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Dyeing of banana fiber using myrobalan natural dye

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Abstract
The use of natural dyes and natural finishes on textiles has become a matter of importance because of the increased environmental awareness to avoid hazardous synthetic dyes (soluble and Non water soluble) and synthetic chemicals. The objective of this study is to dye Banana fiber with myrobalan natural dye for comparative analysis of colour efficiencies (K/S), CIE *L*a*b** values and the colour fastness properties. Pre-mordanting and post-mordanting of banana fiber were carried out using alum, stannous chloride and ferrous sulphate mordants. Results were achieved for dyeing at 90 °C for 60 min at 10%, 30% and 50% concentration of the dye on the weight of fabric using pre- and post-mordant dyeing techniques. Treated fiber showed a substantial increase in colour depth (K/S) and adequate wash, light and rubbing fastness properties with mordanted dyed banana fiber.

Keywords: Banana fiber, myrobalan natural dye, alum, ferrous shulphate, stannous chloride, weighing balance, HTHP dyeing machine, hot air oven

Introduction
Natural dyes are colorants that are extracted from various parts of plants such as leaves, roots, barks, flowers, and fruits as well as from insects. They have been primarily used for coloring leather, and textiles made from natural fibers as silk, wool, cotton. Recently, interest has grown in natural dye applications in the textile industry as a result of the urgent demand for eco-friendly and biodegradable products. Although natural dyes are viewed as a safer alternative to synthetic dyes, they have the following disadvantages: low color yield, poor reproducibility, and inferior color fastness properties.
Natural dyes were used as substitute of synthetic dyes due to environmental conditions. They are non-polluting, non-carcinogenic and eco-friendly. Synthetic dyes are broadly disparaged in the world because; they cause water pollution and waste disposal problems. Natural dyes are environmental friendly, biodegradable and non-toxic. They are attracting the awareness of people. Some of natural dyes are anti-allergic and proved to be safe for body contact.
Myrobalan - This dyestuff consists of ground nuts of the *Terminalia chebula* tree. This tree grows in India, Nepal, Sri Lanka, Burma, Thailand, Indochina and south China. It may be classed as both a dye and a mordant, giving a light buttery yellow when applied. It is an important tannin based mordant for cotton and other fiber in India and Southeast Asia due to the light warm colour it imparts to the cloth. It is a good foundation for over dyeing. Myrobalan is also the perfect colour to lay down under a single indigo dip for teal. When used as tannin mordant it requires 15-20% WOF. If using to create a soft butter yellow use 20-30% WOF. The dye comes from the dried myrobalan nuts, which are ground into a powder. Myrobalan is rich in tannin and can be used both as a mordant and a dye for cotton and other fibres. The word myrobalan has a Greek origin; it comes from ‘muron’ which means balsam or ointment and ‘balanos’ which means acorn. Myrobalan is a dye to modify colours on cotton. It produces butter yellows. It is used for over dyeing with indigo for teals and with madder for oranges. The addition of a little amount of ferrous will produce mossy greens and grey greens; larger amounts of iron produce blue-greys and steel-greys.

Myrobalan (Terminalia chebula)
Grows primarily in the foothills of the Himalayas and is a commonly used dye throughout India. It is an upright tree with small oval leaves and lovely bright yellow flowers. Myrobalan has always been used as a primary component for cotton and other fibers dyeing in India and is

often employed as a mordant prior to creating brown and black on cotton fabrics. Myrobalan extract over dyed with indigo makes a beautiful teal color. Using higher percentages of myrobalan yield a brownish yellow, while the lower percentages yield a light buff color.

- 50 g of Myrobalan extract will dye approximately 500 grams of fiber to a dark shade

Dyestuff Myrobalan dye: It is a natural coloring matter. Coloring substance used was extracted from Terminalia chebula tree.

Fig 1: Myrobalan Nuts

Fig 2: Myrobalan Dye Powder

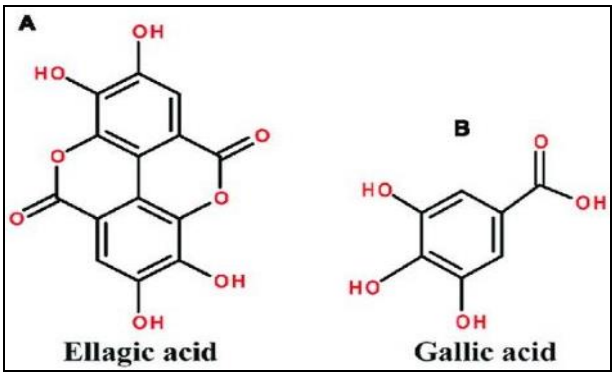

Fig 3: The chemical structures of phytoconstituents of Terminalia chebula (A) Ellagic acid and (B) Gallic acid

Experimental

Chemicals

Laboratory grade metallic salts such as ferrous (II) sulphate, (FeSO4.7H2O manufactured by Rankem RFCL Ltd), Stannous Chloride ($SnCl_2$) manufactured by Fisher Scientific and Alum ($KAl(SO_4)_2$)were used as a mordant.

Materials used for experimental work

The ready for dyeing banana fiber was extracted from plant. Myrobalan was used to obtained brownish yellow, while the lower percentages yield a light buff color shades.

Method

Extraction methods used for madder dye from powder
Madder were crushed to the powder form, and then the coloring matter was extracted using (5 g of the powder in 100 ml water) at the boiling for few minute and then solution was filtered off with filter paper and left to cool down.

Pretreatment with Alam

Alam solution was freshly prepared by dissolving (5%) of alum in distilled water at a liquor ratio 1: 30 and treated at laboratory HTHP dyeing machine with programmable time and temperature control at 60 ^{0}C for 60 min. Fibers were then squeezed and air dried in pre mordanting process and same procedure applied after dyeing in post mordanting process.

Pretreatment with ferrous Sulphate

Ferrous Shulphate solution was freshly prepared by dissolving (5%) of Ferrous Shulphate in distilled water at a liquor ratio 1: 30 and treated at laboratory HTHP dyeing machine with programmable time and temperature control at 60 ^{0}C for 60 min. Fibers were then squeezed and air dried in pre mordanting process and same procedure applied after dyeing in post mordanting process.

Pretreatment with stannous chloride

Stannous chloride solution was freshly prepared by dissolving (5%) of stannous chloride in distilled water at a liquor ratio 1: 30 and treated at laboratory HTHP dyeing machine with program- mable time and temperature control at 60 ^{0}C for 60 min. Fibers were then squeezed and air dried in pre mordanting process and same procedure applied after dyeing in post mordanting process.

Dyeing procedure

Three different mordants (Alum, Ferrous Shulphate, stannous Chloride) were used for dyeing as pre and post-mordanting agents. Mordanting and dyeing were carried out in a laboratory HTHP dyeing machine with programmable time and temperature control. The required amount of dye was taken according to the dyeing shade of 10, 30, and 50%, respectively, on the weight of fabric (o.w.f.). Around neutral pH and material-to-liquor ratio of 1:50 were maintained, and dyeing was carried out at 90 ºC for 60 min.

$$\text{Amount of mordant required in ml} = \frac{\text{Weight of fabric - Required mordant \%}}{\text{Concentration of stock solution prepared \%}}$$

$$\text{Amount of dye required in ml} = \frac{\text{Weight of fabric - Required shade \%}}{\text{Concentration of stock solution prepared \%}}$$

Evaluation of dyeing

Evaluation of dyeing was done by determining K/S and L*, a*, and b* values using computer color matching system. Color depth of the samples was evaluated measuring reflectance values by using I colour computer color matching system.

The relative color strength (in term of the K/S value) of Myrobalan natural dyed banana fiber was measured using the following Kubelka– Munk equation:

$$\frac{K}{S} = \frac{(1-R)^2}{2R}$$

where *K* is the absorption coefficient, *S* is the scattering coefficient, and *R* is the reflectance of the dyed fiber at the wavelength of maximum absorption.

Results and Discussion

Natural dyeing with myrobalan extracts on Banana fiber.

It is observed in Table 1 that the K/S values of the dyed banana fiber with myrobalan extract dye solution itself increased even without the use of mordant with increase in dye concentration. However, the K/S values were, in general, quite low due to the absence of mordant. When mordant was used before or after dyeing, there was increase in the K/S values, which is attributed to distinct chelation and complex formation of coloring compound with mordant, thus improving fixation on the fiber, giving enhanced K/S values. Different mordants, however, influenced this fixation of dye on fiber to a different extent. This is attributed to increasing the amount of colorant. Myrobalan extract in combination with alum Shulphate and stannous Chloride mordants on to Banana Fiber produced good improvement in color depth (K/S), and their values were in positive color coordinates in terms of a* (red) and b* (yellow) values. Thus, they showed shifts in their tones, resulting in beautiful gamut of colors as compared with the dyeing obtained with using mordant.

Table 1: The K/S values of the dyed banana fiber with myrobalan extract dye solution itself increased even without the use of mordant with increase in dye concentration.

Type of Mordant	Dye Conc. % o.w.f.	K/S value	L*	a*	b*
Alam (5%) Pre-mordnting	10	28.13	20.47	7.71	22.60
	30	21.37	12.06	7.61	20.89
	50	13.57	5.60	5.26	16.62
Post Mordanting	10	57.17	41.97	4.55	31.62
	30	45.19	27.71	5.02	28.61
	50	43.22	27.14	9.30	32.21
Ferrous Sulphate (5%) Pre-mordnting	10	39.68	19.57	10.66	20.99
	30	38.72	21.18	11.48	22.92
	50	31.47	16.30	11.90	21.87
Post Mordanting	10	50.40	34.81	12.51	35.02
	30	42.22	24.76	18.06	34.91
	50	32.77	16.69	18.36	27.90
Stannous Chloride (5%) Pre-mordnting	10	31.85	18.15	10.70	20.31
	30	31.56	16.53	16.09	30.58
	50	31.06	18.64	11.83	28.93
Post Mordanting	10	29.76	17.10	11.71	26.24
	30	20.52	10.08	9.47	21.39
	50	16.52	7.94	7.04	17.54

Plate No. 2. K/S values and color coordinates of dyed banana fiber without and with mordant getting fixed on banana fiber.

L*: lightness (0 = black, 100 = white), a*: red–green coordinates (positive values = red, negative values = green), b*: yellow–blue coordinates (positive values = yellow, negative values = blue).

The Table 1 indicated the colour strength (K/S value) of Myrobalan extract dye while using different concentration of 10%, 30% and 50 % of dye using alum mordant. The results representing the k/s value is more in case of Pre-mordanting in comparison to post-mordanting, but in some cases the k/s value is more in case of Post-mordanting in comparison to pre-mordanting. The colour strength of the natural dye extracted from myrobalan extract dye showed the colour strength is more in case of pre- mordanting.

Assessment of fastness properties of dyed Banana Fiber

The fastness ratings of banana fiber dyed with mordant at different dye concentrations of 10, 30, and 50% are presented in table 2. These results indicate that the washing fastness of the banana fiber dyed with myrobalan natural dye was very good to excellent (4 to 4–5) and the light fastness was of good to very good (5 to 5–6) grades. The color fastness was found to be in the range of 4 to 5, i.e. very good to excellent, for the banana fiber dyed with mordant. This clearly indicates that dye fixed during exhaust dyeing may be due to the formation of metal chelates in the presence of tannin. Hence, after mordanting, these tannins become insoluble in water, and thus ultimately improve washing fastness properties. Also, fixation level of dye increases and so also its resistance to photofading and rubbing. Natural dyes are less substantive and thus require a mordant to fix them on fiber and prevent color from exposure to light or washing. These pre- or post-mordanting have different effects on the shade obtained after dyeing and also on fastness properties. Alum is a white powder, safe for hands and easy to use and produces bright shades and relatively good light fastness. It is, therefore, necessary to choose a proper mordanting methodto get the desired shade and fastness properties.

Table 2: The fastness ratings of banana fiber dyed with mordant at different dye concentrations of 10, 30, and 50% are presented

Type of Mordant	Dye Conc. % o.w.f.	Washing fastness		Light fastness		Rubbing fastness (Dry)		Rubbing fastness (wet)	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Alum (5%)	10	4-5	4-5	6	6	5	5	4-5	4-5
	30	4-5	4-5	5-6	5-6	5	4-5	4-5	4-5
	50	4-5	4	5-6	5-6	5	4-5	4-5	4-5
Ferrous Sulphate (5%)	10	4-5	4-5	6	5-6	5	5	5	4-5
	30	4-5	4-5	5-6	5-6	5	4-5	4-5	4-5
	50	4	4	5-6	5	4-5	4-5	4-5	4-5
Stannous chloride (5%)	10	4-5	4-5	6	5-6	5	5	4-5	4-5
	30	4-5	4	5	5-6	5	4-5	4-5	4
	50	4	4	5-6	5	4-5	4-5	4	4

Conclusions

Myrobalan natural dye extract can be successfully employed on banana fiber with different mordants for dyeing of banana fiber as a natural source of colorant. Banana fiber showed higher color depth in terms of K/S values on pre and post mordanting with alum, Ferrous Shulphate, stannous Chloride. The banana fiber showed K/S values as the mordant were varied from Ferrous Shulphate, stannous Chloride alum for pre & post-mordanting technique. The fastness ratings of banana fiber dyed with mordant at different dye concentrations of 10, 30, and 50% indicate that the fastness of the banana fiber was good to excellent, for the banana fiber dyed with pre and post mordanting technique.

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