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Dyeing of Cotton Fabric with Eco-Friendly Natural Dyes Using Single Mordants: Comparison of Fastness Properties and Colour Strength

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Abstract:

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

Keywords:*Achrassapota,*Cotton, Fastness, Mordants, Natural dye,*Spathodeacampanulata*

1. Introduction:

Upto the end of 19th century natural dyes were the main colourants for textiles. 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 (Anitha et al, 2007). 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 (SandeepBains et al, 2003) which impart colour to the materials. 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.

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 (Gulrajani et al, 1992). Many reports are available on application of natural dyes on cotton (Anderson ,1971; Adeel et al, 2009; Kumaresan et al 2010,2011).The present investigation deals with the extraction of natural dyes from the stem extract of the plant *AchrasSapota* and flower of *Spathodeacampanulata*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 stem of *AchrasSapota*and flower of *Spathodeacampanulata*and apply them on cotton fabric. In the present work an attempt has been made to study the effect of mordanting and dyeing properties (Mahangade et al, 2009) of cotton fabrics such as, washing, rubbing, light fastnessand perspiration (Goodarzian, et al,2010) and also to visualize the effect of myrobolanand metallic mordants have been undertaken.

2. Materials and Methods:

2.1 Materials:

Conventionally desized, scoured and H_2O_2 (1%) bleached plain weave cotton fabric (220 ends/ dm, 180 picks/dm,120 g/m^2) fabric obtained from Gandhi Trust, Dindugal**,**wasused for the 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 (*Terminaliachebula*) powder was used for the study. Depending upon the mordant used, the colour obtained on textiles from the stem of *AchrasSapota* and flower of *Spathodeacampanulata extract* may give different shades.

2.2 Methods:

2.2.1 Extraction of colour component:

For optimizing(Vankar et al, 2009) 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 (λ_{420nm}) for the ethanol extract of plant parts were estimated by using Hitachi-U-2000 UV-VIS absorbance spectrometer.

2.2.2 Dyeing of cotton fabrics with the extract of stem of AchrasSapotaand flower of Spathodeacampanulata

The wetted out cotton samples were entered into dye baths containing required amount of dye extract and water. After 10 minutes, required amount of sodium carbonate and sodium chloride were added. The dyeing was carried out for one hour at 60°C. The dyed samples were dried in air without washing to make them ready for pre, simultaneous and post-mordanting using myrobolan and metallic salts.

2.2.3 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°C for 30 min with material-to-liquor ratio of 1:20. The samples treated with metal salts were dyed with the dye extract.

2.2.4 Simultaneous mordanting of cotton fabrics with myrobolan and metallic salts

Bleached cotton 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°C for 30 min with material-to-liquor ratio of 1:20.

2.2.5 Post-Mordanting of cotton fabrics with myrobolan and metallic salts.

Bleached cotton fabrics were dyed with dye extract. The wetted out cotton samples were entered into different dye baths containing required amount of dye extract and water. After 10 minutes required amount of sodium sulphate was added. After 20 minutes required amount of sodium chloride was added. The dyeing was carried out for one hour at 50°C. The dyed samples were taken out, squeezed and used for treatment with metal salts process without washing. The dyed cotton 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°C for 30 min 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 2gpl soap solution at 50°C for 10 min, followed by repeated water wash and drying under sun.

2.2.6 Determination of surface colour strength(K/S value)

The K/S value of the undyed and dyed cotton fabrics was determined (Kumaresan et al, 2011) by measuring surface reflectance of the samples using a computer-aided Macbeth 2020 plus reflectance spectrophotometer, using the following KubelkaMunk equation with the help of relevant software:

$$K/S = \frac{(1- R_{\lambda max})^2}{} = \alpha\, C2R_{\lambda max}$$

where K is the coefficient of absorption; S the coefficient of scattering; C_d, the concentration of the due 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.

2.2.7 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 cotton and stitched all among four sides. The sample was soaked in the test solution (acidic /alkaline) separately with MLR 1:50 for 30 minutes at room temperature. The sample was then placed between two glass plates of perspirometer under load of 4.5kgs (10 lbs). The apparatus was kept in the oven for four hours at 37±2˚C. At the end of this period the specimen was removed and dried in air at a temperature not exceeding 60˚C. The test samples were graded for change in colour and staining using grey scales.

3. Results and Discussion:

The colour strength values of cotton fabrics dyed with stem of Achrassapota and flower of Spathodeacampanulata obtained in this study by using single mordanting method are presented and compared in Tables 1, 2 and 3. From the results, it was observed that among the two plant parts, *Spathodeacampanulata* 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 suphate show excellent colour strength values. For dyeing of cotton, 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 cotton fabrics dyed with stem of Achrassapota and flower of Spathodeacampanulata 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, *Spathodeacampanulata* showed better light fastness properties. Similar rub fastness and perspiration fastness values were obtained. *Spathodeacampanulata* showed better wash fastness when compared with *Achrassapota* dyed cotton 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 suphate show excellent results. Among the three concentrations 3% mordant concentration gave better fastness results.

A better light fastness (GS : 4) was noted in the present study when compared to that of Sandeepbains et al (2003) reports (LF : 2) when ferrous sulphate and aluminium sulphate were separately mordanted in pre mordanting method. The analysis of colour strength in Tables 1,2 and 3 indicate that ferrous sulphate (CS : 8.43) and aluminium sulphate(CS : 3.59) when separately mordanted in pre mordanting method (Vankar et al 2010) showed better colour strength as compared to the colour strength value observed in the present study ($FS_{Colour\ strength}$: 2.56 and $AS_{Colour\ strength}$: 1.91). A better wash fastness (GS : 4) was observed in the present study as compared to Boonroeng et al (2009) study when aluminium sulphate was used as a mordant in premordanting method (GS : 3).Similar results for rub and perspiration fastness were obtained in the previous works reported (Bains et al 2003, Kumar et al 2004 and Shilpamudgal and Geetamahale (2002).

Table 1: Surface colour strength of *Achrassapota (AS)* and *Spathodeacampanulata (SC)* dyed cotton fabric by using 1% mordant concentration. K/S value without mordant: cotton-1.31(AS), 1.53(SC)

Mordant concentration:1%	K/S(λ=420 nm)					
	Pre mordanting		Simultaneous mordanting		Post mordanting	
	AS	SC	AS	SC	AS	SC
Nickel sulphate	1.41	1.45	2.34	2.39	2.07	2.12
Aluminium sulphate	1.71	1.76	2.57	2.63	2.48	2.56
Potassium dichromate	1.18	1.21	1.26	1.28	1.32	1.36
Ferrous sulphate	1.77	1.79	2.61	2.89	2.72	2.75
Stannous chloride	1.62	1.66	2.53	2.58	2.38	2.41
Myrobolan	0.92	1.04	1.22	1.25	1.26	1.31

Table 2: Surface colour strength of *Achrassapota (AS)* and *Spathodeacampanulata (SC)* dyed cotton fabric by using 2% mordant concentration. K/S value without mordant: cotton-1.31(AS), 1.53(SC)

Mordant concentration:2%	K/S(λ=420 nm)					
	Pre mordanting		Simultaneous mordanting		Post mordanting	
	AS	SC	AS	SC	AS	SC
Nickel sulphate	1.46	1.51	2.37	2.42	2.12	2.18
Aluminium sulphate	1.75	1.81	2.59	2.65	2.53	2.59
Potassium dichromate	1.23	1.28	1.29	1.33	1.34	1.39
Ferrous sulphate	1.82	1.89	2.67	2.75	2.76	2.68
Stannous chloride	1.67	1.71	2.56	2.63	2.43	2.48
Myrobolan	0.98	1.05	1.27	1.32	1.31	1.37

Table 3: Surface colour strength of *Achrassapota (AS)* and *Spathodeacampanulata (SC)* dyed cotton fabric by using 3% mordant concentration. K/S value without mordant: cotton-1.31(AS), 1.53(SC).

Mordant concentration:3%	K/S(λ=420 nm)					
	Pre mordanting		Simultaneous mordanting		Post mordanting	
	AS	SC	AS	SC	AS	SC
Nickel sulphate	1.51	1.56	2.41	2.47	2.16	2.22
Aluminium sulphate	1.79	1.85	2.64	2.71	2.58	2.65
Potassium dichromate	1.27	1.33	1.34	1.42	1.38	1.39
Ferrous sulphate	1.87	1.96	2.71	2.91	2.81	2.86
Stannous chloride	1.71	1.76	2.62	2.68	2.48	2.54
Myrobolan	1.03	1.14	1.31	1.36	1.35	1.41

Table 4: Comparison of fastness properties and colour strength of dyed cotton using single mordants

Plant parts used for dyeing	Mordant used	Method	Properties						Reference
			WF	LF	RF		PF		
					Dry	Wet	Acidic	Alkaline	
Stem of *Achrassapota*	Ferrous sulphate (3%)	SM	5	4	5	5	5	5	Present study
		PM	5	4	5	5	5	5	
	Aluminium sulphate (3%)	SM	4-5	4	5	5	5	5	
		PM	5	4	5	5	4	4	
Flower of *Spathodeacampanulata*	Ferrous sulphate (3%)	SM	4	5	5	5	5	5	
		PM	4	4	5	5	5	5	
	Aluminium sulphate (3%)	SM	4	5	5	4	5	5	
		PM	4	4	5	5	5	5	
Flower of *Cordiasebestena*	Ferrous sulphate (3%)	SM	5	5	5	5	5	5	
		PM	5	5	5	5	5	5	
	Aluminium sulphate (3%)	SM	4	5	5	4	4	4	
		PM	5	4	5	5	5	5	
Onosmaechioides	Ferrous sulphate (3%)	SM	5	2	5	5	4	5	Sandeepbains et al (2003)
	Aluminium sulphate (5%)	SM	5	2	4	3-4	5	5	
Fountain flower	Ferrous sulphate (3%)	SM	4-5	5	4-5	4	4-5	4-5	Shilpamudgal and Geetamahale (2002)

Mangifera indica	Ferrous sulphate (2.5%)	SM	5	4	4-5	4	5	5	Bains et al (2003)
	Aluminium sulphate (12.5%)	SM	5	4	4-5	4	5	5	
Colquhouniacoccinea	Ferrous sulphate (2.5%)	PM	4-5	4-5	5	5	5	5	Vankar et al (2010)
	Aluminium sulphate (12.5%)	PM	4	4	4	4	4	4	
Pongamiapinnato	Ferrous sulphate (2.5%)	SM	-	5	4-5	4-5	-	-	Kumar et al (2004)
	Aluminium sulphate (12.5%)	SM	-	5	4-5	4-5	-	-	
Neem tree bark	Aluminium sulphate (12.5%)	PM	3	2-3	4-5	4-5	-	-	Boonroeng et al (2009)

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

4. Conclusion:

From the comparative study of fastness properties and colour strength of the dyed cotton samples, *Spathodeacampanulata* in simultaneous mordanting method with 3% mordant combination gives better results as compared to the *Achrassapota* dye.

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