

Sustainable Dyeing of Soy Fabric using Natural Dye Extracted from Teak Leaves

Dr. Saravanya.K. S¹, Sameeha Kuraisha. S²

¹Assistant professor and Head, Department of Fashion Technology,
Arunachala Arts& Science (women) college,
Vellichanthai, Tamilnadu, India.

²II M. Sc Textiles and Fashion Designing,
Arunachala Arts& Science (women) college,
Vellichanthai, Tamilnadu, India.

Abstract: - Natural dyes have gained increasing attention in textile processing due to their eco-friendly, biodegradable and non-toxic characteristics. The growing environmental concerns associated with synthetic dyes have encouraged the exploration of sustainable dyeing alternatives derived from natural sources. This study focuses on the dyeing of soy fabric using natural dye extracted from teak leaves (*Tectona grandis*). Teak leaves are widely available agricultural waste materials that contain natural pigments suitable for textile coloration. In this study, dye extraction was carried out by boiling teak leaves in water to obtain a dye solution for fabric dyeing. The dyed fabric samples were evaluated through visual inspection parameters such as general appearance, brilliance of colour, evenness of colour and texture. In addition, colour fastness tests including sunlight, washing, pressing and crocking (wet and dry) were conducted to assess the performance of the dyed fabric. The results indicated that soy fabric showed satisfactory dye absorption and acceptable colour fastness properties. The study demonstrates that teak leaf extract can serve as a potential natural dye source for soy fabric and supports the development of sustainable textile dyeing practices. (Keywords) — Natural dye, Soy fabric, Teak leaf extract (*Tectona grandis*), Textile dyeing, Colour fastness, Sustainable textiles

I. INTRODUCTION

Dyes are colourant materials that penetrate into the fibre and appear to become a part of it. Dyes may be either natural or synthetic, and both types are used for dyeing fibres, yarns and fabrics [1]. Nowadays, the use of natural materials and natural methods is considered to be an element that increases the value of a product and contributes to sustainable life in environmental, economic and sociological aspects [2]. Synthetic dyes used in the textile industry pollute a large amount of water because they do not bind tightly to the fabric and are often discharged as effluent into the aquatic environment. As a result, the continuous discharge of wastewater from a large number of textile industries without prior treatment has significant negative consequences for the environment and human health [3]. Soybean protein fibre belongs to the Azlon fibre group and is often referred to as “vegetable cashmere,” “artificial cashmere,” or “soy silk” due to its soft, cashmere-like feel. The natural colour of soybean protein fibres is typically pale yellow or cream [4].

Teak leaves contain anthocyanin pigments which contribute to the appearance of red colour when utilized for dyeing. Anthocyanin is one of the important plant pigments, and its presence in teak leaves enables them to be used as a natural dye

for textile coloration [5]. Due to the harmful, toxic and carcinogenic effects associated with synthetic dyes, many dyers are shifting towards the use of natural dyes which are environmentally friendly [6].

Therefore, the present study focuses on the dyeing of soy fabric using natural dye extracted from teak leaves (*Tectona grandis*). The dye was extracted from teak leaves and applied to soy fabric through a suitable dyeing process. The dyed fabric samples were evaluated to determine their visual and performance characteristics. Visual inspection was carried out to assess parameters such as general appearance, brilliance of colour, evenness of colour and texture. In addition, colour fastness tests including sunlight, washing, pressing and crocking (both wet and dry) were conducted to evaluate the durability and stability of the dye on soy fabric.

II. MATERIALS AND METHODS

A. Materials

The main material used in this study was 100% soy fabric, which was selected for the dyeing process due to its eco-friendly and biodegradable nature. Soy fabric is a regenerated protein fiber produced from soybean residue and is known for its soft texture and good dye absorption properties. Because of its compatibility with natural dyes and its sustainable characteristics, soy fabric was chosen as the base material for this research.

The natural dye used in this study was obtained from waste teak leaves (*Tectona grandis*). Teak leaves contain natural colouring pigments and are commonly available as agricultural waste. Using teak leaves as a dye source helps promote the utilization of natural resources and supports environmentally friendly dyeing practices.

For pre-treatment, natural scouring materials such as wood ash and soapnut were used to remove impurities and improve the fabric's ability to absorb dye. To enhance dye uptake and colour fixation, natural mordants including myrobalan, sappan, and madder were used during the dyeing process. In addition, a 1% iron solution was applied as a post-treatment to improve colour development and fixation on the fabric.

B. Fabric Pre-treatment (RFD Process)

Before dyeing, the fabrics were subjected to a Ready for Dyeing (RFD) pre-treatment process. The RFD solution was prepared by filtering 400 ml of soapnut water and 200 ml of wood ash water, which were then added to 20 litres of water. The solution was heated and boiled for approximately 30 minutes. The soy was immersed in the prepared solution and allowed to soak for 30 minutes to remove impurities, dirt and natural finishes present in the fabric. After soaking, the fabrics were rinsed thoroughly with water and dried. This process improves the absorbency of the fabric and prepares it for effective dyeing.

C. Extraction of Teak Leaf Dye

The natural dye used in this study was extracted from teak leaves, which are considered an abundant agricultural waste and a sustainable source of natural coloring agents. Fresh teak leaves were collected from nearby areas and carefully selected to ensure good quality. The collected leaves were thoroughly washed with clean water to remove dust, soil particles, and other impurities that could affect the quality of the dye extract. This cleaning step is important as it helps in obtaining a pure dye solution and prevents unwanted contaminants from interfering with the dyeing process. After washing, the teak leaves were cut into smaller pieces to increase the surface area for effective extraction of coloring pigments. For the extraction process, 1 kg of teak leaves was added to 20 liters of water in a stainless-steel vessel. The mixture was then heated and boiled for a specific period of time. During boiling, the heat helps break down the plant tissues and allows the natural pigments present in the leaves to dissolve into the water, forming a colored dye liquor. Continuous heating enhances the release of dye molecules and ensures better extraction of the natural color. Once sufficient color was obtained, the dye solution was allowed to cool slightly and then filtered to remove leaf residues and other solid particles. Filtration was carried out using a fine cloth or filter paper to obtain a clear dye extract. The filtered solution contained the natural dye derived from teak leaves and was used for dyeing the fabric samples under controlled conditions. This prepared dye extract served as the primary coloring medium in the dyeing process.

D. Mordanting Process

To improve dye fixation and colour strength, the fabrics were subjected to a mordanting process. Natural mordants such as myrobalan, sappan and madder were used to treat the fabrics prior to dyeing. After mordanting, the fabrics were dipped in a 1% iron solution, which helps enhance colour depth and improves the bonding between the dye and the fabric. The fabrics were then rinsed and washed to remove excess mordant before further evaluation.

E. Evaluation of Dyed Fabrics

1) Visual Inspection

The dyed fabric samples were evaluated through visual inspection to assess their overall appearance. The evaluation parameters included general appearance, brilliance of colour, evenness of colour and texture.

2) Color Fastness Tests

The color fastness properties of the dyed fabrics were evaluated using standard textile testing methods to determine the durability and stability of the natural dye on the fabric. Color fastness refers to the resistance of a dyed fabric to fading or running when exposed to different external conditions such as washing, heat, rubbing, and sunlight. Evaluating these properties is important to understand the performance and suitability of the dyed fabric for practical use.

The following colour fastness tests were conducted on the dyed fabric samples:

- **Washing Fastness Test:**

This test determines the resistance of the dyed fabric to color loss during washing. The dyed fabric sample was washed under controlled conditions using water and detergent. After washing and drying, the fabric was examined for any color fading or staining on adjacent fabrics.

- **Pressing Fastness Test:**

Pressing fastness evaluates the resistance of the fabric color to heat during ironing or pressing. The dyed fabric sample was subjected to heat using a pressing iron under controlled temperature. The sample was then checked for any colour change or transfer caused by heat exposure.

- **Sunlight Fastness Test:**

This test measures the resistance of the dyed fabric color to fading when exposed to sunlight. The dyed samples were exposed to direct sunlight for a specific period. After exposure, the fabric was examined to observe any changes in color intensity or fading.

- **Crocking Test (Dry and Wet):**

The crocking test evaluates the resistance of the dyed fabric to color transfer through rubbing. In the dry crocking test, a dry white cloth was rubbed against the dyed fabric, while in the wet crocking test, a wet cloth was used. The white cloth was then checked to assess the degree of colour transfer.

F. MECHANICAL PROPERTIES

Mechanical properties refer to the physical characteristics of a fabric that determine its behaviour under external forces and during use. In this study, mechanical properties are evaluated by measuring fabric weight and fabric thickness, which influence the fabric's durability, comfort, and overall performance.

- **Fabric Weight:**

Fabric weight is an important mechanical property that indicates the mass of the fabric per unit area, usually expressed in grams per square meter (GSM). It helps determine the density, thickness, and suitability of the fabric for specific applications. In this test, the fabric weight is measured using a fabric weight (GSM) machine. For greater accuracy and reliability, five readings are taken from different areas of the fabric sample. The average of these readings is then calculated to obtain the final fabric weight value. The detailed results of this testing will be presented in the next chapter

- **Fabric Thickness**

A micrometer is a precision measuring instrument used to measure very small dimensions such as the thickness of fabrics, yarns, or other materials with high accuracy. In textile testing, it is commonly used to determine the fabric thickness, which is the distance between the upper and lower surfaces of the fabric. To measure fabric thickness, the fabric sample is placed between the anvil and spindle of the micrometer. The spindle is gently lowered using the rotating thimble until it just touches the fabric surface without applying excessive pressure. The measurement is then read from the micrometer scale, which indicates the thickness of the fabric in millimeters. This test is conducted to evaluate the bulk, handle, and insulation properties of the fabric. The detailed results of this testing will be presented in the subsequent chapter.

III. RESULT AND DISCUSSION

A. Visual Inspection of Dyed Soy Fabric

The dyed soy fabric samples were visually evaluated to assess their aesthetic qualities after dyeing with teak leaf extract. The evaluation was carried out based on parameters such as general appearance, brilliance of colour, evenness of colour and texture. The results obtained from the visual inspection are presented in Table 1.

Table I. Visual inspection

Dyed Sample	General appearance	Brilliance of color	Evenness of Color	Texture
100% Soy Fabric	4	5	5	5

Guidelines for rating

- 5 - excellent
- 4 - very good
- 3 - good
- 2 - fair
- 1 - poor

The results indicate that the dyed soy fabric exhibited good general appearance and colour brilliance. The evenness of colour was rated very high, indicating uniform dye penetration and distribution on the fabric surface. The texture of the fabric remained excellent after the dyeing process, showing that the natural dyeing treatment did not negatively affect the fabric structure. Overall, the visual inspection results demonstrate that teak leaf extract can produce aesthetically pleasing and uniform coloration on soy fabric.

B. Colour Fastness Properties of Dyed Soy Fabric

The colour fastness properties of the dyed soy fabric were evaluated to determine the durability and stability of the natural dye under different conditions. The tests conducted included washing fastness, pressing fastness, sunlight fastness and crocking fastness (wet and dry). The results obtained from these tests are presented in Table 2.

Table II. Color Fastness Properties of Dyed Soy Fabric

S. No:	Dyed Sample	Test	Rate
1.	100% Soy Fabric	Washing Test	5
2.	100% Soy Fabric	Pressing Test	5
3.	100% Soy Fabric	24-hour sunlight Test	5
4.	100% Soy Fabric	48-hour sunlight Test	4
5.	100% Soy Fabric	Dry Crocking Test	4.5
6.	100% Soy Fabric	Wet Crocking Test	4

Table 2 shows that the dyed soy fabric exhibited satisfactory colour fastness properties under the various testing conditions. The washing and pressing fastness results indicate that the dye remained relatively stable on the fabric with minimal colour fading. The sunlight fastness test showed moderate resistance to fading when exposed to light, which is commonly observed in many natural dyes. The crocking fastness results for both wet and dry conditions indicated low colour transfer, demonstrating good dye fixation on the soy fabric.

C. MECHANICAL PROPERTIES

- Fabric Weight:

The fabric weight of the dyed sample was determined using a GSM cutter and a digital weighing balance to obtain accurate results. A circular specimen was first cut using the GSM cutter, ensuring a standard testing area. The cut sample was then carefully placed on the weighing balance to record its weight. To improve the reliability of the results, multiple readings were taken under the same testing conditions. The recorded values were tabulated and the average was calculated by dividing the total weight by

the number of readings. This procedure provides a reliable and precise evaluation of the fabric weight, ensuring accuracy in the assessment of the fabric sample.

Table III. Fabric Weight

Sl. No	Dyed Sample	Weight	Mean
1.	100% Soy Fabric	0.889 g 0.903 g 0.896 g 0.912 g 0.905 g	0.901 g

The table represents the fabric weight measurements obtained for the tested samples using the GSM cutter and weighing balance. Multiple readings were recorded to ensure accuracy and reliability of the results. Slight variations in the values may occur due to minor differences in the fabric structure and measurement conditions. The average value calculated from these readings provides a reliable representation of the fabric weight of the sample.

Fabric Thickness:

The thickness of the dyed fabric sample was measured using a thickness gauge to determine the fabric's dimensional property. The fabric specimen was placed carefully between the pressure foot and the base of the thickness gauge. The instrument was allowed to apply uniform pressure on the fabric surface to obtain an accurate measurement. Multiple readings were taken at different places of the fabric sample to avoid errors caused by uneven surfaces. The observed values were recorded systematically and the average thickness was calculated by dividing the total by the number of readings.

Table IV. Fabric Thickness

Sl. No	Dyed Sample	Thickness	Mean
1.	100% Soy Fabric	0.272 mm 0.279 mm 0.277 mm 0.275 mm 0.283 mm	0.277 mm

The table represents the thickness measurements obtained for the fabric samples during the testing process. Multiple readings were recorded at different points of the fabric to ensure accuracy and consistency. The values show slight variations due to the natural structure and surface irregularities of the fabric. The average thickness calculated from these readings provides a reliable representation of the fabric's overall thickness

IV. CONCLUSION

The present study investigated the dyeing of soy fabric using natural dye extracted from teak leaves (*Tectona grandis*). The results obtained from visual inspection indicated that the dyed fabric exhibited good general appearance, colour brilliance, evenness of colour and maintained a smooth texture after dyeing. The colour fastness tests including washing, pressing, sunlight and crocking (wet and dry) demonstrated satisfactory performance of the dyed fabric under different conditions. These findings suggest that teak leaf extract can be effectively used as a natural dye for soy fabric. The study highlights the potential of using plant-based dyes as sustainable and environmentally friendly alternatives to synthetic dyes in textile dyeing processes.

V. REFERENCE

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