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Analysis of Differences in Shibori Motif Results Using Rust Dyeing Technique on Cellulose Fibers and Synthetic Fibers

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ABSTRACT - Rust Dyeing is a dyeing technique that utilizes iron corrosion to create unique patterns with rust stains, producing colors ranging from yellow to black. The striking and long-lasting rust color makes it an attractive alternative for dyeing fabrics, with the color results influenced by the type of textile fiber. This study aims to: (1) Determine the differences in shibori pattern results in terms of color evenness, color sharpness, and clarity of the pattern, and (2) find the best rust dyeing technique on cellulose and synthetic fibers using the shibori technique. This comparative study uses the type of fiber as the independent variable (cellulose and synthetic) and shibori pattern results as the dependent variable (color evenness, color sharpness, and clarity of pattern). Data were collected from 8 observers and analyzed using ANOVA with SPSS 22 at a significance level of 5%. The results showed differences in shibori pattern results between cellulose and synthetic fibers. The best results were obtained on synthetic fabrics, especially satin fabrics, with the best mean in terms of color evenness (3.62), color sharpness (3.87), and clarity of pattern shape (3.87). The satin fabric produces even colors, clear and bright patterns, and sharp pattern.

Keywords: Rust dyeing, shibori, cellulose fiber, synthetic fiber.

INTRODUCTION

Corrosion is the damage or reduction in the quality of metal due to oxidation and reduction reactions between the metal and various substances around it, which produce undesirable chemical compounds (Caldera Villalobos et al., 2016; Fernianti et al., 2022; Gareev, 2023; Kurniawati & Wati, 2024; Noreen et al., 2020). In Indonesia, corrosion is commonly known as rusting. Iron that has undergone corrosion is usually discarded because it is considered fragile and no longer useful. This can pollute and damage the environment if iron waste is not processed properly. Blackish brown iron rust is metal waste that can pollute the environment (Agustinus et al., 2020; Cheung et al., 2023; Tesnim et al., 2023).

Rusty iron waste has the potential to be used as an alternative natural dye that is not yet widely known and used. Iron waste can be easily found in everyday life. Iron waste can produce a thick color. This has the potential to be developed into a natural material that can print its own color. The striking and long-lasting color of rust stains makes rust an alternative material for coloring and staining fabrics. The type of textile used also affects the color results from dyeing with rust because each textile material has different properties and fiber structures.

The simple textile dyeing process includes mordanting, dyeing, fixation, and drying. Dyeing is a process of evenly coloring textile materials. The mordanting process is the steps to add metal elements (such as alum, tunjung, or others) to the fabric fibers, as a bridge between the fabric and natural dyes so that they will later react with various types of other natural dyes (Evitasari et al., 2023; Kavak et al., 2010). In principle, the dyeing process involves binding between the fiber and the dye. This binding occurs due to a chemical reaction that occurs between the fiber and the dye. There are four basic aspects that need to be considered in the natural dyeing process, namely: the mordanting process, the extraction process with water solvent media, dipping the fiber/fabric into the solution and fixing the dye on the fiber or often called fixation, and washing (Sarwono, 2020). Fabric that has been dipped in natural dyes should not be washed immediately, because the color still needs to be strengthened so that it does not fade, and sometimes an oxidation process is needed. In the coloring process, it is necessary to do color revitalization as well as color binding so that it does not fade easily. This stage is known as the refinement or fixation process. Fixation is the process of locking and awakening the color that has entered the fabric fibers (Sunarya, 2012). Fixation is done after the fabric is dipped in a dry state, because if it is done on a wet fabric, the dye that has stuck to the fiber will come out of the fiber pores. In this study, fixation was done with alum solution. Washing is done after the fixation process to remove the dye that sticks to the fiber surface and the dye that does not completely enter the fiber. Washing that is done properly will increase the color resistance to washing and washing (Hasanudin, 2010).

The potential of rusty iron waste can be processed into a potential alternative natural dye because this dye has not been widely used and is easy to process and creates unique visualizations or one of a kind and produces patterns, different color effect designs in each manufacture and environmentally friendly and safe coloring techniques. Rust Dyeing comes from English, namely rust which means rust and dyeing which means dyeing. Rust Dyeing is a dyeing technique that is made by reacting iron (Fe) to corrode, oxidize to form rust due to the contact of air, water and humidity so as to form a unique motif on the surface that is yellow, reddish orange, brown to black (Ramadhani & Hendrawan, 2020).

Rust dyeing techniques usually use natural fiber fabrics such as cotton and linen. New types of textiles, such as synthetic fibers and specialty fabrics, have brought more options and possibilities for rust dyeing. Rust dyeing techniques usually present a random and natural texture effect. Rust dyeing in modern designs may pay more attention to the regularity, geometry, and symmetry of patterns, reflecting modern aesthetic trends (Yan & Lili, 2024). Rust Dyeing technique in this context is applied to two different types of textile materials, namely cotton fabric made of cellulose fiber and satin made of synthetic fiber. In terms of its properties, cotton is a material that easily absorbs sweat and is very suitable for everyday clothing. Cotton fabric is also used by almost everyone in various types and characteristics, so it can be said that cotton has a great contribution to human life. Polyester satin is a satin fabric made of polyester. Satin fabric has the characteristics of being soft, falling and having a smooth sheen, woven very tightly so that the surface is slippery which makes the satin fabric look quality. Based on the problems that have been found, the author is interested in conducting research entitled "Analysis of Differences in Shibori Motif Results Using Rust Dyeing Technique on Cellulose Fiber and Synthetic Fiber".

LITERATURE REVIEW

As time goes by, the technique of dyeing using natural materials has developed. This discovery began with Flint's journey to India, Flint visited several villages that used natural dyes to dye ikat weaving which was gradually reintroduced, this was because the groundwater had been poisoned by synthetic dye residues that seeped into the ground, they disposed of synthetic dye wastewater by pouring it into the ground, as a result the water in 23 areas there was no longer safe for consumption, and people realized it too late.

Rust dyeing comes from English, namely rust which means rust and dyeing which means dyeing. Rust-dyeing is a dyeing technique on textiles or fabrics that forms a pattern on the surface using rusty or corroded metal such as iron, brass, and copper (Ramadhani & Hendrawan, 2020; Yan & Lili, 2024). Iron rust itself is a natural process that occurs in metals that experience corrosion and form rust due to the contact of air, water, and humidity that undergoes oxidation which forms a unique pattern in yellow, reddish orange to black. The rust dyeing technique has had value from the past to the present, with the specialty lying in the natural process that creates a distinctive and difficult to imitate texture effect. Starting from a discovery that happened by chance to becoming the subject of in-depth research, as well as its application in modern art and design, the rust dyeing technique shows its own appeal and potential for wide application (Nautiyal & Daruwalla, 2024; Yan & Lili, 2024). Rust-dyeing coloring technique is to produce different patterns, designs and color effects. Rust-dyeing coloring technique is different from eco-print and tie-dye techniques, although the colors produced are not so varied, the color effects produced are very interesting (Ramadhani & Hendrawan, 2020).

The natural dye technique is a coloring technique that uses natural dyes as the base material. The absorbed color will blend with the fibers in the fabric, so that it can withstand friction and washing (Nissa & Widiawati, 2008). The rust-dyeing coloring technique is actually almost the same as the ecoprint technique which uses leaves, flowers, roots, and fruit that are attached to the surface of the fabric, then rolled and boiled to transfer the natural color to the fabric fibers (Ramadhani & Hendrawan, 2020). Similar to the rust dyeing technique, the difference lies in the material that uses rusty metal to produce color on the fabric. The metal oxidizes when it comes into contact with air and moisture. When this happens, the surface turns red or brown due to the formation of iron oxide.

There are several Rust Dyeing techniques (Ramadhani & Hendrawan, 2020) that is:

a. *Fold & wrap bundle*

The Rust Dyeing technique involves wetting the cloth and folding or wrapping the cloth with a rusty object to create a striped effect according to the shape of the rusty object.

FIGURE 1. Technique fold & wrap bundle.

b. *Rolled bundle*

Rust Dyeing technique with fabric wrapping poles wrapped around rusty poles to create a zebra striped effect with the fabric creasing as you wrap it around the pole, or forming various rusty objects bound with fabric using wire and leaving the rust behind.

FIGURE 2. Technique *rolled bundle.*

c. *Item placement*

Rust Dyeing technique involves placing a cloth that has been treated with vinegar and then placing it over a rusty object and then drying it in the sun.

FIGURE 3. Coloring technique *item placement.*

d. *Shibori style bundle*

the shibori dyeing technique, namely bonding. To carry out this technique you have to use water from a rusty material to dye the fabric.

FIGURE 4. Coloring technique *shibori style bundle.*

Textile fibers are the main material in making yarn and fabrics that form a long network, have a very large ratio between length and diameter, and have long, flexible, and strong requirements. Textile fibers are objects that have a very large ratio between length and diameter. Fibers can be used as textile fibers must meet the requirements including length, flexibility and strength.

Cellulose fiber is an example of a type of compound that can produce various types of fibers. The chemical properties of fibers generally derived from cellulose are easy to absorb water (hygroscopic) easy to tangle, and if a burning test is carried out it produces an odor and charcoal like burning wood. Cotton is one type of natural fiber that comes from plants used as a raw material for the textile industry. Cotton comes from cotton fiber, where the main content is cellulose. The unique structure of cellulose makes it have special advantages as the main ingredient of cotton fabric, its nature is to absorb sweat, strong and durable so that cotton fabric is very popular and in demand by many people because it is advantageous such as strong when wet, can absorb water (hygroscopic), heat resistant, and soft.

Cotton is made from cotton yarn, while the cotton itself is harvested from cotton plants that require fertile and moist soil. The term cotton is a natural fiber produced by cotton. Fabrics made from cotton absorb sweat so they are comfortable to wear and come in various types from coarse to the smoothest. Polyester satin is a satin fabric made from polyester. Shine is the most prominent character of satin fabric. The type of fiber and yarn used and the length of the effect will affect the shine of satin fabric. Shiny filaments with low twists will make the fabric shinier. Filament yarn is used for satin surfaces because filament fibers, even though they have low twists, are strong enough to be used as warp yarns, while staple yarns with low twists are not strong enough. If the effect of staple yarn is to be emphasized, then sateen weft is used with staple yarn as the weft. Its nature is smoother, shinier, softer and smoother than other weaves, because the small number of crosses in satin causes the threads to overlap each other. Because the number of crosses is small, the warp satin fabric must have many warp threads while the weft satin fabric must have many weft threads. Satin fabric is actually not balanced, but with a large number of threads it will cover up the deficiency.

METHOD

This research is a type of comparative research. In this study, it compares or sees the differences in the motifs produced by rust dyeing techniques using nail rust between cotton fabric as cellulose fiber and satin fabric as synthetic fiber. The object of this study is the results of shibori motifs using the rust dyeing technique on 2 types of fabrics, namely cotton fabric and satin fabric. This study aims to determine the differences in the results of shibori motifs using the rust dyeing technique on cellulose fibers and synthetic fibers.

Research Design

X \ Y		Y		
		Y_1	Y_2	Y_3
X	X_1	Y_1, X_1	Y_2, X_1	Y_3, X_1
	X_2	Y_1, X_2	Y_2, X_2	Y_3, X_2

FIGURE 5. Research design.

Information:

X : Fabric Type
X1 : ClothSatin
X2 : ClothCotton
Y : Coloring Result Criteria
Y1 : Color Flatness
Y2 : Color Sharpness
Y3 : Clarity of Motif Form

Research Implementation Procedures

a. Preparing Tools and Materials
   1) Tool
      a) Gloves
      b) Measuring cup
      c) Pan
      d) Scales
      e) Receptacle
      f) Stove
      g) Clothesline
      h) Iron
   2) Material
      a) Cotton Fabric
      b) Satin Fabric
      c) Vinegar
      d) Alum Powder
      e) Water
      f) String of raffia
      g) Rusty nail

b. Research Procedures Conducted
   1) Mordanting Process
      a) Prepare 4 liters of water, then weigh 30 grams of alum powder, then pour the alum powder into a basin filled with water. Then stir until dissolved
      b) Then put the cloth into the mordant solution, soak it for 2 hours so that the color will be durable and long lasting.
      c) Boil the cloth with mordant solution for 1 hour.

d) After that, throw away the mordant water and rinse the cloth using running water.
e) Dry/air the cloth, try not to expose it to direct sunlight so that the substances contained in the cloth are not lost.

2) Fabric dyeing process
   a) Spread out the cloth and start arranging the rusty metal on the cloth according to the desired pattern.
   b) Then roll the cloth slowly until the metal is well covered.
   c) Next, after the cloth is rolled up, continue by tying the cloth tightly with raffia/rubber so that the metal does not come loose.
   d) Next, put the roll in the vinegar water and let it sit for 15 minutes.
   e) After 15 minutes, the roll is lifted and drained, then put into a basin and covered with plastic and left for 4 days.
   f) The rolled fabric will show rust printing which indicates that rust has been printed on the fabric and can be opened.
   g) Untie the ties and gently unroll and remove the metal from the fabric.
   h) Wash the cloth thoroughly using water first, then neutralize the acidity level of the cloth.
3) Fixation Process
   a) Prepare 1 liter of water, add 50 grams of alum, soak the cloth for 7.5 minutes in the fixation solution to lock the color in the cloth.
   b) Rinse the cloth with clean water, then dry the cloth or air it, try not to expose it to direct sunlight.
4) Finishing Process: Ironing the fabric to get maximum results and the fabric does not wrinkle.

Data Collection Methods

The data collection method in this study used observation and documentation methods. Observations were made on the finished results of the coloring process using the rust dyeing technique between cotton and satin fabrics which included color evenness, color sharpness, and clarity of the resulting shibori motif. A total of 8 people acted as observers in this study, consisting of 3 PKK FT UNM lecturers as trained respondents and 5 Fashion Design FT UNM students as semi-trained respondents.

Research Instruments

The instrument used in this study is an observation sheet to see the differences in coloring results using the rust dyeing technique on cotton and satin fabrics. This observation sheet uses a checklist (√) as a tool for collecting data.

Data Analysis Techniques

The data analysis techniques used in this study are descriptive data analysis and inferential data analysis. Descriptive statistical analysis is used to describe or provide an overview of the data that has been collected in this case related to the results of the rust dyeing technique motif assessment on 2 types of fabrics, namely cotton and synthetic fabrics. After that, the data is then analyzed using the percentage formula.

Next, inferential statistical analysis techniques are carried out to test the proposed hypothesis. However, first, normality and homogeneity tests are carried out to meet two basic assumptions, namely that the data must be normally distributed and homogeneous. After that, the observation results in the form of scores on the observation sheet that have been filled in by the respondents are tested using ANOVA to determine whether or not there are differences in rust dyeing results on 2 types of fabrics, namely satin and cotton fabrics. The calculation was carried out using the help of IBM SPSS Statistics 26, with a significance level of 5%.

RESULTS AND DISCUSSION

Research Results

Based on the results of processing research data regarding the differences in the results of rust dyeing technique motifs on 2 types of fabric, namely cotton and satin fabric, the data is then described as follows:

Color Evenness Aspect

Based on the results of the calculation, the mean value of the types of cotton and synthetic fabrics is as follows:

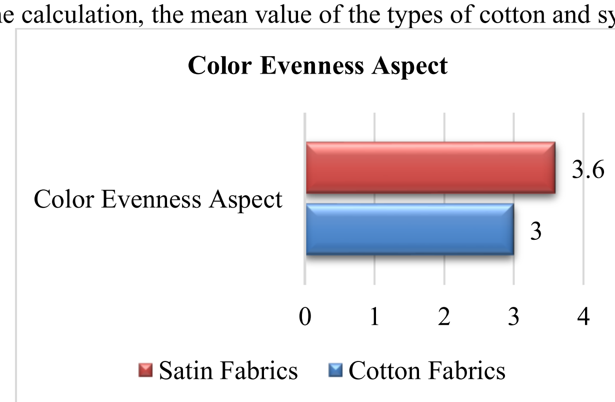

FIGURE 6. Mean color evenness aspect.

Based on the bar chart above, it shows that the mean of the highest color evenness aspect on the fabric is on the fabric dyed using satin fabric, which is 3.625 with good criteria.

Based on the results of the rust dyeing color evenness assessment, it is known that the average frequency of color evenness on cotton fabric after the dyeing process using the rust dyeing technique with a mean value of 3.625 with a good category on satin fabric and while for cotton fabric obtained a mean value of 3.00 with a fairly good category. Thus, in general it can be stated that the color evenness after the dyeing process using the rust dyeing technique with the highest mean was obtained on satin fabric and was in the good category with an even criterion.

ANOVA

Average Score Color Evenness Aspect

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.563	1	1.563	11.667	.004
Within Groups	1.875	14	.134		
Total	3.437	15			

FIGURE 7. Summary of ANOVA test results on the color evenness aspect.

Based on the results of the ANOVA test on the aspect of color evenness, the F count value is 11.667, and the significance value is α 0.004 <0.05, thus F count = 11.667> F table 3.74 means that Ha is accepted, which means that there is a difference in the results of rust dyeing between satin and cotton fabrics in terms of color evenness.

Color Sharpness Aspect

Based on the results of the calculation, the mean value of the types of cotton and satin fabrics is as follows:

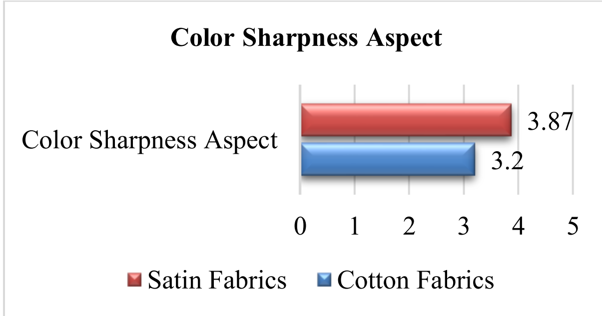

FIGURE 8. Mean aspect of color sharpness.

Based on the bar chart above, it shows that the mean of the highest color sharpness aspect is the result of dyeing using satin fabric, which is 3.875 with a very good category. While for cotton fabric, it has a mean value of 3.20 with a fairly good category. Thus, in general it can be stated that the color evenness after the dyeing process using the rust dyeing technique with the highest mean is obtained on satin fabric and is in the very good category with very sharp criteria.

ANOVA

Average Score of Color Sharpness Aspect.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.563	1	1.563	9.211	.009
Within Groups	2.375	14	.170		
Total	3.938	15			

FIGURE 9. Summary of ANOVA test results on the color sharpness aspect.

Based on the results of the ANOVA test on the aspect of color sharpness, the F count value is 9.221, and the significance value α is 0.009 <0.05, thus F count = 9.221> F table 3.74 means that Ha is accepted, which means that there is a difference in the results of rust dyeing between satin and cotton fabrics in terms of color sharpness.

Aspect of Clarity of Motif Form

Based on the results of the calculation, the mean value of the types of cotton and synthetic fabrics is as follows:

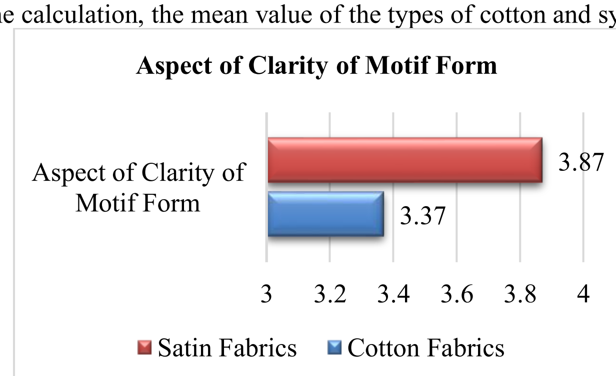

FIGURE 10. Mean aspect of clarity of motif form.

Based on the bar chart above, it shows that the mean of the highest clarity aspect of the motif shape is in the results of dyeing using satin fabric, which is 3.87 with a good category. Meanwhile, cotton fabric has a mean value of 3.37 with a fairly good category.

ANOVA

Average Score of Motif Clarity Aspect

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.000	1	1.000	5.091	.041
Within Groups	2.750	14	.196		
Total	3.750	15			

FIGURE 11. Summary of ANOVA test results on the clarity aspect of motif form.

Based on the results of the ANOVA test on the aspect of clarity of the motif shape, the F count value is 5.091, and the significance value α is 0.041 <0.05, thus F count = 5.091> F table 3.74 means that Ha is accepted, which means that there is a difference in the results of rust dyeing between satin and cotton fabrics in terms of the clarity of the motif shape.

In real terms, the results of rust dyeing using satin and cotton fabrics can be seen in the following image:

FIGURE 12. Rust dyeing results on satin fabric.

FIGURE 13. Rust Dyeing Results on Cotton Fabric

Discussion

Analysis of shibori motifs produced through rust dyeing techniques on cellulose fibers and synthetic fibers revealed significant differences. Based on a review of the aspects of color evenness, color sharpness and clarity of motif shape, satin fabric which is a material derived from synthetic fibers produces superior results compared to cotton fabric derived from cellulose fibers.

The rust dyeing results on cotton and satin fabrics show significant differences in terms of color evenness and color sharpness. The difference in materials affects the final result, where satin fabric made from synthetic fibers is able to provide good color evenness throughout its surface, both on the outside and inside. On the other hand, cotton fabric made from cellulose fibers tends to produce less even colors, especially on the outside. Likewise, in terms of color sharpness, the rust dyeing results on cotton and satin fabrics show significant differences. On satin material made from synthetic fibers, the resulting color is clearly visible on the motif and the color gradation on the motif looks good, while on cotton fabric made from cellulose fibers, the resulting color is less clear, the color of the motif boundary is less sharp and dull.

The difference in fiber properties in these two types of fabrics, which come from different material compositions, affects the evenness and sharpness of the resulting color. Satin fabric has an advantage in this regard because its finer fibers allow for more uniform color absorption compared to cotton fabrics. In addition, the differences in structure and chemical properties between synthetic fibers and cellulose fibers also affect the differences in rust dyeing results in terms of color evenness. Burkinshaw and Liu revealed that the absorption of disperse dyes in poly(ethylene terephthalate) fibers is influenced by the polymer relaxation process, which can increase dye absorption at high temperatures (Burkinshaw & Liu, 2023). This characteristic is particularly relevant in the context of rust dyeing, where the thermal properties of synthetic fibers allow for more optimal dye uptake and retention than cellulosic fibers. The ability of synthetic fibers to maintain structure at high temperatures supports more efficient dye diffusion, resulting in richer and more consistent colors.

Furthermore, seen from the aspect of the clarity of the motif shape produced in the rust dyeing process on cotton and satin fabrics, there are significant differences. In synthetic fabrics, namely satin fabrics, the type of material causes differences in the finished results in terms of the clarity of the motif shape because in satin materials the shibori motif produced is clearly visible and the color gradation in the motif is clearly visible, while in cotton fabrics, the shibori motif produced is less clear. The results of this study are supported by Islam's explanation that synthetic fabrics generally have superior color fastness compared to cellulose fabrics, which is very important for applications that require durability and resistance to fading (Islam, 2021). This is very important in making shibori motifs with the rust dyeing technique, where the shibori pattern produced through a long-lasting dyeing process can be affected if the dye does not adhere well to the fabric.

The durability of synthetic fibers under various conditions ensures that the pattern can maintain its brightness over time. In addition, the structural characteristics of synthetic fibers allow for unique interactions with rust dyes. For example, the crystalline structure of polyester can support more effective binding with iron ions in rust, resulting in clearer and sharper patterns. This is in contrast to cellulose fibers, which despite their high absorbency may not be able to achieve the same level of interaction with rust due to differences in their chemical composition (Stefan et al., 2022). The ability of synthetic fibers to form stronger bonds with dye molecules ultimately results in more vibrant and long-lasting shibori patterns.

CONCLUSION

Based on the research that has been conducted, the conclusion obtained is that the best rust dyeing results in terms of color evenness, color sharpness and clarity of motif shape are on satin fabric.

Based on the results of observations supplemented by data presentation and data analysis on the differences in rust dyeing results between those using satin and cotton fabrics, it can be concluded that:

1. There is a difference in the results of rust dyeing between satin and cotton fabrics when viewed from the aspects of color evenness, color sharpness and clarity of the motif shape. From all aspects, it can be concluded that satin fabric has a mean value of 3.79 with a good category. In terms of color evenness, the resulting color is more even and sharper than cotton fabric.
2. The results of the analysis of shibori motifs created using the rust dyeing technique on cellulose fibers, in this case using cotton fabric compared to synthetic fibers, namely satin fabric, revealed that synthetic fibers generally outperform cellulose fibers in terms of color evenness, color sharpness, and overall motif clarity. The distinctive characteristics of synthetic fibers, such as thermal stability, structural integrity, and reduced dependence on mordants, support their effectiveness in creating bright and durable shibori motifs. With the continued development of the textile industry, the use of synthetic fibers in traditional dyeing techniques such as rust dyeing opens up interesting opportunities for innovation and artistic expression.

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