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Influence of Natural and Artificial Mordants on the Dyeing Performance of Cotton Knit Fabric with Natural Dyes

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Abstract: *This work aims on an effort to determine the effect of some natural and artificial mordants on various natural dyes for cotton fabric dyeing. As natural mordant Eucalyptus Bark, Arjun Bark and Khair was used on cotton knit fabric under the treatment of three natural dyes namely Marigold, Eucalyptus leaf and Henna. As artificial mordants, potash alum and tannic acid were used along with natural mordants for further improvement of color strength. The cotton knit fabrics were scoured & bleached before dyeing. Concentrations of mordants were varied. Color strength and wash fastness properties were evaluated to determine the best mordant for particular dyes. It was observed that both the color strength and wash fastness properties increased with the application of mordants especially artificial mordants.*

Keywords: *Natural dye, Natural Mordant, Artificial Mordant, Color strength, Fastness Properties.*

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I. Introduction

The word 'natural dye' refers the dyes derived from the natural sources like plants, animal and minerals. The majority of natural dyes are vegetable dyes from plant sources such as roots, berries, bark, leaves, and wood and other organic sources such as fungi and lichens. Natural dyes are mostly non-substantive and must be applied on textiles by the help of mordants, usually a metallic salt, having an affinity for both the coloring matter and the fibre [1]. Mordants include tannic acid, alum, chrome alum, sodium chloride, and certain salts of aluminium, chromium, copper, iron, iodine, potassium, sodium, tungsten, potash alum and tin [2]. The type of mordant used affects the shade obtained after dyeing and also affects the fastness property of the dye. There has been a significant work on natural dye and mordant and its application on cellulosic fibre. Dyeing results can also rely on the mordant chosen as the introduction of the mordant into the dye will have a marked effect on the final color. Each dye can have different reactions to each mordant. For example, cochineal scarlet, or Dutch scarlet as it came to be known, used cochineal along with a tin mordant to create a brilliant orange-hued red [3]. A few works have been found using natural source as mordant and its application on natural dye. This work here, finds the influence of some natural mordants along with some artificial ones on the dyeing performance of some natural dyes on cotton knit fabrics.

Marigold

Tagetes (Compositae) is a genus of herbs, commonly known as Marigold (Calendula officinalis). The petals and pollen of Calendula officinalis contain triterpenoid esters and the carotenoids flavoxanthin and auroxanthin (antioxidants and the source of the yellow-orange coloration).The leaves and stems contains carotenoids, mostly lutein (80%), zeaxanthin (5%), and beta-carotene [4] which has a distinct yellow color.

Henna

Henna is a dye prepared from the plant Lawsonia inermis, also known as hina, the henna tree, the mignonette tree, and the Egyptian privet, the sole species of the Lawsonia genus Lawsoniainermis L., commonly known as Henna is a shrub or small tree. In application of Henna onto cellulosic textiles, fastness properties such as wash, light, perspiration, etc. are often very low [2].

Eucalyptus Leaf

Eucalyptus leaf is one responsible for yellowish-golden colorant. The coloring matter of Eucalyptus has ample natural tannins and polyphenols varying from 10% to 12%. The important compounds found in the Eucalyptus leaves are Eriodictyol, Naringenin, Quercetin, Rhamnazin, Rhamnetin and Toxifolin, apart from tannins of which some are colorants [5].

Arjuna Bark

Terminalia arjuna is a tree of the genus Terminalia. It is commonly known as arjuna or arjun tree in English. The redish bark of the plant is the main useful part. Arjun is large sized deciduous evergreen tree which has very strong and long roots. This tree reaches height up to 70-85 feet. It has conical leaves, yellow flower and grey color smooth bark [5, 6].

Eucalyptus Bark

Eucalyptus bark is one of the most important sources of yellowish-brown colourant. The colouring matter of Eucalyptus has ample natural tannins and polyphenols varying from 10% to 12%. It is also used as mordant [3,4].

Khair

Acacia catechu (Linn.f.) willd of Mimosaceae family, commonly known as Khair or Cutch tree, is a moderate sized tree, 20 m in height, spiny with thorny branches and rough bark. Katha predominately consists of a mixture of catechin and its isomers in 55 % (in good quality katha) whereas cutch contains 25-35 % of catechu tannic acid, 2-10 % ocetechin and small proportions of catechu red, quercetin and gum [5].

Potash Alum [$KAl(SO_4)_2.24\ H_2O$]

Alum does not affect color. It is usually used with cream of tartar, which helps evenness and brightens slightly. Potassium alum, potash alum, or potassium aluminum sulfate is a chemical compound; the potassium double sulfate of aluminium. Its chemical formula is $KAl(SO_4)_2$ and it is commonly found in its dodecahydrate form as $KAl(SO_4)_2 \cdot 12H_2O$ [5,6].

Tannic Acid [$C_{27}H_{22}O_{18}$]

Most common mordant for cotton is thus tannin or tannic acid. It occurs in many tannin containing substances, especially in gall nuts which has about 60- 70% tannic acid. It adds brilliancy and fastness to some dye colors, enhances reds with tin [5,6].

II. Materials

Substrate:

In the experiment the scoured and bleached cotton fabric of 160 GSM were used. The amount of NaOH and hydrogen peroxide used in bleaching were 20g/l and 2 g/l respectively.

Natural Dyes:

In the experiment Marigold, Henna, Eucalyptus barks were used as natural dyes. Fresh Marigold flowers and Henna leaves, Potash alum and tannic acid were collected from local market and Eucalyptus leaf from Eucalyptus tree.

Fabric Specification:

Fabric Type	Properties
Single jersey knit fabric	Loop length2.5mm, Yarn count 28Ne, CPI-28,WPI-35,GSM 798

Chemicals used:

Chemicals	Used For	Chemicals	Used For
Caustic Soda	Scouring	Tannic acid	Mordanting
Hydrogen per oxide	Bleaching	Potash Alum	Mordanting

III. Methodology

Marigold Dye Extraction:

300gm fresh Marigold flower was boiled with 3 ltrs water for 40 minutes at 900 C. Then this boiled marigold was placed in a blender and prepared marigold pastes were taken.

Henna Dye Extraction:

150gm henna leaves were boiled with 1.5 liters water at 900 °C for 40 mins. Then the dye liquor was collected by filtration from the boiled leaves.

Eucalyptus bark dye Extraction:

300gm Eucalyptus bark in 3 liters of water were immersed at normal temperature (250°C) for 24 hours. After 24 hours these Eucalyptus were boiled with additional 2ltrs of water at 900 °C for 60mins. Then the dye solution was collected by filtration process.

Arjuna Mordant Extraction:

At first 300gm Arjuna bark in 3 liters of water were immersed at normal temperature (250°C) for 24 hours. After 24 hours these Arjuna were boiled with additional 2 liters of water at 900 °C for 60 mins. Then the dye solution was collected by filtration process.

Khair Mordant Extraction:

First of all 100 gm khair was churned by smasher. Then it was boiled with 1ltr of water at 900 °C for 60 mins. Churned khair was totally melted and turned into a thick solution. This thick solution is used as mordant.

Generally three methods are available for the dyeing process of natural dye with mordants namely; pre -mordanting, mordanting during dyeing and post mordanting. The post mordanting process is used in the experiments. 200 gm of cotton knit sample is prepared by necessary pretreatment process.

Combined Dyeing and Mordanting Process:

For dyeing a common procedure is used for every sample. All these dyeing processes were done in a closed bath at 90°C for minutes. Each sample was of 2gm. After dyeing, the dyed fabrics were washed with soap solution of 1g/L and then dried.

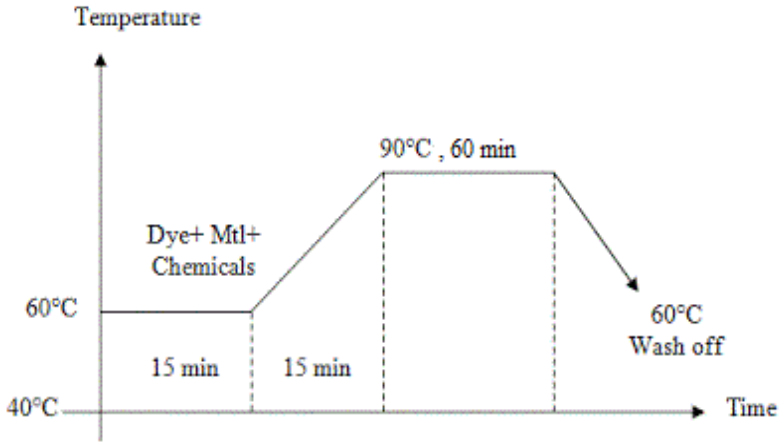

Figure 1: Process curve for combined mordanting and dyeing of natural dyes on cotton knit fabric

Table 1: Recipe variation of natural and artificial mordants' combination for various types of natural dyes

Natural Dye	Natural Mordant		Artificial Mordant
Marigold, Henna and Eucalyptus leaf (10 gm)	No Mordant	-	-
	Arjuna	30 ml & 40 ml	N/A
			Tannic Acid 0.5 gm
			Potash Alum 0.5 gm
	Eucalyptus bark	30 ml & 40 ml	N/A
			Tannic Acid 0.5 gm
			Potash Alum 0.5 gm
	Khair	30 ml & 40 ml	N/A
			Tannic Acid 0.5 gm
			Potash Alum 0.5 gm

IV. Result And Discussions

Color strength for the dye extracted from Marigold

In the figure 2, the color strengths (K/S) for dye extracted from marigold at various mordants combinations are represented. The highest color strength is recorded for the sample no 13 and the lowest for the sample 1. The poor color strength for sample 1 represents the strength of color without the application of any mordant. It is seen that in general, high concentrations of the mordants are responsible for brighter colors. Among the natural mordants, eucalyptus bark shows better color yield than arjuna and khair. With the increment of the concentration of the mordant, color yield increases. Between the artificial mordants, potash alum showed better depth than tannic acid. In a nutshell, eucalyptus bark in combination with potash alum showed best depth of color in cotton fabric.

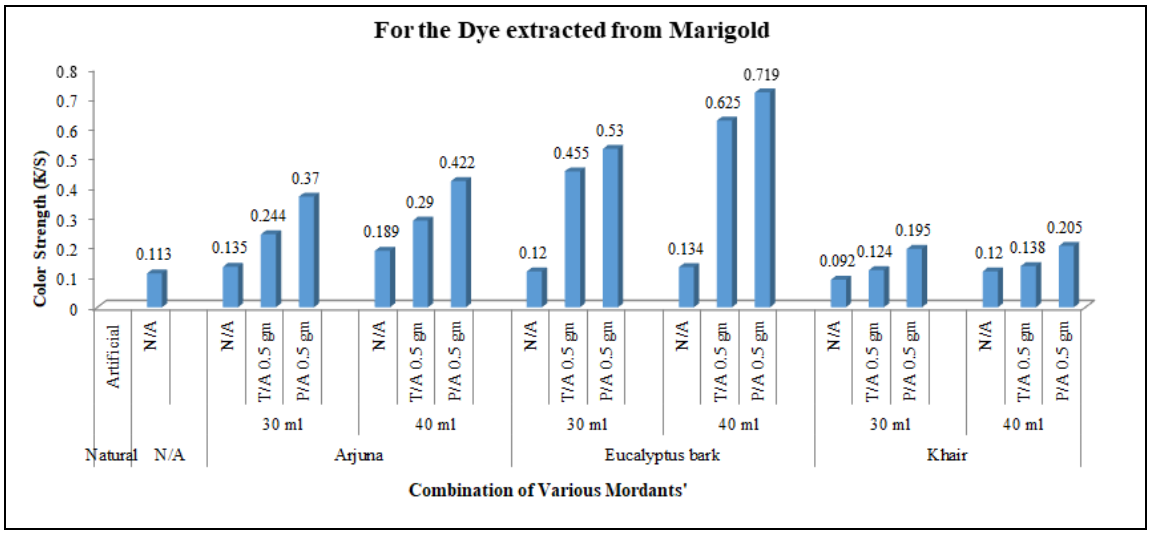

Figure 2: Color strength for dye extracted from Marigold at various mordants' combinations

Color strength for the dye extracted from Henna

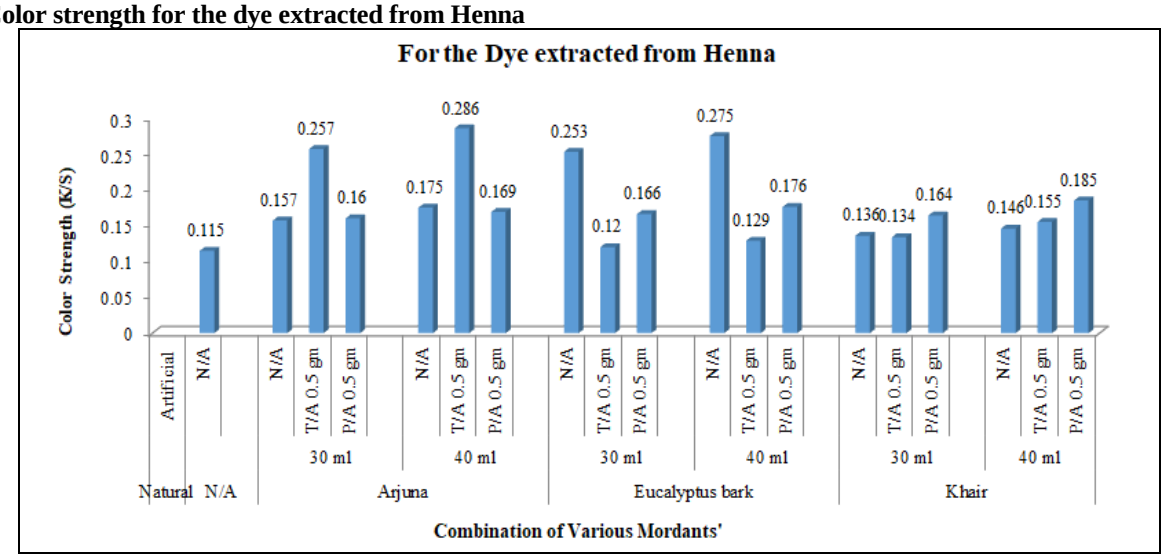

Figure 3: Color strength for dye extracted from Henna at various mordants' combinations

In the figure 3, the color strengths (K/S) for dye extracted from henna at various mordants combinations are represented. The highest color strength is recorded for the sample no 6 and the lowest for the sample 1. The poor color strength for sample 1 represents the strength of color without the application of any mordant. It is seen that in general, high concentrations of the natural mordants are responsible for brighter colors. Among the natural mordants, arjuna shows better color yield than eucalyptus bark and khair. With the increment of the concentration of the mordant, color yield increases. Between the artificial mordants, tannic acid showed better depth than potash alum for arjuna but the result is reverse for the other two natural dyes. Potash alum gave the highest depth than without using artificial mordants or even using tannic acid. For eucalyptus bark, it is interesting that, the effects of artificial mordants are subtractive.

Color strength for the dye extracted from Eucalyptus leaf

In the figure 4, the color strengths (K/S) for dye extracted from henna at various mordants combinations are represented. The highest color strength is recorded for the sample no 13 and the lowest for the sample 1. The poor color strength for sample 1 represents the strength of color without the application of any mordant. It is seen that in general, high concentrations of the natural mordants are responsible for brighter colors. Among the natural mordants, eucalyptus bark shows better color yield than arjuna and khair. With the increment of the concentration of the mordant, color yield increases. Between the artificial mordants, potash alum, in all cases, showed better depth than tannic acid with all the natural mordants' combination.

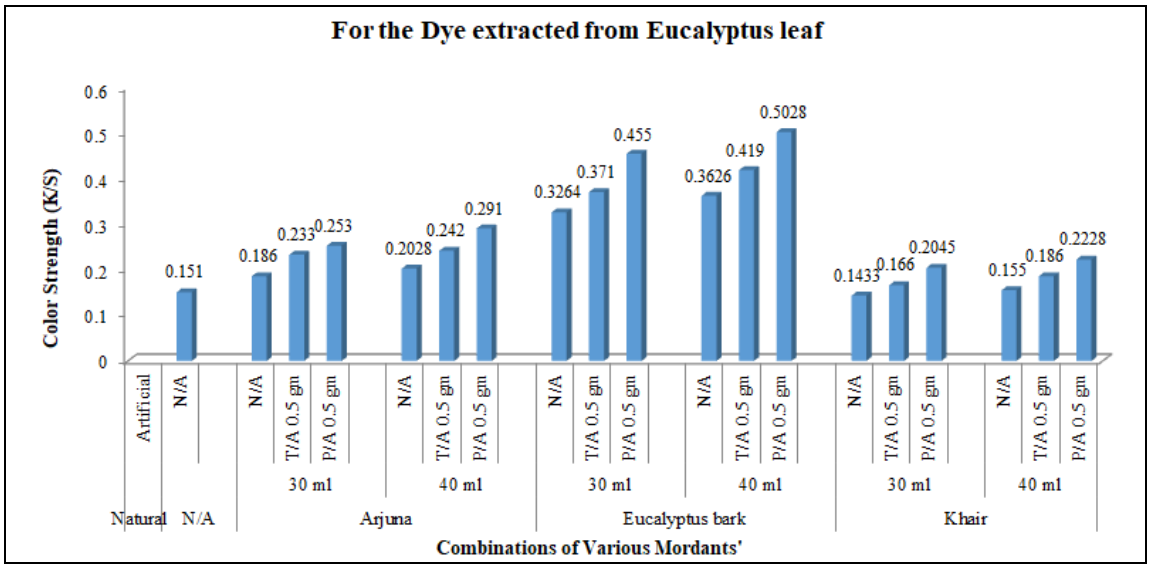

Figure 4: Color strength for dye extracted from Eucalyptus leaf at various mordants' combinations

Wash fastness Results

The wash fastness results for the samples dyed with dyes extracted from marigold, henna and eucalyptus leaf are shown in Table 2, 3 and 4 respectively. From the data shown, it can be easily concluded that the wash fastness property of the samples has been comparatively good while applying mordant. Additionally, using synthetic mordant in the dyeing process, sample has got higher wash fastness in almost all the aspects.

Wash fastness for the Dye extracted from Marigold

Table 2: Wash fastness results for the Dye extracted from Marigold

Sample No	Natural Mordant		Artificial Mordant	Shade Change	DA	CO	PA	PET	AC	VI
1	No Mordant	-	-	3	2-3	2-3	2-3	2-3	2-3	3
2	Arjuna	30 ml	N/A	3	3-4	3-4	3-4	3-4	3-4	3-4
3			TA 0.5 gm	3-4	4-5	4-5	4	4-5	4-5	4-5
4			PA 0.5 gm	4	4	4-5	4-5	4	4	4-5
5		40 ml	N/A	3	3-4	3-4	3-4	3-4	3-4	3-4
6			TA 0.5 gm	4	4	4-5	4-5	4	4-5	4-5
7			PA 0.5 gm	4	4-5	4-5	4-5	4-5	4-5	4-5
8	Eucalyptus bark	30 ml	N/A	3-4	3-4	3-4	3-4	3-4	3-4	3-4
9			TA 0.5 gm	4	4	4-5	4-5	4-5	4-5	5
10			PA 0.5 gm	4	4-5	5	4-5	4	4-5	4
11		40 ml	N/A	4	3-4	3-4	3-4	3-4	3-4	3-4
12			TA 0.5 gm	4	4-5	4-5	4-5	4-5	4-5	4-5
13			PA 0.5 gm	4	4-5	4-5	4	4-5	4-5	5
14	Khair	30 ml	N/A	3-4	3-4	3-4	3-4	3-4	3-4	3-4
15			TA 0.5 gm	4	4	4	4-5	4-5	5	5
16			PA 0.5 gm	4	4-5	4	4-5	4-5	4-5	4-5
17		40 ml	N/A	3-4	4	4-5	4-5	4	4-5	5
18			TA 0.5 gm	4	4-5	4-5	4	4-5	4-5	4-5
19			PA 0.5 gm	4-5	4-5	4-5	4	4-5	4-5	4-5

V. Conclusion

Mordanting is a chemical treatment of improving color strength for natural dye. In this experiment work the effect of natural mordant for dyeing cotton fabric with various natural dyes has been accessed with the further application of artificial mordant. It has been observed that it is difficult to achieve higher color strength and wash fastness with natural mordant. Using small amount with the natural mordants has greatly boosted the color strength of the natural dye. Lesser amount of color strength has also been observed with the lesser amount of concentration of the dye and mordants. In terms of color fastness properties the staining value gradually increased with the increase of natural mordant concentration and boosted even more with the application of artificial mordants.

Wash fastness for the Dye extracted from Henna

Table 3: Wash fastness results for the Dye extracted from Henna

Sample No	Natural Mordant		Artificial Mordant	Shade Change	DA	CO	PA	PET	AC	VI
20	No Mordant			3-4	2-3	2-3	2	2-3	2	2
21	Arjuna	30 ml	N/A	4	3	3	3	3	3-4	3
22			TA 0.5 gm	4-5	4	4-5	4-5	4-5	4	4-5
23			PA 0.5 gm	4-5	3-4	4-5	4	4	4	4-5
24		40 ml	N/A	3-4	3-4	3	3-4	3	3-4	3
25			TA 0.5 gm	4	4	4	4	4	4	4
26			PA 0.5 gm	4	4-5	4	4-5	4-5	4	4
27	Eucalyptus bark	30 ml	N/A	4	3	2-3	3	3	3-4	3
28			TA 0.5 gm	4-5	4-5	4	4-5	4-5	4	4-5
29			PA 0.5 gm	4-5	4	4-5	4	4-5	4	5
30		40 ml	N/A	4	3	3-4	3	3	3-4	3-4
31			TA 0.5 gm	4	4	4-5	4	4-5	5	4-5
32			PA 0.5 gm	4-5	4-5	4	4	4	4	4-5
33	Khair	30 ml	N/A	4	3-4	3	3-4	3	3	3-4
34			TA 0.5 gm	4-5	4	4-5	4-5	4-5	5	5
35			PA 0.5 gm	4-5	4	4-5	4-5	4-5	5	5
36		40 ml	N/A	4	4	4	4	4	4	4
37			TA 0.5 gm	4	4	4	4	4	4	4
38			PA 0.5 gm	4	4-5	5	4-5	4-5	5	4-5

Wash fastness for the Dye extracted from Eucalyptus leaf

Table 4: Wash fastness results for the Dye extracted from Eucalyptus leaf

Sample No	Natural Mordant		Artificial Mordant	Shade Change	DA	CO	PA	PET	AC	VI
39	No Mordant			3	2	1-2	2	2	2	2
40	Arjuna	30 ml	N/A	3-4	3	3-4	3	2-3	3	3
41			TA 0.5 gm	4	4	4	4	4	4	4
42			PA 0.5 gm	4	3-4	3-4	4	4	4	4
43		40 ml	N/A	3-4	3	3	3-4	3	3-4	3
44			TA 0.5 gm	4	4-5	4	4	3-4	4	4
45			PA 0.5 gm	4	4	4	4	4-5	4-5	4
46	Eucalyptus bark	30 ml	N/A	3-4	2-3	2-3	3	3	3	3-4
47			TA 0.5 gm	4	4-5	4	4	4	4	4
48			PA 0.5 gm	4-5	4-5	4-5	4	4-5	4	4-5
49		40 ml	N/A	3-4	3	3	3	3	3	3
50			TA 0.5 gm	4	4	4	4	4	4-5	4
51			PA 0.5 gm	4	4	4	4	4	4-5	4
52	Khair	30 ml	N/A	3-4	3	3-4	3-4	3	3-4	4
53			TA 0.5 gm	4	4	4	4	4-5	4	4
54			PA 0.5 gm	4-5	4-5	4	4-5	4	4	4-5
55		40 ml	N/A	4	3	3	3	3	3-4	3
56			TA 0.5 gm	4	4-5	4	4	4	4	4-5
57			PA 0.5 gm	4-5	4	4	5	4	4	4-5

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