International Journal of Academic Research and Development
ISSN: 2455-4197
Impact Factor: RJIF 5.22
www.academicsjournal.com
Volume 3; Issue 3; May 2018; Page No. 303-307

Dyeing of cotton with eco-friendly natural dye extracted from barks of *Terminalia arjuna* L.

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Abstract
In recent years, it has become significantly important to use non-allergic and non-toxic natural dyes to dye textile materials. Though much research work has been done on the application of natural dyes on textile materials, the performance of natural dyes has not been proved satisfactory. The reason for this in due to the absence of a broad for systematic study of the performance of these natural dyes. The objective of this study is an attempt to assess the dyeing ability of natural dye extraction of *Terminalia arjuna* plant on cotton fabrics. Dyeing of fabric was carried out by pre, post and simultaneous mordanting techniques with and without using mordant. Also the fastness properties of the dyed fabrics were examined. As a result of this study, it was found that the fastness properties and color strength of the dyed cotton fabrics were excellent in the process of post-mordanting techniques with 3% mordant combination.

Keywords: *Terminalia arjuna,* natural dye, cotton dyeing, fastness

1. Introduction
A vast array of colorants obtained from natural sources such as plants, insects/animals and microbes have been scrutinized in recent past for their use in different kinds of applications. Research into new natural dyes sources along with eco-friendly, robust and cost-effective technologies for their processing and application have greatly aided in widening the scope of natural dyes in various traditional and advanced application disciplines [1, 2]. Synthetic dyes have some advantages like colour fastness, good reproducibility of shade, colour brilliants and ease of use [3]. But the artificial dyes were sometimes allergic, carcinogenic and so harmful to human health [4]. Natural dyes are non-toxic and bio degradable and also become economically advantageous over synthetic dyes [5, 6]. Mordants are used for binding the dye to the fabrics in order to improve the color fastness while using the majority of natural dyes. They form a chemical bridge between the dyes to the fabric and thus improve the staining ability of the dye and increase the fastness properties [7]. Mordanting method decides the colour fastness and characteristics of natural dyes on fabrics and mordanting method varies according to dye source.
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 [8] and antiuremic [9] agent. Phytoconstituents like triterperoids for cardiovascular properties, tannins and flavonoids for it 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 cotton fabrics.

2. Materials and Methods
2.1 Materials
2.1.1 Source
Terminalia arjuna barks were collected from Hoganekkal, Dharmapuri district, Tamil Nadu, India.

Fig 1: *Terminalia arjuna. L* tree

Fig 2: *Terminalia arjuna.* L tree

Fig 3: 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.

2.2.3 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 80ºC and continued for one hour.

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

1. **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 80ºC for 1 hour with MLR of 1: 30.
2. **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 80ºc. 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 60ºc 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 50ºc for 10 minutes. The fabrics were repeatedly washed in water and dried under sun.
3. **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 80ºC 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 (13)

3. 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.

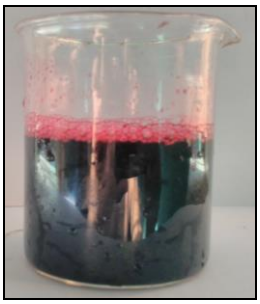

Fig 4: Aqueous extract from the barks of *Terminalia arjuna*

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, simultaneous and post mordanted methods of dyeing. As shown in Table 2. The different L*, a*, b* and K/S values show in Table 2. The L* values indicates perceived lightness ort darkness where values of o 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 28.91, copper sulphate is 23.2, 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 30.5, $CuSo_4$, in 28.78 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 18.63, $CuSo_4$in 18.2 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 cotton dyed with barks of *Terminalia arjuna. L* is shown in Figure 5.

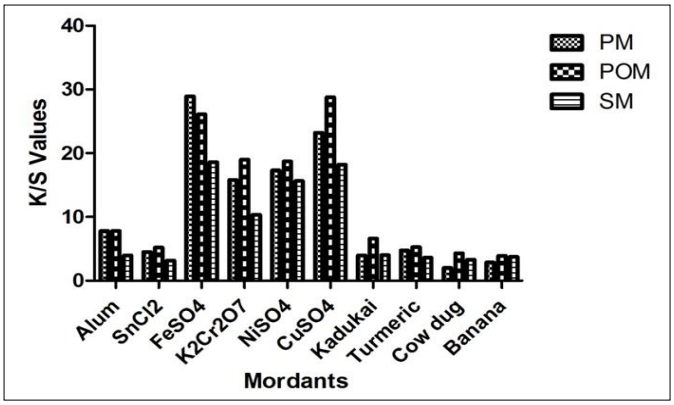

Fig 5: Surface colour strength of *Terminalia arjuna* dyes cotton fabrics by using 3% mordant concentration. K/S value with or without mordant.

Table 1: Colour produced by different chemical and natural mordants in PM, POM, and SM on cotton 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			

3.4 Colour fastness Properties

The colour fastness values of cotton fabrics dyed with Barks of *Terminalia arjuna* obtained in this study by using single mordanting method are presented in Table 3. From the results, it was observed that a *Terminalia arjuna* showed better light fastness properties. In all the three dyeing methods, post mordant method gave excellent results. In all the three methods of dyeing, the mordants ferrous sulphate and aluminium suphate show excellent results.

Table 2: Effect of dyed with bark extract of *terminalia arjuna* on the colour strength of cotton fabric (With or Without mordant**)**

Dyeing Method	**Conventional**				
Colour strength	**Process**	**L***	**a***	**b***	**K/S Value**
					K/S(λ=420 nm)
Without mordant	Pre	45.32	12.38	28.11	3.26
	Post	56.43	18.75	26.32	2.32
	SM	51.21	17.98	19.77	2.11
Alum	Pre	52.35	13.81	19.32	7.81
	Post	49.8	14.32	22.81	7.81
	SM	72.32	12.25	8.32	3.98
$SnCl_2$	Pre	63.81	12.95	19.32	4.51
	Post	55.8	14.3	18.81	5.23
	SM	72.15	11.21	10.25	3.17
$FeSO_4$	Pre	32.1	4.32	7.81	28.91
	Post	38.5	4.32	10.83	30.5
	SM	54.17	6.25	1.85	18.63
$K_2Cr_2O_7$	Pre	63.81	11.93	10.32	15.8
	Post	49.98	12.19	16.32	19.01
	SM	71.89	7.63	4.38	10.34
$NiSO_4$	Pre	54.81	15.38	29.32	17.31
	Post	49.62	19.73	24.68	18.73
	SM	54.32	13.51	15.73	15.66
$CuSO_4$	Pre	52.21	16.32	24.81	23.2
	Post	44.32	16.3	24.42	28.78
	SM	61.32	11.81	17.35	18.2
Myrobolan	Pre	66.71	11.59	18.98	3.98
	Post	57.38	15.39	25.92	6.63
	SM	63.71	13.92	17.3	4.01
Turmeric	Pre	60.32	13.8	34.81	4.76
	Post	59.38	11.62	29.31	5.29
	SM	64.81	13.81	24.99	3.63
Cow dung	Pre	65.71	12.08	17.19	2.03
	Post	53.43	16.75	23.32	4.32
	SM	54.21	14.98	16.77	3.31
Banana sap	Pre	65.15	14.38	18.39	2.87
	Post	63.2	14.9	19.32	3.9
	SM	58.8	14.98	13.62	3.75

Table 3: Fastness Properties for Cotton Fabric Dyed with *Terminalia arjuna.L* (With or without mordant)

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	3	3	3	3	3	3
	Post	3	3	3	3	3	3
	SM	3	3	3	3	3	3
Alum	Pre	4	3-4	4-5	4	4	4
	Post	4	3-4	4-5	4	4	4-5
	SM	4	4	4	4	4	4-5
$SnCl_2$	Pre	4	3-4	4	4-5	4	4-5
	Post	4	3-4	4	4-5	3-4	4-5
	SM	4	3-4	4	4-5	4	4-5
$FeSO_4$	Pre	5	4-5	4-5	4	4	4-5
	Post	5	4-5	4-5	4	4	4-5
	SM	4	4	4	4	4	4-5
$K_2Cr_2O_7$	Pre	4	4	4	4	4	4-5
	Post	4-5	4	4	4	4	4-5
	SM	4	4	4	4	4	4-5

$NiSO_4$	Pre	4	4	4	4	4	4-5
	Post	4	4-5	4	4	4	4-5
	SM	4	4	4	4	4	4-5
$CuSO_4$	Pre	5	4-5	5	4	4	4-5
	Post	5	4-5	5	4	4	4-5
	SM	4	4	5	4	4	4
Myrobolan	Pre	3	3	3	2-3	2-3	3
	Post	3	3	3-4	3	3	3
	SM	3	3	3	3	3	3
Turmeric	Pre	3	3	3	2-3	4	3
	Post	3	3-4	3	3	4	3
	SM	3	3	3	3	4	3
Cow dung	Pre	2	2	2	2	2-3	3
	Post	2-3	2-3	3	3	3	3
	SM	2	2-3	2-3	3	3	3
Banana sap	Pre	3	2-3	3	2-3	3	3-4
	Post	3	3	3	3	3	4
	SM	3	3	3	3	3	4

4. Conclusions

From this study of K/S value, fastness properties and colour strength of the dyed cotton samples, *Terminalia arjuna. L* in post mordanting method with 3% mordant combination gives better results. Thus, on the basis of the results, it can be said that bark of *Terminalia arjuna* have good scope for application on cotton fabrics.

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