Natural Dyeing of Cotton Fabric Using Hibiscus and Turmeric: A Susatainable Approach for Children's Clothing

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Abstract
The growing demand for sustainable and eco-friendly alternatives in the textile industry has encouraged the exploration of natural sources for dyeing fabrics. Hibiscus petals and turmeric powder, both rich in natural pigments and bioactive compounds, present promising potential as plant-based dyes. Hibiscus petals yield shades ranging from soft pink to deep red due to the presence of anthocyanins, while turmeric imparts vibrant yellow hues owing to curcumin content. In addition to their coloring properties, these natural dyes are biodegradable, non-toxic, and possess antimicrobial and antioxidant characteristics, offering functional benefits to textiles. This study investigates the dyeing potential of hibiscus petals and turmeric powder on cotton fabrics, with emphasis on shade variation, color fastness, and the role of natural mordants in improving dye fixation. The findings highlight their suitability as sustainable alternatives to synthetic dyes, supporting eco-conscious approaches in textile processing.

Keywords: Hibiscus Rosa-Sinensis, Curcuma Longa, Alum, Biodegradable, Non-Toxic, Sustainable.

Introduction

The textile processing industry is one of the biggest environmental polluters, because effluent from these industries involve a lot of chemicals including dyes used in the textile processing. There are two main techniques to decrease the environmental influence of textile manufacturing. They are either via developing really large and effective effluent treatment plants or use of eco-friendly dyes & chemicals.

Hibiscus petals (Hibiscus rosa-sinensis) are an abundant floral resource known for their rich red pigments derived from anthocyanins. These compounds not only provide attractive colors ranging from pink to deep burgundy but also offer added benefits such as antioxidant and antimicrobial properties. In dyeing applications, hibiscus extracts can produce soft to deep shades on cotton and other natural fibers, especially when used with suitable mordants.

Turmeric rhizomes (Curcuma longa), on the other hand, have been widely used in food, medicine, and traditional textiles for centuries. The yellow pigment in turmeric, curcumin, is valued for its bright hue and medicinal qualities, including anti-inflammatory and antibacterial properties. In fabric dyeing, turmeric imparts a brilliant yellow shade and enhances the functional value of textiles by providing resistance to microbial growth.

Objectives

1. To achieve vibrant and long-lasting colours.
2. To develop the natural dye in a reasonable price.
3. To reduce the environmental impact caused by synthetic dyes.
4. To promote the natural dyes.

Methodology

Fabric: Cotton. Natural Resources: Hibiscus rosa-sinensis (Hibiscus) and Curcuma longa (Turmeric). Mordant: Aluminium Potassium Sulfate (Alum).

The methodology followed the sequence: Pre-Preparation (Fabric Preparation) – Extraction of Dye (Double boiling method) – Strain & Filter (Separate dye liquid from solid) – Dyeing Method (Tie & Dye) – Pattern Making & Stitching – Testing & Evaluation – Result.

Selection of Raw Materials

Cotton Fabric

Cotton fabric is soft, breathable, and absorbent. It is a wonderful fabric for children's clothing. Cotton fabric is non-toxic, hypoallergenic, and smoothing on the skin. It's also long-lasting and easy to maintain. Cotton fabric is appropriate for manufacturing a wide range of children's clothes such as t-shirts, dresses, and slacks.

Figure 1 Cotton Fabric.

Natural Resources

Hibiscus Petals

Figure 2 Hibiscus (rosa-sinensis).

Hibiscus is an important natural dye source that offers a wide range of eco-friendly colorants. The petals of Hibiscus rosa-sinensis and Hibiscus sabdariffa contain anthocyanin pigments, which impart attractive shades of red, pink, and purple to textiles. This natural dye is biodegradable, non-toxic, and sustainable, making it a safe alternative to synthetic dyes.

Turmeric Rhizomes

Turmeric (Curcuma longa) is one of the most widely used natural dyes, obtained from its underground rhizomes. It contains the colouring compound curcumin, which imparts a bright yellow to golden shade that is highly valued in textile dyeing, food, cosmetics, and traditional practices. Turmeric dye works effectively on natural fibres like cotton, silk, and wool, producing warm yellow hues that symbolize purity and auspiciousness in many cultures.

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Figure 3 Turmeric (Curcuma longa).

Mordant – Potassium Aluminum Sulfate

Alum (potassium aluminium sulphate) is the most widely used mordant in natural dyeing due to its safety, effectiveness, and ability to produce bright, clear shades. It acts as a binding agent between the fibre and the natural dye molecules, thereby improving colour absorption, brilliance, and durability. Alum is suitable for use on cotton, silk, and wool, and it works well with a wide range of natural dyes such as turmeric, hibiscus, onion skin, and madder.

Figure 4 Alum.

Pre-Preparation – Fabric Preparation

- Rinse the cotton cloth with warm water to eliminate any dirt or contaminants.
- Combine 1–2 tablespoons of soap nuts with 1 litre of water. Allow it to steep for 30 minutes to an hour.

- Soak the cotton cloth in the soap nut solution for two to three hours.
- Rinse the fabric well with water, then wash it with a light detergent.

Extraction of Dye

Weight of the fabric = 95g. Material: liquor ratio = Fabric weight – 30 = 95 – 30 = 2,850 ml. Amount of dyestuff required = fabric weight – 10% = 95 – 10/100 = 9.5g. Amount of mordant = Fabric weight – 3% = 95 – 3/100 = 2.85g.

Figure 5 Extraction of dye

- The calculated amount of natural dyestuff is made into paste with calculated amount of salt.
- The paste is mixed with required amount of water according to the material (Liquor ratio).
- Then the solution is allowed in the water bath for 10 mins at 100°C.
- Later the sample fabric is wetted and immersed in the dye solution.
- Dyeing is done at 100°C for 1 hour; finally the material is taken out and given a cold wash.

Strain & Filter

Figure 6 Filtered Dye liquid.

- Place a cheesecloth or cotton cloth over the sieve or colander.
- Carefully transfer the dye mixture from the pot to the sieve or colander.
- Drain the dye liquid into the bowl or container using a cheesecloth or cotton cloth. Discard the solids.
- Use a spoon or spatula to push the solids on the cheesecloth or cotton cloth, extracting as much dye liquid as possible.
- If needed, filter the dye liquid again with a clean cheesecloth or cotton cloth to eliminate any leftover contaminants.
- Transfer the filtered dye liquid to a clean container, discarding any particles or contaminants.

Dyeing

Figure 7 Tie and Dye Method.

- Fold the cloth into a sequence of strips, folding each strip in the opposite direction of the preceding one.
- Bind the folded fabric with thread or yarn to keep it in place.
- Dye the bound cloth with the double boiling process.
- Remove the bindings to show the distinctive patterns produced by the resist dyeing technique.

Figure 8 Dyeing.

Pattern Making & Stitching

Pattern making is the process of making a template or guide to cut out fabric for garment construction or textile design. Stitching is the process of attaching two or more pieces of fabric together with thread or yarn.

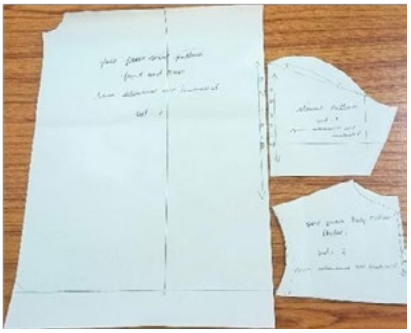


Figure 9 Pattern Making.

Testing & Evaluation

Perspiration Testing

This test assesses how resistant the coloured textile is to both acidic and alkaline sweat. Make a new solution using 0.5g 1-histidine mono-hydrochloride mono-hydrate, 5g sodium chloride, and 2.5g disodium

hydrogen orthophosphate per litre to test for colour fastness to perspiration. Use sodium hydroxide (0.1N) to bring the pH down to 8.0.

Procedure

- To create a composite specimen, sew the test specimen and multi-fiber fabric together at the short edge.
- Each composite specimen should be weighed. Utilizing a liquor ratio of 1:50 per specimen, compute the test solution.
- A composite sample should be soaked for 30 minutes at room temperature in a pH 8.0 solution with a 20:1 liquor ratio. With a force of 4.5 kg, place the composite sample between two 7.5 x 6.5 cm glass plates after removing the solution.
- Apply the same procedure to the other sample, but use a pH of 5.5.
- Put the samples in the oven at 37±2°C for 4 hours.
- Dry the white cloth and the sample separately in air at 60°C.
- Use a grey scale to assess the specimens' colour change after drying.

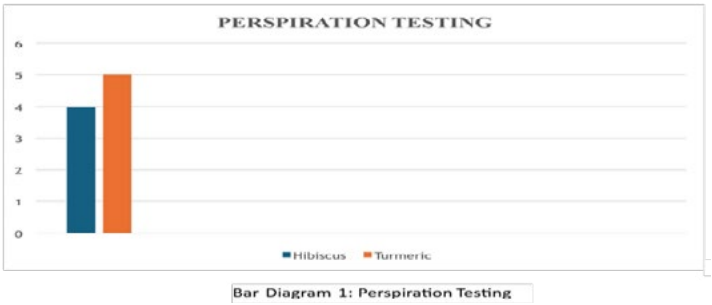


Figure 10 Colour Fastness to Perspiration.

Colour Fastness to Washing

Colour fastness to washing testing is a defined test method for determining a textile material's colour resistance to washing by mimicking colour loss or transfer during laundry.

Bar Diagram 2: Washing Test

Procedure

- A 10–4 cm swatch of dyed cloth is sandwiched between two neighbouring textiles, then sewn.
- The sample and surrounding cloth were washed together.
- Five distinct cleaning techniques are mentioned.

- Preheat the solution to the appropriate washing temperature.
- The liquor ratio should be 1 to 50. After soaping, the specimen should be rinsed twice in cold water, followed by running tap water.
- After being squeezed and dried in air at temperatures below 60°C, the value is analysed using grey scales.

Colour Fastness to Sunlight

Colour fastness to sunlight testing is a standardized test method for determining how resistant a textile material's colour is to fading or deterioration induced by sunlight exposure.

Colour Fastness to Rubbing

Procedure

- Cut 3 swatches of dyed sample, each measuring 10 cm x 4 cm.
- Make sure the samples are clean and free of any dirt, oils, or finishes that could influence the test results.
- Dry the samples to a moisture content of 5% or less to avoid moisture-related influences on test results.
- Give each sample a unique identity (1–3) to guarantee precise tracking and recording of data.
- Place the seven test samples in direct sunshine, either outside or using a sunlight simulator.
- Take one test sample from sunlight exposure every day for three days.
- Evaluate the colour change of each test sample immediately after being removed from sunshine exposure.

Colour Fastness to Rubbing

Colour fastness to rubbing testing, also known as colour fastness to crocking testing, is a standardized test method for determining how resistant a textile material's colour is to rubbing or abrasion. The test is designed to assess how well the colour of a textile material resists transfer or bleeding when subjected to rubbing or friction, replicating real-life events such as wear and tear, washing, or dry cleaning.

Dry Rubbing

Dry rubbing testing, also known as dry crocking testing, is a regulated procedure for determining the colour fastness of textile materials to dry rubbing or abrasion.

Procedure

- Mount the specimen to the Crockmeter's baseboard using the holding clamp. The specimen's long direction parallels the rubbing trail. Ensure that the specimen lies flat on the baseboard.
- Two tests are conducted: one for warp length and one for weft breadth.
- Place a dry rubbing cloth over the Crockmeter's peg and secure with the spring clip. Avoid placing the rubbing cloth diagonally in the same direction as the peg is moving.
- Place your finger on the specimen and avoid touching the spring clip.
- Rub the specimen across a 100mm + 8mm long straight track for 50 full cycles (10 times back and forth) at 1 second each cycle. Stretch materials on the base of the Crockmeter to prevent rucking.

Wet Rubbing

Wet rubbing testing, also known as wet crocking testing, is a standardized test method for determining the colour fastness of textile materials to wet rubbing or abrasion.

Procedure

- Wet a rubbing cloth with distilled/de-ionized water to get 100% pick-up. The following method is suitable, but any method that allows the rubbing cloth to detect its own mass in water is appropriate.
- It's crucial to understand the water quality used here. According to norms, grade water is required.

- Weigh the dry rubbing cloth, then wet it well with distilled/de-ionized water. Squeeze the wet cloth between blotting paper and re-weigh on the balance. Adjust as needed by blotting excess water or rewetting.
- To compute 100% water pick-up, multiply the initial weight of the rubbing cloth by two (65% in AATCC method).
- Perform the appropriate test for dry rubbing.
- Let the tested rubbing cloth dry at room temperature.

In dry state, the fabric retained colour for 10 cycles on both the front and back sides. The fabric showed minimal colour change relative to the grey scale. The dye molecules have a great holding power in dry conditions, but when wet, the rating changes significantly. This indicates that when water comes into touch with the dye molecules, they begin to split and detach from the cloth more quickly. The value of 2 indicates that the fabric has low wet rubbing resistance.

pH Testing

pH testing is required to establish the best dyeing conditions and anticipate the colourfastness of the dyed fabric.

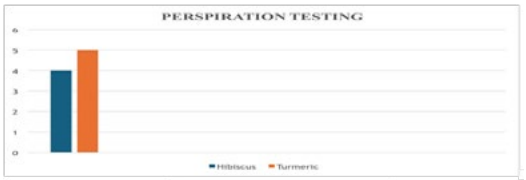
Procedure

- Add a strip of pH paper to the dye bath solution.
- Wait for the paper to change colour (about 1–3 minutes).
- Compare the colour of the pH paper to the reference chart included with it.
- Write down the pH reading.

Results & Discussion

The present study evaluated the dyeing performance of Hibiscus rosa-sinensis and Curcuma longa on cotton fabric using alum as a mordant. The dyed samples were assessed for colour fastness to perspiration, washing, sunlight, rubbing, and pH behaviour. The results indicate that both natural dyes exhibited satisfactory performance, with noticeable variations depending on the dye source and testing conditions.

Colour Fastness To Perspiration

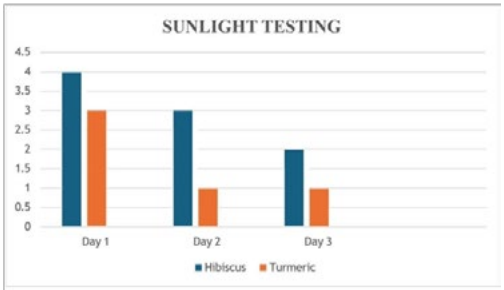


Bar Diagram 1: Perspiration Testing

Colour Fastness To Washing

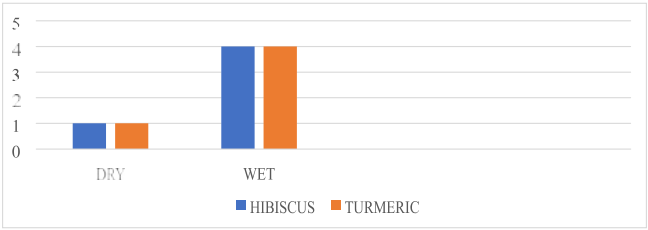
Bar Diagram 2: Washing Test

Colour Fastness To Sunlight



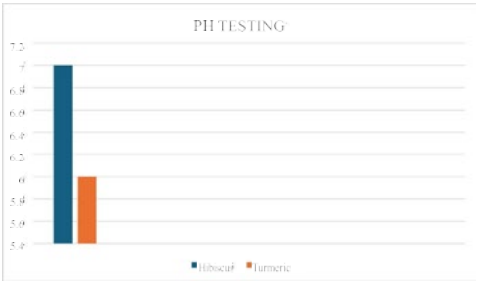
Bar Diagram 3: Sunlight testing

Colour Fastness To Rubbing



Bar Diagram 4: Rubbing Test

PH Testing



Bar Diagram 5: PH Test

Summary and Conclusion

Therefore, this study focuses on the proportion-dependent effects of Hibiscus rosa-sinensis and Curcuma longa on shade variation and antimicrobial activity, aiming to promote sustainable and multifunctional textile dyeing practices. Also to assess the practical suitability and safety of these natural dyes for children's clothing. In summary, this study provided an environmentally responsible substitute for synthetic dyes by showcasing the possibilities of hibiscus and turmeric extracts as natural colourants for children's clothing.

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Annexure

Hibiscusrosa-sinensisandcurcumalongadyedchildrengarmentlaidflatonatable,whichis sustainable and eco-friendly.

Figure 15 Hibiscus rosa-sinensis and Curcuma longa dyed children's garment – sustainable and eco-friendly.

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