

<https://doi.org/10.48047/AFJBS.6.14.2024.8951-8970>



African Journal of Biological Sciences

Journal homepage: <http://www.afjbs.com>



Research Paper

Open Access

STUDIES ON THE EFFECT OF MORDANTING ON COTTON WOOL AND TERYLENE FABRICS DYED WITH ROSELLE DYE

Murugan Thirumalai¹, Lucas T. Mhwagila², Yakobo L Masumbuko², Cosmas K.Said², Meshack K. Maziku² and Kalidoss Rajendran^{3*}.

¹ Faculty, Department of Sciences, Mathematics and Education, St Joseph University in Tanzania.

² Department of Sciences, Mathematics and Education, St Joseph University in Tanzania.

^{3*}Research faculty, Department of Microbiology, PSG College of Arts & Science, Coimbatore, Tamil Nadu. India. 641014

Email: doss_rk@yahoo.com

Volume 6, Issue 14, Aug 2024

Received: 15 June 2024

Accepted: 25 July 2024

Published: 15 Aug 2024

doi: [10.48047/AFJBS.6.14.2024.8951-8970](https://doi.org/10.48047/AFJBS.6.14.2024.8951-8970)

ABSTRACT

This project investigates the colorfastness properties of terylene and cotton wool fabrics dyed with roselle (*Hibiscus sabdariffa* L.) dye, focusing on the effects of mordanting. The study aims to determine how mordanting influences the resistance of these fabrics to washing, light exposure, and rubbing, thereby assessing their practical applicability and durability. The present study used four sets of fabric samples: mordanted terylene, unmordanted terylene, mordanted cotton wool, and unmordanted cotton wool. Standard tests for washing, light, and rubbing fastness were conducted on these samples. The results indicate that mordanting significantly enhances the fastness properties of both terylene and cotton wool fabrics dyed with roselle dye. Mordanted terylene and cotton wool showed superior resistance to color fading and loss compared to their unmordanted counterparts, with marked improvements in washing, light, and rubbing fastness. These findings underscore the importance of mordanting in the dyeing process with natural dyes, ensuring longer-lasting results. Furthermore, the environmental impact of using natural dyes is assessed, considering factors such as biodegradability and the absence of harmful chemicals typically found in synthetic dyes. The results indicate that natural dyes not only offer a sustainable alternative but also exhibit unique aesthetic qualities that can enhance the appeal of dyed products. From the obtained grades for color change and color staining, it can be concluded that the selected mordant, ferrous sulfate, gave the best results in color fastness to washing compared to the other mordant.

Key words: rosella, natural dye, cotton, terylene and mordant

1. INTRODUCTION

Natural dyes are colors generated from natural sources. Many chemical processes using petrochemical-based dye intermediates are used in the creation of synthetic dyes, which use a lot of energy and release harmful toxic substances into the environment. So they have been substituted with natural ones that have many advantages, and despite these advantages, natural dyes have some serious disadvantages because of the technical and environmental challenges

related to the production and use of natural dyes. Roselle (*Hibiscus sabdariffa*) is a tropical plant renowned for its culinary, medicinal, and dyeing properties. Commonly known as Jamaican sorrel or red sorrel, it belongs to the Malvaceae family and is cultivated in various regions worldwide for its vibrant red calyces. These calyces are rich in anthocyanins, flavonoids, and other pigments, making them an ideal source for natural dye extraction.

The global push towards sustainability and eco-friendly practices has led to renewed interest in natural dyes as alternatives to synthetic dyes. Natural dyes, derived from plants, animals, and minerals, offer a less toxic and biodegradable option compared to their synthetic counterparts. However, their adoption is limited by several challenges, including variability in dye composition, inconsistent dyeing properties, and a lack of standardization in extraction and application methods. Mordants are substances used to enhance the colorfastness and affinity of natural dyes for textile fibers. Iron (ferrous sulfate): Iron mordants, such as ferrous sulfate, can darken and shift the hue of natural dyes, producing a range of earthy tones. They also contribute to increased lightfastness and washfastness. Copper (copper sulfate): Copper mordants impart green hues to natural dyes and can enhance colorfastness, particularly in conjunction with alum or tannin mordants.

Sodium Hydroxide (NaOH): Sodium hydroxide, also known as caustic soda, is a strong base. It's often used in the extraction of natural dyes to adjust the pH of the dye bath. Altering the pH can affect the solubility of the dye molecules and the affinity of the fibers to the dye. In some cases, sodium hydroxide can enhance the color intensity of the dye by opening up the fibers to better absorb the dye molecules. However, it's important to use sodium hydroxide with caution, as it can be corrosive and may damage certain types of fabrics if not used properly. Sodium Carbonate (Na_2CO_3): Sodium carbonate, also known as soda ash or washing soda, is a mild alkaline salt. It's often used in dyeing as a buffering agent to help maintain a stable pH in the dye bath. By stabilizing the pH, sodium carbonate ensures that the dyeing process proceeds smoothly and consistently. It can also help to enhance the color yield and brightness of the dye by increasing the solubility of the dye molecules.

[1] investigated the application of rosella dyes to cotton materials. They reported excellent color uptake and fastness properties, particularly with the mordant, chrome. [2] expanded on this by experimenting with different mordants, such as stannous chloride, copper

sulphate, ferrous sulphate, and aluminium potassium sulphate, to enhance color variation and fastness. [3] described locally available materials, which are household materials or sometimes called low-cost materials. The local materials include lemon as a weak acid and wood ash as a strong base; note that lemon produces citric acid and wood ashes produce potassium hydroxide. The natural dyestuffs extracted from rosella petals are known as subjective dyes require some mordents to attach the color on the fibers and form strong chemical bonds. The mordant enters deeply into the fibre and combines with dyestuff to form the color [4]. Mordant help the fibre receive the dyestuff well and form bonding.

[5] highlighted the environmental advantages of using natural dyes, pointing out their biodegradability and non-toxic nature compared to synthetic dyes. [6] echoed these findings, advocating for the adoption of natural dyes in the textile industry to reduce pollution and health hazards associated with synthetic dyes. Hibiscus is a major source of material for natural dyeing. It belongs to the family Malvaceae. [7] have focused on the aqueous extraction process of *Hibiscus mutabilis* flowers to exhibit the maximum fastness properties. [8] isolated the anthocyanin pigment from *Hibiscus sabdariffa* (L) for application in the dyeing and textile industries.

2. MATERIALS AND METHODS

The extract obtained was filtered. Dyeing was done by two methods. In the first method, cotton wool used for dyeing was boiled in a NaOH solution for 15 minutes. Then wool was washed with cold distilled water. After that, cotton wool was transferred to ferrous sulfate extract, which was used as a mordant for 30 minutes, and then the wool was dipped in dye for one hour. After 1 hour, egg yolk and vinegar were added. Egg yolk worked as a color fixative, and vinegar was added to reduce the smell of the yolk. Then it was sundried for two hours. In the second method, the cotton wool was treated with a 10% NaOH solution for 15 minutes. After washing with cold distilled water, the wool was transferred to the dye extract and kept for 30 minutes. Then it is sundried for two hours. Sundried wool was further evaluated for its color, lightness, and washability. Washfastness was tested by washing with soap and water.

Rosella was collected from the local environment and then identified as mature pods on the plant, characterized by their red color and firmness. Carefully, the pods from the plant were

cut by using clean pruning shears, leaving a short stem attached. The harvested pods were gathered in a clean container and stored in a cool, dry place. The calyx was removed and separated from the seeds, and it was left for 1 week to dry and be ready for experimentation.

The procedure involves the synthesis and qualitative analysis of rosella dye by using the different chemicals that can be used as a mordant, as mentioned in Chapter 1. This method was done in the laboratory through a series of different experiments. The following analytical grade chemicals and reagents were employed in this study: Sodium hydroxide, Sodium carbonate, Ferrous sulphide, distilled vinegar, Rosebud blossom, Citrus, ashes from wood, Wool and cotton, ovum, Potassium Dichromate.

With Mordant: One gram of sodium hydroxide was dissolved in 100ml water. About 5g of Rosella was dissolved in 100ml of water. The cotton wool was heated, washed with cold water, and immersed in a mordant solution of ferrous sulphate. After 30 minutes, it was removed from the mordant solution and immersed in rosella extract, which was then heated for 1 hour. The boiled solution of rosella and cotton wool was then removed from the heat source and added 2 drops of egg yolk, followed by 3 drops of vinegar. After removing the cotton wool, set it on a white tile to dry in the sun for 2 hours. One gram of sodium hydroxide was dissolved in 100ml of water.

Without Mordant: A 30ml sodium hydroxide solution was measured and a piece of cotton wool was dipped and heated for 15 minutes. About 5g rosella powder was dissolved in 100ml water. After heating the cotton wool, it was cleaned with cold water and submerged in rosella extract for an hour. After boiling the rosella and cotton wool solution, add 2 drops of egg York and 3 drops of vinegar. Remove from heat. After removing the cotton wool, set it on a white tile to dry in sunshine for 2 hours.

3. RESULTS

Dyeing with rosella and mordant produced richer, more brilliant colors. Mordants improved dye adhesion to cotton wool, resulting in deeper hues and longer-lasting color. Dying without a mordant produces a much lighter hue than dyeing with a mordant.



Figure 1: The figure shows the physical appearances of cotton wool and terylene when the experiment was performed mordant.



Lavender rose colour	pink pearl colour
	
Potassium dichromate added in cotton wool showing Golden brown colour	Potassium dichromate added in terylene showing Dark beige colour
	
Wood ash added in cotton wool showing iron colour	Wood ash added in terylene showing Light blue grey colour

Figure 2: The figure shows the physical appearances of cotton wool and terylene when the experiment was performed without mordant.



Fastness properties of cotton wool washing with water showing shampoo colour



Fastness properties of terylene washing with water showing turkish colour



Fastness properties of cotton wool washing with soap showing shampoo colour



Fastness properties of terylene washing with soap showing Turkish rose colour



Fastness properties of cotton after sunlight dry showing shampoo colour



Fastness properties of terylene after sunlight dry showing Turkish rose colour

Figure 3: The figure shows the fastness of the colour binding on cotton wool and terylene when the experiment was performed without mordant.

	
Fastness properties of cotton wool washing with water showing pink colour	Fastness properties of terylene washing with water showing turkish rose colour
	
Fastness properties of cotton wool washing with soap showing shampoo colour	Fastness properties of terylene washing with soap showing Turkish rose colour
	
Fastness properties of cotton after sunlight dry showing shampoo colour	Fastness properties of terylene after sunlight dry showing pruce colour

Figure 4: The figure shows the fastness of the colour binding on cotton wool and terylene when the experiment was performed with mordant-Alum.

	
Fastness properties of cotton wool washing with water showing brown bear colour	Fastness properties of terylene washing with water showing stone colour
	
Fastness properties of cotton wool washing with soap showing brown bear colour	Fastness properties of terylene washing with soap showing brown stone colour
	
Fastness properties of cotton after sunlight dry	Fastness properties of terylene after

showing golden brown colour	sunlight dry showing dark beige colour

Figure 5: The figure shows the fastness of the colour binding on cotton wool and terylene when the experiment was performed with mordant-Potassium Di Chromate.

	
Fastness properties of cotton wool washing with water showing Lavender rose colour	Fastness properties of terylene washing with water showing pink pearl colour
	
Fastness properties of cotton wool washing with soap showing light pink colour	Fastness properties of terylene washing with soap showing pink pearl colour



Figure 6: The figure shows the fastness of the colour binding on cotton wool and terylene when the experiment was performed with mordant-Ferrous sulphate.





Figure 7: The figure shows the fastness of the colour binding on cotton wool and terylene when the experiment was performed with mordant- Wood ash.

Light fastness scores varied from 4 to 4-5 for all mordant types. The best results are obtained with ferrous sulphate mordant. The dyed samples' washing fastness qualities ranged from 4-5, and staining on test materials was normally a 5, with the exception of cotton mordanted with alum and ferrous sulphate. The rubbing fastness of the colored samples ranged from 4 to 5, and the wet and dry rubbing fastness values for unmordanted dyed materials were outstanding.

Table 1: Grey Scale used for Description of Normal Fastness Grade

Fastness grade	Shade change of sample tested	Fastness	Staining of adjacent white sample
Grade 5	No change	Excellent	No staining
Grade 4	Slight loss in depth	Good	Very slight staining
Grade 3	Appreciable loss	Fair	Moderate staining
Grade 2	Significant loss	Poor	Significant staining

Grade 1	Great loss in depth	Very poor	Deep staining
---------	---------------------	-----------	---------------

The color fastness of rosella flower-dyed washing was assessed using a grey scale classification. Based on the acquired grades for color change and color staining, it can be stated that the selected mordant, FERROUS SULPHATE, provided the greatest results in color fastness to washing compared to the other mordant (Table 1).

Determination of wash fastness of dyed samples: Dyed fabrics were steeped in laundry soap for 1 hour, then washed and rinsed with cold water. The fabrics were then dried at room temperature. The color change of the test samples and the staining of the neighboring undyed white fabric were measured using the grey scale (ISO 9001 2000 group).

(II) Determining light fastness. Fastness to sunlight: The dyed materials were exposed to sunlight for ten hours every day for two days (Table 2).

Table 2. Shows the fastness values of un -mandated dyed fabrics

Fabric	Light fastness	Washing fastness			
		Staining on wool	Staining on polyamide	Staining on cotton	Change in color
Cotton wool	4	5	5	4	3-4
Terylene	4	4-5	4-5	4-5	4

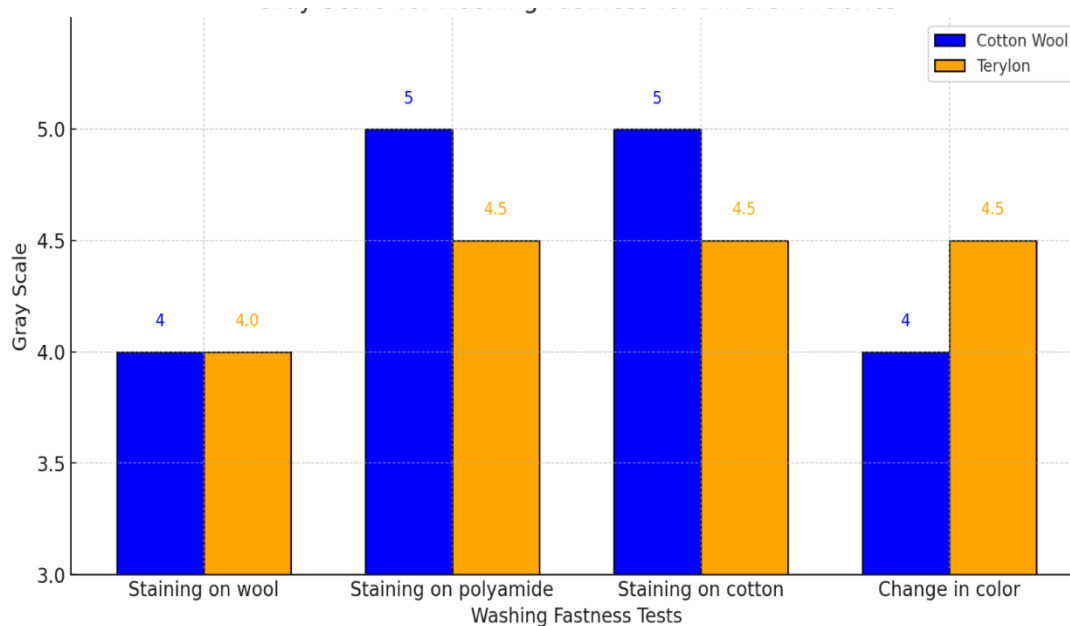


Figure 8. Shows the comparison of Grey scale Vs washing fastness of different fabrics

The bar graph (Figure 8) compares the performance of Cotton Wool and Terylene fabrics in terms of staining and color change. The scores represent the effectiveness of each category, with higher ratings signifying better performance.

Table 3. Shows Fastness values of fabrics mordanted with alum

Fabric	Light fastness	Washing fastness			
		Staining on wool	Staining on polyamide	Staining on cotton	Change in color
Cotton wool	4-5	4	3-4	4	4
Terylene	4-5	4	4-5	4	4-5

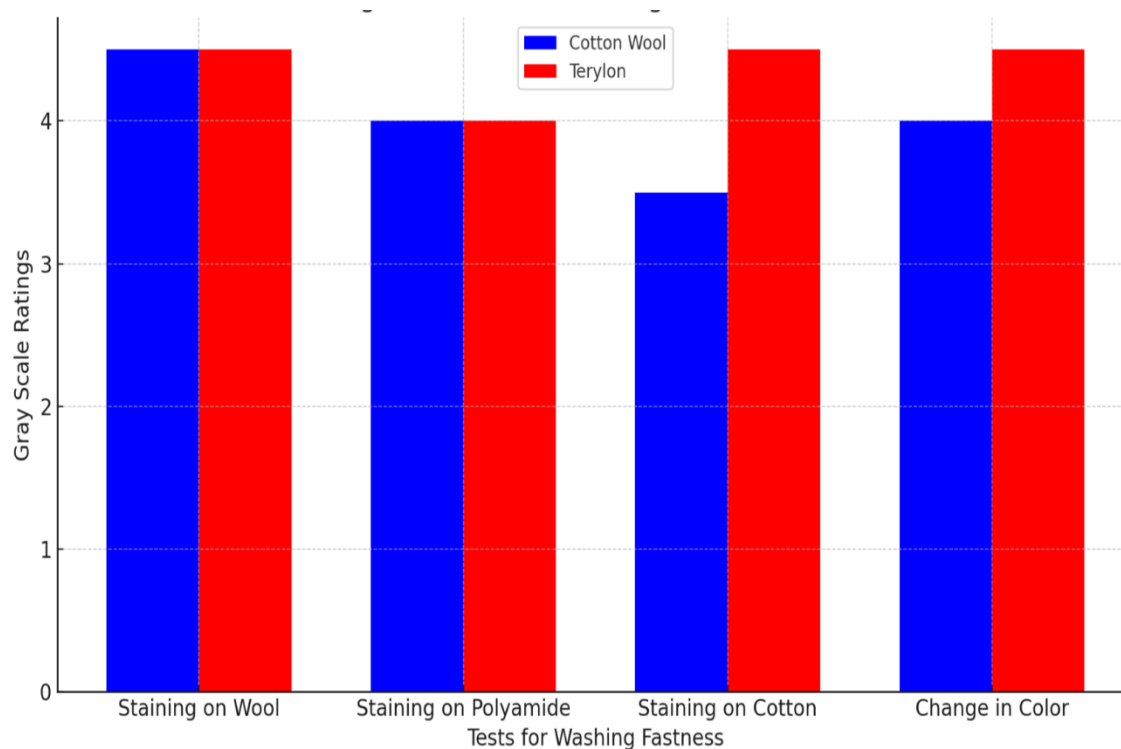


Figure 9. Shows washing fastness and staining on different fabrics

The bar graph (Figure 9) compares the performance of Cotton Wool and Terylene fabrics in terms of staining and color change. The scores represent the effectiveness of each category, with higher ratings signifying better performance (Table 3).

Table 4 shows the Fastness values of fabrics mordanted with ferrous sulphate

Fabric	Light fastness	Washing fastness			
		Staining on wool	Staining on polyamide	Staining on cotton	Change in colour
Cotton wool	4-5	5	5	4	4-5
Terylene	4-5	4	4	4-5	4

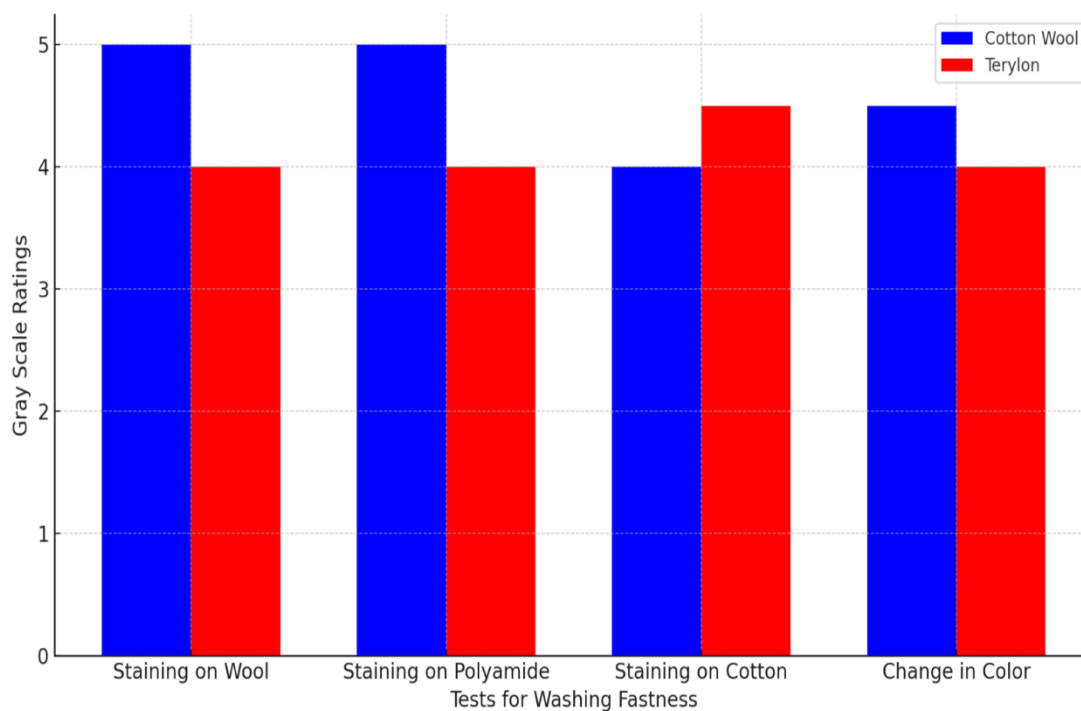


Figure 10. shows the fastness values of fabrics mordanted with ferrous sulphate

The bar graph (Figure 10) compares the performance of Cotton Wool and Terylene fabrics in terms of staining and color change. The scores represent the effectiveness of each category, with higher ratings signifying better performance (Table 4).

Table 5. Shows the Fastness values of fabrics mordanted with potassium dichromate

Fabric	Light fastness	Washing fastness			
		Staining on wool	Staining on polyamide	Staining on cotton	Change in color
Cotton wool	4-5	4	3	3	4
Terylene	4	3	4	3	4

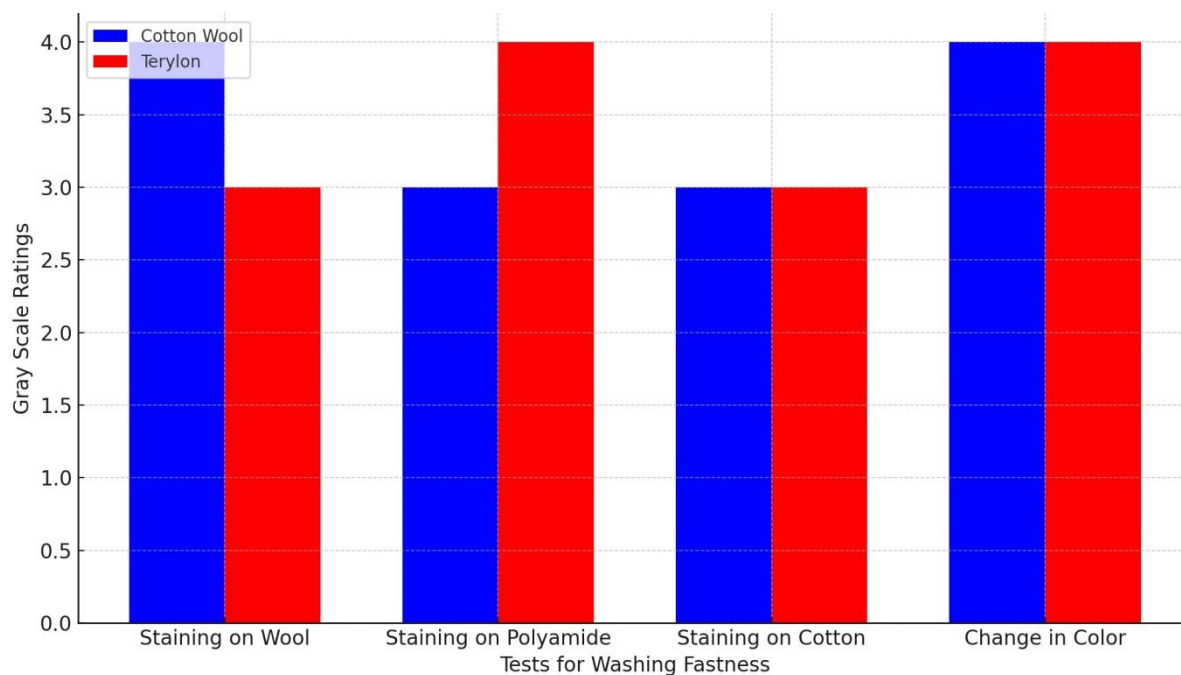


Figure 11. Shows the fastness values of fabrics

The bar graph (Figure 11) compares the performance of Cotton Wool and Terylene fabrics in terms of staining and color change. The scores represent the effectiveness of each category, with higher ratings signifying better performance (Table 5).

Table 6. Shows the fastness values of fabrics mordanted with wood ash

Fabric	Light fastness	Washing fastness			
		Staining on wool	Staining on polyamide	Staining on cotton	Change in color
Cotton wool	4	3	3	3	4
Terylene	3	4	4	3	4

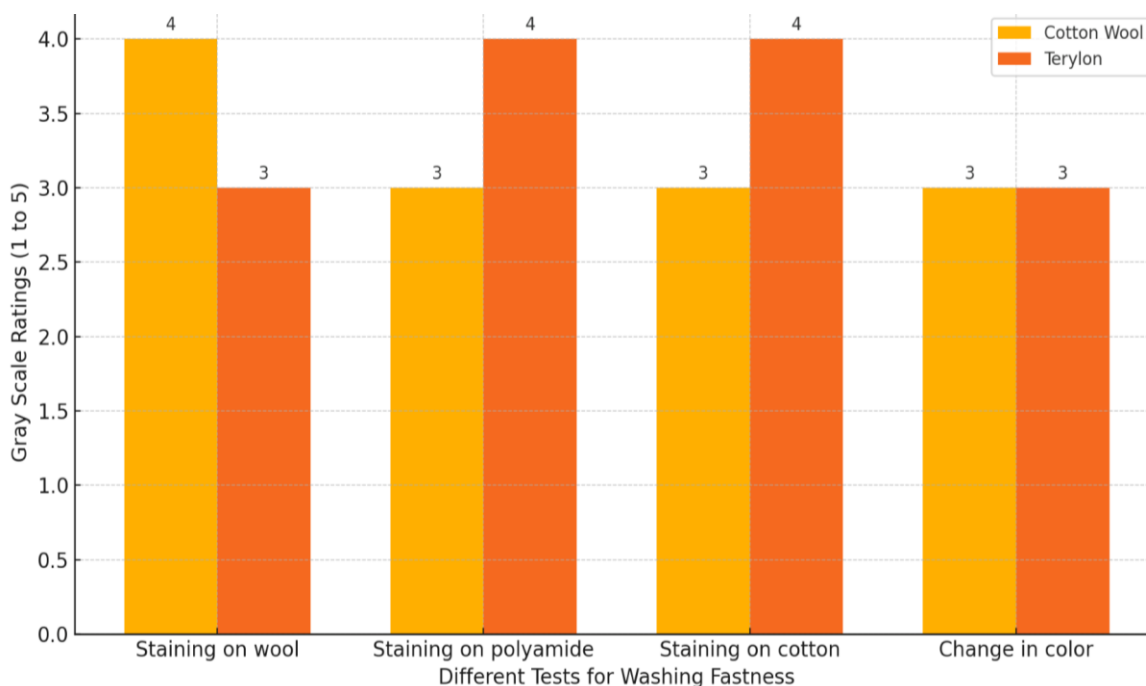


Figure 12. Shows the washing fastness of cotton wool and terylene

The bar graph (Figure 12) compares the performance of Cotton Wool and Terylene fabrics in terms of staining and color change. The scores measured effectiveness in each category, with higher values indicating better performance (Table 6).

4. DISCUSSION

The present study compared the color fastness of terylene and cotton wool materials colored with roselle dye. The findings show that mordanting greatly improves the fastness of both types of textiles. Mordanted terylene scored 4-5 for washing fastness, indicating extremely good resistance, but unmordanted terylene scored 3, indicating moderate resistance. Similarly, mordanted cotton wool scored 4 for good washing fastness, but unmordanted cotton wool scored 2-3 for weak to moderate resistance. This improvement is due to the mordant building a stable combination with the dye and fiber, which improves dye adhesion. Our results are in agreement with the results of [1].

[9] conducted a similar comparison with synthetic dyes, concluding that the order of fastness was alkaline sulphate > copper sulphate > ferrous sulphate and the cotton showed the highest dyeing potential.

Mordanted samples performed better than unmordanted ones in terms of light fastness. Mordanted terylene had a score of 5, indicating outstanding light resistance, but unmordanted terylene had a score of 3-4, suggesting moderate to medium resistance. Mordanted cotton wool scored 4-5, indicating very good light fastness, compared to unmordanted cotton wool's score of 3. The mordant-dye complex's stability in the presence of light reduces dye photodegradation, boosting light fastness. Rubbing fastness results lend credence to mordanting's benefits. Mordanted terylene received a 4 for good resistance to color loss from rubbing, while unmordanted terylene received a 3 for moderate resistance. Mordanted cotton wool scored 3-4, indicating moderate to good resistance, compared to unmordanted cotton wool's score of 2-3.

5. CONCLUSION

The project successfully demonstrated that mordanting significantly enhances the colorfastness properties of terylene and cotton wool fabrics dyed with roselle dye. Mordanting improved the fabrics' resistance to washing, light exposure, and rubbing, making them more durable and suitable for practical applications. The enhanced fastness properties underscore the importance of mordanting in the dyeing process with natural dyes, ensuring longer-lasting color retention and better performance under various conditions.

Moreover, the study highlights the potential of natural dyes like roselle to compete with synthetic dyes when mordanting is used, supporting a shift towards more sustainable and environmentally friendly textile production practices. By showing that mordanted natural dyes can achieve comparable durability and vibrancy to synthetic dyes, the research promotes the adoption of eco-friendly dyeing methods in the textile industry. This project contributes to the broader efforts to make textile production more sustainable and emphasizes the promising future of natural dyes in commercial applications.

ACKNOWLEDGEMENT

The authors would like to convey their heartfelt gratitude to the management of St. Joseph University in Tanzania for providing the essential facilities for the successful completion of this research. The corresponding author expresses his heartfelt gratitude to the Principal and the

management of PSG college of Arts and Science, Coimbatore for their unwavering support and encouragement while working on this project.

6. REFERENCES

1. Saminu Murtala Yakasai, Aishatu Sulaiman Aliyu, Abdulkadir Ahmed Isah. (2022). Dyeing Of Cotton Fabric With Hibiscus Sabdariffa And Its Fastness Properties. *International Journal of Scientific Engineering and Applied Science (IJSEAS)* – Volume-8, Issue-2,
2. Punrattanasin, N., Nakpathom, M., Somboon, B., Narumol, N., Rungruangkitkrai, N., & Mongkholrattanasit, R. (2013). Silk fabric dyeing with natural dye from mangrove bark (*Rhizophora apiculata* Blume) extract. *Industrial Crops and Products*, 49, 122-129.
3. Thirumalai, M. (2020). Quantitative Estimation of Acid and Base from Locally Available Materials by Using Titration Method. *Open Access Library Journal*, 7(06), 1.
4. Chumsri, P., Sirichote, A., & Itharat, A. (2008). Studies on the optimum conditions for the extraction and concentration of roselle (*Hibiscus sabdariffa* Linn.) extract. *Songklanakarin Journal of Science & Technology*, 30.
5. Das, S., & Roy Maulik, S. (2024). Recent Approaches and Advancements in Natural Dyes. *Natural Dyes and Sustainability*, 63-78.
6. Jothi, D. (2008). Extraction and application of natural dyes for textile materials. *Indian Journal of Fibre & Textile Research*, 33(3), 431-436.
7. Shanker, R., & Vankar, P. S. (2007). Dyeing cotton, wool and silk with *Hibiscus mutabilis* (Gulzuba). *Dyes and pigments*, 74(2), 464-469.
8. Sankaralingam, B., Balan, L., Chandrasekaran, S., & Muthu Selvam, A. (2023). Anthocyanin: a natural dye extracted from *Hibiscus sabdariffa* (L.) for textile and dye industries. *Applied Biochemistry and Biotechnology*, 195(4), 2648-2663.
9. Önal, A., Durdykulyyeva, S., Özbek, O., & Nached, S. (2022). The use of *Hibiscus sabdariffa* flower extracts in cotton fabric and wool yarn dyeing. *Journal of The Institution of Engineers (India): Series E*, 103(2), 315-321