

# Silk Dyeing with Eco-friendly Natural Dye Extracted from barks of *Terminalia arjuna*

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**Abstract:** Sustainable and eco-friendly natural dyes can be produced different shades of colors and have lowers colors fastness when compared to synthetic dyes. As the products of natural dyes are able to produce different shades and eco-friendly nature, they are in high demand. Leaves, barks, roots, fruits or berries of plants are the sources of natural dyes. Such dyes are obtained by boiling leaves, barks, roots, fruits or berries in water. This study deals with the process of dyeing silk fabric with barks of *Terminalia arjuna*.L. In this study, the color fastness and color strength (K/S) of the dyed silk fabric is assessed and compared. The conclusion arrived at this study is that the fastness properties and color strength of the dyed silk fabric by adopting simultaneous mordanting method with 3% mordant combination yielded better results.

**Key-Words:** *Terminalia arjuna*; Natural dye, Silk dyeing, Fastness

## 1. Introduction:

Natural dyes are environmental friendly (1) and they are also biodegradable, less toxic and non-allergenic than synthetic dyes. In the last century, synthetic dyeing methods have taken over but natural dyeing materials are still abundantly available today. Consumption of synthetic dyes stood at 1% of the natural dyes (2). The advantage of natural dyes is that they have a wide range of shade as they are obtained from insects, minerals, fungi, roots, barks, leaves, flowers, skins, fruits, and shells of plants (3). Natural dyes were used for coloring food, leather, wood as well as wool, silk, cotton fibers since time immemorial. For printing and dye- sensitized solar cells also natural dyes were used. (4). Some of the natural dyes are reported to dye with unique and elegant colors as well as provide antibacterial, deodorizing and UV protective functions to fabrics (5). There is a rapid growth in the use of natural dyes on textiles at present. The main reason for this trend-change is due to strict environmental standards pressurized by many countries order to avoid the health hazards of synthetic dyes used in textiles. In addition, there is a recent ban on the use of azo dyes by the European Union which has facilitated the scope for the use of natural dyes (6).

Raw silk is available in the form of long filaments that have about 275-900 meters long. It is spun by the silk worm having two layers and is a continuous protein filament. Fibroin-the central layer-constitutes the main fiber. The outer layer, called sericin, is a gum. Mulberry, wild, tussar, muga, eri, spider etc are some of the varieties of available silk. Sericulture, reeling, throwing and manufacturing are the four sectors of silk industry. Production and culture of silk worms, their care, formation and harvesting of cocoons are taken care of by sericulture. Long strands of silk fibers are unwound from the cocoons, two or more filaments in done in reeling. In order to reel silk, the cocoons are softened in hot water to loosen the outer mass. The outer mass is then removed. Reeled silk is not suitable either for weaving or knitting. So it is 'thrown' or doubled. The thrower takes the proper number of reeled threads together and gives them a twist in order to obtain yarns that are suitable for weaving and knitting. Sericin is outermost protective layer of raw silk-known as gum sericin restricts penetration of chemicals in raw silk. It is removed through degumming. But the inherent yellow colour has to be bleached. UV rays of sun light very easily attack silk and so it is more sensitive to light, if silk treated in boiling water, it loses its inherent luster.

*Terminalia arjuna* is 30 meter tall and 2-2.5 meter diameter tree can be found in the south Asian region. It is an evergreen tree; its leaves are sprouting during February – April. In India it is associated as exoticism. It has medicinal quality: its barks acts as anti-dysenteric anti-pyretic, astringent, cardiotoxic, lithotriptic, anticoagulant, hypolipidemic, antimicrobial [8] and antiuremic [9] agent. Phytoconstituents like triterpenoids for cardiovascular properties, tannins and flavonoids for anticancer, antimicrobial properties have been obtained from *T. arjuna* [10]. Its bark powder is diuretic in cirrhosis of liver and relieves symptoms of hypertension [11]. The study aims at finding out the dyeing ability and fastness of natural dye extraction of *Terminalia arjuna* plant on silk fabrics.

## 1. Materials and Methods

### 2.1 Materials:

#### 2.1.1. Source:

*Terminalia arjuna* barks were collected from Hoganekkal, Dharmapuri district, Tamil Nadu, India.



Figure 1: *Terminalia arjuna. L* tree



Figure 2: *Terminalia arjuna .L* tree



Figure3: Barks of *Terminalia arjuna. L*

#### 2.1.2. Substrate:

Desired, scoured and bleached cotton cloth was purchased from Saraswathi Departmental Stores, Kancheepuram.

#### 2.1.3. Chemicals used

Laboratory grade chemicals Alum, Stannous chloride, potassium dichromate, Nickel sulphate, copper sulphate and ferrous sulphate were supplied by Maruthi trader Agencies, Kancheepuram. A natural mordant myrobolan, Turmeric, Cow dung, Banana sap juice was used for the study.

#### 2.1.4. Equipment used in the present work:

- Weighing balance (Ciezen)
- Water bath (Neolab WB344)

#### 2.2 Methods:

##### 2.2.1 Extraction of Dyes:

*Terminalia arjuna* barks were cleaned by washing with water in order to remove dirt. The cleaned barks were dried under direct sunlight. Then the barks were ground into very small pieces in a grinder. A fine strainer was used to remove the wastages. Finally, the contents were weighted. After all these, process, 100 g of barks was weighed then, it is put in 1 litre distilled water and heated in a breaker which in kept over a water bath for 2 hour. After this the contents were filtered and kept in a separate beaker.

##### 2.2.3 Dyeing of Fabrics:

The 100% scoured, desized bleached cotton fabrics were dyed with the dye extract keeping M: L Ratio at 1:30. Dyeing was carried out at 80°C and continued for one hour.

##### 2.2.2 Degumming

An aqueous solution containing soap (14g/L), sequestering agent (1g/L) and wetting agent(1g/L) is taken and raw silk in degummed maintaining the both at pH .5. The ratio of material and liquor is maintained at 1:30. The temperature is raised gradually to 80° degree and run for 60 minutes. The fabric thus degumming is washed with 2g/L) detergent for 10 minutes at 65°C.

### 2.2.3 Bleaching

The fibre thus degumming is bleached by treating it with 35% hydrogen peroxide (3mL/L), sequestering agent (1g/L), wetting agent (1g/L) and trisodium phosphate (2g/L). The ratio of material and liquor is maintained at 1:30 at pH 8.5 and the temperature at 65°C for 60 minutes. This is followed by washing with 2g/L detergent for 10 minutes at 65°C.

### 2.2.4 Mordanting

Different metallic salts and natural mordants were used to dye bleached cotton fabrics.

#### (i) Pre-mordanting

Bleached cotton fabric was mordanted before dyeing using 3% of any one of the chemical mordants like alum, stannous chloride, potassium dichromate, ferrous sulphate, nickel sulphate, copper sulphate and natural mordant like myrobolan, turmeric, cow dung and banana sap juice at 80°C for 1 hour with MLR of 1: 30.

#### (ii) Post- mordanting

Bleached cotton fabrics dyed with dye extract were made to become wet and put into different dye baths which contains the required amount of dye extract and water. Sodium sulphate was added to it after 20 minutes. The cotton fabric was dyed for about one hour at 80°C. The fabrics thus dyed were removed, squeezed and put to treatment with metal salts without washing. Different metal salts were used for treatment using 3% of any one of the chemical mordants like alum, stannous chloride, potassium dichromate, ferrous sulphate, nickel sulphate, copper sulphate and natural mordants such as myrobolan, turmeric, cow dung, Banana say juice at 60°C for 30 minutes with MLR of 1:30. The dyed fabrics were washed repeatedly in all the three methods in water and dried in air. At last, the dyed fabrics were put to soap with 2gpl soap solution at 50°C for 10 minutes. The fabrics were repeatedly washed in water and dried under sun.

#### (iii) Simultaneous mordanting

Here, the treatment of bleached cotton fabrics in carried out simultaneously using dye extract and mental salt using 3% of any one of the chemical mordants like alum, stanrous chloride, pofassium dichromate, ferrous sulphate, nickel sulphate, copper sulphate and natural mordants such as myrobolan, turmeric, cow dung , Banana say juice at 80°C for 1 hour with MLR 1:30.

### 2.2.5 Colour fastness

The dyed samples were tested according to IS standards. Colour fastness to washing, light and rubbing, perspiration were determined from standard test methods IS-105-C03, IS-2454-85, IS-766-88 and IS-105-E04 respectively.

### 2.2.6 Measurements of colour strength

The K/S value of the undyed and dyed cotton fabrics was determined 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:

$$K / S = (1 - R)^2 / 2R$$

Where R is the decimal fraction of the reflectance of the dyed samples at  $\lambda$ . K is the absorption coefficient and S is scattering coefficient (13)

## 3.0 Results and Discussion:

### 3.1 Optimization aqueous extract of *Terminalia arjuna*

Aqueous Extract of *Terminalia arjuna* barks were found to discharge colour in hot water very easily. Increasing the quantity of barks 5 g to 20 g per 100 ml water boiled for 1 hour is accompanied with the increase in colour strength and depth in colour [14]. It was observed that, colour of the dye extract was dark red colour as shown in Figure 4.



Figure: 4 Aqueous extract from the barks of *Terminalia arjuna*

### 3.2 Dyeing behavior of the extract

The dye extract was found to be suitable for silk. The silk fabrics were dyed with chemical and natural mordants. It was observed that, the dye uptake was found to be good in simultaneous mordanting method is shown in Figure 5.

### 3.3 Optimization of mordant with K / S values and colour Hues changes

Various shades of colour were obtained from pre, simultaneous and post mordanted methods of dyeing different mordants determined the various shades of colour on the dyed fabric according to K/S values. As shown in Table 1. The different  $L^*$ ,  $a^*$ ,  $b^*$  and K/S values show in Table 2. The  $L^*$  values indicates apparent lightness or darkness where values of 0 indicates black and 100 indicates white. The values of  $a^*$  and  $b^*$  indicate red (+a) and green (-a) while  $b^*$  values indicate yellow (+a) and blue (-b). In pre-mordanting method K/S values  $FeSO_4$  is 35.02, copper sulphate is 32.89, and the shades of colour in found to be darker. But when  $L^*$  values are lower, the hues of colour obtained will be darker. In post-mordanting method K/S values for  $FeSO_4$  is 37.83,  $CuSO_4$ , in 33.09 and the shades of colour are found to be darker while the lower  $L^*$  values show lighter shades. In simultaneous mordanting method,  $FeSO_4$  is 40.9,  $CuSO_4$  in 38.85 which shows the shades of colour are darker. But if the  $L^*$  values are lower, the shades of colour will be darker.

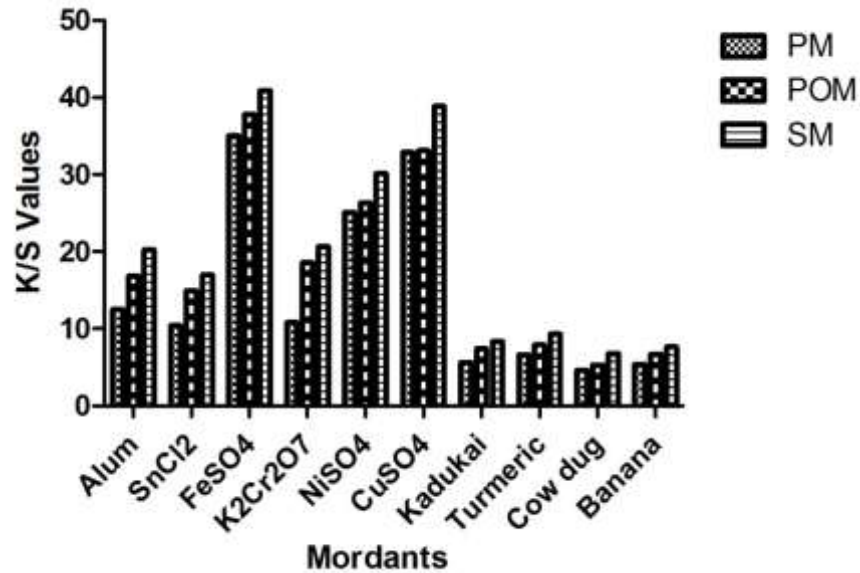


Figure 5: Surface colour strength of *Terminalia arjuna* dyes silk fabrics by using 3% mordant concentration. K/S value with or without mordant.

Table 1: Colour produced by different chemical and natural mordants in PM, POM, and SM on silk by conventional method, dyed with barks extract of *Terminalia arjuna*

S. No.	Name of the mordants	Pre mordanting (PM)	Post mordanting (POM)	Simultaneous mordanting (SM)
1	Alum			
2	SnCl <sub>2</sub>			
3	FeSO <sub>4</sub>			
4	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>			
5	NiSO <sub>4</sub>			
6	CuSO <sub>4</sub>			
7	Myrobolan			
8	Turmeric			
9	Cow dung			
10	Banana sap juice			

### 3.4 Colour fastness Properties:

The fastness properties of dyed silk fabrics are shown in Table 3. It was observed that, dyeing with *Terminalia arjuna.L* gave good washing, light and rubbing, perspiration fastness properties. Overall, it could be used for commercial purposes and attain acceptable range.

Table 2: Effect of dyed with barks extract of *terminalia arjuna* mordants on the colour strength of silk fabric

Dyeing Method	Conventional				
Colour strength	Process	L*	a*	b*	K/S Value
					K/S( $\lambda=420$ nm)
Without mordant	Pre	55.91	17.98	25.6	2.63
	Post	47.6	21.28	24.15	3.32
	SM	45.12	21.08	26.63	4.8
Alum	Pre	51.09	13.82	22.62	12.5
	Post	43.82	13.15	22.59	16.81
	SM	42.15	15.62	21.32	20.21
SnCl <sub>2</sub>	Pre	63.81	10.32	17.63	10.4
	Post	45.32	12.1	21.08	14.92
	SM	46.7	15.72	23.61	16.99
FeSO <sub>4</sub>	Pre	36.72	5.38	9.62	35.02
	Post	29.22	15.09	20.92	37.83
	SM	32.9	5.55	12.67	40.9
K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	Pre	73.62	5.92	17.64	10.81
	Post	31.08	15.15	18.19	18.61
	SM	33.92	15.32	18.7	20.63
NiSO <sub>4</sub>	Pre	51.62	15.9	28.9	25.11
	Post	47.8	16.38	22.15	26.32
	SM	45.15	16.92	21.5	30.15
CuSO <sub>4</sub>	Pre	49.78	16.63	21.10	32.89
	Post	34.12	17.15	21.98	33.09
	SM	34.15	16.32	20.62	38.85
Myrobolan	Pre	55.40	15.13	24.13	5.63
	Post	44.08	17.93	24.32	7.38
	SM	49.7	17.9	23.52	8.36
Turmeric	Pre	53.13	16.32	52.18	6.66
	Post	46.5	16.72	28.67	7.91
	SM	48.92	16.32	38.67	9.31
Cow dung	Pre	52.91	15.98	22.6	4.63
	Post	44.6	19.28	21.15	5.32
	SM	43.12	19.08	24.63	6.8
Banana sap	Pre	56.3	15.32	21.08	5.38
	Post	44.92	18.98	20.63	6.71
	SM	42.67	18.3	21.08	7.63

Table 3: Fastness Properties for silk Fabric Dyed with *Terminalia arjuna.L*

Dyeing Method	Conventional				
Fastness	Process	Washing fastness (IS-105-C03)	Light fastness (IS-2454-85)	Rubbing fastness (IS-766-88)	Perspiration (IS-105-E04)

Mordant concentration: 3%				Dry	Wet	Acid	Alkali
Without mordant	Pre	4	4	4	4	4	4
	Post	4	4	4	4	4	4
	SM	4	4	4	4	4	4
Alum	Pre	4-5	4-5	5	4-5	5	5
	Post	5	5	5	5	5	5
	SM	5	5	5	5	5	5
SnCl <sub>2</sub>	Pre	4	5	4	4-5	5	4
	Post	4	5	4	5	5	4
	SM	4-5	5	4	4-5	5	5
FeSO <sub>4</sub>	Pre	4-5	5	4-5	4	5	4
	Post	5	5	5	4	5	4
	SM	5	5	5	4-5	5	5
K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	Pre	4-5	5	5	5	5	5
	Post	5	5	5	5	5	5
	SM	5	5	5	5	5	5
NiSO <sub>4</sub>	Pre	4	5	5	5	5	5
	Post	4	5	5	5	5	5
	SM	4-5	5	5	5	5	5
CuSO <sub>4</sub>	Pre	4-5	5	5	4	4	4
	Post	5	5	5	4	4	4
	SM	5	5	5	4-5	4-5	4-5
Myrobolan	Pre	4	3-4	4	3-4	4	4
	Post	4	3-4	4	3-4	4	4
	SM	4	4	4	4	4	4
Turmeric	Pre	4	3-4	3	3	4	3
	Post	4	3-4	3	3	4	3
	SM	4	4	3-4	3	4	3-4
Cow dung	Pre	3-4	3	3	3-4	3	3-4
	Post	4	3	3	4	3	3-4
	SM	4	3	3-4	4	3-4	3-4
Banana sap	Pre	4	3-4	4	4	4	4-5
	Post	4	4	4	4	4	4-5
	SM	4	4	4	4	4	4-5

#### 4.0 Conclusions

Out of the three mordanting methods, Simultaneous mordanting method shows the K/S values as higher and so darker shades are obtained colour fastness also is found to be better. Different shades of colour can be obtained using different chemical and natural mordants. The washing, light, perspiration and rubbing fastness of all dyeing with mordants were quite good.

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