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EFFECT OF VARIOUS MORDANTS ON DYEING ABILITY OF SAFFLOWER DYE

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ABSTRACT

The production and implementation of synthetic dyes generate significant waste and unfixed colorant. Which raises health risks, and pollution and disrupts eco-balance. Nature has always dominated over synthetic or artificial materials since the beginning of time because nature was the only choice for humans at the time, and now with the advantageous properties of naturally derived materials over synthetics, they have priority(Yusuf et. al., 2017). Safflower is an all-natural red dye that is frequently used to color cotton. It includes the well-known constituents reddish carthamin and yellowish safflower yellow. In the present study, the dyeing behaviour of safflower is examined by the use of an aqueous method and different mordants on linen, cotton, and silk. The relationship between the dye-uptake of linen, cotton, and silk fabric investigated with the various dyeing conditions is discussed.

Keywords: Natural dye, safflower, Aqueous dye, mordants, Percentage absorption.

INTRODUCTION

Since ancient times, natural pigments have been used as coloring agents in food, leather, and textiles. These dyes are produced using only minimal or no chemical processing from plant and animal materials. Natural dye uses drastically decreased after the introduction of more affordable and accessible synthetic colors in 1856. Natural dyes, however, are once again gaining popularity due to their non-polluting, non-carcinogenic, and environmentally beneficial properties (NF Ali et. al.,2011) (Siva, 2007).

The annual, herbaceous, broad-leaf oil seed product known as safflower (Carthamus tinctorius L.) belongs to the Asteraceae family. Safflower is widely grown for the vegetable oil that is extracted from the seeds, and it is thought to have its origins in southern Asia. This plant has the ability to produce an adequate yield in areas that are favorable for the growth of wheat and barley, and it is unquestionably a crop with comparatively untapped potential and broad compatibility. (Gilbert, et. al., 2008) Several yellow dyes are found in the petals of the safflower plant (Carthamus tinctorius L.), but carthamin, a red dye, is the most well-known and has been used as a red dye for textiles and cosmetics for centuries, particularly in Asia (Laursen, 2013). Safflower petals are thoroughly washed in water to eliminate the yellow dyes, then the insoluble red pigment is extracted into an alkaline solution, and finally, the red dye itself is precipitated by acidification with citric or acetic acid. (e.g., from lemon juice, vinegar, etc.) By adhering to cotton or other materials, the dye is frequently further purified before being re-extracted and used for coloring (Laursen, 2013).

Safflower dye was used in Egypt to color cotton, silk, and sacred ointments that were applied to mummies before binding and used in religious rituals. Along with 4000-year-old corpses, safflower seeds, packets, and garlands of flowers have been determined.

In the Middle East, India, and Africa, safflower has been used for purgative (antidote) effects, as well as in a medicated oil, to boost sweating and relieve fevers. Florets were frequently used to color and flavor soups, rice, fabric, potions, and other household products. Safflower was employed as a laxative and a pot plant. Safflower pigment was utilized in the 18th century in Italy, France, and Britain to color cheese and flavour sausage. Before the invention of less expensive aniline dyes in the 19th century, the fabric was frequently colored with carthamin dye. Eastern Europe, the Middle East, and the Indian subcontinent's carpet-weaving sectors all relied heavily on safflower dyes (Gautam et. al., 2014) .

METHOD

1. Collection of Plant Material:

Dried petals of Carthamus tinctorius L. (Safflower) were collected from a store named Saipro Nature our Future Store, in January 2023. Terminalia chebula Retz. Fruits were collected from the local Ayurvedic store of Gandhinagar in the month of January 2023. And the practical work was done at the Horticulture Laboratory, Department of Botany, Bioinformatics and Climate Change Impacts Management, Gujarat University, Ahmedabad.

2. Selection of sample fibers:

Pure white linen, cotton, and silk were purchased from the local market of Gandhinagar. Each type of fabrics samples was cut into 10×10 cm in size and was used for further Scouring, mordanting and dyeing process.

3. Scouring

Scouring is the first process of cleaning the fibers with soap and detergent. Grease, dirt, and other vegetable impurities in raw fibers (linen, cotton, and silk) influence dye take-up by the fibers. As a result, before dyeing, it is critical to give fibers a thorough scouring procedure. Scouring of cotton, linen, and silk cloth was done by washing it in a solution containing 8 ml tween 80 and 15 gm sodium carbonate at 50°C for 30 minutes. Keep the material-to-liquor ratio at 1:40. The scored material was thoroughly washed with distilled water and dried at room temperature. The scoured material was soaked in clean water for 30 minutes before dyeing or mordanting (Jothi, D. 2008, Kulkarni et. al., 2011).

4. Mordanting

Mordanting can be accomplished in three ways, Pre-mordanting (Mordanting before dyein, Simultaneous mordanting (Mordanting with dyeing) and Post-mordanting (Mordanting after dyeing).

Here mordanting of the fibers was done by pre-mordanting method. The weighed amount of mordant was dissolved in the required amount of hot/cold water as per different mordants. The pre-soaked and weighed fibers were dipped in the beaker and raised the temperature if the heat was required. The fibers were stirred continuously and heating was carried out as per the required time. The sample was allowed to cool at room temperature, remove from the bath, rinsed, and dried in shade before dyeing. Also, make sure you have enough mordant to enable it to move freely; this will allow the mordant to spread equally.

In this work, 7 different mordants were used. For cellulosic fiber and protein fiber followed mordants were used.

4.1 $CuSO_4$ + glacial acetic acid

2% Weight of Fiber $CuSO_4$ with 40 ml glacial acetic acid for 100 gm fiber was used. Now, scoured cellulosic fiber – cotton and linen were Mordanted using 90°C temperature for 1 hour and then rinsed with distilled water. Mordanted fabric samples were dried by shade drying. (Elsahida, et. al., 2019)

4.2 $FeSO_4$

0.25 % Weight of Fiber iron was used and made the final volume of up to 100 ml distilled water stir continuously with the help of glassware. Now, scoured (cotton, linen) was mordanted using 55°C for 30 minutes. And then rinsed with distilled water and dried by shade drying (Burkinshaw et. al., 2009).

4.3 Alum

4.3.1 for cellulosic fibers:

15% Weight of Fiber Alum was used by adding enough distilled water to hold the fabrics. Mix them both with a glass rod and add scoured and pre-soaked cellulosic fabrics into it. Now heat at 60°C temperature for 1 hour in a water bath. Rinse fabrics with distilled water and shade dry.

4.3.2 for protein fiber:

50% Weight of Fiber Alum was used by adding enough distilled water to hold the fabrics. Mix them both with a glass rod and add scored and pre-soaked protein fabrics into it. Now heat at 45°C temperature for 30 minutes in a water bath. Rinse fabrics with distilled water and shade dry.

4.4 Alum + Sodium acetate

15% Weight of Fibers Alum was used with 15% Weight of Fiber sodium acetate used. Now both Alum and sodium acetate were mixed into the beaker, by adding enough distilled water to hold the fabrics. Now add scoured and pre-soaked cellulosic fabrics into that and no heat

was required (cold extraction) at this point, wait for 1 hour after that Rinse fabrics with distilled water and shade dry.

4.5 Alum + Soda ash + glacial Acetic acid

20% Weight of Fiber Alum was used, 1.5 %Weight of Fiber glacial acetic acid was used, and 10% Weight of Fiber soda ash was mixed into the beaker, by adding enough distilled water to hold the fabrics. Now add scoured and pre-soaked cellulosic fabrics into that and stir it well. Heat at 90°C temperature for 1 & ½ hours. Rinse fabrics with distilled water and shade dry.

4.6 Soy Milk

Add 500 ml of soy milk to the pot, followed by 2.5 liters of tap water, to make a 1:5 mordant solution.

Dampen the fabric with tap water, then add it to the mordant and carefully swish it around with the tongs. Allow soaking for at least 24 hours in a cool location. After 24 hours of soaking, remove the cloth with tongs and shade dry, and leave it to dry for about a week. Repeat the process 3 or 4 times. (If soaking for longer, store it in the fridge to extend its life by a day or two). And leave it to dry for about a week. To achieve the best results, scour your cloth before adding it to the mordant to remove any oils, waxes, or other impurities.

Once the cloth has been cured, it can be dyed or stored for later use. Dispose of the mordant properly, preferably in the garden. Soaking refers to steeping the fibers in clean distilled water for long contact. It was carried out by dipping fibers in clean cold water for 30 minutes, before dyeing in order to remove water-soluble impurities from wool, cotton, and silk.

4.7 Harda + Alum

100% Weight of Fiber Harda was used with 50% Weight of Fiber Alum used. Now both Harda and alum were mixed into the beaker, by adding enough distilled water to hold the fabrics. Now add scoured and pre-soaked cellulosic fabrics into that and apply heat at 55°C temperature for 30 minutes. After that Rinse fabrics with distilled water and sundry both sides (each side 15 minutes).(Samanta et. al., 2020)

5. Extraction of dye

Dye was extracted using Aqueous Extraction method, with the help of the same batch of safflower petals, one can easily make both yellow and pink dyes.

5.1 Aqueous Yellow Dyed Fabrics

25 gm of dried petals were soaked in 1500 ml of distilled water at room temperature overnight. After that mixture was filtered using Whatman filter paper no. 1 and now yellow-colored filtrate was used as a dye.

5.2 Aqueous Pink Dyed Fabrics

After filtration of the yellow dye remained safflower petals were used to make pink-colored dye.

10 gm of remaining petals were soaked in 1% sodium carbonate (soda ash) solution with 11 pH for 2 hours at room temperature. After that pink dye was filtered using Whatman filter paper no. 1. Now, the pink dye was neutralized (7 pH) with 1% citric acid solution and used for dyeing fabrics.

6.0 Dyeing of fabrics:

Through aqueous yellow dye and pink dye scoured, unmordanted, and mordanted fabric samples of silk, cotton, and linen were dyed at using 60°C temperature for 2 hours.

7.0 Percentage absorbance-

To check the percentage absorbance of fabric samples through taken absorbance of dye, before and after dyeing at 420 nm. Percentage absorbance was calculated using the following formula:

$$\text{Percentage Absorbance} = \frac{\text{O.D. before dyeing} - \text{O.D. after dyeing}}{\text{O.D. before dyeing}} \times 100$$

RESULT AND DISCUSSION:

The yellow-colored dye was extracted using 60°C temperature after 2 hours using the aqueous extraction method. After the yellow dye extraction, pink-colored dye was extracted from remained petals of safflower. Scoured Cotton and Linen were mordanted using $CuSO_4$ + glacial acetic acid, $FeSO_4$, Alum, Alum + Soda ash + glacial acetic Acid, Alum + Sodium Acetate, Soy milk, and Harda + Alum. Scoured Silk was mordanted using Alum and Soy milk. Aqueous yellow dye was produced and different yellow-colored shades respectively on mordanted and unmordanted linen, cotton, and silk fabric samples. But dyed mordanted fabrics were given more intense color than unmordanted fabric samples. Similarly, Aqueous

pink dye was produced different pink colored shades respectively on mordanted and unmordanted linen, cotton, and silk fabric samples. But dyed mordanted fabrics were given more intense pink color than unmordanted fabric samples.

Aqueous Yellow Dyed Fabrics:

Table 1: Absorbance and Percentage absorbance of mordanted [$CuSO_4$ + glacial acetic acid] and unmordanted cotton and linen fabric samples dyed with yellow aqueous dye.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.689	10.36	3.000	2.800	6.66
Linen	3.000	2.575	14.16	3.000	2.790	7.00

Table 1 shows, the more percentage Absorbance found in mordanted than in unmordanted fabric samples. More percentage absorbance found in $CuSO_4$ + glacial acetic acid mordanted Linen Fabric sample 14.66% than linen 10.36%.

Table 2: Absorbance and Percentage absorbance of mordanted [$FeSO_4$] and unmordanted cotton and linen fabric samples dyed with yellow aqueous dye.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.720	9.33	3.000	2.800	6.66
Linen	3.000	2.680	10.66	3.000	2.790	7.00

Table 2 shows, $FeSO_4$ mordanted Linen Fabric shows High Percentage Absorption 10.66% than cotton fabric samples. And more percentage absorbance was found in mordanted than unmordanted fabric samples.

Table 3: Absorbance and Percentage absorbance of mordanted [Alum] and unmordanted cotton and linen fabric samples dyed with yellow aqueous dye.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.788	7.06	3.000	2.800	6.66
Linen	3.000	2.655	11.50	3.000	2.790	7.00
Silk	3.000	2.483	17.23	3.000	2.659	11.36

Table 3 shows, the more percentage Absorbance in mordanted than in unmordanted fabric samples. More percentage absorbance was found in Alum mordanted Linen and Silk Fabric samples respectively 11.50% and 17.23%. Dyed mordanted silk shows highest percentage absorbance.

Table 4: Absorbance and Percentage absorbance of mordanted [Alum + Soda ash + glacial acetic acid and unmordanted cotton and linen fabric samples dyed with yellow aqueous dye.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.643	11.90	3.000	2.800	6.66
Linen	3.000	2.544	15.20	3.000	2.790	7.00

Table 4 shows, Alum + Soda ash + glacial acetic acid mordanted Linen Fabric shows more Percentage Absorption 15.20 % than cotton fabric samples. And also more percentage absorbance was found in mordanted than unmordanted fabric samples.

Table 5: Absorbance and Percentage absorbance of mordanted [Alum + Sodium acetate] and unmordanted cotton and linen fabric samples dyed with yellow aqueous dye.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.616	12.80	3.000	2.800	6.66
Linen	3.000	2.52	16.00	3.000	2.790	7.00

Table 5 shows, the more percentage Absorbance in mordanted than in unmordanted fabric samples. More percentage absorbance found in Alum + Sodium acetate mordanted Linen Fabric sample 16.00%

Table 6: Absorbance and Percentage absorbance of mordanted [Soy milk] and unmordanted cotton and linen fabric samples dyed with yellow aqueous dye.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.472	17.60	3.000	2.800	6.66
Linen	3.000	2.387	20.43	3.000	2.790	7.00
Silk	3.000	2.395	20.16	3.000	2.659	11.36

Table 6 shows, Soy milk mordanted Linen and Silk Fabric shows Higher Percentage Absorption respectively 20.43% and 20.16% than cotton fabric samples. And more percentage absorbance was reported in mordanted than unmordanted fabric samples.

Table 7: Absorbance and Percentage absorbance of mordanted [Harda + Alum] and unmordanted cotton and linen fabric samples dyed with yellow Aqueous dye.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.525	15.83	3.000	2.800	6.66
Linen	3.000	2.438	18.73	3.000	2.790	7.00

Table 7 shows, the more percentage Absorbance in mordanted than in unmordanted fabric samples. More percentage absorbance found in Harda + Alum mordanted Linen Fabric sample 18.73%

Aqueous Pink Dyed Fabrics:

Table 8: Absorbance and Percentage absorbance of mordanted [$CuSO_4$ + glacial Acetic acid] and unmordanted cotton and linen fabric samples dyed with pink Aqueous dye.

Table 8 shows, the more percentage Absorbance found in unmordanted than in mordanted fabric samples. More percentage absorbance found in unmordanted Linen Fabric sample 13.30%.

Table 9: Absorbance and Percentage absorbance of mordanted [$FeSO_4$] and unmordanted cotton and linen fabric samples dyed with pink aqueous dye.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.714	9.53	3.000	2.682	10.60
Linen	3.000	2.682	10.60	3.000	2.600	13.30

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.794	6.86	3.000	2.682	10.6
Linen	3.000	2.887	3.73	3.000	2.600	13.30

Table 9 shows, the more percentage Absorbance found in unmordanted than in mordanted fabric samples. More percentage absorbance found in unmordanted Linen Fabric sample 13.30%.

Table 10: Absorbance and Percentage absorbance of mordanted [Alum] and unmordanted cotton and linen fabric samples dyed with pink aqueous dye.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.910	3.00	3.000	2.682	10.6
Linen	3.000	2.880	4.00	3.000	2.600	13.30
Silk	3.000	2.755	8.16	3.000	2.705	9.83

Table 10 shows, the more percentage Absorbance found in unmordanted than in mordanted fabric samples. More percentage absorbance found in unmordanted Linen Fabric sample 13.30%.

Table 11: Absorbance and Percentage absorbance of mordanted [Alum + Soda ash + glacial Acetic acid] and unmordanted cotton and linen fabric samples dyed with pink Aqueous dye.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.672	10.93	3.000	2.682	10.60
Linen	3.000	2.592	13.60	3.000	2.600	13.30

Table 11 shows, Alum + Soda ash + glacial Acetic acid mordanted Linen Fabric shows Higher Percentage Absorption 13.60% than cotton fabric samples. And more percentage absorbance was found in mordanted than unmordanted fabric samples.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.875	4.16	3.000	2.682	10.60
Linen	3.000	2.762	7.93	3.000	2.600	13.30

Table 12: Absorbance and Percentage absorbance of mordanted [Alum + Sodium acetate] and unmordanted cotton and linen fabric samples dyed with pink aqueous dye.

Table 12 shows, the more percentage Absorbance in unmordanted than in mordanted fabric samples. More percentage absorbance found in unmordanted Linen fabric sample.

Table 13: Absorbance and Percentage absorbance of mordanted [Soy milk] and unmordanted cotton and linen fabric samples dyed with pink aqueous dye.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.698	10.06	3.000	2.682	10.60
Linen	3.000	2.519	14.40	3.000	2.600	13.30
Silk	3.000	2.613	12.90	3.000	2.705	9.83

Table 13 shows, Soy milk mordanted Linen Fabric shows Higher Percentage Absorption 14.40 % than cotton fabric samples. And more percentage absorbance was found in mordanted than unmordanted fabric samples.

Table 14: Absorbance and Percentage absorbance of mordanted [Harda + Alum] and unmordanted cotton and linen fabric samples dyed with pink Aqueous dye.

Fabric type	Mordanted			Unmordanted		
	Absorbance at 420 nm		Percentage Absorbance (%)	Absorbance at 420 nm		Percentage Absorbance (%)
	Before dyeing	After dyeing		Before dyeing	After dyeing	
Cotton	3.000	2.650	11.66	3.000	2.682	10.60
Linen	3.000	2.504	15.16	3.000	2.600	13.30

Table 14 shows, Harda + Alum mordanted Linen Fabric shows Higher Percentage Absorption 15.16 % than cotton fabric samples. And more percentage absorbance was found in mordanted than unmordanted fabric samples.

CONCLUSION

Presented study concludes that, various mordants makes effects on absorbance ability of Fabric samples and also on color intensity of dyed fabrics. Yellow dyed mordanted linen shows higher percentage absorbance than cotton. Yellow dyed mordanted fabric samples shows higher percentage absorption than unmordanted fabric samples but pink dyed fabric which was mordanted respectively with soymilk, Harda +Alum and Alum + Soda ash + glacial acetic acid only shows the high percentage absorption than unmordanted fabric samples. Pink and Yellow dyed soymilk mordanted silk fabric shows more percentage absorption but shows less intense color. In contrast Harda + Alum mordanted silk fabric shows less percentage absorption but shows high intense color after dyeing. Safflower dye is a plant based dye, so it is eco-friendly and safe for environment.

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