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The coloration of cotton fabric with natural dye extracted from turmeric powder

Abstract

The goal of this project is to assess the effect of natural dye absorption from turmeric powder on cotton fabrics. At the commencement, the cotton fabrics are mordanted with two different processes, one is synthetic mordanting, and another one is bio mordanting. Both mordanting processes are done at 100°C temperature for 60 minutes and then dyed the fabrics with turmeric powder at 80°C for 60 minutes. The Application was made at different mordants. After completing the dyeing process, color fastness to wash and water, and dry and wet rubbing tests were evaluated. The results show that the samples dyed with $cuso_4$ mordanting have not so good rubbing fastness properties. But, in the case of mordanting with aloe vera, the rubbing fastness properties are relatively better. The results show that the samples mordanting with $CuSO_4$ have not so good color fastness to washing. But, in the case of mordanting with aloe vera sample has relatively better color fastness to wash. But, in the case of color fastness to water, both $CuSO_4$ and aloe vera mordanted fabrics have good color fastness to water. The tests conducted for this project maintained the ISO standard.

Keywords: natural dyes, turmeric powder, temperature, fastness properties, color fastness to washing, color fastness to water, color fastness to rubbing.

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Introduction

Dyeing is a mechanism that is required for the coloration of fibers, Yarns, and Fabrics. It is done for the value addition, appearance, and desirable of the consumer. It has been used since ancient times and is still used. The coloration was initiated using natural sources.[1] The process has become more advanced with time and strategies using natural coloring from smashed fruit, berries, and other plant materials which have been boiled into the cloth. In contrast, some light and water-fastness (resistance) tests have been developed.[2] The Application of natural fibers is growing due to environmental awareness.[3] The use of natural dyes also increases with it. Natural dyes are generally non-toxic, non-allergic, environmentally friendly, and less costly than synthetic colorants.[4] Many organizations have begun exploring the feasibility of using natural dyes for dyeing and printing.[5] Compared to artificial dyes, natural dyes provide a gentle and light shade. Synthetic dyes develop a wide range of colors and negatively affect humans. Many colorings are accessible from plant waste or can be conveniently grown in gardens. Natural dyes can provide an enticing alternative to regions where synthetic colors, mordants, and other chemicals are manufactured and often relatively expensive.[6]

Natural dyes can be used for dyeing almost all types of natural fibers. Recent research shows that they can also be used to dye some synthetic fibers.[7] Apart from their Application in textiles, natural dyes are also used in the coloration of food, medicines, handicraft articles, and leather processing. Many of the dye-yielding plants are used as medicines in various traditional medicinal therapies.[8–10] Despite their inferior fastness, many natural dyes are antibacterial, antifungal, antioxidant, antileishmanial, and anticancer.[3,11–15] Furthermore, they are more acceptable to environmentally conscious people around the world.[16] Natural colorants from plants with antimicrobial properties have been widely used as both herbal medicines and dyes for at least 4000 years. For example, black kohl or green malachite was used as cosmetics and also to cure or prevent eye diseases as well.[17] renaissance in research and development on natural dye production and application is observed due to the increasing popularity of a more natural lifestyle based on naturally.

Sustainable goods.[18] Natural flora/fauna is full of incomparable colors, fascinating and attracting human beings toward a vast range of possibilities.[19] A large number of plant and animal/insect sources have been identified for the extraction of color[10] and their diver- sifted use in textile dyeing[20] and functional finishing,[21] food coloration,[22] cosmetics,[23] dye-sensitized solar cells,[24] histological staining,[25] pH indicator[26] and several other application disciplines.[27] During the last few decades, increasing attention has been paid by researchers to various aspects of natural dyes. This chapter is intended to collect different information about natural dye classification, extraction, and applications. The use of plants, seashells, and coccid insects to create color is common to all civilizations.[28] With the advent of widely available and cheaper synthetic dyes in 1856, the use of natural dyes with poor to moderate wash and light fastness declined drastically and was replaced by more moderate to excellent color fastness properties of synthetic materials. Yet, it is primordial to note that the revival of natural dyes was mainly due to synthetic dyes' hazardous and cancer-genic nature.[29]

In this project, Turmeric powder was used as a natural dye to dye cotton fabric. After dyeing, the dyed fabrics will be evaluated with some properties. In this project work, no extra chemicals are used while dyeing the fabrics.

Materials and method

Materials

For this research work, 100% cotton twill fabric was used to dye the fabric with Turmeric powder. The sample fabric was collected from well fabric Ltd. Chittagong-, and the Turmeric powder was collected from the Turmeric stem by grinder machine. As mordant, $CuSO_4$ and aloe vera gel were used. The $CuSO_4$ was collected from Harvard Scientific Bangladesh and aloe vera was collected from the location market in Chittagong (Figure 1).

Figure 1 Fabric (top left), and mordanting agents.

Machines

The following instruments were used to develop and analyze the samples:

a. Sample dyeing machine
b. Balance machine
c. Crock meter
d. Perspirometer
e. Greyscale
f. Universal strength tester
g. P^H meter

Methods

Sampling (Table 1)

Table 1 Sample identification

Samples	Identification
Mordanted with $CuSO_4$, 2g	A
Mordanted with Aloe Vera, 200ml	B
Mordanted with $CuSO_4$, 3.5g	C
Mordanted with Aloe Vera, 160ml	D

Mordanting: For this research work, two types of mordanting have been done. One was synthetic, and another was natural. Both are in mordanting processes.

Synthetic mordanting: At first, the samples of cotton fabric were cut into 5g, then two (for sample A & C) different pot was taken. Both of the pot was filled with 200ml water, 2g of $CuSO_4$ for sample A and 3.5g of $CuSO_4$ for sample C. Then both of the pot was taken into the sample dyeing machine and run for 60 minutes at 100ºC temperature.[30]

Bio-mordanting: At first the samples of cotton fabric were cut into 5gm, then two (for sample B & D) different pot was taken. Both of the pot was filled with 200ml water and 150ml of Aloe-Vera for sample B and 200ml Aloe-Vera for sample D. Then both of the pot was taken into the sample dyeing machine and run for 60 minutes at 100ºC temperature (Figure 2).[31]

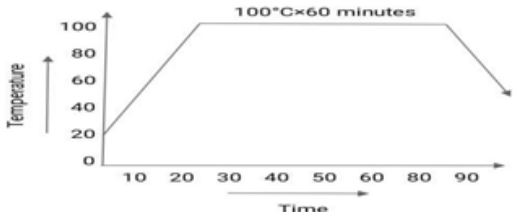

Figure 2 Process curve of mordanting process.

Dyeing method

After mordanting the cotton fabric, samples of the synthetic mordanted process were taken into dyeing pots and filled with 200ml of water, 0.5g of salt, and 2g of Turmeric Powder (For samples B & D). And after the Bio-Mordanting process, the mordanted samples were taken into dyeing pots and filled with 200ml of water, 0.5g of salt, and 2g of Turmeric powder (For Samples B & D). Then taken into the dyeing machine and run for 60 minutes at 80ºC temperature. Upon completion of dyeing for all samples, all samples were not washed, they are just kept at a normal temperature for drying (Figure 3).[32]

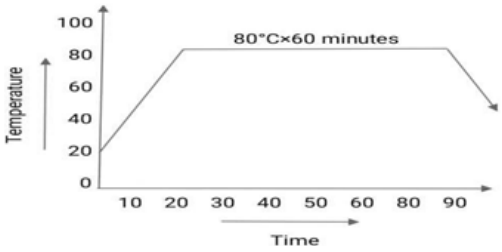

Figure 3 Process curve of dyeing process.

Process flowchart

The following procedure has been executed to prepare the sample for this research work. At first, the fabric was prepared for mordanting with $CuSO_4$/Aloe vera, and then add the Turmeric powder in the dye batch, finally, dyeing has been done. After dyeing, Fabric is dried at room temperature and prepared for tests (Figure 4).

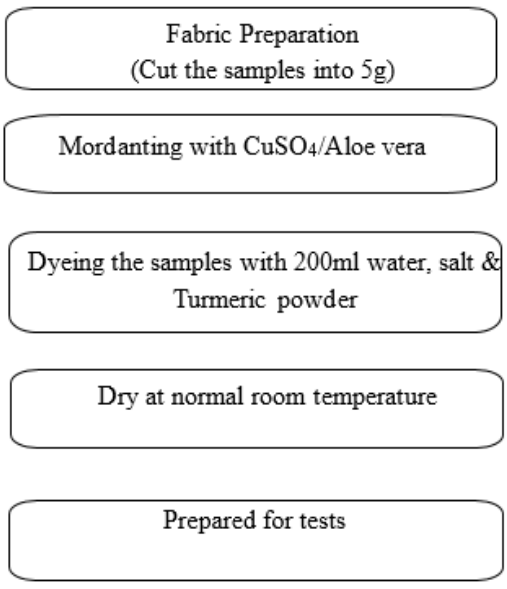

Figure 4 Process flowchart.

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Testing methods

To analyze the experimental work and the confirmation of dyeing, different analytical tests have been carried out. The Color Fastness to rubbing, wash, water, perspirations (acid/alkali), and light was done by using the standard ISO 105 X 12, ISO 105 C06, ISO 105 E01, ISO 105 E04, and, ISO 105 E03 respectively. The pH values of the mordanting agents were also evaluated by ISO 3071. And finally, the Shrinkage, and Tensile properties of the treated samples were investigated by AATCC 135 and ASTM D5035-95 standards.

Results and discussions

Colorfastness to rubbing

Table 2, Shows that the color fastness of rubbing in both dry and wet conditions, sample B and sample D find better than other samples. Because of the treatment of aloe vera mordant, its fabric sample shows little smooth surface than the treated sample with $CuSO_4$. So, it can say that all synthetic mordanted fabric has less color fastness from properties to rubbing than bio mordanted fabric (Figure 5).[33]

Table 2 Colorfastness to rubbing

Sample	Grade (Dry)	Grade (Wet)
A	3-4	2-3
B	4-5	3-4
C	3-4	2-3
D	4	3-4

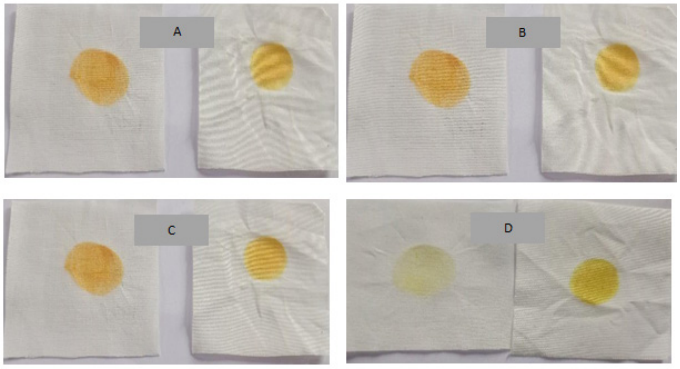

Figure 5 Colorfastness to Rubbing (Sample A, B, C and D).

Colorfastness to washing

Colorfastness to washing means, that a specimen of the textile, in contact with one or two specified adjacent fabrics, is mechanically agitated under described conditions of time and temperature in a soap solution, then rinsed and dried. The change in color of the specimen and the staining of the adjacent fabric are assessed with the grey scales.[34]

Table 3, It shows that the color fastness to washing for all samples is almost the same (3-4) except for mordanting with aloe vera and that is very good (4-5). Because, the aloe vera mordanted fabric makes the coordination bonding with dye fiber which can't break during washing (Sample B) (Figure 6).

Table 3 Colorfastness to washing

Sample	Change in color	Staining in color					
		Wool	Acrylic	Polyester	Polyamide	Cotton	Acetate
A	2	4-5	4-5	4-5	3-4	3-4	3-4
B	1	3-4	4-5	4-5	4-5	4-5	4-5
C	2	3-4	3-4	3-4	3-4	3-4	4-5
D	3-4	4-5	4-5	4-5	3-4	3-4	3-4

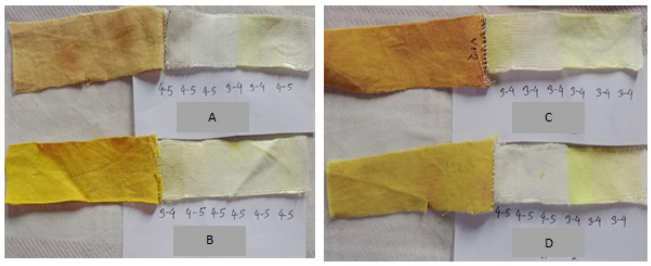

Figure 6 Colorfastness to wash (Sample A, B, C & D).

Colorfastness to water

From the Table 4, it shows that the collar fatness values of sample B, D and Sample A, C are 4-5 and 3-4 respectively. It means that the water fastness values of B and D is higher than A and C. Because of the use of aloe vera mordant and the dye-fibre bond formation between the fibre and the dyes.

Color fastness to perspirations (acid/alkali)

For measuring color fastness to perspiration testing method EN ISO 105 E04-2013 is followed. Skyline perspiration tester machine is used for measuring the color fastness to perspiration (acid/alkali).

Table 4 Colorfastness to water

Sample	Change in color	Staining in color					
		Wool	Acrylic	Polyester	Polyamide	Cotton	Acetate
A	3-4	3-4	3-4	3-4	3-4	3-4	3-4
B	3-4	4-5	4-5	4-5	4-5	4-5	4-5
C	3-4	3-4	3-4	3-4	3-4	3-4	3-4
D	3-4	4-5	4-5	4-5	4-5	4-5	4-5

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The bio-mordanted samples have displayed better colorfastness against perspiration due to the dye-metal-dye chelation. The Bio-mordanted natural dyed samples have no staining revealed (Table 5) (Table 6). From both Table 5 and Table 6), no major changes were found in term of color fastness to perspirations in acid and alkali. But one thing here cleared that the greater amount of aloe vera mordant shows better fastness property than the lower (Sample B and D). That's why, the color fastness value of sample B (200ml aloe vera) is higher than sample D (160ml aloe vera).

Table 5 Color fastness to perspirations (acid)

Sample	Change in color	Staining in color					
		Wool	Acrylic	Polyester	Polyamide	Cotton	Acetate
A	3	4	3-4	4-5	4-5	4-5	4-5
B	4	4-5	4-5	4-5	4-5	4-5	4-5
C	3	4-5	4-5	4-5	4-5	4-5	4-5
D	3-4	4-5	4	4-5	4-5	4-5	4-5

Table 6 Color fastness to perspirations (alkali)

Sample	Change in color	Staining in color					
		Wool	Acrylic	Polyester	Polyamide	Cotton	Acetate
A	3	4	4	4-5	4-5	4-5	4-5
B	4	4-5	4-5	4-5	4-5	4-5	4-5
C	3	4	4	4-5	4-5	4-5	4-5
D	3-4	4-5	4	4-5	4-5	4-5	4-5

Color fastness to light

From Table 7 Light-fastness is defined as the resistance to fading under exposure to light. Samples B and D exhibited better (4–5) color fastness against light whereas samples displayed moderate light-fastness (3). Samples A and C showed 3-4 color rating values due to their low fastness attributes than samples B and D (Table 7).

Table 7 Color fastness to perspirations (alkali)

Sample	Grading
A	3-4
B	4–5
C	3-4
D	4–5

pH test mordanting

The pH value of both mordanting agents is slightly acidic P^H. So, the dyeing condition will be preferred as acidic condition (Table 8).

Table 8 pH test

Description	Value
Mordanting with $CuSO_4$	6.4
Mordanting with Aloe Vera	6.1

Shrinkage

Table 9, indicates that all samples exhibited about an equal amount of shrinkage properties in length and widthwise. No major changes were found in all sample shrinkage ranges were in the standard level. The shrinkage value was about 3% which was acceptable for garment making.

Table 9 Shrinkage behavior of all dyed samples

Sample	Shrinkage%	
	Length %	Width %
A	-2.8	-3
B	-2	-2.4
C	-2.7	-2.3
D	-2.3	-2.9

Table 10 Tensile properties

Fabric direction	Tensile properties	A	B	C	D
Lengthwise	Max. breaking force (N)	202	200	213	218
	Elongation (%) at break	112.2	131.4	119.4	129
Widthwise	Max. breaking force (N)	151	166	159	165
	Elongation (%) at break	130.4	142.5	135.2	140.5

Tensile properties

Table 10 indicates the change of tensile strength as a function of dyed with Turmeric powder before dyeing and after dyeing on receptive 4 fabric samples (A, B, C & D). From the above table, it has been observed that tensile strength and elongation percent at break of 100% cotton. According to the experimental data, the order of tensile properties lengthwise is D>C>A>B and widthwise is B>D>C>A.

Conclusion

The world is getting sustainability day-by-day. So, it is high time to think about the use of hazardous chemicals and go for natural products. From this study, the use of natural dyes and bio-mordants plays a vital role to product eco-friendly natural dyes garment. Although, the naturally dyed cotton fabric may not be used for commercial purposes but it can be used for some important use such as face masks where color is not an issue. But considering, its availability in nature, biodegradable, non-toxic, and eco-friendly concepts, the natural dyed fabric is safer than the chemically production. The complete project indicates that it has a future value and the idea can be applied commercially if further research or work is performed. This project will help the researchers a lot in acquiring knowledge about natural dyes and their application along with their significance and the future applications.

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None.

Author's contributions

SSA planned and supervised the research work and provided guidelines to JG and DJD. Moreover, they have also done the specimen

fabrication, characterization, testing, data analysis, and presentation part. All authors read and approved the final manuscript.

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Conflicts of interest

The authors declare no conflicts of interest regarding the publication of this manuscript.

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