Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2020; 9(1): 650-654
Received: 10-11-2019
Accepted: 12-12-2019

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Effect of mordanting methods on colour strength and colour fastness properties of organic cotton dyed with *Terminalia arjuna* bark

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Abstract
Natural dyes produce special aesthetic qualities which are environmentally friendly, add value to textile industry and helps in saving the environment from pollution. The scoured and bleached organic cotton hank was pretreated with myrobolan and dyed with *Terminalia arjuna* bark extract with varied dye concentration in different mordanting methods. The control and mordanted dyed cotton hanks were subjected to colour strength and colour fastness properties. Cotton yarn mordanted with Myrobolon+alum and Potash alum with 10 and 15 per cent dye concentration exhibited greater colour strength. The mordanted samples showed good to excellent (4/5) colour fastness to washing compared to control (4). Cotton yarn dyed through pre mordanting possessed excellent fastness properties than the simultaneous and post mordanting methods with light brown to dark brown shades. Thus, natural dyeing of *Terminalia arjuna* bark extract with organic cotton yarn is unique and new venture for the dyers, painters and fashion designers.

Keywords: *Terminalia arjuna* bark, organic cotton yarn, colour fastness, K/S value, reflectance value, mordant

Introduction
India has a very rich diversity and with variety of plant resources and is certainly treasure house of diverse natural products. One such product from nature is the dye. Dye is a liquid containing coloring matter, for imparting a particular hue to cloth, paper, *etc.* The environmental friendly natural dyes are enjoying resurgence in popularity because of concern with the carcinogenic, mutagenic and sensitizing characteristics of synthetic dyes. Natural dyes derived from flora and fauna are believed to be safe because of non-toxic, non-carcinogenic and biodegradable nature, hence ecofriendly and user friendly. The processing of which does not pose the hazardous environmental problems as encountered in the manufacturing of synthetic dyes, particularly from the point of view of generation of dye effluent.
Environmental issues are becoming more crucial all over the world. Natural dyes due to their ecofriendly nature create superior value to the textile substrate with the advent of synthetic dyes stuff in abundance and a wide range of colors of remarkable fastness properties (Wanyama, *et al.,* 2010) [6]. Natural colorants find the application in a wide range of colouration like dyeing and printing of textiles and they produce very uncommon, soothing and soft shades as compared to synthetic dyes and it has anti-allergic property and less harmful to human beings. The main sources of natural dyes are plants, animals and minerals. In plants, they can be obtained from any part of the plants, *viz.,* leaves, fruits, seeds, flowers, bark and roots. In India, nearly 500 verities of plants are available from which natural dyes can be extracted (Bhuyan, *et. al.,* 2004) [1].
Terminalia is a genus of large trees of the flowering plant family Combretaceae, comprising around 100 species distributed in tropical regions of the world. This genus gets its name from Latin *terminus*, referring to the fact that the leaves appear at the very tips of the shoots. Trees of this genus are known especially as a source of secondary metabolites, *e.g.* cyclic turpentine and their derivatives, flavonoids, tannins, and other aromatics. In this genus *Terminalia arjuna*, *Terminalia bellarica*, *Terminalia chebula*, *Terminalia catapa*, *Terminalia paniculata* and *Terminalia tomentosa* are the major well known tree species in the region of Uttar Kannada and surroundings.
Terminalia arjuna is one of the most versatile medicinal plants having a wide spectrum of biological activity. The bark of *Terminalia arjuna* consist of properties like, anti-dysentric, antipyretic, astringent, cardiotonic, lithotriptic, anticoagulant, hypolipidemi, antimicrobial and

Antiuremic agent. Many useful phytoconstituents have also been isolated from *Terminalia arjuna* which include triterpenoids for cardiovascular properties, tannins and flavonoids for its anticancer, antimicrobial properties and so on. The powder of the bark acts as a diuretic in cirrhosis of liver and gives relief in symptomatic hypertension. Its leaves have been shown to have analgesic and anti-inflammatory properties (Mandal *et. al.,* 2013) [3].

The reddish bark of the plant is the main useful part and has been used to balance the three "humors": kapha, pitta, and vata. *Terminalia arjuna* bark can be utilized for the extraction of color components without destroying whole plant (Bhuyan *et. al.,* 2004) [1]. Due to above positive qualities of *Terminalia arjuna* can be effectively used on cotton for colouring. Since, cotton is one of major fibre yielding field crop cultivated in the Karnataka and the dye source is abundantly available in the study area. Hence, an attempt has been made to know the possibilities of dyeing cotton with *Terminalia arjuna* with the following objectives:

1. To optimize the dyeing conditions and mordanting methods for dyeing cotton yarn with *Terminalia arjuna* bark
2. To assess the color fastness and color strength properties of dyed cotton yarn

Materials and Methods

Cotton Yarn

Single 30s count organic cotton yarn was procured from Department of Textile and Apparel Designing, College of Community Science, UAS, Dharwad for dyeing with *Terminalia arjuna* bark.

Dye Source

The fresh bark of *Terminalia arjuna* was collected from Yellapura forest area. The collected fresh barks were partially shade dried half a day followed by oven dry with optimized temperature 50℃ for 24 hours. Dried samples were crushed into fine power by traditional pounding technique. The dye power was store in poly bags to protect from moisture and used for the research work as and when required.

The powdered *Terminalia arjuna bark* (5, 10 and 15 g) was soaked overnight in different M.L.R (1:20, 1:30 and 1:40) for optimize the dye-concentration and it was extracted by aqueous method. Optimization of dyeing conditions is essential to get the desired properties of dye source. The dyeing variables are influences on reflectance and colour strength of the dye source. The variables like, method of extraction, time of extraction (for example 30, 45, 60 min), dyeing time (30, 45, 60 min) were optimized based on the spectral value at 430 (λ) wavelength of the dye source. Based on the reflectance and K/S value, 10 and 15g dye-concentration, 1:30 M.L.R, 30 min extraction-time were optimised for dye extraction.

One natural mordant *viz.,* myrobolan and metallic salt a potash alum (5) in pre, simultaneous and post mordanting methods were used for the study.

The scoured and bleached cotton yarn was pre treated with myrobolan (20g owf for 11/2 hour) and dyed with 10 and 15% dye concentration (owf) in open dye bath (1:40) at 30 min dyeing time. The optimised dye bath was keep it for dyeing. When the bath reached boiling temperature the pre treated cotton hanks were slowly dipped in dye bath. The cotton hank were continuously stirred with the help of steel rods to get an even dye absorption. Based on the mordanting methods, mordants were added to the dye bath. In pre mordanting method cotton hanks were pre mordanted prior to dyeing, while in simultaneous and post mordanting mordants were added during and after dyeing. Irrespective of mordant concentration and mordanting methods dyed cotton yanks were further subjected to K/S value & colour co-ordinates and colour fastness tests using the following BIS standards.

Assessment of Colour strength

Spectrophotometer, measures the spectral reflectance and spectral transmittance of the sample through the visible spectrum relative to a particular reference. The viewing angle and the illuminating condition, considerably influence the perceived color. The geometry of a color- measurement instrument is therefore, an important factor in its design.

Colour strength (K/S) of the samples

Color is a sensation which occurs when light enters the eyes. Color of any substance decides the ultimate appearance of article. Color strength (K/S) values of the samples were measured by using spectrophotometer. Five reading were recorded for each and an average value was calculated. Where, 'K' is the absorption coeffient and 'S' is the scattering coefficient. Higher the K/S values, greater the color yield and dye uptake.

Assessment of colour fastness properties

Color fatness of the dyed samples was assessed for washing and sunlight.

Color fastness to sunlight (IS:686-1985)

A test specimen of 1 × 6 cm was wound closely on card and was mound in the exposure rack. The rack was placed at an angle of 45^0. The rack was exposed every day from 9 am to 3 am (6hrs/ day) for days. The samples were evaluated for color change after 48 hrs of exposure using grey scale.

Color fastness to washing (IS: 3361-1979)

A test specimen was placed between the two adjacent pieces of fabrics, one side silk and the other side being cotton and stitched along all four sides. The composite specimen was agitated with preheated (40± 2 ℃) soap solution (5g/l) of MLR 1:50 and agitated for 30 minutes in the rotator shaker (42 rmp). Then the samples were rinsed and shade dried. The change in color of the specimen and the staining of the adjacent fabrics were assessed with gray scale.

Statistical Analysis

The experimental results of the dyeing cotton yarn with *Terminalia arjuna* bark were subjected to two way ANOVA by implying the CRD effect of different mordants on cotton yarn was assessed.

Results and Discussion

Colour strength is an indicator for accessing the absorption rate of dyed samples. It is inferred from the Table 1 that, control samples possessed significantly lower colour strength (6.212) than the cotton yarn mordanted with myrobolan+alum and Alum alone in all the methods. Among the mordanting methods cotton yarn dyed with Arjuna bark at 10 percent concentration in premordanting method possessed significantly higher colour strength than the simultaneous and post mordanting methods. However, cotton yarn mordanted with potash alum and dyed with Arjuna bark dye solution showed significantly greater K/S (60.546) in pre mordanting method followed by cotton cotton yarn mordanted with

myrobolan+alum (43.797) and control sample. In case of simultaneous mordanting method, myrobolan+alum treated cotton yarn dyed and Arjuna bark showed slighter darker shade (11.234) than the Alum treated (7.866) and control sample. The similar trend was noticed in post mordanting methods i.e., darker shade was obtained in the sample dyed with myrobolan+alum (9.397) followed by potash alum (7.632) and control samples.

Irrespective of mordents methods, cotton yarn mordanted with Myrobolan+alum and Potash alum using 10 percent dye concentration exhibited greater colour strength than the simultaneous and post mordanting methods. This may be due to application of heat during simultaneous and post mordanting supplies more energy usually facilitates higher rate of dye transportation and breaking of fibre, mordant, dye complexes leads to lower dye uptake and less colour strength (Jamadar and Sannapapamma, 2016) [2].

Irrespective of mordant treatments and mordanting methods. The mordant treated samples that is the cotton yarn dyed with myrobolan+alum and alum in 10 per cent dye concentration possessed lesser reflectance value than the control sample. The control sample exhibited greater reflectance, indicates the sample became more lighter and brighter shade compare to cotton yarn dyed with mordants (Table 2).

However, it is true that, as the K/S increase there is decrease in reflection value as noticed in the table 2. Among the mordanting methods, the cotton yarn pre mordanted with potash alum exhibited least reflectance value (4.248) resulting into darker and reddish colour of dyed yarn. Control samples possessed significantly lower colour strength (7.101) than the cotton yarn mordanted with myrobolan+alum and Potash alum alone in all the methods. Among the mordanting methods cotton yarn dyed with Arjuna bark at 15 percent concentration in premordanting method possessed significantly higher colour strength than the simultaneous and post mordanting methods. However, cotton yarn mordanted with myrobolan+alum and dyed with Arjuna bark dye solution showed significantly greater colour strength (11.547) in pre mordanting method followed by cotton yarn mordanted with potash alum (10.362) and control sample (7.101). In case of simultaneous mordanting method, myrobolan+alum treated cotton yarn dyed with Arjuna bark showed slighter darker shade (8.55) than the alum treated (7.2206) and control sample. The similar trend was noticed in post mordanting methods i.e., darker shade was obtained in the sample dyed with myrobolan+alum (10.422) followed by potash alum (9.422) and control samples (Table 3). Color parameters of cotton fabric pre mordanted & dyed with the extract of arjuna bark showed higher colour strength values (Rane *et al.*, 2017) [4].

Irrespective of mordants methods, cotton yarn mordanted with Myrobolan+alum and Potash alum using 15 percent dye concentration exhibited greater colour strength than the simultaneous and post mordanting methods. This may be due to application of heat during simultaneous and post mordanting supplies more energy usually facilitates higher rate of dye transportation and breaking of fibre, mordant, dye complexes leads to lower dye uptake and less colour strength.

Reflectance value was found to be comparatively less in case of control sample (3.536) compared to mordant dyed cotton yarn. Among the mordant treatments and mordanting methods the cotton yarn dyed with myrobolan+alum possessed lesser reflectance value than the other samples due to higher colour strength resulting into darker shades (Bhuyan, *et. al.*, 2004) [1]. The control sample exhibited greater reflectance, indicates the sample became more lighter and brighter shade compare to cotton yarn dyed with mordents possessed darker brown shades (Table 4 and Fig 1) .

Table 1: Influence of dyeing methods on color strength (K/S) of cotton yarn dyed with *Terminalia arjuna* bark (10% dye concentration)

Sl. No	Treatments	Mordanting methods		
		Pre	Simultaneous	Post
1	Control	6.2124	6.2124	6.2124
2	Myrabolan + Potash Alum (MA)	43.797**	11.234**	9.397**
3	Potash alum	60.546**	7.8664	7.6322
	SEm	0.2	0.2	0.18
	CD @ 1%	0.86	0.9	0.81
	CV	6.62	7.2	6.78

** Significant @ 1% level

Table 2: Influence of dyeing methods on reflectance value (R) of cotton yarn dyed with *Terminalia arjuna* bark (10%)

Sl. No	Treatments	Mordanting methods		
		Pre	Simultaneous	post
1	Control	9.952	9.952	9.952
2	Myrabolan + Potash Alum (MA)	10.816**	9.952	8.478
3	Potash	4.248	5.64*	9.764
SEm		0.27	0.3	0.72
CD@ 1%		1.18	1.29	3.14
CV		9.5	10.2	23.7

** Significant @ 1% level

Table 3: Influence of mordanting methods on Color strength of cotton yarn dyed with *Terminalia arjuna* bark (15% Dye concentration)

Sl. No	Treatments	Mordanting methods		
		Pre	Simultaneous	Post
1	Control	7.101	7.101	7.101
2	Myrabolan + Potash Alum(MA)	11.5476**	8.558**	9.422**
3	Potash Alum	10.3622**	7.220	8.429**
	SEm	0.42	0.38	0.42
	CD@ 1%	1.8	1.6	1.8
	CV	13.1	14.5	15.1

** Significant @ 1% level

Table 4: Influence of dyeing methods on Reflectance value (%) of cotton yarn dyed with *Terminalia arjuna* bark (15%)

Sl. No	Treatments	Mordanting methods		
		Pre	Simultaneous	post
1	Control	3.536	3.536	3.536
2	Myrabolan + Potash Alum(MA)	3.410	4.164	4.892
3	Potash Alum	4.122	3.638	6.536
	SEm	0.29	0.27	0.41
	CD 1%	1.29	1.19	1.79
	CV	12.5	14.2	18.6

** Significant @ 1% level

Fig 1: Shades of organic cotton dyed with dyed with *Terminalia arjuna* bark with different dye concentrations

Colour fastness to sunlight and washing

There is universally accepted explanation for the fading of dyed in sunlight. It is suggested that fading may be due to some kind of breakdown in the light energy absorption capacity of the electrons of the chromophores or a breakdown in the structure of the dye molecule. When sunlight energy is absorbed, the loosely held electrons of the chromophores are raised to a higher level; that is, they become more active. It is known that the ultraviolet component of sunlight initiates chemical reactions in time. Such chemical reactions shall be accelerated under moist conditions. Fading in sunlight is due to partly ultraviolent radiation which initiates chemical degradation of the dye molecule through the loosly held electrons of the chromophores. Fading of dyed textile materials does not occur so readily in artificial light, specially incandescent and florescent lights, since these light sources do not emit significant quantities of ultraviolet radiation.

The effect of sunlight on colorfastness of *Terminelia Arjuna* dyed cotton is presented in Table 5. Irrespective of mordanting methods and dye concentrations the mordanted samples showed good to excellent (6/7) colorfastness to sunlight compared to control (4) this may be due to, probably formation of complex with transitional metal which protects the chromophore from photolytic degradation and the photons sorbed by the chromophoric group dissipate their energy by resonating within the six member ring thus forming and protecting the dye and improve the light fastness. It may also be due to the stable arrangement of electrons which is resistant to photo degradation by the UV rays stated by Gohl and Vilensky (1987) [5].

The loss of colour during laundering is referred to as a lack of wash fastness or bleeding. Colour loss shall occur during laundering if dyes are held loosely by the fibre *i.e.* dyes that have not penetrated the fibre sufficiently or dyes which are held only by weak forces such as hydrogen bonds or vanderwaal's forces. Irrespective of mordanting methods and dye concentrations the mordanted samples showed good to excellent (4/5) colourfastness to washing compared to control (4). However, among the mordanting methods, cotton yarn dyed through pre mordanting possessed excellent fastness properties than the simultaneous and post mordanting methods.

Table 5: Washing and light fastness properties of cotton yarn dyed with *Terminalia arjuna* bark with different dye concentrations

Treatments		Pre mordanting		Simultaneous mordanting		Post mordanting	
		Wash fastness	Light fastness	Wash fastness	Light fastness	Wash fastness	Light fastness
Control	No Mordant	4	5	4	5	4	5
10% concentration	Myrobolon+alum	4/5	6	4	6	4	6
	Potash Alum	4	6	4	6	4	6
15% concentration	Myrobolon+alum	4/5	6/7	4	6	4	6
	Potash Alum	4/5	6	4	6	4	6

Conclusion

Terminalia is a genus of large trees of the flowering plant family Combretaceae. Due to the dyeing properties of *Terminalia arjuna* bark it can be can be effectively used on cotton for colouring. Based on the findings of the study it was stated that, Myrabolon+ Alum and Potash Alum pre-mordanting method can effectively be used as dye source on cotton with good to very good fastness properties. Thus, natural dyeing of *Terminelia arjuna* with cotton yarn is unique and new venture for the dyers, printers and fashion designers. Rural folk can take up these activities as a enterprise to sustain their livelihood

Acknowledgement

The authors are grateful to the Dean (Forestry), HOD, Dept. of FPU, College of Forestry Sirsi (UK) for their valuable help during the fieldwork and staff of AICRP-HSc (Clothing and Textiles), UAS, Dharwad for helping us to conduct this research work.

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