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Natural dyes: A recent opportunity for sustainable fashion designers

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Abstract

In recent years, consumers and brands realized that they must move towards sustainable solutions. Plant dyeing is considered an eco-friendly solution that can offer a great marketing boost. It consists of dyeing clothes with plant-based extracts and it allows the creation of many fashion techniques that fashion designers can incorporate into their creations. This study aims to create fashion designs using agricultural by-products as a dye for the finishing of cotton fabrics. Cotton fabrics were prepared before dyeing and the tie and dye technique was applied. The treated fabrics were analyzed using a Datacolor 650™ spectrophotometer. In addition, washing fastness, rubbing fastness, and light fastness were evaluated. Results show that the tie and dye technique can be successfully applied when using plant-based dyes. The washing and rubbing fastness of the cotton samples were good. However, the light-fastness was fair.

***Keywords*:** Cotton; fashion design; fastness; natural dyes; sustainable fashion

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1. Introduction

Fashion effects are important to consumers (Choo and Kim, 2003). They have a positive influence over how they perceive garments and they highly impact their purchasing intentions (Kim and Lennon, 2008). One of the biggest challenges of the textile industry is to offer new designs using ecological materials to hit a widespread market (Franco, 2017). Sustainability and relevance in clothing design are becoming an increasingly important topic to enhance its growth (Gardetti & Larios-Francia 2023; Liu et al., 2022). Clothing industry activity causes many environmental problems, including the generation of large amounts of hazardous waste at every stage of the garment manufacturing process (Dzhengiz et al., 2023; Sharma & Narula 2020; Palacios-Mateo et al., 2021)

The literature suggests that sustainable practices in the textile and clothing sector include the use of safe, environmentally friendly, renewable, and green materials and also the reuse or recycling of wastes (Muthu, 2022). The concept of sustainable design was developed under the guidance of several studies related to sustainable development design (Black, 2008; Chen and Burns, 2006; Hethorn and Ulasewicz, 2008; Joergens, 2006; Poole et al., 2009). The results of these studies were summarized and used to establish different categories of sustainable design. For example, the application of natural dyes can be proposed as a potential sustainable method as it can provide an alternative to toxic synthetic dyes (Kadolph and Casselman, 2004).

The tie and dye effect are a result of a dyeing technique that creates a design on the fabrics (Belfer, 2012). This design is obtained using techniques like tying, sowing, or folding. A part of the fabric is not dyed (Pujeeb, 2020). The tie and dye effect will vary depending on the applied technique. Tie and dye effects are being developed to offer unique, new, and nice designs by creating patterns that are different. Tie and dye effects using natural dyes are emerging. Consumers are looking for safe and eco-friendly products. These dyes are in the significant revival of interest. They offer the advantage of offering unique colors as well as the potential to be non-toxic. Plants and minerals are a good source of natural colors. The application of plant-based dyes has been widely applied and has shown effective modern and unique designs. However, the application of natural dyes has always been associated with bad properties of use. The challenge for designers is to develop tie and dye effects that are suitable for the industrial scale. Designers need to be modern, interesting, and standardized. In addition, final products must be of high quality. The developed textile must respond to the fashion trends, but it also must present good properties of use such as washing, rubbing, and light fastness.

1.1. Purpose of study

The present work investigates the use of pomegranate peel as an important source of renewable natural dye for textile finishing. Many research works have reported the use of pomegranate peel for dyeing fabrics and garments. However, there have been relatively few works investigating the creation of fashion designs using this material.

2. Materials and methods

2.1. Concept board development

Designing a concept board is a useful tool that helps designers when they start a new design project. It helps to make the design process clearer and easier. It will talk about the style of the model, texture of the garment, and color palette inspired by trends of 2024/2025, and communicate the design ideas that can be explored. Taking inspiration from the fruit waste, the bright colors from pomegranate peel have been a source of inspiration for the development of our eco fashion for the spring-summer season. These colors give freshness and life to the design. The category chosen was young women. In this way, a concept board was developed (Figure 1).

Figure 1

Concept board developed

2.2. Tie and dye finishing process

Based on our research on trends, we realize that tie and dye are back in style and can be seen in a variety of purposes, such as clothing, accessories, and home furnishings (WGSN, 2023). To apply this technique in our design process, pomegranate peels were collected and impurities were removed by washing with water. After washing, the peels were dried at room temperature (25 ± 2 ◦C) for 72 h. To apply the colors and texture of the fabric inspired by the concept board, the tie and dye art technique was applied to 100% cotton fabrics. Commercially available woven cotton fabrics were used. Natural fibers like cotton were chosen because they provide consistent comfort.

2.2.1. Fabric finishing

First, cotton was pretreated in a bath containing the cationizing agent and sodium hydroxide for 20 minutes at 50°C. Cationising agent and sodium hydroxide (NaOH) were kindly provided by Chimitex Plus company. After pretreatment, the cotton fabrics were tied as shown in Figure 2. For a random splatter effect, the item was scrunched and twined with elastic and rubber bands to create unique and surprising graphic effects.

Figure 2

Tying methods using elastic and rubber bands

Then, the tied pretreated fabric was immersed in a bath containing the pomegranate peel for 45 minutes at 80°C. Finally, the fabric is rinsed with cold water and the rubbers are removed.

2.3. Textile surface characterization

Natural dyeing has always been associated with the application of mordants to enhance dye exhaustion and fastness. Cotton fibers present a low affinity towards natural dyes. Several studies have treated this problem by application of bio-mordants or modification of cotton fibers' surface using physical and chemical treatments. The introduction of cationic groups is a very used method to improve the dye uptake of cotton fabrics. Numerous chemicals are used to create amino groups on the fiber's surface and to enhance dye-ability. Some natural polymers, such as chitosan and starch were also found to introduce amino groups on the cotton surface.

Surface characterization is a crucial step to control the creation of cationic groups on cotton fibers. The differences in cotton samples before and after cationization were detected using the technique of Attenuated total reflectance Fourier transform infrared (ATR-FTIR). Spectra were recorded using an ATR-FTIR attachment (Spectrum Two™ FTIR, Per-kin Elmer). Spectra were recorded between 4000 cm^{-1} and 400 cm^{-1}.

The treated fibers were observed using an Optical microscope (Leica DM 500, Leica Microsystems, Heerbrugg, Switzerland) was connected to the Colorview camera and controlled by analytics software. The microscope is equipped with different objectives, allowing images to be taken with different magnifications.

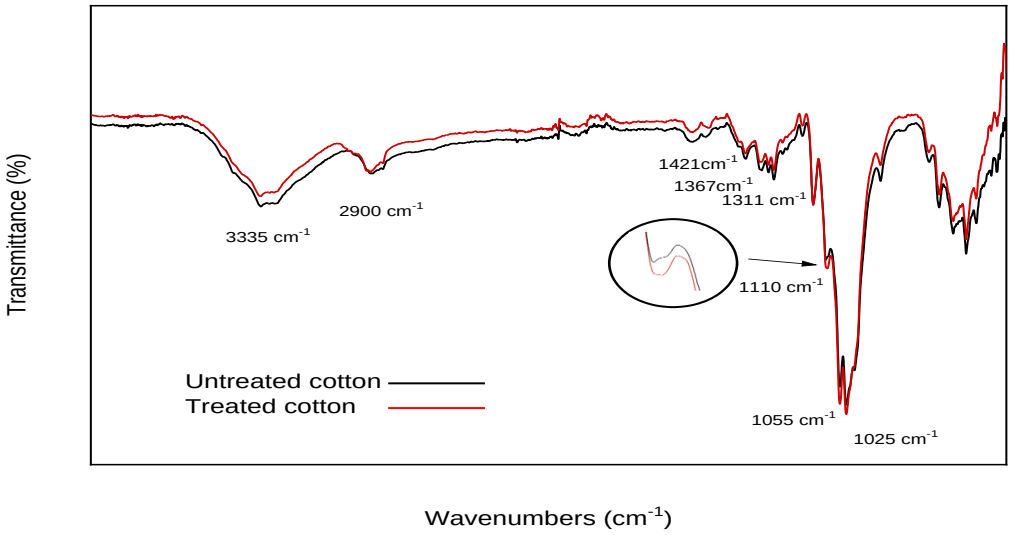
3. Results

3.1. Surface characterization

All spectra show the characteristic absorbance bands of cellulose. A wide absorbance band at 3335 cm-1 is attributed to the elongation vibration of the hydroxyl groups (OH). An absorbance band centered at 2900 cm-1 attributed to elongation vibration C–H. Absorbance bands at 1421, 1367, and 1311 cm-1 are attributed to deformation vibration C–H. An absorbance band at 1110 cm-1 attributed to elongation vibration C–O–C. of absorbance bands at 1055 cm-1 and 1025 cm-1 attributed to elongation vibration C–O (Gargoubi et al., 2016).

Figure 3

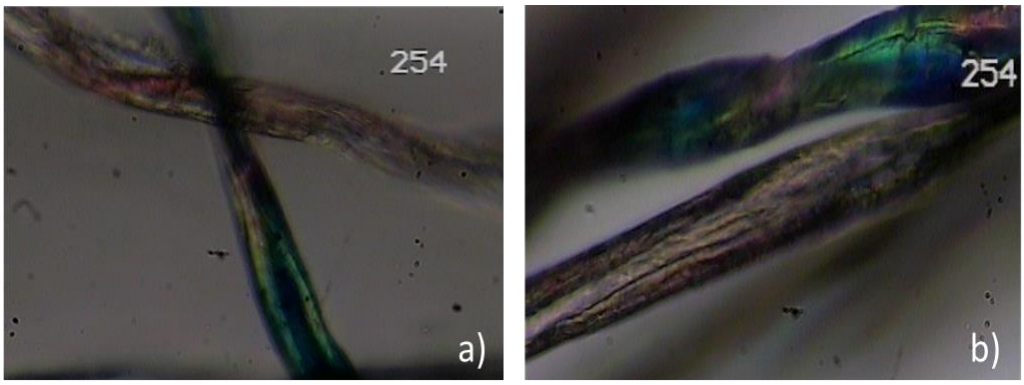
ATR-FTIR spectra of the treated and untreated cotton fabrics



For a better exploitation of the infrared spectra, we opted for a shift between the spectra and an enlargement of the peaks of the characteristic zones (Figure 3). We note that the absorbance band observed at 1110 cm-1 becomes more intense after cationization. This is probably due to the appearance of characteristic peaks of quaternary ammoniums.

Figure 4

Optical photographs



(a) untreated fibers (b) treated fibers

The general appearance of the surface of the sample treated with a cationising agent as well as that of the untreated fabric was examined using an optical microscope. The results presented in Figure 4 show that the cationisation treatment leads to an increase in the diameter of the fibers. We detect a remarkable difference between the diameter of the treated fibers (36,78 µm) and that of the untreated fibers (28,49 µm). This can highlight a state of change in the fiber surface and the adhesion of the product to the fibers.

3.2. Design from fruit waste

The print results obtained by the use of pomegranate peel via tie and dye technique indicated that this technique could be adapted to introduce new effects in fashion design and to establish an eco-fashion process. The results indicated that tie and dye enable varieties of natural shapes, lines; forms, colors, and textures. It transforms the visual aspect of the garment into a unique artistic fabric. Such technique could not only highlight a different natural texture pattern which has a unique charm and attractivity, but also design patterns with rich and modern styles. Figure 5 exposes the characteristics of different textures of the tie-dye process in a garment and the trims that will be used in the new design model.

Figure 5

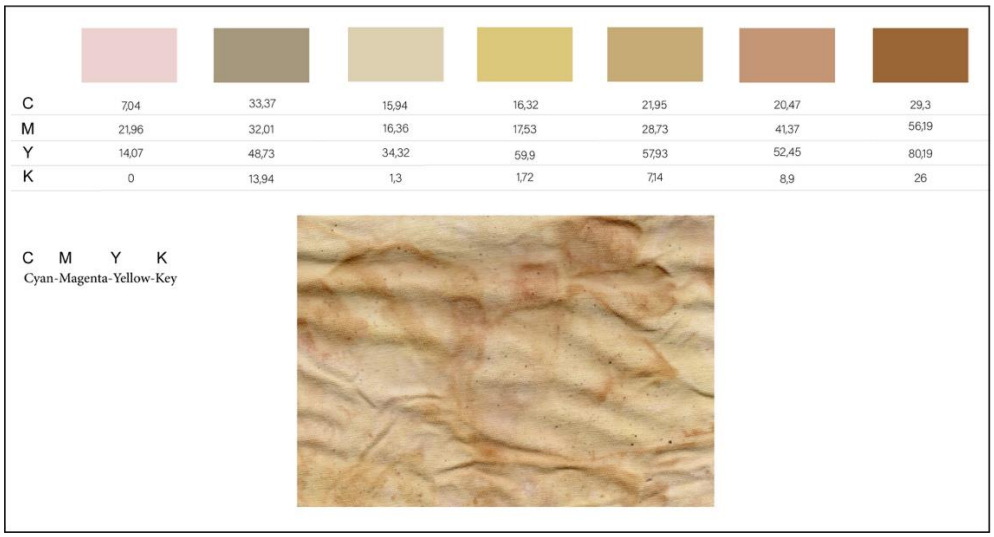
Texture effects of the tie and dye process on fabric

3.3. Color palettes of dyed textile

The color palettes created from the tie and dye technique were shades of yellow, brown, and pink. Each color presents its properties and uniqueness (Figure 6).

Figure 6

Color tying developed



To perfectly combine tie and dye art with the characteristics of industrial tying clothes, designers must use a standardized code used by industries.

3.3.1. Color characterization

To characterize color palettes, we analyzed the colors created from the tie and dye effect using Data Color 650™ spectrophotometer (Table I). Colorimetric data were determined using a spectrophotometer (Data Color 650®, USA) under illuminant D65, with a 10° standard observer. CIELab color coordinates (L, a, b) are specified by the International Commission on Illumination.

Table 1

CIELab color coordinates

Color tying	Color code	Color coordinates		
		L	***A***	***B***
	19-1331 TCX	66.47	13.27	16.38
	16-1328 TCX	63.16	20.47	27.67
	12-0807 TCX	86.23	4.13	14.20
	14-1107 TCX	79.44	1.31	12.59
	13-2805 TCX	83.39	13.05	-2.29
	13-1108 TCX	83.72	8.03	11.99
	16-0928 TCX	67.58	8.11	29.76

The color code is used to transmit color requirements from the designer to the manufacturer to reproduce the desired color. It is a standardized code used by industries to describe color using a number (ex: 13-2805 TCX).

3.3.2. Colorfastness tests

To be sure that obtained colors and effects are resistant to fading, the treated fabrics were tested for fastness properties according to standard methods: Washing color fastness (ISO 105-C02), rubbing fastness (ISO 105-X12), and light color fastness (ISO 105-B02). Fading and staining of samples in color were evaluated using grey and blue scales.

The color fastness was evaluated based on a visual assessment of change in the color of fabrics operated after each test (washing, rubbing, and light). Treated fabrics present fair to excellent fastness properties. The rubbing fastness showed excellent properties. However, the washing fastness was relatively good and the light fastness was fair (table 2).

Table 2

Fastness results

Rubbing (Wet)	Rubbing (dry)	Washing	Light
4-5	5	3-4	2-3

3.4. Garment design and model making.

After verification and validation of the finished fabric quality, pieces of tie and dye fabric were combined by using the patchwork technique to create new compositions with a unique and harmonious visual aspect. This method could not only preserve the textures and colors obtained but also, design a textile fabric with a unique visual charm while allowing the design of an infinite number of compositions. What's more, by changing the position of one or more pieces of tie-dye fabric, the simulation of the texture of each composition will make it possible to preserve the graphic effects of the original motifs, which is the key to success.

After this step of the design process, the collection plan should be created. Listed on this plan are the sketches, techniques, materials, and colors that will be used. In this work, virtual 3D from 2D model, garment was proposed to generate precise simulations. In the design process, 3D simulation is used to visualize the 2D model, parametric avatar, and true-to-life digital fabric reflecting the behavior of the used material (Figure 7).

Figure 7

Garment design and model-making

3D visualization of the model aims to develop fashion sketches and their corresponding patterns rapidly and to check if the generated garment patterns correspond with the fashion sketches. Modification is made directly on digital prototypes. This technique helps to save time, resources, and costs, and to reduce material waste. This approach allows a more sustainable design process.

As shown, the reuse of fruit waste such as pomegranate peel by using the tie and dye technique creates natural colors, various shapes, textures, and a more striking resistance effect. This technique is one of the key sustainability aspects of these textiles, it can therefore give a variety of textures and shapes that are creative and changeable from one model to another. Using local food waste such as pomegranate peel via tye-dye technique in fashion design is a potential approach to produce green colors, sustainable fashion design solutions, and reduce environmental impact.

Finally, from the point of view of artistic effects, based on the result of our approach, we argue that colors and patterns could be improved by trying other techniques and processes of knotting and folding. Applications that we will try to develop in another research. Tie and dye applications can be used also as enrichment items bringing natural color and texture to various other fabrics such as interior design elements, and accessories... Exploring opportunities for sustainable design practices is essential to promote eco-fashion textiles and can contribute to reducing waste and pollution.

4. Conclusion

In conclusion, ecological fashion can offer new design ideas, to create green collections, support the circular economy, and respect the environment. Sustainability and environmentally friendly fashion will be demanded through improved practices and processes. Today, the reuse of waste has become another part of the visual language of fashion in which different techniques can give added value to clothing. Lots of fashion designers have understood the new values and they are trying to extend this trend on the market.

A radical change via a problem-solving approach to reduce waste in fashion is emerging. Eco-design in Fashion can be applied by choosing sustainable processes and selecting techniques that have no impact on the environment. 3D design tools can develop exciting new design ideas, generate precise garment simulations, and help support a more sustainable design process. 3D digital tools open up a whole new world of possibilities for sustainable design. In this work, we developed a new design elaborated using pomegranate waste, an important source of renewable natural dye. Therefore, it is important to work with textile engineers to improve the quality of the results obtained and ensure that the colors comply with the standards and regulations in place.

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References

Belfer, N. (2012). *Batik and tie dye techniques*, Courier Corporation. https://books.google.com.cy/books/about/Batik_and_Tie_Dye_Techniques.html?id=ZR7CAgAAQBAJ&redir_esc=y

Black, S. (2008). *Eco-chic: The fashion paradox*, Black Dog. London. https://search.worldcat.org/title/Eco-chic-:-the-fashion-paradox/oclc/190393995

Chen, H.-L., & Burns, L. D. (2006). Environmental analysis of textile products. *Clothing and textiles research journal, 24*(3), 248-261. https://journals.sagepub.com/doi/abs/10.1177/0887302x06293065

Choo, S., & Kim, Y. (2003). Effect of color on fashion fabric image. *Color Research & Application 28*(3), 221-226.

Trabelsi, J. & Gargoubi, S. (2024). Natural dyes: A recent opportunity for sustainable fashion designers. *Global Journal of Arts Education. 14*(1), 24-32. https://doi.org/10.18844/gjae.v14i1.9281

Dzhengiz, T., Haukkala, T., & Sahimaa, O. (2023). (Un) Sustainable transitions towards fast and ultra-fast fashion. *Fashion and Textiles*, *10*(1), 19. https://link.springer.com/article/10.1186/s40691-023-00337-9

Franco, M. A. (2017). Circular economy at the micro level: A dynamic view of incumbents' struggles and challenges in the textile industry. *Journal of Cleaner Production 168*, 833-845. https://www.sciencedirect.com/science/article/abs/pii/S0959652617320450

Gardetti, M. Á., & Larios-Francia, R. P. (Eds.). (2023). *Sustainability Challenges in the Fashion Industry: Civilization Crisis, Decolonization, Cultural Legacy, and Transitions*. Springer Nature.

Gargoubi, S., Tolouei, R., Chevallier, P., Levesque, L., Ladhari, N., Boudokhane, C., & Mantovani, D. (2016). Enhancing the functionality of cotton fabric by physical and chemical pre-treatments: A comparative study. *Carbohydrate Polymers, 147*, 28-36. https://www.researchgate.net/publication/299495482_Enhancing_the_functionality_of_cotton_fabric_by_physical_and_chemical_pre-treatments_A_comparative_study

Hethorn, J., & Ulasewicz, C. (2008). *Sustainable fashion: why now? a conversation about issues, practices, and possibilities*. Fairchild Books, New York. https://search.worldcat.org/title/sustainable-fashion-why-now-a-conversation-about-issues-practices-and-possibilities/oclc/456123970

Joergens, C. (2006). Ethical fashion: myth or future trend? *Journal of Fashion Marketing and Management: An International Journal, 10(*3), 360-371. https://www.researchgate.net/publication/238325010_Ethical_fashion_Myth_or_future_trend

Kadolph, S. J., & Casselman, K. D. (2004). In the bag: Contact natural dyes. *Clothing and textiles research journal, 22*(1-2), 15-21. https://journals.sagepub.com/doi/10.1177/0887302X0402200103

Kim, M., & Lennon, S. (2008). The effects of visual and verbal information on attitudes and purchase intentions in internet shopping. *Psychology & Marketing, 25*(2), 146-178. https://onlinelibrary.wiley.com/doi/10.1002/mar.20204

Liu, H., Guo, C., & Zhang, B. (2022). Attractiveness consumption, personality traits, and sustainability: Construction and empirical application of evaluation indicators for attractive attributes of China-chic T-shirt products. *Frontiers in Psychology*, *13*, 1101978. https://www.frontiersin.org/articles/10.3389/fpsyg.2022.1101978/full

Muthu, S. S. (Ed.). (2022). *Sustainable Approaches in Textiles and Fashion: Manufacturing Processes and Chemicals*. Springer Nature. https://books.google.com/books?hl=en&lr=&id=W99mEAAAQBAJ&oi=fnd&pg=PR5&dq=Sustainable+Approaches+in+Textiles+and+Fashion+Manufacturing+Processes+and+Chemicals,+by+Subramanian+Senthilkannan+Muthu&ots=N_U9J2QI9E&sig=FC5OGyFf3TMrjbkCSQbMarTAGKw

Palacios-Mateo, C., Van der Meer, Y., & Seide, G. (2021). Analysis of the polyester clothing value chain to identify key intervention points for sustainability. *Environmental Sciences Europe*, *33*(1), 2. https://link.springer.com/article/10.1186/s12302-020-00447-x

Poole, A. J., Church, J. S., & Huson, M. G. (2009). Environmentally sustainable fibers from regenerated protein. *Biomacromolecules, 10*(1), 1-8. https://pubmed.ncbi.nlm.nih.gov/19035767/

Pujeeb, N. (2020). THE DEVELOPMENT OF NATURAL DYED FABRIC PRODUCT WITH SHIBORI FABRIC DYEING TECHNIQUE. *PalArch's Journal of Archaeology of Egypt/Egyptology, 17*(4), 1123-1133. https://archives.palarch.nl/index.php/jae/article/view/8750

Sharma, A., & Narula, S. A. (2020). What motivates and inhibits Indian textile firms to embrace sustainability? *Asian Journal of Sustainability and Social Responsibility*, *5*(1), 1-23. https://ajssr.springeropen.com/articles/10.1186/s41180-020-0032-8

WGSN (2023). https://www.wgsn.com/en/products/fashion