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RESEARCH ARTICLE

EFFECTIVELY UTILIZE THE NATURAL RESOURCES AS MORDANTS AND DYES FOR DYEING OF COTTON

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ABSTRACT

Marigold and Turmeric were used for the extraction of the natural dye material. Tannic acid, Cow dung, Pomegranate rind and Lemon juice were selected as natural mordant to standardize the dyeing effect of Marigold and Turmeric dyes on silk and knitted cotton fabric. The method appropriate for natural dye dyeing on knitted cotton was found to be premordanting by studying with other methods such as simultaneous and post mordanting method. The colour developed range on dyed materials is evaluated by dye uptake measurement and the improvement of colour strength on fabric using mordants was also examined. Tannic acid and pomegranate increase the colour strength effectively than the other. The dyeuptake values have been found to be good in all dyed samples but some cases produced poor fastness. Marigold with tannic acid and pomegranate rind produced good dye uptake and fastness properties. All the mordanted fabric showed good dye uptake.

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INTRODUCTION

Tirupur and all textile industrial areas are major problem due to synthetic dye effluent. In the synthetic dye bath effluents total dissolved salts (TDS) level is approximately 58000–61000 mg/L for conventional reactive dyeing and 23000–30000 mg/L for low salt reactive dyeing [1,2]. Dye bath effluents are treated and reuse by various methods and other hand reduces water pollution at source level reduction by using natural mordant and dyes in textile dyeing [3,4]. Disposal of the salt laden effluents into ground and surface water bodies cause pollution and render them unfit for domestic, industrial and agricultural use. Higher doses of salt are toxic to aquatic organisms as they expose the organisms to changes in osmotic pressure, causing swelling or dehydration. The quality of irrigation water mainly depends on its salt content and the proportion of sodium to other ions. Sodium chloride corrodes steel. Sodium sulfate corrodes concrete [5,6]. A mordant is a substance used to set dyes on fabrics section by forming a coordination complex or covalent bond with the dye which then attaches to the fabric or tissue. Most of the natural dyes require chemical in the form of metal salts to produce an affinity between the fiber and pigments and this chemical is known as mordants. Mordants help binding of dyes to fabric by forming a chemical bridge from dye to fiber and also light fastness[7,8]. Mordants include alum, chromium, copper, iron, and tin. Some of these metals are quite toxic and hazardous, in addition to be environmentally damaging. Chromium is the most hazardous of mordants. The hexavalent form of chromium, in potassium dichromate, which called for in some recipes, is a known human carcinogen. Alum is the least toxic of the mordants, though it can be irritating and should be used with care [9,10]. The important of the natural dyes with natural mordant and the harmful effect of synthetic dyes with synthetic mordant, an effort had been made to formulate an eco-friendly herbal dye with a natural mordant. Effort was also made to standardize the dyeing effect on human and animal hair [11]. Natural mordants also used for dyeing of silk fabric with non-azo dyes and applied in five substituted chalcones have been synthesized by Claisen-Schmidt condensation of substituted acetophenones and benzaldehydes in the presence of a base by conventional and microwave assisted method[12]. Extraction and application of natural mordant from plant source which is available almost every where in Myanmar. Extracted natural mordant is applied on cotton fabrics by using natural and synthetic dyestuffs. After dyeing, the fastness properties were tested for dyed cotton fabrics such as light, rubbing, and washing fastness. Staining and changing in colour are assessed by using standard grey scale and the results are compared to those obtained from the dyed samples which are dyed by using basic dye with tannin mordant [13].

Dyeing is an ancient art, which predates written records. It was practiced during the Bronze age in Europe. Primitive dyeing techniques included sticking plants to fabric or rubbing crushed pigments into cloth. The methods became more sophisticated over time and techniques were developed using natural dyes from crushed fruits, berries and other plants, which were boiled into the fabric and gave light and wash

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fastness [14]. Today, the protection of environment has become a challenge for the chemical industries worldwide. All over the world environment regulations are becoming stricter. The need to realize the importance and the technology of natural dye is more urgent. This is then led to returning to a traditional for more natural way of life. A part of this trend there is now a lobby for using natural coloring matter to dye textiles [15]. The natural dyes present in plants and animals are pigment molecules[16]. Studies to increase the efficiency of the extraction process and identify plants with the highest concentration of dyes were already being conducted in middle of the century[17]. Conventional methods wisdom leads to the belief that natural dyes are friendlier to the environment than their synthetic counter parts. Natural dyes can exhibit better biodegradability and generally have a higher compatibility with the environment[18-21]. Natural dyeing of cotton fabric has always posed challenges, although silk is an easy to dye. Several metallic salts, and bio-mordants have been used by researchers in recent days [22].This paper discusses an integrated approach for minimization of Total Dissolved Solids (TDS), pollution load and poor color fastness in natural dye.

EXPERIMENTAL DETAILS

Materials

The natural dye sources Marigold -*Tagetes erecta* and Turmeric -*Curcuma longa* were selected for dyeing. Well scoured and bleached Knitted cotton used. The natural mordants tannic acid, cow dung, pomegranate rind and lemon juice were selected.

Aqueous extract of color from fresh Marigold

Dye was extracted from Marigold flowers into the proportion of 1:2 ratios of flower and water[21]. This process is carried out at a temperature range of 80-85ºC for 1 hour. After the extraction procedure was completed and dye was filtered using nylon mesh and subjected to dyeing.

Aqueous extract of color from Turmeric

In order to extract the dye the aqueous mode is utilized with turmeric powder which is 1gm is diluted with 100ml of water and bring it to boil for 15 minutes. After extraction, it was allowed to cool and then used for dyeing.

Premordanting

In premordanting method fabric was first mordanted by using the following recipe, Mordant - 3%, pH- 7, Time - 30 minutes, Temperature - 60ºC and MLR - 1:30. The bleached fabrics of cotton were subjected to mordanting process using the above recipe with four different mordants such as tannic acid, cow dung, pomegranate rind and lemon juice separately. The mordanted fabrics were squeezed without washed and dried.

Dyeing

Premordanted fabric was entered into the dye bath containing the calculated amount of dye, water and required chemicals. The temperature and ML ratio were maintained at 75ºC and 1:20 respectively (Table 1). After the completion of the dyeing process, the samples were taken out, rinsed and dried. The optimized (Table 2) recipe is used for simultaneous and post mordanting dyeing.

Dye exhaustion measurement

The exhaustion values of dyed samples were measured by taking the absorbency value of the dye liquor sample (before and after dyeing) using an UV – Visible spectrophotometer at a wave length of maximum absorbency (λ_{max}) of the dye concerned. The exhaustion value was calculated using equation

$$\text{Exhaustion } (\%) = \frac{1 - A_1}{A_2} \times 100\%$$

Where, A_1 = Absorbance of dye solution before dyeing and A_2 =Absorbance of dye solution after dyeing.

TDS measurement (TDS)

The dye bath liquor was tested for Total Dissolved Solid (TDS) content before and after dyeing process by Merck make TDS meter.

Washing fastness

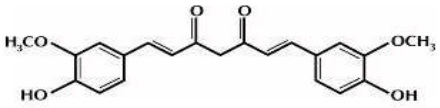
The dyed cotton was tested for fastness properties according to standard ISO Test 3 testing method (ISO 105-C03:1989, Geneva). Dyed samples of 10 x 4 cm were stitched with one of the shorter side of the adjacent bleached fabric and put into the Launderometer at 60°C for 30 min and then washed with hot water, cold water and dried.

Light fastness

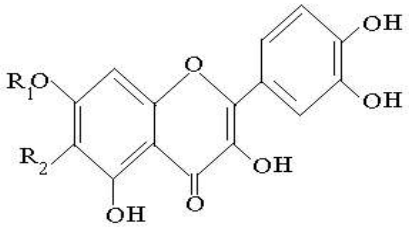
Dyed samples were cut and placed on a cardboard. One half of the sample was masked and the other was exposed to sunlight for 24 hours. Then the light fastness of the samples was assessed according to their degree of fading using grey scale.

RESULTS AND DISCUSSION

Natural dyes are extracted from natural sources Marigold and Turmeric. The extracted dye was applied with four different natural mordants. Mordanting and dyeing properties with knitted cotton studies have shown some interesting discussions are given. The approximate quantum yield of the coloring matter from Marigold has been found to be 3% and from Turmeric has been found to be 4%. The color of the dye extracted from marigold is light yellow in color. The color of the dye extracted from turmeric is yellow at room temperature. When the extracted dye was subjected to boiling experiments, it produced reddish brown color. The natural dyes from the marigold and turmeric were found to be suitable for dyeing of cotton. Knitted cotton was dyed with and without mordants. It is imperative that the yellow extracts may contain flavonoids. These well known organic molecules were found to be mordanted with metal ions to yield different colors on fabrics [23]. In UV-Visible study, the marigold dye solution was subjected to UV-Visible Spectral analysis. It showed two peaks at 424nm and 312nm. For turmeric dye the peak is at 348nm and 238nm. Dye extracts of marigold and turmeric



a. Structure of Curcumin



b.Structure of quercetol

Figure 1. Structures of Curcumin and quercetol

Table 1: Trial work for natural dyeing recipe

Parameters	Trial 1	Trial 2	Trial 3	Trial 4
Dye Concentration (ml)	5	5	5	5
Sodium chloride (gpl)	15	-	15	-
Sodium carbonate (%)	3	3	-	-
Acetic acid (%)	-	-	0.5	0.5
ML (ratio)	20	20	20	20
Time (minutes)	120	120	120	120
Temperature (ºC)	75	75	75	75

Table 2: Optimization condition for dyeing

	Variable studied	Range examined	Fixed other variables (constant)
A	Dye conc. ml	5,8,10	B=5,C=120,D=75
B	pH	5,7,9	A=10,C=120,D=75
C	Time (mins.)	60,90,120	A=10,B=5,D=75
D	Temperature(ºC)	45,60,75	A=10,B=5,C=90

Table 3: Colors obtained on cotton with different natural mordants and dyes

Dye	Mordants	Colors obtained
Marigold	Tannic acid	Pale greenish yellow
	Cow dung	Pale greenish yellow
	Pomegranate rind	Pale yellow
	Lemon juice	yellow
Turmeric	Tannic acid	Pale yellow
	Cow dung	Pale yellow
	Pomegranate rind	Brown
	Lemon juice	Yellow

Table 4: Optimization of variables in dyeing

Variable studied	Range examined	Optimized value	
		Marigold	Turmeric
Dye conc. (ml)	5,8,10	10	10
pH	5,7,9	5	5
Time (minutes)	60,90,120	90	90
Temperature (ºC)	45,60,75	75	75

Table 5: Dye uptake and TDS values for knitted cotton at optimized condition

Dyes	Mordants	Dye uptake (%)	TDS (ppm)
Marigold	Tannic acid	69.4	692
	Cow dung	60.3	681
	Pomegranate rind	69.2	690
	Lemon juice	62.9	690
Turmeric	Tannic acid	67.2	678
	Cow dung	59.2	680
	Pomegranate rind	66.7	693
	Lemon juice	63.5	690

Table 6: Wash Fastness ratings of cotton samples dyed

Mordanting Method	Mordants	Marigold		Turmeric	
		Change in shade	Change in stain	Change in shade	Change in stain
Unmordant	-	**2**	**2**	**2**	**2**
Premordanting	TA	**4**	**3**	**4**	**4**
	CD	**2**	**2**	**2**	**2**
	PR	**4**	**3**	**3**	**3**
	LJ	**2**	**2**	**2**	**3**
Simultaneous Mordanting	TA	**2**	**3**	**2**	**3**
	CD	**1**	**1**	**1**	**1**
	PR	**2**	**3**	**3**	**3**
	LJ	**1**	**1**	**2**	**1**
Post mordanting	TA	**2**	**2**	**2**	**2**
	CD	**1**	**1**	**2**	**1**
	PR	**2**	**2**	**2**	**2**
	LJ	**2**	**2**	**2**	**1**

Table 7: Light Fastness ratings of cotton samples

Mordanting Method	Mordants	Marigold	Turmeric
Unmordant	-	4	4
Premordanting	TA	7	6
	CD	4	4
	PR	5	5
	LJ	4	4
Simultaneous Mordanting	TA	5	5
	CD	3	3
	PR	4	4
	LJ	4	4
Post mordanting	TA	4	5
	CD	3	4
	PR	4	3
	LJ	4	4

have been applied on knitted cotton. The different Mordants with dye extract produce different colors and hues.

Structure of Curcumin

Curcumin is the principal curcuminoid of the popular Indian curry spice turmeric. The other two curcuminoids are desmethoxy curcumin and bisdesmethoxy curcumin (Fig. 1.a). The curcuminoids are polyphenols and are responsible for the yellow color of turmeric[23].

Structure of quercetol

The colorants in tagetes erecta flowers are mainly quarcetagitrin and tagetin, two glycosides of the flavonoid quarcetagitrin (Fig. 1.b.), giving strong and beautiful dyes for textiles [24].

Colour of Dyed Fabric

The marigold dye extract is dyed by using four different mordants such as tannic acid, cow dung, and pomegranate and lemon juice. Tannic acid and cow dung mordanted fabric produce pale greenish yellow color for knitted cotton. The Pomegranate and lemon juice mordanted fabric produce reddish yellow and yellow color produced on knitted cotton respectively. For the turmeric dye extract is dyed by using four different mordants, Tannic acid and cow dung mordanted fabric produce pale yellow color. Pomegranate and lemon juice mordanted fabric produced brown and yellow color on knitted cotton respectively is shown in the Table 3.

Effect of dying optimization

Table 4 showed that the properties and effect of four main parameters of dyeing as follows, as the dye concentration was increased from 5 to 10 ml, the exhaustion increased for all the fabrics studied. The unmordanted fabric showed poor exhaustion in dyeing. The tannic acid and pomegranate rind mordanted fabric showed good exhaustion than the other mordants. Increase in dye concentration does not show any significant change in exhaustion. So, the dye concentration is optimized as 10 ml. The dyeing was carried out in three pH ranges acid, alkali and neutral. The exhaustion was good with acid pH than the alkali and neutral condition. Now the optimised condition is acid medium. When the dyeing time was increased from 60, 90 and 120 minutes, the exhaustion was also increased. The exhaustion was significant and a dyeing time of 90 minutes was found to be good. As the dyeing temperature was increased from 45, 60 and 75ºC, there is no change in exhaustion and therefore 75 ºC was found to be optimum. The Unmordanted fabric showed poor exhaustion than the mordanted fabric for all cases.

Comparison on the effect of variables in the dyeing of cotton

Table 5 showed that the unmordanted fabric**,** as the dye concentration increased from 5 to 10 ml, the exhaustion increased for all the fabrics studied. All the fabrics showed good exhaustion at acid pH range. As the dyeing time was increased from 60 to 120 minutes, the change in exhaustion was significant and a dyeing time of 90 minutes was found to be good. When the temperature was increased from 45 to 75 ºC, the exhaustion was also increased and after 75ºC there is no significant change in exhaustion.

Effect of mordanted fabric

When the dye concentration was increased the exhaustion increased for all the fabrics studied. All the fabrics showed good exhaustion at acid pH range. At the optimized recipe, the Marigold dyed fabric showed good exhaustion than the Turmeric dyed fabric. As the dyeing time and temperature was increased from 60 to 12 minutes, there is no significant change in exhaustion. When the temperature was increased from 45 to 75 ºC, the exhaustion was also increased. The TDS value obtained for both dyes is almost similar for all spent dye bath. Marigold and Turmeric dyeing on knitted cotton is premordanting because of its best dye uptake and better depth of shade. The effect of four different mordants and dye uptake for dyed knitted fabrics were investigated. The order of dye up take is Tannic acid > pomegranate > lemon juice > cow dung (Table5).

Fastness properties

From the table 6 and 7, the mordanted fabrics produced better wash and light fastness than the unmordanted fabrics. The premordanted fabrics produce better fastness than the post and simultaneous mordanted fabrics. The washing fastness value of 1 and 2 were reported for many of the systems studied. When comparing the washing fastness values of four different mordants tannic acid and pomegranate showed better fastness than the other mordanted knitted cotton. Light fastness value of knitted dyed with marigold dye showed almost similar value Turmeric but few cases marigold produced good fastness.

CONCLUSION

The above results have strongly exposed that the mordanting method suitable for Marigold and Turmeric dyeing on knitted

cotton is premordanting because of its best dye uptake and better depth of shade. The effect of four different mordants and dye uptake for dyed knitted fabrics were investigated. The order of dye uptake is Tannic acid > pomegranate > lemon juice > cow dung. Thus the net enhancement of dye uptake and wash fastness values has been found to be best for Tannic acid and pomegranate and compared to other mordants and unmordanted. The premordanted fabrics produce better fastness than the post and simultaneous mordanted fabrics. When comparing the washing and light fastness values of four different mordants tannic acid and pomegranate showed better fastness than the other mordanted knitted cotton. Low TDS values were noted and similar results were obtained for all the cases.

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