

Dyeing of Cotton Fabric using Malabar Spinach (*Basella alba*) Leaves Aqueous Extract

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Abstract:- With the increasing awareness of synthetic dyes' health and environmental hazards, the coloring agents are manufactured using natural products due to their biodegradability, and high environmental compatibility is widespread nowadays. This study dyed cotton fabrics with the natural color extracted from Malabar spinach (*Basella alba*) leaves. The colorant was extracted from the leaves using an aqueous extraction technique, and the cotton fabric was dyed in two processes by only the pure coloring extraction and added NaCl as a fixation agent to increase the fixation rate of natural dyes. Finally, dyed fabrics have been subjected to different textile laboratory tests, e.g., color absorbance %, tensile strength, tear strength, water fastness, wash fastness, perspiration fastness, and rubbing fastness (dry and wet). Considering the results, dyeing with purely natural dyes without any fixation agent could be an effective process for cotton dyeing.

Keywords:- natural dye; cotton; cotton fabric dye; eco-friendly dyeing; malabar spinach; colorfastness.

I. INTRODUCTION

Dyes impart color to textiles, paper, leather, food, and other materials. The coloring is not readily altered by washing, heat, light, or other factors to which the material is likely to be exposed. The dyes can be classified into two main categories, synthetic and natural. In modern days, synthetic dyes have been used frequently due to their bright colors, various colors, stable properties, convenient use, and low price. But, after dyeing with synthetic dyes, the wastewater is removed without proper treatment, affecting the land and water [1]. According to scientists, textile production is the second sizeable polluting sector, and synthetic dyes with 40% carcinogens pollute 17-20% of water [2].

The United Nations designed a blueprint by producing 17 goals that call Sustainable Development Goals to achieve a better sustainable future for all. These goals talk about good health and well-being, clean water and sanitation, climate action, life below water, and life on land. So, to achieve this goal, synthetic dyes are entirely threatening to us [3]. In the present scenario, people's environmental consciousness about natural more minor environmental damage renewable products, and the sustainability of the natural products have further revitalized natural dyes in dyeing textile materials [4].

Natural dyes are colorants with eco-friendly characteristics obtained from plants, invertebrates, or minerals without chemical processing [5] and the ability to

be composed quickly in the soil after end-use due to their sustainability [6]. Due to frequent changes in fashion trends, the development of the natural dye production process and the application of natural dyes draw significant attention [7]. Researchers are attracted to an extensive scope of opportunities in natural resources with attractive colors [8]. Many plants and animal/insect sources have been identified newly as sources for the extraction of color. Various extractions techniques are used to collect natural dyes from different sources. In the simple dyeing process, the natural material is put in a pot of water and heated to extract the dye compounds from it into a solution with the water. Then the textile product is added to the pot and heated until the desired color is achieved. Textile fiber may be dyed on yarn condition or fabric condition [5].

Natural dyes are suitable for the dyeing of animal fibers, and it is more challenging to dye cellulosic fibers like cotton, flax, and jute [9]. With the sustainable impact, the natural dyes face poor to moderate colorfastness [10], non-reproducibility of shades, absence of a standardized procedure for extraction and application [11], and high energy consumption during extraction with high cost [12, 13]. Natural dyes also have a significantly lower affinity for fibers [14]. As a fixing agent, mordant can be used for this situation, and metallic mordant can be the opposite of an eco-friendly condition [4]. Mordants are substances utilized to fix a dye to the fibers. Like other fixing agents, they are generally metallic salt of aluminum, chromium, iron, copper, and tin [15].

This work chose Malabar spinach (*Basella alba*) as a representative source for a plant-based natural dye. It is an edible leaf vegetable [16], and the leaf is used here. The product not only represents the color but also is used for antipruritics, burn, acne, and freckle treatment. In ayurvedic treatment, it has been used for anticancer such as melanoma, leukemia, and oral cancer [17, 18]. Malabar spinach also contains sodium, potassium, calcium, iron, magnesium, protein, carbohydrate, vitamins [19]. So, the wastewater of dyeing without mordant can be used as fertilizer. The present work aims to investigate the suitability of Malabar spinach in the form of natural dye, dyeing, and characterization in the textile field.

II. MATERIALS AND METHOD

A. Materials

- Leaves of Malabar spinach (*Basella alba*)
Malabar spinach leaves available in Dhaka city were used for this study to extract natural dyes.
- Chemicals

Common salt NaCl (Sodium chloride) was used as a fixation agent for natural dye.

c) Fabric

A plain woven bleached cotton fabric was used for dyeing studies with one up one down plain structure and 120 GSM.

B. Methods

a) Extraction of natural dyes

For dye extraction, one part of Malabar spinach (*Basella alba*) leaves was mixed with six parts of distilled water at room temperature. The coloring agent was extracted by heating the mixed elements at 100°C temperature. The boiled materials were then filtered using a cotton cloth to remove insoluble residues, and the remaining residue was extracted again to get maximum colorant. This filtrate was afterward used for cotton dyeing.

a) Fabric dyeing process

The cotton fabric was dyed with the colorant in two processes. Firstly without fixation agent, secondly with fixation agent. Table I shows the recipe for dyeing cotton fabric with or without the fixation agent. Then the samples were dyed with different dye baths for the specified time and at a specific temperature. All the parameters were optimized to obtain the maximum possible dye bath exhaustion, best shade, and highest colorfastness.

Before the dyeing process, the pre-treatment was carried out with immersion of the sample fabric in hot water to boost the uniform penetration of the dye molecules. The dyeing of cotton fabric with or without a fixation agent was carried out at 60°C for 60 minutes. Dyed samples were extensively washed with cold water to remove any unfixed materials and residues and finally dried at ambient temperature.

Dyeing process	MLR	Temperature	Time	Fixation agent	Concentration of fixation agent
Without fixation agent	1:30	60°C	1 hour	No	N/A
With fixation agent	1:30	60°C	1 hour	NaCl	50 g/l

Table 1

III. RESULTS AND DISCUSSIONS

A. Absorption of natural dyes

A T 92+ Double Beam UV-Vis Spectrophotometer (PG Instrument, UK) was used to measure the absorbance. The absorbance was found 1.852 for the initial dye solution without any agent. However, after 30 min and 60 min of dyeing, the absorbance was found to be 1.763 and 1.736, indicating the dye exhaustion percentage of 4.806% and 6.263%, respectively.

Furthermore, the absorbance was found 1.994 for the initial dye solution without any agent. However, after 30

min and 60 min of dyeing, the absorbance was found to be 1.263 and 1.179, indicating the dye exhaustion percentage of 36.723% and 40.873%, respectively.

Here, the fixation agent helps to absorb more colorant than the without fixation process. Both the samples showed greenish-gray color. However, the sample fabric dyed with the fixation agent showed a little darker than the other.



Fig. 1: Dyed sample without fixation agent



Fig. 2: Dyed sample with fixation agent

A. pH of natural dyes

The pH of the aqueous extracted dye was 7.03 and 9.66 for without and with fixation agents, respectively. The process without the fixation agent showed neutrality while dyeing.

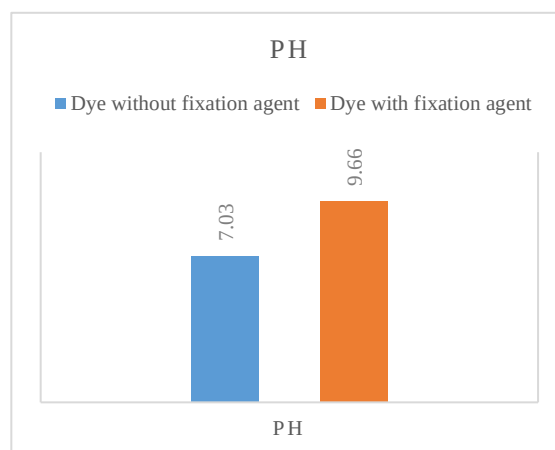


Fig. 3: pH of natural dyes

B. Tensile strength

Tensile strength test was performed on three samples based on ISO 13934 - 2:2014 grab test method to determine the maximum tensile strength in both warp and weft directions. After dyeing without fixation agent, tensile strength has reduced 1.88% in the warp direction, but with the fixation agent, it increased 2.51% than the raw, bleached fabric. For the weft direction, both without and with fixation agent

reduced tensile strength to 6.11% and 11.07%, respectively. However, the dyeing process with fixation agent showed better results than without fixation agent, while all the results are within the tolerable range. So, the process can be run without the fixing agent.

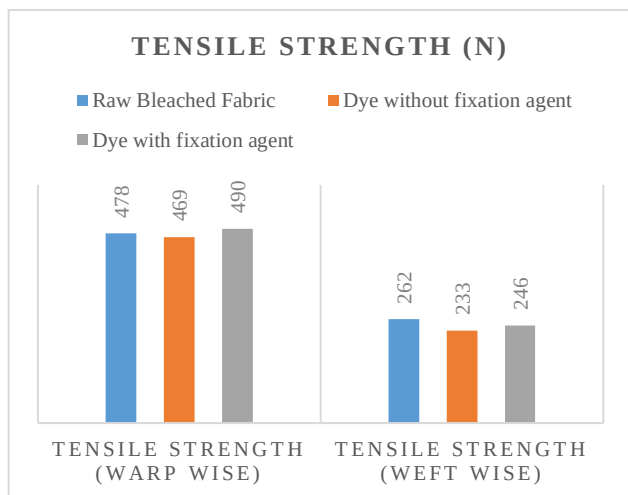


Fig. 4: Tensile strength of sample fabric

C. Tear resistance

Tear resistance test was performed on ISO 13937 - 1:2000 to determine the maximum tear resistance force in both warp and weft directions. After dyeing without fixation agent, the tear resistance for both warp and weft directions increased 24.43% and 17.07%, respectively. Otherhand the dyeing with fixation agent reduce the tear resistance for warp and weft direction to 4.69% and 15.6%, respectively. In this case, the dye without the fixation agent showed excellent results.

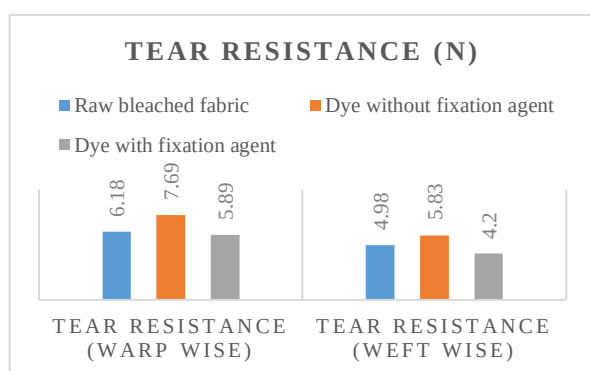


Fig. 5: Tearresistance of sample fabric

D. Color fastness

The dyed fabric's fastness properties (water fastness, wash fastness, perspiration fastness, and rubbing fastness) are presented in Tables II and III. All the selected dyeing processes perform acceptable fastness properties with the same result for the different dyeing procedures. The good colorfastness properties show that the dyeing was done correctly, and there is no need to add a fixation agent at all. So, for this situation use of the fixation agent is useless. Water fastness test, wash fastness test, perspiration fastness test, and rubbing fastness test were performed on ISO 105-

E01, ISO 105-C06, ISO 105-E04, and BS 105 X12-2016, respectively.

IV. CONCLUSION

The natural dye extracted from Malabar spinach (*Basella alba*) leaf might be a possible substitute for synthetic dyes. An organized study of extraction can improve the dye's properties to minimize the cost of investment and dye fixation. The dyeing performances of the dyed fabrics were determined considering the amount of dye absorption, tensile strength, tear strength, and colorfastness properties. Both the dyed sample with or without fixation agents showed satisfactory results. The good thing is that the extraction's dyes and wastages are eco-friendly and biodegradable. There are still need some improvements in the dyeing process and selection of raw materials that need further studies.

Types	Water fastness		Wash fastness		Perspiration fastness (Acid)	
	Without fixation agent	With fixation agent	Without fixation agent	With fixation agent	Without fixation agent	With fixation agent
Color change	4	4	3/4	3/4	3	3
Staining (Acetate)	4/5	4/5	4/5	4/5	4/5	4/5
Staining (Cotton)	4/5	4/5	4/5	4/5	4/5	4/5
Staining (Nylon)	4/5	4/5	4/5	4/5	4/5	4/5
Staining (Polyester)	4/5	4/5	4/5	4/5	4/5	4/5
Staining (Acrylic)	4/5	4/5	4/5	4/5	4/5	4/5
Staining (Wool)	4/5	4/5	4/5	4/5	4/5	4/5

Table 2

Rubbing fastness							
Dry				Wet			
Without fixation		With fixation		Without fixation		With fixation	
Color change	Stainin g	Color change	Staini ng	Color change	Staini ng	Color change	Stainin g
4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5

Table 3

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