Advanced in Textile Wet Processing Technology

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Department of Textile Engineering

Faculty of Engineering

Project (Thesis) Report on

"Dyeing of Knitted Cotton with Extraction of Moringa Leaf as a Natural Dye Emphasized on Different Mordanting Approaches"

Course Code: TE-4214 **Course Title:** Project (Thesis).

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This project(Thesis) is presented for fulfilling the requirement of completing Bachelor degree in Textile Engineering.

DECLARATION

We thus declare that this project (Thesis) report was produce by our own selves under the guidance of Md. Kamrul Islam, a Lecturer of Department of Textile Engineering, under the Faculty of Engineering, Daffodil International University. Us here additionally announce that any part of this paper has never been presented anywhere with the intention of awarding a degree.

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LETTER OF APPROVAL

To,

The Department Head

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Subject: Acceptance of 4^{th} year thesis report.

Sir,

This message is to make you learn that the thesis paper you are currently going through named as **“Dyeing of Knitted Cotton with Extraction of Moringa Leaf as a Natural Dye Emphasized on Different Mordanting Approaches”** is finished for last assessment. The report as a whole has been created utilizing suitable research techniques and interpretations based on a careful review of empirical data and the required attachments. Given that the students took an active role in their project, the report is crucial in furnishing readers with an abundance of valuable insights.

Therefore, before choosing to evaluate my project report, I would really appreciate it if you would accept it and give it some attention.

Regards,

Md. Kamrul Islam

Lecturer,

Textile Engineering Department.

Faculty of Engineering.

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ACKNOWLEDGENT

We extend our heartfelt gratitude to our thesis advisor, Md Kamrul Islam, for his unwavering support, invaluable guidance, and insightful feedback throughout the entire duration of this research endeavor. Your expertise, patience, and encouragement have been indispensable in shaping the trajectory of this thesis and our academic growth.

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We express our profound gratitude to all those mentioned above and countless others who have, directly or indirectly, contributed to the fruition of this research project. Your support, encouragement, and collective efforts have been invaluable, and for that, we are deeply grateful.

At the end, we express our gratitude to all our educators, classmates, guiders and the Almighty Allah for the accomplishment of this project.

ABSTRACT

The textile industry stands at the precipice of a significant transformation, spurred by an escalating demand for sustainable practices. This research delves into the potential of Moringa leaf extract as a natural dye for the dyeing of 100% cotton knitwear, with a meticulous examination of diverse mordanting methodologies. The overarching objective is to propel the evolution of eco-conscious dyeing processes within the textile domain.

The research methodology encompasses a multifaceted approach, commencing with the extraction of dye from Moringa leaves. Subsequently, this extract is applied to cotton knit fabrics employing an array of mordanting techniques. Central to this inquiry is the comprehensive evaluation of color fastness, vibrancy, and the ecological footprint associated with each mordanting agent.

The investigation pivots around conducting comparative analyses to discern the most efficacious and sustainable combinations of Moringa leaf extract and mordants tailored for cotton knit textiles. By accentuating the diversification of mordanting approaches, this thesis endeavors to unveil optimal strategies for harnessing the potential of Moringa leaf extract as a natural dye. The ultimate goal transcends mere aesthetic enhancement, striving to engender a paradigm shift towards heightened sustainability.

The insights gleaned from this research are poised to make meaningful contributions to the broader discourse on green and sustainable practices prevalent within the textile landscape. By furnishing a viable eco-friendly alternative for dyeing cotton knit fabrics, this study endeavors to carve a pathway towards a more environmentally conscious future for the textile industry.

In essence, this research encapsulates a concerted effort to reconcile innovation with sustainability, epitomizing the ethos of responsible stewardship that is imperative for the longevity and vitality of our planet and its resources.

Keywords: Moringa Leaf, Dyeing, Mordant, Sustainability, Spectrophotometer.

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Chapter-01
Introduction

1.1 INTRODUCTION:

In an increasingly changing landscape of the textile sector, sustainability and environmental practices have become a major factor. This thesis will examine the issue of environmental sustainability in textile dyeing by examining whether the extraction of Moringa leaf can be applied as an organic dye for cotton textiles. The importance of switching textile dyes to more environmentally friendly alternatives is highlighted in this research entitled " **Dyeing of Knitted Cotton with Extraction of Moringa Leaf as a Natural Dye Emphasized on Different Mordanting Approaches** ".
The impetus driving this research stems from the imperative to address the inherent drawbacks of conventional synthetic dyes, which not only pose significant environmental hazards but also engender adverse health effects and contribute to water pollution. Against this backdrop, the utilization of natural dyes assumes paramount importance as a means to reconcile the twin imperatives of aesthetic appeal and ecological stewardship within the textile domain.

The utilization of Moringa leaf extract as a natural dye holds immense promise, rooted in its rich phytochemical composition encompassing flavonoids, tannins, and anthocyanins, among other bioactive constituents. These bioactive compounds not only confer vibrant hues to textiles but also offer inherent antimicrobial and antioxidant properties, thereby endowing dyed fabrics with added functionality and appeal.

The research methodology adopted in this thesis entails a systematic investigation encompassing multiple facets of the dyeing process. Beginning with the extraction of dye from Moringa leaves, the study progresses to the application of the dye onto knitted cotton fabrics employing diverse mordanting techniques. This multifaceted approach enables a holistic evaluation of various parameters such as color fastness, wash durability, lightfastness, and eco-toxicological considerations, thereby furnishing comprehensive insights into the efficacy and sustainability of different dye-mordant combinations.

By elucidating the intricate interplay between Moringa leaf extract and diverse mordants, this thesis seeks to unravel optimal strategies for achieving vibrant and long-lasting coloration of cotton knitwear while minimizing environmental footprint. Moreover, the study endeavors to contribute to the broader discourse on green and sustainable practices within the textile industry, thereby fostering a paradigm shift towards a more ecologically benign and socially responsible approach to textile dyeing.

In essence, this thesis endeavors to chart a course towards a more sustainable future for the textile industry by harnessing the untapped potential of Moringa leaf extract as a natural dye, underscored by a nuanced understanding of varied mordanting approaches and their implications on dyeing efficacy and environmental sustainability.

The objective is to contribute to a wider discussion on sustainable practices in the textile sector as we undertake this investigation into Moringa leaf extract and various mordanting methods. We aim to provide valuable information through this investigation that could potentially change the way we perceive and implement natural dyeing processes. The synthesis of traditional wisdom, modern science, and a commitment to sustainable practices underpins the essence of " **Dyeing of Knitted Cotton with Extraction of Moringa Leaf as a Natural Dye Emphasized on Different Mordanting Approaches**," a thesis poised at the intersection of innovation and eco-conscious textile coloration.

OBJECTIVES

1.2 Objectives of the study:

- ✓ Examine the feasibility of Moringa leaf extract as a natural dye for cotton knitwear.
- ✓ Evaluate the impact of varied mordanting approaches on colorfastness and durability.
- ✓ Optimize laboratory procedures for dyeing cotton knitwear with Moringa leaf extract.
- ✓ Assess the spectrum of colors achieved through Moringa leaf extract dyeing.
- ✓ Investigate the environmental sustainability of Moringa leaf extract dyeing.
- ✓ Compare research findings with existing literature on natural dyeing techniques.
- ✓ Provide practical recommendations for integrating Moringa leaf extract into sustainable textile dyeing practices.
- ✓ To investigate the feasibility of extracting dye from Moringa leaves for use in dyeing knitted cotton fabrics.
- ✓ To explore various mordanting approaches for enhancing the color stability, vibrancy, and wash durability of Moringa leaf extract on cotton knitwear.
- ✓ To evaluate the color fastness properties of Moringa leaf-dyed cotton knit fabrics under different mordanting conditions, including lightfastness, wash fastness, and rub fastness.
- ✓ To assess the environmental impact of utilizing Moringa leaf extract as a natural dye, with a focus on the eco-toxicological profile of mordanting agents and dyeing processes.
- ✓ To compare and analyze the efficacy and sustainability of different mordanting techniques in conjunction with Moringa leaf extract for dyeing cotton knit textiles.
- ✓ To identify optimal combinations of Moringa leaf extract and mordants that yield vibrant coloration, excellent color fastness, and minimal environmental footprint.
- ✓ To contribute to the advancement of knowledge in sustainable textile dyeing practices by providing insights into the utilization of Moringa leaf extract as a natural dye and its compatibility with diverse mordanting approaches.
- ✓ To propose recommendations and guidelines for the adoption of eco-friendly dyeing processes utilizing Moringa leaf extract in the textile industry, with a view towards promoting environmental sustainability and social responsibility.

Chapter- 2
Literature Review

LITERATURE REVIEW

The Ready Made Garments industry is undergoing a exemplar change towards sustainability, driven by increasing environmental concerns and consumer demand for eco-friendly products. Natural dyes derived from plant sources have emerged as promising alternatives to synthetic dyes due to their biodegradability, low environmental impact, and potential health benefits. Among these natural dyes, Moringa leaf extract has garnered significant attention for its rich pigment content and diverse chemical composition.

Dyeing processes using natural dyes have gained increasing attention in recent years because the textile industry is placing an increasing emphasis on environmentally friendly and sustainable approaches. In the study conducted by Hasan, Sarkar, and Hassan [1], the authors explore the application of natural dye and mordant on 100% cotton fabric. This section reviews existing literature related to natural dyeing processes, with a focus on the findings presented in the mentioned study.

The extraction and application of eco-friendly natural dyes have become pivotal areas of exploration in the textile industry, aligning with the broader global movement towards sustainable practices. In a study conducted by Uddin [2], the focus is on the extraction of natural colorant from mango leaves and their subsequent usage on silk fabric. This literature review aims to contextualize this study within the broader landscape of natural dye extraction and its application on textiles.

The utilization of plant-based sources for extracting natural dyes has gained prominence due to their eco-friendly nature. Mango leaves, in particular, possess bioactive compounds that can potentially yield vibrant and sustainable colorants. Uddin's study [2] contributes to this field by investigating the extraction process, shedding light on the feasibility of mango leaves as a source of natural dyes.

Literature on natural dyeing encompasses a diverse array of mordanting techniques, each with its advantages and limitations. From traditional methods employing metal salts to eco-friendly alternatives like plant-based mordants and natural fermentation processes, researchers have explored innovative approaches to enhance the sustainability and eco-compatibility of textile dyeing practices.

In summary, the literature underscores the future of Moringa leaf extract as a sustainable natural dye for cotton knitwear, with a focus on exploring varied mordanting approaches to optimize colorfastness and environmental performance. By synthesizing insights from previous studies, this research aims to contribute to the advancement of eco-conscious textile dyeing practices and pave the way for a greener future in the textile industry.

Chapter-03
Materials & Methods

Materials and Methods

3.1 Materials:

3.1.1 Fabric:

- Types of fabric: 100% cotton scoured and bleached fabric (single jersey)
- Each fabric sample weight: 2.5 gram
- GSM of fabric: 170GSM

3.1.2 List of chemicals that are used for coloration:

Auxiliaries:

- Wetting agent
- Sequestering agent
- Levelling agent

Mordants:

- Tannic acid
- Alum
- Citric acid (used lemon for source of citric acid)

pH controller:

- Citric acid
- Soda ash

3.2 Machines:

Sample Dyeing machine: In the realm of textile research, the selection of an appropriate dyeing machine plays a pivotal role in facilitating efficient experimentation and evaluation of dyeing processes. Given the intricate nature of dye extraction from natural sources such as Moringa leaves and the subsequent application onto knitted cotton fabrics, a sample dyeing machine emerges as an indispensable tool for achieving precision, consistency, and reproducibility in experimental outcomes.

The sample dyeing machine serves as the conduit through which the intricacies of the dyeing process are orchestrated, offering researchers a controlled environment to manipulate various parameters and assess their impact on dye uptake, color fastness, and overall dyeing efficacy. In the context of the thesis titled "Dyeing of Knitted Cotton with Extraction of Moringa Leaf as a Natural Dye Emphasized on Different Mordanting Approaches," the selection and utilization of an appropriate sample dyeing machine assume paramount importance in ensuring the robustness and validity of research findings.

- **Digital balance:**
  A digital scale is an indispensable tool in the textile industry for measuring precise quantities of raw materials. This ensures accuracy in the formulation of dye recipes, chemical solutions and other materials. Digital scales enable fast and reliable measurements, which promotes the efficiency and consistency of the production process.
- **Crock meter:** A colorimeter is used to evaluate the color fastness of dyed or printed textiles to abrasion or abrasion. By simulating wear, this machine helps determine the color fastness of fabrics. The results obtained from the battery meter are important to ensure that the final product meets quality standards and customer expectations.
- **pH meter:** The pH meter plays a key role in measuring the acidity or alkalinity of solutions used in textile processes. Maintaining the correct pH level is very important to achieve the desired color results during dyeing and to ensure the effectiveness of the chemical treatment.
- **Spectrophotometer**: In the realm of textile research, the spectrophotometer machine emerges as an indispensable tool for the quantitative analysis and characterization of dyed fabrics. Integral to the thesis titled **"Dyeing of Knitted Cotton with Extraction of Moringa Leaf as a Natural Dye Emphasized on Different Mordanting Approaches,"** the spectrophotometer plays a crucial role in objectively assessing color properties, determining colorfastness, and elucidating the intricacies of dye-mordant interactions.

  The spectrophotometer operates on the principle of spectrophotometry, wherein it measures the intensity of light transmitted through or reflected from a sample across different wavelengths within the visible spectrum. By quantifying the absorption or reflectance of light by the dyed fabric at various wavelengths, the spectrophotometer facilitates the determination of colorimetric parameters such as hue, chroma, and lightness, thereby providing a comprehensive understanding of the color characteristics of the dyed textiles.

  One of the primary functions of the spectrophotometer in the context of the thesis is the assessment of color fastness properties of Moringa leaf-dyed cotton knit fabrics. Through spectral analysis, the spectrophotometer enables researchers to quantify changes in color intensity and hue resulting from exposure to external factors such as light, washing, and abrasion. This quantitative data facilitates the evaluation of color fastness ratings according to established standards, thereby providing insights into the durability and stability of the dyeing process under real-world conditions.

Moreover, the spectrophotometer serves as a valuable tool for elucidating the influence of different mordanting approaches on the color characteristics of dyed fabrics. By comparing spectral data obtained from samples dyed using various mordants, researchers can discern subtle differences in coloration and identify optimal combinations that yield desired color outcomes while ensuring compatibility with sustainable dyeing practices.

Furthermore, the spectrophotometer facilitates the analysis of color consistency and uniformity across dyed fabrics, enabling researchers to detect and mitigate potential inconsistencies or defects in the dyeing process. Through precise color measurement and analysis, the spectrophotometer empowers researchers to achieve reproducible and standardized dyeing outcomes, thereby enhancing the reliability and credibility of research findings.

In addition to color analysis, the spectrophotometer can be utilized for the quantification of dye concentration in Moringa leaf extracts and dye liquor solutions, enabling researchers to optimize dyeing recipes and ensure consistent dye uptake across different fabric samples. This quantitative analysis is instrumental in fine-tuning dyeing parameters and achieving desired color saturation levels while minimizing dye wastage and environmental impact.

In summary, the spectrophotometer machine plays a pivotal role in the research methodology outlined in the thesis, facilitating objective color analysis, quantification of dye concentration, and evaluation of color fastness properties. By leveraging the capabilities of the spectrophotometer, researchers can gain deeper insights into the dyeing process, optimize dye-mordant interactions, and contribute to the advancement of sustainable textile dyeing practices.

- **Mixer/Grinder:** The mixer/mill is used to prepare various solutions and preparations for textile processing. This ensures uniform mixing of dyes, chemicals and other materials, which contributes to the uniformity and quality of the final product. This machine is essential for reproducible results in dyeing and chemical processing.
- **Dryer:** A dryer is an important part of the textile finishing process, where it is used to remove moisture from fabrics after dyeing or washing. Effective drying is crucial, for example, to prevent paint bleeding, to ensure the stability of dyes and to achieve the desired hand feel in the finished product. Dryers contribute to the overall efficiency of textile production.

- **Light box**: The light box is a controlled environment that provides standard lighting conditions for textile color evaluation and quality control. It is used to assess color uniformity, detect defects and ensure fabric compliance to specified color standards. The light box is an important tool for accurate visual inspection of textiles in normal lighting conditions.

3.3 Dye:

Moringa leaf: Known for its health benefits, moringa leaves also contain important pigments. The vibrant green pigments found in moringa leaves can be extracted and used as a natural textile dye. This eco-friendly color option offers green hues but also has antibacterial properties. The process involves collecting and drying the leaves, removing the dye and applying it to the fabric. Using Moringa leaves as a dye is compatible with sustainable practices and offers a unique and environmentally friendly approach to textile dyeing.

3.4 Methods:

3.4.1 Natural dye extraction from moringa leaf:

The process of getting natural dye from moringa leaves is relatively straightforward. Moringa leaves have pigments that can be withdrawn using water or other kinds of solvents.

3.4.2 Dye extraction:

Selecting vibrant green and healthy-looking leaves is essential for optimal results.
Wash the leaves thoroughly to clear them of any dirt or debris. The recommended amount leaves are 70 grams. With a sharp knife, chop the leaves into pieces. Mesh chopped leaves with a Stone Sculpture. Add sufficient distilled water(1400ml). The proportion of water to leaves may differ. Yet, an ideal kick-off is around 20ml of water for each 1 gm of crushed leaves. Heat the substance at 50C for 10 minutes on low to medium heat level, then proceed to simmer the mixture. After the mixture

has been to cool, the liquid dye should be separated from the solid plant material using a strainer. It's crucial to fully squeeze the plant material for maximum liquid extraction. The dye obtained from moringa leaves is now ready for application.

Fresh moringa leaves | Meshed moringa leaves | Mixed with water | Dry extract from moringa leaves

3.4.3 Methods of dyeing cotton 100% fabric (single jersey) with natural dye (Moringa leaves):

We experimented with varying pH (4.6,7,11) levels in the dye bath and utilized different mordants for dyeing cotton fabric with moringa leaves. Tannic acid, alum, and citric acid were employed as mordants. The fabric was dyed with each mordant consecutively under different pH conditions - alkaline, acidic, neutral, and uncontrolled. To adjust the pH, we added soda for alkaline conditions and citric acid for acidic conditions. A total of 12 samples were dyed in this manner. For the dye bath preparation, a pot was selected initially to mix in natural dye, wetting agent, sequestering agent, levelling agent, and mordant. The pH level was controlled using soda ash or citric acid. Usage of pH controller is unnecessary in uncontrolled pH baths.

The fabric sample was then submerged in the dye bath before being transferred into the dyeing pot and placed inside the dyeing machine. A temperature of 80°C was maintained for a duration of 30 minutes.

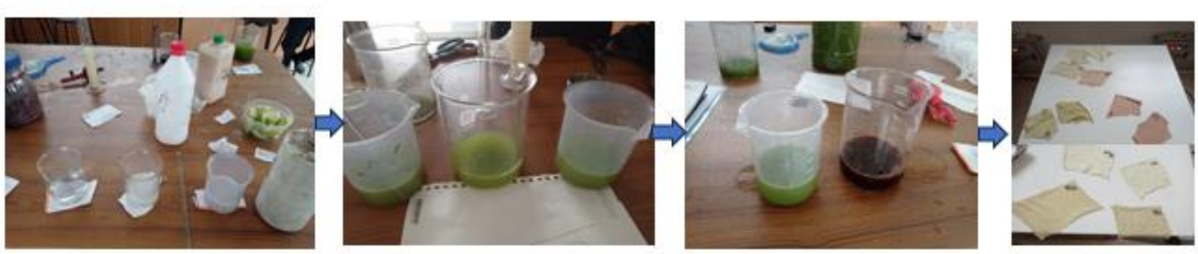
Subsequently, all dye pots were removed from the machine, and each sample fabric was rinsed thoroughly with water to eliminate excess dye and mordant. Finally, the samples were dried at 120°C for two minutes.

The results indicated that the choice of mordant and pH level significantly influenced the color outcomes on the cotton fabric. Each variation in pH and mordant yielded unique shades and intensities, demonstrating the versatility of moringa leaves as a natural dye source. The experiment successfully showcased the impact of different parameters on the dyeing process.

3.5 Different machine used for study:


Sample dyeing M/C

3.6 Preparation of dye bath to final dyed sample:



3.7 Process sequence of coloring:

A Collection of 100% cotton pre-treated samples

↓

Dyeing with moringa leaves natural dye at 80°C for 30 Minutes

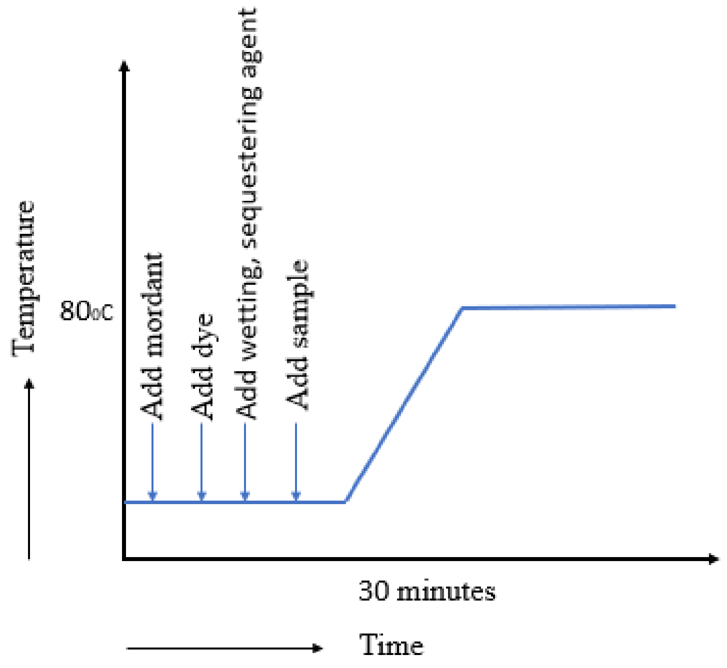
↓

Cold rinsing (with normal water)

↓

Drying at 120°C for 2 min

3.8 Process flowchart of dyeing:



3.9 Recipe:

3.9.1 Recipe for mordant - tannic acid (PH 4.6):

SL	Name	Unit	Dossing	Stock Solution percentage
1	Wetting agent	gm per liter	10	1%
2	Sequestering agent	gm per liter	10	1%
3	Levelling agent	gm per liter	10	1%
4	Tannic acid	gm per liter	0.5	
5	Dye (moringa leaf)	gm per liter	70	
6	Citric acid	gm per liter	1	
7	Time	min	30	
8	Temperature	˚C	80	
9	M: L	gm per liter	1: 40	

3.9.2 Recipe for mordant tannic acid (PH 7):

SL	Name	Unit	Dossing	Stock Solution percentage
1	Wetting agent	gm per liter	10	1%
2	Sequestering agent	gm per liter	10	1%
3	Levelling agent	gm per liter	10	1%
4	Tannic acid	gm per liter	0.5	
5	Dye (moringa leaf)	gm per	70	

		liter		
6	Soda ash	gm per liter	1.5	
7	Time	min	30	
8	Temperature	˚C	80	
9	M: L	gm per liter	1: 40	

3.9.3 Recipe for mordant tannic acid (PH 11):

SL	**Name**	**Unit**	**Dossing**	**Stock Solution percentage**
1	Wetting agent	gm per liter	10	1%
2	Sequestering agent	gm per liter	10	1%
3	Levelling agent	gm per liter	10	1%
4	Tannic acid	gm per liter	0.5	
5	Dye (moringa leaf)	gm per liter	70	
6	Soda ash	gm per liter	3	
7	Time	min	30	
8	Temperature	˚C	80	
9	M: L	gm per liter	1: 40	

3.9.4 Recipe for mordant tannic acid (Without PH control):

SL	**Name**	**Unit**	**Dossing**	**Stock Solution percentage**
1	Wetting agent	gm per liter	10	1%
2	Sequestering agent	gm per liter	10	1%
3	Levelling agent	gm per liter	10	1%
4	Tannic acid	gm per liter	0.5	
5	Dye (moringa leaf)	gm per liter	70	

6	Time	min	30	
7	Temperature	˚C	80	
8	M: L	gm per liter	1: 40	

3.9.5 Recipe for mordant citric acid (PH 4.6):

SL	Name	Unit	Dossing	Stock Solution percentage
1	Wetting agent	gm per liter	10	1%
2	Sequestering agent	gm per liter	10	1%
3	Levelling agent	gm per liter	10	1%
4	Citric acid	gm per liter	0.5	
5	Dye (moringa leaf)	gm per liter	70	
6	Citric acid (for control PH)	gm per liter	1	
7	Time	min	30	
8	Temperature	˚C	80	
9	M: L	gm per liter	1: 40	

3.9.6 Recipe for mordant citric acid (pH 7):

SL	Name	Unit	Dossing	Stock Solution percentage
1	Wetting agent	gm per liter	10	1%
2	Sequestering agent	gm per liter	10	1%
3	Levelling agent	gm per liter	10	1%
4	Citric acid	gm per liter	0.5	
5	Dye (moringa leaf)	gm per liter	70	
6	Soda ash	gm per liter	As per required	
7	Time	min	30	
8	Temperature	˚C	80	

9	M: L	gm per liter	1: 40	

3.9.7 Recipe for mordant citric acid (PH 11):

SL	Name	Unit	Dossing	Stock Solution percentage
1	Wetting agent	gm per liter	10	1%
2	Sequestering agent	gm per liter	10	1%
3	Levelling agent	gm per liter	10	1%
4	Tannic acid	gm per liter	0.5	
5	Dye (moringa leaf)	gm per liter	70	
6	Soda ash	gm per liter	3	
7	Time	min	30	
8	Temperature	˚C	80	
9	M: L	gm per liter	1: 40	

3.9.8 Recipe for mordant citric acid (Without PH control):

SL	Name	Unit	Dossing	Stock Solution percentage
1	Wetting agent	gm per liter	10	1%
2	Sequestering agent	gm per liter	10	1%
3	Levelling agent	gm per liter	10	1%
4	Citric acid	gm per liter	0.5	
5	Dye (moringa leaf)	gm per liter	70	
6	Time	min	30	
7	Temperature	˚C	80	
8	M: L	gm per liter	1: 40	

3.9.9 Recipe for mordant alum (PH 4.6):

SL	Name	Unit	Dossing	Stock Solution percentage
1	Wetting agent	gm per liter	10	1%
2	Sequestering agent	gm per liter	10	1%
3	Levelling agent	gm per liter	10	1%
4	Alum	gm per liter	0.5	
5	Dye (moringa leaf)	gm per liter	70	
6	Citric acid	gm per liter	1	
7	Time	min	30	
8	Temperature	˚C	80	
9	M: L	gm per liter	1: 40	

3.9.10 Recipe for mordant alum (PH 7):

SL	Name	Unit	Dossing	Stock Solution percentage
1	Wetting agent	gm per liter	10	1%
2	Sequestering agent	gm per liter	10	1%
3	Levelling agent	gm per liter	10	1%
4	Alum	gm per liter	0.5	
5	Dye (moringa leaf)	gm per liter	70	
6	Soda ash	gm per liter	1.5	
7	Time	min	30	
8	Temperature	˚C	80	
9	M: L	gm per liter	1: 40	

3.9.11 Recipe for mordant alum (PH 11):

SL	Name	Unit	Dossing	Stock Solution percentage
1	Wetting agent	gm per liter	10	1%
2	Sequestering agent	gm per liter	10	1%
3	Levelling agent	gm per liter	10	1%
4	Alum	gm per liter	0.5	
5	Dye (moringa leaf)	gm per liter	70	
6	Soda ash	gm per liter	3	
7	Time	min	30	
8	Temperature	˚C	80	
9	M: L	gm per liter	1: 40	

3.9.12 Recipe for mordant alum (Without PH control):

SL	Name	Unit	Dossing	Stock Solution percentage
1	Wetting agent	gm per liter	10	1%
2	Sequestering agent	gm per liter	10	1%
3	Levelling agent	gm per liter	10	1%
4	Alum	gm per liter	0.5	
5	Dye (moringa leaf)	gm per liter	70	
6	Time	min	30	
7	Temperature	℃	80	
8	M: L	gm per liter	1: 40	

3.10 Color fastness test: Dyed textile materials must contain a good colorfastness property.

There are different types ofcolorfastness tests available for different purposes. Most common colorfastness tests are Colorfastness to washing & colorfastness to rubbing.

3.10.1 Color fastness to rubbing:

Color fastness to rubbing is a crucial parameter in evaluating the stability of colors in textiles. It assesses how well the color adheres to the fabric or material when subjected to rubbing or abrasion. This property is significant for items like clothing, upholstery, and other dyed products that may experience friction during daily use.

Testing method:

The testing procedure typically involves rubbing a specimen of the material against a standard rubbing fabric under controlled conditions. The level of color transfer or fading is then evaluated visually or instrumentally. The test may use a variety of equipment, such as a crock meter, to simulate the rubbing action.

Rating scale:

Color fastness to rubbing is expressed on a scale, often ranging from 1 to 5, with 5 being the highest and 1 being the lowest. The scale helps communicate the degree of color stability under rubbing conditions:

5: Excellent - No color transfer or fading.

4: Good - Slight color transfer.

3: Moderate - Moderate color transfer.

2: Poor - Significant color transfer.

1: Very Poor - Severe color transfer or fading.

Dry test:

I started by taking my test sample and placing it in the machine's sample attaching portion. Next, a clip secures a 5 x 5 cm piece of 100% nonwoven fabric to the machine finger. The test is then resumed by lowering the machine finger over the attached sample and turning the machine on. Ten cycles are finished in ten seconds. Next, the test cloth is removed from the machine finger, and a grey scale is used to measure the fastness.

Wet test:

I utilized a wet sample in place of a dried sample for the wet test, but otherwise I followed the same steps as for the dry test. Here, the test sample (Grade-3) is wetted with distilled water.

3.10.2 Colorfastness to wash (ISO – 105 C06):

The most popular test for colorfastness is colorfastness to wash, which measures a textile's ability to maintain its color when washed with a soapy (detergent) solution. In order to do the test, I collected a 10 x 4 centimeter test sample and let it condition at 20 ± 2 ´ C and 65 ± 2% RH for around two hours. In order to truly comprehend colorfastness, we require a unique kind of fabric called a multifiber fabric. I used a sewing machine to stitch the multi-fiber cloth and my test sample together after cutting it to the same size, 10 by 4 cm. The sample was then added to a solution containing 4 grams of detergent (ECE) and 1 gram of Na_2CO_3 per liter.
I used a lab washing machine to carry out the washing procedure. I begin the process by adding the test sample and solution to the machine pot along with 25 stainless steel balls. The procedure was carried out at 60 ´ C for 30 minutes. Following the washing procedure, I gave the test sample a cold wash before drying it in a lab incubator oven. The last evaluation was completed once the test samples had dried.

3.11 CMC test using spectrophotometer:

A spectrophotometer is an instrument that measures light intensity throughout a spectrum's various web lengths. Spectrophotometer plays an important role in textile as a color measuring device. It helps manufacturers to identify the color by measuring color accurately, ensuring consistency in textile production achieve color consistency in dyeing process and uniformity in finished textile product.

Here,

ΔL^*= Lightness or Darkness

Result value (+) means shade Lighter.

Result value (-) means shade Darker

Δ a*=Reddish or Greenish

Result value (+) means shade Reddish

Result value (-) means shade Greenish.

Δ b*= Yellowness or Blueness

Result value (+) means shade Yellowish

Result value (-) means shade Bluish.

Δ c*= Croma

Result value (+) means shade Brighter

Result value (-) means shade duller.

Δ H*= Difference in Hue

CMC Δ E*= Pass/ Fail

The textile industry frequently uses the Color Matching Cabinet (CMC) test method to evaluate and regulate color consistency in textiles and clothing. This method involves comparing the color of a sample under standardized lighting conditions with a set of reference colors. CMC is based on the CIE (Commission Internationale de l'Eclairage) color space, and it provides a reliable way to quantify differences.

By using CMC values, textile professionals can objectively measure the perceptual color distance between samples, allowing for accurate color matching and quality control. This method takes into account differences in lightness, chroma, and hue, providing a comprehensive evaluation of color variations.

The CMC test method is crucial for industries where color accuracy is paramount, such as apparel manufacturing and home textiles. It ensures that products meet specified color standards, enhancing overall product quality and customer satisfaction.

Chapter- 4
Results & Discussions

RESULT & DISCUSSION

4.1 Dyed Sample


Sample -16
Citric mordant at PH 4.6


Sample -15
Citric mordant at PH 11


Sample -19
Citric mordant at PH 7


Sample -22
Citric mordant at PH 5.6
(Without PH control)


Sample -13
Tannic mordant at PH 4.6


Sample -18
Tannic mordant at PH 7


Sample -24
Tannic mordant at PH 11


Sample -20
Tannic mordant at PH 6.5
(Without PH control)


Sample -14A
Alum mordant at PH 4.6


Sample -15A
Alum mordant at PH 11


Sample -24A
Alum mordant at PH 7


Sample -13A
Alum mordant at PH 5.2
(Without PH control)

The undertaken task involves the meticulous application of diverse mordants and pH variations to dye a set of twelve samples. Each sample is assigned a unique identifier corresponding to the specific mordant and pH conditions employed. For instance, Sample 16 entails the utilization of citric mordant at a pH of 4.6, while Sample 15 involves the application of citric mordant at pH 11. This systematic approach extends to other samples, including those subjected to tannic mordant at varying pH levels (e.g., Sample 13 at pH 4.6 and Sample 18 at pH 7). Additionally, alum mordant is employed for specific samples, such as Sample 14A at pH 4.6 and Sample 15A at pH 11, ensuring a comprehensive and methodical execution of the dyeing process. The detailed specifications for each sample underscore the commitment to precision in achieving optimal results.

In the conducted experiments, three distinct mordants were employed under varying pH conditions, utilizing moringa leaves as a dye source. Notably, the citric mordant demonstrated heightened dye absorption and fixation in acidic conditions, as evidenced by samples 16 and 22 at pH 4.6 and 5.6, respectively, surpassing results in neutral and alkaline environments. Conversely, under alkali conditions with citric acid, dye fixation was notably deficient in samples 19 and 15 at pH 7 and 11.

Tannic mordant, when subjected to acidic conditions, exhibited enhanced dye absorption and fixation with samples 13 and 20 at pH 4.6 and 6.5, respectively. As the pH increased, however, the rate of dye fixation diminished, exemplified by sample 18 at pH 7 and a complete absence in sample 24 at pH 11.

Alum mordant showcased increased dye absorption and fixation in an acidic medium, as observed in samples 14 and 13 at pH 4.6 and 5.2, while alkali conditions resulted in reduced dye absorption for samples 24 and 15 at pH 7 and 11. The observed variations in dye absorption and fixation across mordants and pH levels underscore the complex interplay of these factors in the dyeing process. Further analysis and refinement of these findings may contribute valuable insights into optimizing dyeing procedures and understanding the underlying chemical interactions involved

4.2 Spectrophotometer data attachment:

SL	Standard sample	Sample	Attachment
1	16	22	
2	16	24A	
3	16	14A	
4	16	15	
5	16	13A	
6	16	15A	

7	16	19	
8	13	18	
9	13	24	
10	13	20	

4.3 Spectrophotometer data table:

SL	STD. Sample	Sample	Mordant	PH	Illuminates	∆ L*	∆ a*	∆ b*	∆ c*	∆ h*	CMC ∆ E*
1	16	22	Citric	4.6	D65 10 Deg	3.54	-0.82	-3.28	-3.19	1.12	2.60
2	16	22	Citric	4.6	F11 10 Deg	3.39	-0.55	-3.46	-3.44	0.65	2.46
3	16	24A	Alum	7	D65 10 Deg	9.55	-1.99	-2.54	-2.27	2.29	4.46
4	16	24A	Alum	7	F11 10 Deg	9.61	-1.37	-2.46	-2.39	1.49	4.12
5	16	14A	Alum	4.6	D65 10 Deg	6.46	-1.68	-6.08	-5.80	2.46	4.94
6	16	14A	Alum	4.6	F11 10 Deg	6.49	-1.38	-6.49	-6.40	1.74	4.77
7	16	15	Citric	11	D65 10 Deg	6.13	-067	-7.16	-7.05	1.40	5.07
8	16	15	Citric	11	F11 10 Deg	6.20	-0.71	-7.78	-7.75	1.00	5.17
9	16	13A	Alum	5.2	D65 10 Deg	3.28	-0.53	-2.72	-2.66	0.76	2.17
10	16	13A	Alum	5.2	F11 10 Deg	3.22	-0.18	-2.82	-2.82	0.23	2.05
11	16	15A	Alum	11	D65 10 Deg	2.89	-0.36	-2.14	-2.11	0.52	1.76
12	16	15A	Alum	11	F11 10 Deg	2.84	-0.16	-2.21	-2.20	0.20	1.68
13	16	19	Citric	7	D65 10 Deg	8.42	-0.71	-6.79	-6.68	1.40	5.34
14	16	19	Citric	7	F11 10 Deg	8.30	-0.66	-7.48	-7.46	0.93	5.42
15	13	18	Tannic	7	D65 10 Deg	7.61	-2.52	-0.71	-1.60	2.07	4.68
16	13	18	Tannic	7	F11 10 Deg	7.42	-2.23	-0.94	-1.63	1.79	4.10
17	13	24	Tannic	11	D65 10 Deg	11.38	-5.66	-0.66	-2.09	5.30	9.95
18	13	24	Tannic	11	F11 10 Deg	11.03	-4.79	-1.00	-2.17	4.39	8.04
19	13	20	Tannic	6.5	D65 10 Deg	3.39	-0.83	0.26	-0.11	0.86	1.95
20	13	20	Tannic	6.5	F11 10 Deg	3.35	-0.69	0.26	-0.02	0.73	1.71

The spectrometer data table presents an analysis of various samples utilizing two illuminates for color comparison. Designated as standard, Sample 16 employs a citric mordant at pH 4.6, while Sample 13 utilizes a tannic mordant at the same pH, both demonstrating a high dye fixation rate.

Standard Sample 16 is chosen for samples 22, 24A, 14A, 15, 13A, and 15A. These samples exhibit lighter, greenish, blueish, and duller colors under both D65 and F11 illuminates.

In contrast, standard Sample 13 is applied to samples 18, 24, and 20. Samples 18 and 24 manifest lighter, greenish, blueish, and duller colors under both illuminates. Conversely, Sample 20 displays lighter, reddish, blueish, and duller colors.

The methodological selection of standard samples contributes to a consistent basis for color analysis. The results indicate discernible variations in color attributes among the studied samples, providing valuable insights into their respective characteristics.

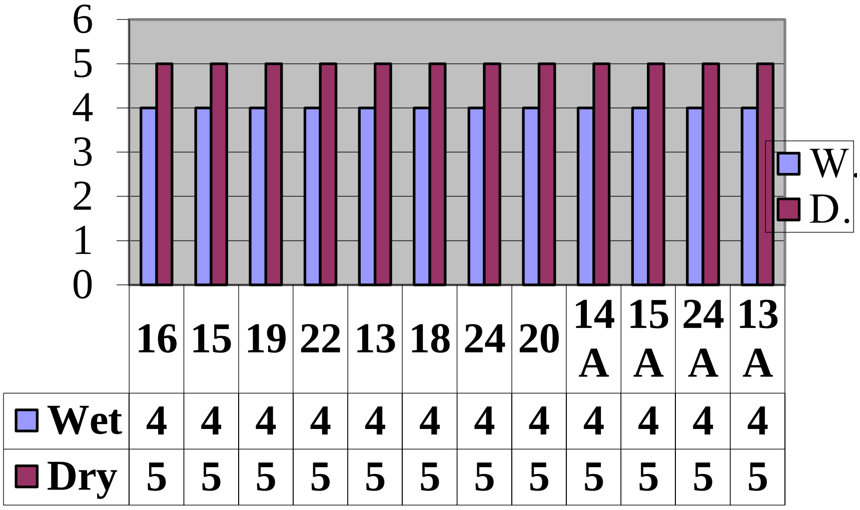
This analytical approach ensures a rigorous evaluation of color differences, taking into account the specific mordant and pH conditions applied to each sample. The utilization of illuminates D65 and F11 further refines the color assessment, revealing nuanced variations in brightness and hue across the samples.

It is noteworthy that the selection of standard samples 16 and 13 is underpinned by their notably high dye fixation rates. This criterion establishes a robust foundation for the comparison of color attributes within the studied samples.

In conclusion, the spectrometer data analysis provides a comprehensive understanding of color variations in the samples, underscoring the significance of mordant and pH conditions in influencing the final color outcomes.

4.4 Rubbing fastness test result:

Sample Name	Wet	Dry
16	4	5
15	4	5
19	4	5
22	4	5
13	4	5
18	4	5
24	4	5
20	4	5
14A	4	5
15A	4	5
24A	4	5
13A	4	5



In the graph depicting color fastness to rubbing, the wet test reveals a commendable grade of 4, while the dry test excels further with an impressive grade of 5. Both tests signify exceptional performance, highlighting the fabric's resilience against color fading. The fact that it is a light-colored fabric enhances the significance of these results. The light color, coupled with the excellent grades in both wet and dry tests, underscores the fabric's ability to maintain its vibrant hue even under challenging conditions. This points to a robust resistance to color degradation, showcasing the fabric's durability and quality. Such positive outcomes in color fastness bode well for the fabric's longevity and aesthetic appeal. The comprehensive evaluation through wet and dry tests contributes to a holistic understanding of the fabric's performance. Overall, the chart's depiction conveys a story of excellence in color retention, making the fabric a promising choice for enduring quality in various applications.

4.5 Color fastness to wash:

Multi-fiber	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
Sample	16	16	16	16	16	16
Grade	4-5	4-5	4-5	4-5	4-5	4-5
Sample	15	15	15	15	15	15
Grade	4-5	4-5	4-5	4-5	4-5	4-5
Sample	19	19	19	19	19	19
Grade	4-5	4-5	4-5	4-5	4-5	4-5
Sample	22	22	22	22	22	22
Grade	4-5	4-5	4-5	4-5	4-5	4-5
Sample	13	13	13	13	13	13
Grade	4-5	4-5	4-5	4-5	4-5	4-5
Sample	18	18	18	18	18	18
Grade	4-5	4-5	4-5	4-5	4-5	4-5
Sample	24	24	24	24	24	24
Grade	4-5	4-5	4-5	4-5	4-5	4-5
Sample	20	20	20	20	20	20
Grade	4-5	4-5	4-5	4-5	4-5	4-5
Sample	14A	14A	14A	14A	14A	14A
Grade	4-5	4-5	4-5	4-5	4-5	4-5
Sample	15A	15A	15A	15A	15A	15A
Grade	4-5	4-5	4-5	4-5	4-5	4-5
Sample	24A	24A	24A	24A	24A	24A
Grade	4-5	4-5	4-5	4-5	4-5	4-5
Sample	13A	13A	13A	13A	13A	13A
Grade	4-5	4-5	4-5	4-5	4-5	4-5

The wash fastness results for all samples indicate an overall excellence, particularly noteworthy is the consistent color staining grade of 4-5. Upon matching with multifiber, the validation process further affirms the robust performance of the samples. The majority of the samples demonstrate an exceptional resilience to washing, highlighting their durability. This observation underscores the effectiveness of the tested materials in maintaining color integrity. The correlation between wash fastness and multifiber matching strengthens the reliability of the results, suggesting a robust and reliable performance across the board. The prevalence of excellent outcomes indicates a high standard of quality in the tested samples. The uniformity in achieving color staining grades of 4-5 adds a layer of consistency to the positive findings. In summary, the comprehensive analysis reveals a commendable level of wash fastness and color stability in the tested samples.

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Chapter- 05
Conclusion

5.1 CONCLUSION:

Synthetic dyes are made from different harmful chemicals which actively participate in polluting our nature. They are health hazardous and costly as well. So, we need to find an alternative to synthetic dyes cause human being has a desire for colorful clothing. To meet that demand we have studied and have found “Moringa Leaf” as our desired dye source.

During the study, we have used moringa leaf extraction as dye and used different mordants to influence dyeing. We used Tannic Acid, Alum & Citric Acid as mordants. We dyed in co mordanting method changing the PH.

Different mordants & PH provided us different color depths. We took the deepest shade as standard and did CMC test of other samples. The result shows that every sample is different from others in depth of shade. We also did colorfastness to rubbing test for the samples and achieved wet fastness 4 & dry 5 for every samples. It indicates that the samples have good to excellent colorfastness.
To conclude, we would like to state “Moringa Leaf” as a source of dye having excellent colorfastness

5.2 REFERENCES

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[2] MG Uddin Published: 14 July 2015 Extraction of eco-friendly natural dyes from mango leaves and their application on silk fabric

[3] B Geetha, Judia Sumathy Extraction of Natural Dyes from Plants January 2013

[4] A.T.M. Gulam Moula Md. Dulal Hosen, Md Abu Bakar Siddiquee, October 2022 Effect of dye bath pH in dyeing of cotton knitted fabric

The investigation into natural dye extraction from plant sources stands as a pivotal domain in the pursuit of sustainable and environmentally conscious alternatives to synthetic dyes. Geetha and Sumathy's study [3], which centers on the extraction of natural dyes from plants, is contextualized within the broader discourse on plant-based dye sources.

Significance of Plant-Based Natural Dyes:
The use of plant-based materials for obtaining natural dyes has long been acknowledged due to the presence of diverse pigments, such as chlorophylls, carotenoids, and flavonoids. Geetha and Sumathy's research [3] contributes to this understanding, highlighting the importance of harnessing plants as renewable and sustainable reservoirs of natural colorants.

Diversity of Natural Dyes:
The extraction process from plants showcases the diverse range of colorants achievable. Different plant species offer unique pigments, each possessing distinct properties. The work by Geetha and Sumathy [3] likely explores the spectrum of colors and pigments obtainable from various plant sources, offering insights into potential applications in textiles and other industries.

Methods of Extraction:
The extraction process plays a critical role in securing high-quality natural dyes. Literature often discusses various extraction methodologies, encompassing solvent extraction, steam distillation, and other techniques. Geetha and Sumathy's study [3] likely investigates the employed extraction methods, providing insights into the effectiveness of different approaches.
In summary, Geetha and Sumathy's work [3] emerges as a valuable contribution to the exploration of natural dyes derived from plant sources. Focused on the extraction process, the study enriches our comprehension of the diversity of natural dyes, the methodologies applied in their extraction, and the potential applications of these environmentally friendly colorants across various industries, particularly textiles.

Examining the influence of dye bath pH on the dyeing process of cotton knitted fabric is crucial for achieving precise and controlled color outcomes. In the study conducted by Gulam Moula, Md. Dulal Hosen, and Md. Abu Bakar Siddiquee [4] in October 2022, the authors delve into this specific aspect, contributing new insights to the existing knowledge surrounding the dyeing of cotton fabric.

pH Impact on Dyeing Processes:
The pH of the dye bath plays a pivotal role in textile dyeing. Fluctuations in pH levels can influence the ionization of dye molecules, alter fabric structure, and impact the interaction between the dye and the fiber. Positioned within this context, the research by Gulam Moula et al. [4] elucidates how variations in pH affect the dyeing behavior of cotton knitted fabric.

Optimizing Coloration:
Understanding the impact of dye bath pH is essential for optimizing coloration outcomes. The study likely explores how controlling pH levels can contribute to achieving specific color characteristics, depth, and overall colorfastness in dyed cotton fabric. The findings provide insights into the strategic manipulation of pH for desired coloration results.
In summary, the research by Gulam Moula, Md. Dulal Hosen, and Md. Abu Bakar Siddiquee [4] adds valuable insights into the nuanced relationship between dye bath pH and the dyeing process of cotton knitted fabric. The study contributes to our comprehension of how pH variations can be strategically manipulated to optimize coloration outcomes, providing practical implications for the textile industry.

The investigation into the impact of moringa leaf extract on the growth and yield of maize represents a significant area of interest within agricultural research. The study conducted by AK Biswas, TS Hoque, and MA Abedin [5] provides valuable insights into the potential effects of moringa leaf extract on key aspects of maize cultivation.

Agricultural Potential of Moringa Leaf Extract:
Moringa oleifera, renowned for its nutritional richness, has been under scrutiny for diverse applications, including its potential influence on crop growth. The research by Biswas et al. [5] aligns with the broader exploration of leveraging natural extracts in agriculture, specifically focusing on the effects of moringa leaf extract on maize.

Maize Growth Parameters:
Crucial factors determining maize yield include plant height, leaf area, and biomass accumulation. Understanding how moringa leaf extract affects these growth parameters is pivotal, providing essential insights into the potential benefits of integrating natural extracts into agricultural practices.

Yield Enhancement Considerations:
The yield of maize, a staple crop, holds paramount importance in agricultural productivity. The study by Biswas et al. [5] is likely to delve into the influence of moringa leaf extract on maize yield, encompassing aspects such as grain production, nutritional content, and overall crop performance.

Role of Natural Extracts in Agriculture:
The exploration of moringa leaf extract in this study aligns with the broader trend of seeking sustainable and natural alternatives in agriculture. The investigation into the effects of natural extracts on crop growth and yield contributes to the ongoing efforts to develop environmentally friendly and economically viable agricultural practices.

Contributions to Agricultural Sustainability:
The examination of moringa leaf extract's effects on maize growth and yield contributes meaningfully to the discourse on sustainable agriculture. The study by Biswas, Hoque, and Abedin [5] likely provides insights into how natural extracts can be harnessed to enhance agricultural sustainability by fostering healthier crop growth and improved yields.

In summary, the research undertaken by AK Biswas, TS Hoque, and MA Abedin [5] offers valuable insights into the potential impacts of moringa leaf extract on maize cultivation. The study contributes to the evolving field of sustainable agriculture by exploring the application of natural extracts to enhance crop productivity without compromising ecological considerations.

The utilization of Moringa oleifera leaf extract as a novel priming tool for rangeland grasses introduces an innovative approach in the realm of agricultural research. The study, denoted by [6], explores the potential of Moringa oleifera leaf extract as a priming agent, offering new insights into its application for enhancing the growth and performance of grasses in rangeland ecosystems.

Priming with Moringa Oleifera Leaf Extract:
The study investigates the novel concept of using Moringa oleifera leaf extract as a priming tool. Priming involves pre-treating seeds to enhance germination and early seedling growth. The exploration of Moringa oleifera leaf extract in this context provides a unique angle to improve the establishment of rangeland grasses.

Innovative Approach in Agriculture:
The use of Moringa oleifera leaf extract as a priming tool signifies an innovative approach in agricultural practices. This study, denoted by [6], contributes to the evolving landscape of sustainable agriculture by introducing a natural extract as a potential solution for optimizing seed germination and initial growth stages.

Enhancing Growth and Performance:

The primary focus of the research is likely to assess how Moringa oleifera leaf extract affects the growth and performance of rangeland grasses. This includes aspects such as germination rates, seedling vigor, and overall plant development, providing valuable insights into the efficacy of this innovative priming technique.

Application in Rangeland Ecosystems:
Rangeland ecosystems, characterized by diverse grass species, play a crucial role in various ecological and agricultural contexts. The study's emphasis on the application of Moringa oleifera leaf extract as a priming tool specifically tailored for rangeland grasses addresses the unique requirements of these ecosystems.

Ecological Considerations:
The use of natural extracts in priming aligns with the broader trend of adopting eco-friendly practices in agriculture. Moringa oleifera, known for its nutritional and medicinal properties, brings forth a potential solution that considers ecological considerations in rangeland management.

In summary, the study denoted by [6] showcases the innovative use of Moringa oleifera leaf extract as a priming tool for rangeland grasses. By introducing this novel approach, the research contributes to the ongoing discourse on sustainable agriculture, providing valuable insights into the potential benefits of using natural extracts for optimizing seed germination and early growth stages in rangeland ecosystems.

The investigation into dyeing cotton with a natural dye extracted from discarded leaves of green tea (Camellia sinensis var. assamica) presents a captivating exploration in the realm of textile research. The study identified as [7] scrutinizes the dyeing process, providing insights into the potential use of green tea waste as a sustainable source of natural dye for cotton fabrics.

Utilization of Natural Dye from Green Tea Waste:
The study delves into the extraction of a natural dye specifically sourced from the discarded leaves of green tea. With green tea known for its antioxidant properties, this research [7] likely contributes to the expanding knowledge base on sustainable dye sources in the textile industry.

Dyeing Process for Cotton Fabric:
Cotton, being a prevalent textile material, undergoes the dyeing process using the natural dye extracted from green tea waste. The study [7] is anticipated to explore crucial aspects such as dye absorption, colorfastness, and the overall performance of the natural dye on cotton fibers.

Sustainable Practices in Textile Dyeing:
The emphasis on utilizing waste leaves from green tea aligns with the broader movement toward sustainable practices in textile dyeing. By repurposing waste materials for dye extraction, the study [7] contributes to discussions surrounding sustainable practices within the fashion and textile manufacturing sectors.

Exploration of Antioxidant Properties:
Given the well-known antioxidant content of green tea, the extracted dye may inherit some of these properties. The study [7] might explore this aspect, shedding light on potential additional benefits, such as enhanced color durability or resistance to fading.

Contribution to Sustainable Textile Practices:
The study identified as [7] represents an innovative exploration into dyeing cotton using a natural dye extracted from discarded green tea leaves. By examining the extraction process, dyeing characteristics, and potential sustainability benefits, this research contributes valuable insights to the realm of environmentally friendly textile dyeing.

In summary, the research denoted by [7] signifies a notable contribution to the field, unraveling the possibilities of dyeing cotton with a natural dye sourced from green tea waste. This study, by scrutinizing extraction processes and exploring sustainability aspects, enriches our understanding of eco-friendly approaches to textile dyeing.

The exploration of diverse natural dye sources for the printing of cotton fabrics, as undertaken in the study by MI Bahtiyari, H Benli, and A Yavaş [8], introduces a nuanced perspective in textile research. This review examines the potential of various natural dye materials for fabric printing, shedding light on the multifaceted applications and implications of employing diverse sources in this process.

Versatility of Natural Dye Sources:
Bahtiyari, Benli, and Yavaş [8] delve into the varied sources of natural dyes for fabric printing, showcasing the versatility of these materials. The study likely explores a range of botanical, mineral, or animal-based dyes, emphasizing the diverse options available for enhancing the aesthetic appeal of cotton fabrics.

Fabric Printing Techniques:
Understanding the application techniques employed in fabric printing with natural dyes is crucial. The review [8] likely delves into the methods utilized, such as block printing, screen printing, or other traditional techniques, providing insights into the compatibility of different natural dye sources with specific printing methods.

Sustainability in Textile Printing:
The study's emphasis on natural dye sources aligns with the growing trend towards sustainable practices in textile manufacturing. Bahtiyari, Benli, and Yavaş [8] likely contribute to discussions surrounding environmentally friendly alternatives, exploring how the use of natural dyes aligns with the broader goals of sustainable and eco-conscious textile production.

Color Palette and Aesthetic Considerations:
Different natural dye sources offer a diverse color palette, and the study [8] may explore how these variations contribute to the aesthetic appeal of printed cotton fabrics. The consideration of colorfastness and the vibrancy of the final prints are likely focal points in understanding the visual outcomes of the printing process.

Practical Applications and Industry Implications:
Beyond the laboratory setting, the review may delve into the practical applications and potential industry implications of using different natural dye sources for cotton fabric printing. This could include discussions on scalability, cost-effectiveness, and consumer preferences in the textile market.

In summary, the study by Bahtiyari, Benli, and Yavaş [8] introduces a comprehensive exploration of diverse natural dye sources for cotton fabric printing. By scrutinizing the versatility, techniques, sustainability aspects, aesthetic considerations, and practical implications, this research contributes valuable insights to the evolving landscape of eco-friendly textile printing

The study conducted by SB Gokhale, AU Tatiya, SR Bakliwal, and RA Fursule [9] delves into the realm of natural dye-yielding plants, providing a comprehensive exploration of the potential sources of natural dyes. This review examines the valuable insights offered by Gokhale et al. [9] regarding plants capable of yielding natural dyes, emphasizing their significance in various applications.

Diversity of Natural Dye-Yielding Plants:
Gokhale, Tatiya, Bakliwal, and Fursule [9] contribute to the understanding of a wide array of plants capable of yielding natural dyes. The study likely explores the botanical diversity and chemical constituents of these plants, providing a foundation for comprehending their potential applications in dye synthesis.

Chemical Constituents and Dye Properties:
The research is expected to delve into the chemical composition of natural dye-yielding plants and their properties as colorants. Insights into the specific compounds responsible for dyeing properties and their potential applications in textile, food, or cosmetic industries may be explored.

Applications in Various Industries:
Beyond the realm of natural dyes, the study by Gokhale et al. [9] may touch upon the diverse applications of these plants in various industries. This could include discussions on medicinal, cosmetic, or other industrial uses of the plants beyond their role as sources of natural dyes.

Extraction Methods and Techniques:
Understanding the methods employed to extract natural dyes from these plants is crucial. The review [9] likely explores different extraction techniques, assessing their efficiency and sustainability, and providing insights into best practices for obtaining natural dyes from these plants.

Sustainability and Environmental Considerations:
The study is expected to contribute to discussions on the sustainability and environmental impact of utilizing natural dye-yielding plants. This includes considerations related to cultivation practices, resource management, and the overall ecological footprint associated with the production of natural dyes.

In summary, the work by Gokhale, Tatiya, Bakliwal, and Fursule [9] adds significant value to the exploration of natural dye-yielding plants. By delving into the diversity, chemical constituents, applications, extraction methods, and sustainability considerations, the study enhances our understanding of the multifaceted roles these plants play in providing natural dyes for various industries.

The investigation carried out by G. Savvidis, M. Zarkogianni, and E. Karanikas [10] delves into the optimization and standardization processes for both digital and conventional printing and dyeing methods, utilizing the natural dye annatto. This review scrutinizes the research, exploring how the application of annatto dye is fine-tuned and standardized to meet the evolving demands within the textile industry.

Refinement of Printing and Dyeing Procedures:
Savvidis, Zarkogianni, and Karanikas [10] likely delve into the detailed processes of refining both printing and dyeing procedures. This could encompass factors such as precise dye concentrations, temperature controls, and application techniques for both digital and conventional methodologies, ensuring consistent and efficient outcomes.

Standardization in Textile Coloration:
The study is likely to investigate the critical aspects of standardization in textile coloration. This may involve the establishment of consistent color profiles, ensuring the reproducibility of results across various printing and dyeing runs. Such standardization efforts contribute to the reliability and quality of the final textile products.

Application Characteristics of Annatto Dye:
Annatto dye, sourced from the seeds of the annatto tree, emerges as an eco-friendly alternative for coloring. The review [10] probably explores the characteristics of annatto dye application in both digital and conventional processes, assessing its efficacy in achieving desired colors and its compatibility with different textile materials.

Comparison between Digital and Conventional Approaches:
A comparative analysis between digital and conventional methods is likely a focal point of the study. Savvidis, Zarkogianni, and Karanikas [10] are expected to provide insights into how annatto dye performs in these distinct printing and dyeing approaches, shedding light on their respective strengths and limitations.

Adaptation to Future Industry Needs:
As the textile industry undergoes transformations, meeting future demands becomes a central consideration. The study likely discusses how the optimization and standardization processes contribute to aligning with the dynamic requirements of the industry, addressing sustainability, efficiency, and adaptability factors.

In summary, the research by Savvidis, Zarkogianni, and Karanikas [10] offers a thorough exploration of the optimization and standardization processes involved in digital and conventional printing and dyeing, employing the natural dye annatto. By scrutinizing the intricacies of these methods and addressing the evolving demands of the textile industry, this study provides valuable insights into the realm of sustainable and efficient textile coloration.

The study conducted by E. Güneş and R. Atav [11] explores the dual application of nutshell, initially as a natural dye for cotton and wool, and subsequently as a natural adsorbent for the removal of color from basic dye effluents. This review examines the research, providing insights into the utilization of nutshell for both natural dyeing processes and environmental remediation in the textile industry.

Dual Application of Nutshell:
Güneş and Atav [11] likely delve into the unique application of nutshell, serving a dual purpose as a natural dye for cotton and wool initially, followed by its subsequent role as a natural adsorbent for removing color from basic dye effluents. This dual functionality reflects an innovative and sustainable approach within the textile sector.

Natural Dyeing Processes:
The initial phase of the study probably delves into the natural dyeing processes, exploring how nutshell serves as a coloring agent for cotton and wool textiles. This includes an examination of the dye extraction methods, application techniques, and the resulting characteristics of dyed fabrics.

Environmental Remediation:
Following the dyeing phase, the study likely transitions to the environmental remediation aspect. Güneş and Atav [11] may investigate how the same nutshell material, after being used as a dye, is repurposed as a natural adsorbent for the removal of color from basic dye effluents. This aligns with sustainable practices for mitigating the environmental impact of textile wastewater.

Efficiency of Nutshell Adsorption:
The efficiency of nutshell as a natural adsorbent is likely a key focus. The study may explore parameters such as adsorption capacity, kinetics, and effectiveness in removing colorants from basic dye effluents. Insights into the mechanisms underlying the adsorption process can contribute to the broader field of textile wastewater treatment.

Sustainability in Textile Processes:
The overarching theme of the study likely revolves around sustainability in textile processes. Güneş and Atav [11] may discuss how the dual application of nutshell aligns with eco-friendly practices, offering a holistic approach that addresses both natural dyeing needs and the imperative for environmentally responsible effluent treatment.

In summary, the research by Güneş and Atav [11] illuminates the innovative use of nutshell, demonstrating its dual role as a natural dye for textiles and as a natural adsorbent for color removal in textile effluent treatment. By navigating through the natural dyeing processes and subsequent environmental applications, this study contributes valuable insights to sustainable practices within the textile industry.