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A Comparative Study on Dyeing of Cotton and Silk Fabric Using Madder as a Natural Dye

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Abstract: *Madder is considered the queen of the reds which is one of the oldest used natural dyes. In this study, madder was applied to cotton and silk fabrics by using mordants in various ways to investigate the coloring effects. Alum and copper sulphate were used as mordants not only before and after dyeing process but also during the process. The aqueous extract of the dye was applied on the scoured cotton and silk fabrics with and without mordants and the acquired samples have been subjected to different textile laboratory tests e.g. color fastness to light, wash, rubbing (wet and dry) and perspiration. The dye extraction procedure applied in this experiment was conventional.*

The obtained color of silk samples found deeper than cotton samples and mordanted silk fabrics with alum show greater color fastness to wash than cotton fabrics(alum and copper sulphate mordanted) show. Other tested dyeing properties of silk fabrics observed better than those in cotton fabrics. Finally the test concluded with the result that silk fabrics can be made more sophisticated with strong versatile shades of madder.

Keywords: *Natural dye, Madder, Cotton and Silk fabric, Alum, Copper Sulphate.*

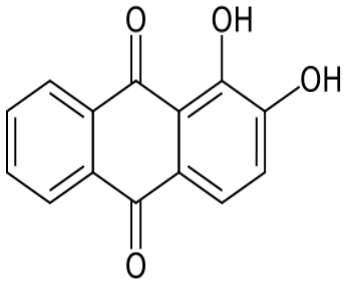
I. Introduction

Dyeing is an ancient art which predates written records and it was practiced since Bronze Age[1].In textile processing dyeing is an integral part where textile coloration is done to make the fabric lively. Synthetic dyes are produced from cheap petroleum sources, vastly used commercially to impart color to textiles because they have simple dyeing process with good fastness properties[2].Despite the complimentary effect of synthetic dyes, research has shown that synthetic dyes are suspected to release harmful chemicals that are allergic, carcinogenic and detrimental to our environment and human body[3]. In Bangladesh due to textile dyeing industries, the main negative impact afflicting the local environment severely is the hazards caused by dye effluents, which contain both chemical and organic pollutants, pushing our beautiful country to garbage[4].This effluent of textile processing discharge in environment, which spoils the living condition of human being, other animals and plant life. The serious environmental problems of public health concern related to colored waste waters containing synthetic dyes have diverted researchers promptly to look for eco-friendly products[5]. So to recover our living condition we need to introduce environment friendly materials to use in textile processing that can accomplish the consumer's requirement as well as economy of country. We can generate interest in natural dyes instead of synthetic dyes which are biodegradable as well as non-toxic and non-allergic to human body.

Natural dyes are found from natural sources such as from plants, animals, insects or minerals. Although the ancient art of dyeing with natural dyes withstood the ravages of time, a rapid decline in natural dyeing continued due to the wide availability of synthetic dyes at an economical price, but now-a-days the importance of natural dyes is more relevant worldwide in the context of increasing environment consciousness[6, 7]. The use of natural organic dyes obtained from renewable resources such as plants and trees has the potential for not only preserving the precious petrochemicals but also the all-endangered environment for our coming generations[8]. In many of the world's developing countries, however, natural dyes can offer not only a rich and varied source of dyestuffs, but also the possibility of an income through sustainable harvest and sale of these dye plants[9]. Natural dyes, when used by them have many limitations of fastness and brilliancy of shade but when they are used along with metallic mordants they produce bright and fast color[10]. For successful commercial use of natural dyes, the appropriate and standardized dyeing techniques are needed to be adopted without scarifying required quality of dyed textile materials[6]. Manufacturer can easily turn the attention of consumer to the natural dyed products by changing their marketing strategy and proper experiment and research should be done to use natural dyes in the industry. If it is possible to increase the demand of natural dyed products to the foreign markets, it will not only be beneficial to our environment but also to our economy of the country.

In Bangladesh, there is a huge source of natural dyes like Khair, Manjit, Mehedi etc. In this experiment we used Manjit as a natural dye which is known as Madder- a very popular source of red tones. In several regions of Asia, the Middle East and Europe, madder, was largely cultivated and also used to obtain pinks, oranges, purples etc[11]. The roots of madder contain several polyphenolic compounds such as 1, 2-

dihydroxyanthraquinone (alizarin) which gives it its red colour to a textile dye known as Rose madder. Its chemical structure is given below.



Alizarin

So, considering all the points of above, this work was carried out to study about the suitability of madder which is a natural colorant, in dyeing of cotton and silk fabric using pre-mordanting, post-mordanting, simultaneous mordanting and without mordanting. Then the color characteristics and various color fastness properties of dyed cotton and silk fabric was measured. All of these mordanting processes were carried out by using two different mordants.

II. Materials and Methods

The root of Madder plant, cotton fabric and silk woven fabric was purchased from local market. Alum and Copper sulphate were used as mordant. In this project we followed aqueous extraction method for dye extraction. Cotton and Silk fabrics were scoured before dyeing. Mordanting was done by three processes- Pre mordanting before dyeing, Post mordanting after dyeing and mordanting and dyeing simultaneously. Fabrics were also dyed without mordanting to compare with mordanted samples.Wash fastness, perspiration fastness, rubbing fastness and light fastness tests were done to compare fastness properties. Color measurement of the dyed samples was done by using spectrophotometer Datacolor 600 by Datacolor International.

Dye extraction:

For this experiment the aqueous extraction of Madder roots was done to bring out the dye from the roots. At first they were washed and dried. Then those dried roots were converted into powder form by using grinder, followed by boiling this powder. 1 litre of water was used for 100 gm of madder powder to make a solution. This dye solution was boiled for 2 hours and then filtered to get a clean dye solution.

Mordanting Process:

Mordants are metal salts which produce an affinity between the fabric and dye[1]. Here we used two different mordants –alum and copper sulphate. In pre-mordanting, the mordants are applied to the fabric prior to dyeing. For pre-mordanting of the fabric at first we weighed the dry materials followed by rinsing the fabric with cold water. Then we took mordant, water and fabric in a vessel. In the post-mordanting method, the fabric was treated with mordant in a separate bath after dyeing and in the simultaneous mordanting method, both dyeing and mordanting processes were carried out in the same bath itself.

For this study we used 3% mordant, 1:40 liquor ratio. Then we started mordanting at 80^0c temperature for 30 mins for premordanting, post mordanting and simultaneous mordanting.[9]

Dyeing:

Dyeing of cotton and silk fabric was done by extraction of madder maintaining the liquor ratio 1:10 and temperature 100°c for 30 mins.

Color characteristics measurement:

Color characteristics of all the dyed samples (without mordanting, premordanting ,postmordanting and simultaneous mordanting) were measured by using a spectrophotometer Datacolor 600.

Testing the quality of dyes samples:

Color fastness to light of dyed samples was tested according to ISO 105:B02.
Washing fastness of dyed samples was tested according to ISO 105:CO3 at 60°c for 0.5h.
Color fastness to rubbing of dyed samples was tested according to ISO 105/12.

Color fastness to perspiration of dyed samples was tested according to ISO 105 E04 at 37°c under a pressure of 12.5 kpa for 4 hours.

III. Results and discussions

Color characteristics and fastness of cotton fabric dyed with madder(with and without mordants):

Presence of mordants in the cotton samples dyed with madder influences significtly on the depth of shade. Tables show that in the presence of alum and copper sulphate as mordants cotton fabrics gain darker shades with both pre-mordanting and post-mordanting and ligther shades when those are dyed and mordanted simultaneously than cotton fabrics show without mordanting. It also can be said that when mordants are used both before and after the dyeing process, color strength of madder on cotton samples becomes more than that on cotton when mordants are applied during the dyeing process. Alum imparts darker shades than copper sulphate does to the samples.

Cotton fabrics dyed in the presence of mordants (alum and copper sulphate) show almost same color fastness to light as samples dyed without mordants as shown in Table-6.

Washing of cotton samples in the method of ISO 105:C03 releases some amount of dyes that signifies poor color fastness of cotton to wash, especially when mordants are used during dyeing process. But mordanting of cotton fabrics imparts greater fastness to rubbing than cotton samples without mordants. Simultaneous use of mordants and dyes shows an excellent color fastness to rubbing.

Color fastness to perspiration test has also been carried out in both alkaline and acidic condition. Madder does not show good fastness to perspiration (alkaline and acidic) on cotton fabrics.

Color characteristics and fastness of silk fabric dyed with madder (with and without mordants):

Depth of shade on silk fabrics dyed with madder with and without mordants is shown in Table-5. In case of silk dyeing copper fabrics create comparatively lighter shades on silk than alum does. Moreover simultaneous use of dyes and mordants imparts lighter shades and both pre-mordanting and post-mordanting of dyes give darker shades on silk samples.

Silk samples dyed with madder shows an average fastness to light with (alum) and without mordants as shown in Table-6, though post-mordanting with copper sulphate imparts a great fastness to light. Mordanting with both alum and copper sulphate has a positive impact on silk samples dyed with madder as silk fabrics exhibit better fastness to rubbing (wet and dry) in the presence of mordants than they show without mordants. When colorfastness to perspiration has been tested in method ISO 105 E04, it has been observed that silk fabrics loose a significant amount of dyes in both alkaline and acidic solution; thus showing considerable color staining in cotton fibres of multifibre fabrics.

According to the experimental results, it has been observed that cotton fabrics make less color difference while comparing the depth of shades between samples dyed with mordants and those without mordants than silk samples while doing the same. It is also noticeable that not only silk fabrics show darker color shades than cotton fabrics but also they possess a better fastness properties than cotton fabrics have, though perspiration (acidic and alkaline) hampers dyeing properties of silk more than that of cotton fabrics.

Table 1 Dyed samples (without mordant)

	Fabric type	
Method	Cotton	Silk
Without mordanting		

Table 2 Dyed samples (using Copper Sulphate as mordant)

	Fabric type	
Method	Cotton	Silk
Pre-mordanting		

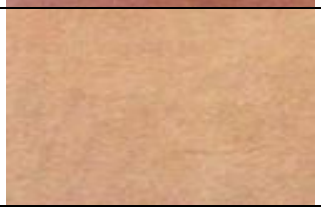
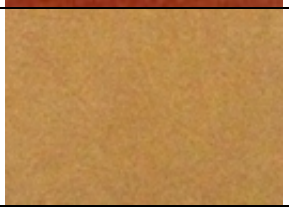
Post-mordanting		
Simultaneous mordanting		

Table 3 Dyed samples (using Alum as mordant)

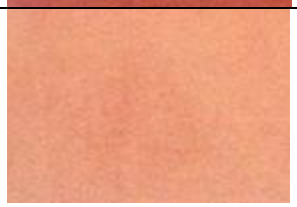
	Fabric type	
Method	**Cotton**	**Silk**
Pre-mordanting		
Post-mordanting		
Simultaneous mordanting		

Table 4 Color characteristics of Cotton fabric dyed with Madder, with and without mordanting

Sample	delE	delL	delC	delH	Description
Standard sample	-	-	-	-	Dyed without mordanting
Premordant(copper sulphate)	3.90	0.26	1.74	3.49	Darker more red more yellow
Premordant (Alum)	7.82	-1.56	7.65	0.43	Darker more red more yellow
Simultaneous mordanting (copper sulphate)	9.93	5.61	-3.11	7.58	lighter more green more yellow
Simultaneous mordanting (Alum)	7.80	4.56	3.02	5.56	lighter more red more yellow
Postmordant(copper sulphate)	2.79	-0.31	-2.17	-1.72	Darker more green more blue
Postmordant(Alum)	5.31	-1.43	5.09	-0.46	Darker more red more yellow

Table5 Color characteristics of Silk fabric dyed with Madder, with and without mordanting

Sample	delE	delL	delC	delH	Description
Standard sample	-	-	-	-	Dyed without mordanting
Premordant(copper sulphate)	16.03	1.42	2.52	15.77	Lighter more green more yellow
Premordant (Alum)	3.87	-1.56	2.59	2.41	Darker more red more yellow
Simultaneous mordanting (copper sulphate)	16.61	5.68	-6.20	14.32	Lighter more green more yellow
Simultaneous mordanting (Alum)	13.41	4.78	3.01	12.16	Lighter more green more yellow
Postmordant(copper sulphate)	4.81	-2.04	-2.62	3.47	Darker more green more yellow
Postmordant(Alum)	5.05	-3.48	2.91	2.21	Darker more red more yellow

Table 6 Color Fastness to Light

Mordant	Fabric Type	Grade (Color Staining)			Without mordanting
		Pre mordanting	Post mordanting	Simultaneous mordanting	
Alum	Cotton	3	4/5	4	4/5
	Silk	3/4	3	3	4
Copper sulphate	Cotton	4/5	4	4	
	Silk	3/4	4/5	3/4	

Table 7 Color Fastness to Wash

		Cotton		Silk	
Mordant	Method of mordanting	Change In Color	Color staining in cotton	Change In Color	Color staining in cotton
Alum	Pre mordanting	3/4	4/5	3	2
	Post mordanting	4	4	2/3	4/5
	Simultaneous mordanting	1/2	3/4	2	3
Copper sulphate	Pre mordanting	2	2/3	3	3
	Post mordanting	3	4	3/4	2/3
	Simultaneous mordanting	1	4/5	1/2	4/5

Table 8 Color Fastness to Rubbing

Mordant	Fabric Type	Method of Rubbing	Gray Scale Rating			Without Mordanting
			Pre mordanting	Post mordanting	Simultaneous mordanting	
Alum	Cotton	Wet Rub	1/2	4	4/5	2/3
		Dry Rub	4/5	4/5	5	4/5
	Silk	Wet Rub	4	4/5	5	3
		Dry Rub	3	3	4/5	2
Copper sulphate	Cotton	Wet Rub	3/4	2/3	4/5	
		Dry Rub	4	3/4	5	
	Silk	Wet Rub	4/5	3/4	4/5	
		Dry Rub	4/5	3	4/5	

Table 9 Color fastness to perspiration

For Acidic Solution						For Alkaline Solution					
		Cotton		Silk				Cotton		Silk	
Mordant	Method of mordanting	Change in color	Color staining in cotton	Change in color	Color staining in cotton	Mordant	Method of mordanting	Change in Color	Color staining in cotton	Change in color	Color staining in cotton
Alum	Pre mordanting	4/5	4/5	4	3/4		Pre mordanting	2/3	4	3/4	3/4
	Post mordanting	3/4	4	3	4	Alum	Post mordanting	3/4	4	3/4	4
	Simultaneous mordanting	4	4	3/4	3		Simultaneous mordanting	3/4	4	3	4
Copper sulphate	Pre mordanting	3	3/4	3	4/5		Pre mordanting	3/4	4	2/3	4
	Post mordanting	4	4/5	3	3	Copper sulphate	Post mordanting	4	2/3	3	2/3
	Simultaneous mordanting	3	3/4	4	3/4		Simultaneous mordanting	4	3	4	3
Without mordanting		3/4	4	3	3/4			3	2/3	3/4	2/3

IV. Conclusion

Madder creates a wide variety of red shades on cotton and silk materials those can be highly appealing to many fashionable customers. Cotton and silk both are attracted significantly by this kind of dye though they both are totally different in chemical composition as cotton is completely cellulosic and silk highly protein. This dye generates more color strength on silk materials than on cotton. Depth of shades and fastness of color depend on material types, presence or absence of mordants , mordant types, duration of dyeing process, when to apply mordants and many more factors. Therefore, mordants can be applied to other natural or synthetic materials to obtain many more variety of shades and to create more sophisticated tones of shades by changing types of mordants or duration of dyeing process or even by mixing this dye with other types of natural dyes.

Nowadays, fortunately, there is increasing awareness among people towards natural products. Due to lack of availability of precise technical knowledge on the extraction and dyeing technique, it has not commercially succeeded like synthetic dyes. More detailed studies and scientific investigations are needed to assess the real potential and availability of natural dyes – yielding resources for propagation of species in great demand on commercial scale. Bio-technical and other modern techniques are required to improve the quality and quantity of dye production. We all hope, in the near future, investigators and scientists would be successful

to meet all the demands of the dyers and their customers to introduce a new era regarding natural sources of dyes and their extraction procedures and improving their performances.

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