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Application of madder natural dye on banana fiber

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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. Dyeing of combined scoured & bleached banana fiber with Madder natural dye at 90 °C for 60 min at neutral pH at 10%, 30% and 50% concentration of the dye on the weight of banana fiber using pre- without and post-mordant dyeing techniques using alum, stannous chloride and ferrous sulphate mordants. Treated fiber showed a substantial increase in colour depth (K/S) and adequate wash, light and rubbing fastness properties without and with mordanted and dyed banana fiber.

Keywords: Banana fiber, madder natural dye, alum, ferrous shulphate, stannous chloride, digital thermometer, controlled temp & time dyeing machine

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.

Madder and related plants of the genus Rubia are native to many temperate zones around the world, and were already used as sources of good red dye, such as rose madder, in prehistory. Madder has been identified on linen in the tomb of Tutankhamun, (Barber 1991) [9] and Pliny the Elder records madder growing near Rome. (Goodwin 1982), Madder was a dye of commercial importance in Europe, being cultivated in the Netherlands and France to dye the red coats of military uniforms until the market collapsed following the development of synthetic alizarin dye in 1869. Indian madder (Rubia cordifolia) is native to the Himalayas and other mountains of Asia and Japan.

Dyestuff Madder dye
It is a natural coloring matter. Coloring substance used was extracted from Madder.

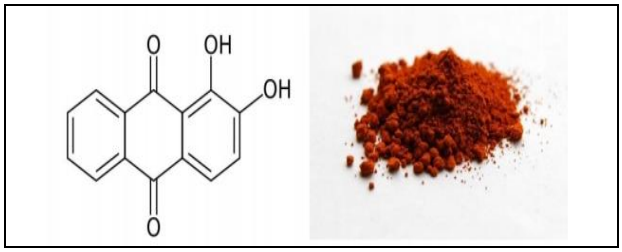

Fig 1(a): Chemical structure of Madder Dye (b) Madder dye

Experimentals

Materials used for experimental work

The ready for dyeing banana fiber was extracted from plant The Natural madder dye was supplied by Sky Morn Fashion Accessories Exports, Ghaziabad, India.

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 $(SO4)_2$ manufactured by were used as a mordant

Extraction methods used for madder

Madder were crushed to the powder form, and then the coloring matter was extracted using (5 gram of the powder in 100 ml water) at the boiling for few minute and then 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 centigrade for 60 min. Fibers were then squeezed and dried dried in pre mordanting 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 centigrade for 60 min. Fibers were then squeezed and dried dried in pre mordanting 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 programmable time and temperature control at 60^0 centigrade for 60 min. Fibers were then squeezed and air dried dried in pre mordanting 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 90ºC 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 color control computer color matching system.

The relative color strength (in term of the K/S value) of madder natural dyed banana fibers 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 madder extracts on Banana fiber.

It is observed in Table 1 that the K/S values of the banana fiber with madder 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 fabric to a different extent. This is attributed to increasing the amount of colorant.

Table 1: K/S values and color coordinates of dyed banana fiber without and with mordant getting fixed on banana fiber.

Type of Mordant	Dye Conc.% o.w.f.	K/S value	L*	a*	b*
Without Mordant	10	49.57	35.35	15.63	15.97
	30	53.98	27.59	25.68	18.85
	50	37.06	13.87	26.45	18.71
Alam (5%) Pre-mordnting	10	53.33	37.98	13.09	18.21
	30	46.53	26.64	22.76	23.60
	50	45.12	18.84	28.44	29.60
Post Mordanting	10	29.72	17.68	9.98	23.01
	30	24.53	12.80	9.64	17.43
	50	21.63	8.47	10.75	14.66
Ferrous Sulphate (5%) Pre-mordnting	10	37.44	17.59	14.08	15.92
	30	37.68	17.26	18.10	16.10
	50	35.36	13.33	19.67	15.70
Post Mordanting	10	52.44	33.21	19.96	23.73
	30	45.46	23.92	24.23	23.37
	50	27.56	10.97	22.43	19.76

Stannous Chloride (5%) Pre-mordnting	10	32.00	15.54	13.60	23.24
	30	28.35	12.05	12.89	18.19
	50	24.99	9.57	11.50	16.88
Post Mordanting	10	33.87	16.36	16.87	19.62
	30	36.83	18.22	19.11	18.57
	50	30.38	13.09	20.96	17.73

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).

Maddar extract in combination with Alum, ferrous Shulphate and stannous Chloride mordants onto 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.

The Table 1 indicated the colour strength (K/S value) of Madder 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 without and 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 maddar 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 to rubbing was found to be in the range of 4 to 5, i.e. very good to excellent, for the banana fiber dyed with or without mordant. Fixation level of dye increases and so also its resistance to photo fading and rubbing. Natural dyes are less substantive and thus require a mordant to fix them on fiber and prevent color from either fading with 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 method to get the desired shade and fastness properties.

Table 2: The fastness ratings of banana fiber dyed without and 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	6	5-6	5	4-5	4-5	4-5
	50	4-5	4	5-6	5	5	4-5	4-5	4
Ferrous Sulphate (5%)	10	4-5	4-5	6	5-6	5-6	5	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	5	4-5	4-5	4-5
Stannous chloride (5%)	10	4-5	4-5	6	5-6	5-6	5	4-5	4-5
	30	4-5	4-5	5-6	5-6	5	4-5	4-5	4
	50	4-5	4	5-6	5	5	4-5	4	4

Conclusions

Madder 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 prperties of the banana fiber was good to excellent, for the banana fiber dyed with pre and post mordanting technique

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