Sustainable Dyeing of Jute Fabric with Natural Dye Sources by Cold Pad Batch Technique

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Abstract

Jute is popularly known as perishable, reusable and ecological friendly fiber having golden & silky shine appearance; therefore termed as the Golden fibre in Bangladesh. Jute is budget friendly vegetable fiber procure from the bast or skin of the plant's stem and most important fiber after cellulosic cotton fibre in terms of variation in usage, universal consumption generation & availability. Natural dyestuffs are popular now days for sustainable issues in textiles industries. This research was focused on environment friendly natural dyeing technique on jute fabric with natural dye sources through cold pad batch (CPB) dyeing technique. Java plum fruit, kadamba flower & malbar spinach vegetable were selected as natural dye sources and extracted dye liquors using methanol solvent. Evaluated dyed samples by color co-ordinate values by spectrophotometer where lighter to darker shades were achieved on dyed Jute samples with the dye extracts and K/S value was analysis to assess color strength among dyed samples. Different Color fastness test was done to find better dyeing performance on jute where sample dyed with malbar spinach vegetable extract showed better performance compared to other dye extracts. Moreover, the research was intended to observe dyeing possibilities of jute fabric with natural sources without focusing on mordant for opening a new export area of sustainable dyed jute goods maintaining sustainable textile processing.

Keywords: Jute fiber, Natural dye, Extraction, Cold pad batch dyeing, Sustainable.

1. Introduction

Jute is ecofriendly as well as being one of the most affordable bast fiber like flax and hemp fiber; jute plants are easy to grow and high production per acre need less amount of pesticides and fertilizers unlike cotton fiber. Implementation of natural bio sources have been getting importance due to sustainability issues in 21 century [1] . The application of fiber & dye from natural sources in textile sectors is now a concerning issue of many countries & organizations to avoid the toxic and health hazard problems associated with synthetic dyes which are mostly used in textiles to save our environment [2]. To save our upcoming generations we should find sustainable ways to minimize hazardous dyes & chemicals as well as synthetic fibers usages. Therefore, Little research was done on jute fabric dyeing with natural dyes[[3][4][5]] specially there is no work on cold pad bath jute dyeing technique using natural dyes and also the application of dyed jute fabric is very limited . This research have taken an attempt to research natural dyes applications on jute fiber where dyes were extracted from three natural sources like java plum fruit, kadamba flower & malbar spinach vegetable and used cold pad batch technique for dyeing without using mordant.

2. Experimental

2.1 Materials

2.2.1 Fabric

A raw plain weave jute fabric was used in the experiment. Jute fabric was sourced from a manufacturing plant named Hasan Fabric Limited, madhabdi, Narshindi, Bangladesh. Table 1 presented the fabric specification. Prior to dyeing collected jute fabric was pretreated using following recipe displayed in Table 2 where H_2O_2 and NaOH are not sustainable chemical yet so further research can be possible to use sustainable chemical for pretreatment of jute fabric. In this research, only dyes are used from sustainable sources.

Table 1. Specification of Jute fabric

Fabric	EPI	PPI	Count (Ne)	GSM
Jute	12	12	2	311

Table 2. Recipe of pretreatment of raw jute fabric

Parameter	Amount
Hydrogen peroxide	15 g/l
Sodium Hydroxide	10 g/l
Stabilizer	2 g/l
Sequestering Agent	5 g/l
Wetting Agent	1 g/l
Detergent	3 g/l
Time	90 Minutes
Temperature	98 ^oC
pH	10
M:L	1:10

2.2.2 Dyes

- Java plum fruit,
- Kadamba flower
- Malbar Spinach vegetable
-

2.3 Methods

2.3.1 Extractions

The color components of java plum fruit, kadamba flower and malbar spinach vegetable were extracted using solvent (methanol) extraction method. At first, java plum fruit, kadamba flower and malbar spinach vegetable were collected, thoroughly washed and cleaned. Then dried by sunlight for a week and grinded into fine powdered. Then weighting 50 g of dried powered materials and dissolved with 500 ml of methanol maintaining 1:10 material liquor ratio in a conical flask separately and covered the open end slightly and let them simmer for seven days for extraction facilitation. After seven days, extracted dye liquors of java plum fruit, kadamba flower and malbar Spinach vegetable were filtered and collected. Then the extractions were heated to evaluate the remaining solvent.

2.3.2 Cold pad batch dyeing

Cold pad batch (CPB) lab dyeing machine (figure 1) was used for the experiment. Padder pressure was set before dyeing as minimum pressure was set to achieve maximum pick up percentage. Then dyeing solutions were prepared according to following recipe presented in table 3 individually and padded and

squeezed fabric for 5 times to achieve shade on fabric. Usually in cold pad batch dyeing technique follows low liquor ratio but here considered 1:10 liquor ratio in the experiment for developing shade properly during dyeing. Then dyed samples were cold washed and dried for 100 ^{o}C temperature for 5 minutes. Table 4 represent labeling of jute samples

Table 3. Recipe for cold pad batch dyeing

Parameter	Quantity
Sample size	(3x3) inch
Extractions (java plum fruit,kadamba flower and malbar spinach vegetable)	50g/l
padder pressure	0.12 Mpa
pick up (%)	80
Padding cycle	5 times
MLR	1:10

Figure 1. Cold pad batch lab dyeing machine

Table 4. Labeling of Samples

Sample identification	Sample description
JR	jute sample in raw condition
JT	Treated jute fabric
J1	Dyed jute fabric with java plum fruit
J2	Dyed jute fabric with kadamba flower
J3	Dyed jute fabric with malbar spinach vegetable

2.2.3 Characterization of dyed samples

Dyed samples were characterized by color co-ordinate values and color strength results using spectrophotometer where kubelka-Munk equation (equ.1) is followed to find k/s value of dyed samples.

$$\frac{k}{s} = \frac{(1-R)^2}{2R} \quad (1)$$

Different color fastness (C/F) test method like C/F to wash (ISO 105 C06), C/F to water (ISO 105 E01) , C/F to perspiration (ISO 105 E04), C/F to light (ISO 105 B02) and C/F to rubbing (ISO-105-X12) were done for evaluating fastness properties of dyed samples.

3. Results and discussions

3.1 Visual Assessment of dyed samples

The pictorial view of treated and dyed jute fabric was exhibited on table 4. It was observed that dyed sample with java plum fruit gave better color yield than dyed sample of kadamba flower and malbar spinach vegetable. The chromophoric group of java plum fruit extract yield light purple in hue where kadamba flower extract gave light yellow color and malbar spinach extract gave light green hue. Mordant was not used during dyeing that why yield color on dye extracts produced lighter shade on jute fabric. Table 5 presented pictorial view of jute samples where effects are not properly visualized due to electric scan.

Table 5. Pictorial view of jute samples dyed with java plum fruit, kadamba flower and malbar spinach vegetable extract.

Serial no.	Samples	Pictorial view
1	JR	
2	JT	
3	J1	

4	J2	
5	J3	

3.2 Colorimetric value

Table 6 plotted the color co-ordinate value of dyed jute samples that are characterized by CIE L* a* b* Under D65 artificial light source d/2 viewing geometry. It was observed that scoured and bleached samples gave highest lightness value, whereas lightness value all dyed samples was decreased compared to bleached sample. Moreover, J1 has -24.32 blueness and 6.24 redness in tome where J2 give 16.52 yellowish and 2.92 redness. Again, J3 has -7.15 greenish and 11.43 yellowish in tone. It is clearly observed that samples dyed with java plum fruit extract gave darker shade yield compared to other extractions.

Table 6. Colorimetric value of dyed jute fabric

sample	**D65**				
	L^*	a^*	b^*	C	H
JT	67.02	5.19	17.91	19.71	70.32
J1	58.03	6.24	-24.32	20.62	60.12
J2	61.15	2.92	16.52	15.18	55.17
J3	62.02	-7.15	11.43	12.06	59.01

3.3 Color strength analysis

Color strength value is related to reflectance value. Darker shade of samples have high reflectance value and high k/s value. Figure 2 plotted color strength value of tested samples. Dyed jute fabric with Java plum fruit extraction (J1) gave darker shade among other dyed samples that's why it has high color strength value compared to other dyed samples.

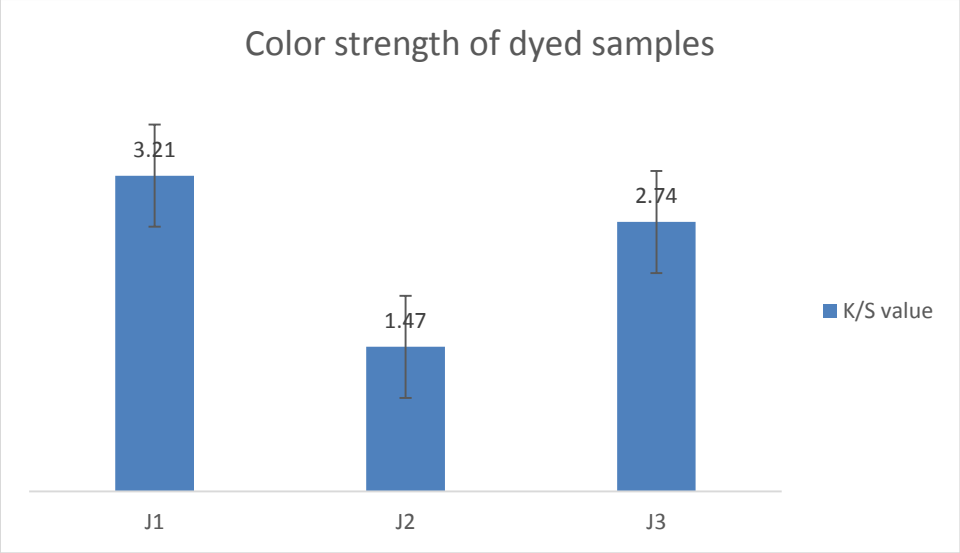

Figure 2. Comparison among dyed samples by color strength value

3.4 Analysis of different color fastness test results

Dyed jute sample with malbar spinach extact (J3) has very excellent color fastness to wash results against color staining to multifiber fabric and color change (grey scale rating 5 and 4/5) where dyed jute sample with kadamba extract (J2) showed 4 and 4/5 grey scale rating against multifiber fabric and dyed jute sample with java plum extract gave satisfactory color fastness to wash rating (grey scale rating 2/3, 3,4) plotted in the figure 3. Again, dyed jute samples showed satisfactory color fastness to light test result whereas jute sample dyed with java plum extract (J1) showed very poor blue scale test rating (figure 4). Therefore, J3 and J2 samples have better acid and alkali perspiration and color fastness to water test result compared to J1 samples displayed in the figure 5 and figure 6. .Moreover, dry rubbing of all dyed samples showed better performance compared to wet rubbing (figure 7).

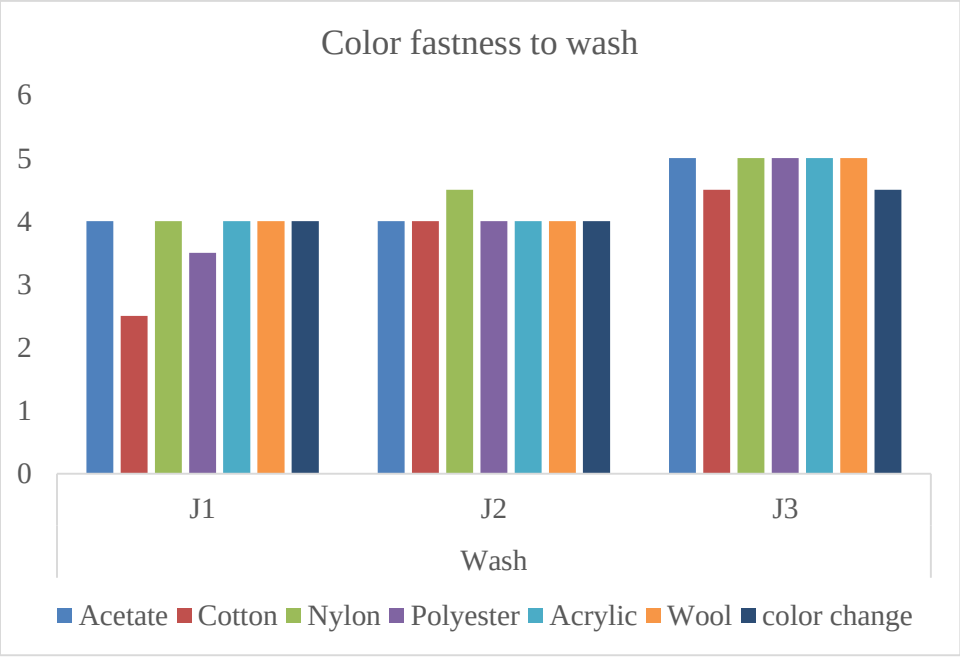

Figure 3. Comparison of color fastness to wash test results among dyed jute samples

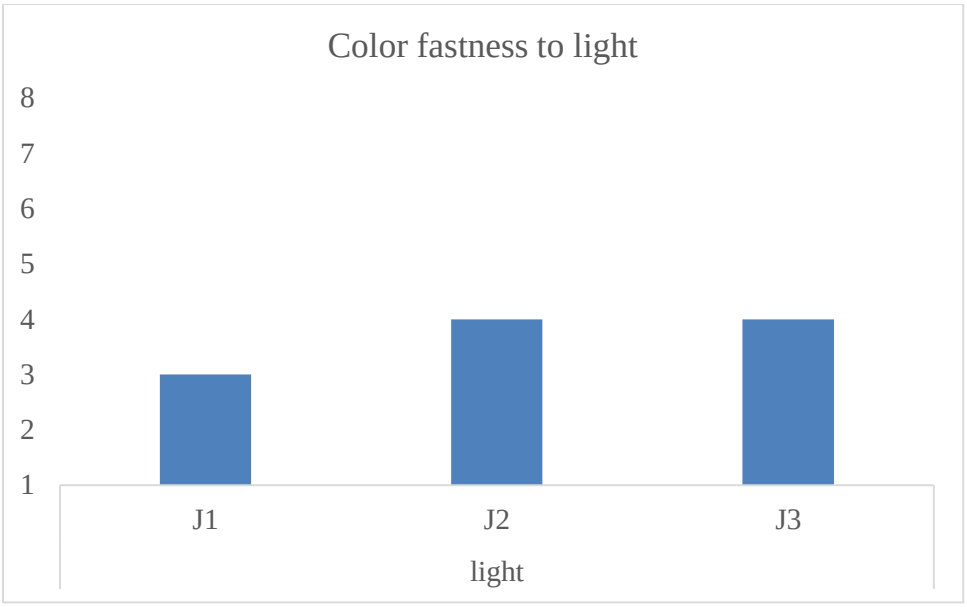

Figure 4. Comparison of color fastness to light test results among dyed jute samples

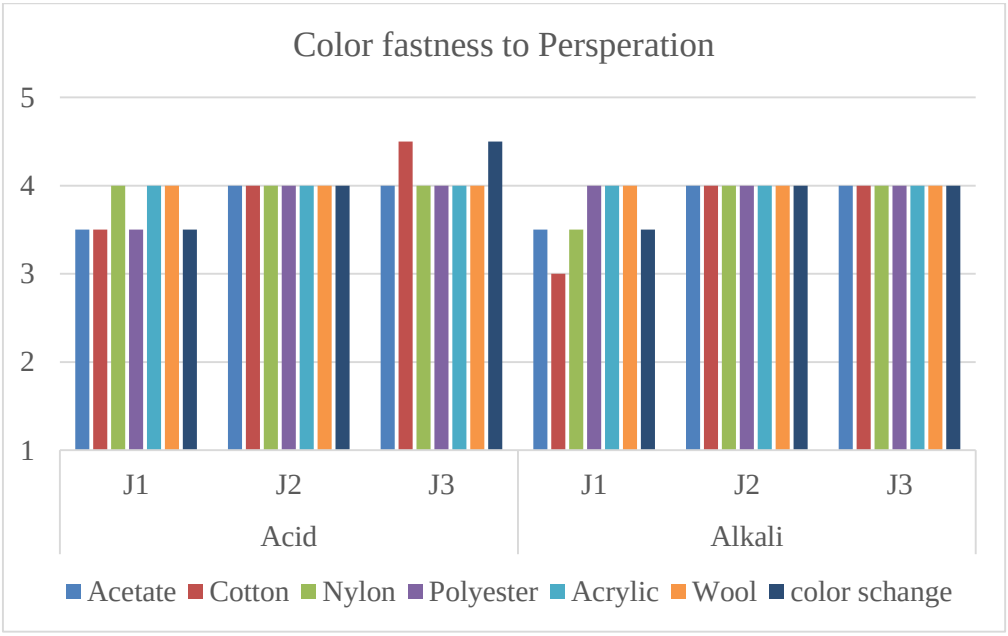

Figure 5. Comparison of color fastness to perspiration test results among dyed jute samples

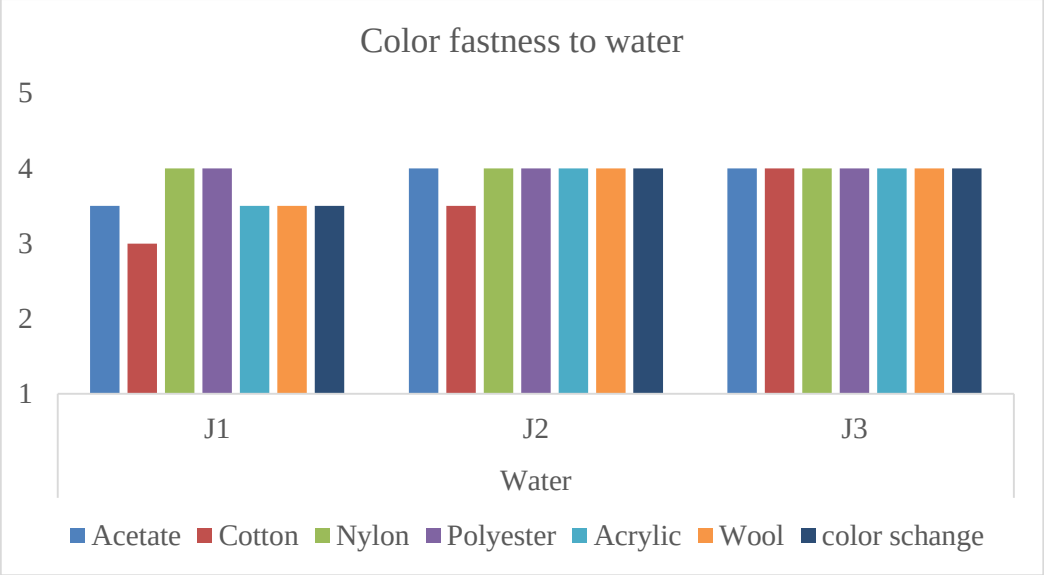

Figure 6. Comparison of color fastness to water test results among dyed jute samples

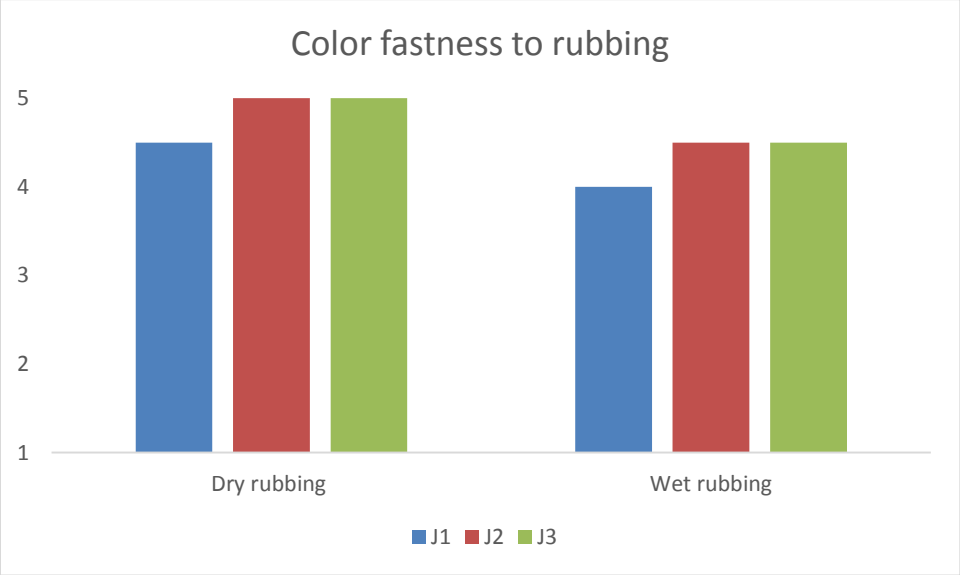

Figure 7. Comparison of color fastness to rubbing test results among dyed jute samples

4 Conclusion

Jute is one of the most affordable natural fibers and is the second after cotton fiber in amount of production and variety of uses. This research have showed pad batch natural dyeing technique on jute fabric with three different types of natural dye sources and characterized and evaluated samples by colorimetric value and fastness properties where Jute samples dyed with malbar spinach leave extract showed better natural dyeing performance compared to other samples. In a conclusion it can be said that all the extracts can be good substitute of synthetic dyes for sustainable jute dyeing in future prospect. The limitation of this research is that levelness of dyeing was not achieved properly due to less substantively of jute fiber with these dye sources and used of non-sustainable chemical in

pretreatment process. In this research, no finishing treatment was done of the samples for color retention for a long period. So further research work is need to study its after finishing behaviors & color longevity and levelness with different natural dye sources on jute fabric.

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Conflict of interest

All authors are confirming that there is no conflict of interest of this work

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