

Dyeing of Silk Using Natural Dyes Extracted From Local Plants

Redwan Jihad

ABSTRACT - The uses of natural dyes are having an age old history since ancient periods. The name natural dyes cover all the dyes derived from the plants, insects and minerals. After the invention of synthetic dyes, they are withdrawn from market, due to their limitations. In long term use the synthetic dyes are very much harmful for human skin due to the presence of other chemicals used during manufacturing. Natural dyes have now entered a new era where they are required and used for their many intrinsic values. Local plants are one source of natural colorant which is grouped under plant sources. They are easily available in the country and can be considered as zero cost dyes as they are planted for other purposes. Plants are the major sources of natural colorants and almost all their parts such as stem, leaves, fruits, seeds and pills are used for extracting natural color and they have antimicrobial, antifungal, insect repellent, deodorant, disinfectant and other medicinal values. In this project the chemical constituent, the coloring component and extraction method of plant dyes are reviewed in detail. Dyes were extracted from leaves, roots and bark of plants and silk was dyed with these dyes by different mordanting techniques with different mordants. After dyeing, the dyed silk was subjected to different fastness tests.

Index Terms – natural dyes, mordanting, fastness, silk, medicinal values, synthetic dyes;

1. INTRODUCTION

Up to the end of the 19th century natural dyes were the main colorants for textiles. The introduction of synthetic dyes led to an almost complete replacement of natural dyes, due to favorable application properties of synthetic dyes. Besides a wide range of available colors, higher reproducibility and improved quality of dyeing could be achieved at lower specific cost. Recently, interest in the use of natural dyes has been growing rapidly due to the result of stringent environmental standards imposed by many countries in response to toxic and allergic reactions associated with synthetic dyes (Thomas Bechtold, 2006). With the world becoming more conscious towards ecology and environment, there is greater need today to revive the tradition of natural dye (K.Anitha, 2007) and dyeing techniques as an alternative of hazardous Synthetic dyes is extremely crude.

The beginning of the new millennium surely brings many drastic changes in the life of mankind. One of them is going to be the shift towards revival of natural dyes and their efficient usage as compared to their counter parts ie. synthetic dye, which has been slowly losing its place mainly due to international awareness to environment and ecology preservation. The natural dyes, which are non-pollutant, appear as an ideal choice due to their non-toxic nature and easy handling. The world wide natural dyes have several advantages over synthetic dyes from the point of view of health, safety and ecology. There is increased awareness and demands for the natural dyed products in international market.

Natural dyes can be sorted into three categories: natural dyes obtained from plants for example indigo, those

obtained from animals for example cochineal, and those obtained from minerals for example ocher. Natural dyes/colorants derived from flora and fauna are believed to be safe because of its non-toxic, non-carcinogenic and biodegradable in nature.

Local plants are one source of natural colorant which is grouped under plant sources. They are easily available in the country and can be considered as zero cost dyes as they are planted for other purposes. Plants are the major sources of natural colorants and almost all their parts such as stem, leave, fruits, seeds and pills are used for extracting natural color and they have antimicrobial, antifungal, insect repellent, deodorant, disinfectant and other medicinal values.

However, the use of natural dyes to color textiles declined rapidly after the discovery of synthetic the main reason for the replacement of natural dyes by their synthetic counterparts is that most natural dyes have poor to moderate wash and light fastness, while synthetic dyes represent the full range of wash and light fastness at moderate costs. Lately however, there is a growing interest in the revival of natural dyes in textile coloration this is as a result of the worldwide concern over the carcinogenic effects, toxicity and allergic reactions associated with synthetic dyes.

The choice of dyes and dyeing methods for textiles depends upon the type of fabrics, their utilization, fastness to in-service requirements and type of preparatory and finishing processes. Many types of dyes can be used to dye silk but in this project we are going to do dyeing of silk using natural dyes that are extracted from local plants found in our country among those we are trying to dye silk by extracting dyes from eucalyptus leaf, roots of *Rumex abyssinicus* Jacq (Locally called mokmoko), roots of *impatience tricolor* (locally known as *ensosila*) and *Hagenia abyssinica* flower.

• Redwan Jihad is currently working as Head of Textile Engineering Department at Kombolcha Institute of Technology, Wollo University, Ethiopia.
PH: +251 929231350
E-mail: redwan446@gmail.com

2. OBJECTIVES

The main objective of this project is to study the dye ability of the most abundant silk fabric with natural dyes extracted from local plants found in our country.

The detailed objectives are:

- To extract dye from local plants such as eucalyptus leaf, flower of hyginia abisinica, Rumex abyssinicus Jacq (Locally called mokmoko) and impatiens tricolor (locally known as ensosila).
- To dye silk with dyes extracted from different parts of local plant.
- To study the dye ability of silk under different conditions with these dyes.
- To study the fastness properties of these dyes on silk fabric.

3. RELEVANCE TO INDUSTRY

The production or extraction of natural dye can be commercialized in solution form or in powder form. The raw materials used for the extraction of natural dyes are easily accessible or they are available from our surroundings at cheaper or low cost.

If the natural dye sources that give rise to spectrum of colors are identified and activities related to collection, cultivation & product making of these are planned to enhance the value chain. Seeds of improved varieties are supplied to targeted local farmers for production this can create job opportunity and enhance the poverty eradication plan of the country.

Natural dyes in their nature are eco-friendly and they have no carcinogenic or allergic effect for human being especially for dyers. They can get these natural dyes at cheap prices when it was compared with the cost of synthetic dyes that are used mostly in our industry for dyeing of silk fabric (acid and reactive dyes) if this project is implemented at industry scale. The application of this project can also create job opportunity for micro enterprises engaged in textile and garment field.

4. SIGNIFICANCE

The main problem with those synthetic dyes is that they are not environmental friendly they cause carcinogenic/allergic effect to human being and they are also costly. Especially in our country now small scale enterprises are expanding on different fields among those textiles and garment is the main job area which creates job opportunity for local spinners and weavers. Those peoples engaged on this field from rural areas have no knowledge about different synthetic chemicals or textile dyes. The use of those synthetic textile dyes without any knowledge is very dangerous for their health. For these people the use of natural dye is very important. The

importance of use of natural dye is not restricted only to the dyers but it also has national benefit by eliminating environmental pollution caused by synthetic dyes. The issue of environmental pollution is the main hindering factor for textile factories, so this project will fill the gap of environmental issue and it can contribute its part for the attainment of green economy strategy plan of Ethiopia.

As I have said above now a day's Ethiopia is importing some of natural dyes from foreign country such as India, if these project is implemented in it saves foreign currency that is spent for the import of natural dyes from abroad, in addition to elimination of environmental pollution and creating of job opportunity.

5. LITERATURE REVIEW

In the new millennium maintenance of a safe environment balance will become a necessary requirement in every textile wet processing. Most of the synthetic dyes are not only based on toxic raw materials and intermediate but their use in textile wet processing also produce effluent which causes environmental pollution. Natural dyes are free from such problem. Moreover, if steps are taken to commercialize the cultivation of plants from which most natural dyes are generated, it will definitely assist in preserving the eco-balance.

Currently ecological consideration is becoming important factor in the selection of consumer goods all over the world. The production of synthetic dyes involves reaction which is conducted at high temperature and pressure using primarily from petroleum derivative. Some of the synthetic dyes contain toxic or carcinogenic amines or other such chemical groups which have environmental impact. Lately there has been increasing interest in natural dyes cuts down significantly on the amount of toxic effluent resulting from dye process.

Some limitations exist with natural dyes such as dyeing efficiency, process complicity, viability, etc. The main problem associated with the dyeing of natural dyes is low exhaustion so standing dyes bath study is also carried out to minimize the wastage of natural colorants. Because of this they were not successful. But making consumer aware of environmental problem caused by synthetically dyed textiles and making an alternative widely available is the key to success of natural dye producers.

5.1 COMPARISON BETWEEN NATURAL AND SYNTHETIC DYE

5.1.1 Natural dye

As it has been said though natural dyes have many advantages they have also some disadvantages and. But in the twenty first century maintaining a safe

environmental balance becomes even more important. The co-operation of individuals, communities and countries to make this happen become a global necessity and the following properties are often considered to be advantages of natural dyes.

Advantages

- The use of natural colorants will offer no effluent problem and will provide a natural finish to textile treated with these materials.
- Cultivation of plants from which most natural dyes are generated will definitely assist in preserving the eco-balances.
- The resources which most natural dyes are generated are not only replaceable but also biodegradable.
- Have pharmacological effects and possible health benefits.
- Can give harmonizing color.
- The extraction of aqueous dye with alkali is most economical and produces acceptable results.
- Technology for production could vary from simple aqueous to complicated solvent system to sophisticated super crucial fluid extraction techniques.

Disadvantages

- Low dyeing efficiency.
- Only few have good fastness to light and washing.
- Costly either in money or time (process complexity and the cost of the mordant is equal or greater than cost of synthetic dye).
- Some of the mordants are harmful.
- Mostly used for protein and cellulosic fibers.

5.1.2 Synthetic dye

Comparing with natural dyes synthetic dyes have the following advantage and disadvantage.

Advantages

- Quick and simple procedure {easy to process}.
- Inexpensive.
- Good fastness to wash and light.

Disadvantages

- Certain chemical compounds used in synthetic dyestuff have been found to be carcinogenic and have skin allergic problem.
- Most of the natural dye chemicals not only based on toxic raw material but also their use in textile wet processing produce effluents, which causes environmental pollution.
- Knowledge of color design is necessary.

5.2 SOURCES OF NATURAL DYES

Natural dyes comprise those colorants (dye and pigments) that are obtained from animal and vegetable matter without chemical processing. Natural dyes fall into three categories on the basis of their origin: plant, animal and mineral. [3]

5.2.1 Plant source

There were as many as 500 plant species identified as sources for dyes. These dyes are derived from various parts of the tree (flower, bark, seeds, leaves and roots). These vegetable sources are not only replaceable but also bio-degradable. They also have pharmaceutical and health benefit.

5.2.2 Animal sources

Secretion of insects and dried insect bodies are the major source of natural dyes. For example shell-fish provides the coloring matter.

5.2.3 Mineral source

As minerals are used for fixing or improving the fastness of vegetable dye, the name natural dye is more appropriate which cover all the dyes derived from natural resources including vegetable dyes as well as minerals. And some minerals are also used to give a coloring matter. For example seru, cow urine, cow dung, egg albumin.

5.3 CLASSIFICATION OF NATURAL DYES

Natural dyes can be classified in to different groups based on their application, chemical composition and color.

5.3.1 Classification based on application

Natural dyes can be classified in to three major types based on their application.

- Substantive dyes
- Vat dyes
- Mordant dye

Substantive dyes

Substantive dyes are used by simply combining the dye stuff with the fiber and it has substantively to the fiber. An example is turmeric the spice which works on cotton as well as wool and silk; others included onion, walnut, husk and tea.

Vat dyes

The vat dyes work the same way on protein and cellulose by being introduced in to the surface of the fiber in their soluble form and then converted in to an insoluble form. They are complex to use. For example the vat dye indigo

and the ancient Tyrian purple dye extracted from shell fish.

Mordant dye

Most natural dyeing is done with the use of mordant, most commonly used are the heavy metal ions, but sometimes tannins. The mordant allows many natural dyes which would otherwise just wash out to attain acceptable wash fastness. Mordant remains in the fiber permanently holding the dye. Each different metal used as mordant produces a different range of colors for each dye.

5.3.2 Classification based on chemical composition

Natural colors cover a wide range of chemical classes as shown below:

Indigoid dye

Indigo dye is dye with a distinctive blue color. The chemical compound that constitutes the indigo dye is called indigotin. A variety of plants have provided indigo throughout history, but most natural indigo is obtained from those in the genus *Indigofera*, which are native to the tropics. Dye was obtained from the processing of the plant's leaves. The powder was then mixed with various other substances to produce different shades of blue and purple. Indigo is a dark blue crystalline powder that melts at 390–392 °C. It is insoluble in water, alcohol, or ether but soluble in chloroform, nitrobenzene or concentrated sulfuric acid. The chemical structure of indigo corresponds to the formula $C_{16}H_{10}N_2O_2$. It has 262.27 g/mol molar mass and 1.99g/cm³ density.

Carotenoids

Carotenoids are a class of natural fat-soluble pigments found principally in plants, algae, and photosynthetic bacteria, where they play a critical role in the photosynthetic process. Carotenoids are responsible for many of the red, orange and yellow hues of plant leaves, fruits and flowers, as well as the colors of some birds, insects, fish and crustaceans. Some familiar examples of carotenoid coloration are the oranges of carrots and citrus fruits, the reds of peppers and tomatoes, and the pinks of flamingoes and salmon. The majority carotenoids are derived from a 40-carbon polyene chain, which could be considered the backbone of the molecule

Flavones

Flavones are a class of flavonoids based on the backbone of 2-phenylchromen-4-one (2-phenyl-1-benzopyran-4-one). Natural flavones includes Apigenin, Luteolin and Tangeritin. Synthetic flavones are Diosmin and Flavoxate. A coloring compound in many plants that yields from yellow to orange colors in the fabric.

Dihydropyrans (C₅H₈O)

It is a clear liquid, stable under ordinary condition. It has boiling point of 84 °C, melting point of 70°C and Specific gravity of 0.922 g/ cm³.

Alpha-hydroxyl Napthaquinone dyes

The most prominent member of this class of dyes is lawsone or henna, obtained from *lawsomia inermis*.

5.4 NATURAL DYEING PRINCIPLES

Application of natural dyes in today's scenario makes use of modern science and technology not only to revive the traditional technique but also to improve its rate of production, cost effectiveness and consistency in shades. It therefore, requires some special measures to ensure even-ness in dyeing. Many factors have to be accounted for when one works with natural dyes. They are: nature of Material to be dyed, measurements of mordants and dyestuffs, temperature, agitation, natural dyes are unpredictable, wet fibers look darker and rinsing.

5.4.1 Mechanism of dyeing

Natural dyes work best with natural fibers such as cotton, linen, wool, silk, jute, and sisal. Amongst this wool is by far the easiest to take up dyes followed by cotton, linen, silk and then the coarse fibers such as sisal and jute. Nearly every plant will yield some of color whether we use leaves, bark, wood, roots or fruits. Nearly all require or are enhanced by, some sort of mordant. The trick then is to determine which plants or which part of the plants will give not only beautiful tones but also colorfast shades as well. A coloring material that has the strength to bind itself to a fiber and remain there by staining the fiber is considered to be the best.

Natural dyes can neither dye animal nor vegetable fibers directly, but require a mordant, which depends upon the nature of the dye. If the dye is acidic, the mordant must be basic (the most common basic mordants are the salts of Cr, Al, Sn, Fe) on the other hand, if the dye is basic, the mordant must be acidic (the most common acidic mordant is tannin or tannic acid). The fabric to be dyed is first soaked into a solution of the metallic salt (i.e. mordant) and then steamed or otherwise treated to form the insoluble metallic hydroxide. The fiber so obtained is known as mordanted fiber; it is dried then placed in a solution of the dye when the latter is held by the hydroxide of the metal on the fiber by means of chelation. Such chelated complexes can be formed only when the resulting dye has a five- or six- membered ring, which is again possible only when OH group in the dyestuff is present, ortho to one of the following groups:

-OH, -CO, -NO, -NO₂, -COOH, -NH, -NH₂ and -N=N-.

The chemistry of bonding of dyes to fibers is complex; it involves direct bonding, H-bonds and hydrophobic interactions. Mordants to this effect increase binding of dye to fabric by forming a chemical bridge from dye to fiber.

The mordant has affinity for both fiber and the dye. Thus those dyes, which do not have any affinity for a fiber, can be applied by using mordants. Thus improves the staining ability of any dye along with increase in fastness properties. Mordant forms an insoluble compound of the dye within the fiber.

The mordant dyes include those differing widely in the origin but those form more or less insoluble compounds with metal salts. Presence of certain functional groups in suitable position in the dyes molecule helps in coordination of the metal salt. Generally, either two hydroxyl groups, ortho to each other, or one hydroxyl groups, ortho to carbonyl, nitroso or azo groups are the main features of mordant dyes.

They produce a wide range of hues of remarkable resistance to wet treatments, but the shades lack brilliancy. With protein molecules the interaction between the dye and the fabric where the polypeptide linkages have H-bonding with the dye.

6. MATERIALS AND METHODS

Commercially available loom state silk (430 ends/dm, 212 picks/dm, 50g/m²) fabrics purchased from saba har were used for this study. Analytical reagents ferric sulphate, aluminium Sulphate, stannous chloride, commercial grade formic acid were used. Locally available plant parts such as eucalyptus leaf flower of hyginia abisinica, Rumex abyssinicus Jacq (Locally called mokmoko) and impatiens tricolor (locally known as ensosila) were used to extract dye.

Methods

The dyeing of silk with natural dye was carried out in three stages; Extraction of dyes from plant parts, Mordanting (fixing dye with fiber) and Dyeing

6.1 Extraction of colorant

Different plant parts (used as source of dye) were crushed and dissolved in distilled water and allowed to boil in a beaker kept over water bath for quick extraction for 2 hours. All the color was extracted from flowers, roots and leaf by the end of 2 hours. The solution was filtered for immediate use.

6.2 Mordanting

A - Pre mordanting

Accurately weighed silk fabric samples were treated with different metal salt, for pre-mordanting with metal salts was carried out before dyeing. The mordant 2% (owf) was dissolved in water to make a liquor ratio 1:40. The wetted

sample was entered into the mordant solution and then brought to heating.

Temperature of the dye bath was raised to 80°C over a period of half an hour and left at that temperature for another 30 minutes. The mordanted material was then rinsed with water thoroughly, squeezed and dried. Mordanted silk needed be used immediately for dyeing because some mordants are very sensitive to light.

B - Simultaneous -Mordanting of silk fabrics with metallic salts

Bleached silk were treated with both dye extract and metal salts simultaneously, using 1- 3% of any one of the chemical mordants, such as aluminium sulphate, nickel sulphate, stannous chloride, at 60°C for 30 min with material-to-liquor ratio of 1:20.

C - Post-Mordanting of cotton and silk fabrics with metallic salts

Bleached silk were dyed with dye extract. The wetted out silk fabric samples were entered into different dye baths containing required amount of dye extract and water. The dyeing was carried out for 30 minute at 70°C. The dyed samples were taken out, squeezed and used for treatment with metal salts process without washing.

The dyed silk fabric samples were treated with different metal salts using 1-3% (o.w.f) of chemical mordants, such as aluminium sulphate, stannous chloride, ferric sulphate at 60°C for 30 min with material-to-liquor ratio of 1:40. In each case, for general study of dyeing behavior using different mordants, a prefixed normal dyeing condition was used. In all the above three methods, after the dyeing is over, the dyed samples were repeatedly washed with water and then dried in air. Finally, the dyed samples were subjected to soaping with 5gpl soap solution at 50°C for 10 min, followed by repeated water wash and drying under sun.

6.3 Determination of surface colour strength

The K/S value (Gulrajani, 1992 and Ashis Kumar Samanta, 2007) of the undyed and dyed cotton and silk fabrics was determined by measuring surface reflectance of the samples using a computer-aided Macbeth 2020 plus reflectance spectrophotometer, using the following Kubelka Munk equation with the help of relevant software:

$$K / S = \frac{(1 - R_{\lambda_{\max}})^2}{2R_{\lambda_{\max}}} = \alpha C_d$$

Where K is the coefficient of absorption; S the coefficient of scattering; C_d, the concentration of the dye and R_{λ_{max}} the surface reflectance value of the sample at a particular wavelength, where maximum absorption occurs for a particular dye/colour component.

6.4 Evaluation of Colour Fastness

Colour fastness to washing of the dyed fabric samples was determined as per ISO: 105-A02 – 1995 method using a launder-O-meter following ISO-3 wash fastness method. The wash fastness rating was assessed using grey scale as per ISO-105-A02 (loss of shade depth) and ISO-105-A03 extent of staining. Colour fastness to rubbing (dry and wet) was assessed manually by hand rubbing one sample ten times and grey scale as per ISO-105-A03 extent of staining.

7. RESULTS & DISCUSSION

Bleached silk fabrics mordanted with varying concentration of mordants have been subsequently dyed by using pre, simultaneous and post-mordanting methods as reported. All the dyed fabrics have been assessed for their color strength (K/ S) value as reported in table 1, 2 and 3 below. All the dyed fabrics have been assessed for their color fastness behavior to washing, rubbing and exposed to light and perspiration and the results are given in the table.

Fabric	Mordant Conc: 1%	K/S(λ =400 nm)		
		Pre-Mordanting	Simultaneous Mordanting	Post-Mordanting
Silk	Alum	7.8622	10.3088	5.7847
	ferric sulfate	4.1356	8.8679	4.3448
	Stannous	5.6342	4.3887	

Table-1: Surface colour strength of dyed silk fabrics after pre, simultaneous and post -mordanting methods by using 1% mordant concentration for eucalyptus.

All the treated samples subjected to washing shows good grade to washing fastness and all the treated samples no color staining to washing fastness. The color change to dry and wet rubbing for all the treated samples was excellent (5). There was slight color staining except for simultaneous mordanting method where it was negligible staining (4-5).

Fabric	Mordant Conc: 1%	K/S(λ =400 nm)		
		Pre-	Simultaneous	Post-

Mordants	Method of mordanting	Mordant Concentration (%)	Rubbing					
			Washing		dry		wet	
			cc	cs	cc	cs	cc	cs
	Pre-Mordanting	1	5	4	5	4	4	5
		2	5	4	5	5	5	5

Silk	Mordant	Mordanting	Mordanting	Mordanting
		11.8400	10.4152	9.1258
		5.4330	9.3975	7.6202
	Stannous	5.8952	4.564	

Table-2: Surface color strength of dyed cotton fabrics after pre, simultaneous and post-mordanting methods by using 2% mordant concentration for eucalyptus.

All the treated samples subjected to washing fastness and all the treated samples shows no color staining to washing fastness. The color change to dry and wet rubbing for all the treated samples was excellent (5) and there was slight no color staining.

Fabric	Mordant Conc: 1%	K/S(λ =400 nm)		
		Pre-Mordanting	Simultaneous Mordanting	Post-Mordanting
Silk	Alum	10.6225	13.9868	11.1565
	ferric sulfate	14.9393	13.9668	10.0359
	Stannous	4.4575	6.1075	

Table-3: Surface color strength of dyed cotton fabrics after pre, simultaneous and post -mordanting methods by using 3% mordant concentration for eucalyptus.

As it was seen from the above tables simultaneous mordanting gave excellent results (K/S value) as compared to other mordanting system. It is observed that among differently mordanted bleached silk subsequently dyed with eucalyptus with 3% aluminum sulphate by simultaneous mordanting technique, renders the fabric relatively higher K/S value 13.9868 as compared to other mordanting system. The use of 3% ferric sulphate by simultaneous mordanting technique followed by further dyeing with comparable dose of eucalyptus shows the K/S value of 13.9668 and thus is considered as next good performer and 3% stannous chloride which shows the K/S value of 6.1075.

Alum	Simultaneous Mordanting	3	5	5	5	5	5	5
		1	4	4	5	4	5	4
		2	4	4	5	4/5	5	4/5
	Post-Mordanting	3	4	4	5	5	5	5
		1	5	4	5	5	5	5
		2	5	4	5	5	4	5
	Pre-Mordanting	3	5	4	5	5	5	5
		1	4	4	5	5	5	5
		2	4	4	5	5	5	5
Ferric sulfate	Simultaneous Mordanting	3	4	5	5	5	5	5
		1	5	4/5	5	4	5	5
		2	5	4	5	4/5	5	5
	Post-Mordanting	3	5	5	5	5	5	5
		1	5	4	5	5	5	5
		2	5	4	5	5	5	5
	Pre-Mordanting	3	5	4	5	5	5	5
		1	4	4	5	4	4	4/5
		2	4	4	5	4/5	5	4/5
Stannous	Simultaneous Mordanting	3	5	5	5	5	5	5
		1	5	4	5	5	5	5
		2	5	4	5	5	5	5
	Post-Mordanting	3	5	5	5	5	5	5
		1	4	4	5	4	4	4/5
		2	5	5	5	5	5	5
	Pre-Mordanting	3	5	5	5	5	5	5
		1	4	4	5	4	4	4/5
		2	5	5	5	5	5	5

Table- 4: Colour fastness of dyed silk fabrics with selective mordants using pre, simultaneous and post-mordanting methods for eucalyptus. (Note CC color change CS color staining)

Mordants	Method of mordanting	Mordant Concentration (%)	Rubbing					
			Washing					
			cc	cs	dry		wet	
	Pre-Mordanting	1	4	4	5	5	4	5
		2	5	4	5	5	5	5
		3	5	5	5	5	5	5

Alum	Simultaneous Mordanting	1	5	4	5	5	5	5
		2	5	5	5	5	5	5
		3	5	5	5	5	5	5
	Post-Mordanting	1	4	4	5	5	4	5
		2	5	4	5	5	5	5
		3	5	5	5	5	5	5
ferric sulfate	Pre-Mordanting	1	4	4	5	5	4	5
		2	4	4	5	5	4/5	5
		3	5	5	5	5	5	5
	Simultaneous Mordanting	1	4	4	5	5	4/5	5
		2	5	5	5	5	5	5
		3	5	5	5	5	5	5
	Post-Mordanting	1	4	4	5	5	4	5
		2	4	4	5	5	4/5	5
		3	5	5	5	5	5	5
Stannous	Pre-Mordanting	1	5	4	5	5	4	5
		2	5	5	5	5	5	5
		3	5	5	5	5	5	5
	Simultaneous Mordanting	1	5	5	5	5	5	5
		2	5	5	5	5	5	5
		3	5	5	5	5	5	5
	Post-Mordanting	1	5	4	5	5	4	5
		2	5	5	5	5	4	5
		3	5	5	5	5	5	5

Table-5: Colourfastness of dyed silk fabrics with selective mordants using pre, simultaneous and post -mordanting methods for Rumex abyssinicus Jacq

Fabric	Mordant Concn: 1%	K/S(λ =400 nm)		
		Pre-Mordanting	Simultaneous Mordanting	Post-Mordanting
Silk	Alum	2.1326	3.0546	2.6896
	Ferric sulfate	5.7397	7.4331	9.3124

	Stannous	2.2553	3.0251	1.8500
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Table-6: Surface colour strength of dyed silk fabrics after pre, simultaneous and post -mordanting methods by 1% mordant concentration for Rumex abyssinicus Jacq

Fabric	Mordant Concn.: 2%	K/S(λ =400 nm)		
		Pre-	Simultaneous	Post-

		Mordanting	Mordanting	Mordanting
Silk	Alum	2.7847	4.1770	2.8426
	ferric sulfate	6.8934	7.5763	9.9638
	Stannous	2.4794	3.3979	2.1880

Table-7: Surface colour strength of dyed silk fabrics after pre, simultaneous and post -mordanting methods by 2% mordant concentration for Rumex abyssinicus Jacq

Fabric	Mordant Concn.: 3%	K/S(λ =400 nm)		
		Pre-Mordanting	Simultaneous Mordanting	Post-Mordanting
Silk	Alum	2.8398	5.6342	3.1298
	ferric sulfate	5.9613	6.6780	9.6844
	Stannous	2.2711	4.2563	2.5161

Table-8: Surface colour strength of dyed silk fabrics after pre, simultaneous and post -mordanting methods by 3% mordant concentration for Rumex abyssinicus Jacq

This increase in K/S value to a different extent after pre, simultaneous and post-mordanting may be due to the changes in scattering because of the chemical interaction between fibers and metallic salts along with the additional inherent color input of the corresponding mordants.

Hence, considering the dyeing results, the sequential mordanting systems using 3% FeSO₄ and dye extracted from rumex abisinicuss jaq, 3% Al₂(SO₄)₃ and rumex abisinicuss jaq are found to be more prospective, rendering a higher degree of increase in surface color strength.

These three systems of mordanting have therefore been chosen for further study of dying process variables for silk fabrics. However, the use of ferrous sulphate in any case always renders both silk and cotton fabrics a deep brownish /grey color owing to the inherent color of this transition metal salt anchored to the corresponding fiber, besides the improvement in K/S value due to the natural dye component.

The observed highest K/S value in case of fiber-mordanting system on bleached silk substrate, indicating the synergistic intensification of colour yield, is assumed

to be due to higher absorption and Fixation of the dye by the complex formed between the Fe salts and the -COO- group which is not possible in cotton due to the absence of -COO- group. The observed slow increase in K/S value in cotton treated with same mordants is only due to additive color yield for additional incorporation of the inherent color of FeSO₄ itself.

7.1 CONCLUSION

It was found from the study that the root of rumex abisinicuss jaq and eucalyptus leave, dye can be successfully used for dyeing of silk to obtain a wide range of soft, pastel and light colours by using natural dyes and metallic mordants. With regards to colourfastness, test samples exhibited excellent fastness to washing (except pre and post mordanting); excellent fastness to rubbing (except pre, simultaneous and post mordanting-K₂Cr₂O₇);

Among the different fiber-mordanting systems studied, the use of 3% of ferrous sulphate applied by simultaneous mordanting for subsequent dyeing on cotton and silk with extract of eucalyptus dye 3% of aluminum sulphate applied by simultaneous mordanting for subsequent dyeing on silk with 5% extract of rumex abisinicuss jaq and 3% of stannous chloride applied by simultaneous mordanting for subsequent dyeing on silk with 5% extract of rumex abisinicuss jaq show maximum K/S values as compared to other selective pre, simultaneous and post mordanting systems.

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