Sustainable and Eco-friendly Aspects of Banana Flower Petal Dyeing on Cotton/Banana Fabric

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***Abstract*—This study presents an innovative, eco-friendly dyeing method that utilizes waste banana flower petals, transforming them into a vibrant, sustainable dye. By harnessing the natural pigments of these discarded petals, we reduce waste and promote sustainable textile production. This closed-loop approach embodies the principles of recycling, reusing, and reducing waste, thereby minimizing the environmental impact of textile manufacturing. The banana flower petal dyeing method not only reduces pollution and water consumption associated with traditional dyeing methods but also produces soft, breathable fabrics with excellent colorfastness. By embracing this eco-friendly dyeing technique, the fashion industry can significantly reduce its environmental footprint, conserve resources, and promote a more circular economy, ultimately contributing to a more sustainable future.**

***Index Terms*—Banana flower petal, eco-friendly, natural dye, sustainability.**

I. INTRODUCTION

The word “textile” means to weave and was taken from the Latin word “texere.” Nowadays, textiles not only fulfill humankind’s basic necessity for clothing, they also allow individuals to make fashion statements. As one of the oldest industries, the textile industry occupies a unique place in India. [Sughosh Madhav, et.al, (2018)].

The Indian Textile Industry represents a rich and diverse spectrum of activities with the hand-woven sector on one end and the capital-intensive mill sector on the other. The spectrum includes activities in the decentralized power looms,hosiery and knitting sectors, the handicrafts segments and also covers a wide range of fibers which include man-made fibre, cotton, silk, jute and wool.[Pankaj Dixit,(2019)].

The textile industry being a very good example for the most advancing and ecologically harmful industry in the world, various innovations are done in order to safeguard our mother earth. The production stages of textile include bleaching, dyeing etc..Contribute to a large extend of pollution thus making it important to make it more sustainable. Controlling pollution is as vital as making a product free from the toxic effect.So in order to safeguard our environment we must take some preventive measures and technologies that can maintain the balance of our eco system and makes the final product free from toxic effects.[Suparna M G,Rinsey Antony,(2018)].

Any textile product, which is produced in eco-friendly manner and processed under ecofriendly limits (defined by agencies like oekotex, ifoam etc.) are known as eco textiles. [Poonam Kumari,et.al,(2013)].

In the eco-friendly environment, it is very important to assure that the human beings live in a world of hygiene and freshness. The necessities of human beings are not fulfilled with the provision of food, clothing and shelter alone, but it is important that the environment is clean and liveable with pure and safe air as well as water. The people are becoming more and more health conscious and demands for producing textile products through environment friendly and sustainable dyes and dyeing processes. [Asim Kumar Roy Choudury,(2018)].

In this regard natural dyes are eco-friendly, safe, cheap, need no special care, uncommon and soothing shades, wonderful and rich in tones, act as health cure, have no disposal problems, non-carcinogenic, non-allergic, non-toxic, easily biodegradable, require simple dye house to apply on matrix and mild reactions conditions are involved in their extraction and application. [Md. Reazuddin Repon,et.al,(2016)].

Dyes and pigments derived from natural sources suchas plants (leaves, stems, fruits, seeds, flower heads, bark, root, etc) animals (Lac, Cochineal and kermes) and minerals (prussion blue, red ochre and ultramarine blue) for coloring materials have been

used for centuries.Dyes are substantive or adjective. Substantive dyes are absorbed and fixed by chemical bonds within the fiber without further chemical treatment. [Nasreen Begum, (2022)].

Among numerous natural dyes, banana is promising sustainable agricultural bio waste dye source. The ashes of banana leaves, bark and fruit rind have been reported to be in use of dyeing of textile. The cell sap of banana contains a considerable amount of tannin, which stains the cloth in almost dark black colour. The stain on the cloth is fairly permanent and very difficult to wash out.During performing research work it was presumed, in mature banana plant relative percentages of different parts assumed as 9% floral stems, 41% outer part of pseudo-stem, 11% fruit, 6% peel, 3% peduncle,14% underground parts and 16 % leaf and stalks. So it concluded, after harvesting banana fruits almost 89% of banana plant is accounts as waste. The huge amount of banana waste has no remarkable exploitation so far.[Neha Singh and Archana Singh,(2023)].

The primary objective of this research is to investigate the feasibility of extracting a natural dye from banana flower petaloids and utilizing it to dye cotton/banana fabric, employing a natural mordant to achieve a soft, eco-friendly shade.

II. REVIEW OF LITERATURE

2.1 BANANA FLOWER PETAL AS SUSTAINABLE & ECO-FRIENDLY DYES:

Banana (Musa), a member of the Musaceae family, is the fourth-largest food crop in the world, after wheat, rice, and maize. [Bishal Thagunnaa, et.al, (2023)]. The banana flower, also called banana blossom, is a significant part of the banana plant (Musa species) and is widely recognized for its nutritional and medicinal value. It is a large, cone-shaped, maroon-purple flower that emerges at the tip of the banana fruit cluster. Known for its culinary versatility, the banana flower is a staple in South and Southeast Asian cuisines. [Mahapatra et al., (2012)]. It is also a source of bioactive compounds such as flavonoids and tannins, which contribute to its antioxidant and anti-inflammatory properties. [Ravindran & Jaiswal, (2016)].

Petals contain bioactive compounds like anthocyanins (responsible for red, purple, and blue colors) and carotenoids (yellow and orange hues), which make them ideal for use as natural colorants in textiles. For example, banana flower petals, rich in anthocyanins, can produce shades of purple and red in textile dyeing. [Subramanian et al., (2017)].

The colors obtained from flower petals can vary depending on several factors, including the pH of the dyeing solution, the type of fabric, and the mordants used. Different mordants (e.g., aluminum, iron, or copper salts) can alter the final color produced by the flower petals, offering a wide range of color possibilities. [Ramesh et al., (2018)].

The colorfastness of dyes derived from flower petals can be influenced by the type of fabric and mordant used. Properly mordanted fabrics dyed with flower petals exhibit good color retention under various conditions, such as washing, light exposure, and rubbing. [Mehta et al., (2020)].

The use of flower petals as dyes is a sustainable practice, as it reduces reliance on synthetic dyes, which are often toxic and harmful to the environment. Natural dyes derived from flowers are biodegradable and produce minimal environmental waste compared to their synthetic counterparts. [Patra & Mohanty, (2020)].

2.2 COTTON/BANANA FABRIC:

Banana fibers, extracted from the pseudostem of banana plants, have been utilized in traditional textiles for centuries in regions like South Asia and Africa. Their inherent strength, biodegradability, and sustainability have garnered interest for blending with cotton, a soft, breathable, and versatile natural fiber. Combining these fibers results in fabrics that balance comfort with durability, appealing to both consumers and environmentally conscious industries.

Blending banana fibers with cotton enhances the mechanical properties of the resulting yarns and fabrics. Research indicates that yarns with a 5% to 15% banana fiber content exhibit up to 14% higher tensile strength and 18% greater elongation compared to 100% cotton yarns. Additionally, these blended fabrics demonstrate up to 22% superior tear strength and 30% higher friction resistance. [Hafez S. Hawas, (2021)].

Banana fibers are renewable and derived from agricultural residues, making their integration into textiles a low-impact and sustainable solution. Cotton, when sourced responsibly, further enhances the eco-friendliness of the blend. [Aruna, K., & Vignesh, B. (2018)].

III. METHEDOLOGY

3.1 SELECTION OF FABRIC & DYE:

Cotton/banana fabric was sourced from the Ayurvastra Textile Research and Training Centre. Banana flowers were collected from Vadasery, Nagercoil, Tamil Nadu. The petals were dried, processed, and boiled in distilled water to extract the natural dye. A total of 4 kg of petals yielded the dye extract used in this research.

3.2 Ready For Dyeing (RFD Process) :

To initiate RFD treatment, combine 11L distilled water, 1.5L soap nut base, and 1L wood ash in a container. Boil for 1 hour, then submerge cotton/banana fabric and let it prepare for dyeing. Rinse twice in normal water and dry in direct sunlight.

3.3 pre-Mordanting:

After RFD treatment, the fabric underwent pre-mordanting with an iron water solution to enhance dye absorption. The fabric was submerged in 0.5L iron water diluted in 20L water for 1 hour, then removed, dried, and prepared for natural dyeing.

3.4 Colouration of Cotton/Banana Fabric:

The colouration process marks the commencement of the actual dyeing stage, subsequent to the Ready For Benefits (RFD) treatment. To intensify the colour yield, the pre-extracted dye was subjected to further extraction through boiling for 1 hour, releasing additional colourant. The fabric was then submerged in the dye solution for 2 hours, allowing the natural colours to penetrate and bind with the fabric. Following the dyeing process, the fabric was removed from the dye solution and rinsed repeatedly in normal water for 2-3 cycles. Finally, the fabric was dried under direct sunlight until completely dry.

3.5 Colour Evaluation:

The final step involves evaluating the colour fastness of the treated fabric, assessing its resilience to washing, rubbing, ironing, and heating. This evaluation determines the fabric's ability to withstand colour degradation, with results presented in subsequent sections.

a) COLOUR FASTNESS TO IRONING:

The ironing test was conducted to evaluate the colour fastness of the dyed fabric to heat and pressure. In this assessment, the dyed sample was ironed onto an undyed sample, and the results showed no noticeable colour bleeding or transfer onto the undyed fabric. This indicates that the natural dyes used in the dyeing process exhibited excellent colour fastness properties, even when subjected to heat and pressure.See in Fig 1.

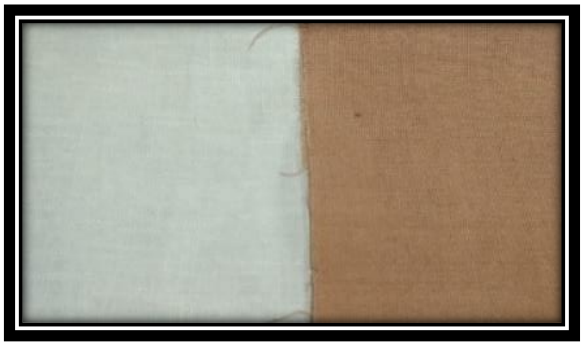


Fig.1 By Ironing there was no Colour Bleed onto the Undyed Fabric

b) COLOUR FASTNESS TO WASHING:

The standardized washing test revealed remarkable colour fastness of the dyed fabric, characterized by minimal colour bleeding. This exceptional colour retention can be credited to the natural dyes' excellent fixation, resulting in enduring colour stability and durability. The outstanding colour fastness performance makes the fabric exceptionally suitable for applications demanding minimal colour transfer, thereby meeting stringent quality requirements.See in Fig.2

Fig.2 By Washing there was no colour Bleed onto the Undyed Fabric

c) COLOUR FASTNESS TO CROCKING [WET]:

The colour fastness to crocking test (wet) was conducted to assess the fabric's resistance to colour transfer when subjected to wet rubbing. The test results showed that the dyed fabric exhibited excellent colour fastness to wet crocking, with negligible colour bleeding or transfer onto the testing cloth. This indicates that the natural dyes used in the dyeing process have good colour binding properties, ensuring minimal colour loss or transfer when the fabric comes into contact with water or moisture.See in Fig.3

Fig.3 By Crocking [wet] sample there was no colour Bleed onto the Undyed Fabric

d) COLOUR FASTNESS TO CROCKING [DRY]:
The colour fastness to dry crocking test was performed to evaluate the fabric's colour transfer resistance when subjected to dry rubbing. The results demonstrated that the dyed fabric showed minimal colour bleeding or transfer onto the testing cloth, indicating excellent colour fastness to dry crocking. This suggests that the natural dyes have strong colour retention properties, ensuring that the fabric's colour remains stable and vibrant even when subjected to dry friction.See in Fig.4

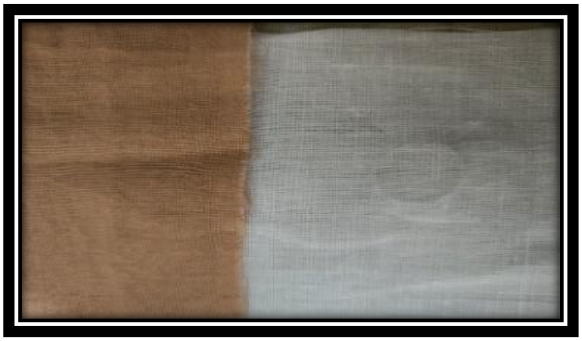
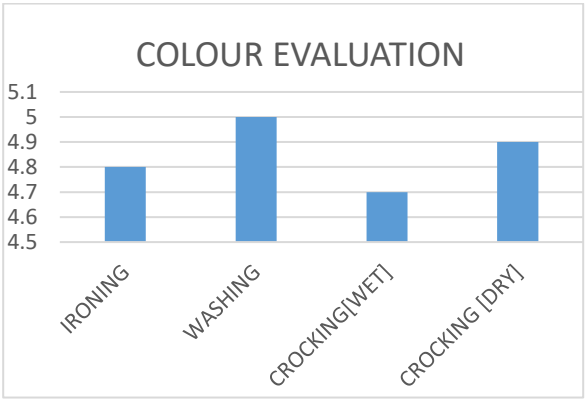


Fig.4 By Crocking [Dry] sample there was no colour Bleed onto the Undyed Fabric

IV. RESULT AND DISCUSSION

The colour fastness properties of the dyed fabric were evaluated, and the results showed excellent colour retention and minimal colour bleeding. The colour fastness to washing test yielded a rating of 4.5-5, indicating that the fabric retained its vibrant colour even after repeated washing cycles. Similarly, the colour fastness to dry and wet crocking tests demonstrated negligible colour transfer, with ratings of 4.5-5 and 4-4.5, respectively.As Shown in Graph below.



COLOUR FASTNESS RATINGS

V. CONCLUSION

The study successfully demonstrates the potential of banana flower petal dye as a sustainable and eco-friendly alternative for dyeing cotton/banana fabric. With excellent colour fastness test results, achieving ratings of 4.5-5 for washing,ironing, dry crocking, and wet crocking, this natural dyeing method has proven its viability for textile applications. The use of banana flower petal dye not only reduces environmental impact and waste generation but also promotes sustainable fashion practices and supports a circular economy. Overall, this eco-friendly dyeing method offers a promising solution for the textile industry, combining aesthetic appeal, sustainability, and exceptional colour fastness.

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