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Short Communication

Sustainable dyeing of Eri silk fabric with "*Rubia cordifolia*": process optimization and effect of alum and myrobalan mordants

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Among the genus Rubia's most important and practical species in the Indian subcontinent is *Rubia cordifolia* Linnae, which has very long, cylindrical, flexuous roots with thin red bark. This plant's most valuable component "entire root", which is quite long but not much thicker is considered as the most valuable portion (Yusuf *et al*., 2017)[1].Natural dye "*Rubia cordifolia*", Eri Silk fabric, mordant myrobalan and alum, were selected for the study. The highest K/S value 16.26 was given by myrobalan mordanted fabric, and a greater depth of colour was given by the non-mordanted fabric. Additionally, it was observed that because of various mordants, the dyed samples varied from one another. Compared to alum-mordanted fabric, myrobalanmordanted fabric has a smooth, uniform surface (Sarma, P.*et al.,*2025)[2]. This paper describes how Eri silk fabric is dyed using natural dyes extracted from *Rubia cordifolia*. The mordants used were alum and myrobalan. The colourfastness properties and colour co-ordinates of dyed fabrics were evaluated and the fabric samples showed very fair to good ratings of colourfastness with slightly stained to no staining (Kaswan, S., *et al.,* 2025)[3].

Keywords: Alum, Colourfastness, Eri silk, Rubia cordifolia, Mordants, Natural dye

Introduction

Plants were utilized for food, fibre, fire and shelter in the earliest human civilizations (Chanu, V. 2022)[4]. Moreover, they served as supplies of colour for cave paintings, design and textile dyeing (Jose *et al*., 2017)[5]. The variety of colours found in naturally occurring flora and animals fascinates and draws people toward a wide range of possibilities. There are numerous plant, animal, and insect sources that can be used to extract colour for a variety of textile dyeing applications. It may also provide opportunities for sustainable harvest and sale of these dye plants, in addition to a variety of rich sources of dyestuff (Tripathi *et al*., 2015)[6]. Madder is known to be the queen of the reds which is an oldest used dye (Jahan and Datta, 2015)[7]. Red colours can be created with madder or manjistha. This originates from the plant's root and is similar to turmeric, which obtains its colour by washing, drying in the sun, and cooking in water. The main fabrics on which madder root pigments are applied are cotton, silk, and wool. Alizarin is a colouring agent found in madder (Khattak *et al*., 2019)[8]. Madder root extracts produce orange-red to scarlet-colored dye. Additionally, deep hues can be created through some type of repeated dyeing (Miller, B. and Tyomik, I., 1984)[9]. Using combinations of colours like yellow, red, blue, and black, a wide range of colours can be produced (Khattak *et al*., 2019)[8]. Without a mordant, the majority of natural colours are unstable on fibres (Kumaresan, M, 2018)[10]. The majority of natural dyes require a mordanting substance (metal salt or tannins) to bind the colour to the fibre. Following mordanting, the dye is drawn to the fibres by the metal salts, which then form the connecting link between the dye molecules and the fibre (Rajpoot, S.S. and Thakur, P.K., 2020)[11]. Two different kinds of mordants exist: (a) Mordants made of metal (Ex; Salts of Aluminum, Chromium, Copper, Iron and Tin) Tannins (b) (Ex: Myrobalan and Sumach) (Singh *et al*., 2020)[12].Because natural dyes have a tendency to produce poor colour and have insufficient fastness, mordants and additions are required. In addition to offering shade, it also offers UV protection, antibacterial action, and fungal activity. In the field of agriculture, waste water from the natural dye production process can be used as a nutrient. Natural colours, as compared to manufactured dyes, provide extremely rare, smoothing, and soft colours (Karthikeyan, 2020)[13]. Silk clothing that was dyed in dazzling hues was seen as a symbol of communal royalty. Silk is natural dyed produces beautiful glossy tones that add value to the fabric (Saikia, S. and Kalita, B., 2016)[14]. Even after a long time, they are still incredibly beautiful and charming (Boruah *et al*., 2019)[15]. Baby clothes are also created from Eri silk due to its smooth texture and excellent moisture absorption (Patil, H. *et al.,* 2023)[16].

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Materials

Rubia cordifolia or Indian madderwas bought from Guwahati, Assam was chosen as the natural dye. From the Department of Textiles and Apparel Designing, AAU, Jorhat-13. Eri Silk fabric was chosen and collected and myrobalan were collected from Jorhat, Assam.

Preparation of *Rubia Cordifolia*and myrobalan

*Rubia Cordifolia*was cleaned to remove the impurities and it was sundried for further use (Fig. 1). The natural mordant myrobalan were dried under sunlight then it was ground into powdered form and kept in a tight container (Fig. 2).

Fig. 1 — Rubia Cordifolia

Fig. 2 — Myrobalan powder

Preparation of fabric for dyeing

Washing soda along with Eri silk fabric were added to water and heated for degumming, after 30 minutes the fabric was removed and thoroughly cleaned, and allowed to air dry. With 1% hydrogen peroxide the Eri silk fabric was added to water for Bleaching. In the middle of the procedure, Sodium silicate was added to the bleaching bath as a stabilizing agent. After half an hour, the fabric was removed, thoroughly cleaned, and allowed to air dry.

Dyeing of Eris ilk fabric

The Eri silk fabric was dyed for 45 minutes at material to liquor ratio 1:30. The percentage of dye absorption (%) of the fabric was estimated.

% dye absorption=

$$\frac{\text{OD of the liquid before dyeing - OD of the liquid after dyeing}}{\text{OD of the liquid before dyeing}} \times 100$$

Mordanting

Pre-mordanting method was carried out by keeping the material-to-liquor ratio of 1:30 using 2g of alum and 6g of myrobalan at 70 ˚ C for 75 min on Eri silk fabric.

Amount of mordant =

$$\frac{\text{Weight of the fabric in gm} \times \text{\% of mordant}}{100}$$

Evaluation of colourfastness properties of the dyed fabric

The dyed Eri silk fabric samples were tested for the following fastness types:

Colourfastness to washing

Colourfastness to washing was conducted to analyse the change in colour colours while subjecting the dyed or printed fabrics to washing under four sets of washing formulas in specific time, temperature and alkalinity conditions. A metal jar with a few stainless-steel balls was taken and 100 ml of a 0.5 percent soap solution was added and boiled at the required temperature. The fabric is then immersed and the container was sealed and set within the Launder-O-meter at required temperature. Then samples were taken out from launder-O-meter and were forcefully shaken for one minute while being washed twice with distilled water at 40°C. The specimens were then dipped in a 100 ml solution of acetic acid at a concentration of 0.015 percent for 1 minute at room temperature, followed by another 1-minute washing in 100 ml of water. The samples were squeezed, dried and ironed.

Colourfastness to crocking or rubbing

Transfer of colour from the surface of dyed textile materials to other surface by rubbing determined the property of colourfastness to crocking or rubbing. On the crock-o-meter the test sample was placed and the finger's tip like structure extends downward from the weighed sliding arm was covered by a white testing cloth. A unique wire clip was used to test specimen. One turn per second was determined by using 10 full crank rotations,the covered finger was lowered onto the test specimen and made to move back and forth twenty times.

For the wet crocking (rubbing) test, a white testing cloth that had been properly wet out was used. Before performing the actual crock test, care was taken to ensure that evaporation didn't lower the moisture content below the required level. The remaining steps were the same as those in the dry crocking test.

Colourfastness to pressing (dry and wet)

The test Colourfastness to pressing (dry and wet) shows colour change, colour transfer or both when subjected to hot pressing.

Under controlled circumstances, a flat iron is used to press a pair of test specimens, one moist and one dry. A preheated flat iron was used to test the specimen by placing directly under the iron and left there for 10 seconds.

Dry test (colour transference)

The samples of a standard size were covered with a dry white cloth and by using a flat iron the samples were heated to a specific temperature for 10 seconds.

Wet test (colour transference)

In distilled water at room temperature a white cloth was thoroughly moistened for the wet test and any extra water was pressed out. The test specimens were placed on top of the pressed fabric, which was then heated to a specific temperature and pressed for 10 seconds.

Colourfastness to Sunlight

The amount of colour faded by sunlight determined the colourfastness to sunlight. About.6 cm long pieces of the fabric swatches were cut out and were exposed simultaneously under certain circumstances from 9 am to 5 pmfor long enough to cause "appreciable fading" of the test sample. Light was concurrently projected at the specimen and standards. After 48 hours of exposure, at intervals of 8, 16, 24, 32, 40 and 48 hours samples were evaluated for colour changes.

Colourfastness to perspiration

To determine the fastness of coloured textiles to the effects of perspiration the Colourfastness to perspiration test was done. The test sample of colourful textiles was soaked in alkaline and acidic perspiration solution, and then dried slowly at a moderately high temperature under a fixed mechanical pressure.For the test, acidic and alkaline solutions were made by mixing the specified amounts of various compounds with distilled water to form 1 litre.

Kumpikaite *et al., (*2021)[17] stated that there are various levels of colour fastness to sunlight, and a variety of elements, including fibre types, dyes, colour combinations, the atmospheric makeup of the environment, sample moisture content ratios, temperature, and others, can influence this property. Regarding the colour fastness properties of coloured silk fabric, infrared dyeing beats exhaustion dyeing.

Interpretation of results of the colour fastness test

The indicators for Colour Change (CC) and Colour Staining (CS) were evaluated for each sample accordingly and were given in Table 1 and Table 2.

Colour co-ordinates value of dyed fabric

Colour co-ordinate values of dyed fabric samples were determined by CIE Lab system (Fig. 3) via the spectrophotometer with an average of five times readings in Opacity, Colour Tester and Brightness. The colour parameters L* indicated depth of colour, a* indicated positive value redness and negative greenness, and b* indicated positive value yellowness and negative value blueness were recorded. In order to show the colour difference between mordanted and non-mordanted samples, the lower value of L* indicate higher depth of colour. C_4 denotes the concentration of the hue and R denotes the surface reflectance value of the dyed sample at a particular wavelength, where maximum absorption occurs for a

Table 1 — Ratings for Colour Change (CC) and Colour Staining (CS)

Colour Change (CC) Ratings		Ratings Colour Staining (CS) Ratings	
Grade	Stained	Grade	Stained
6	Very good	5	Negligible or no staining
5	Good	4	Slightly stained
4	Very fair	3	Noticeable stained
3	Fair	2	Considerably stained
2	Poor	1	Heavily stained
1	Very Poor	-	-

Table 2 — Evaluation of colour fastness properties of dyed Eri silk fabric

Sl. No.	Mordant used	Washing		Crocking				Pressing				Sunlight	Perspiration			
				Dry		Wet		Dry		Wet			Acidic		Alkaline	
		CC	CS	CC	CS	CC	CS	CC	CS	CC	CS	CC	CC	CS	CS	CS
1	Non-mordanted	5	4	5	5	4	5	5	5	4	5	5	4	4	5	5
2	Alum mordanted	4	5	5	5	4	4	5	5	4	4	4	5	5	5	5
3	Myrobalan mordanted	5	4	5	5	4	4	4	5	3	4	5	3	3	4	4

CC: Colour change; CS: Colour staining
CC Ratings: 1=v very poor, 2=poor, 3=fair, 4=very fair, 5=good, 6=very good
CS Ratings: 1=heavily stained, 2=considerably stained, 3=noticeable stained, 4=slightly stained, 5= negligible or no staining

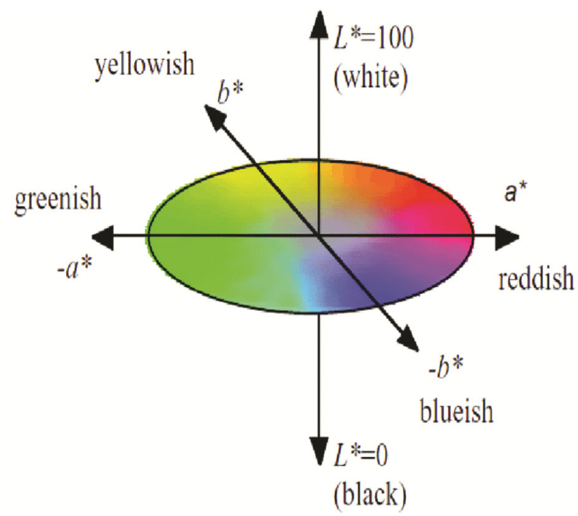

Fig. 3 — Hunter Lab Colour Graph

particular dye/colour component (Mukherjee, S and Kanakarajan, S., 2017)[18].

Results and Discussion

Evaluation of colourfastness properties of dyed Eri silk fabric

Colourfastness to washing

The samples of coloured fabric all had noticeable stains but the non-mordanted or mordanted with alum and myrobalan, displayed good fastness to washing and colour change (AATCC Method)[1]. Alum-mordanted samples exhibited little to no colour fading following washing.

Colourfastness to crocking or rubbing (wet and dry)

In dry crocking, both mordanted and non-mordanted-exhibited good fastness and negligible staining. All of the samples, whether they were alum-mordanted or not, exhibited good fastness during wet crocking, while the myrobalan-mordanted sample displayed very fair fastness. In non-mordanted dyed fabric, no colour staining occurred; in samples that had been mordanted, a small staining had occurred.

Table 3 — CIE Lab values

Dyed fabrics	CIE Lab values		
	L*	a*	b*
Non-mordanted	45.21	31.24	21.48
Alum mordanted	45.89	33.79	33.14
Myrobalan mordanted	56.28	15.13	35.95

Colourfastness to pressing (wet and dry)

Non-mordanted sample had no staining to wet pressing. However, other samples displayed good fastness and light staining.

Colourfastness to sunlight

Alum mordanted dyed samples showed very fair colour fastness characteristics to sunlight, non-mordanted and naturally mordanted coloured fabrics displayed good colour fastness to sunlight.

Colourfastness to perspiration (acidic and alkaline)

The colourfastness of every dyed fabric sample to perspiration in both acidic and alkaline medium was evaluated. In acidic All samples were found to have fair to very fair perspiration medium. No colour staining was observed in the alum-mordanted dyed fabric, non-mordanted and myrobalan-mordanted dyed fabrics were found to be noticeably to slightly stain. All of the dyed fabric samples in an alkaline medium had very fair to fair colourfastness to perspiration, with minor colour stains in non-mordanted and alum-mordanted dyed fabrics, compared to somewhat stained results in myrobalan-mordanted dyed fabric.

Evaluation of Colour co-ordinate values of dyed fabric

Table 3 indicated highest L* value 56.28 was given by myrobalan-mordanted dyed sample, L* value 45.89 showed by Alum-mordanted dyed sample followed by myrobalan-mordanted dye and L* value 45.21 which was lowest shown by non-mordanted dyed fabric. The CIE lab colour values may show the hue and lustre that coloured fabric produced. As, the value decreases, the depth increases.

Table 4 — Colour Strength (K/S) values of *Rubia cordifolia* Dyed fabric

Dyed fabric	Colour Strength K/S value
Non-mordanted	6.14
Alum mordanted	9.66
Myrobalan mordanted	16.26

It was discovered that non- mordanted fabric had the lowest L* value among the dyed fabric that has been mordanted. The presence of redness and yellowness in the coloured fabric was indicated by the positive values of a* and b*.

Colour Strength (K/S) values of Manjistha dyed fabric

Table 4 indicated that greatest K/S value (16.26) showed by myrobalan-mordanted fabric. Lowest 6.14 K/S value was shown by natural mordanted coloured samples, in comparison to non-mordanted fabric, because alum's alkaline nature eliminated the colour and produced a lighter tint when combined with natural dye (Vankar, 2009)[19].

Conclusion

Eco-friendly dyeing of textile products produced by natural dyes has a significant potential due to awareness of health throughout the world to reduce the toxic as well as hazardous substance from the environment which isproduced by the synthetic dyes. From this study it was concluded that use of natural mordants resulted in greater depth of colour and higher colour strength (K/S) values as compared to metallic mordant. Natural mordanted fabric showed good fastness to sunlight. By use of natural mordants in dyeing with natural dye the light fastness property can be improved.

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