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Evaluation of cotton fabric dyed with *Lantana camara* dye, using pre-mordant dyeing technique

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Abstract

The increasing environmental concerns associated with synthetic dyes have stimulated interest in sustainable and eco-friendly natural dyes for textile applications. The present study aimed to evaluate the subjective quality of cotton fabrics dyed with *Lantana camara* leaf extract using the pre-mordanting technique. Desized and scoured cotton fabrics were pre-mordanted with Myrobalan (*Terminalia chebula*) and ferrous sulphate (FeSO₄) at two concentrations (2% and 5%), followed by dyeing with *Lantana camara* extract at two dye concentrations (30% and 60%) for 30 and 60 minutes. The developed dyed samples were assessed by a panel of ten experts using a five-point rating scale based on colour uniformity, brightness of shade, dyeing defects, shade evenness, hand of fabric and overall appearance. Mean and Standard Deviation were used to analyze the subjective evaluation data. The results revealed significant variation in the visual quality and acceptability of the dyed samples. Among all treatments, samples DCF 03, DCF 07 and DCF 15 recorded the highest mean scores (46.0–47.0) with zero standard deviation, indicating excellent agreement among the evaluators regarding their superior aesthetic qualities. In contrast, samples DCF 09 and DCF 10 received the lowest mean scores (20.3 and 22.0), reflecting comparatively poor visual acceptance. After subjective evaluation, the best samples were tested for their color fastness towards light, wash & rubbing. Objective evaluation demonstrated good to excellent rubbing, washing and light fastness properties of the selected dyed fabrics, with DS 7 exhibiting the best overall fastness performance and DS 15 recording excellent light fastness (Grade 8). These findings indicated that the pre-mordanting technique not only enhances the aesthetic quality of cotton fabrics but also improves their durability, confirming the potential of *Lantana camara* as an eco-friendly natural dye for sustainable textile coloration.

Keywords: *Lantana camara*, natural dye, cotton fabric, pre-mordanting, subjective evaluation, eco-friendly dyeing, sustainable textiles, colour quality, textile coloration, natural colorants

Introduction

The textile industry is one of the largest manufacturing sectors worldwide, contributing significantly to economic development, employment generation and international trade. However, conventional textile dyeing predominantly relies on synthetic dyes and chemicals, which generate large volumes of toxic effluents and pose serious environmental and health concerns due to their non-biodegradable and potentially carcinogenic nature. Increasing awareness of environmental sustainability and stricter regulations on hazardous chemicals have stimulated renewed interest in eco-friendly dyeing technologies using natural colorants (Shahid and Mohammad, 2013) [1].

Natural dyes obtained from plants have emerged as sustainable alternatives because they are renewable, biodegradable and environmentally benign. In addition to imparting attractive shades, many plant-based dyes possess functional properties such as antimicrobial, antioxidant and ultraviolet (UV)-protective activities. The colour obtained from natural dyes depends on several factors, including the source of the dye, extraction method, textile substrate, mordant type, and dyeing technique. Among these factors, mordanting plays a crucial role in improving dye uptake,

colour strength, shade variation and colour fastness.

Cotton is the most widely used natural fibre in the textile industry because of its comfort, softness, breathability, and excellent moisture absorbency. However, its cellulose structure exhibits relatively low affinity for many natural dyes, making mordanting essential for achieving satisfactory dye fixation and durable colour. Pre-mordanting, in which the fabric is treated with a mordant before dyeing, is considered an effective technique for enhancing dye absorption, producing uniform shades and improving the overall quality of naturally dyed cotton fabrics (Mall, Saxena, Agrawal and Sarkar 2015) [2].

Lantana camara L. (Verbenaceae), a widely distributed ornamental shrub and invasive plant species, has recently gained attention as a promising source of natural dye. Its leaves contain abundant phenolic compounds, flavonoids, tannins and other bioactive constituents capable of producing attractive yellow to greenish shades on natural fibres. The utilization of *Lantana camara* as a dye source not only offers an eco-friendly alternative to synthetic dyes but also promotes the value addition of an underutilized plant resource (Hossain, Islam and Samanta, 2018) [3].

Besides colour strength and fastness, the commercial

acceptance of naturally dyed fabrics largely depends on consumer perception of aesthetic attributes such as colour appearance, brightness, uniformity, texture and overall acceptability. Subjective evaluation provides valuable information regarding these visual and sensory characteristics, enabling the identification of dyeing treatments that best satisfy consumer preferences. Such evaluations are particularly important for naturally dyed textiles, where subtle shade variations contribute to their uniqueness and market appeal (Arun and Yoogamurthi, 2014) [4].

Therefore, the present study was undertaken to evaluate the subjective quality of cotton fabrics dyed with *Lantana camara* extract using the pre-mordanting technique. The study aims to assess the visual and aesthetic acceptability of the developed fabrics and to explore the potential of *Lantana camara* as an eco-friendly natural dye for sustainable textile applications.

Methodology

The study was conducted using a completely experimental laboratory design to evaluate the subjective & objective qualities of cotton fabrics dyed with *Lantana camara* leaf extract using the pre-mordanting technique. Cotton fabrics were dyed under different combinations of mordant concentration, dye concentration and dyeing duration. The developed samples were subsequently evaluated by an expert panel based on selected aesthetic and visual quality parameters. Desized and scoured 100 per cent cotton fabric of medium weight was used as the textile substrate. Fresh leaves of *Lantana camara* were collected locally, shade-dried, powdered and used as the natural dye source. Two mordants were selected for pre-mordanting, namely Myrobalan (*Terminalia chebula*) as a natural mordant and ferrous sulphate (FeSO_4) as a synthetic mordant. Distilled water and analytical-grade laboratory chemicals were used throughout the study.

Preparation of Cotton Fabric

The cotton fabric was scoured prior to dyeing to remove natural impurities, waxes and sizing materials. Scouring was carried out using Sodium Hydroxide (5%), sodium carbonate (2%) and a wetting agent (0.5%) at a material-to-liquor ratio of 1:20. The treatment was performed at 90°C for 60 minutes, followed by washing, neutralization with dilute acetic acid and shade drying.

Extraction of *Lantana camara* Dye

The natural dye was extracted from powdered *Lantana camara* leaves using the aqueous extraction method. Dye powder (10 g) was mixed with 100 ml distilled water (1:10 w/v) and heated at 90°C for 60 min. The extract was cooled, kept at room temperature for 12 hours, filtered and subjected to ultrasonication to improve dye release and dispersion before dyeing.

Pre-Mordanting and Dyeing

Cotton fabrics were pre-treated with myrobalan and ferrous sulphate at two concentrations (2% and 5% owf) using a material-to-liquor ratio of 1:50. Mordanting was carried out

at 60°C for 60 minutes. The pre-mordanted fabrics were then dyed with *Lantana camara* extract at two dye concentrations (30% and 60%) for 30 and 60 minutes under standardized dyeing conditions. After dyeing, the samples were rinsed thoroughly and dried under shade before evaluation.

Subjective Evaluation

The developed cotton fabrics were evaluated by a panel of ten experts from the Department of Apparel and Textile Science. Each sample was assessed for colour uniformity, brightness of shade, shade evenness, dyeing defects, hand (fabric feel), and overall appearance using a five-point rating scale, where 5 = Excellent, 4 = Very Good, 3 = Good, 2 = Fair, and 1 = Poor. Mean scores were calculated for each parameter and the highest-rated samples were identified as the most acceptable combinations for natural dyeing with *Lantana camara*.

Objective Evaluation

The mordant treated dyed fabric samples were assessed for colour properties i.e. colour fastness. The colour of dyed samples in terms of colour fastness was assessed against different agencies i.e. wash, light and rubbing.

Results and Discussion

Subjective Evaluation of developed dyed cotton sample with *Lantana camara* dye using pre-mordanting technique

The data in Table 1 shows the mean scores and Standard Deviations of cotton fabrics dyed with *Lantana camara* dye using pre-mordanting technique. The assessment was carried out based on parameters like colour uniformity, brightness of shade, dyeing defects, shade evenness hand of fabric and overall appearance. The mean scores ranged between 20.3 to 47.0 which showed the visual and aesthetic acceptance of the developed samples.

The highest mean scores were found in DCF 07, 47.0, followed closely by DCF 03 and DCF 15 with mean scores of 46. All the samples were rated with good scores in all the evaluation parameters such as colour uniformity, brightness of shade, dyeing defects, evenness of shade, hand of fabric and overall appearance. Moreover, the Standard Deviation (SD) for DCF 03, DCF 07 and DCF 15 was 0.00, which means that there was excellent acceptability of those samples. The lowest mean score was obtained by DCF 09 and DCF 10, which was 20.3 and 22.0, respectively. This has comparatively lower aesthetic, appeal and acceptability. The ratings of these samples were lower for most of the parameters assessed. The mean scores of the sample DCF 16 were relatively low and the Standard Deviation (SD) of the mean scores was relatively high (7.40), which means that there was a relative larger variation in the evaluators' opinions about the appearance and quality characteristics of the sample.

The other samples had moderate level of acceptance between 37.2 to 39.5. Within this group, the mean values for samples DCF 02, DCF 06 and DCF 08 were relatively high, a desirable quality for good visual appeal and acceptable fabric properties. The Standard Deviations of these samples were not very high and indicated a fairly good level of agreement for all respondents.

Table 1: Rating Scores, mean and SD of the dyed cotton fabric using pre-mordanting technique

Sample	Mordants	Parameters						Mean	SD
		Color uniformity	Brightness of shade	Dyeing defects	Shade evenness	Hand of fabric	Overall appearance		
DCF 01	Myrobalan	34	38	37	38	39	40	37.7	1.89
DCF 02		37	40	40	39	40	41	39.5	1.26
DCF 03		46	46	46	46	46	46	46	0.00
DCF 04		32	41	38	40	40	37	38	3.00
DCF 05		35	38	38	38	38	38	37.5	1.12
DCF 06		39	39	37	39	38	39	38.5	0.76
DCF 07		47	47	47	47	47	47	47	0.00
DCF 08		35	41	36	38	40	39	38.2	2.11
DCF 09	FeSO ₄	17	16	20	25	24	20	20.3	3.30
DCF 10		19	19	21	26	25	22	22	2.71
DCF 11		35	39	37	38	39	37	37.5	1.38
DCF 12		31	40	38	39	39	37	37.3	2.98
DCF 13		21	21	22	23	28	24	23.2	2.41
DCF 14		20	18	20	21	26	22	21.2	2.48
DCF 15		46	46	46	46	46	46	46.0	0.00
DCF 16		34	40	20	21	26	22	27.2	7.40

The overall results of the subjective evaluation showed that DCF 03, DCF 07 and DCF 15 fabrics were the most preferred among the developed dyed cotton fabrics. They had high mean scores and zero standard deviation, which indicated the high aesthetic qualities and acceptance of the evaluators. Hence, these samples can be inferred as the most successful dyeing combination which have been made with the use of pre-mordanting technique with the use of the dye material *Lantana camara*.

These results are in line with the research conducted by Datta *et al.* (2022) ^[5], who examined the use of several mordanting techniques to colour cotton fabrics with *Lantana camara* flower extract. When compared to contemporaneous and post-mordanting methods, the scientists found that pre-mordanting resulted in greater dye uptake, higher colour strength (K/S values), enhanced colour uniformity and better fastness qualities. They came to the conclusion that pre-mordanting strengthens the link between cellulose fibres and natural dye molecules, enhancing the dyed materials' functional and aesthetic qualities. Similar result was found on Dhanania, Singhee and Samanta, (2022) ^[6], Feng and Chen, (2025) ^[7], Freddi, Mossotti and Innocenti (2003) ^[8] and Haji (2017) ^[9].

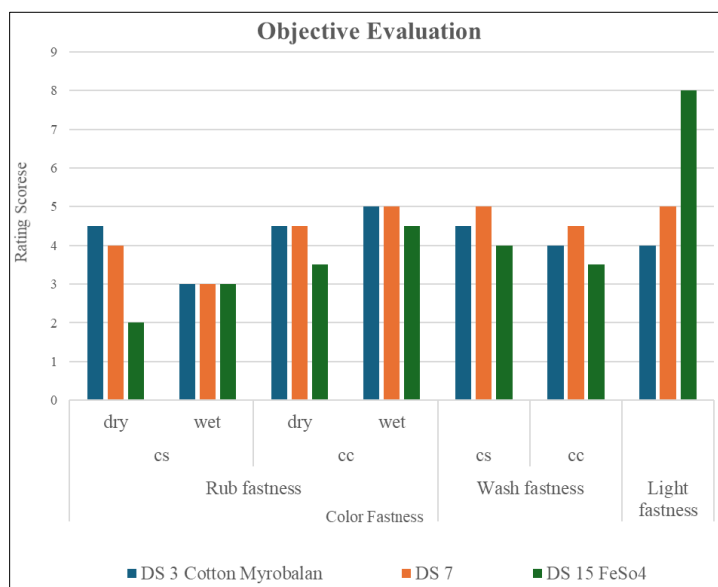
Objective evaluation of dyed samples on various textile substrates

Table 2: Objective evaluation of rubbing, washing and light fastness of naturally dyed cotton fabrics

Samples	Fabric	Mordant	Rub fastness				Wash fastness		Light fastness
			CS		CC		CS	CC	
			dry	wet	dry	wet			
DS 3	Cotton	Myrobalan	4/5	3	4/5	5	4/5	4	4
DS 7			4	3	4/5	5	5	4/5	5
DS 15		FeSo ₄	2	3	¾	4/5	4	¾	8

(DS= Dyed sample, CC= color change, CS= color staining)

The objective evaluation revealed that the developed cotton fabrics exhibited good to excellent colour fastness properties. Among the selected samples, DS 7 showed the best overall performance with excellent wash and light fastness, while DS 3 also demonstrated satisfactory rub, wash and light fastness. DS 15 exhibited excellent light fastness (Grade 8) but comparatively lower rub and wash fastness than the Myrobalan-treated samples.



Conclusion

The present investigation demonstrated that *Lantana camara* leaf extract can be successfully utilized as a natural dye for cotton fabrics using the pre-mordanting technique. Subjective evaluation revealed significant differences in the visual and aesthetic quality of the developed samples, with DCF 03, DCF 07 and DCF 15 receiving the highest ratings for colour uniformity, shade brightness, evenness, fabric handle and overall appearance. The objective evaluation further confirmed that the selected samples exhibited good to excellent rub, wash and light fastness, with DS 7 showing the best overall fastness performance and DS 15 exhibiting excellent light fastness (Grade 8). These findings indicated that pre-mordanting enhances both the aesthetic appeal and durability of naturally dyed cotton fabrics. Therefore, *Lantana camara*, an abundant and underutilized plant resource, represents a promising, sustainable and environmentally friendly alternative to synthetic dyes for textile applications. Further investigations on functional properties, instrumental colour analysis and large-scale commercial processing are recommended to promote its industrial utilization.

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