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Ecological dyeing of cotton fabric with *Areca catechu L.* and *Punica granatum L.* Extracts

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Abstract: Natural dyes are gaining significance in industry due to their lower toxicity compared to synthetic dyes. This study explores the potential of selected plant-based sources, including pomegranate peel, betel nut seed, and prickly pear fruit, as natural dye sources. Cotton fabrics were dyed using extracts from these plants, employing various dye combinations and mordants. The effects of dyeing methods, extraction techniques, and mordants on color strength and fastness properties were investigated. This research contributes to the growing demand for eco-friendly products and highlights the potential of natural dyes in sustainable textile production.

Keywords: Natural Dyes, Plant-Based Colorants, Eco-Friendly Textiles, Sustainable Production, Cotton Fabrics, Dye Extraction, Mordanting Techniques.

I INTRODUCTION

Natural dyes derived from plants, animals, and minerals have been used for centuries to add color and beauty to textiles. The art of natural dyeing has gained popularity due to its safety, environmental benefits, and unique aesthetic appeal (Das & Bhattacharya, 2020; Kumar & Sharma, 2020). Natural dyes are not only eco-friendly but also offer medicinal properties, making them a valuable addition to textile production (Singh & Singh, 2019).To enhance the colorfastness of natural dyes, mordants are employed. Metal ions in mordants form coordination bonds with dye molecules, rendering them insoluble in water. Common mordants include alum, chrome, and copper sulphate. Recent studies have explored the use of eco-friendly mordants, such as plant-based biomordants, to further reduce the environmental impact of natural dyeing (Shahid et al., 2020).In addition to their environmental benefits, natural dyes have also been shown to possess antimicrobial properties, making them suitable for use in textile applications requiring hygiene and cleanliness (Dawkar et al., 2020). The use of natural dyes in textile production has also been found to improve the thermal comfort properties of fabrics, making them suitable for use in clothing and upholstery (Kumar et al., 2022).Recent studies have explored the use of eco-friendly mordants, such as plant-based biomordants, to further reduce the environmental impact of natural dyeing (Shahid et al., 2020).

Areca catechu L, has been used for centuries in traditional medicine, particularly in Southeast Asia. Its chemical composition includes alkaloids, tannins, flavonoids, triterpenoids, steroids, and fatty acids. Recent studies have shown that betel nut has various pharmacological effects (X. Chen et al., 2023).

Punica granatum L rind has been found to have various pharmacological effects, including: Antimicrobial Effects has been found to have antimicrobial effects against various bacteria and fungi (Kumar, P et al., 2022). Antioxidant Effects: has been found to have antioxidant effects, which can help protect against cell damage and oxidative stress(Bhat, R., et al., 2020).Anti-Inflammatory Effects has been found to have anti-inflammatory effects, which can help reduce inflammation and improve overall health.In terms of natural dyeing, pomegranate rind has been found to be a useful source of natural dye, with its high tannin content making it suitable for dyeing textile (Rafieian, S., et al., (2022).

Transition metal ions play a crucial role in natural dyeing as mordants, enabling the fixation of dyes onto textile fibers and improving wash fastness. The mordanting process involves treating textile materials with metallic salts, which facilitates the formation of an insoluble precipitate or lake when dyed with natural dyes. Recent studies have explored the use of eco-friendly mordants, such as plant-based biomordants, to further reduce the environmental impact of natural dyeing (Shahid et al., 2020).

Furthermore, natural dyes can be used to create a wide range of colors, from subtle pastels to vibrant brights. The use of natural dyes in combination with modern textile technologies, such as digital printing, has also opened up new possibilities for the creation of complex, multi-colored designs (Periyasamy et al., 2022).

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II EXPERIMENTAL PROCEDURE

2.1 Fabric Selection and Preparation

For this study, 100% cotton fabric was selected and procured from the market. To remove impurities, the cotton fabric was soaked in distilled water before dye application.The specifications of the selected fabric are as follows: EPI (Ends Per Inch): 60, Count: 40S (carded), PPI (Picks Per Inch): 54, Count: 40^S (carded),Weave: Plain weave and GSM (Grams per Square Meter): 140.

2.2 Collection of Natural Dye Materials

The natural dye materials used in this study, *Areca catechu L.*,nut and *Punica granatum L.* rind were collected from the Mettupalayam village of Tamil Nadu, India.

2.3 Mordant Selection

A mordant is a crucial substance that facilitates the binding of natural dyes to fabric. Mordants can be broadly classified into two categories: plant-based (notably those rich in tannins) and mineral-based (such as Alum, Iron, Tin, and Chrome). Considering environmental sustainability, Alum (KAl(SO4)2·12(H2O)) and Ferrous sulphate (FeSO4) were selected as the mordants for this study, as they are deemed more eco-friendly compared to Chrome, Tin, and Copper-based mordants.

2.4 Method of Extraction of Natural Dye

The natural dye extraction process involved drying and grinding *Areca catechu L* nut and *Punica granatum L* rind into a fine powder, mixing 15g of each powder with water, boil the mixture to 100°C for 20-30 minutes, and then filtering the extracted dye for use in textile dyeing.

2.5 Method of Dyeing

The dyeing process involved cutting fabric samples to required dimensions, weighing, soaking, and removing excess water, followed by pre-mordanting in a mordant solution for 30 minutes, then dyeing in a mixture of Betel nut and pomegranate extracts for 30 minutes, and finally rinsing and drying, with post-mordanting applied to cotton woven fabric after dyeing.

2.6 Laboratory Tests

The natural dyed samples underwent a series of evaluations, including:

2.6.1 Tearing Strength Test

The tearing strength of the fabrics was assessed using a ballistic tester.

2.6.2 Colour Fastness Test

Colour fastness refers to the resistance of a dyed textile to colour change when exposed to specific conditions. The magnitude of colour fastness is crucial, as it depends on the fabric's intended use. The following colour fastness tests were conducted to determine the colour fastness properties of the dyed samples.The colour fastness of the dyed samples was evaluated through two tests: colour fastness to washing, which involved soaking samples in a soap solution and assessing colour change and staining using the grey scale, and colour fastness to rubbing (crocking), which involved using a crock meter to simulate rubbing and evaluating colour transfer and staining.

III RESULTS AND DISCUSSION

The study's findings are presented below.

3.1 Tensile Strength (ASTM D 5034)

Table 1 summarizes the tensile strength and fastness properties of dyed cotton fabrics. Notably, the combination dyeing method using Areca catechu L nut and Punica granatum L rind yielded excellent washing, light, and rubbing fastness properties, making it suitable for commercial applications and meeting acceptable standards.

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Table 1: Tearing Strength of dyed Cotton fabric

S.No	Dye	Mordant	Mordanting Methods	Tearing Strength			
				Warp		Weft	
				1″	4″	1″	4″
1	Areca catechu L + Punica granatum L	Alum	Pre Mordanting	80	81	78	83
			Post Mordanting	79	81	76	79
2	Areca catechu L + Punica granatum L	Ferrous Sulphate	Pre Mordanting	78	78	81	80
			Post Mordanting	77	83	79	80

Table 1 reveals that the tensile strength (kg/cm2) of the dyed samples remained relatively consistent. Notably, the tearing strength of the dyed samples showed minimal loss.

3.2 Colour fastness to Laundering

Table 2 indicates that the combinations of *Areca catechu L* nut and *Punica granatum L* rind exhibited good to excellent colour fastness to laundering. Notably, the Alum pre-mordanted sample and Ferrous Sulphate pre-mordanted sample achieved a rating of 4, demonstrating very good colour fastness to laundering.

Table 2: Colour fastness to Laundering

S.No	Dye	Mordant	Mordanting Methods	Laundering
				Colour change Ratings
1	*Areca catechu L + Punica granatum L*	Alum	Pre Mordanting	**4**
			Post Mordanting	3-4
2	*Areca catechu L + Punica granatum L*	Ferrous Sulphate	Pre Mordanting	**4**
			Post Mordanting	**4**

Ratings: 5-Excellent, 4- Very good, 3- Good, 2- Fair, 1- Poor.

3.3 Colour fastness to Rubbing

Table 3 presents the colour fastness to rubbing results for the cotton dyed fabrics.

Table 3: Colour fastness to Rubbing

S.No	Dye	Mordant	Mordanting Methods	Rubbing	
				Staining	
				Dry	Wet
1	*Areca catechu L + Punica granatum L*	Alum	Pre Mordanting	4	3
			Post Mordanting	3-4	3
4	*Areca catechu L + Punica granatum L*	Ferrous Sulphate	Pre Mordanting	4	3
			Post Mordanting	3-4	2-3

Ratings: 5-Excellent, 4- Very good, 3- Good, 2- Fair, 1- Poor.

Table 3 reveals that the *Areca catechu L + Punica granatum L* with Alum and Ferrous Sulphate pre-mordanted sample are exhibited superior colour fastness to crocking. Specifically, the dry sample showed a rating of 4, while the wet sample achieved a rating of 3, indicating good colour fastness properties.

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CONCLUSION

This study demonstrates that Areca catechu L and Punica granatum L are suitable natural dye sources for cotton woven materials, particularly when used with Alum and Ferrous mordants. The pre-mordant and post-mordant techniques yielded desirable results, with the latter producing lighter shades with Alum. Notably, the pre-mordanting method outperformed post-mordanting in some cases.The study highlights the potential of combining natural dyes to achieve a wide range of bright colors and soft textures. Specifically, the combination of Pomegranate and Betel nut dyes resulted in brighter colors and improved color fastness to rubbing and washing.The natural dyes used in this study offer several benefits, including: Eco-friendliness and safety, minimal health hazards compared to synthetic dyes and potential medicinal properties.Overall, this study showcases the viability of natural dyes as a sustainable and healthier alternative to synthetic dyes.

REFERENCES

[1]. X. Chen, Y. He, and Y. Deng, (2023).Chemical Composition,Pharmacological, and Toxicological Efects of Betel Nut. Ev-idence-Based Complementary and Alternative Medicine,vol. 2021, Article ID 1808081, (7)
[2]. Bhat, R., et al. (2020). Antioxidant activity of pomegranate rind extract. Journal of Food Science and Technology, 57(4), 1478-1485.
[3]. Kumar, P., et al. (2022). Antimicrobial activity of pomegranate rind extract against foodborne pathogens. Journal of Food Protection, 85(1), 42-48.
[4]. Rafieian, S., et al. (2022). Anti-inflammatory effects of pomegranate rind extract in lipopolysaccharide-stimulated macrophages. Journal of Inflammation, 19(1), 1-11.
[5]. Periyasamy, A. P., et al. (2022). Digital printing of natural dyes on textiles: A review. Journal of Digital Printing Technology, 3(1), 1-12.
[6]. Shahid, M., et al. (2020). Eco-friendly natural dyeing of textiles using plant-based biomordants. Journal of Cleaner Production, 247, 119138.
[7]. Das, D., & Bhattacharya, S. (2020). Natural dyes and their applications: A review. Journal of Textile and Apparel Technology Management, 9(3), 1-13.
[8]. Kumar, R., & Sharma, S. (2020). Eco-friendly natural dyes for textile coloration: A review. Environmental Science and Pollution Research, 27(10), 10871-10885.
[9]. Singh, R., & Singh, D. (2019). Natural dyes and mordants: A review on their application and sustainability in textile industry. Journal of Cleaner Production, 235, 1478-1486
[10]. Shahid, M., et al. (2020). Eco-friendly natural dyeing of textiles using plant-based biomordants. Journal of Cleaner Production, 247, 119138.