Wool Dyeing with Eco-friendly Natural Dye Extracted from barks of Terminalia arjuna

S.Saivaraj[1*], G.Chandramohan[2], P.Saravanan[3]

[1] Department of Chemistry, Thirumalai Engineering College, Kanchipuram, Tamil Nadu, India.

[2] Department of Chemistry, A.V.V.M Sri Pushpam College, Thanjavur, Tamil Nadu, India.

[3] Kings College of Engineering, Punalkulam, Thanjavur, Tamil Nadu, India.

Abstract

Sustainable and eco-friendly natural dyes can be produced different shades of colors and the can 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 wool fabric with the dye of the barks of *Terminalia arjuna.L*. In this study, the color fastness and color strength (K/S) of the dyed fabric is assessed and compared. The conclusion arrived at the study is that the fastness properties and color strength of the dyed wool fabric by adopting pre- mordanting method with 3% mordant combination yielded better results.

I. Introduction

Ever since the Bronze Age [1], dyeing was practiced. Dyeing forms an integral part in processing the textile fabrics and it is done in order to make the fabric look lively. The vast commercial use of synthetic dyes in vogue as they were produced from cheap petroleum sources and as they imparted color to textiles due to their simple dyeing process resulting in good fastness properties [2]. But, in due course, synthetic dyes were found to release harmful, allergic, carcinogenic and environment-detrimental and human-detrimental chemical [3]. The local environmental was severely afflicted in India due to dye affluent of textile dyeing industries containing both organic and chemical pollutants [4]. This pollution spoiled the living conditions of the human, animal and plant life. The discharge of pollutants from the dyeing units changed the color of the water of the water-bodies prompted the researchers to look for the eco-friendly products [5]. So, in order to improve our living condition, the introduction of an environment-friendly materials become essential to be used in textile processing so that both the consumers ' requirement and economy of the country can be accomplished. For this purpose, natural dyes in place of synthetic dyes can be utilized as they are biodegradable as well as non-toxic to human body. Plants animals, insects, or minerals can be sources of natural dyes. As synthetic dyes were widely available at an economical price, there was a rapid decline in the use of natural dyes which were used to dye fabrics in the ancient times. But, in recent times, owing to increased environmental consciousness, the use of natural dyes has become important and relevant throughout the world [6, 7]. By using natural organic dyes extracted from plants and trees has the potential for the preservation of the precious petrochemical as well as the endangered environment in future [8]. Such natural dyes can offer rich and varied sources of dyes stuffs as well as offering a considerable income by way of sustainable harvest and sale of these dye plants [9]. When natural

dyes are used they provide limitations of fastness and brilliancy of shade. But if they are used with metallic mordants, the colors obtained will be bright and fast [10]. If we want to use natural dyes successfully and commercially, we have to adopt appropriate and standardized dyeing techniques without compromising the required quality of the textile materials dyes [6]. It is very easy for a manufactures to turn the attention of the consumer to the naturally dyed products as he can change his marketing strategy. It is very important and essential that proper experiment and research should be carried out to use natural dyes in the industry. If our manufactures can increase the demand of natural dye products in the foreign markets, it will definitely be beneficial to our environment as well as to the betterment of our economy.

Terminalia arjuna is 30 mater fall and 2-2.5 meter diameter tree can the 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, cardiotonic, lithotriptic , anticoagulant, hypolipidemi, antimicrobial [11] and antiuremic [12] agent. Phytoconstituents like triterperoids for cardiovascular properties, tannins and flavonoids for it anticancer, antimicrobial properties have been obtained from *T. arjuna* [13]. Its bark powder is diuretic in cirrhosis of liver and relieves symptoms of hypertension [14]. The study aims at finding out the dyeing ability and fastness of natural dye extraction of *Terminalia arjuna* plant on cotton 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 suphate, 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.

2.2.2 Degumming

An aqueous solution containing soap (14g/L), sequestering agent (1g/L) and wetting agent (1g/L) is taken and raw wool 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^{o}C degree and run for 60 minutes. The fabric thus degumming is washed with 2g/L) detergent for 10 minutes at 65^{o}C.

2.2.3 Bleaching

The fiber 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^{o}C for 60 minutes. This is followed by washing with 2g/L detergent for 10 minutes at 65^{o}C.

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^{o}C and continued for one hour.

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^{o}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^{o}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^{o}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^{o}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^{o}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 λ. K is the absorption coefficient and S is scattering coefficient (16)

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.

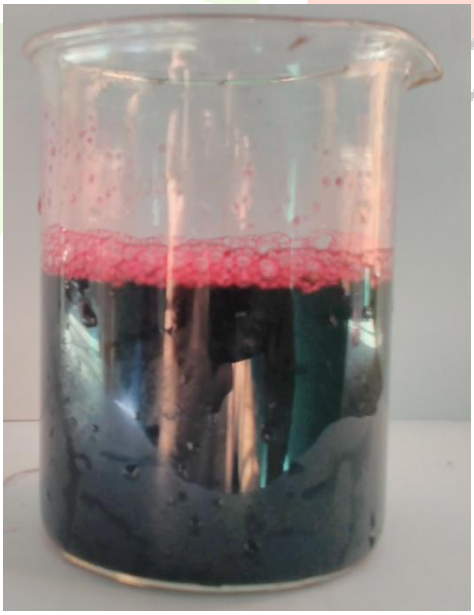

Figure: 4 Aqueous extract from the barks of *Terminalia arjuna*

3.2 Dyeing behavior of the extract

The colour strength values of cotton fabrics dyed with barks of *Terminalia arjuna* obtained in this study by using single mordanting method are presented in Tables 1. From the results, it was observed that

Terminalia arjuna showed better colour strength values. In all the three dyeing methods, post mordantning method gave excellent results. In all the three methods of dyeing, the mordants ferrous sulphate and aluminium suphate show excellent colour strength values. For dyeing of cotton, 3% mordant concentration gave better results.

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

Various shades of colour were obtained from pre mordanted, simultaneous mordanted 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 perceived lightness ort 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-mordenting method K/S values $FeSO_4$ is 28.92, copper sulphate is 27.38, and the shades of colour in found to be darker. But when L* values are lower, the hues of colour obtained will be danker. In post-mordanting method K/S values for $FeSO_4$ is 26.31, $CuSo_4$, in 26.12 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 24.61, $CuSO_4$ in 24.71 which shows the shades of colour are darker. But if the L* values are lower, the shades of colour will be darker. The effect of mordtants on colour values of on wool dyed with barks of *Terminalia arjuna.L* is shown in Figure 5.

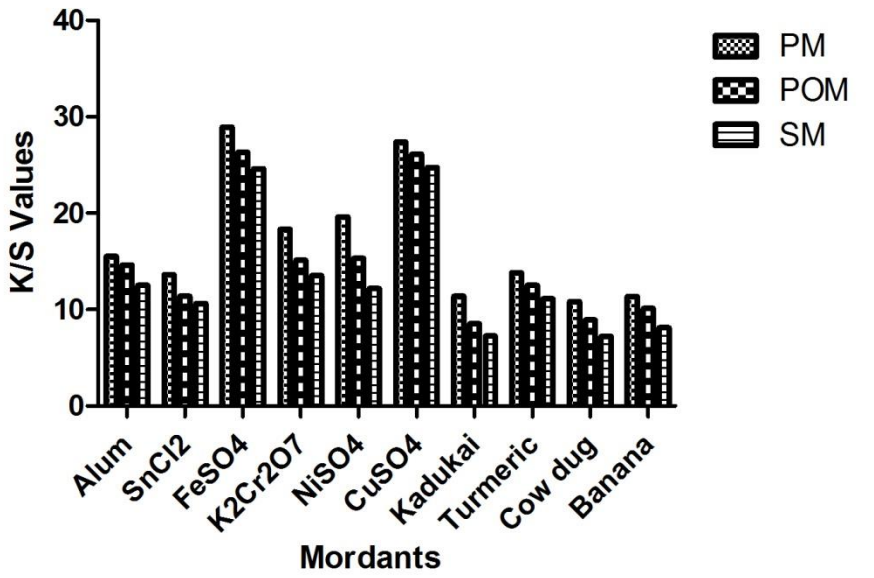

Figure 5: Surface colour strength of *Terminalia arjuna* dyes silk fabrics by using 3% mordant concentration. K/S value with or without mordant.

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

S. No.	Name of the mordants	Pre mordanting (PM)	Post mordanting (POM)	Simulataneous mordanting (SM)
1	Alum			
2	$SnCl_2$			
3	$FeSO_4$			
4	$K_2Cr_2O_7$			
5	$NiSO_4$			
6	$CuSO_4$			
7	Myrobolan			
8	Turmeric			
9	Cow dung			
10	Banana sap juice			

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

Dyeing Method	Conventional				
Colour strength	Process	L*	a*	b*	K/S Value
					K/S(λ=420 nm)
Without mordant	Pre	71.23	14.3	23.79	6.8
	Post	67.34	14.3	22.95	6.91
	SM	75.12	14.03	25.12	5.21
Alum	Pre	55.73	12.86	20.62	15.53
	Post	54.3	13	19.9	14.62
	SM	51.29	12.97	19.87	12.5
$SnCl_2$	Pre	55.73	13.46	19.37	13.62
	Post	59.4	12.75	19.07	11.38
	SM	65.69	11.89	18.01	10.63
$FeSO_4$	Pre	38.63	4.74	11.1	28.92
	Post	45.79	4.03	8.4	26.31
	SM	45.13	3.5	7.17	24.61
$K_2Cr_2O_7$	Pre	64.49	8.2	15.54	18.32
	Post	56.54	9.01	15.73	15.11
	SM	76.58	5.68	14.2	13.52
$NiSO_4$	Pre	67.14	9.19	20.7	19.62
	Post	62.45	10.4	20.59	15.3
	SM	59.8	11.7	21.6	12.2
$CuSO_4$	Pre	5.62	6.05	23.46	27.38
	Post	43.73	8.28	20.7	26.12
	SM	46.96	6.67	23.53	24.75
Myrobolan	Pre	66.25	9.58	18.4	11.39
	Post	64.32	10.52	18.19	8.51
	SM	68.5	8.21	17.57	7.25
Turmeric	Pre	62.29	3.05	64.2	13.81
	Post	63.84	4.05	76.48	12.5
	SM	65.59	3.44	67.04	11.11
Cow dung	Pre	66.23	11.3	19.79	10.8
	Post	64.34	11.3	18.95	8.91
	SM	70.12	9.03	19.12	7.21
Banana sap	Pre	66	10.58	19.23	11.35
	Post	65.93	10.67	18.47	10.1
	SM	68.75	10.35	18.71	8.1

Table 3: Fastness Properties for wool 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	5	4-5	5	4-5	5	5
	Post	5	4-5	5	4-5	5	5
	SM	4-5	5	5	4-5	4-5	5
$SnCl_2$	Pre	4	5	4	4-5	5	4
	Post	4-5	5	4-5	4	5	4-5
	SM	4-5	5	4-5	4	5	4-5
$FeSO_4$	Pre	5	5	5	4	5	4
	Post	5	5	4-5	4	5	4-5
	SM	4-5	5	4-5	5	5	4-5
$K_2Cr_2O_7$	Pre	5	5	5	5	5	5
	Post	5	5	5	5	5	5
	SM	4-5	5	5	4-5	5	5
$NiSO_4$	Pre	4	5	5	5	5	5
	Post	4-5	5	5	5	5	5
	SM	4-5	5	5	5	5	5
$CuSO_4$	Pre	5	5	5	5	5	4-5
	Post	5	5	5	5	5	4-5
	SM	5	5	5	5	5	4-5
Myrobolan	Pre	4	3-4	4	3-4	4	4
	Post	4	3-4	4	3-4	4	4
	SM	4	3-4	4	3-4	4	4
Turmeric	Pre	4	4	4	3	4	3
	Post	4	4	4	3	4	3
	SM	4	4	4	3	4	4
Cow dung	Pre	4	3	4	3-4	4	3-4
	Post	3-4	3	4	3-4	3-4	3-4
	SM	3-4	3	4	3-4	4	3-4
Banana sap	Pre	4	3-4	4	4	4	4-5
	Post	4	3-4	4	4	4	4-5
	SM	4	3-4	4	4	4	4-5

4.0 Conclusions

The extraction process and dyeing method is ecologically safe. The final results have shown the dyeing potential of *Terminalia arjuna* as source for wool dyeing. High K/S value and Good fastness exhibited by the dyed clothes is because of the mordants used. There is a lot of scope to use the *Terminalia*

arjuna dye for obtaining various colour shades using safe mordants under eco-friendly textile dyeing. The process of production of *Terminalia arjuna* dye was found to be cost-effective as compared to the cost of dyes in local market. There is need for proper knowledge, documentation and assessment of dye yielding plants as well as the dying techniques so as to increase the use of natural dyes.

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