



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 11, November 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118

9940 572 462

6381 907 438

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Studies on Compatibility of Dyes for Jute Fabric Dyed with Binary Mixture of Selective Natural Dyes

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ABSTRACT: Jute, a lignocellulosic fibre is dyed with the aqueous extract of three natural dyes namely marigold flower petals, onion skin and pomegranate peels. The fabrics were dyed with binary mixtures of two natural dyes among the three at a time. The binary mixtures taken were of three different proportions – 75:25, 50:50 and 25:75. All the fabrics were pre-mordanted with 10% myrobalan and 10% natural potash alum applied in sequence before dyeing. Compatibility of each pair of binary mixture was determined by CDI value based relative compatibility rating (RCR) method. The fabrics dyed with the binary mixture of marigold and pomegranates have the higher compatibility with RCR value 3-4 (moderate compatibility), than those dyed with other two sets of dyes having RCR value 2 for both (poor compatibility for both). Fastness of the fabrics dyed with onion and pomegranate show the best wash fastness properties while rubbing fastness of all types of samples are of similar grade.

KEYWORDS: Jute, marigold, onion skin, pomegranate Rind, myrobalan, potash alum, binary mixture of natural dyes, relative compatibility rating, natural dyeing, Colour Difference Index, Compatibility of dyes.

1. INTRODUCTION

At the present time, people have become very conscious of global ecological hazards and imminent dangers it is posing to the all living being. Everywhere new demands are coming for environmentally safe or less hazardous materials to be used for production and consumption. Textiles, mostly textiles products made of natural fibres are considered to have safer than those made of petroleum-based synthetic fibres and coloration of textiles materials is important treatment imparted to them (Özdemir, 2017). So, the coloration with environmental friendly natural dyes is need of the hour.

Jute, a lignocellulosic agro-renewable bast fibre, is mostly used for packaging products, but it is being tried to augment more of its diversified applications so that the fibre can create a niche market of consumers (Wang and Cai, 2008). Natural dyes have not achieved the desired level of acceptance due to scant availability, limited range of shades, and absence of standard procedure of dyeing along with lack of scientific knowledge of compatibility of among them (Jose et al., 2017). There are some discreet research works on compatibility of natural dyes on cellulosic materials reporting of colour yield, interaction of dyes, etc (Samanta et al., 2008; Samanta et al., 2009; Samanta et al., 2011). New dyes extracted from bioresources need to be examined for the interaction among them to find their compatibility for use as binary mixture to obtain compound shades.

This is mentioned by earlier group of researchers (H D Sinnur & Samanta Et. Al., 2018) as a synergistic effect of the combination of potash alum with harda as a mordant and mordanting assistant both acting together to form more giant complex with fibre and dye due to presence of harda. This helps water soluble metallic salt mordants not to wash out in aqueous dye liquor bath i.e. hold aluminium with fabrics by above said complex of cellulose (say, jute cellulose or cotton cellulose) + Aluminum + Harda complex formed during such dual mordanting and hence harda is said to be acting like a catcher for metallic entity (say, Aluminum) of metallic salt mordant preventing its auto wash out in aqueous dye liquor bath. Hence it results a better colour yield in even jigger dyeing industrially for mill sector. So, for cotton and jute dyeing, it has become now a practice for mordanting such cellulose or ligno-cellulose materials, to use this dual mordanting with harda and aluminum salt or any other eco safe metallic mordant, to apply in sequence one by one (applying together as mixture is not possible, as it will form harda-aluminium salt complex immediately in bath and

will precipitate in the mordant bath without forming complex with cellulosic fabrics or dye) i.e also harda pre-treatment or pre-mordanting as first mordanting and aluminum salt or any other metallic salt to apply as 2nd mordant in another bath become beneficial.

So, in the present work, studies have been undertaken to assess the compatibility of binary pairs of three natural dyes applied for dyeing of jute after dual pre-mordanting with 10% myrobalan (harda)+ 10% potash alum as dual bio pre-mordanting applied in sequence. Though there are several methods to assess the compatibility such as subjective visual assessment of the colour build-up, comparison of rates of dyeing, comparing and plotting ΔC vs ΔL or K/S vs ΔL values for two sets of progressive shades, etc. But in the present study, an important colour parameter named colour difference index (CDI) for different proportion of binary pair of mixture of two dyes and the differences in $CDI_{max} - CDI_{min}$ has been evaluated, which in turn is considered as to grade compatibility of those two dyes in terms of charted value of Relative compatibility grade 1-5 to assess the compatibility between two dyes to use as a binary mixture to obtain compound shade. This relative compatibility rating (RCR) method of determining compatibility based on CDI values for use of two dyes as binary mixture has been come up as a simple and easy industrial method of compatibility assessment between two dyes (Samanta et al 2009). Hence in the Present work , this RCR method is adopted to find the compatibility of Binary pair of different natural dyes including Marigold petal ,Pomogrenate Rind, Onion skin etc for their binary pair mixture dyeing on jute. .

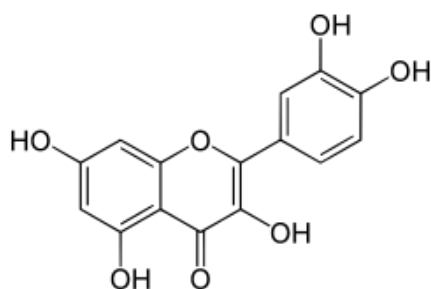


Figure 1. Structure of quercetin

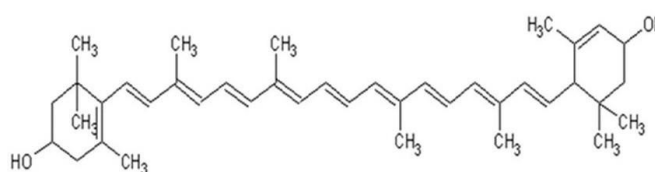


Figure 2. Structure of lutein

II. MATERIALS AND METHODS

2.1. Materials

Fabric: Bleached jute fabric of 47 ends/dm (warp count: 7.65 lb/spy) and 42 picks/dm (weft count: 8.23 lb/spy), 260 g/m² area density was used.

Natural dye: Three natural resources were – marigold flower petals, onion skins and pomegranate peels – were used as source of natural dyes. The main colorant component of onion skin is quercetin. The structure of quercetin is shown in Figure 1. The main colouring component of the marigold petal is lutein (C₄₀H₅₆O₂), a carotenoid compound whose structure is shown in Fig. 2 (Shabbir et al., 2020). Marigold petals, onion skin and pomegranate peels were procured from local market.

Inorganic mordant: Natural potash alum (aluminium potassium sulphate, [KAl(SO₄)₂·12H₂O]) and myrobalan were procured from a local shop.

Auxiliary chemicals: LR-grade acetic acid and sodium carbonate (for adjustment of pH) and non-ionic detergent were procured from M/s Ma Kali Chemicals, Kolkata.

2.2. Methods

2.2.1. Extraction of natural dye

Sun dried Onion skin, marigold petals and pomegranate rind/peels were pulverised to powder in a mechanical grinder and the powder was put into aqueous medium at boil for 60 min with MLR 1:30 for the maximum colour extraction. The aqueous extract was filtered and filtrate was used as natural dyecoloured solution.



2.2.2. Mordanting of jute fabric

Bleached jute fabrics were pre-mordanted (mordanting done before dyeing process) using 10% myrobolan(harda) and then in sequence pre treated further with 10% natural potash alum (Fitkari) applied in sequence. Both the mordants being natural and are applied individually with 10% add-on onto the fabric as dual bio-mordant. The method was followed as mentioned by Samanta (Samanta et al, 2009)..

2.2.4 Dyeing of Pre-mordanted Jute Fabric

Jute fabrics already mordanted were dyed with the binary pairs of two natural dyes in different ratios (100:0, 75:25, 50:50, 25:75 and 0:100), applying overall 30% (owf) concentration of the each natural dyes (based on the mass of powdered dye) at 90°C using MLR 1:40 for 60 min adding 10g/L sodium chloride as only additive. In each case, the dyed sample was rinsed in cold water followed by soaping using 2 g/L of non-ionic detergent dissolved in water at 1:50 MLR at 60°C temperature for 15 minutes and then it was again rinsed in cold water twice and dried in air.

2.2.4. Testing of dyed jute fabric

Surface colour strength (K/S at $\lambda_{\text{userwavelength}}$ for dyeing with binary pairs of dyes) and other colour-related parameters like ΔL , Δa , Δb , ΔC , ΔH , of the dyed jute fabrics were measured using Reflectance Spectrophotometer (Make: Premier Colorscan; Model: S-5100A) using Kubelka-Munk equation and following CIE-Lab equations, 1976 for all other colour parameters. Colour fastness to wash and colour fastness to rubbing of the dyed jute fabrics were measured using IS: 764:1984 and IS: 766:1984 respectively. Colour Difference Index (CDI) values were evaluated on the basis of earlier given empirical formula (Samanta, et al., 2009)

2.2.5 Determination of Compatibility between any two dyes by Relative compatibility rating

A relatively newer method of judgement of compatibility between two dyes or a selective pair of dyes for application of binary mixture of natural dyes to obtain compound shade can be determined by calculating relative compatibility rating, based on differences of CDI values with charted relative compatibility rating values for dyeing same fabric by different proportions of selected binary pair of mixture of two dyes, after calculating corresponding CDI values that has been postulated earlier and tested in numerous literature is applied also in the present work. After application of different proportions of binary mixture of selective pair of natural dyes (maintaining same pre-fixed overall shade percentage for each binary mixture/pair of natural dyes using corresponding natural dye extract for each natural dye) on the same fabric.

Colour Difference Index (Samanta et al, 2009) is expressed by the following empirical relationship, where magnitudes of the respective ΔE , ΔH , ΔC , and MI values (irrespective of their sign and direction) may be utilized to obtain an index as a ratio of certain colour parameters, without any unit and sign or direction, expressed by the following empirical relationship (Samanta et al, 2009)

$$\text{Colour Difference Index (CDI)} = \frac{\Delta E \times \Delta H}{\Delta C \times MI}$$

CDI values is used to measure dispersion of colour values for understanding the effect of any one dyeing process variable with other dyeing process variable or can be used to understand rate of colour build up for two separate dyes used to dye a fabric using different ratio of the two dyes as a binary mixture, so that lower values of CDI differences amongst two dyes used in mixture dyeing, indicate more dye compatibility.

Closer are the Colour Difference Index (CDI) values for use of different proportions of binary mixtures of any pair of dyes applied on the same fabric for compound shade under the comparable conditions of dyeing, the higher is the compatibility rating (between 0 to 5, where rating 5 is considered as the maximum or excellent compatibility and rating 1 is considered as the minimum or worst compatibility and rating 0 (zero) is considered as completely non-compatible). According to earlier reports (Samanta -2019) on CDI based Relative Compatibility rating method, established earlier is used here to calculate and to determine Relative Compatibility Rating (RCR) with numerical grade (0-5) of Compatibility grading system (Samanta-2019) as is depicted in **Chart-1** below:



Chart-1 Relative compatibility Rating chart against differences between maximum CDI value and minimum CDI values of dyed jute fabrics dyed with different proportions of binary mixtures of selective pair of dyes, after standardized dual pre-mordanting 10% Harda +10% Alum^{12,24}

Compatibility Grade	Relative Compatibility Rating(RCR) Scale/grade	Highest value amongst the differences between maximum CDI value and minimum individual CDI values for dyed fabric for any pair of natural dyes applied a standard double pre-mordanted fabric under the comparable dyeing condition using different proportions of binary mixtures of selective natural dyes.
		Maximum value amongst differences of ($CDI_{max} \sim CDI_{individual}$)
Excellent	5	>0 but ≤ 0.05
Very good	4-5	>0.05 but ≤ 0.10
Good	4	>0.10 but ≤ 0.20
Moderate	3-4	>0.20 but ≤ 0.30
Average	3	>0.30 but ≤ 0.50
Fair	2-3	>0.51 but ≤ 1.00
Poor	2	>1.01 but ≤ 5.00
Very poor	1-2	>5.01 but ≤ 10.0
Worst	1	> 10.0 but ≤ 15.0
Non-Compatible	0	$>>15.00$

III. EXPERIMENTAL RESULTS AND DISCUSSION

3.1. Surface colour strength of jute fabric dyed with single and binary pair of dyes

The surface colour strength and other related color parameters of jute fabrics dyed with three binary pairs of natural dyes are shown in Table 1. The table shows the surface colour strength, L^* , a^* , b^* , C^* , H^* and metameric indices of jute fabrics dyed with binary mixtures of dyes in different proportions (75:25, 50:50 and 75:25). It is found that marigold produces the maximum colour strength for the binary mixtures of marigold petals and onion skin. With the increase in onion proportion in the mixture, the colour strength starts decreasing. Difference of hue (ΔH) is found to be negative for only marigold and for 75:25 proportion of marigold to onion skin. Metameric indices are in the range of 2.15 and 2.21 for these binary mixtures. In the case of second binary mixture of onion skin and pomegranate peel, it is found that colour strength is higher for higher proportion of pomegranate dye where the colour strength for only onion dyed fabric is 4.89. ΔH values of these five samples are positive. In the case of third binary mixture of dyes viz. marigold petals and pomegranate peel, colour strength is found to be higher with the higher presence of marigold petal dye. The metameric indices of the jute samples dyed with this binary mixture of dyes lie in the range of 3.1 and 3.5. For the compatibility analysis, colour difference index (CDI) values of jute fabrics dyed with the first binary mixtures viz. marigold petals and onion skin dye are found to be in the range of 1.91 and 3.00 i.e., the difference of the highest and the lowest CDI in this binary mixture is 1.09 (Corresponding RCR grade is 2 as poor dye compatibility as evident from values of chart-1). In the case of second binary mixture dyes viz. onion and pomegranate dye, CDI values are between 3.01 and 4.1 i.e., the difference of the highest and the lowest CDI in this binary mixture is also 1.09 (Corresponding RCR grade is 2 as poor dye compatibility as evident from values of chart-1) indicating poor dye compatibility of first two pairs of dyes (Marigold and onion and also Onion and pomegranate). In the case of third binary mixture dyes viz. marigold and pomegranate dye, CDI values are between 2.05 and 2.35 i.e., the difference of the highest and the lowest CDI in this binary mixture is 0.30 (Corresponding RCR grade is 3-4, as moderate to good dye compatibility as evident from values of chart-1) indicating moderately good dye compatibility of this third pair of dyes (marigold and pomegranate dye). So, among these three sets of dyed samples, the third set of jute samples dyed with binary mixture of marigold and pomegranate dye seem to be better compatible, though not very highly compatible as very good or excellent.



Table 1. Colour strength and related colour parameters of jute dyed with binary pairs of natural dyes after mordanting

Dyeing conditions		K/S	L*	a*	b*	C*	H*	ΔC	ΔH	ΔE	M.I. (LABD)	CDI	CDI _{maxm} —CDI _{minm}
	Control	0.26	79.33	0.17	12.08	12.22	83.23						
Binary mixture of dyes (Marigold and onion)	M:O :: 100:0	5.89	55.40	4.30	20.32	25.44	77.90	13.22	-5.33	25.64	2.08	4.97	3.00-1.91=1.09 RCR=2(poor)
	M:O :: 75:25	5.2	54.30	4.40	20.10	27.57	85.60	15.35	2.37	26.62	2.15	1.91	
	M:O :: 50:50	5.01	57.1	4.23	20.78	26.9	86.3	14.68	3.07	24.21	2.12	2.39	
	M:O :: 25:75	4.92	56.9	4.1	21.4	27	87.21	14.78	3.98	24.60	2.21	3.00	
	M:O :: 0:100	4.89	60.1	5.1	18.9	20.1	86.1	7.88	2.87	20.99	3.60	2.12	
Binary mixture of dyes (Onion and pomegranate)	O:P :: 100:0	4.89	60.1	5.1	18.9	20.1	86.1	7.88	2.87	20.99	3.60	2.12	4.10—3.01 =1.09 RCR=2(poor)
	O:P :: 75:25	5.1	52.8	5.3	17.8	22.4	87.45	10.18	4.22	27.62	3.80	3.01	
	O:P :: 50:50	5.21	49.8	5.2	17.2	23.9	88.32	11.68	5.09	30.39	4.10	3.23	
	O:P :: 25:75	5.32	49.1	5.8	17.53	23.5	89.11	11.28	5.88	31.23	3.97	4.10	
	O:P :: 0:100	5.43	48.1	6.12	18.2	24.9	90.1	12.68	6.87	32.37	4.20	4.18	
Binary mixture of dyes (Marigold and pomegranate)	M:P :: 100:0	5.89	55.40	4.30	20.32	25.44	77.90	13.22	-5.33	25.64	2.08	4.97	2.35-2.05=0.30 RCR=3-4 (Moderate)
	M:P :: 75:25	5.54	51.45	4.8	20.54	25.1	80.45	12.88	-2.78	29.50	3.10	2.05	
	M:P :: 50:50	5.69	50.1	5.3	19.12	24.9	81.5	12.68	-1.73	30.50	3.50	2.19	
	M:P :: 25:75	5.81	50.3	5.5	19.01	24.4	86.3	12.18	3.07	30.32	3.25	2.35	
	M:P :: 0:100	5.43	48.1	6.12	18.2	24.9	90.1	12.68	6.87	32.37	4.20	4.18	

3.2. Fastness properties of jute fabrics dyed with binary mixtures of dyes

The fastness values of jute fabrics dyed with binary mixtures of dyes in different proportions are given in Table 2. Rubbing fastness of the samples dyed with the first set of binary mixture i.e., with marigold and onion dye is moderate for dry samples, but wet rubbing fastness has been found 3 for all binary samples. Change in colour for wash fastness in this set of fabric samples is 3 for all and staining on other jute fabric is 4. In case of the fabric dyed with second set of dyes i.e., with onion and pomegranate dye, dry and wet rubbing fastness are 3 and 4 respectively. Similarly, change in colour and staining on jute are 3-4 and 4 respectively. In case of the fabric dyed with third set of dyes i.e., with marigold and pomegranate dye, dry rubbing fastness are 3-4 for 50:50 mixture and 4 for the other samples while wet rubbing fastness is 3 for all samples. Similarly, change in colour of wash fastness grade is 3-4 for 25:75 (M:P) and 3 for the other two samples while staining on jute 4 for all samples of this set.

Table 2. Colour fastness of jute fabrics dyed with binary mixtures of dyes

Dyeing conditions		Rubbing fastness		Wash fastness	
		Dry	Wet	Change in colour	Staining on jute
Binary pair of dyes (Marigold and onion)	M:O :: 100:0	3-4	2-3	2-3	4
	M:O :: 75:25	4	3	3	4
	M:O :: 50:50	4	3	3	4
	M:O :: 25:75	4	3	3	4
	M:O :: 0:100	4	3	3	4
Binary pairs of dyes (Onion and pomegranate)	O:P :: 100:0	4	3	3-4	4
	O:P :: 75:25	4	3	3-4	4
	O:P :: 50:50	4	3	3-4	4
	O:P :: 25:75	4	3	3-4	4
	O:P :: 0:100	4	3	3-4	4
Binary pairs of dyes (Marigold and pomegranate)	M:P :: 100:0	3-4	2-3	2-3	4
	M:P :: 75:25	4	3	3	4
	M:P :: 50:50	3-4	3	3	4
	M:P :: 25:75	4	3	3-4	4
	M:P :: 0:100	4	3	3-4	4

IV. CONCLUSION

It is found that the compatibility of dyes is highest for marigold and pomegranate while the other two sets i.e., marigold and onion & onion : pomegranate are of similar compatibility. Colour strength is highest for the fabrics dyed with marigold and pomegranate set binary mixture of dyes. Though rubbing fastness is almost similar for all three sets of dyed samples, wash fastness is highest in case of fabrics dyed with onion and pomegranate mixture of dyes.

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