

Printing of jute fabric with natural dyes extracted from manjistha, annatto and ratanjot

S N Chattopadhyay^a, N C Pan & A Khan

Chemical & Biochemical Processing Division, ICAR-National Institute of Research on Jute & Allied Fibre Technology,
Kolkata 700 040, India

Received 1 September 2016 ; revised received and accepted 1 March 2017

Grey jute fabric has been treated with cellulase / zylanase enzyme combination (4% owf) in presence of non ionic detergent and mild alkali, bleached by ecofriendly oxidising bleaching agent, double mordanted and then printed with natural dyes extracted from manjistha, annatto and ratanjot. Bioscouring and bleaching make the fabric white (whiteness Index 82.44 in HUNTER scale) and soft (flexural rigidity 623-686 mg.cm), which are very much essential for good printing effect. The fabrics are double mordanted with myrobolan (biomordant) extract and potash alum (chemical mordant). Natural dyes are extracted from seeds of annatto, roots of manjistha and bark of ratanjot by aqueous extraction method. The particle size of the dyes is found in the range of 400-900nm. Mordanted jute fabrics are printed by screen printing method using different mesh sizes (20,40,60). Guar gum is used as thickener and urea as hygroscopic agent. After printing, steaming is done for 30 min at 100°C followed by soaping and washing. The findings reveal that the printed jute fabric with very good wash and rub fastness can be produced from natural dyes and natural thickener (guar gum) by substantive screen printing method, and these can be used as decorative, furnishing and apparel textiles.

Keywords: Annatto, Bioscouring, Bleaching, Jute fabric, Manjistha, Mordants, Natural dyes, Printing, Ratanjot

1 Introduction

Natural dyes and colouration are as old as textiles themselves, being practised from the Bronze age in Europe¹. Since the advent of widely available and cheaper synthetic dyes in 1856 having moderate to excellent fastness properties, the use of natural dyes having poor to moderate fastness has declined to a great extent.

However, nowadays the increased environmental awareness has forced the use of non-toxic and ecofriendly natural dyes on textiles in order to avoid some hazardous synthetic dyes². The worldwide use of natural dyes for the colouration of textiles has mainly been restricted to craftsman, small scale dyer & printer as well as small scale exporters & producers, dealing with high value ecofriendly textiles production & sales³⁻⁵. Recently, a number of commercial dyes and small scale export houses have started looking at the possibilities of using natural dyes on regular basis for dyeing and printing of textiles to overcome environmental pollution caused by the synthetic dyes⁶. Natural dyes produce very uncommon, soothing and soft shades as compared to

synthetic dyes. At present there are a small number of companies that are known to produce natural dyes commercially but the numbers are increasing day by day. For commercial exploitation of natural dyes, the appropriate and standardised dyeing and printing techniques need to be adopted without sacrificing required quality of coloured textile materials. A need has also been felt to reinvestigate and rebuild the traditional process of colouration to control each treatment, i.e. preparatory and printing process variables for producing different shades with balanced colour fastness.

A lot of work has been carried out for dyeing of textiles using natural dyes but the work on printing is very limited. Rekaby *et. al.*⁷ studied the printing of natural fabrics (wool, silk, cotton and flax) with natural dyes from alkanet and rhubarb by using pigment printing technique. Karolia and Buch⁸ studied the resist printed natural dyed textile of Ajarkh. Hebeish *et. al.*⁹ evaluated the reactive cyclodextrin in cotton printing with henna as natural dyes. Hakeim *et. al.*¹⁰ studied the cotton fabric pretreated by chitosan and printed with natural colouring matter, curcumin. The colour yield was found to increase by increasing the molecular weight of chitosan.

^a Corresponding author.
E-mail : sambhu_in@yahoo.com

Jute is a lignocellulosic golden fibre and is being utilised in a number of diversified and value-added products apart from its traditional use as packaging material. Area of application extends from wall hanging, appliance cover & curtains to apparels, where attractive look and feel are must. Attractive look can be obtained either by dyeing or by printing. Cellulosic constituents of jute fibre, about 60% of its weight, are primary responsible for colouration of jute fibre. Synthetic dyes are mainly used for colouration of jute fabric, but recently some endeavour has been made to replace the synthetic dyes with natural dyes for dyeing of jute fibre¹¹⁻¹³. However, there is hardly any work on printing of jute using natural dyes and development of a process to produce printed jute fabric with natural dyes with satisfactory fastness properties. It has been found that jute fabric can be dyed with natural dyes with reasonable fastness properties. It is assumed that printing of jute fabric can be tried using natural dyes and suitable printing additive to produce printed fabric with reasonable fastness to washing, rubbing and light. Therefore, in the present work, jute fabric has been subjected to bioscouring, ecofriendly bleaching and mordanting, and subsequently printed with natural dyes extracted from roots of manjistha, bark of ratanjot and seeds of annatto; natural thickener has been utilised for preparing print paste.

2 Materials and Methods

2.1 Materials

A plain weave grey jute fabric having the specifications, warp 60 ends/dm (count 260 tex), weft 52 ends / dm (count, 256 tex) and fabric mass 250 gms/m² (at 65% RH, 27°C), was used.

Analytical grade hydrogen peroxide (30%), trisodium phosphate, sodium carbonate, acetic acid, sodium silicate, Glauber's salt, urea, guar gum and Ultravon JU (non-ionic surface active agent) were used in the experiment.

A commercial cellulase enzyme (Texbio M) and xylanase enzyme (Texzyme J), obtained from M/s Textan Chemicals Pvt Ltd, Chennai, were used.

Two types of mordant namely biomordant Myrobolan (*Terminila chebula*) and chemical mordant potash alum (hydrated salt of potassium aluminium sulphate) were used.

Three different types of natural dyes namely manjistha, ratanjot and annatto were used in the experiment (Table 1).

2.2 Methods

2.2.1 Bioscouring

Raw jute fabric was treated with mixture of xylanase enzyme (Texzyme J, 2% owf), cellulase enzyme (Texbio M, 2% owf) and non-ionic surface active agent (Ultravon JU, 2 g/L) at 50°C for 2 h, keeping the material-to-liquor ratio at 1:10 and pH at 7-9. After this treatment, the temperature of the bath was raised to 90°C and maintained as such for 15 min. After treatment, the fabric was washed thoroughly in cold water and dried.

2.2.2 Bleaching

Bleaching of grey and bio-scoured jute fabrics was done in a closed vessel for 90 min at 80-85°C, keeping the material-to-liquor ratio at 1:20 with hydrogen peroxide (2 Vol.), trisodium phosphate (5 g/L), Ultravon JU (2 ml/L), sodium hydroxide (1 g/L) and sodium silicate (10 g/L). The pH of the bath was maintained at 10. After bleaching, the fabrics were washed thoroughly in cold water, neutralised with acetic acid (2 ml/L), washed again in cold water and finally dried.

2.2.3 Mordanting

Mordanting with Myrobolan

The myrobolan powder (20%, owm) was soaked in water (material-to-liquor ratio 1:10) for overnight (12 h) at 30°C to obtain swelled myrobolan gel. This gel was then mixed with a known volume of water and heated at 80°C for 30 min. This solution was then cooled and filtered in a 60 mesh nylon cloth and the filtrate was used as final mordant solution for mordanting using material-to-liquor ratio at 1:20. Bleached jute fabric was then treated with myrobolan solution initially at 40 – 50°C and then temperature

Table 1 — Details of natural dyes used

Common name	Botanical name	Parts used	Colour index number	Chemical class
Manjistha	<i>Rubia cordifolia</i>	Roots	C.I. Natural Red 16	Antraquinone
Ratanjot	<i>Onosma echoides</i>	Bark of roots	C.I. Natural Red 20	Napthoquinone
Annatto	<i>Bixa orellana</i>	Seed	C.I. Natural Orange 4	Carotenoid

was raised to 80°C. The mordanting continued for 30 min. Then the fabric was dried without washing.

Mordanting with Potash Alum

Bleached jute fabric and biomordanted (myrobolan) bleached jute fabrics were mordanted with potash alum (10% owm) at 80°C for 30 min, keeping the material-to-liquor ratio at 1:20. The mordanted jute fabrics were dried without washing for subsequent printing with natural dyes.

2.2.4 Extraction of Natural Dyes

Respective parts of different plants like manjistha, annatto and ratanjot were dried, ground to powder and soaked in water for 12h at different pH conditions (alkaline for annatto & ratanjot and neutral for manjistha). After soaking, the dye solution was boiled for one hour. After the extraction, the extracts were cooled to 30°C and filtered to remove the insoluble residues. The solutions were then dried in hot sand bath by evaporative drying process and dry powder was produced.

2.2.5 Evaluation of Particle Size of Extracted Natural Dyes

Particle size of the extracted natural dyes was evaluated using the instrument, nano particlesizer (Model Zetasizer Nano ZS, Malvern, U.K) in nm scale.

2.2.6 Preparation of Print Paste

Guar gum solution (10%) was boiled for 15-20 min and then kept at ambient condition to bring down the solution to normal temperature. Then natural dye powder (4%) and urea (4%) were added to the thickener paste and stirred well. The paste thus prepared was used for printing.

2.2.7 Printing of Jute Fabric

Printing of jute fabric was carried out using the flat screen technique. Printed samples were then dried and steamed at 100°C for 30 min. The printed samples were rinsed with cold water for 20 min, followed by

soaping with non-ionic detergent (2 g/L) at 40°C for 10 min. The printed fabric was washed with cold water and dried in air.

2.2.8 Evaluation of Fabric Properties

Grey, chemically scoured, bioscoured and printed jute fabric samples were evaluated for different properties by using different standards, such as weight loss (IS:1383-1977), absorbency (IS:2369-1967), whiteness index (HUNTER), yellowness index (ASTM D1925), brightness index (TAPPI 452), K/S value (Kubelka-Munk equation), L, a*, b* values (computer colour matching system), wash fastness (IS: 3361-1979), rub fastness (IS:766-1956), light fastness (IS:2454-1967), handle properties (IS:6490-1971) and tensile properties (ASTM D1682-1975).

3 Results and Discussion

Grey jute fabric was treated with cellulase-xylanase enzyme combination (4%, owf) in presence of non-ionic detergent and mild alkali, and bleached with hydrogen peroxide by conventional process. Weight loss of jute fabric was 1.0% and 6.0 % respectively during bioscouring and bleaching operations. The fabric becomes absorbent and white after this treatment. Physical and optical properties of grey, bioscoured and bleached jute fabrics are shown in Table 2.

The enzyme used in this study consists of cellulase enzyme and xylanase enzyme. Cellulase enzyme acts on the cellulose part of the fibre and xylanase enzyme acts on the hemicellulose part of the fibre. The cumulative action of the enzyme results in loss of weight by removing a part of cellulose and hemicellulose portion. The mixed enzyme treatment has synergistic effect and leads to removal of both cellulose and hemicellulose component, making the structure loose. They are removed during washing, resulting in an open structure. Addition of non-ionic surface active agent helps easy removal of reaction

Table 2 — Physical and optical properties of grey and processed jute fabric

Sample	GSM	Weight loss %	Absorbency	Tenacity		Bending length		Bending modulus		Flexural rigidity		WI	YI	BI	K/S value
				g/ tex		cm		kg/ cm ²		mg.cm					
				Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft				
Grey	225	-	900	4.42	5.83	4.75	4.63	71.39	66.13	2411	2233	44.75	55.31	15.49	2.04
Biosourced	262	1.00	7	3.56	4.60	3.55	3.51	24.59	23.77	1172	1132	39.44	49.99	12.63	1.88
Bleached	235	6.00	7	3.10	4.06	2.98	3.08	14.04	15.50	623	686	82.44	21.37	62.53	0.21

WI— Whiteness index, YI— Yellowness index and BI— Brightness index.

products of enzymolysis along with natural and added impurities, resulting in cleaner surface of the jute fabric which is more absorbent. So, the absorbency of the fabric obtained by using mixed enzyme with surface active agent is much better. There is a substantial improvement of whiteness and brightness with reduction of yellowness after conventional bleaching. These fabrics are then utilised for printing with natural dye.

3.1 Extraction of Natural Dye

Yield of dyes are as follows:

- Manjistha : 11.7%
- Annatto : 29.64%
- Ratanjot : 24.9 %

Particle size of the extracted natural dye powders were evaluated , they are as follows:

- Manjistha : > 560-860nm (93%), 64-89 nm (7%)
- Annatto : > 520-800 nm

Ratanjot : > 480-810nm (91%), 61-89nm (9%)

It is observed that the yield of dyes produced after evaporative drying varies from dye to dye. It is found low in case of manjistha. The particle size of the dyes ranges from 480 nm to 860 nm.

In order to improve the dye affinity as well as fastness properties of printed jute fabric, biosourced and bleached jute fabrics were mordanted using myrobolan extract by exhaustion method. A portion of these samples was further treated with ecofriendly chemical mordant potash alum. So, following three different samples were produced:

- Bioscoured-bleached jute fabric (A)
- Bioscoured-bleached-biomordanted jute fabric (B)
- Bioscoured-bleached-double mordanted jute fabric (C)

All these bioscoured-bleached-mordanted jute fabrics are printed and then evaluated for colour yield and fastness properties (Table 3)

It is observed that the colour yield of the printed samples improves appreciably in terms of *K/S* value in case of mordanted fabric. This may be attributed to the interaction of natural dyes with mordants, resulting in improvement in colour strength and fixation of colour onto the fabric. Both the wash and rub fastness properties are found best in case of double mordanted jute fabric.

Mesh size of the printing screens plays an important role in print sharpness, fastness and colour yield of the print. Porosity of the screens varies with the change in mesh size and it is more in case of 20 and less in case of 60. Printing is carried out on bioscoured-bleached jute fabric using three extracted natural dyes, i.e. manjistha, annatto and ratanjot. All the samples are evaluated for optical, wash fastness and rub fastness properties and results are given in Table 4.

Table 3 — Color yield and fastness properties of different printed jute fabrics using natural dyes

Sample	Dye	<i>K/S</i>	Wash fastness	Rub fastness	
				Dry	Wet
A	Manjistha	5.48	2	5	4 - 5
	Annatto	3.94	2	4	3 - 4
	Ratanjot	3.36	2	4	4 - 5
B	Manjistha	11.14	2 - 3	4 - 5	3 - 4
	Annatto	10.3	2 - 3	5	4
	Ratanjot	7.09	2 - 3	4 - 5	3 - 4
C	Manjistha	17.50	3 - 4	5	4
	Annatto	14.76	3	5	4 - 5
	Ratanjot	15.73	3	4 - 5	4

Table 4 — Effect of mesh size on pigment printed jute fabric

Mesh size	<i>K/S</i> value	L	a*	b*	Wash fastness	Rub fastness	
						Dry	Wet
Manjistha							
20	5.98	55.34	12.66	18.19	3	5	4-5
40	5.09	55.49	12.32	18.23	3	5	4-5
60	4.76	57.48	10.40	19.37	2	5	4-5
Annatto							
20	4.86	58.75	19.54	37.65	2-3	4	3-4
40	4.95	60.54	19.21	39.43	2-3	4	4
60	3.45	58.76	18.16	36.51	2	4	3-4
Ratanjot							
20	4.86	58.75	19.54	37.65	2-3	4	3-4
40	4.95	60.54	19.21	39.43	2-3	4	4
60	3.45	58.76	18.16	36.51	2	4	3-4

4 Conclusion

4.1 Bioscouring and bleaching make the jute fabric white, bright and soft, which is suitable for printing.

4.2 Particle sizes of natural dyes extracted from manjistha, annatto and ratanjot are found to be in the range of 400-800 nm.

4.3 Colour yield and fastness properties are found better in case of printing on double mordanted bioscoured-bleached jute fabric.

4.4 Screen mesh size of 20 or 40 is found better in case of printing of jute fabric.

4.5 Wet and dry rub fastness are excellent in case of printed jute fabric using manjistha while it is good in case of annatto

References

- 1 Siva R , *Current Sci*, 92(7) (2007) 916.
- 2 Yi E & Cho J , *Color Research Application*, 23(2) (2008) 148.
- 3 Samanta A K & Agarwal P, *Indian J Fibre Text Res*, 34(4)(2009) 384.
- 4 Bechtold T & Mussak R, *Handbook of Natural Colorants* (John Wiley & Sons, West Sussex), 2009.
- 5 Vankar P S, *Handbook on Natural Dyes for Industrial Applications* (National Institute of Industrial Research, New Delhi), 2007.
- 6 Glover B & Pierce J H, *Soc Dyers Colour*, 109(1) (1993) 5.
- 7 Rekaby M, Salem A A & Nassar S H, *Text Inst*, 100(6) (2009) 486.
- 8 Karolia A & Buch H, *Indian Trad Knowledge*. 7(1) (2008) 93.
- 9 Hebeish A A, Ragheb A A, Nassar S H, Allam E E & El Thalouth, J I A, *Appl Polym Sci*, 102(1) (2006) 338.
- 10 Hakeim O A, Abou-Okeil A, Abdob L A W & Waly A, *Appl Polym Sci*, 97(2) (2005) 559.
- 11 Chattopadhyay S N , Pan N C., Roy A K, Saxena S & Khan A, *Text Inst*, 104(8) (2013) 808.
- 12 Samanta A K & Aggarwal P. *Indian Fibre Text Res*, 32(4) (2007) 466.
- 13 Samanta A K & Aggarwal P, *Indian Fibre Text Res*, 33(1) (2008) 664.