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Research Article

Organic Colouration and Antimicrobial Finishing of Organic Cotton Fabric by Exploiting Distillated Organic Extraction of Organic *Tectona grandis* and *Azardirachta indica* with Organic Mordanting Compare to Conventional Inorganic Mordants

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Abstract

Eco-friendly dyeing on cotton fabric was conceded out with organic dyes distillate from organic extraction process of organic ***Tectona grandis*** **(**Teak Leaf) and *Azadirachta indica* (Neem Leaf) using ecofriendly metallic mordents and natural mordents (Ferrous Sulphate as ecofriendly metallic mordant and Lemon juice as an organic mordant were used in the research work and their results were compared with results of Copper sulphate as conventionally used mordant. All the treated and untreated cotton fabric samples were tested for their Colour Strength and Colour fastness (colour fastness to Washing, UV-Light and Rubbing) properties, besides measurement of other colour interaction parameters (L*, a*, b* and ΔE) as well as anti-bacterial performance as Per AATCC-100-2012 method. Results of colour parameters showed lower ΔE values are obtained when treated with lemon mordanting agent for both the case of dyeing cum finishing treatment with Teak leaf and Neem leaf (though amongst the two dye extract used, Neem leaf extract showed higher K/S value) as compared to conventional mordanting with Copper Sulphate. While, Ferrous Sulphate render moderate K/S value than all due to inherent own colour of iron in $FeSO_4$. comparing lemon mordanting with conventional copper sulphate mordant, colour fastness properties of teak leaf extract with lemon mordanting are found to be better and is in the order of Rubbing Fastness > fol-lowed by colour fastness to Light > colour fastness to wash than that for synthetic mordanting, but for dyeing with extract of neem leaf with lemon mordanting showed very attractive colour fastness considering to all colour fastness properties studied here. In this study, a newer approach / attempt had been made to impart a simultaneous antibacterial finish along with above said natural dyeing. Hence, the antibacterial properties of neem leaf extract dyed cotton using lemon mor-danted sample resulted better reduction/ killing of bacteria. Thus, this work has led to development of a process of simultaneous dyeing and finishing with natural agents on organic cotton with organic mordents to make the fabric colour full and anti-bacterial too.

Keywords: Inorganic Mordanting; Organic Dyeing and Finishing; Organic Extraction; Organic Mordanting; Organic *Tectona grandis* (Teak Leaf) and *Azadirachta indica* (Neem Leaf.)

Introduction

Promoting traditional textiles by highlighting its value added aspects is a very common practice of Apparel Manufacturers/ prominent brands. Among the various value added tools employed presently with antimicrobial finish and natural dyed colour are on the major front. Natural dyes have a great demand in the international market. Due to the current economic and environmental consciousness, research in this front should be titled towards the use of natural dyes for dyeing textile materials. Today, people around the globe are rediscovering colour through the use of renewable and non-toxic natural sources. For successful commercial use of natural dyes for any particular fibres, the appropriate scientific standardized techniques/procedures are to be derived. Thus, relevant scientific studies and its output on standardization of dyeing methods, dyeing process variables, dyeing kinetics and test of compatibility of selective natural dyes and natural mordents have become very important. Many natural mordents like hard, lemon juice and *Aloe vera* etc. are reported to be rarely used and these are till now renowned for human health benefits as well as beauty products, is now proving its prospect as a substantial mordant for natural dyes. Lemon juice is also selected as the most important natural mordant to standardize the dyeing effect. Most of the natural dyes as well as natural finish with few exceptions are based on vegetable/ animal origin and are renewable, biodegradable, energy-efficient and eco-friendly [1,2]. Single and binary mixtures of aqueous extracts of red sandalwood (RSW) with aqueous extract of other natural dyes like Man Jistha (MJ), Jack Fruit Wood (JFW), Mari Gold (MG), Sappan Wood (SW) and BaBool (BL) in different proportions are applied on bleached jute fabric for its dyeing after double pre-mordanted with myrobolan and aluminium sulphate applied in sequence under optimized conditions of mordanting with effects of use of different proportions of binary mixture of selective natural dyes on colour strength and other colour where good fastness properties were observed [3]. Bleached cotton fabric (after sequential pre-mordanting with myrobolan and then with aluminium sulphate applied in sequence) had been dyed with a pre-fixed concentration of purified binary mixtures of Jack Fruit Wood (JFW) and other natural dyes, like Man Jistha (MJ), Red Sandal Wood (RSW), Marie Gold (MG), Sappan Wood (SW) and BaBool (BL) in different proportions to obtain a variety of compound shades wherever colour strength (K/S values), washing and colour fastness properties were improved [4].Natural extracted dyes, manjistha was applied on cotton fabric and observed the improvement of wash and light fastness properties [5]. Myobolan (Harda) and metallic salts (Potash alum and aluminium sulphate) as mordents and aqueous extract of Tesu (Palash flower petals) as dyeing agent was used and found improved wash and light fatness [6]. Myrobo-lan (harda) and other mordants (metallic salts) followed by dyeing with aqueous extract of Jackfruit and found good color fastness properties [7]. Thomas bechtold & Rita Mussak were studied that main colorant of turmeric is curcumin (brown-red crystals) does not dissolve in water but it does in alcohol, ether and a polar solvent. In acid solution the dye changes color to scarlet; in alkali solution the color is first red and then violet [8]. Rajan. S was studied that Turmeric is a tropical plant is the most popular natural dye in textile dyeing. The root of the turmeric plant (*Curcuma longa*) creates strong colors, from bright yellow with no mordant to dark green with an iron modifier [9]. Md. Mahabub Hasan1, Khandakar Abu Nayem, Abu Yousuf Mohammad AnwarulAzim were studied that Cotton and silk fabrics are dyed with the curcumin dye at a liquor ratio of 1:40 and concentrations on color strength, mordanting is carried out with three metallic salts such as; aluminium potassium sulphate, copper sulphate and tartaric acid. Mordanting is carried out through two ways: 1) pre-mordanting, 2) postmordating. And observed that mordant has a great effect to increase the color strength of the fabric [10]. Bukhari. H, Heba. M & Khadijah.Q were studied that Neem leaves was extracted by grinding into fine powders and followed by mixing with methanol at room temperature then was left closed for 3 days. So this method is time consuming and might promote the degradation of color compounds [11]. Normal Pal, who is a Textile Engr. and is the Chief Executive Officer of NKP-Engineers & IPRs Consultants, Kolkata has developed neem medicated **textiles [12]. Deo &** B.K. Desaiwere studied that Tea (*Camellia sinensis*) is an evergreen plant that grows mainly in tropical and subtropical climates. *Camellia sinensis* which is the most popular non-alcoholic beverage in the world. Cotton and jute fabrics were dyed with an aqueous extract of tea, containing tannins as the main colorant species. The dyeing was carried out with and without metal salts as mordants, using three different dyeing methods: pre-mordanting, meta-mordanting and post-mordanting. The resulting wash and light fastness of the dyed fabrics were good to excellent. The color of the fabrics was investigated on computer color matching system in terms of K/S, and CIELAB color-difference values. Deep shades (K/S= 3.9) were obtained for jute in acidic media, while cotton fabrics could be dyed in medium depths (K/S= 2.0) under identical conditions of dyeing [12]. Varinder Kaur was studied that dyeing of cotton fabric with green tea as a natural colorant had been investigated. The dyeing process was carried out (with and without mordant) with dye extracted from three different qualities of tea leaves using four different mediums. The dyeing properties on cotton fabric had been evaluated and comparative study of optical density, washing fastness, light fastness, K/S and reflectance values were investigated. The build-up, color yield and washing fastness

were excellent and light fastness properties were found to be moderate to good The dyeing properties on cotton fabric using dye extracted from tea leaves has been evaluated and comparative study of optical density, washing fastness, light fastness, K/S & reflectance values have been done. So, tea as a natural colorant gives good results on cotton [13]. Tea was applied on cotton fabric [14]. Nurizza Fauziyah & Luchman Hakim were studied that the fresh teak leaves were collected from home garden and plantation as natural dye. The extraction of teak leaves produces red hearts color. Young teak leaf contains several compounds, especially anthocyanin pigments. This anthocyanin compound gives red, purple, dark red. The results of teak leaf extract are also used as a dye for yarn well by the community of West Bengal, India [15]. Geeta Mahale was studied that the silk was dyed with teak extract, mordanting was done by mixing two mordants in different proportions and assessed the fastness properties of dyed silk [16]. Padma S Vankar was studied that the chemical composition of the teak leaves colorant is anthraquinoid compounds, with the leaves reportedly containing a yellow or red dye used for dyeing silk, in yellow, olive or related shades and *Tectona* can be used as a natural colorant in textile dyeing on a commercial scale [17]. Sanjay R. Malpaniwas studied that Aloe vera also possesses antifungal and antibacterial properties, which can be exploited for medical textile applications, such as wound dressing, suture bioactive textiles, etc. [18]. Abu Naser, Md. Ahsanul Haque were studied that Aloe Vera, till now renowned for human health benefits as well as beauty products, is now proving its prospect as a substantial mordant for natural dyes. For instance, Turmeric- the most popular natural dye does not only have coloring ability but also have anti-inflammatory, anti-microbial, anti-parasitic and some other significant activities. [19]. Sundrarajan. M., Selvam. S., Rajiv Gandhi. R. and Sujesh. J. were studied that Marigold and Turmeric were used for the extraction of the natural dye material. Tannic acid, Cow dung, Pomegranate rind and Lemon juice were selected as natural mordant to standardize the dyeing effect of Marigold and Turmeric dyes on silk and knitted cotton fabric. The method appropriates for natural dye dyeing on knitted cotton was found to be pre-mordanting by studying with other methods such as simultaneous and post mordanting method. The color developed range on dyed materials is evaluated by dye uptake measurement and the improvement of color strength on fabric using mordants was also examined. Tannic acid and pomegranate increase the color strength effectively than the other. The dye uptake values have been found to be good in all dyed samples but some cases produced poor fastness. Marigold with tannic acid and pomegranate rind produced good dye uptake and fastness properties. All the mordanted fabric showed good dye uptake [20]. Abdu Zubairu, Yusuf M Sheliawere studied that coloration of fabric is a major process in the production of textile material. In this work, natural dye was extracted from onion skin and used to dye cotton fabrics using selected synthetic and natural mordants. The synthetic mordants considered in this work are potassium dichromate, iron sulphate, copper sulphate and alum whereas the natural mordants are aloe Vera and lemon. Cotton fabrics were dyed using each of the selected mordants under three different conventional mordanting techniques; pre-mordanting, simultaneous-mordanting and post-mordanting, adopting the well-known vat dyeing method. A wide range of soft and light colors were obtained using the various mordants considered, also the mordanting technique was found to influence the results of the dyeing process. Natural mordants gave pale yellow colors, while synthetic mordant such as copper sulphate and alum also gave yellow colors. On the other hand, iron sulphate gave darker shades of colors. It was concluded that onion skin dye with iron sulphate as mordant under post-mordanting technique gave the best result of color fast of the onion skin dye. Natural Mordent's: Lemon juice and Aloe Vera were used as natural mordent's. This paper highlights the use of ferrous sulphate, copper sulphate, alum and tannic acid as mordents' in the pre-mordanting bath with cotton fabrics. After dyeing ferrous sulphate imparted darker impact whereas copper sulphate showed saddening effect on dyed fabrics, alum was responsible for increasing lightness but tannic acid made the dyed samples brilliant. Ferrous sulphate and copper sulphate mordanted samples showed good washing and light fastness but alum and then tannic acid helped the dyed fabrics to be poor to fair color fast to washing and light but fair to good to rubbing. Almost all the mordent's had less impact on perspiration fastness and shown appreciable loss of color [22]. Arsheen Moiz, M. Aleem Ahmed, Naheed Kausar, Kamran Ahmed, Munnaza Sohail were studied that aqueous extract of natural dye, tea was dyed on the wool fabric with dark brown for 2% and 5% shade. The tea containing tannins as the main colorant species to produce different shade with different mordant salts. The mordant salts Alum, $CuSO_4$, $FeSO_4$, $ZnSO_4$, Na_2SO_4, and $MgSO_4$ were used to dye fabric using three different dyeing methods: pre-mordanting, meta-mordanting and post-mordanting. The color of the fabric was investigated on Data Color matching system in terms of *K*/*S* and CIE Lab-color difference values. The post-mordanting method gave the great depth of shade of natural dye tea with 2% and 5% shade, it also gives good light fastness and wash fastness properties. Copper was found as a good mordant to achieve the best results with transition metal ions effect. Deep shades (K/S = 17.50) were obtained for original sample of 5% with color difference ΔE value is 0.17, as compare to 2% original sample of tea of light brown shades (K/S = 10.50) with color difference ΔE value is 0.50 under maintained temperature at 85°C for 35 min of dyeing [23]. Many recent report on standardization of natural dyeing and test of compatibility etc. are available in literature [24-28]. In last few years, FEAT, IIT Kanpur and Dept. of Jute and Fiber Technology, University of Calcutta jointly has standardized identification and

natural dyeing methods with more than six natural dyes and the same work is being continued now for another 4-5 natural dyes. The present work therefore is a small part of that endeavor supported financially by Ministry of Textiles, Govt of India through Textile Commissioner's Office, Mumbai. India.

Materials and Experimental Methods

Materials Used:

Materials	Sources
Organic Cotton Fabric: GSM 150 (Scoured & Bleached)	From Local Markert , India and also from Alim Knit Bd Ltd., Kashimpur, Gagipur, Bangladesh
$FeSO_4$, $CuSO_4$ (For Comparison), Distilled water	E Marc - India and also from Mother trade International Mirpur, Dhaka, Bangladesh
Organic Lemon	Vegetable Garden, Ashulia, Savar, Dhaka, Bangladesh.
Organic Teak Leaf	Tree Garden at IIT-Kanpur and also from Ashulia, Savar, Dhaka, Bangladesh.
Organic Neem Leaf	Tree Garden, At IIT Kanpur and also from Ashulia, Savar, Dhaka, Bangladesh.

Experimental Methods:

Dyeing and Finishing with Teak Leaf:

Stock Solution Preparation:

Teak leaf Solution: 3.5% Stock Solution

Process:

Distilled Water 200ml
↓
Heat (70^0x20'')
↓
Added Teak Leaf 7gm
↓
Heat (75^0x30')
↓
Filtering
↓
Stock Solution of Extracted Teak leaf

Preparation of $FeSO_4$ Stock Solution

$FeSO_4$ Solution: 5% Stock Solution

Process:

$CuSO_4$ Solution: 5% Stock Solution of $CuSO_4$ for Conventional mordanting process for comparison purpose.

Process:

Distilled Water 100ml
↓
Add $CuSO_4$ 5gm
↓
Mixer
↓
Filtering
↓
$CuSO_4$ Solution for Mordanting
↓
$CuSO_4$ Stock Solution

Experiment: T- 1

Collected fresh Teak leaf was dried in sun light for one week. During drying it was checked several times that it was in cringe condition or not. After confirming fully drying it was converted into powder form by automatic blender machine. Then 3.5% solution of powder Teak leaf 100ml was prepared for dyeing and finishing on cotton fabric. After that 5gm fabric was dyed at (70 to 75)°C temperature running time of 30 minutes. Temperature checked by thermometer and finished with padding and drying method.

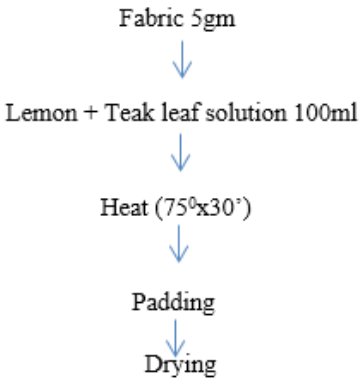
Dyeing Process Flowchart:

Fabric 5gm
↓
Teak leaf solution 100ml
↓
Heat (75^0x30)
↓
Padding
↓
Drying

Experiment: T- 2

Collected fresh Teak leaf was dried in sun light for one week. During drying it was checked several times that it was in cringe condition or not. After confirming fully drying it was converted into powder form by automatic blender machine. Then 3.5% solution of powder Teak leaf 100ml was prepared for dyeing and finishing on cotton fabric as well as 30 ml Lemon solution was prepared. After that 5gm fabric was dyed at (70 to 75)˚C temperature running time of 30 minutes. Temperature checked by thermometer and finished with padding and drying method.

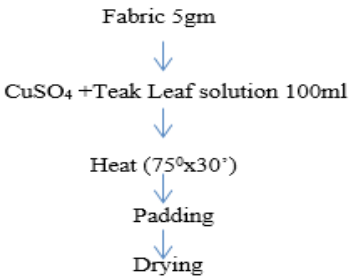
Dyeing Process Flowchart:



Experiment: T- 3

Collected fresh Teak leaf was dried in sun light for one week. During drying it was checked several times that it was in cringe condition or not. After confirming fully drying it was converted into powder form by automatic blender machine. Then 3.5% solution of powder Teak leaf 100ml was prepared for dyeing and finishing on cotton fabric as well as 5% stock solution of $CuSO_4$ 30 ml was prepared. After that 5gm fabric was dyed at (70 to 75)˚C temperature running time of 30 minutes. Temperature checked by thermometer and finished with padding and drying method.

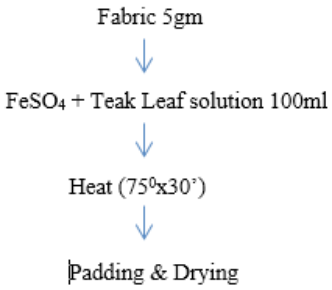
Dyeing Process Flowchart:



Experiment: T- 4

Collected fresh Teak leaf was dried in sun light for one week. During drying it was checked several times that it was in cringe condition or not. After confirming fully drying it was converted into powder form by automatic blender machine. Then 3.5% solution of powder Teak leaf 100ml was prepared for dyeing and finishing on cotton fabric as well as 5% stock solution of $FeSO_4$ 30 ml was prepared. After that 5gm fabric was dyed at (70 to 75)˚C temperature running time of 30 minutes. Temperature checked by thermometer and finished with padding and drying method.

Dyeing Process Flowchart:

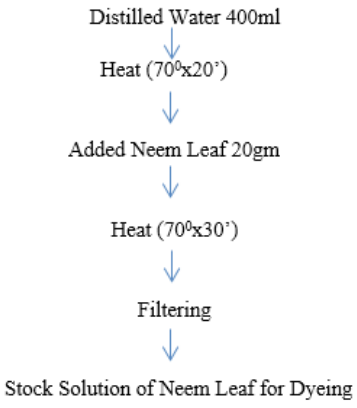


Dyeing and Finishing with Neem Leaf:

Stock Solution Preparation for Neem Leaf dyeing:

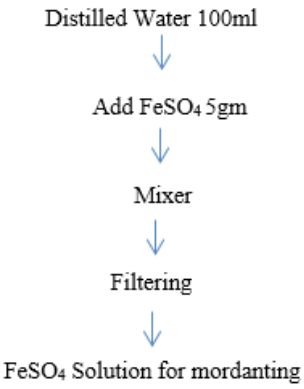
Neem Solution: 5% Stock Solution of Neam Laef

Process:



$FeSO_4$ Solution: 5% Stock Solution of $FeSO_4$

Process:

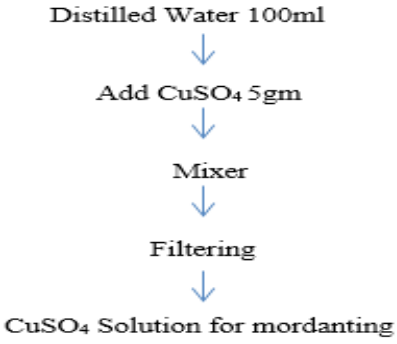


Experiment: N- 1

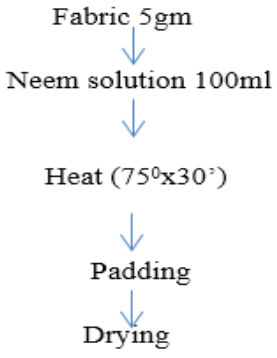
Collected fresh Neem leaf was dried in sun light for one week. During drying it was checked several times that it was in cringe condition or not. After confirming fully drying it was converted into powder form by automatic blender machine. Then 5% solution of powder Neem leaf100ml was prepared for dyeing and finishing on cotton fabric. After that 5gm fabric was dyed at (70 to 75) ˚C temperature running time of 30 minutes. Temperature checked by thermometer and finished with padding and drying method.

$CuSO_4$ Solution: 5% Stock Solution

Process:



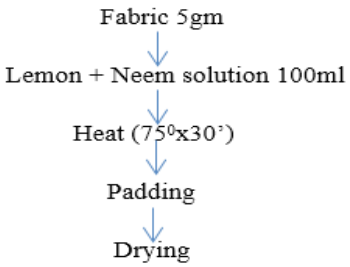
Dyeing Process Flowchart:



Experiment: N- 2

Collected fresh Neem leaf was dried in sun light for one week. During drying it was checked several times that it was in cringe condition or not. After confirming fully drying it was converted into powder form by automatic blender machine. Then 5% solution of powder Neem leaf 70ml was prepared for dyeing and finishing on cotton fabric as well as 30ml stock solution of Lemon was prepared. After that 5gm fabric was dyed at (70 to 75)˚C temperature running time of 30 minutes. Temperature checked by thermometer and finished with padding and drying method.

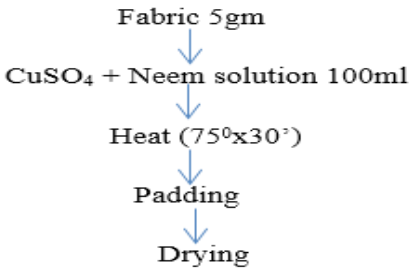
Dyeing Process Flowchart:



Experiment: N- 3

Collected fresh Neem leaf was dried in sun light for one week. During drying it was checked several times that it was in cringe condition or not. After confirming fully drying it was converted into powder form by automatic blender machine. Then 5% solution of powder Neem leaf 70ml was prepared for dyeing and finishing on cotton fabric as well as 5% stock solution of $CuSO_4$ 30ml was prepared. After that 5gm fabric was dyed at (70 to 75)˚C temperature running time of 30 minutes. Temperature checked by thermometer and finished with padding and drying method.

Dyeing Process Flowchart:

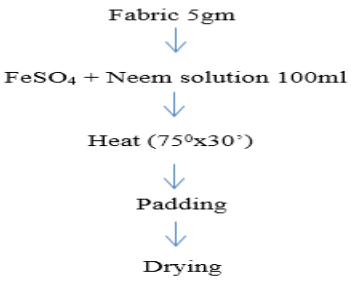


Experiment: N- 4

Collected fresh Neem leaf was dried in sun light for one week. During drying it was checked several times that it was in cringe condition or not. After confirming fully drying it was con-

verted into powder form by automatic blender machine. Then 5% solution of powder Neem leaf 70ml was prepared for dyeing and finishing on cotton fabric as well as 5% stock solution of $FeSO_4$ 30ml was prepared. After that 5gm fabric was dyed at (70 to 75)°C temperature running time of 30 minutes. Temperature checked by thermometer and finished with padding and drying method.

Dyeing Process Flowchart:



Testing Methods

Color strength (K/S value) was measured by measuring surface reflectance value where Computer color measuring instrument (Macbeth 2020 plus spectrophotometer). Color strength of untreated and treated cotton fabric samples is measured from the reflectance value at maximum wave length from which surface color strength (K/S value) can be

determined by kubelka- munk equation: $K/S = \frac{(1-R\lambda max)}{2R\lambda max}\ \alpha CD$

Where, K = coefficient of absorption, S = coefficient of scattering, Rλmax = reflectance of the substrate at maximum absorbance wavelength, CD = concentration of dye.

Light fastness was tested by AATCC TM16 in Q-SUN XE-2 Xenon Test chamber against blue wool standards (BS -1006-B01-1978.

Colour Fastness to washing was tested as per ISO-I method using 5gpl neutral soap at 50°C with 1:50 MLR for 45 min at 40 RPM using launder-o meter and was assessed with grey scale.

Color fastness to Rubbing was tested as per ISO 105-X12:2001(E) which finger and force were used in the test. Whether dry or wet rubbing was performed along with the percentage of soak the numerical rating for staining for each test specimen. The staining of the cotton rubbing cloths with the grey scale for staining under suitable illumination.

Antimicrobial Test Was done as per AATCC-100-2012 method.

Results & Discussions

Distinct appearance of natural color in Tea leaf and Teak leaf had been studied with color order system like **a*, b*, L*, and ΔE** in the terms of Da* Db* Dc* and DE have been presented here in comparison to bleached cotton fabric and proved that deeper shade was produced for organic mordanted sample and ecofriendly inorganic and metallic mordanted sample comparing to Copper sulphate modanted sample. Similarly, higher K/S value showed for lemon and ferrous sulphate mordanting for Teak Leaves as well as higher K/S value showed for lemon and ferrous sulphate mordanting for Tea Leaves with having minor differences than copper sulphate mordanted sample. The complex formation of Cu_2^+ and Fe_2^+ are responsible for higher k/S value but very good hand fell/softness of dyed cotton fabric was also observed by the researchers for organic mordanting due to absence of Cu_2^+ and Fe_2^+. Both natural dyes in the presence of organic mordanting as well as hydrophilic nature of fiber improved the good leveling on the surface of cotton fabric. As per visual appearance of color difference both lemon mordanted sample dyed with tea and Teak Leaf extraction showed very even color distribution comparing to Cupper Sulphate and Ferrous sulphate as per commented by present researcher team. As per dyeing theory, penetration and diffusion of the dye into the substrate is the main phenomenon to make the cotton fabric dyeing with natural coloring agent which confirmed the interaction taking place when dyes molecules like tannin and anthocyanin become absorbed by and evenly diffuse into the cotton fabric while mordanted with lemon containing with citric acid. So it may be confirmed that there was an equilibrium reaction of chemistry in dyeing reaction with good crosslinking and showed the balanced chemistry among organic dye-fiber-mordent's. The tea containing tannin and anthocyanin in teak leaf as the main colorant species to produce different shade with different natural and synthetic mordents' like Lemon containing Citric Acid, $CuSO_4$ and $FeSO_4$. Lower ΔE values were found when treated with lemon mordanting both dyeing with Teak leaf and Neem leaf comparing to synthetic mordanting with Copper Sulphate and Ferrous Sulphate. For fastness properties of Teak leaf with lemon mordanting like color fastness to rubbing>Light fastness>color fastness to wash wherever better fastness were showed for synthetic mordanting, but for dyeing of Neem with lemon mordanting showed very attractive fastness considering to all parameters studied in this research work as well as an attempt had been made to approach of developing antibacterial finish also and the antibacterial testing of neem and lemon mordanted sample resulted killing of bacteria successfully where e-coli bacteria was trialed for the exceptional antibacterial property of organic mordanted sample.

[Comparison of (Table 1 & 2) indicates the color parameters for dyeing with Teak leaves and tea leaves on cotton fabric have been showed in Annex (Table 1) and Comparison of (Table 2 & 4) indicates the fastness properties of Teak leaves and Tea leaves on cotton fabric have been showed in Annex (Table 2)]

Treatments	Color Parameters				
	Da*	Db*	Dc*	DE	K/S value
Bleached untreated cotton	-	-	-	-	0.89
Treated fabric with Only Teak	10.01	11.25	14.02	5.17	1.2
Treated fabric with Teak Leaf & lemon	12.01	8.72	13.20	4.18	3.90
Treated fabric with Teak Leaf & $CuSO_4$	1.02	15.63	15.63	6.98	2.80
Treated fabric with Teak Leaf & $FeSO_4$	9.43	13.67	14.79	6.87	4.00

Table 1: Color Parameters for dyeing with Teak Leaves on cotton Fabric.

The color parameters of spectrophotometer tabulated in result table shows in graph that Da* Db* Dc* and DE have been presented here in comparison to bleached cotton fabric and proved that deeper shade was produced for organic mordanted sample and ecofriendly inorganic and metallic mordanted sample comparing to Copper sulphate modanted sample. Similarly, higher K/S value showed for organic lemon and ferrous sulphate mordanting than copper sulphate mordanted sample.

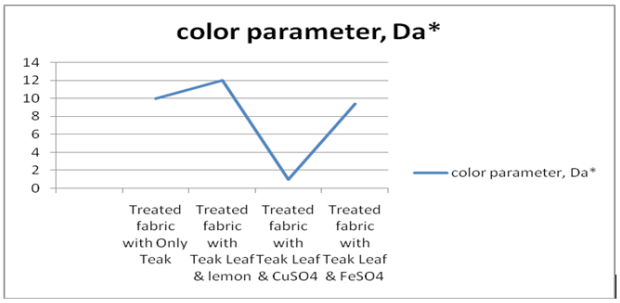


Figure 1: Color parameter, Da*.

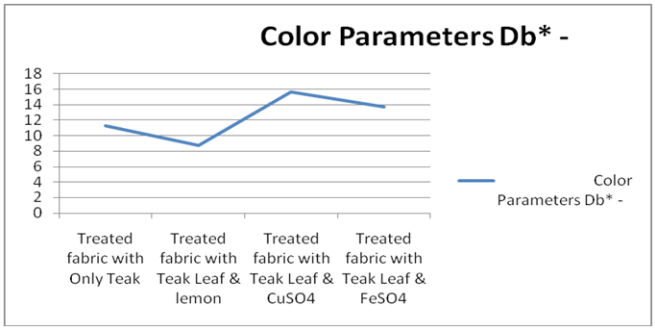


Figure 2: Color parameter, Db*.

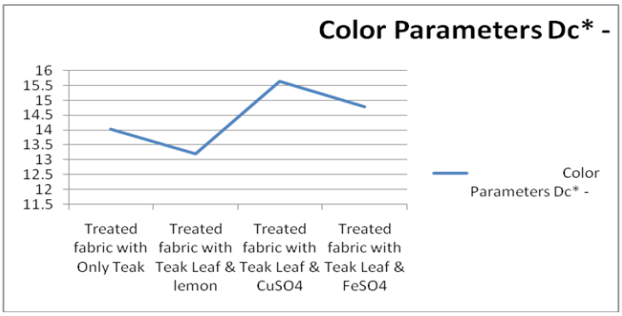


Figure 3: Color parameter, Dc*.

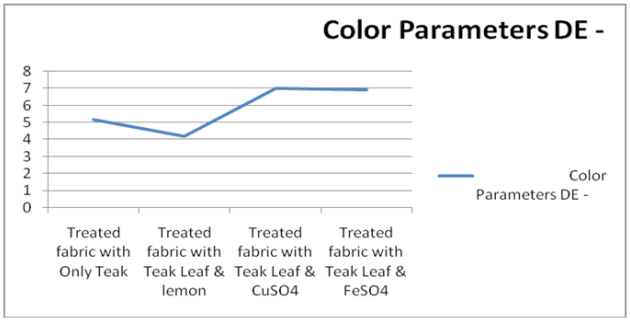


Figure 4: Color parameter, DE.

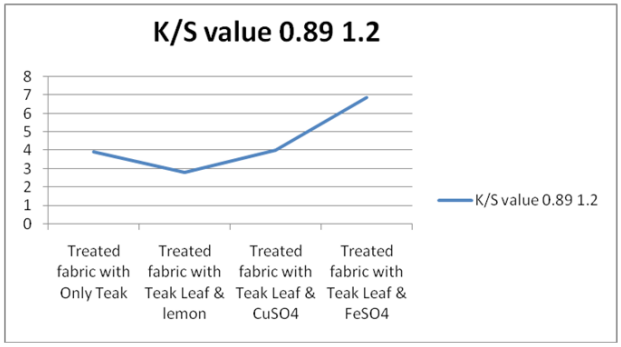


Figure 5: Color parameter, K/S Value.

Treatments	Color fastness to wash	Light fastness	Color fastness to Rubbing	
			Dry	Wet
Treated fabric with Only Teak Leaf	3	4	4	3
Treated fabric with Teak leaf & lemon	3-4	4	4	3
Treated fabric with Teak Leaf & $CuSO^4$	3-4	4	3	2-3

Treated fabric with Teak Leaf & $FeSO_4$	3-4	4	4	3

Table 2: Fastness properties for dyeing with Teak Leaves on cotton fabric.

Fastness Properties for Dyeing with Teak Leaves on Cotton Fabric

The mordanted samples with Lemon and Ferrous Sulphate were confirmed less color difference, enhanced rubbing fastness under both crocking conditions in dry and wet, moderate to excellent color fastness to wash comparing to Copper Sulphate mordanting as well as almost no color change in light fastness property also observed when no mordanting agent was used with teak leaf due to having superior sustainability of remaining coloring agent in teak leaf i.e. anthocyanin pigments in teak leaf which is directly accelerating the establishment of present work to apply teak leaf as natural coloring agent. For Teak leaf the color fastness to wash tabulated in the result table shows in graph that the mordanted sample teak leaves with $FeSO_4$ and treated fabric have provided good color fastness and unmordanted sample only teak and teak with lemon have provided medium color fastness.

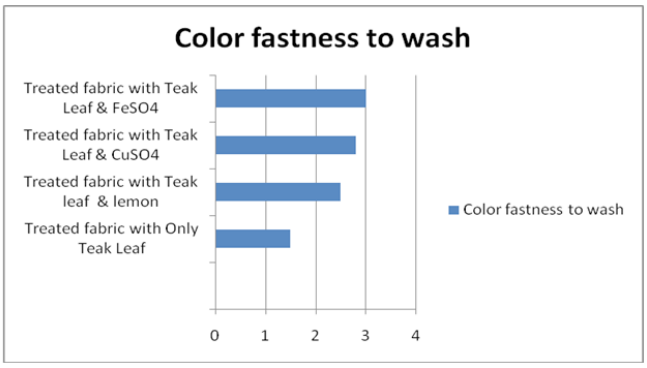


Figure 6: Color fastness to wash.

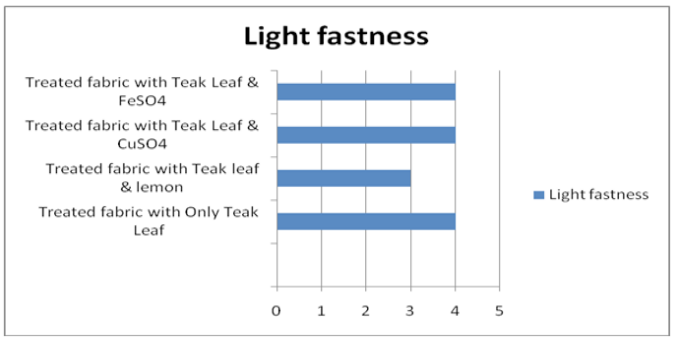


Figure 7: Color fastnesws to light.

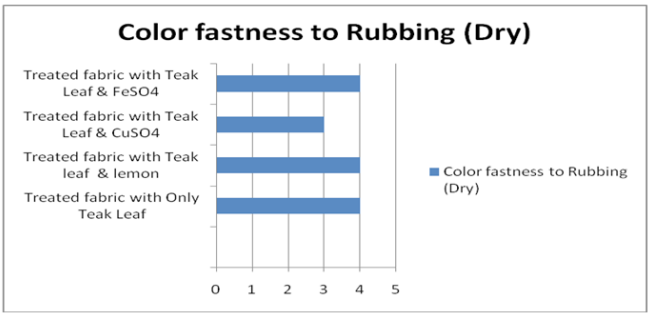


Figure 8: Color fastness to rubbing (Dry).

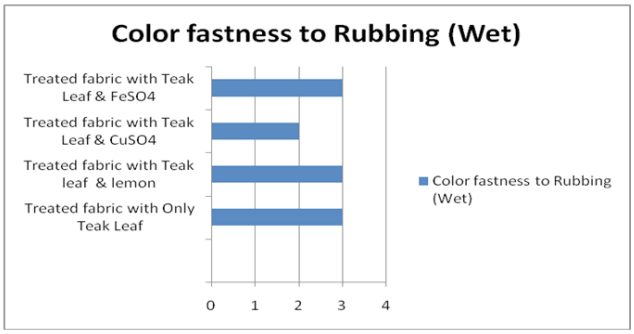


Figure 9: Color fastness to rubbing (wet).

Color Parameters for Dyeing with Neem Leaves on Cotton Fabric

The color parameter to spectrophotometer tabulated in result table shows in graph that Da* Db* Dc* and DE have been presented here in comparison to bleached cotton fabric and proved that deeper shade was produced for organic mordanted sample and ecofriendly inorganic and metallic mordanted sample comparing to Copper sulphate modanted sample. Similarly, higher K/S value showed for lemon and ferrous sulphate mordanting with having minor differences than copper sulphate mordanted sample.

Treatments	Color Parameters				
	Da*	Db*	Dc*	DE	K/S value
Bleached untreated cotton	-	-	-		0.89
Treated fabric with Only Neem	-0.63	14.37	14.38	4.57	1.99

Treated fabric with Neem & lemon	-1.04	9.92	9.98	3.00	4.00
Treated fabric with Neem & $CuSO_4$	-4.66	20.26	20.75	8.10	4.50
Treated fabric with Neem & $FeSO_4$	-3.23	15.35	18.27	6.00	4.20

Table 3: Color Parameters for dyeing with Neem Leaves on cotton Fabric.

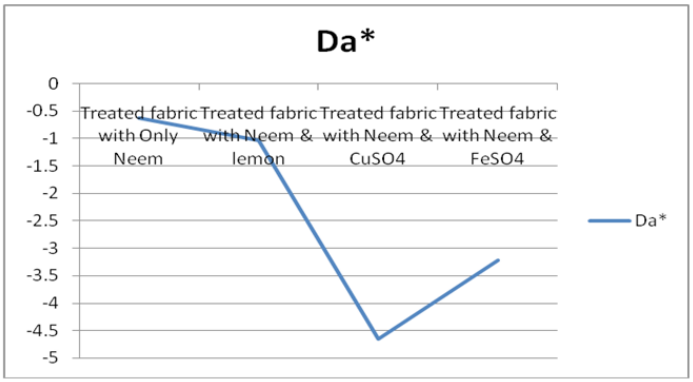


Figure 10: Color parameter, Da*.

Fastness Properties for Dyeing with Neem Leaves on Cotton Fabric

The colorfastness to sunlight tabulated in result table shows that the unmordanted sample, only Neem, Neem with Lemon samples exhibited better fastness than other mordanted samples to sunlight exposure. The Lemon mordanted samples was the best with little color change. Some mordanted samples dyed with Neem extract after with $CuSO_4$ Mordanting also showed good color fastness to Uv light.

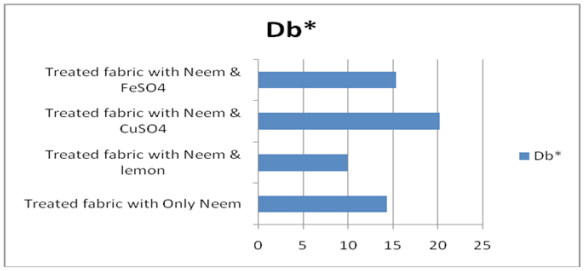


Figure 11: Color parameter, Db*.

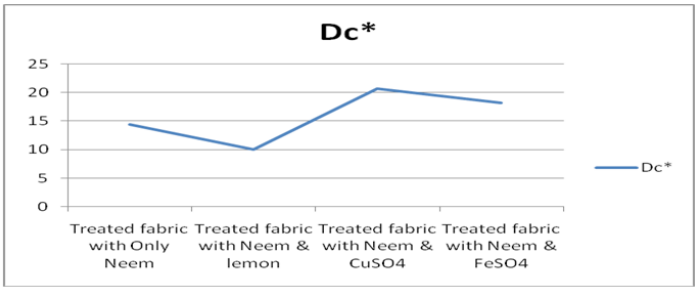


Figure 12: Color parameter, Dc*.

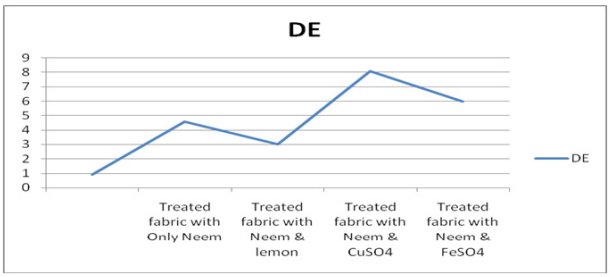


Figure 13: Color parameter, DE.

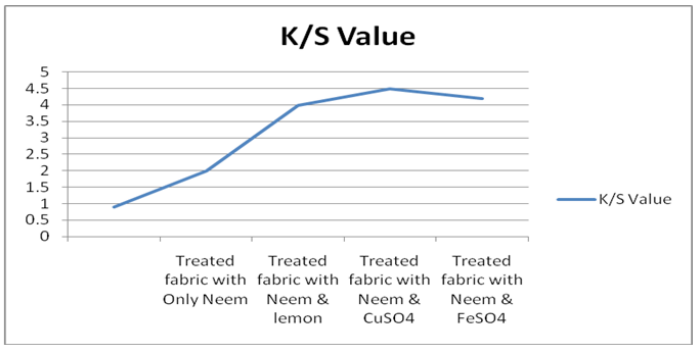


Figure 14: Color parameter, K/S Value.

Treatment	Color fastness to wash	Light fastness	Color fastness to Rubbing	
			Dry	Wet
Treated fabric with Only Neem	2	4	4	3
Treated fabric with Neem and lemon	3	4	4	3

Treated fabric with Neem and $CuSO_4$	3	4	4	2
Treated fabric with Neem and $FeSO_4$	3	3	3	2

Table 4: Fastness properties for dyeing with Neem Leaves on cotton fabric.

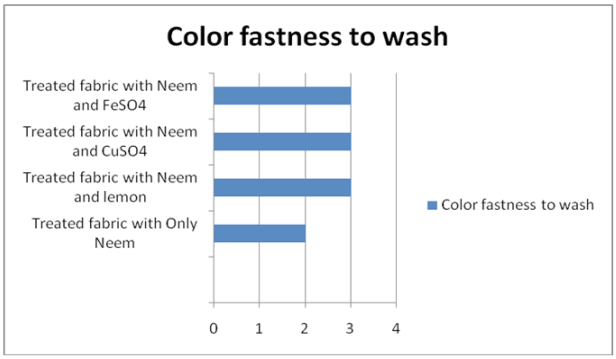


Figure 15: color fastness to wash.

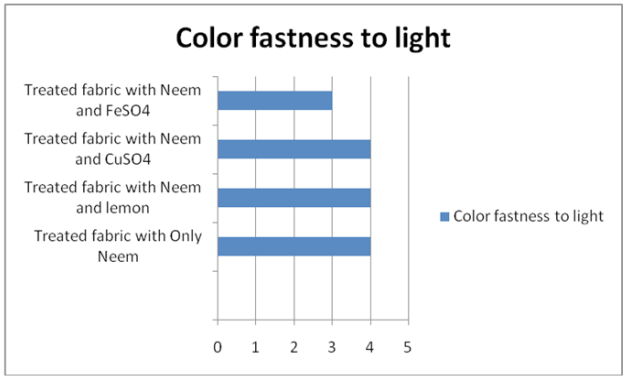


Figure 16: Color fastness to light.

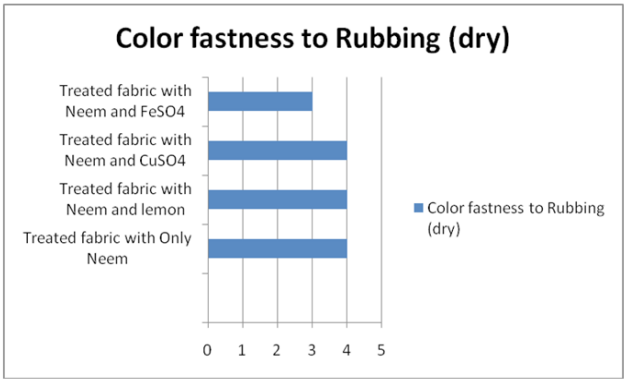


Figure 17: Color fastness to rubbing (dry).

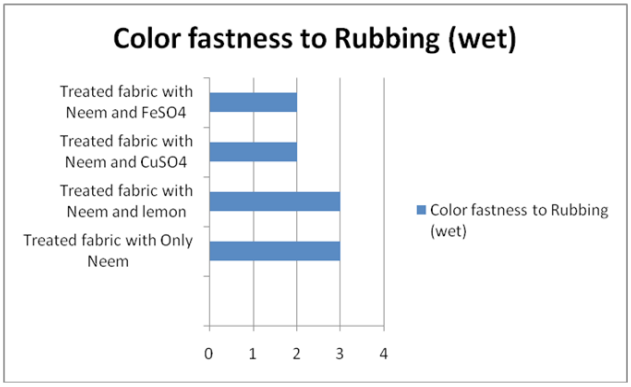


Figure 18: Color fastness to rubbing (wet).

Anti-bacterial Testing of Dyed and Finished Cotton Fabric with Neem and Lemon Mordating

Anti-bacterial testing of cotton fabric dyed and finished with Neem and Lemon had been tested in Bangladesh Council of Scientific and Industrial Research (BCSIR). In this testing, E-coli bacteria were applied on dyed and finished cotton fabric. After effective times, the E-coli bacteria were absent. From this testing result, we can say that this dyed and finished cotton fabric is anti-bacterial. So, natural dyeing and finishing with Neem and Lemon will be anti-bacterial.

Conclusions

Results of measurement of colour parameters showed that lower ΔE values are obtained when treated with lemon mordanting agent for both the case of dyeing cum finishing treatment with extract of Teak leaf and Neem leaf (though amongst the two dye extract used, Neem leaf extract showed higher K/S value) as compared to conventional mordanting with Copper Sulphate.

Ferrous Sulphate render moderate K/S value than all other mordents due to inherent own colour of iron in $FeSO_4$. Comparing lemon mordanting with conventional copper sulphate mordant, colour fastness properties of teak leaf extract with lemon mordanting are found to be better and is in the order of Rubbing Fastness > colour fastness to Light > colour fastness to wash than that for synthetic $CuSO_4$ mordanting,

For dyeing with extract of neem leaf with lemon mordanting showed very attractive all round colour fastness properties studied here.

For the newer approach of natural dyeing cum simultaneous antibacterial finish the antibacterial properties of neem leaf extract dyed cotton using lemon mordanted sample resulted better reduction/ killing of bacteria.

Thus, the present work has led to development of a process of simultaneous dyeing and finishing with natural natural mordents (lemon juice) and natural dye (Neem leaf extract) to make the fabric colour full and anti-bacterial too.

References

1. Samanta AK, Singhee D, Sethia M (2003) Application of Single and Mixture of Selective Natural Dyes On Cotton Fabrics-A Scientific Approach. Colourage 50: 29-42.
2. Dedhia EM (1998) Natural Dyes. Colourage 3: 45-49.
3. Samanta AK, Agarwal P, Singhee D, Datta S (2009) Application of single and mixtures of red sandalwood and other natural dyes for dyeing of jute fabric: studies on colour parameters/colour fastness and compatibility. The Journal of textile institute 100: 565-587.
4. Samanta AK, Agarwal P, Datta S (2009) Studies on Color Interaction Parameters and Color Fastness Properties for Dyeing of Cotton Fabrics with Binary Mixtures of Jackfruit Wood and other Natural Dyes. Journal of natural fibre 6: 27-45.
5. **Samanta AK, Konar A, Chakraborty S, Datta S (2010) Effect of different Mordants, Extraction Conditions and Dyeing Process Variables on colour interaction Parameters and Colour Fastness properties in dyeing of Jute Fabric with Manjistha, a Natural Dye. Journal of Institution of Engineers (India)-Textile Engg 91: 7-15.**
6. Samanta AK, Konar A, Chakraborti S, Datta S (2011) Dyeing of Jute fabric with Tesu extract: part 1-effects of different mordants and dyeing process variables. Indian Journal of Fibre and Textile Research 36: 63-73.
7. Samanta AK, Agarwal P (2007) Dyeing of Jute and Cotton fabrics using Jackfruit wood extract: part 1-effects of mordanting and dyeing process variable on color yield and color fastness properties. Indian Journal of Fibre and Textile Research 32: 466-476.
8. Bechtold T and Mussak R (2009) Handbook of Natural Colorants. Franzens University Austria.
9. Rajan S, Gopinath M. Natural Dyeing of Cotton Fabric Using Terminalia Chebula and Turmeric Part-5. Textile Chemistry, SSM College of Engineering, Komarapalayam, Namakkal, India.
10. Hasan M, Nayem KA, Azim AYMA (2014) Dyeing of Cotton and Silk Fabric with Purified Natural Curcumin Dye. Department of Textile Engineering 3: 838-844.
11. Bukhari H, Heba M, Khadijah Q (2014) Eco- friendly dyeing textiles with neem herb for multifunctional fabrics. Part 1: Extraction Standardization. International Journal of Technical Research and Applications 2: 51-55.
12. Nirmal Pal, Neem wave exhibitions, Neem coated textiles.
13. Deo HT and Desai BK (2006) Dyeing of cotton and jute with tea as a natural dye. Coloration Technology 115: 224-227.
14. Kaur V (2015) Dyeing of Cotton with Tea as a Natural Dye. International Journal of Engineering Innovation & Research 4: 184-187.
15. Nurizza F, Luchman H (2015) Plants as Natural Dyes for Jonegoroan Batik Processing in Jono Cultural Tourism Village, Bojonegoro, East-Java. Journal of Indonesian Tourism and Development Studies 3: 41-44.
16. Geeta M, Department of textile and apparel, University of Agricultural Sciences, Dharwad.
17. Vankar PS, Tiwari V, Shanker R (2003) Dyeing cotton, wool and silk with *Tectona* leaves dye. Analytical Chemistry, Biochemistry, Chemical Engineering 12: 86-88.
18. Malpani SR (2013) Antibacterial treatment on cotton fabric from neem oil, *Aloe vera* & tulsi. International Journal of Advance Research in Science and Engineering 2: 35-43.
19. Naser A. Haque A (2017) *Aloe vera*: Natural mordant for natural dye. Department of Textile Engineering Daffodil International University.
20. Sundrarajan M, Selvam S, Gandhi RR, Sujesh J (2007) Effectively utilize the natural resources as mordants and dyes for dyeing of cotton. International Journal of Current Research 3: 363-367.
21. Zubairu A, Mshelia YM (2015) Effects of Selected Mordants on the Application of Natural Dye from Onion Skin (*Allium cepa*). Science and Technology 5: 26-32.
22. Alamgir R (2014) Scope of cotton dyeing with natural color extracted from-*Tagetes erecta* L.*, Lawsonia inermis*, *Rosa* L., *Allium cepa* and-*Camellia sinensis*-by-using-different-mordants, Textile Today.
23. Moiz A, Ahmed MA, Kausar N, Ahmed K, Sohail M (2014) Study the effect of metal ion on wool fabric dyeing with tea as natural dye. Journal of Saudi Chemical Society 14: 69-76.
24. Alemayehu T, Teklemariam Z (2014), Application of natural dyes on textile: A review. international journal of research-Granthaalayah 2: 61-68.
25. Lakshmi CG (2014) Food Coloring: The Natural Way. Research Journal of Chemical Sciences 4: 87-96.
26. Samanta AK, Adwaita K (2012) Technical Handbook on Natural Dye and Colouration. Dept of Jute and Fibre Tech 45-72.
27. Samanta AK, Agarwal P, Konar A, Datta S (2008) Characterisation and application of purified selective natural dyes on jute. International Dyer 193: 25-33.
28. Samanta AK, Agarwal P (2008) Application of Mixture of Red Sandal Wood and Other Natural Dyes for Dyeing of Jute Fabric-Studies on dye Compatibility. International Dyer 193: 37-42.