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Dyeing of jute with natural dyes

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Grey jute fabric was bleached with hydrogen peroxide (1 vol.) by the conventional method, mordanted with different concentrations of ferrous sulphate and dyed separately with natural dyes extracted from deodara leaf (*Cedrus deodara* L.), jackfruit leaf (*Artocarpus integrifolia* L.) and eucalyptus leaf (*Eucalyptus globulus* L.). Lighter shades were obtained after dyeing of bleached jute fabric with the above extracts without applying mordant. Dye uptake increased with the increase in mordant concentration. The use of mordant in the dyeing of jute fabric resulted in deeper shade with good wash fastness.

Keywords : Bleaching, Deodara leaf, Dyeing , Eucalyptus leaf, Jackfruit leaf, Jute, Mordant, Natural dye

1 Introduction

The use of natural dyes[1-4] in textile applications is growing day by day. It is the effect of the stringent environmental standards set by many countries / organizations to avoid the toxic and health hazard problems associated with synthetic dyes which are mostly used in textiles. Natural dyes[5] are derived from plants, insects and minerals without any chemical processing and have several advantages, viz. renewable resources, no health hazards, no disposal problem and harmonised with nature. Still there are some problems associated with the natural dye, e.g. limited number of colours, inadequate degree of fixation, inadequate fastness properties, reproducibility of shades, etc. All these drawbacks can be minimized by the judicious application of natural dyes on to the substrate.

The application of natural dyes on jute is very limited. Little research work has been carried out in the field of application of natural dyes on jute fibre. Natural dyes and jute fibre both are ecofriendly. In the present work , an attempt has been made to dye jute fabric with three natural dyes extracted from deodara leaf, jackfruit leaf and eucalyptus leaf with and without using mordant. These leaves are abundantly available in India at a cheaper rate and it is easy to apply the colour extracted from these leaves on jute fabric.

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2 Materials and Methods

2.1 Materials

2.1.1 Substrate

A plain weave grey jute fabric having the following specifications was used :

Warp : 60 ends/dm (count, 260 tex)
Weft : 51 ends/dm (count, 268 tex)
Fabric mass : 260 g/m^2 (at 65% RH and 20°C)

2.1.2 Natural Dyes

Three natural colourants obtained from plants were used as natural dyes. The details of plant source and dyes are given in Table 1.

2.1.3 Mordant

Hydrated salt of ferrous sulphate (Fe $S0_4$,$7H_20$) was used as mordant.

Table 1 — Details of natural dye sources and dyes extracted

Plant source			Dye	
English name	Botanical name	Part used	Colour index No	Constitution No.
Deodara	*Cedrus deodara* L.	Leaf	C.I. Natural Brown 3	75250
Jackfruit	*Artocarpus integrifolia* L.	Leaf	C.I. Natural Yellow 11	75660
Eucalyptus	*Eucalyptus globulus* L.	Leaf	C.I. Natural Yellow 2	75590

2.1.4 Chemicals

Hydrogen peroxide, sodium hydroxide, sodium sulphate, trisodium phosphate, sodium silicate, Ultravon JU (non-ionic detergent) and acetic acid were used . All these chemicals were of analytical grade.

2.2 Methods

2.2.1 Extraction of Natural Dyes

The green leaves of deodara, jackfruit and eucalyptus were cut into small pieces and soaked in soft water (1000 g of green leaves in 1000 ml of water) and thereafter boiled for 4 h separately. The replenishment of evaporated water was carried out during boiling. The dye constituents present in the natural colourants were transferred to the aqueous solution during boiling. The dye solution was filtered twice and evaporated to dryness at normal pressure and 95°C to make it a powder form and preserved for application on jute fabric.

2.2.2 Bleaching of Grey Jute Fabric

Bleaching of grey jute fabric was done in a closed vessel for 1 h at 80-85°C, keeping the material-to-liquor ratio at 1:20, with hydrogen peroxide (1 vol.), trisodium phosphate (5 g/L), sodium hydroxide (1 g/L), sodium silicate (10 g/L) and non-ionic detergent (5 g/L). The pH of the bath was maintained around 10. After bleaching, the fabric was washed thoroughly in cold water , neutralized with acetic acid (2 ml/L), washed in water and dried in air.

2.2.3 Dyeing of Bleached Jute Fabric with Natural Dyes

Bleached jute fabrics were dyed separately with 8% natural dyes (owf) extracted from deodara leaf, jackfruit leaf and eucalyptus leaf separately at a temperature of 95°C for 1 h, keeping the material-to-liquor ratio at 1:20. Sodium sulphate (5 g/L) was added during dyeing as levelling agent. The pH of the bath was maintained at 5. After dyeing, the dyed fabrics were washed thoroughly in cold water and then soaped with 5 g/L non-ionic detergent at 40°C for 15 min, followed by usual washing and drying.

2.2.4 Mordanting of Bleached Jute Fabric

Bleached jute fabric was mordanted separately with hydrated ferrous sulphate of different concentrations, viz 1%, 2% and 3% (owf), at a temperature of 90°C for 30 min, keeping the material-to-liquor ratio at 1:20. The mordanted fabric was then used for dyeing without any washing.

2.2.5 Dyeing of Mordanted Jute Fabric with Natural Dyes

Mordanted jute fabrics were dyed with the natural dyes extracted from deodara leaf, jackfruit leaf and eucalyptus leaf separately following the procedure described in **2.2.3.**

2.2.6 Determination of Whiteness, Yellowness and Brightness Indices

Whiteness index in the 'HUNTER' scale, yellowness index in the 'ASTM D1925' scale and brightness index in the 'TAPPI 45' scale of grey, bleached and dyed jute fabric samples were measured by the Spectrascan - 5100 (R) computer colour matching system using relevant softwares.

2.2.7 Evaluation of Dyeing

This was done by determining *K/S* values, colour strength and L^*, a^*, b^* values using computer colour matching system. The reflectance was determined at different wave lengths and the *K/S* value was calculated at λ_{max} using the following relationship:

$$K/S = \frac{(1 - R)^2}{2R}$$, where R is the reflectance.

2.3.8 Evaluation of Wash Fastness

All the natural colour dyed samples were subjected to wash fastness test in a launderometer as per IS : 3361-1979[6] . Wash fastness rating of all the natural dyed samples was evaluated with the help of computer colour matching system.

3 Results and Discussion

Whiteness, yellowness and brightness indices of grey and bleached jute fabrics at 10° angle of observation are given in Table 2. Whiteness, yellowness and brightness indices of grey jute fabric after bleaching with hydrogen peroxide are satisfactory enough for the purpose of dyeing with natural dyes to get lighter shades. Bleached jute fabrics were dyed separately with deodara leaf extract, jackfruit leaf extract and eucalyptus leaf

Table 2 — Whiteness, yellowness and brightness indices of grey and bleached jute fabrics

Fabric	Whiteness index (HUNTER)	Yellowness index (ASTM D1925)	Brightness index (TAPPI 45)
Grey jute	45.69	52.62	19.41
Bleached jute	77.47	28.45	53.27

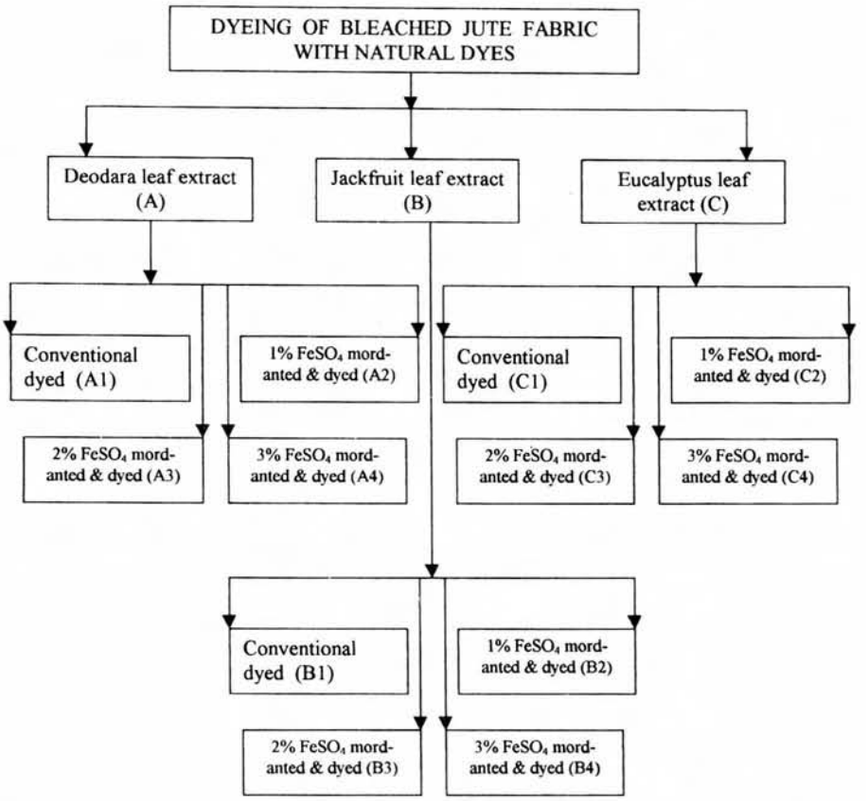

Fig. 1— Schematic diagram of alphabetical representation of different processes

Table 3 — Dyeing properties of jute fabric dyed using natural dye extracted from deodara leaf

Fabric sample	λ_{max} nm	*K/S* value	Colour strength %	L^*	a^*	b^*	Brightness index (TAPPI 45)	Wash fastness
A_1	430	3.53	100.00	39.54	12.33	7 20	11.34	3-4
A_2	430	5.10	144.77	34.95	7.34	6.73	8.57	4
A_3	430	6.49	184.07	29.23	7.17	3.87	6.86	4
A_4	430	8.95	253.78	25.35	6.84	3.12	5.27	4

extract without and with ferrous sulphate mordant of different concentrations. The diagrammatic flow chart of the total experiment is shown in Fig. 1.

It is clear from Table 3 that the bleached jute fabric dyed with deodara leaf extract showed lower dye uptake (in terms of *K/S* value) as compared to pre-mordanted bleached jute fabric dyed with the same natural dye. As a result, light mustard brown shade appears in the fabric. As the mordant concentration increased, the dye uptake also increased proportionally. The dye uptake was greater at the higher mordant concentration. This could be attributed to the darkening and dulling of shades due to mordant effect. Bleached jute fabric dyed with deodara leaf extract after applying 3% (owf) ferrous sulphate as mordant showed dull dark brown shade. Lower L^* values contribute to deeper depth of shade. The appearance of dyed fabric became duller as the mordant concentration increased. The brightness index value decreased as the mordant concentration increased, whereas the wash fastness was almost same for all the cases.

When the bleached jute fabric was dyed with jackfruit leaf extract without applying mordant, the

Table 4 — Dyeing properties of jute fabric dyed using natural dye extracted from jackfruit leaf

Fabric sample	λ_{max} nm	*K/S* value	Colour strength %	L^*	a^*	b^*	Brightness index (TAPPI 45)	Wash fastness
B_1	470	4.10	100.00	35.79	10.96	4.70	10.00	4
B_2	470	5.07	123.50	31.57	8.10	3.12	8.24	3-4
B_3	470	6.90	168.10	28.57	6.51	3.09	6.52	4
B_4	470	9.41	229.32	25.05	5.89	3.67	4.68	4

Table 5 — Dyeing properties of jute fabric dyed using natural dye extracted from eucalyptus leaf

Fabric sample	λ_{max} nm	*K/S* value	Colour strength %	L^*	a^*	b^*	Brightness index (TAPPI 45)	Wash fastness
C1	420	4.14	100.00	44.22	4.68	12.11	12.05	4
C2	420	11.03	226.24	21.96	4.07	2.28	4.08	4
C3	420	16.86	407.14	19.68	2.61	2.66	3.37	3-4
C4	420	17.37	419.31	17.65	1.47	1.61	2.69	4

lower dye uptake (Table 4) was achieved and the light brown shade was observed on the fabric. As the mordant concentration increased, the shade of jackfruit leaf extract dyed jute fabric became darker and duller. Deep brown shade was developed on the jute fabric after applying 3% (owf) ferrous sulphate mordant before dyeing. Wash fastness was satisfactory in all the mordant concentrations.

Dyeing properties of jute fabric dyed with eucalyptus leaf extract (Table 5) were similar to that in the earlier cases. Application of 3% (owf) ferrous sulphate mordant resulted in dark black shade on to the fabric. Lower L^* values contributed to deeper depth of shade. About 60% lower L^* value was obtained as compared to that for fabric dyed without mordant (Table 5). Similarly, the brightness index value was also decreased by about 77% in case of 3% mordant concentration. Good wash fastness rating was observed and there was no change in λ_{max} value.

4 Conclusions

4.1 Aqueous extracts of deodara leaf, jackfruit leaf and eucalyptus leaf yield light brown to light mustard shades with good wash fastness on bleached jute fabrics.

4.2 The use of ferrous sulphate mordant in the dyeing of bleached jute fabric with extracts of deodara leaf, jackfruit leaf and eucalyptus leaf resulted in deeper shades with darkening and dulling. This was evident from the significant changes in *K/S* values, L^* values and brightness index values.

4.3 Among the three concentrations of ferrous sulphate mordant, 1% (owf) concentration gave better results with respect to shade and brightness.

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