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DYEING OF 100% COTTON FABRIC WITHOUT USING SYNTHETIC DYES & CHEMICALS

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ABSTRACT

Textile materials are colored for the value addition purpose. Normally synthetic dyes are used for this purpose. In few cases fabric is dyed with natural dyes using synthetic mordant. Here this is clarified that 100% cotton fabric is dyed with natural dyes using natural mordant without the use of metallic mordant and at the same time applied natural finish (Neem, Aloevera and Holy Basil (Tulsi) exudates). Ingredients which are applied collected from surrounding environment that leads to a cost-effective dyeing process. Moreover, this is advantageous in easy application process as well as harmful free substances. Natural saps were collected from respective ingredients and at the same time the sample fabrics were conditioned for the purpose of easy penetration of dye molecules. Here all 60 methods (i.e. natural ingredients applied at 60^0C) were applied for uniform and level dyeing and subsequently natural finishes were applied. The quality of the dyed fabric levelness was good which was checked on quality control table under D65 light source & also by using 4 point system. The fastness properties are also satisfactory which rating were around 4 in every case. In comparison with chemical procedure, the applied natural dyeing process is easy to operate as well as less time consuming which meets all the necessary requirements of a perfect dyed fabric.

Keywords: *Red Spinach, Betel Nut, Neem & Holy Basil (Tulsi) exudate, color fastness*

1. INTRODUCTION

The use of dye stuffs is as old as textiles themselves and pre-dates written history. Angelini *et al.* (2003) clarified that in textile industries various synthetic dyestuffs as well as pigments are commonly used for better color fixation with maintain low cost. Synthetic dyestuffs & pigments are manufactured through different chemical process. Dalby (1993) has studied that synthetic dyes are harmful to the body and thus the increased search into the arrays of plants for natural dyes which is more environmental friendly. These color providing materials are ruled out because of their toxicity & non biodegradable characteristics highlighted in Ibrahim *et al*. (2010). Recently these toxic & non ecological materials are going to be replaced. Bio degradable dyestuffs are supplanted by synthetic dyes due to their non toxic & ecological characteristics. Ali *et al*. (2011) has suggested that because of increasing environmental awareness & also pollutants produced by synthetic coloring materials, a great interest has been arisen in textile dyeing sector to color materials using natural colorants. Natural dyes can be defined as those organic materials that have the ability to impart color to any substrates which they must have had affinity for. Until the mid-19th century, all dyestuffs were made from natural materials, mainly vegetable matters. Islam *et al*. (2015) made a study that natural dyes are biodegradable and very compatible with the environment. These dyes can be obtained either from plants, animals, and minerals.

Some researchers have already been successfully completed to dye textile materials by using color from natural source like acaciacyanophylla flowers (Ghouila *et al.,* 2012), terminaliaarjuna, punicagranatum, rheumemodi (Vankar *et al.,* 2007), rutin (Nasirizadeh *et al*., 2012), mader (Nateri, 2011), bixaorellana seeds (Kamel *et al*., 2007), lak natural dyes (Kamel *et al.,* 2007), henna (Shaukat *et al*., 2009), cochineal (Kamel *et al*., 2009) and turmeric (Ibrahima *et al.,* 2010). Different technologies have already been started in Textile wet processing purpose. Plasma Technology has provided a positive impact in pretreatment process of textiles with low water & low energy consumption. In addition to that micro wave energy in dying process has been started in dying process with minimum energy required to raise temperature & dyeing rate also be increased.

Normally textile factories use synthetic dyes & chemicals. Waste water produced due to the processing of dyes & chemicals. Factories discharge the water to the environment with or without after treatment of the polluted water. Normally most of the cases the waste water of the factories directly discharged to the environment without any treatment. This water has higher value of BOD & COD. These BOD & COD are harmful for the environmental. Specially living organisms in water are directly affected by the higher amount of BOD & COD. The P^H of water is also high in the discharge water. So, with the increasing of environmental concern, alternative way has been going to be established in order to save the environment & get positive outcome. Natural colorants & mordants can be good alternative of fabric dyeing considering all the environmental factors. Recently a competing interest in the use of natural coloring materials in textiles has been growing. Natural dyes are friendly to the environment in comparison to synthetic dyes.

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In this article work, no inorganic textile chemicals, auxiliaries & inorganic textile dyes were used & even the mordant is also natural as well as the natural finisher. Everything was collected from nature & our surrounded area and the full dyeing process was completed by using these natural items. The whole dyeing process is easier process and also have satisfactory result on color fastness test. The aim of this work is to dye textile bleached fabric without the use of chemicals with maintaining good physical quality of dyed fabric. The verdicts of this work provide a new space of utilization of large quantities of natural ingredients which are available in the surrounding environment for textile coloring purpose.

2. MATERIAL AND FABRIC USED

2.1 Fabric description

Composition : 100% Cotton 180 GSM
Construction : Single Jersey
Condition : Bleached

2.2 Natural ingredient

Natural ingredients Red Spinach, Henna, Sajina, Betel nut, Banana stem, and Tamarind leaf were used. *Aloevera,* Neem, Holy Basil (Tulsi) leaves were used for natural finishing.

2.3 Extraction of dye & finishing solution from natural ingredients

i. Firstly, the required ingredients were collected and cleaned properly by using water.
ii. Ingredients were blended and turned into paste form.
iii. These pastes were boiled at a certain temperature.
iv. After boiling the exudates were filtrated.

2.4 Fabric Preparation

100% Cotton 180 GSM scoured and bleached knitted fabric was collected from wet processing laboratory. To get proper absorbency, the below treatment was carried out:

Soda ash 2g/L
Detergent 3g/L
Hot at 80^0C for 20 min

2.5 Identification of Sample and Dyeing Recipe

Table1: Dyeing Recipe

Component	% of total water		
	Sample 1	Sample 1	Sample 1
Red Spinach	25	10	10
Henna	10	25	10
Sajina	10	10	25
Mordant	30	30	30

Rest of the quantity was water to make the solution 100%. Mordant such as betel nut sap used for sample 1, tamarind leaves paste for sample 2 and banana bark sap for sample 3.

3. PROCEDURE OF DYEING

At first bleached fabric was selected for this dyeing purpose. For proper absorbency of the fabric so that the natural dyes can penetrate easily into the fabric, the bleached fabric was washed at high temperature. Three nozzles/dyeing pots were selected and the collected saps of different colors were put in the nozzles as per materials. Nozzles were kept in sample dyeing machine to run for 30 minutes at 60^oC. After that the natural fixer was added and kept additional 30 minutes at 60^oC for proper & adequate take up of dye by the fabric. Here the total operation time was approximately 3 hours. From the above curve this is illustrated that full process of dyeing was carried out at 60^oC. Normally the consumption of energy is less here as no steam was used to raise the temperature greater than 60^oC which is sometimes necessary for dyeing with synthetic dyes.

3.1 Treatment after dyeing

After dyeing the dyed fabric samples were washed properly to remove the unfixed surface color. Firstly cold wash was done. After that hot wash was carried out. Then soaping chemical like detergent was used to wash for obtaining good fastness result. Again fabric was rinsed properly to make the surface clean.

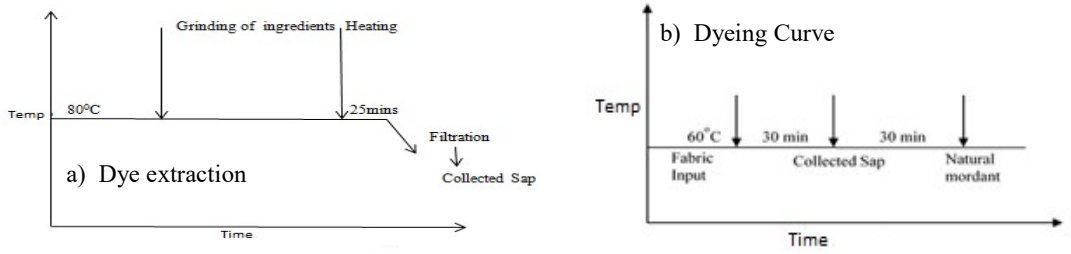


Figure 1: Natural dye extraction & dyeing process curve

3.2 Natural finish application

For finishing purpose, *Aloevera* was used for sample 3, Neem paste for sample 2, Holy Basil (Tulsi) paste for sample 2. Firstly, the required ingredients were turn into paste form, then adequate amount of water have been added to turn the paste into juicy liquor so that the finishers can easily penetrate into the dyed fabric sample. The finishing treatment was continued for 1 hour at 60°C. After finishing treatment, the samples were rinsed with water for three times so that the surface particles (of the liquor) may be removed. When fabric dyeing with natural dyes was completed & after the application of natural finish, the dyed fabric was slightly washed & allowed to dry properly.

3.3 Used natural ingredients &color of dyed fabric

Different tones & depth of color was achieved by using different natural ingredients in different proportion. Various shades were found after dyeing the bleached fabric.

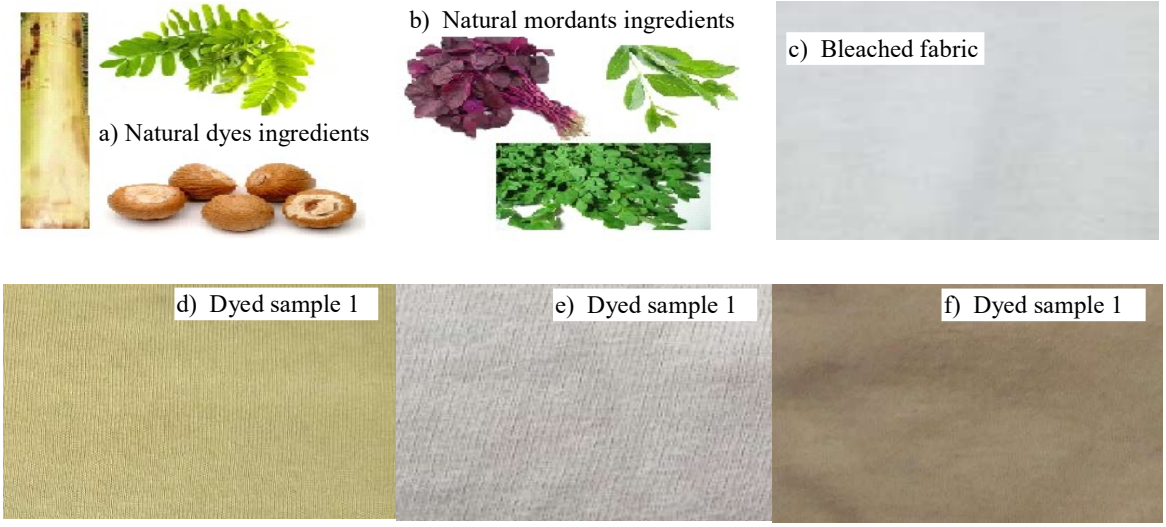


Figure 2: Natural ingredients & bleached fabric to be dyed and the dyed samples

Different tones of shade were found when the dyed samples were checked under light box. Used light source was D65.This was observed that not only different tone but different depth of color was found after checking the samples. One sample was light shade which was sample 2, one sample was medium shade which was sample 1 & another sample was dark shade which was sample 3. All the samples were viewed keeping at 45^0 angle in the light box.

3.4 Different Tests

Different tests were carried out to check the fastness properties & dyeing accuracy. All the samples were tested in third party testing company A-ONE POLAR Limited which is a sister concern of Micro Fiber group. Test name & results of different tests are provided below:

3.5 Color fastness to wash (ISO-105-C06)

The color fastness to wash test was carried out for all the samples & the test procedure was ISO-105-C06 method. After carried out testing, multi fiber fabric was checked to understand the fastness rating. Color fastness to wash rating for sample 1 was 4, for sample 2 rating is 4-5 & for sample 3 rating is 3-4.

3.6 Color fastness to water (ISO-105-E01)

The color fastness to water test of all the samples was carried out by ISO-105-E01 method. Gyro wash machine was used in this purpose. Multi fiber fabric shows that the result is good. Fastness rating for sample 1 was 4, for sample 2 was 4-5 & for sample 3 were 4. This means the fastness rating for all the samples is satisfactory.

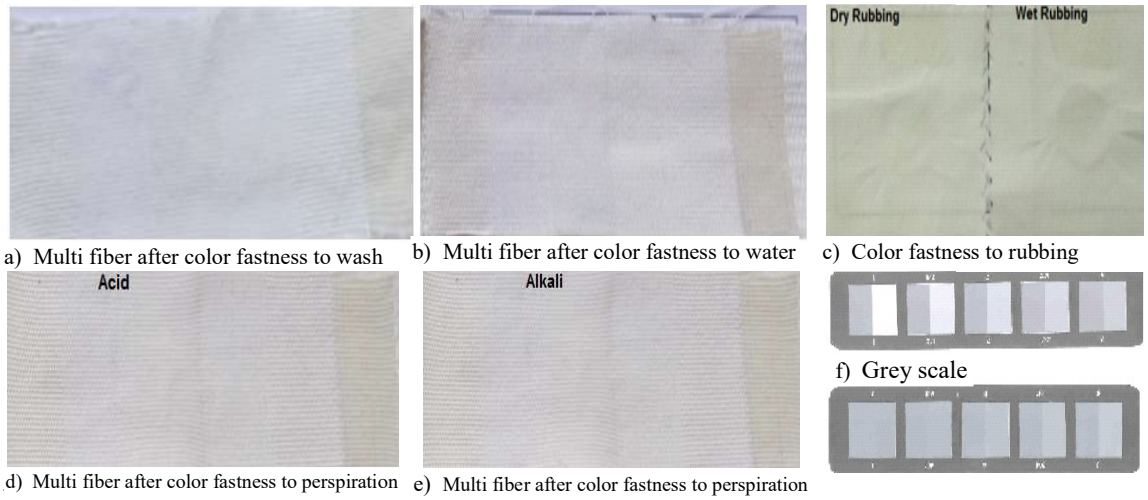
3.7 Color fastness to rubbing (ISO-105-X12)

Color fastness to rubbing of all the samples was carried out by ISO-105-X12 method. Crock meter was used for this purpose. Both dry rubbing as well as wet rubbing were tested for all the samples. Dry rubbing & wet rubbing test result of all the samples was satisfactory & the rating was not below 3 for all the samples. Bleached fabric was used to check the rubbing & 10 cycles were applied in crock.

3.8 Color fastness to perspiration (ISO-105-E04)

The color fastness to perspiration test of all the samples was tested & the test was carried out by ISO-105-E04 method. Both the acid & alkali tests were carried out in every sample. In every case the test result is satisfactory. Fastness rating for sample 1 was 4, for sample 2 rating was 4-5 and for sample 3 rating was 3-4. This means the fastness rating of all the samples is not below 3.

All the dyed fabric was tested separately. After testing, the change in color of multi fiber fabric for different tests & bleached fabric color change for rubbing test is given below as well as the grey scale which was used to measure the fastness rating:



a) Multi fiber after color fastness to wash
b) Multi fiber after color fastness to water
c) Color fastness to rubbing
f) Grey scale
d) Multi fiber after color fastness to perspiration
e) Multi fiber after color fastness to perspiration

Figure 3: Multi fiber fabric changes after color fastness to wash, water & perspiration and grey scale for measurement.

Multi fiber fabric of different tests from the above figure illustrates that change in color is not so much significant as the test rating was not below 3. Bleached fabric color change was also not significant as the rating is above 3 which are clearly understood from the figure. Average color fastness rating of all the samples is given below:

Table 2: Fastness (wash, water, perspiration) rating of sample1, sample 2 & sample 3.

Test Name	Dyed Sample 01	Dyed Sample 02	Dyed Sample 03
Color fastness to wash	4	4-5	3-4
Color fastness to water	4	4-5	4
Color fastness to perspiration	4	4-5	3-4

After plotting all the data of the above table of color fastness wash rating 4 for dyed sample 1, rating 4-5 for dyed sample 2, rating 3-4 for dyed sample 3, color fastness to water rating 4 for dyed sample 1, rating 4-5 for dyed sample 2, rating 4 for dyed sample 3, color fastness to perspiration rating 4 for dyed sample 1, rating 4-5 for dyed sample 2 & rating 3-4 rating for dyed sample 3, the below graphical representation was obtained.

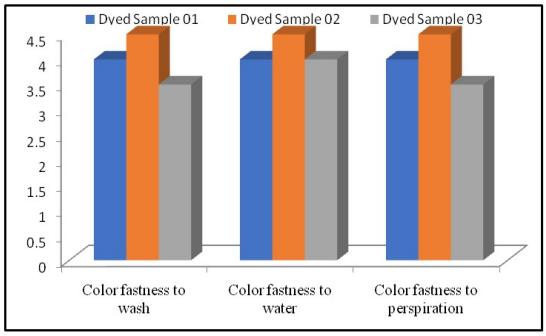


Figure 4: Fastness (wash, water, perspiration) rating of dyed sample1, sample 2 & sample 3.

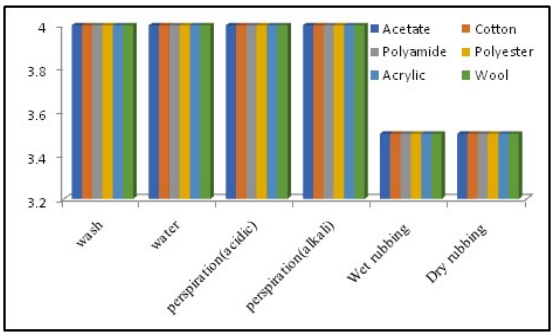


Figure 5: Specific color fastness rating in different fiber of the multi fiber fabric for dyed sample 1

3.9 Comparison between synthetic & natural dyeing

Normally synthetic dyes are used for normal dyeing in textile field. Different shades which were achieved here by dyeing with natural dyes & natural mordants. If similar shades on 100% cotton fabric should be achieved by synthetic dyes, reactive dyes would be used. Here Remazol Red RR, Remazol Blue RR, Remazol Yellow RR can be used to achieve the similar shades of natural dyeing. Dye bath P^H should be adjusted slightly acidic condition before start dyeing. Then electrolyte (glubar salt) was transferred to the dye bath to reduce electronegativity. After 20- 25 min hold time, linear color dosing should be carried out to the dye bath for 35-40 min. After that 30 min hold time was carried out for uniform distribution of the dyes to the fabric. Then (progressive -3) soda dosing was done to the dye bath for 30-35 min for fixation of the synthetic dyes with the fabric. During fixation period, the P^H should be kept 10.5 for light shade & around 10.8 for medium shade. After shade checking, neutralization should be carried out at 60^0c with 1 g/L acetic acid. Finally hot washing with soaping chemicals should be used to remove unfixed dyes. Additional time was required to raise, lower the temperature for required operation & also for washing purpose. Full dyeing process of pretreated bleached fabric was around 4 hours up to unloading from dyeing machine & the cost of 1 kg fabric dyeing was 1500-2000 taka considering the cost of the dyes & chemicals. But comparing with this natural dyeing which was carried out here in this article, the full dyeing process was carried out at 60 ^{0}C. After the addition of natural dyes, 30 mins hold time was carried out. Then natural mordant was applied all were explained in Figure 1b. Here full dyeing process was carried out for 1 hr -1.30 hr with natural ingredients & the cost of dyeing was maximum 400-500 taka. Natural dyes & natural mordants were collected freely from the environment .The main cost was the utility purpose to raise, lower the temperature & also the use of non ionic detergent to remove unfixed dyes. The quality of the natural dyed fabric shade was good without any unlevelness, dye spot, crease mark & color fastness properties were good in rating. The water after the natural dyeing was not harmful and amount of BOD & COD were less as no synthetic dyes & chemicals were used. But these amounts are normally high for dyeing with synthetic dyes, chemicals. Dyeing textile fabric with natural dyes is environmental friendly. So, in comparison of this natural dyeing with conventional synthetic dyeing, the dyeing cost & time are less consumed for natural dyeing as well as the good quality of the dyed fabric. Natural dyes along with natural mordants are convenient to use & also productive to get good quality in dyeing, financial and environmental point of view.

4. RESULTS AND DISCUSSION

Different physical parameters were observed to understand the dyeing quality. Considering dyeing quality, all the dyed samples were free from uneven shade. No running shade was found. There was no color/dye spot on all the samples. The fabric used for dyeing was single jersey. So there was possibility of having crease mark. But

actually this was not happened. All the dyed samples were free from any crease mark. Shrinkage of the fabric after dyeing was not significant. Actually the visual appearance of the samples was good. The samples were checked under light box & D65 light source was used for this purpose. Different physical tests were carried out to understand the fastness properties of dyed samples. The results of all the tests which were carried out are in acceptable range. Multi fiber fabric information illustrates that color change was not significant as well as the color staining. The depth of sample 3 was maximum (dark shade) where banana bark was used as mordant & result rating is 3-4 for all the tests excluding color fastness to water where the rating is 4. The depth of sample 2 in was light shade where tamarind leaves was used as mordant & the result of all the tests is 4-5. The depth of sample 1 was in medium shade where betel nut was used as mordant & the result of all the tests was 4 excluding color fastness to rubbing rating is 3-4. As per the color depth of the dyed sample 3 is the darkest, then sample 1 and last one is sample 2. Banana bark sap is used as a mordant for sample 3, betel nut sap for sample 1, tamarind leaf pastes for sample 2. Among the mordants banana bark is comparatively better mordant than other two. Hand feel of the dyed samples was checked. This was observed that sample 3 hadfeel was the best among the other two. Hand feel quality of sample 1 is better than that of sample 2. So, considering the performance of had feel, aloe vera is the best for this natural finishing purpose as well as to keep good quality had feel.

Normally what happened in dyeing with synthetic dyes & chemicals. Temperature, PH as well as the time is the considerable factors. To adjust P^H in acidic & alkaline medium, extra chemicals are used & for temperature increasing, steam need to be supplied from boiler. For all this purpose, costing is a big issue as well as to dye fabric with maintaining good quality. In comparison to this natural dyeing without the use of synthetic dyes & chemicals, costing is just minimum which is convenient to maintain. Specific fastness rating of multi fiber fabric of different samples are clarified in the below tables. After plotting all the data of specific color changes in multi fiber fabric of sample 1, the below graph was obtained where x –axis represented the types of color fastness according to multi fiber fabric and Y-axis represented the rating.

Another graph was obtained after plotting all the data of specific color changes in multi fiber fabric of sample 2, the below graph was obtained where x –axis represented the types of color fastness according to multi fiber fabric and Y-axis represented the rating.

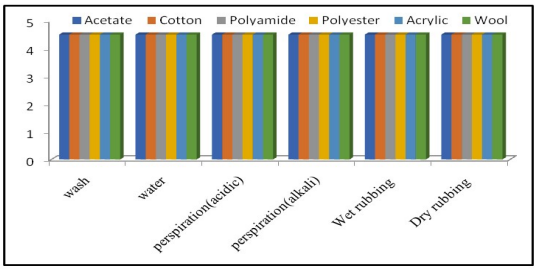


Figure 6: Specific color fastness rating in different fiber of the multi fiber fabric for dyed sample 2

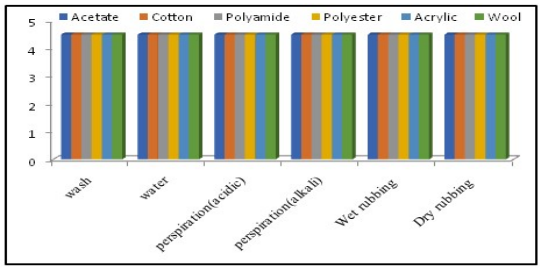


Figure 7: Specific color fastness rating in different fiber of the multi fiber fabric for dyed sample 3

Graph for dyed sample 3 was obtained after plotting all the data of specific color changes in multi fiber fabric for that sample 3 , the below graph was obtained where x –axis represented the types of color fastness according to multi fiber fabric and Y-axis represented the rating. Dyed fabric quality of all three samples & fastness properties provide a clear idea about proper dyeing. This natural dyeing is also cost effective. All the natural coloring materials & mordants were sourced easily from surrounding area & collection of sap from these materials was easy. Natural dyeing using the ingredients like red spinach, henna, sajina & mordants banana bark, tamarind leaves, betel nut is convenient to get light, medium & dark shade with maintain good dyeing quality & fastness parameters.

5. CONCLUSIONS

Different type of natural dyes was collected from our surrounding environment. In this work, natural dyes are applied on the 100% cotton fabric with different natural mordant. Acceptable results obtained in various testing such as color fastness to wash, water, rubbing and perspiration tests. Also better results were obtained of perspiration and rubbing fastness tests. Main success is that without using any salt, soda or other chemicals it becomes successful to dye with natural ingredients. From this research this has come to know that the natural dyes along with natural mordant are giving better dyeing result on 100% cotton fabric. This natural dyeing is environmental friendly, cost effective, less time consuming & good quality. The basic target considering the environmental issue as well as the quality factors of natural fabric dyeing was achieved & wide range of colors can be achieved with natural dyes.

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