Faculty of Engineering

Department of Textile Engineering

Thesis Report on

Dyeing of Cotton Woven Fabrics Using Natural Tulsi (Ocimum sanctum) Leaf.

Course code: TE-4214 **Course title: Project (Thesis)**

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A thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Textile Engineering.

Advance in Wet Processing Technology

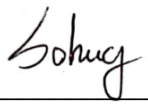
Fall-2024

DECLARATION

We hereby attest that the thesis report on "Dyeing of Cotton Woven Fabrics Using Natural Tulsi (Ocimum sanctum) Leaf" was created entirely by us, working under the supervision of **Mr. Tanvir Ahamed Chowdhury**, Assistant Professor & Head, Department of Textile Engineering, Daffodil International University.

We affirm that neither this project nor any component of it has ever been submitted somewhere else.

Submitted by:



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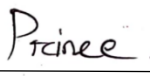

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LETTER OF APPROVAL

This is a certification that **Md Sohag Hasan**, bearing **ID: 211-23-1001**, and **Prince Mahmud Rabin**, bearing **ID: 211-23-1014**, are students in the Department of Textile Engineering at Daffodil International University, have successfully completed the thesis report they were assigned under my supervision. Under the title "Investigation on the pre-shipment inspection (PSI) reports of a denim garment industry," they were handed a report name, which they fulfilled admirably.

The thesis report submitted by Md Sohag Hasan and Prince Mahmud Rabin seems like authentic work and up to the mark.

I have gone through the final draft of the report and recommend its submission for the degree of Bachelor of Science in Textile Engineering.

Mr. Tanvir Ahmed Chowdhury

Assistant Professor & Head

Department of Textile Engineering

Daffodil International Engineering

ACKNOWLEDGEMENT

First we are expressing our heartiest thanks and gratefulness to almighty Allah for his divine blessing makes us possible to complete this report successfully.

To begin with, we would like to extend our appreciation to Almighty Allah for empowering us with the capacity and opportunity to fulfill the report within the scheduled timeframe successfully. We are taking this privilege to express our gratitude to each person who is involved with us in every phase of our lives.

We are deeply indebted to our supervisor, **Mr. Tanvir Ahamed Chowdhury, Assistant Professor & Head**, Department of Textile Engineering, Daffodil International University, for his unwavering guidance and support during the duration of our academic thesis.

Finally, we are grateful to our parents, without them, we would not be here. Without the support of our parents, we would not be able to achieve our objectives and goals.

ABSTRACT

The project titled “Dyeing of Cotton Woven Fabrics Using Natural Tulsi (Ocimum sanctum) Leaf” decrease synthetic dye use and minimize chemical uses, it is environmentally friendly.

The demand for sustainable and environmentally friendly textile production techniques has raised interest in natural dyeing techniques. This study examines the use of Tulsi (Ocimum sanctum) leaf extract as a natural colour for cotton-woven fabrics. In order to increase dye production and minimise chemical inputs, the extraction process was optimised using environmentally friendly procedures. Cotton fabrics were treated with mordants including tannic acid, ferrous sulphate, and alum to enhance dye absorption and colour fastness. Along with their antimicrobial properties, the coloured textiles' colour, wash, rub, and light fastness were evaluated. The results indicated that Tulsi extract gives a spectrum of natural earthy tones, and that the type of mordant used affected the colour differences.

The fastness properties were comparable to those achieved with synthetic colours, while the antibacterial properties added utilitarian value. According to the study, Tulsi leaf extract offers a viable, sustainable alternative to the textile dyeing sector, supporting global efforts to reduce environmental impact and promote green technologies.

Table Of Contents

List Of Figure:

List Of Table:

Chapter 1

Introduction

1.1 Background Information

One of the largest producers of pollution in the world is the textile sector, which uses synthetic colours extensively. Although these dyes work well to give fabrics vivid, long-lasting colours, they also present serious risks to both human health and the environment. Toxic chemicals are released into water systems during the production and usage of synthetic dyes, endangering aquatic life and contaminating the water. Many synthetic colours can harm the environment over time since they are not biodegradable.

The need for sustainable and environmentally friendly alternatives has grown in the textile sector in recent years. Natural hues derived from plants, minerals, and animals have drawn attention because they have the potential to replace synthetic colours in the future. These hues are a popular choice for the environmentally conscious textile industry because they are renewable, biodegradable, and generally non-toxic.

The medicinal plant tulsi (Ocimum sanctum), which is prized in traditional Indian rites, is one example of a natural colour source. In addition to having antibacterial and antifungal properties, tulsi leaves, which are rich in bioactive compounds like flavonoids, phenolics, and essential oils, may also contribute colour. These additional benefits align well with the increased demand for functional yet beautiful fabrics.

The perfect substrate for natural dyeing is cotton, a common natural fibre with exceptional absorption qualities. The broad usage of natural dyes may occasionally be constrained by issues such as attaining vivid hues, consistent tints, and enough fastness qualities. This study attempts to solve these issues and promote sustainable textile practices by investigating the possibility of using tulsi leaf extract to dye cotton-woven garments.

This study investigates how to best extract dye from tulsi leaves, optimise the dying process, and evaluate the final fabric's properties. By demonstrating the feasibility of tulsi-based dyeing, this study seeks to reduce the environmental effect of conventional dyeing methods and promote the use of renewable resources in textile production.

1.2 Significance and Motivation

The textile industry is one of the main causes of environmental contamination due to the extensive use of synthetic dyes, which release harmful chemicals into waterways and the ecosystem. Eco-friendly substitutes must be created to satisfy customer demand for luxury textiles.

One potential remedy for this problem is the use of natural dyes, which are made from plants, flowers, and other biological sources. Because of its abundance, simplicity of cultivation, and natural bioactive qualities, Tulsi (Ocimum sanctum), a well-known medicinal plant, has a lot of potential among them. Using Tulsi leaves as a natural dye has two advantages: it gives textiles advantageous qualities, such as antibacterial activity, and it does away with the need for hazardous chemicals.

The motivation for this study stems from the need to:

Address Environmental Issues: Encourage eco-friendly dyeing techniques while reducing reliance on synthetic dyes that pollute land and water.

Use Natural Resources: Investigate the unrealised potential of Tulsi leaves as a biodegradable and renewable substitute for chemical dyes.

Enhance Textiles with Functional Value: Make use of Tulsi's antibacterial and therapeutic qualities to produce fabrics with additional value that meet the rising need for multipurpose textiles.

Encourage the SDGs (sustainable development goals): Participate in international initiatives to achieve sustainability, especially those pertaining to water conservation (SDG 6) and responsible production and consumption (SDG 12).

Fulfil Customer Preferences: Take advantage of consumers' growing need for sustainable and eco-friendly products without sacrificing design or quality.

1.3 Aims and Objectives

Develop a Sustainable Dyeing Method: Develop a method that uses Tulsi (Ocimum sanctum) leaf extract as a natural dye for cotton fabrics in a way that is both environmentally friendly and efficient.

Optimise Dyeing Parameters: Determine and optimise important parameters such the extraction method, dye concentration, temperature, duration, and pH to achieve optimal dye uptake and uniform colouring.

Enhance Colour Fastness: Analyse the effects of various natural and synthetic mordants, including alum, ferrous sulphate, and tannic acid, on the colour vibrancy and fastness properties of the dyed materials.

Analyse Fastness Properties: Assess the coloured fabrics' light, rub, and wash fastness to ensure durability and utility.

Examine antibacterial Properties: Examine Tulsi dye's bioactive properties to determine whether it has any potential antibacterial effects on textiles that have been dyed. This could increase the dye's utility.

Encourage Eco-Friendly Practices: Emphasise the benefits of using natural dyes to reduce the ecological impact of the textile industry and to encourage sustainable practices.

Comparing Tulsi leaf dye to conventional synthetic colours allows you to assess its performance in terms of quality, usefulness, and environmental impact.

1.4 Methodology

This study adopted an eco-friendly approach to dye cotton woven fabrics using Tulsi (Ocimum sanctum) leaf extract as a natural dye.

In order to get rid of natural contaminants like oils, waxes, and leftover dirt, cotton-only textiles were first prepared by scouring and bleaching. This pretreatment process guaranteed consistent colouring and improved the fabric's ability to absorb dye. To maintain their bioactive qualities, fresh or dried Tulsi leaves were gathered, cleaned to get rid of any debris, and then left to dry in a shady place. To enhance the surface area available for colour extraction, the dried leaves were milled into a fine powder.

The colour was extracted using an aqueous method since it was simple to use and environmentally benign. The pulverised leaves were cooked in distilled water for 10 minutes at a controlled temperature of 100°C in order to maximise the colour yield. After that, the extract was filtered through filter paper or muslin cloth to remove any remaining plant material. If necessary, the filtrate was further reduced by evaporation to achieve the desired concentration.

A variety of mordants, including organic ones like citric acid, are utilised to ensure effective colour fixing and enhance fastness properties. During the dyeing process, the pretreatment cotton fibres were immersed in the dye bath. The temperature, pH, and length of the dye bath were carefully regulated for efficient dye absorption and reliable application.

After the dying process, the fabrics were thoroughly cleaned to remove any leftover dye and dried under well watched conditions. The dyed textiles were then subjected to extensive evaluations, which included colour analysis utilising spectrophotometric methods to determine shade, intensity, and homogeneity. Fastness properties such as wash, rub, and light fastness were assessed using recognised protocols in order to gauge the dye's endurance. Utilising Tulsi's inherent bioactive properties, the antibacterial activity of fabrics dyed with it was also investigated in order to evaluate its usefulness. The strategy ensured a sustainable, low-impact method, showcasing Tulsi's potential as a competitive alternative to synthetic dyes in the production of environmentally friendly fabrics.

Environmental Impact Assessment: This process Sustainable, less water consumption, no chemical usage, and biodegradability of waste materials.

Flow chart of this project:

Fabric Preparation

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Scouring and Bleaching

↓

Mordanting (Optional)

Tulsi Leaf Extraction

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Collection and Cleaning of Tulsi Leaves

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Boiling in Fresh Water (100°C, 10 Minutes)

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Filtering to Obtain Dye Extract

Dyeing Process

↓

Immersion of Pre-treated Cotton Fabric in Dye Bath

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Heating and Stirring (100°C, 60 Minutes)

↓

Rinsing and Air-Drying

Evaluation of Results

↓

Testing Fabric Properties (Color Depth, Uniformity)

↓

Wash, Light, and Rubbing Fastness Tests

Optimization and Scalability

↓

Adjust Parameters (Temperature, Mordants, Dye Concentration)

↓

Analyze Environmental Impact (Effluent Assessment)

↓

Develop Commercial Scaling Plan

Figure-1: Details Flow Chart

1.5 Report Outline

In this report, We explained our project in detail. In chapter 1, we described the background, aims and methods. In chapter 2, we reviewed some literature. In Chapter 3, we discussed the produce and model description, methodology and implementation. In chapter 4, we talked about result and discussion. In chapter 5, Professional Responsibilities, Health, Safety, Socio-Culture and Environmental considerations are given. In chapter 6, we concluded the report. Lastly, we given references.

CHAPTER-2

LITERATURE REVIEW

2.1 Overview of Natural Dye

Colourants made from plants, minerals, and certain animals are known as natural dyes. For millennia, people have employed these dyes to provide colour to leather, food, fabrics, and other objects.

Minerals, plants, and invertebrates are the sources of natural colourants and dyes. The bulk of natural colours are made from vegetable dyes that come from plants, such as berries, roots, bark, leaves, and wood, as well as other biological sources like fungi.

Archaeologists have found evidence of textile dyeing throughout the Neolithic period. In China, dyeing has been done for more than 5,000 years using plants, barks, and insects.The basic dyeing technique hasn't altered much over time. The dye material is typically boiled in a pot of water to extract the dye compounds into solution with the water. The materials to be dyed are then placed in the pot and heated until the desired colour is achieved.

The textiles to be dyed are added to the pot, and the heat is then kept there until the desired colour is achieved. Textile fibre can be coloured ("dyed in the wool"), spun ("yarn-dyed"), or piece-dyed ("piece-dyed") before or after spinning or weaving. Many natural dyes require the addition of substances called mordants in order to attach the dye to the textile strands. Together with natural fibres and dyes, metal salts called mordants—derived from the Latin mordere, which means "to bite"—can form a stable molecular coordination complex.

The most widely used mordants in the past were alum (potassium aluminium sulphate, a metal salt of aluminium) and iron (ferrous sulphate). Many other metal salt mordants were once utilised, but due to recent research demonstrating their detrimental effects on the environment, human health, or both, they are now seldom ever used. Lead, copper, tin, chrome, and other metal salts are among them. A range of non-metal salts can also be employed either alone or in combination with metal salt mordants to aid in the molecular bonding of natural dyes to natural fibres. These include tannin from oak galls and other plant parts, "pseudo-tannins" like oxalic acid generated from plants, and ammonia from stale urine. Additionally, plants that bioaccumulate aluminium have been used.

After artificial synthetic dyes were developed in the mid-19th century, the large-scale market for natural dyes experienced a prolonged decline. In the early years of the twenty-first century, the fashion industry is experiencing a resurgence in demand for natural dyes. Because Western consumers are growing increasingly worried about the health and environmental implications of synthetic dyes, which are produced using hazardous byproducts of fossil fuels, there is a growing demand for products that use natural hues.

Figure-2: Natural Dye

2.1.1 Sources of Natural Dyes

Plant-Based Natural Dyes' Sources:

Indigo leaves (from the Indigofera tinctoria plant).

Flowers: saffron (golden) and marigold (yellow).

Bark: Quebracho (brown) and logwood (purple/black).

Roots: turmeric (yellow) and madder (red).

Fruits/Seeds: orange annatto seeds, yellow pomegranate rind.

Based on Animals:

Insects: Dactylopius coccus, or cochineal (red).

Tyrian purple is a marine animal that comes from sea snails like Murex.

Based on Minerals:

Cinnabar (red), azurite (blue), and ochres (reds, yellows, and browns).

2.1.2 Characteristics of Natural Dyes

Eco-friendly natural dyes have the qualities of being biodegradable and non-toxic.

Mordant Dependency: Many require a mordant to help the dye adhere to the fibres and increase durability.

Various Shades of Colour: Produce subtle, earthy tones with noticeable variations.

Sustainability Concerns: Oversourcing may have an impact on ecosystems by, for instance, overharvesting plants or animals.

2.2 Overview of Natural Dyeing: Historical and Contemporary Perspectives

2.2.1 Historical Background of Natural Dyeing

One of the earliest methods that people have used to add colour to fabrics is natural dyeing. Natural dyes have been used since at least 2000 BCE, according to archaeological evidence, and have their origins in ancient civilisations like Mesopotamia, Egypt, India, and China**.**

2.2.2 Important Historical Events:

Ancient Civilisations

In Egypt, fabrics were frequently dyed with madder and indigo.

India became well-known around the world for its vibrant natural dyes, particularly indigo (Indigofera tinctoria) and turmeric (Curcuma longa).

The Chinese developed intricate dyeing techniques using plant-based colours like woad (Isatis tinctoria) and mulberry bark.

The Middle Ages:

The Silk Road made it easier to trade dyeing techniques and raw ingredients.

Both Europe and Asia placed a great emphasis on cochineal insects (for red dye) and tyrian purple (made from sea snails).

Colonial Times:

Trade networks and colonial development were propelled by the great demand for natural hues such as logwood and indigo.

As synthetic dyes became more accessible in the 19th century, the use of natural colours declined.

2.2.3 Revival of Natural Dyeing in Modern Times

Awareness of the Environment:

Toxic chemicals released into water systems by synthetic dyes contribute to environmental deterioration.

Natural dyes are less harmful to the environment and biodegradable.

Cultural Legacy:

It is believed that maintaining traditional dyeing techniques and indigenous knowledge is essential to maintaining cultural identity.

Demand from Customers:

As people's lifestyles become more environmentally sensitive, there is a growing demand for materials that are dyed sustainably and organically.

2.3 Properties of Tulsi

In Ayurveda, holy basil, also called tulsi (Ocimum sanctum or Ocimum tenuiflorum), is a highly prized medicinal herb. It is widely recognised for its numerous therapeutic, spiritual, and ecological benefits. The following is a summary of its primary attributes:

2.3.1 Physical Properties

Look: A little shrub with fragrant, green or purple foliage.

Taste: Astringent, peppery, and slightly bitter.

Fragrance: Strong and fragrant, the scent is frequently compared to mint or clove.

2.3.2 Medicinal Properties

Antimicrobial: Effective against bacteria, viruses, and fungi.

Antioxidants contain flavonoids and phenolic compounds that combat free radicals.

Anti-inflammatory: Reduces inflammation to help with conditions including arthritis.

Adaptogenic: Promotes mental balance and helps the body adjust to stress.

The immune system's defences against infections are strengthened via immunomodulation.

Cardioprotective: Reduces cholesterol and supports heart health.

Hypoglycemic: Lowers blood sugar levels to help treat diabetes.

Digestive Aid: Assists with indigestion, bloating, and other digestive issues.

Respiratory Support: Treats colds, coughs, and respiratory ailments like asthma.

2.3.3 Chemical Properties

Active Compounds:

Eugenol: Analgesic and anti-inflammatory.

Ursolic acid has antimicrobial and anticancer properties.

Rosmarinic acid: antioxidant and neuroprotective.

Linalool: Calming and anti-anxiety.

Tannins and flavonoids: Guard against oxidative damage.

Essential Oils:

Contains volatile oils (0.1–0.9%), such as camphene, cineole, and methyl chavicol.

Figure-3: Tulsi Leaf (Ocimum sanctum)

2.3.4 Challenges of Natural Dyeing

Colour Variability: Because raw ingredients vary, natural dyes may produce uneven effects.

Restricted Colour Selection: Natural dyes come in fewer hues than synthetic ones.

Problems with Fastness: Natural dyes are frequently less resilient to rubbing, light, and washing.

Scalability: Excessive output can increase expenses and put a strain on natural resources.

Chapter-3

Experimental Procedure

3.1 Required Materials

Fabric:

Pre-treated 100% cotton woven fabric (scoured and bleached for uniform absorption).

Natural Dye:

Fresh or dried Tulsi (Ocimum sanctum) leaves.

Mordants:

Malta Juice (Orange)

Chemicals:

Mild detergent, Fresh water, and acetic acid (for pH adjustment).

Equipment:

Stainless steel dyeing vessel, stirring rod, thermometer, Ph meter, weighing scale, and drying rack.

3.2 Methodical Procedure

3.2.1 Fabric Preparation

Scouring and Bleaching

Scouring is the pre-treatment process of wet processing technology. The initial step of pre-treatment is scouring. Textile materials must go through a scouring procedure before being dyed or printed. Scouring is the process of getting rid of as many natural (oil, wax, gum, fat, etc.) and introduced (during manufacture process) contaminants as feasible. Scoured 100% cotton woven fabric.

- Bleach to ensure a uniform dye uptake.
- Dry the fabric.

Table-1: Typical Scouring Recipe

SL	Process Parameter	Unit	Dossing	Stock Solution
01	Detergent	g/L	2	1%
02	Sequestering Agent	g/L	1	1%
03	Caustic Soda	g/L	4	
04	Sample Weight	gm	10	
05	M: L	-----	1:30	
06	Temperature	°C	100	
07	Time	min	20	

Flow chart of woven cotton fabric scouring:

Cotton fabric/fiber

↓

Inspection

↓

Wetted by NaOH solution

↓

Emulsification

↓

Detergency

↓

Washing

↓

Scoured fabric

Figure-4: Woven cotton Fabric scouring Flow chart

Table-2: Typical bleaching Recipe

Chemical	Amount (gm/l)
Wetting agent	**1 gm/l**
Sequestering agent	**3 gm/l**
Detergent	**2 gm/l**

Stabilizer	**0.8 gm/l**
Caustic soda	**3gm/l**
Hydrogen peroxide	**4 gm/l**
Temperature	**90-95^0 C**
Time	**20 min**
pH	**10-11**
M:L	**1:30**
Sample weight	**10 gm**

Procedure for Operations:

- Set the bleaching bath with sample with auxiliary agent, stabilizer and caustic soda at room temperature.
- Now rise the temperature and add hydrogen per-oxide after 5 min.
- Then rise the temperature to 90-95C.
- For rapid bleaching need higher temperature at lower time. Run the bath for 20-45 min. this time calculate as bleaching time.
- After 20-45 min, cool down to 70 degrees Celsius and drop the bath.
- Now per-oxide killer is applied to remove residual per-oxide from the sample.
- Then neutral the sample.

3.2.2 Preparation of Tulsi Dye Extract

- Collect fresh Tulsi leaves.
- To get rid of any dust or debris, the leaves are properly cleaned with clean water.
- Fresh leaves sun-dried.
- Crushed /blended Tulsi Leaf.
- For 10 minutes at 100°C, boil 10g of fresh leaves in 200 of water.
- For 10 minutes at 100°C, boil 10g of dried leaves in 200 of water.

- Use a fine sieve or muslin cloth to strain the extract in order to remove the solids.
- Allow the extract to cool to room temperature.

Figure-5: Dye Extract from Tulsi Leaf

Figure-6: Tulsi Leaf Blending.

3.2.3 Mordanting

Pre-mordanting:

- Immerse the fabric in a mordant solution malta juice at room tempeature for 5 hours.
- Natural (Citric Acid) mordants Malta (Malta is the fruit, its English name is Orange) will be selected to improve dye fixation and color fastness.
- Rinse and dry the fabric.

Figure-7: Prepare Mordanting solutions

Figure-8: Fabric Pre-Mordanting

3.2.4 Dyeing Process

- In a stainless steel vessel, submerge the cotton fabric in the Tulsi leaf extract.
- Maintain a material-to-liquor ratio of 1:20 (1 part fabric, 20 parts extract).
- Heat the dye bath to 100°C and maintain the temperature for 1 hours, stirring occasionally for even dye uptake.
- Add Soda Ash (Na_2CO_3) adjust the pH.
- pH is 11..

Figure-9: Dyeing Pot & Dyeing Machine

3.2.5 Post-Dyeing Treatment

- After removing the dyed cloth from the bath, thoroughly rinse it in cold water to remove any remaining dye.
- To enhance color fastness, use a mild detergent.
- Allow the fabric to air dry in a protected area to prevent fading.

3.2.6 Fastness Testing

Wash Fastness

Procedure:

- Use 5 g/L of non-ionic detergent and filtered water to create a solution.
- Set the temperature to 40°C for hand washing and 60°C for machine washing.
- Gently agitate the material that has been dyed in the water for 30 minutes.
- Rinse thoroughly and allow to air dry.

Light Fastness

Procedure:

- Direct sunshine should be shining on the dyed fabric.
- The fabric should be exposed for 24 to 72 hours.
- Examine and contrast the fabric's revealed and unexposed areas.
- Using the grey scale for rating.

Rubbing (Crocking) Fastness

Procedure:

- Using a piece of uncoloured cotton cloth, apply 10–20 strokes to the dyed sample.
- Perform tests that are both wet and dry:

  Dry: Use a white cotton cloth that has been dried to rub.

  Wet: Before rubbing, wet the white cotton fabric until it is 65% wet.
- Verifing whether the dye has transferred to the rubbing cloth.
- Rating use the grey scale.

Perspiration Fastness

Procedure:

- Construct alkaline solutions:
  Alkaline: Mix half a percent sodium carbonate and half a percent sodium chloride.
- Immerse the dyed fabric in each solution for 30 minutes.
- After pressing between glass plates, incubate at 37°C for 4 hours.
- Take note of the colour shift and stains on the white cloth adjacent.
- The Grey Scale is used to rate.

Chapter-4

Result & Discussion and Sample Attracts

4.1Result

1. Coloration

- The cotton fabrics dyed with fresh tulsi leaves exhibited a light brownish colours.
- The cotton fabric dyed with dried tulsi leaves exhibited a deep brownish colours.

2. Color Uniformity

- Fabrics demonstrated consistent dye absorption.

Sample-01

Table-3: Color Fastness Scores for Woven Cotton Fabric Dyeing with Fresh Tulsi Leaf:

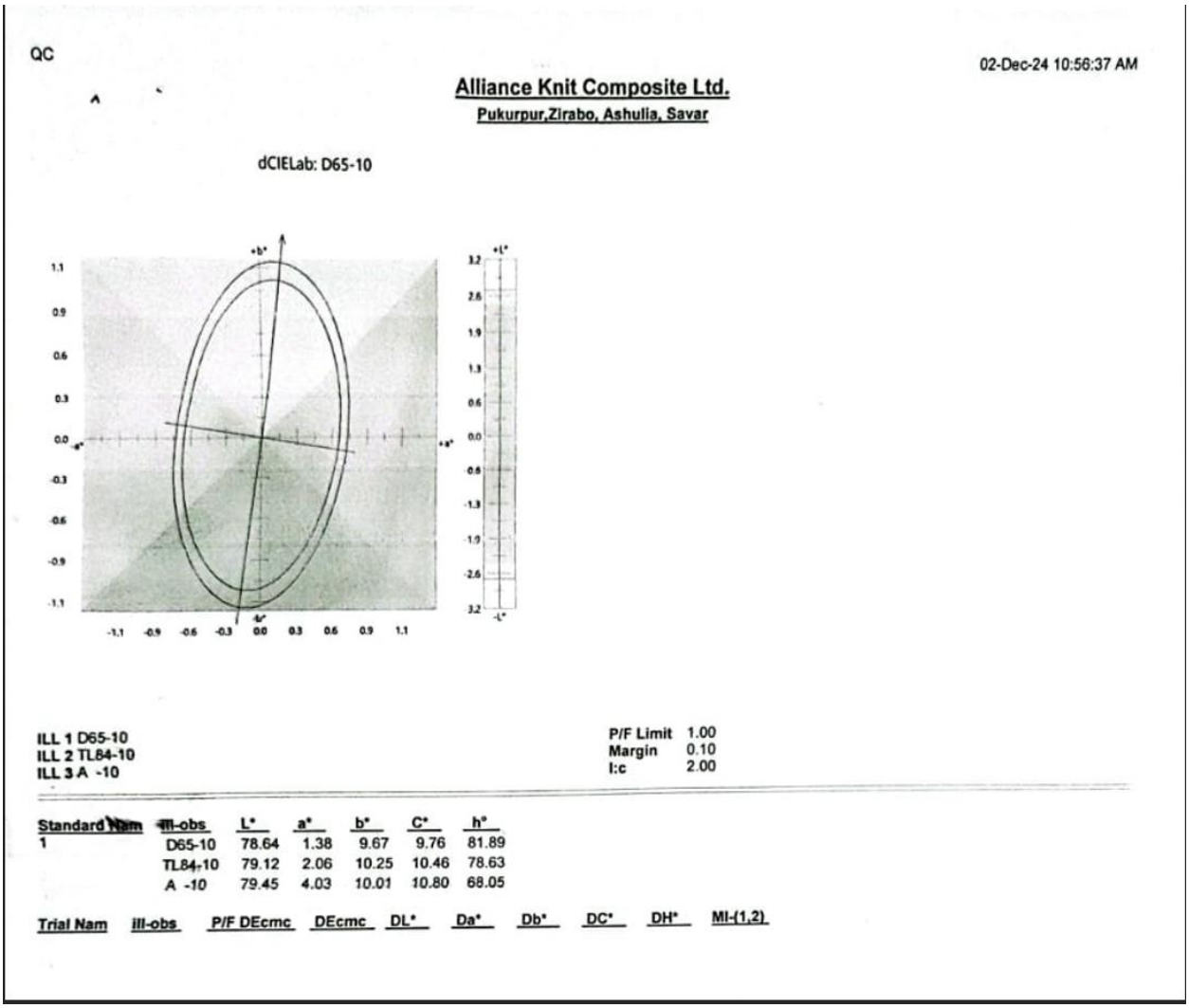
Fastness Type	Grade	Remarks
Wash Fastness	3-4	Wash fastness might be good
Light Fastness	3-4	Light fastness might be moderate
Dry Rubbing Fastness	3-4	Tulsi-dyed fabrics might have good dry rubbing fastness
Wet rubbing fastness	2-3	Tulsi-dyed fabrics might have fair wet rubbing fastness
Color Fastness to Perspiration	3-4	Color Fastness to Perspiration Might be Good

Sample-02

Table-4: Color Fastness Scores for Woven Cotton Fabric Dyeing with Dried Tulsi Leaf:

Fastness Type	Grade	Remark
Wash Fastness	3-4	Wash fastness might be good
Light Fastness	3-4	Light fastness might be moderate
Dry Rubbing Fastness	3-4	Tulsi-dyed fabrics might have good dry rubbing fastness
Wet Rubbing Fastness	3-4	Tulsi-dyed fabrics might have fair wet rubbing fastness
Color Fastness to Perspiration	3-4	Color Fastness to Perspiration Might be Good

Sample-01 CCMS Test Report



QC

02-Dec-24 10:56:37 AM

Alliance Knit Composite Ltd.

Pukurpur,Zirabo, Ashulia, Savar

dCIELab: D65-10

ILL 1 D65-10
ILL 2 TL84-10
ILL 3 A -10

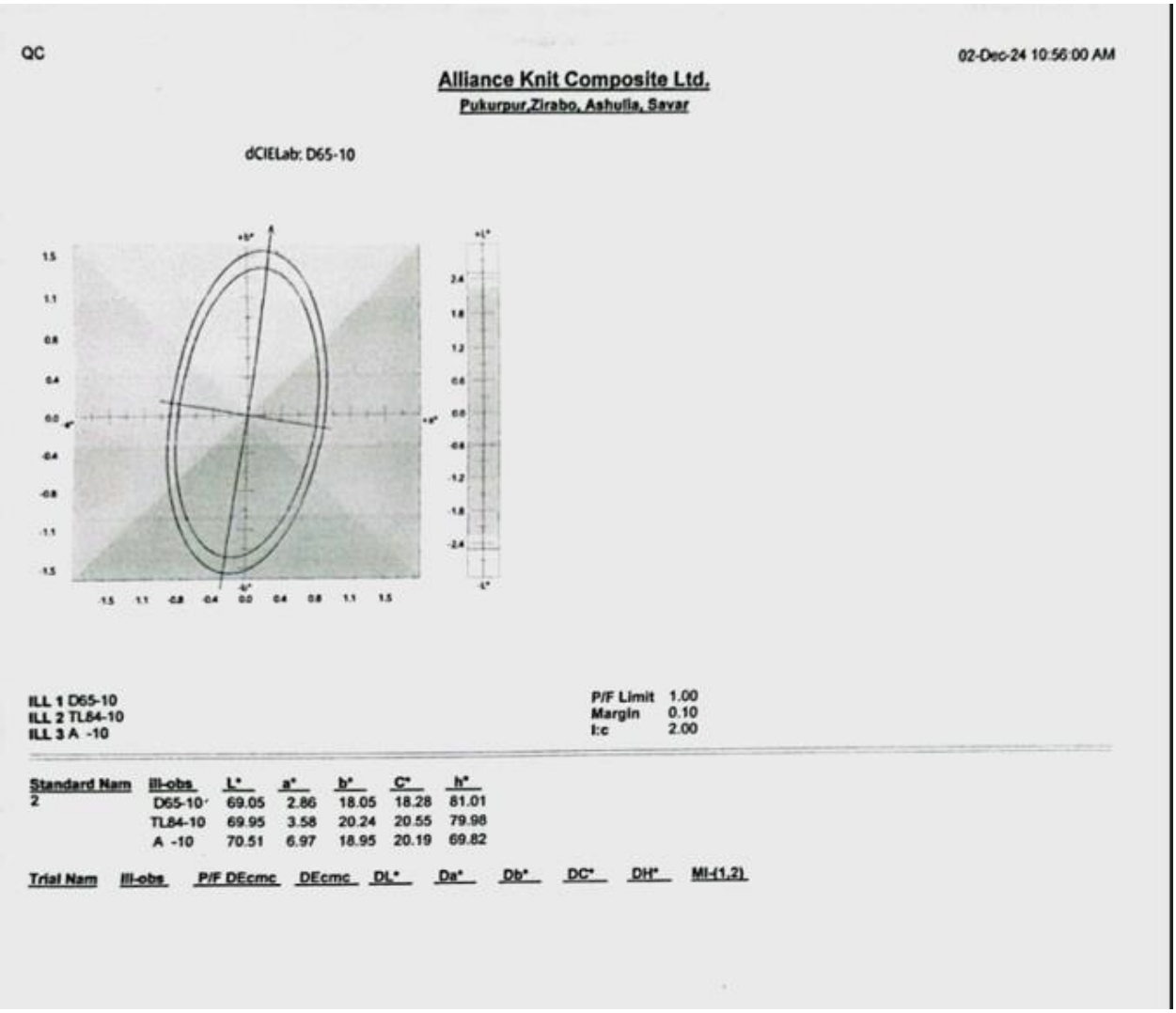
P/F Limit 1.00
Margin 0.10
I:c 2.00

Standard Nam	Ill-obs	L*	a*	b*	C*	h°
1	D65-10	78.64	1.38	9.67	9.76	81.89
	TL84-10	79.12	2.06	10.25	10.46	78.63
	A -10	79.45	4.03	10.01	10.80	68.05

Trial Nam	Ill-obs	P/F DEcmc	DEcmc	DL*	Da*	Db*	DC*	DH*	MI-(1,2)

Figure-10: CCMS test result of Woven Cotton Fabric Dyeing with Fresh Tulsi Leaf.

Sample-02 CCMS Test Report



QC

02-Dec-24 10:56:00 AM

Alliance Knit Composite Ltd.

Pukurpur,Zirabo, Ashulia, Savar

dCIELab: D65-10

ILL 1 D65-10
ILL 2 TL84-10
ILL 3 A -10

P/F Limit	1.00
Margin	0.10
l:c	2.00

Standard Nam	Ill-obs	L*	a*	b*	C*	h*
2	D65-10	69.05	2.86	18.05	18.28	81.01
	TL84-10	69.95	3.58	20.24	20.55	79.98
	A -10	70.51	6.97	18.95	20.19	69.82

Trial Nam	Ill-obs	P/F DEcmc	DEcmc	DL*	Da*	Db*	DC*	DH*	MI-(1,2)

Figure-11: CCMS test result of Woven Cotton Fabric Dyeing with Dried Tulsi Leaf.

4.2Discussion

Tulsi leaf extract serves as a natural dye, highlighting its potential as an eco-friendly alternative to synthetic dyes. The bioactive compounds in Tulsi, such as flavonoids and tannins, contributed to effective dyeing and offered possible antimicrobial benefits, adding functional value to the dyed fabric. The role of mordants was critical in achieving varied shades and improving dye fixation.

The dyeing procedure produced moderate fastness attributes, but it was adequate for applications that needed to be environmentally friendly and have a minimal influence on the environment. Additional fixatives or post-treatment techniques, for example, could improve light fastness and moist rubbing resistance.

Tulsi's scalability is guaranteed by its biodegradable nature and the ease of the dye extraction process, albeit industrial adoption may require automated extraction and application methods.

The dyeing technique generates minimal waste, uses fewer chemicals, and is biodegradable, making it a safer and better alternative for the environment.

Additionally, the use of Tulsi, a plant that is readily available and grows quickly, supports a sustainable supply of raw materials, which is crucial when it comes to resource conservation.

4.3 Sample Attachment

4.3.1 Sample 01

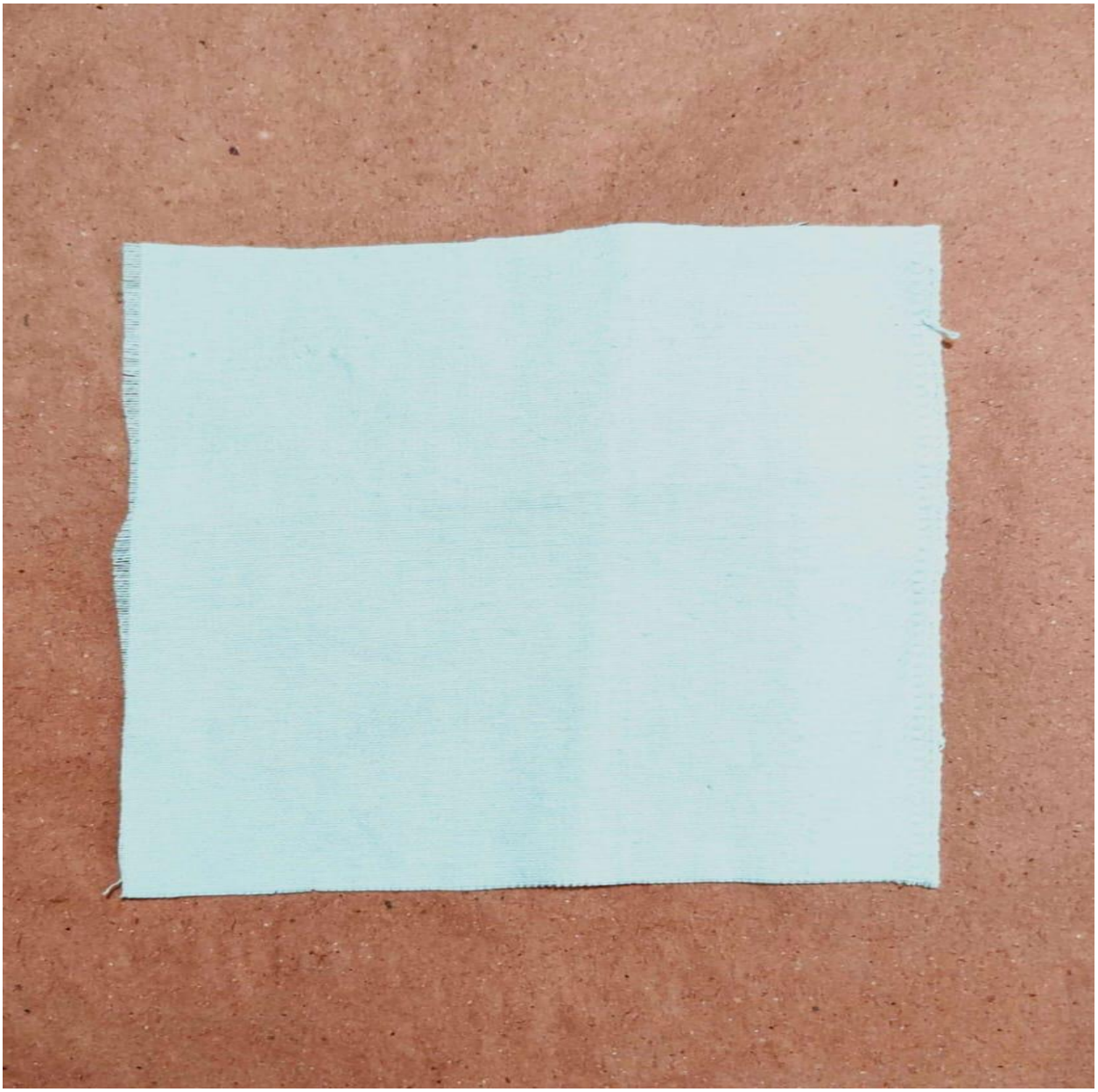


Figure-12: Sample of Grey Fabric before dyeing.

4.3.2 Sample 02

Figure-13: Sample of Woven Cotton Fabric Dyeing with Fresh Tulsi Leaf.

4.3.3 Sample 03

Figure-14: Sample of Woven Cotton Fabric Dyeing with Dried Tulsi Leaf.

Chapter-5

Professional Responsibilities, Health, Safety, Socio-Cultural, and Environmental consideration

5.1 Introduction

There are several environmental advantages to colouring cotton-woven clothing with natural dyes, such Tulsi (Ocimum sanctum) extract, in compliance with sustainable textile industry standards. But it also involves a lot of professional duties, especially when it comes to upholding safety and health regulations, managing sociocultural fallout, and taking environmental effects into consideration. To support an ethical, sustainable method of textile production, professionals engaged in the natural dyeing process must take the initiative to manage these problems.

5.2 Professional Responsibilities

Professionals who use natural dyes, like Tulsi leaf extract, must prioritise ethical and environmentally friendly practices throughout the dyeing process. This involves choosing fixatives and mordants that are suitable for the environment and ensuring that raw materials, such as tulsi leaves, are supplied ethically and securely.

They must keep being transparent and truthful with consumers about the benefits of Tulsi-dyed textiles for the environment and human health while guaranteeing that the final products meet stringent standards for quality, performance, and sustainability.

In order to enhance the dyeing process and maximise elements like colour uniformity, fastness characteristics, and scalability for industrial production, experts must also encourage continuous research and innovation.

5.2.1 Respect for Health and Safety Standard

Professionals must put the health and safety of employees, customers, and local communities first because the procedure uses plant-based extracts and mordants. This involves making certain that the mordants and dyes utilised are safe for human contact and non-toxic.

To reduce the hazards connected with the use of chemical and natural mordants, particularly in industrial-scale manufacturing, regulatory norms and guidelines, such as those established by organisations like the International Organisation for Standardisation (ISO), must be adhered to.

To avoid health risks, dyeing processes must also follow proper ventilation, handling, and disposal procedures.

5.2.2 Advocacy for Sustainability in the Textile Industry

Promoting more extensive industry-wide sustainability practices should be a priority for professionals. In order to promote the use of more environmentally friendly and sustainable dyeing

techniques, this entails working with various stakeholders, such as textile producers, designers, environmental groups, and legislators.

Promoting the use of natural colours, like tulsi, in both large-scale industrial applications and small-scale artisanal crafts can significantly lessen the environmental impact of the textile sector overall.

Furthermore, promoting laws and guidelines that support the use of environmentally friendly colours might influence how the textile sector develops in the future to become more environmentally conscious.

5.2.3 Consumer Education and Transparency

It is also the duty of eco-friendly dyeing experts to inform customers about the advantages of using textiles dyed with tulsi. To effectively communicate the sustainable nature of these fabrics, transparent labelling, product information, and communication are crucial.

Customers are becoming more aware of how their purchases affect the environment, so giving them thorough information about the dye's place of origin, the advantages of using natural dyes, and the environmental benefits can build confidence and encourage wise choices.

5.2.4 Innovation and Quality Assurance

Although natural dyes, such as tulsi, have many advantages, they can have drawbacks, especially when it comes to getting uniform colour outcomes and high fastness qualities. It is the duty of experts to keep developing new techniques for natural dyeing in order to enhance the calibre and functionality of textiles dyed with tulsi.

To improve the longevity, colour brightness, and fastness characteristics of textiles coloured with tulsi, research into substitute mordants, post-dyeing procedures, and dyeing methods is essential. To guarantee that the finished product satisfies consumer expectations, quality assurance procedures should be strictly followed.

These procedures should cover everything from colour quality to durability and fastness.

5.3 Health and Safety Considerations

Natural dyes are not an exception to the rule that health and safety come first in any dyeing procedure. Although tulsi extract is generally regarded as harmless, professionals should use

caution when handling mordants, particularly metallic ones like iron or aluminium, which can be dangerous if improperly handled.

To prevent direct contact with chemicals or dye vapours, protective equipment such respirators, goggles, and gloves should be worn during the dyeing process. In order to reduce exposure to irritants or fumes, ventilation systems ought to be implemented in dyeing operations.

All dyeing ingredients, including as the Tulsi extract and any mordants, must be non-toxic and safe for both employees and customers.

5.4 Socio-Cultural Considerations

Utilising natural colours, particularly those made from regionally grown plants like tulsi, can benefit society and culture. Tulsi is highly valued for its therapeutic qualities and use in spiritual rituals in many parts of India and other places, where it has profound cultural and religious importance. Professionals can encourage the preservation and appreciation of ancient knowledge and traditions by employing Tulsi as a natural dye.

Additionally, this promotes the revival of regional farming methods by giving farmers new sources of revenue from the sustainable production of tulsi. Additionally, by incorporating natural dyes into contemporary textile design, encouraging the use of Tulsi-dyed textiles can contribute to the preservation and enhancement of cultural legacy and forge a link between innovation and tradition.

However, when employing Tulsi or any other locally obtained resources, practitioners must be cognisant of the socio-cultural milieu. It is essential to make sure that the plant's cultural significance is honoured and that it is sourced responsibly from areas where it is valued. Furthermore, local populations should be included and involved in any commercial usage of tulsi, especially those who depend on it for spiritual or medical purposes.

5.5 Environmental Considerations

The environmental benefits of employing Tulsi leaf extract for dyeing are among its main advantages. Compared to synthetic dyes, which frequently depend on hazardous petrochemical processes, tulsi is a plant that grows quickly and has a lower ecological impact during cultivation. Tulsi and other natural colours lessen the need for heavy metals, hazardous chemicals, and water-intensive procedures that are frequently used in synthetic dyeing. Nonetheless, it is crucial to make sure that there are no environmental hazards associated with the extraction and colouring procedures.

One such issue is water management; although though natural dyes usually use less water than synthetic ones, experts must be careful to prevent water contamination from incorrect colour

residue removal. Water consumption should be minimised during the dyeing process, and any effluent should be cleaned before being discharged into the environment. The effects on the environment must also be considered while using mordants, particularly metallic ones. If not handled properly, many mordants can contaminate soil or water since they are not biodegradable.

The sustainability of plant cultivation should also be taken into account by experts. Despite being a renewable resource, tulsi needs to be acquired carefully to avoid overharvesting, particularly in areas where it is prized for other uses. In order to guarantee that the demand for Tulsi leaves does not result in deforestation or the deterioration of regional ecosystems, sustainable farming methods such as organic production and agroforestry systems must to be promoted.

Chapter-6

Conclusions

6.1 Conclusions

Natural Tulsi (Ocimum sanctum) leaf extract is used to dye cotton woven garments in an environmentally responsible manner, offering a creative and sustainable substitute for traditional synthetic dyeing methods. As the need for sustainably produced textiles grows worldwide, this approach offers a natural, renewable, and biodegradable option that lessens ecological harm. Tulsi, a plant with cultural and medicinal significance that lends earthy and soothing colours to cotton fabrics, is an alluring option for creating sustainable textiles with added aesthetic and functional value.

By using plant-based ingredients instead of the dangerous chemicals present in synthetic dyes, Tulsi extract significantly lowers environmental pollution during the dyeing process. The sustainability profile of natural dyes is further enhanced by the fact that less water and energy are used in their creation. Because Tulsi-dyed fabrics can have moderate wash, light, and rubbing fastness, natural or eco-friendly mordants are required to increase lifespan and performance. Iron and alum are examples of mordants that have shown promise in increasing speed without compromising environmental friendliness.

The use of tulsi as a natural dye raises ethical and societal issues. By promoting the use of traditional dying methods, it revitalises regional expertise and workmanship. Furthermore, Tulsi cultivation supports rural lives and encourages the sustainable use of natural resources by providing farmers with a second source of income. By adopting these principles, professionals in the textile industry promote fair trade, biodiversity conservation, and community development.

Despite its benefits, Tulsi-based dyeing's scalability remains an issue. Two significant concerns that must be addressed are the uniformity of colour results and the availability of raw components. Further research and development is needed to improve the fastness properties, optimise the extraction process, and look into new applications for tulsi dye. By merging state-of-the-art technologies with traditional methods, these limitations can be overcome, improving the process's feasibility for widespread industrial applications.

In conclusion, the eco-friendly dyeing of cotton fabrics using Tulsi extract is a step toward a more sustainable textile industry. This strategy can be used as a model for striking a balance between social and economic advantages and environmental responsibility by tackling the issues of resource management, scalability, and speed as well as by guaranteeing the ethical and sustainable sourcing of raw materials. Tulsi-dyed textiles have the potential to make a substantial contribution to a future for the textile industry that is healthier, more environmentally friendly, and socially conscious because to the rising demand from consumers for sustainable products and the continuous advancements in natural dyeing techniques.

Chapter-7

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