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A Study on Application of Eco-Friendly Natural Dye Extracted from Mango Leaves on Silk Fabric with Metallic and Natural Mordants

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Abstract - *The utilization of eco-friendly natural dyes on textile coloration have raised significant importance because of expanded natural mindfulness to maintain a strategic distance from unsafe impact of some manufactured colorants. But use of metallic mordant in natural dyed textile goods make them not completely ecological cordial. Having this in mind, this research concerns with dyeing of silk fabric with dyes extracted from mango leaves in the presence of natural mordants. Alkaline aqueous extraction method was employed for collecting coloring components. Silk fabric was dyed with the extracted natural dyes without mordant and in the presence of metallic and natural mordants using two mordanting techniques. The metallic mordants used were Alum, Ferrous Sulphate, Copper Sulphate, Tin and natural mordants were Alovera, Lemon, Myrobalan and Mango bark. The main purpose of this research was to unveil the potential outcomes of silk coloring with dyes extracted from mango leaves and analyze the impact of different metallic mordants and their mixes and natural mordants on various coloring properties like shading yield, color co-ordinates, color difference and evaluate fastness properties of dyed fabric.*

Keywords: Eco-Friendly, Natural Dyes, Mango Leaves, Natural Mordants, Metallic Mordants, Unveil, Shading Yield.

1. INTRODUCTION

Natural dyes are popular since pre-historic period as it was utilized for coloration of food substrate, leather, and wood also natural fibers viz: wool, silk, cotton, flax etc. (Ashis 'et al' 2009). Natural colors have wide extend of shade and majorities of these colors are collected from various parts of plants including roots, bark, leaves, flowers, fruits etc. For textile dyeing purpose, the utilization of natural colors diminished in a more prominent degree after the disclosure of synthetic colors in 1856 (Purohit, 2011). There is currently an exceeding usage of synthetic dye to accomplish the necessary coloring of worldwide textile dealings due to cheaper costs, an extensive variety of brilliant shades and a major increase in the properties of fastness compared to natural dyes (El-Nagar 'et al' 2005; Iqbal 'et al' 2008).These dyes are produced and applied to release large quantities of waste and unfixed dyes, causing significant health risks and disrupting the eco-balance of nature (Goodarzian 'et al' 2010). As a result, increased environmental awareness of avoiding certain harmful synthetic dyes, an increasing interest in natural dyes in textile application has arrived a matter of significance (Ashis 'et al' 2009). Natural dyes are thought to have greater biodegradability, non-carcinogenic, non-skin sensitive, readily obtainable and sustainable materials, eco-friendly and generally greater environmental compatibility with an acceptable color fastness level. As a result, compared to synthetic dyes, it is the best choice to use natural dyes in textile applications (Acquah 'et al' 2012). Natural dyes can create unique aesthetic qualities that offer added value to the textile industry in combination with the ethical significance of a product that is ecofriendly (Gyanendra, 2015). In an important focal point to be studied, the aspects of the processing of textile products without affecting ecological equilibrium influence both human and environmental health (Teklemedhin 'et al' 2018).

Most of the natural colors have no substantivity for the fibers and mordant must be used for fixing natural colors to the fibers and it also made strides to the take up qualities and the color brightness of the fabric. They are usually metallic salt of Alum, Ferrous Sulfate, Copper Sulphate, Tin (stannous chloride) (R. Silva, 2007; Mahangade 'et al' 2009; Samantha 'et al' 2009; K. Antha, 2007). These chemicals act as mordant by fixing themselves on fiber conjointly combines with the dyestuff. However, the use of metallic mordants during natural dyeing puts an address question on the Eco-friendliness of natural colors as only a small amount of these metal salts get fixed on the textile and the rest are released as effluent which leads to contamination of land and water resources (Wangatia 'et al' 2015). Furthermore, the presence of some of these metal salt in the finished good exposes the wearer to some harm (Sujata 'et al' 2014; Shamim 'et al' 2019). In this respect it is urgent to search for natural mordants which are bio-friendly also check their reasonability and sustainability for seeking to have satisfying fastness properties against the toxic synthetic mordants of metallic salts.

Addressing some of these issues, this study aimed to assess the possibilities and opportunities to dye silk fabric using natural dyes derived from mango leaves with metallic and natural mordants.

2. MATERIALS & METHOD

2.1. Materials

For extraction purposes, Mango leaves were collected from Shahid Abdur Rab Serniabat Textile Engineering College, Barishal, Bangladesh. The chemical responsible (Ediriweera 'et al' 2017) for the Mango leaf color delivery was mangiferin (1, 3, 6, 7 tetrahydroxyxanthone-c-2-B-D glycoside) as shown in Figure 1.

Raw silk fabric of plain construction EPI 132, PPI 132, 22 denier warp counts and 22 denier weft counts were collected from Rajshahi, Bangladesh. Two forms of mordant used for the experiment were metallic mordants such as Alum (potassium aluminium sulphate), Ferrous Sulphate, Copper Sulphate, Tin (stannous chloride) and natural mordants such as Alovera, Lemon, Myrobalan, and Mango Bark. The final objective of this analysis is to compare the color yield, color co-ordinates and color fastness properties of dyed fabric with mango leaves using metallic and natural mordents.

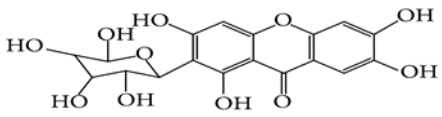


Fig. 1: Chemical structure of mangiferin.

Equipment and Testing Device

Mechanical grinder was used for grinding purpose, Sandolab sample lab dyeing machine for dyeing, pH meter to check pH, digital electronic balance for measuring weight of the fabric and chemical, X-rite spectrophotometer was used to measure reflectance, K/S & CIE L* a* b* and fastness (wash fastness, rubbing fastness). All of these equipment's and testing instruments were collected from wet process laboratory of Shahid Abdur Rab Serniabat Textile Engineering College, Barishal.

2.2. Method

Degumming

The raw silk fabric was degummed by treating with soap (20 g/l), sequestering agent (1 g/l) and wetting agent (1 g/l), maintaining a material and liquor ratio of 1:20 at pH 9 and temperature 80˚C for 60 minutes in the Sandolab sample lab dyeing machine.

Bleaching

The degummed silk fabric was bleached by treating with Hydrogen Peroxide (3 g/l), sequestering agent (1 g/l) and wetting agent (1 g/l), maintaining a material and liquor ratio of 1:20 at pH 10 and temperature 85˚C for 60 minutes. Sodium Carbonate was used to maintain pH value.

Dye Extraction from Mango Leave

To extract dirt and dust, the leaves were thoroughly washed with water. They were dried under intense sunlight and grinded into a tiny unit. Using a fine strainer, the waste is removed and weight is eventually taken away. The dye was then extracted from the grinded Mango leaves by boiling it maintaining a substance and liquor ratio of 1:10 at pH 10 at temperature of 100˚C for 60 minutes in Sandolab Sample Lab Dyeing Machine. The hot dye solution was cooled down and the dye extract was eventually filtered carefully.

Raw Leaves

Dried Leaves

Grinded Leaves

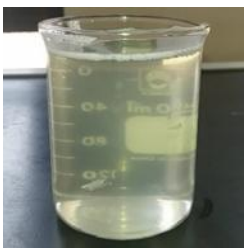
Extracted Dyes

Extraction of Mordants

Fresh alovera was collected from local market of Barishal. Fresh leaves of alovera, was collected and washed thoroughly then outer green surface removed and the linear white mass collected and crushed to a semi solid consistency using electronic agitator. The semi-solid liquid was filtered. 100 ml of filtered alovera solution mixed with 300 ml distilled water (Zubairu 'et al' 2015). Then the resulting mordant solution used in mordanting.

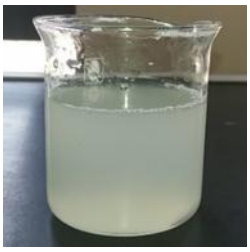
Fresh lemon was collected from nearby market in Barishal. Collected lemon was crushed and the juice was gathered and filtered. Filtered 50ml of lemon juice blended in with 500ml of refined water (Zubairu 'et al' 2015). Then the resulting mordant solution was utilized in mordanting.

Fresh Alovera



Alovera Juice

Fresh Lemon



Lemon Juice

The new ripe Myrobalan has been collected from SARSTEC and thoroughly washed to extract dirt. They have been dried under direct sunlight and removed the outside surface of Myrobalan fruit. Then using a grinder the fresh Myrobalan was grinded into very small units. A fine strainer eliminates the waste and gradually gains weight.

To separate the contaminations, the Bark of the Mango Tree was washed with water and dried at direct daylight and granulated into small units with the help of mechanical grinder. As indicated by(wangatia LM 'et al' 2015) mango bark with a concentration of 15g and 200ml water was treated at a temperature of 90 degrees for 1 hr. Comparable mordant extraction strategies were followed for accepting this literature as reference and filtered solution was used in mordanting.

Dried Myrobalan

Grinded Myrobalan

Mango bark

Grinded Mango bark

Dyeing Technique

Dyeing was carried out in Sandolab Sample Lab dyeing Machine. For dyeing we maintain M:L ratio 1:30 at pH-5 and 80˚C for 60 min. The dyed samples were taken out, squeezed, washed with water and dried in room temperature. Here Pre mordanting and Post mordanting techniques were used.

Pre Mordanting

Pre-mordanting was performed on silk fabric using Alum (potassium aluminum sulfate), Ferrous Sulfate, Copper Sulfate, and Tin (stannous chloride) mordants independently and using three particular severe blends such as, Alum-Ferrous Sulfate (1.5%+1.5%), Alum-Tin (1.5%+1.5%), and Ferrous Sulfate-Copper Sulfate (1.5%+1.5%).

Silk fabric was pre mordanted using natural mordants by following procedure. 100ml of separated Alovera arrangement blended in with 300ml of refined water. At that point the subsequent stringent arrangement utilized in pre mordanting keeping up material to liquor ratio 1:30 at a temperature of 100^{0}C for 60 minutes.

Similarly 50ml of lemon juice was blended in with 500ml of refined water. At that point the subsequent severe arrangement utilized in pre mordanting keeping up material to liquor ratio 1:30 at a temperature of 100˚C for 30 minutes.

The pre mordanting was done using 3% (owf) of Myrobalan and extracted mango bark solution keeping up the material to liquor ratio 1:30 at a temperature of 80˚C for 60 minutes.

Post Mordanting

The bleached silk fabric was dyed in extracted dye solution at 80˚C for 60 min. Then cooled, washed & dried. Post mordanting was carried out on dyed silk fabric using 3%(owf) of Alum (potassium aluminum sulphate), Ferrous Sulphate, Copper Sulphate and Tin (stannous chloride) mordants individually and using three different combinations of mordants such as Alum-Ferrous Sulphate (1.5%+1.5%), Alum-Tin (1.5%+1.5%), Ferrous Sulphate-Copper Sulphate (1.5%+1.5%) at a temperature of 80˚C for 60 min keeping a material to liquor ratio 1:30.

On the other hand silk fabric was pre mordanted by natural mordants by following procedure. 100ml of filtered Alovera solution mixed with 300ml of distilled water. Then the resulting mordant solution used in pre mordanting maintaining material to liquor ratio 1:30 at a temperature 60˚C for 60 minutes.

Similarly filtered 50ml of Lemon juice mixed with 500ml of distilled water. Then the resulting mordant solution used in pre mordanting maintaining material to liquor ratio 1:30 at a temp of 60˚C for 60 minutes.

The post mordanting was carried out on dyed fabric using 3% (owf) of Myrobalan and extracted Mango Bark solution respectively maintaining the material to liquor ratio 1:30 at 80˚C for 60 minutes.

2.3. Method of Assessment

Measurement of Color Strength

The spectral reflectance of the dyed samples were measured using an X-rite spectrophotometer of with illuminants D65 at 10 degree observer. Two measurements were taken for each sample, and the variation in percentage reflectance values over a range of 360-750nm was recorded.

The minimum reflectance value used to determine the K/S value by using Kubelka Munk equation $K/S = (1-R)^2/2R$. Where R is the reflectance at λ_{max}, K is absorption co-efficient and S is light scattering co-efficient.

Color Co-ordinates of Dyed Fabric

The color co-ordinates of dyed fabric with selected mordants were determined in term of CIE L*a*b* co-ordinates with illuminant D65 with 10 degree standard observer. In addition ΔE values were determined to show the color difference among un-mordanted, pre & post mordanted samples.

Fastness Test

Color fastness to washing of the dyed samples was determined as per ISO 105–C06, C2S test method. Color fastness to rubbing was assessed as per ISO105-X12-2016 method.

Table-1: Shade of Dyed Samples

Mordants	Method of Mordanting		Mordants	Method of Mordanting	
	Pre Mordanting	Post Mordanting		Pre Mordanting	Post Mordanting
No mordant			Alum-Tin		
Alum			Ferrous Sulphate-Copper Sulphate		
Ferrous Sulphate			Alovera		
Copper Sulphate			Lemon		
Tin			Myrobalan		
Alum-Ferrous Sulphate			Mango Bark		

3. RESULT & DISCUSSION

Silk fabric were dyed with natural dyes extracted from mango leaves using various mordants and mordanting techniques are shown in the table-1. The results indicate that there were many shade of colors obtained after dyeing of silk fabric samples with mango leaves using different mordants and mordanting techniques. Dyeing performance of the dyed samples were examined by several elementary parameters such as color yield, color coordinates, color fastness to wash and color fastness to rubbing (dry & wet). The results of color measurements were shown in table-2.

3.1. Color Yield of Dyed Fabric

Pre Mordanting

K/S value of un-mordanted dyed sample was found to be 11.74. In pre mordanting, mordant resulted in improved color yield of dyed fabric for both metallic and natural mordants except Alum, Tin and Myrobalan. In case of metallic mordants Ferrous Sulphate as a mordant

significantly increased the color yield of silk. The K/S value was found to be 13.40 using Ferrous Sulphate which showed the relative surface color strength value of 122.54% considering the un-mordanted dyed sample as standard. Besides using Ferrous Sulphate-Copper Sulphate combination the maximum color strength of 149.61% (K/S=17.46) and using Alum-Ferrous Sulphate as a combination the color strength 144.56% (K/S=16.01) was found. The order of color yield in single mordanting process on silk was found to be Ferrous Sulphate>Copper Sulphate>Alum>Tin that is color yield was gradually decreased when approached from Ferrous to Alum/Tin. Again among the three different combinations of mordants that is Alum-Ferrous Sulphate, alum-Tin, ferrous sulphate-copper sulphate the order of in the combination process was found to be Ferrous Sulphate–Copper Sulphate>Alum-Ferrous Sulphate>Alum-Tin.

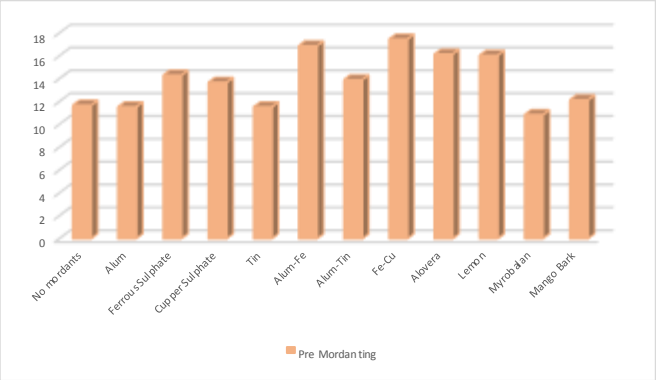


Fig. 2: Graphical Representation of Color Yield of Pre Mordanted Dyed Fabric.

In case of natural mordant Alovera as a mordant significantly increase the color yield of silk, the K/S value was found to 16.13 using of Alovera which showed the highest maximum relative surface color strength value of 138.22% considering the un-mordanted dyed fabric as reference. Besides using Lemon and mango bark as mordant color strengths were found to be 137.36 %(k/s=16.03) and 103.41 %(k/s=12.14) respectively.

Post Mordanting

K/S value of un-mordanted dyed sample was found to be 11.74. In post-mordanting technique the mordant resulted in improved color yield of the dyed fabric for both metallic and natural mordants especially in metallic mordants except Tin, Alum-Tin, Alovera, Lemon & Myrobalan. In case of metallic mordants Ferrous Sulphate as a mordant significantly increased the color yield of silk. The K/S value was found to be 13.94 using ferrous sulphate which showed the relative surface color strength value of 119.45% considering the un-mordanted dyed sample as standard. Besides using Ferrous Sulphate-Copper Sulphate combination the maximum color strength 134.36% (K/S=15.68) and using alum-ferrous sulphate as a combination the color strength 120.22% (K/S=14.03) was found. The order of color yield in single mordanting process on silk was found to be Ferrous Sulphate>Alum>Copper Sulphate>Tin that is color yield is gradually decreased when approached from Ferrous to Copper /Tin. Again among the three different combinations of mordants that is Alum -Ferrous, Alum-Tin, Ferrous Sulphate–Copper Sulphate the order of in the combination process was found to be Ferrous Sulphate–Copper Sulphate> Alum–Ferrous Sulphate >Alum–Tin.

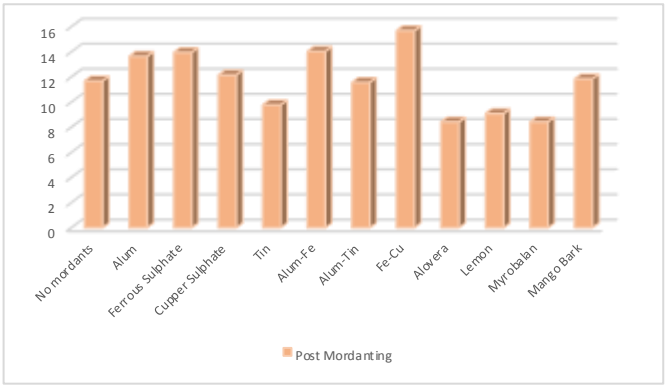


Fig. 3: Graphical Representation of Color Yield of Post Mordanted Dyed Fabric.

In case of natural mordants Mango Bark as a mordant showed the highest relative surface color strength value of 100.85 % (K/S=11.84) considering the un-mordanted dyed sample as reference. Besides using Alovera, Lemon and Myrobalan as mordant color strengths were found to be 72.07% (K/S=8.41), 77.46% (K/S=9.04) and 92.88% (K/S=10.84) respectively. The order of color yield in natural mordants were found to be mango Bark>Myrobalan>Lemon >Alovera.

Table-2: Color Yield, Color Co-Ordinates & Color Difference of Dyed Fabrics

Mordents	Mordanting Method	K/S at λ_{max}	Color Strength %	ΔL*	Δa*	Δb*	ΔC*	ΔH*	ΔE
	No mordants	11.74	100%	Standard					
Alum	Pre mordanting	11.52	98.71%	-5.47	-0.63	1.24	1.04	0.93	2.34
	Post mordanting	13.63	116.80%	-9.96	-0.40	-1.03	-1.10	0.12	3.90
Ferrous Sulphate	Pre mordanting	14.30	122.54%	-36.21	-1.50	-18.81	-19.45	-18.71	5.52
	Post mordanting	13.94	119.45%	-10.68	-0.41	-0.74	-0.82	0.20	4.17
Copper Sulphate	Pre mordanting	13.67	117.14%	-16.62	-0.37	-1.75	-1.79	-0.11	6.50
	Post mordanting	12.14	104.03%	-8.08	-0.82	-1.30	-1.46	0.45	3.23
Tin	Pre mordanting	11.01	93.78%	-2.39	-2.84	0.11	-0.54	2.79	2.79
	Post mordanting	9.77	83.71%	-2.53	-2.71	4.14	3.46	3.54	3.82
Alum-Ferrous Sulphate	Pre mordanting	16.01	137.18%	-32.05	-1.69	-16.78	-16.40	-3.91	15.03
	Post mordanting	14.03	120.22%	-36.15	-8.29	-24.10	-25.29	3.10	18.52
Alum-Tin	Pre mordanting	13.89	119.02%	-1.76	-0.11	1.57	1.49	0.51	1.08
	Post mordanting	11.55	98.97 %	-5.59	-1.37	-1.38	-1.68	0.98	2.48
Ferrous Sulphate-Copper Sulphate	Pre mordanting	17.46	149.61%	-29.72	-2.85	-14.90	-15.08	-1.61	13.57
	Post mordanting	15.68	134.36%	-37.44	-7.36	-24.54	-25.59	1.15	18.79
Alovera	Pre mordanting	16.13	138.22%	-6.87	1.30	3.24	3.47	-0.37	3.13
	Post mordanting	8.41	72.02%	-0.71	-0.62	-7.85	-7.69	-1.68	3.91
Lemon	Pre mordanting	16.03	137.36%	-7.74	0.75	-0.74	-0.50	-0.92	3.13
	Post mordanting	9.04	77.46%	-6.57	-1.21	-3.25	-3.45	0.32	3.02
Myrobalan	Pre mordanting	10.84	92.88%	-6.66	-0.63	-0.72	-0.86	0.42	2.64
	Post mordanting	7.97	68.29%	0.95	-0.39	-6.50	-6.34	-1.50	3.28
Mango bark	Pre mordanting	12.14	103.41%	-9.52	0.11	-1.09	-1.02	-0.41	3.74
	Post mordanting	11.84	100.85%	-5.41	-1.12	-4.47	-4.60	-0.11	3.00

3.2. Color Co-ordinates of Dyed Fabric

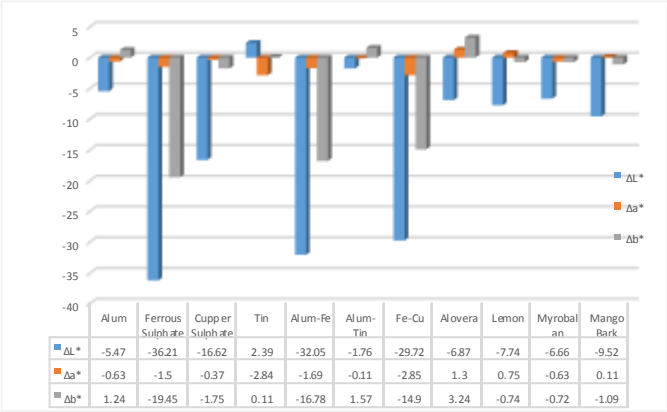
Pre Mordanting

In case of metallic mordents ferrous sulphate mordant resulted in the highest increase color depth (ΔL* values were lower) followed by tin where single mordant is considered. Darkness was increased 51.22% using Ferrous Sulphate mordant in comparison to standard sample. Among the combined application of mordents it was observed that the highest darkness achieved by alum- ferrous sulphate 45.33%, was reduced while Copper Sulphate used with Ferrous Sulphate and further reduced while Alum is used with the combination of Tin. In case of natural mordanted

dyed sample highest increase in color depth was found in Mango Bark (13.47%) than standard sample where Lemon, Alovera and Myrobalan increased darkness 10.95%, 9.71% and 9.42% respectively over the reference dyed sample.

From Δa* values of dyed samples in case of metallic mordants it was clear that all samples were greener than the reference sample. The significant greenness value was increased 30.97% and 31.07 % in Tin and Ferrous Sulphate-Copper Sulphate combination respectively over the reference dyed sample. In case of natural mordanted sample all sample is greener than reference dyed sample. Significant greenness value was increased in Lemon (16.88%) over the reference dyed sample.

The Δb* values in case of dyed sample were shown in table-2 and fig-4 indicate that in case of metallic mordanted sample Tin and Alum–Tin mordanted sample is yellower than reference dyed sample. In other cases, blueness of dyed fabrics were increased. Significant blueness were increased in case of Alum-Ferrous, Ferrous Sulphate-Copper Sulphate combinations and Copper Sulphate which were 50.38%, 44.73% and 5.25% respectively over the reference dyed samples. In case of natural mordanted sample all samples were bluer than standard dyed sample except Alovera. Significant yellowness was increased in Alovera mordanted sample (9.73%) over the reference sample.



	Alum	Ferrous Sulphate	Copper Sulphate	Tin	Alum-Fe	Alum-Tin	Fe-Cu	Alovera	Lemon	Myrobalan	Mango Bark
ΔL*	-5.47	-36.21	-16.62	2.39	-32.05	-1.76	-29.72	-6.87	-7.74	-6.66	-9.52
Δa*	-0.63	-1.5	-0.37	-2.84	-1.69	-0.11	-2.85	1.3	0.75	-0.63	0.11
Δb*	1.24	-19.45	-1.75	0.11	-16.78	1.57	-14.9	3.24	-0.74	-0.72	-1.09

Fig. 4: Graphical Representation of Color Co-ordinates of Pre Mordanted Dyed Fabric.

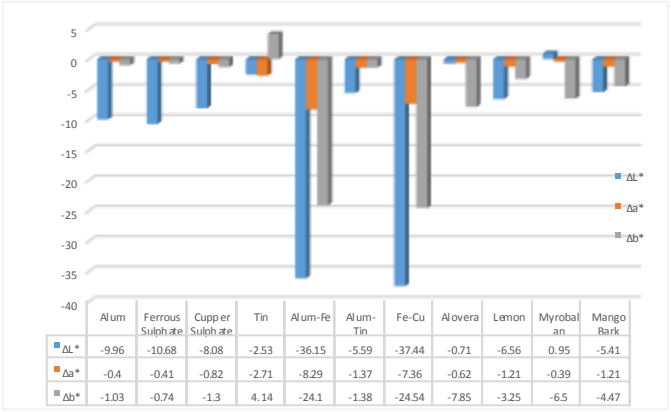
Post Mordanting

In case of metallic mordants Ferrous Sulphate mordant resulted in the highest increase of color depth (ΔL values were lower) followed by Tin where single mordant is considered. Darkness was increased about 15.10% using Ferrous Sulphate mordant in comparison to standard sample. Among the combined application of mordants it was observed that the highest darkness was achieved by Ferrous Sulphate-Copper Sulphate combination 52.36% was reduced while Alum used with Ferrous Sulphate and further reduced while Alum is used with the combination of Tin.

In case of natural mordanted dyed fabrics, the highest increase in color depth was found in Lemon followed by Alovera. 10.62% darkness was increased by Lemon in comparison to standard sample. On the contrary Myrobalan produced 0.40% lighter shade than standard.

From Δa* values of dyed samples in case of metallic mordant, it was clear that all samples were greener than the reference sample. The highest greenness value was found in case of Tin, Alum-Ferrous Sulphate, and Ferrous Sulphate-Copper Sulphate combinations mordanted sample. Greenness quality increased 29.55% and 90.40%, 80.26% respectively over the reference dyed sample. In case of natural mordanted sample, all samples are greener than reference dyed sample. Significant greenness value was increased in case of Lemon (13.20%) over the reference dyed sample.

The Δb* values of dyed sample as shown in table-2 and fig-5 indicates that in case of metallic mordanted sample Tin mordanted sample is yellowish than reference dyed sample. In other cases, blueness of dyed fabric was increased. Significant blueness was increased in case of Ferrous-Copper, Alum-Ferrous combinations and Copper Sulphate which were 73.67 %, 72.36% and 3.90% respectively over the reference dyed samples. In case of natural mordanted sample all sample were bluer than reference dyed sample. Significant blueness was increased in case of Alovera, Myrobalan mordanted sample 23.57%, 19.51% respectively over the reference sample.



	Alum	Ferrous Sulphate	Copper Sulphate	Tin	Alum-Fe	Alum-Tin	Fe-Cu	Alovera	Lemon	Myrobalan	Mango Bark
ΔL*	-9.96	-10.68	-8.08	-2.53	-36.15	-5.59	-37.44	-0.71	-6.56	0.95	-5.41
Δa*	-0.4	-0.41	-0.82	-2.71	-8.29	-1.37	-7.36	-0.62	-1.21	-0.39	-1.21
Δb*	-1.03	-0.74	-1.3	4.14	-24.1	-1.38	-24.54	-7.85	-3.25	-6.5	-4.47

Fig. 5: Graphical Representation of Color Co-ordinates of Post Mordanted Dyed Fabric.

3.3. Washing fastness

Pre Mordanting

In case of metallic mordants the color change rating were found to be within 3 to 5, where a rating 5(excellent) was found in case of Alum, Tin and Alum-Tin combination. The ratings of Ferrous Sulphate and Copper Sulphate was found 4/5 where 3/4 was found in case of Alum-Fe and Fe-Cu combination. In case of natural mordants the ratings were found 5 to 4/5.

On the other hand in metallic mordants, the color staining ratings were found to be from 4 to 5 for all dyed samples. In natural mordants, the color staining ratings were also found to be from 3/4 to 5 for all dyed samples.

Post Mordanting

In post mordanting the metallic mordants color change rating were found to be within 3 to 5, where a rating 5(excellent) was found. The ratings of Ferrous Sulphate and Copper Sulphate was found 4/5 where 3/4 was found in case of Alum-Fe and Fe-Cu combination. In case of natural mordants the ratings were found 5 to 4/5, where a 5(excellent) was found in case of Alovera & lemon, where 4/5 in case of Myrobalan, Mango Bark.

On the other hand in metallic mordants, the color staining ratings were found to be from 4 to 5 for all dyed samples. In natural mordants, the color staining ratings were found to be from 3/4 to 5 for all dyed samples.

3.4. Rubbing Fastness

This test was designed to determine the degree of color which may be transferred the surface of a colored fabric to a specify test cloth for rubbing (which could be dry and wet). It also determines how well a fabric will resist stains. Color fastness to rubbing was done by Crock-Meter and observed by Grey-Scale for staining in color. The result shown in table 3.

Pre Mordanting

In case of metallic mordants all staining ratings of dry and wet rubbing fastness were ranged within 4/5 to 5 and 4 to 5 respectively where natural mordants staining ratings of dry and wet rubbing fastness were ranged within 5 and 4/5 to 5 respectively. It was clear that both dry and wet rubbing ratings in pre mordanting was good when natural mordants sample than metallic mordants.

Post Mordanting

In metallic mordants whereas ratings of dry and wet rubbing fastness was found within 4/5 to 5 and 4 to 4/5 respectively where all natural mordanted sample ratings was 5 in dry rubbing fastness and 4/5 to 5 in wet rubbing fastness. Between pre mordanting and post mordanting technique, it was noticed that rubbing fastness (dry & wet) of pre mordanted sample is slightly better than post mordanted sample.

Table-3: Washing & Rubbing Fastness

Mordants	Mordanting Method	Washing Fastness							Rubbing Fastness	
		Color Change	Color Staining							
			Di Acetate	Bleached Cotton	Polyamide	Polyester	Acrylic	Wool	Dry	Wet
	No mordants	4	5	4/5	5	5	5	4/5	4/5	4
Alum	Pre mordanting	5	5	4/5	5	5	5	5	4/5	4/5
	Post mordanting	4/5	4	3/5	3/5	4/5	4/5	4/5	5	4/5
Ferrous Sulphate	Pre mordanting	4	5	4/5	5	5	5	5	5	4
	Post mordanting	4/5	5	4/5	5	5	5	4/5	4/5	4
Copper Sulphate	Pre mordanting	4	5	4	5	5	5	5	4/5	4
	Post mordanting	4/5	5	4/5	5	5	5	4/5	4/5	4/5
Tin	Pre mordanting	5	5	4/5	5	5	5	5	5	4

	Post mordanting	5	5	5	5	5	5	5	5	4/5
Alum-Ferrous Sulphate	Pre mordanting	3/4	5	4/5	5	5	5	4/5	5	4/5
	Post mordanting	3	5	4/5	4	4/5	4/5	4/5	4/5	4/5
Alum-Tin	Pre mordanting	5	5	4/5	5	5	5	5	5	4/5
	Post mordanting	4/5	5	4/5	5	5	4/5	4/5	5	4/5
Ferrous Sulphate – Copper Sulphate	Pre mordanting	3/4	5	4/5	5	5	5	4/5	5	4
	Post mordanting	3	5	4/5	4	4/5	4/5	4/5	5	4/5
Alovera	Pre mordanting	5	5	5	5	5	5	5	5	4
	Post mordanting	4	5	4/5	4/5	5	5	5	5	4/5
Lemon	Pre mordanting	5	5	5	5	5	4/5	5	5	4/5
	Post mordanting	4/5	5	4/5	4/5	5	5	5	5	4/5
Myrobalan	Pre mordanting	4/5	5	5	5	5	5	5	5	4/5
	Post mordanting	4	5	4/5	4/5	4/5	4/5	5	5	5
Mango Bark	Pre mordanting	4/5	5	3/4	5	5	5	5	5	4/5
	Post mordanting	4/5	5	4/5	5	5	4/5	5	5	4/5

4. CONCLUSION

In this Research Work, It was demonstrated that mango leaves can be used as a potential source of dyes for dyeing silk fabric. It gave the chance to produce different fashion hues on silk fabric from the same dye extracted from mango leaves using natural and metallic mordants and their combinations. From the study, it is revealed that mordants and mordanting technique have a synergistic effect on color strength and color fastness properties. Pre-mordanting technique provides better color strength, wash and rubbing fastness than post mordanting technique for both metallic and natural mordants. Using these dye extract for coloration of silk fabric would give the benefits of reducing import of synthetic dyes and minimizing environment pollution. The wash and rubbing fastness of directly dyed sample without mordant and dyed sample using metallic and natural mordants was almost similar (very good to excellent). Thus on the basis of result, it can be said that there is a possibility of dyeing silk fabric using natural dyes extracted from mango leaves directly without mordant or in the presence of Alovera, Lemon in pre mordanting technique with acceptable range of color fastness properties.

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