From Waste to Wonder: Leveraging Rust Dyeing and Eco-Printing for Modern Sustainable Textiles

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Abstract
In rust dyeing, rusted objects are repurposed to transfer unique patterns and earthy tones onto fabric, transforming what might be considered waste into beautiful, sustainable works of art. This study investigates the combined effects of rust dyeing and eco-printing on different fabric types—cotton, modal, viscose, and polyester. Rust dyeing was performed using rusted iron nails to impart earthy tones of brown and orange to the fabrics. Following the dyeing process, eco-printing was carried out using *Psidium guajava* (guava) leaves that were pre-mordanted with a ferrous sulphate solution. The colourfastness, pattern quality, and overall appearance of the rust-dyed fabrics post eco-printing was assessed. Results revealed that rust dyeing produced distinct shades on each fabric type, with cotton and modal showing the most pronounced colour retention and eco-print detail. Viscose exhibited moderate colour absorption, while polyester showed limited dye adhesion and eco-print definition. The study concludes that while rust dyeing and subsequent eco-printing can effectively enhance the aesthetic qualities of natural and regenerated cellulosic fabrics, polyester's synthetic nature poses challenges in achieving vibrant and durable impressions. The findings provide insights into optimizing eco-printing techniques for diverse fabric types and contribute to the broader understanding of sustainable textile processes. By embracing the unpredictability of nature, artists and designers can create one-of-a-kind designs that reflect the textures, shapes, and hues found in the environment. These eco-friendly approaches not only reduce reliance on synthetic dyes but also transform everyday materials, often considered waste, into beautiful works of art.

Keywords: Rust Dyeing, Eco-Printing, Textile Patterns, Sustainable Textiles

Introduction

Dyeing is an ancient art that has been used to enhance the beauty of clothing for millennia. This practice has captivated civilizations from the Egyptian, Greek, and Roman eras, evolving continuously to the present day. Since earliest times, humans have sought to colour fabrics using natural sources such as Brazilwood, logwood, kermes, lac insects, cochineal, Persian berries, and madder [1]. Archaeological evidence suggests that textile dyeing dates back to the Neolithic period. Excavations at Çatalhöyük in southern Anatolia revealed the use of ochre, a red dye derived from iron ore. The earliest textile fragments from this site are preserved at the Museum of Anatolian Civilizations in Ankara, Turkey. Natural Iron oxides, often referred to as "earth" colours, are widely distributed across the globe in muted shades of red, orange, yellow, and green. And the enduring visibility of cave paintings created with these mineral colorants during the pre-historic times serves as a testament to their remarkable stability and durability [2-3]. It is believed that natural dyes were in use by the Chinese as far back as 5,000 years ago. Wu Shusheng and Tian Bingyi's "History of Chinese Dyeing and Weaving" reveals that the practice of dyeing clothing using iron ore by the people living in the mountaintop cave of Zhoukoudian in Beijing [4]. The term "corrosion" has been around for as long as the Earth, though it has been referred to by various names over time. Commonly, corrosion is called rust, which is an unwanted process that tarnishes and degrades the appearance of objects and reduces their lifespan. The Roman philosopher Pliny (AD 23–79) discussed the deterioration of iron in his work 'Ferrum Corrumpitar'[5]. When iron (or an iron alloy) is exposed to oxygen and moisture, rust forms as a result of this chemical reaction. This process is gradual and occurs over an extended period. During this time, oxygen atoms combine with iron atoms to create iron oxides. Rust primarily consists of two different iron oxides, i.e. Iron(II) oxide or ferrous oxide and Iron(III) oxide or ferric oxide, which differ based on the oxidation state of the iron atoms.

Rust dyeing is an innovative and eco-friendly textile art that leverages the natural process of oxidation to create unique patterns and colours on fabric. This method involves using rusty metal objects to transfer intricate designs onto textiles, resulting in organic, earthy tones and patterns that are visually striking. Both cellulosic and protein fibre fabrics are suitable for rust dyeing as they have good affinity to rust resulting in permanent impressions or colouration. The method of rust dyeing is extremely simple as the rust acts as a dye source and the wet fabric is placed in contact with rusted items till the desired patterns and colours are formed. Rusted items, often seen as useless or discarded, are metal objects that have undergone oxidation, resulting in a layer of rust. This process occurs when iron or steel reacts with oxygen and moisture over time, creating a reddish-brown coating. While rust is typically associated with decay and degradation, these items hold potential for creative reuse, especially in art and design.

Eco-printing or plant transfer printing is a textile design technique that harnesses the natural world to create intricate and vibrant patterns on fabric. This method involves using plant materials, such as leaves, flowers, seeds, and berries, to imprint their colours and shapes directly onto textiles. Natural plant dyes are mostly classified as flavonoid acid mordant dyes, and their primary application throughout history has been on protein-based materials. These colours can be applied to common cellulosic textiles including cotton, viscose, and Tencel, as well as their blends with polyester, using plant transfer printing. Based on the treatment of textiles with various mordants (metal salts), variation in the hue and colour fastness can be achieved. Eco-printing usually utilizes iron salts to achieve darker shades emphasizing the contrasting structures of plant material [6].

The process typically begins with the careful arrangement of these natural elements on a pre-washed or mordanted fabric, which is then rolled, bound, and subjected to heat or steam. This treatment not only fixes the dye molecule in the fabric structure but allows the pigments and tannins from the plant materials to transfer onto the fabric, resulting in a rich array of colours and patterns that reflect the unique characteristics of the plants used and are colourfast. Eco-printing is celebrated for its sustainable approach, as it utilizes readily available, biodegradable materials. The technique produces one-of-a-kind, nature-inspired designs, making it a popular choice for artists and designers seeking to incorporate organic aesthetics into their work [7]. Through eco-printing, fabrics become canvases that capture the beauty and diversity of the natural world, offering a harmonious blend of artistry and environmental mindfulness.

Rust dyeing and eco-printing are innovative techniques that combine the beauty of natural processes with artistic creativity to produce unique and sustainable prints on fabric. These methods utilize natural materials—rusted metal objects in rust dyeing and plant matter in eco-printing—to transfer organic patterns and colours onto textiles.

Materials and Methods

100% Cotton fabric (200 GSM), Modal (200 GSM), Viscose (300 GSM) and Polyester (150 GSM) fabrics were used in this study. Vinegar, common salt, and discarded rusted iron nails were utilized for rust dyeing. 2 g/L ferrous sulphate solution was used as mordant for the pre – mordanting process of fabrics. Ferrous sulphate is often used with cellulosic fibres and improves the wash and light fastness of treated fabrics. Leaves of *Psidium guajava,* the common guava were utilized as printing substance in this study.
RFD fabrics were soaked in salt solution of 10 g/L for an hour. The fabrics were then squeezed to remove extra solution. The rusted pieces (rusted iron construction nails) were placed in the desired pattern on the wetted fabrics (Figure 1). A solution made from mixing 1 g of salt in 2 L of vinegar and 5 L of water, was sprayed every 4 hours on the rusted material placed on the fabric and exposed to atmospheric oxygen. The oxygen in the atmosphere reacted with the rust (ferrous oxide) and transferred the colour on to the fabric. The fabrics were left for two -three days to obtain the desired pattern. Rust dyed fabrics were then rinsed with plain water and subsequently soaked in salt solution to help the developed patterns resist fading for a longer time. All the fabric samples were air dried at room temperature.

Figure 1: Rusted Iron Nails Placed on Wetted Cotton, Modal, Viscose and Polyester Fabrics

The collected leaves of *Psidium guajava* (guava) were washed and immersed in the mordant solution for 30 minutes (Figure 2). The leaves were then arranged over the rust-dyed pre- mordanted fabric (Figure 3) and a plastic sheet was placed over the leaves. The bundle was then rolled and tied with cotton thread tightly. These fabric bundles were placed over stainless steel water pots for steaming for an 45 minutes (Figure 4). This step helped in transfer of leaf print on the fabrics. The fabrics were then taken out from steamer and leaves were removed. They were then air dried at room temperature.

Figure 2: *Psidium guajava* in Ferrous Sulphate Mordant Solution

Figure 3: Arrangement of *Psidium guajava* Leaves on Rust Dyed Fabrics

Figure 4: Fabric Bundles for Steaming after Tying

The developed samples were assessed for colourfastness to washing through ISO 105-C06:2010 Textiles — Tests for colour fastness — Part C06 Colour fastness to domestic and commercial laundering method.

Results and Discussions

In this study an effort has been made to develop botanic print of *Psidium guajava* over rust dyed cotton, modal, viscose and polyester fabrics.

When the fabrics were exposed to the rusted nails, the iron oxides interacted with the fibres. Vinegar acted as catalyst and accelerated the process of rusting. Iron ions in the rust solution oxidized or reacted with the fibres, causing the iron oxides to deposit on and bind to the fabric. As the iron oxides bind to the fabric, they created a range of reddish-brown to rusty colours, depending on the specific iron compounds and the fabric's response to them. The colour deepens over time as additional oxidation occurs and more iron is fixed to the fibres. After the desired effects on fabrics were achieved, they were rinsed in salt solution where salt acted as a neutralizing agent which prevented the further process of rusting [8].

After multiple experiments, it was observed that cotton, viscose and modal fabrics developed reddish-brown stains or patterns as well as sharp contours of rusted material (Figure 5). This phenomenon is logical and can be explained on the basis of good absorbency properties of these fabrics. The stains developed due to the capillary movement of the dye on the wet surface of fabrics. The intensity of stains varied, depending on the amount of rust. However, polyester fabric had less staining and sharp contours of rusted material in comparison to the natural and regenerated cellulosic fabrics (Figure 5). Polyester, being a synthetic fibre, does not absorb dyes as readily as natural and regenerated cellulosic fibres and thus experience less staining.

Figure 5: Effect of Rust Dyeing on Cotton, Modal, Viscose and Polyester Fabrics

This technique was enhanced by combining it with eco-printing, a method where natural guava leaves were applied to the fabric and then steamed to imprint botanical designs. It was observed that modal fabric developed clear impressions of leaves in comparison to viscose and cotton fabric whereas polyester did not develop any print (Figure 6).

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Figure 6: Results of Impressions Created by Mordant Applied *Psidium guajava* Leaves Over Rust Dyed Fabrics After Steaming Technique

Combining rust dyeing with eco-printing on textiles created a unique fusion of natural art forms that resulted in richly textured and visually dynamic fabrics. Rust dyeing utilized the oxidation of metal objects to impart earthy tones onto the fabric, while eco-printing involved transferring the colours and shapes of *Psidium guajava* leaves onto textiles. When these two methods were combined, the contrast between the abstract patterns of rust and the sharp imprints of leaves produced complex and one-of-a-kind designs. This synergy not only enhanced the aesthetic appeal of the textiles but also embodied a commitment to sustainable and eco-friendly practices by using natural and discarded materials. All the samples exhibited good colour fastness to washing (4-5 in grayscale).

CONCLUSION

Rust dyeing was achieved by placing rusted items like nails, bolts, or iron filings directly onto variety of fabrics such as cotton, viscose, modal and polyester, creating unique, earthy patterns through the oxidation of iron. When rusted objects were placed in contact with these materials, iron oxides transferred onto the fibres, producing distinctive reddish-brown hues. This technique was enhanced by combining it with eco-printing method. By overlaying the rust dyeing process with eco-printing, interesting visual textures and colours were achieved. The rust provided an organic, variegated backdrop while the eco-printed elements introduced intricate patterns and natural pigments. This combination resulted in fabrics adorned with complex, nature-inspired designs that seamlessly blended the industrial aesthetic of rust with the delicate, organic patterns of plant prints, offering a sophisticated and visually dynamic textile surfaces.

REFRENCES

1. https://ebooks.inflibnet.ac.in/hsp09/chapter/chapter-1/
2. https://edu.rsc.org/resources/prehistoric-pigments/1540.article
3. https://panerosclothing.com/blogs/blog/experimenting-with-natural-dye-techniques?srsltid=AfmBOooC-PWjNwWau5FkNTHWFuYREIJGYYDVK0XugVlQsRaN7zwFj57v
4. Yan X., Lili F., “Research on Modern Women's Clothing Creative Design Based on Rust Dyeing”, Frontiers in Art Research, 2024, 6 (4), 102-107. https://doi.org/10.25236/FAR.2024.060417.
5. Ahmad Z., “Principles of Corrosion Engineering and Corrosion Control”, Elsevier Science & Technology Books Publisher, 2006 , 1-8. https://doi.org/10.1016/B978-075065924-6/50002-7
6. Šabarić I., Sutlović A., Filipčić J., & Karin F., “Contribution of Plant Transfer Printing to Sustainable Fashion, Sustainability, 2024, 16 (11), 4361. https://doi.org/10.3390/su16114361
7. https://textilevaluechain.in/in-depth-analysis/articles/sustainability-waste-management-recycling-upcycling/eco-printing-a-step-towards-sustainable-fashion
8. https://kbaxterpackwood.com/archives/2008/07/rust-dyeing-introduction.html