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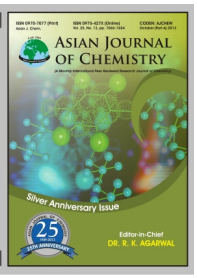

Dyeing of Silk Fabric with Eco-Friendly Natural Dyes Obtained from *Spathodea campanulata* and *Cordia sebestena*: A Comparison

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Bleached silk fabric was dyed with natural dyes obtained from the flower of *Spathodea campanulata* and *Cordia sebestena*. The colour fastness properties and colour strength of dyed silk fabric were determined and compared. From the comparative study of fastness properties and colour strength of the dyed cotton samples, *Spathodea campanulata* in simultaneous mordanting method with 3 % mordant combination gives better results as compared to the natural dye obtained from the flower of *Cordia sebestena*.

Key Words: *Cordia sebestena*, Cotton, Fastness, Mordants, Natural dye, *Spathodea campanulata*.

INTRODUCTION

With the world becoming more conscious towards ecology and environment, there is greater need today to revive the tradition of natural dye and dyeing techniques as an alternative of hazardous synthetic dyes is an extremely crude.

Until about 150 years ago all dyes were natural substances, derived mainly from plants and animals. The natural dyes present in plants and animals are pigmentary molecules[1] which impart colour to the materials. Recently, interest in the use of natural dyes has been growing rapidly due to the result of stringent environmental standards imposed by many countries in response to toxic and allergic reactions associated with synthetic dyes[2].

There are several plants/plant parts that provide natural dyes which are used in the textile industry. However, the common drawbacks of natural dyes are their non-reproducible and non-uniform shades, poor to moderate colour fastness and lack of scientific information on the chemistry of dyeing and standardised dyeing methods[3]. Many reports are available on application of natural dyes on cotton[4-6].

The present investigation deals with the extraction of natural dyes from the flower of *Spathodea campanulata* and flower of *Cordia sebestena* grow in all warm and damp parts of India.

The aim of present work has been carried out to prepare eco-friendly natural dyes from the flower of *Spathodea campanulata* and flower of *Cordia sebestena* and apply them on silk fabric. In the present work an attempt has been made to study the effect of mordanting and dyeing properties[7] of silk fabrics such as, washing, rubbing, light fastness and perspiration[8] and also to visualize the effect of myrobolan and metallic mordants have been undertaken.

EXPERIMENTAL

Loom state silk (430 ends/dm, 212 picks/dm, 50 g/m^2) fabric, obtained from Khadhi Trust, Dindugal, was used for this study. Analytical reagents (AR) grade ferrous sulphate, aluminium sulphate, nickel sulphate, potassium dichromate, stannous chloride, commercial grade acetic acid, common salt, sodium carbonate were used. A natural mordant myrobolan (*Terminalia chebula*) powder was used for the study. Depending upon the mordant used, the colour obtained on textiles from the flower of *Spathodea campanulata* and flower of *Cordia sebestena* extracts may give different shades.

Extraction of colour component: For optimizing[9] the extraction method the ethanol extraction of dye liquor was carried out under varying conditions, such as time of extraction, temperature of extraction bath and material-to-liquor ratio. In each case, the optical density or absorbance value at a particular maximum absorbance wavelength ($\lambda_{420\ nm}$) for the ethanol extract of plant parts were estimated by using Hitachi-U-2000 UV-VIS absorbance spectrometer.

Dyeing of silk fabrics with the extract of flower of *Spathodea campanulata* and flower of *Cordia sebestena*: The wetted out silk samples were entered into dye baths containing

required amount of dye extract and water. After 10 min, required amount of sodium carbonate and sodium chloride were added. The dyeing was carried out for 1 h at 60 ºC. The dyed samples were dried in air without washing to make them ready for pre, simultaneous and post-mordanting using myrobolan and metallic salts.

Pre-mordanting of cotton fabric with myrobolan and metallic salts: Bleached cotton fabric with or without pre-mordanting were further mordanted prior to dyeing using 1-3 % of any one of the chemical mordants, such as aluminium sulphate, nickel sulphate, potassium dichromate, stannous chloride, copper sulphate and the myrobolan, at 60 ºC for 0.5 h with material-to-liquor ratio of 1:20. The samples treated with metal salts were dyed with the dye extract.

Simultaneous mordanting of silk fabrics with myrobolan and metallic salts: Bleached silk fabrics were treated with both dye extract and metal salts simultaneously, using 1-3 % of any one of the chemical mordants, such as aluminium sulphate, nickel sulphate, potassium dichromate, stannous chloride, copper sulphate and the myrobolan, at 60 ºC for 0.5 h with material-to-liquor ratio of 1:20.

Post-mordanting of silk fabrics with myrobolan and metallic salts: Bleached silk fabrics were dyed with dye extract. The wetted out silk samples were entered into different dye baths containing required amount of dye extract and water. After 10 min required amount of sodium sulphate was added. After 20 min required amount of sodium chloride was added. The dyeing was carried out for 1 h at 50 ºC. The dyed samples were taken out, squeezed and used for treatment with metal salts process without washing. The dyed silk samples were treated with different metal salts using 1-3 % of any one of the chemical mordants, such as aluminium sulphate, nickel sulphate, potassium dichromate, stannous chloride, copper sulphate and the myrobolan, at 60 ºC for 0.5 h with material-to-liquor ratio of 1:20.

In all the above three methods, after the dyeing is over, the dyed samples were repeatedly washed with water and then dried in air. Finally, the dyed samples were subjected to soaping with 2 gpl soap solution at 50 ºC for 10 min, followed by repeated water wash and drying under sun.

Determination of surface colour strength (K/S value): The K/S value of the undyed and dyed cotton fabrics was determined[10] by measuring surface reflectance of the samples using a computer-aided Macbeth 2020 plus reflectance spectrophotometer, using the following Kubelka Munk equation with the help of relevant software:

$$\frac{K}{S} = \frac{(1 - R_{\lambda_{max}})^2}{2R_{\lambda_{max}}} = \alpha Cd$$

where K is the coefficient of absorption; S the coefficient of scattering; Cd, the concentration of the hue and $R_{\lambda_{max}}$ the surface reflectance value of the sample at a particular wavelength, where maximum absorption occurs for a particular dye/colour component.

Evaluation of colour fastness: Colour fastness to washing of the dyed fabric samples was determined as per IS: 764-1984 method using a Sasmira launder-O-meter following Is-3 wash fastness method. The wash fastness rating was assessed using grey scale as per ISO-05-A02 (loss of shade depth) and ISO-105-AO3 (extent of staining) and the same was cross-checked by measuring the loss of depth of colour and staining using Macbeth 2020 plus computer-aided colour measurement system attached with relevant software. Colour fastness to rubbing (dry and wet) was assessed as per IS: 766-1984 method using a manually operated crock meter and grey scale as per ISO-105-AO3 (extent of staining).

Colour fastness to exposure to light was determined as per IS: 2454-1984 method. The sample was exposed to UV light in a Shirley MBTF Microsal fade-O-meter (having 500 watt Philips mercury bulb tungsten filament lamp simulating day light) along with the eight blue wool standards (BS 1006: BOI: 1978). The fading of each sample was observed against the fading of blue wool standards (1-8).

Colour fastness to perspiration assessed according to IS 971-1983 composite specimen was prepared by placing the test specimen between two adjacent pieces of fabrics of silk and stitched all among four sides. The sample was soaked in the test solution (acidic /alkaline) separately with MLR 1:50 for 0.5 h at room temperature. The sample was then placed between two glass plates of perspirometer under load of 4.5 kgs (10 lbs). The apparatus was kept in the oven for 4 h at 37 ± 2 ºC. At the end of this period the specimen was removed and dried in air at a temperature not exceeding 60 ºC. The test samples were graded for change in colour and staining using grey scales.

RESULTS AND DISCUSSION

The colour strength values of silk fabrics dyed with the natural dyes obtained from the flower of *Spathodea campanulata* and flower of *Cordia sebestena* by using single mordanting method are presented and compared in Tables 1-3.

From the results, it was observed that among the two plant parts, *Spathodea campanulata* showed better colour strength values. In all the three dyeing methods, simultaneous method gave excellent results. In all the three methods of dyeing, using two plant parts, the mordants ferrous sulphate and aluminium sulphate show excellent colour strength values. For dyeing of silk, 1, 2 and 3 % mordant concentrations were used for the present study. Among these three concentrations 3 % mordant concentration gave better results.

The colour fastness values of silk fabrics dyed with the flower of *Spathodea campanulata* and flower of *Cordia sebestena* obtained in this study by using single mordanting method are presented and compared in Table-4.

From the results, it was observed that among the two plant parts, *Spathodea campanulata* showed better light fastness properties. Similar rub fastness and perspiration fastness values were obtained. *Spathodea campanulata* showed better wash fastness when compared with *Cordia sebestena* dyed silk fabrics.

In all the three dyeing methods, simultaneous method gave excellent results. In all the three methods of dyeing, using two plant parts, the mordants ferrous sulphate and aluminium sulphate show excellent results. Among the three concentrations 3 % mordant concentration gave better fastness results.

Similar results were obtained in the previous study reported by Das *et al.*[12]. The present study shows excellent wash fastness (GS:4) and light fastness (GS:4) when compared

TABLE-1
SURFACE COLOUR STRENGTH OF *Spathodea campanulata* (SC) AND *Cordia sebestena* (CS) DYED SILK FABRIC AFTER PRE, SIMULTANEOUS AND POST MORDANTING METHODS BY USING 1 % MORDANT CONCENTRATION. K/S VALUE WITHOUT MORDANT: SILK-2.41 (SC), 2.37(CS)

Mordant concentration: (1 %)	K/S(λ = 420 nm)					
	Pre-mordanting		Simultaneous mordanting		Post mordanting	
	SC	CS	SC	CS	SC	CS
Nickel sulphate	2.21	2.27	2.51, 2.51	2.59	2.42	2.32
Aluminium sulphate	2.48	2.38	2.78	2.66	2.56	2.49
Potassium dichromate	1.94	1.45	2.21	1.91	2.14	1.72
Ferrous sulphate	2.54	2.48	2.83	2.70	2.69	2.54
Stannous chloride	2.44	2.32	2.70	2.57	2.59	2.44
Myrobolan	1.91	1.33	2.25	2.12	2.12	2.00

TABLE-2
SURFACE COLOUR STRENGTH OF *Spathodea campanulata* (SC) AND *Cordia sebestena* (CS) DYED SILK FABRIC AFTER PRE,SIMULTANEOUS AND POST MORDANTING METHODS BY USING 2% MORDANT CONCENTRATION. K/S VALUE WITHOUT MORDANT: SILK-2.41 (SC), 2.37(CS)

Mordant concentration: (2 %)	K/S(λ = 420 nm)					
	Pre-mordanting		Simultaneous mordanting		Post mordanting	
	SC	CS	SC	CS	SC	CS
Nickel sulphate	2.31	2.37	2.62	2.69	2.53	2.39
Aluminium sulphate	2.59	2.38	2.87	2.75	2.61	2.51
Potassium dichromate	1.95	1.39	2.29	2.09	2.18	1.88
Ferrous sulphate	2.63	2.59	2.94	2.81	2.74	2.67
Stannous chloride	2.50	2.41	2.72	2.63	2.63	2.53
Myrobolan	1.81	1.39	2.21	2.23	2.15	2.14

TABLE-3
SURFACE COLOUR STRENGTH OF *Spathodea campanulata* (SC) AND *Cordia sebestena* (CS) DYED SILK FABRIC AFTER PRE, SIMULTANEOUS AND POST MORDANTING METHODS BY USING 3 % MORDANT CONCENTRATION. K/S VALUE WITHOUT MORDANT: SILK-2.41(SC), 2.37(CS)

Mordant concentration: (3 %)	K/S(λ = 420 nm)					
	Pre-mordanting		Simultaneous mordanting		Post mordanting	
	SC	CS	SC	CS	SC	CS
Nickel sulphate	2.26	2.39	2.62	2.65	2.51	2.36
Aluminium sulphate	2.58	2.51	2.89	2.79	2.67	2.55
Potassium dichromate	2.01	1.33	2.35	1.98	2.24	1.73
Ferrous sulphate	2.63	2.58	2.95	2.81	2.76	2.67
Stannous chloride	2.53	2.41	2.76	2.66	2.67	2.51
Myrobolan	1.78	1.43	2.21	2.32	2.19	2.19

TABLE-4
COMPARISON OF FASTNESS PROPERTIES AND COLOUR STRENGTH OF DYED SILK USING SINGLE MORDANTS

Plant parts used for dyeing	Mordant used	Method	Properties						Reference
			WF	LF	RF		PF		
					Dry	Wet	Acidic	Alkaline	
Stem of *Achras sapota*	Ferrous sulphate (3 %)	SM	5	5	5	5	4	4	Present study
		PM	4	4	5	5	5	5	
	Aluminium sulphate (3 %)	SM	4	4	5	5	4	4	
		PM	5	4	5	5	5	5	
Flower of *Spathodea campanulata*	Ferrous sulphate (3 %)	SM	5	5	5	4	5	5	
		PM	5	4	5	5	5	5	
	Aluminium sulphate (3 %)	SM	4	5	5	4	4	4	
		PM	4	4	5	5	5	5	
Eclipta prostata	Ferrous sulphate (3 %)	PM	5	8	5	5	5	5	Sharada devi *et al.*[11]
Rheum emodi	Aluminium sulphate (3 %)	SM	4	3	–	–	–	–	Das *et al.*[12]
	Ferrous sulphate (3 %)	SM	4	3	–	–	–	–	
Bixa orellana	Aluminium sulphate (3 %)	PM	3-4	4	–	–	–	–	Das *et al*.[13]
	Ferrous sulphate (3 %)	PM	2-3	3	–	–	–	–	

WF-Wash fastness LF-Light fastness PF-Perspiration fastness RF-Rub fastness CS-Colour strength PM-Pre mordanting SM-Simultaneous mordanting.

with Das *et al*.[13] study (WF:2-3 and LF:3). A better light fastness (GS:8) was reported by Sharada devi *et al.*[11] in pre mordanting method.

Conclusion

From the comparative study of fastness properties and colour strength of the dyed silk samples, *Spathodea campanulata* in simultaneous mordanting method with 3 % mordant combination gives better results as compared to the Achras sapota dye.

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