Fig: Beetroot peels

Fig: Dye extract

Mordanting methods

Three different mordanting techniques were applied to evaluate their effect on dye uptake and fastness properties:

Pre-mordanting: The Tencel fabric was treated with Myrobalan solution (200 g in 1 L water) at 60°C for 30 minutes, then rinsed and dried before dyeing.

Simultaneous mordanting: Myrobalan was added directly to the dye bath along with the dye extract, and the fabric was dyed without pre-treatment.

Post-mordanting: The fabric was first dyed and then treated with Myrobalan solution at 60°C for 30 minutes.

All mordanting methods used a material-to-liquor ratio (M:L) of 1:20, with 200 g of Myrobalan and 200 g of salt per bath.

Fig: Pre-mordanting

Fig: Simultaneous mordanting

Fig: Post-mordanting

Dyeing procedure

The mordanted or unmordanted Tencel fabric samples were immersed in the beetroot dye solution and dyed at 100°C for 60 minutes with continuous stirring. After dyeing, the fabrics were rinsed in cold water to remove excess dye and were then cured at 180°C for 2 minutes to enhance dye fixation. The dyed fabrics were shade-dried under ambient condition.

Testing and evaluation

The dyed samples were subjected to the following standard textile tests: Color fastness to washing (ISO 105-C06)
Color fastness to rubbing (dry and wet) (ISO 105-X12) Color fastness to perspiration (ISO 105-E04)
Color fastness to light (ISO 105-B02)
Tensile strength and tear strength using a universal strength tester
All tests were conducted under standardized laboratory conditions. Fastness ratings were recorded using the standard gray scale for color change and staining.

Results and Discussion

Evaluation of mordanting techniques

The effectiveness of dyeing Tencel fabric with beetroot peel extract was assessed through three different mordanting methods: pre-mordanting, simultaneous mordanting, and post-mordanting. The results clearly indicated that pre-mordanting yielded the most intense and uniform color shade, with deeper penetration of dye molecules. This can be attributed to the tannin-rich Myrobalan treatment, which provided increased binding sites on the fiber surface prior to dye application. Simultaneous mordanting showed moderate results, while post- mordanting produced the lightest shades, suggesting poor dye-fiber int eraction in the absence of pre-treatment.

Color fastness properties

The dyed samples were evaluated for color fastness to washing, rubbing, perspiration, and light using ISO-standard test methods. The pre-mordanted samples consistently showed superior fastness ratings (4-5) across all tests, indicating strong dye-fiber affinity and mordant fixation. Simultaneous mordanting resulted in acceptable ratings (3-4), while post-mordanting samples showed noticeable fading and staining (ratings of 2-3).

Table 1: Role of myrobalan as an effective natural mordant that enhances dye fixation and wash durability

Test type	Pre-mordanting	Simultaneous	Post-mordanting	Standard
Washing fastness	4-5	3-4	3	ISO 105-C06
Light fastness	3	2-3	2	ISO 105-B02
Rubbing (Dry)	4	3-4	3	ISO 105-X12
Rubbing (Wet)	3	2-3	2	ISO 105- X12
Perspiration fastness	4	3	2-3	ISO 105-E04

These results confirm the role of myrobalan as an effective natural mordant that enhances dye fixation and wash durability

Tensile and tear strength analysis

The mechanical properties of the fabric were tested before and after dyeing to evaluate the effect of natural dyeing on structural integrity. There was no significant deterioration in tensile strength or tear resistance observed in any of the samples. In fact, a slight increase in weight was noticed after dyeing, likely due to the deposition of natural dye particles and mordant on the fiber surface. This suggests that the dyeing process was non-destructive and preserved the fabric's usability for functional purposes.

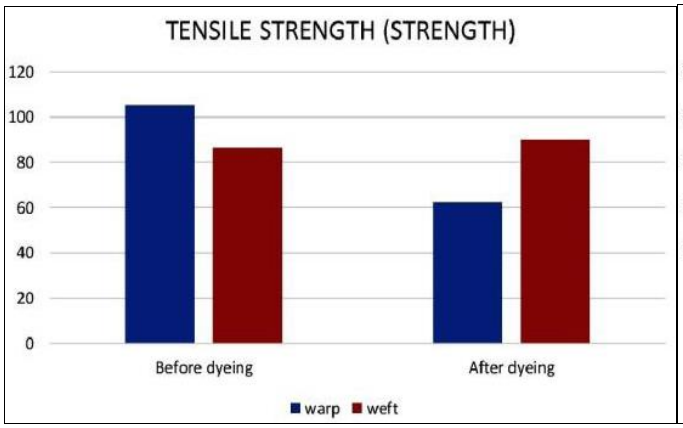

Fig: Tensile strength (Strength)

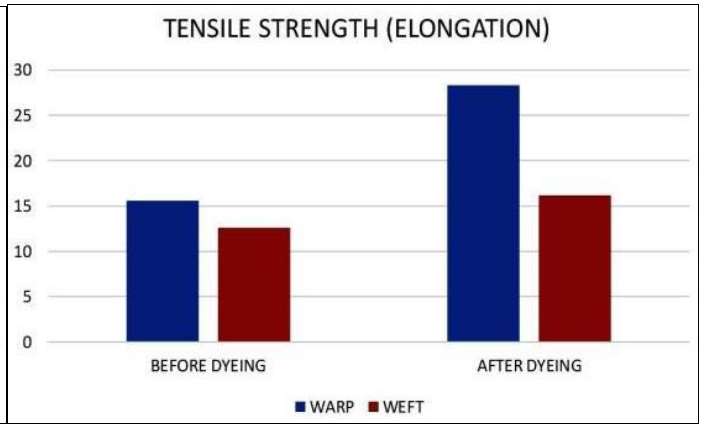

Fig: Tensile strength (Elongation)

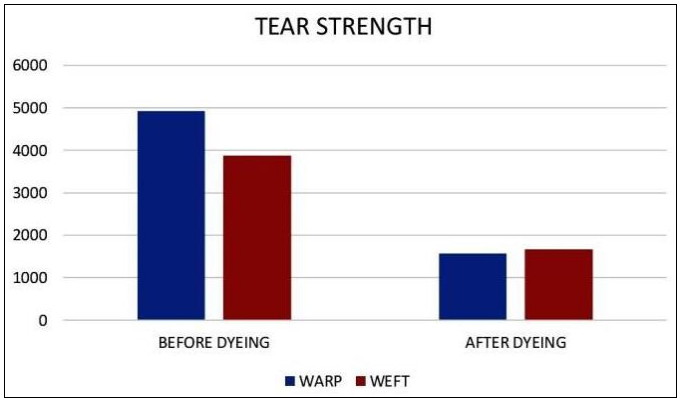

Fig: Tear strength

Development of end-use products

To demonstrate practical application, the pre-mordanted and dyed Tencel fabrics were developed into handkerchiefs. The handkerchiefs were finished with folded hems and corner stitching. Subjective evaluation of the products revealed high consumer appeal in terms of color vibrancy, softness, and

eco-aesthetic value. The use of waste-derived dye also adds a sustainability narrative, aligning with current eco-fashion trends.

Fig: Hand kerchief

Visual assessment

The dyed fabrics retained a uniform pinkish-red shade after curing and drying. The visual depth of color was clearly influenced by the mordanting method, with pre-mordanting giving the richest tones. No dye bleeding or color migration was observed during rinsing, reinforcing the fabric's stability and compatibility with natural dyeing techniques.

Conclusion

The present study successfully demonstrates that beetroot peel, an agricultural waste product, can serve as an effective natural dye source for Tencel fabric, particularly when used in combination with Myrobalan as a natural mordant. Among the three mordanting techniques evaluated, pre-mordanting emerged as the most effective method, yielding deeper color shades and superior fastness properties in comparison to simultaneous and post-mordanting.

The dyed fabrics exhibited excellent color fastness to washing and rubbing, along with acceptable performance in perspiration and light fastness tests. Importantly, the dyeing process did not compromise the fabric's tensile and tear strength, indicating that the natural dyeing approach is gentle on the fiber structure.

Additionally, the development of functional end-use products such as handkerchiefs and curtains from the dyed fabric validated the practical applicability of the process. The products were visually appealing, structurally stable, and well-received during subjective evaluation, reinforcing their market potential in sustainable fashion and home textiles.

Overall, this research supports the viability of using natural dyes and herbal mordants as sustainable alternatives to synthetic dyeing systems. It aligns with current global efforts to reduce the environmental impact of textile processing while promoting the use of biodegradable, skin- friendly, and renewable resources in textile coloration.

References

1. Samanta AK, Agarwal P. Application of natural dyes on textiles. Indian J Fibre Text Res. 2009;34:384-399.
2. Amin R, Haque M. Effect of weave structure on fabric properties. Ann Univ Oradea, Fasc Text Leatherwork. 2011;12:161-165.
3. Antigo JLD, Bergamasco RC, Madrona GS. Effect of pH on the stability of red beet extract (*Beta vulgaris* L.) microcapsules produced by spray drying or freeze drying. Food Sci Technol. 2018;38:72-77.
4. Karur I, Singh GS. Dying of cotton with natural dye extracted from *Terminalia chebula* (myrobalan) and its combination with other natural dyes. J Clean Prod. 2012;37:121-129.
5. Herbach KM, Stintzing FC, Carle R. Impact of thermal treatment on color and pigment pattern of red beet (*Beta vulgaris* L.) preparations. J Food Sci. 2004;69:491-498.
6. Indian Standards Institution. ISI Handbook of Textile Testing. New Delhi: ISI; 1982, p. 538-9, 550-1.
7. Angappan P. Textile Testing: Fibers Testing, Yarns Testing, Fabrics Testing and Quality Control. 1st ed. 2009.
8. Paul R. Textile Processing: Printing, Dyeing, Finishing and Emerging Technologies. Cambridge: Woodhead Publishing; 2015.