

# Dyeing of silk with eco-friendly natural dyes obtained from flower of *Plumeria* species using single mordants

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## ABSTRACT

The silk fabric was dyed with natural dye from the flower of *Plumeria* species. The colour fastness properties and colour strength of dyed fabric were determined and compared. From these studies of fastness properties and colour strength of the dyed silk samples, it is resulted that *Plumeria* species in simultaneous mordanting method with 3% mordant combination gives excellent results.

**KEY WORDS:** Colour strength, Fastness, Mordant, Natural dye, *Plumeria* species, Silk.

## 1. INTRODUCTION

In general all dyes were natural substances, derived mainly from plants, minerals and animals in ancient days. In the 19th century various plant parts, minerals, and animal parts are the main sources for natural dyes. The constituents of natural dyes present in minerals, plants parts and animals give colour to the fabric materials. The awareness about the environment safety is increased nowadays. Today's need is to give importance of natural dyes are the alternative to the synthetic dyes. The interest in the use of the natural dyes has been growing rapidly today due to severe environmental standards resulted in avoiding the synthetic dyes, causing ill effects. These standards are framed by most of the recommended to reduce the toxic and allergic effects associated with synthetic dyes. But the main drawbacks are non-uniform and reproducibility shades and also scientific information on the chemistry of dyeing and dyeing methods are not enough. Many literatures are available for these type of applications on fabrics.



**Fig.1. *Plumeria* species**

The present research deals about the natural dyes obtained from the flower of the *Plumeria* species plant. *Plumeria* species grows like a spreading shrub and small tree with a height of 2–8 m (5–25 ft). The flowers are red in colour and placed in terminal, appearing at the ends of branches over the summer. Often, they are strongly fragrant, and have five petals.

The ranges of colour from the common pink to white and the yellow shades in the centre of the flower. The present work is to extract the dye from the flower of *Plumeria* species and apply them on silk fabric. In this present research, the importance is given to study the effect of mordanting and dyeing properties on the fabrics like, rubbing, light, washing and perspiration and also to examine the effect of myrobolan, a natural mordant, have been undertaken.

## 2. MATERIALS AND METHODS

**2.1. Materials:** The silk fabric (430ends/ dm, 212 picks/dm, 50g/m<sup>2</sup>) obtained from Gandhi Trust, Dindugal, was the source material for this study. Analytical reagents grade potassium dichromate aluminium sulphate, stannous chloride, ferrous sulphate, nickel sulphate, acetic acid, sodium carbonate, common salt were used. Natural mordant named as myrobolan (Botanical name: Terminalia chebula, Tamil: Kadukkai) powder was utilized in this study. Different shades were obtained when *Plumeria* species dye was applied with different mordants.

The first step is to prepare myrobolan powder and put it into water in the ratio of 1:10 and for overnight (12hrs) at the room temperature and finally to obtain myrobolan gel. The resulting gel was mixed with a known volume of water and heated at the temperature 80°C for 30 minutes. The resulting myrobolan solution is filtered and then it was used for the dyeing process.

**2.2. Extraction of colour component:** Optimization technique was carried out under varying conditions, such as extraction time, material-to-liquor ratio and extraction temperature for the dye liquor. Among all the above studies, optical density or the absorbance value is at the absorbance wavelength ((max420nm) for the extract of dye was estimated by using the instrument Hitachi-U-2000 UV-VIS spectrometer.

**2.3. Dyeing of silk fabric with the extract of the flower extract of the plant *Plumeria species*:** The samples were soaked into the dye baths a required amount of water and dye extract. After ten minutes, the required sodium carbonate and sodium chloride were added to the solution and boiled the same for one hour at the temperature 60°C.

**2.4. Pre-Mordanting of silk fabrics with metallic mordants and myrobolan:** Silk fabric was mordanted and prior to dyeing of dye using the concentrations 1-3% of any one of the chemical mordants, at the temperature 60°C for 30 minutes in MLR ratio of 1:20. Finally fabric samples treated with metallic mordants were dyed with the dye

**2.5. Simultaneous -Mordanting of silk fabrics with metallic mordants and natural mordant myrobolan:** The silk fabrics were treated with both dye and metallic mordants simultaneously, using 1-3% of any one of the chemical mordants and myrobolan, at the temperature 60°C for 30 minutes in MLR ratio of 1:20.

**2.6. Post-Mordanting of silk fabric with metallic mordants and natural mordant myrobolan:** The samples were dyed with natural dye extract. Then the sfabrics were put into different dye baths containing the amount of dye and water. After ten minutes, the required sodium sulphate was added. After twenty minutes required of sodium chloride was added to the bath. The dyeing process was carried out for one hour at the temperature 50°C. The samples were dried and used for treatment with metallic mordants. The dyed samples were treated with metallic mordants using 1-3% of concentrations at the temperature 60°C for 30 minutes in MLR ratio of 1:20. After the completion of dyeing process, the samples were washed with water and then dried. Then, the samples were washed with soap at the temperature 50°C for ten min, followed by water wash and drying in the air.

**2.7. Determination of surface colour strength (K/S value):** The determination of K/S value of the silk fabrics was determined by surface reflectance of the samples using a special spectrophotometer called Macbeth 2020 plus spectrophotometer and using the following Kubelka Munk equation as follows:

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

Where S is the coefficient of scattering; K is the coefficient of absorption;  $R_{\lambda max}$  is the surface reflectance of the dyed sample at a particular wavelength and  $C_d$ , the concentration of the hue.

**2.8. Determination of Wash Fastness:** It was determined as per IS: 764 – 1984 method and using a Sasmira launder-O-meter with Is-3 wash fastness method. Wash fastness rating was determined by using grey scale as per ISO-05-A02 (loss of shade depth) and ISO-105-A03 (extent of staining).

**2.9. Determination of Colour fastness to rubbing (dry and wet):** It was determined as per IS: 766-1984 method using a manually operated crock meter and grey scale as per ISO-105-A03 (extent of staining). Determination of Colour fastness to exposure to light. It was determined as per IS: 2454-1984 method. Finally the sample was exposed to UV light in a Shirley MBTF Microsal fade-O-meter along with the eight blue wool standards according to BS 1006: BOI: 1978. The fading of each sample was observed against the fading of blue wool standards from 1 to 8.

**2.10. Determination of colour fastness to perspiration:** It was determined by IS 971-1983 method. For this purpose of assessment, composite specimen was prepared by placing all the test specimens were placed between two adjacent pieces of fabrics of silk. The sample was put it into the test solution like acidic or alkaline, separately with the Material liquor ratio 1:50 for 30 minutes at the room temperature.

### 3. RESULTS AND DISCUSSION

The K/S values of dyed silk fabrics dyed with the flower of *Plumeria species*, obtained by using single mordanting method. The results are presented and compared in Table 1, Table 2 and Table 3. From the results, simultaneous dyeing method gave excellent results when compared with the other.

The metallic mordants aluminium sulphate and ferrous sulphate which gave good results in all the three dyeing methods. In this research work, metallic mordant concentrations 1%, 2% and 3% were used. Among all the three concentrations 3% metallic mordant gave better results. Determined values of colour fastness of dyed silk fabrics obtained are presented and compared in Table 4.

**Table.1. Surface colour strength of the flower extract of the plant *Plumeria species* dyed with silk fabric after pre, simultaneous and post mordanting methods by using 1% mordant concentration (K/S value without mordant: silk-2.45)**

Mordant concentration:1%	K/S( $\lambda=420$ nm)		
	Pre mordanting	Simultaneous mordanting	Post mordanting
Nickel sulphate	1.88	1.98	1.96
Aluminium sulphate	2.33	2.45	2.41
Potassium dichromate	1.68	1.70	1.66
Ferrous sulphate	2.40	2.55	2.62
Stannous chloride	2.22	2.32	2.30
Myrobolan	1.89	1.98	1.91

**Table.2. Surface colour strength of the flower extract of the plant *Plumeria* species dyed with silk fabric after pre, simultaneous and post mordanting methods by using 2% mordant concentration (K/S value without mordant: silk-2.45)**

Mordant concentration:2%	K/S( $\lambda=420$ nm)		
	Pre mordanting	Simultaneous mordanting	Post mordanting
Nickel sulphate	1.98	2.12	2.10
Aluminium sulphate	2.41	2.55	2.49
Potassium dichromate	1.72	1.78	1.75
Ferrous sulphate	2.51	2.65	2.58
Stannous chloride	2.36	2.45	2.41
Myrobolan	1.91	2.10	2.07

**Table.3. Surface colour strength of the flower extract of the plant *Plumeria* species dyed silk fabric after pre, simultaneous and post mordanting methods by using 3% mordant concentration (K/S value without mordant: silk-2.45)**

Mordant concentration:3%	K/S( $\lambda=420$ nm)		
	Pre mordanting	Simultaneous mordanting	Post mordanting
Nickel sulphate	2.12	2.25	2.19
Aluminium sulphate	2.52	2.62	2.58
Potassium dichromate	1.67	1.82	1.78
Ferrous sulphate	2.58	2.69	2.60
Stannous chloride	2.41	2.49	2.44
Myrobolan	1.95	2.11	2.08

**Table.4. Colour fastnesses of flower of *Plumeria* species dyed with silk fabrics with selective mordants using pre, simultaneous and post mordanting methods**

Mordants	Method of mordanting	Mordant Concentration (%)	Washing		Rubbing				Sun light	Perspiration			
			CC	S	Dry		Wet			Acidic		Alkaline	
					CC	CS	CC	CS		CC	CS	CC	CS
Nickel sulphate	Pre-mordanting	1	4	4	5	5	5	5	4	5	5	5	4
		2	4	4	5	5	5	4	4	5	5	5	4
		3	4	5	5	5	5	5	4	4	5	4	4
	Simultaneous mordanting	1	4	4	5	5	5	4	4	5	5	5	5
		2	5	4	5	4-5	5	4	4	5	5	5	5
		3	5	4	5	5	5	4	5	4	5	4	5
	Post-mordanting	1	4	4	5	5	4	4	4	4	5	5	4
		2	4	4	4	5	4	4	5	4	5	5	4
		3	4	5	5	5	4	5	4	4	5	4	5
Aluminium sulphate	Pre-mordanting	1	4	4	5	5	5	5	4	5	5	5	4
		2	4	4	5	4-5	5	5	4	5	5	5	4
		3	4	5	5	5	5	5	4	4	5	4	5
	Simultaneous mordanting	1	5	4	5	4	5	4	4	5	4	5	5
		2	4	4	5	4-5	5	4-5	4	5	4	5	5
		3	5	5	5	5	5	5	4	4	4	4	5
	Post-mordanting	1	5	4	4	4	5	5	4	5	4	5	5
		2	5	4	4	4	5	5	5	5	4	5	5
		3	5	4	4	4	5	5	4	4	4	4	5
Potassium dichromate	Pre-mordanting	1	3	3	3	3	3	3	3	4	3	4	3
		2	3	4	3	3	4	3	3	3	3	4	3
		3	4	5	4	4	4	4	4	3	4	4	3
	Simultaneous mordanting	1	3	4	5	4	5	4	3	3	3	3	3
		2	3	3	5	4-5	5	4-5	3	3	4	3	4
		3	4	4	5	5	5	5	4	3	4	4	5
	Post-mordanting	1	4	4	5	5	5	5	3	3	5	3	3
		2	3	3	5	5	5	5	3	3	5	3	3
		3	4	4	5	5	5	5	4	4	5	4	3
Ferrous sulphate	Pre-mordanting	1	4	4	5	4	5	5	4	4	5	4	5
		2	5	4	5	5	5	5	4	4	5	4	5
		3	4	5	5	4	5	5	4	4	5	4	5
	Simultaneous mordanting	1	5	4-5	5	4	5	4	4	4	5	4	5
		2	5	4	5	4-5	5	5	5	5	5	4	5
		3	4	5	5	5	5	4	4	4	5	4	5
	Post-mordanting	1	4	5	5	4	5	5	4	4	4	5	4

		2	5	4	5	5	5	5	5	5	5	5	5
		3	4	4	5	4	5	5	4	4	4	4	4
Stannous chloride	Pre-mordanting	1	5	4	5	5	5	4	4	4	5	4	5
		2	4	4	4	5	5	5	5	4	5	4	5
		3	5	5	5	5	5	4	4	4	5	4	5
	Simultaneous mordanting	1	4	4	4	4	5	4-5	4	4	4	4	4
		2	5	4	5	4-5	5	4-5	5	3	4	4	4
		3	5	5	4	5	5	5	4	4	4	4	5
Post-mordanting	1	4	4	4	4	4	4	4	4	5	5	4	
	2	4	4	4	4	4	5	3	4	5	5	4	
	3	5	5	5	5	5	5	4	4	5	4	5	
Myrobolan	Pre-mordanting	1	3	3	4	4	3	3	4	4	4	4	4
		2	3	4	4	4	4	3	3	3	4	4	4
		3	4	4	4	4	4	4	4	4	4	4	4
	Simultaneous mordanting	1	4	3	4	3	3	4	3	4	4	4	4
		2	4	3	3	4	4	3	3	4	4	4	3
		3	3	4	4	4	4	3	3	4	4	4	3
Post-mordanting	1	3	4	4	4	3	4	4	4	4	4	4	
	2	4	4	4	4	4	3	4	4	4	4	4	
	3	4	4	4	4	3	3	4	4	4	4	4	
Control	-	-	4	4	5	5	5	5	4	4	5	4	4

CC-Colour change, CS – Colour staining, S-Silk

From the results, all the samples showed better light fastness values with similar rub fastness and perspiration fastness values. Flower extract of *Plumeria* species showed better wash fastness. Simultaneous mordanting method gave excellent results when compared to all the three dyeing methods. Metallic mordants aluminium sulphate and ferrous sulphate which gave good results in all the three methods. In this research work, metallic mordant concentrations 1%, 2% and 3% were used. The 3% concentration of metallic mordant results better when it is compared with the other two concentrations

#### 4. CONCLUSION

From the results that the study of fastness values and colour strength of samples, flower of *Plumeria* species in simultaneous mordanting method with 3% metallic mordant which gives better results when compared to the other concentrations 1% and 2%.

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