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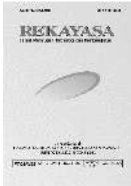

# Sustainable Dyeing: Utilizing Natural Ketapang Colors for Shibori Products

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**Abstract**

The use of synthetic dyes in the textile industry produces wastewater with high potential for environmental pollution. Utilizing natural dyes from Ketapang leaves offers an alternative for reducing such wastewater and can be considered a sustainable dyeing method. According to data from the UNNES Conservation Development Agency, there are 5,170 Ketapang trees around the UNNES campus, indicating a plentiful supply for natural dye production. The purpose of this study is to explore the potential of Ketapang leaf dye in enhancing the aesthetic quality of Shibori products, specifically in terms of motif aesthetics and color direction. The research employs a quantitative approach with an experimental design, using a single variable. Data analysis was conducted through descriptive percentage statistics. The Shibori with the highest aesthetic value was produced using lime as a fixative, achieving a 95% rating (highly quality). Color direction analysis showed that each fixative produced different color outcomes: lime resulted in a Dijon color, alum produced a Corn color, and ferrous sulfate yielded a Seaweed color. Based on these findings, it can be concluded that natural dyes from Ketapang leaves contribute significantly to both motif aesthetics and color direction in Shibori dyeing, offering a sustainable and environmentally friendly alternative for textile production.

Keywords: alum fixative, color direction, environmental pollution, ferrous sulfate, motif aesthetics

## INTRODUCTION

Sustainable dyeing with natural dyes is becoming increasingly important in efforts to reduce the environmental impact of the textile industry. The use of dyes can enhance the market value of a product. Color acquisition is divided into two types: natural dyes, derived from plant, animal, and mineral extracts, and synthetic dyes, which are manufactured. Natural dyes have been used by humans since 3500 BCE. They can be obtained from plants such as leaves, stems, fruits, flowers, roots, and sap. With the advancement of technology, synthetic dyes have become more commonly used due to their lower cost, ready availability, and resistance to fading. Synthetic dyes are produced globally. However, excessive use of synthetic dyes causes water pollution and waste disposal issues. The waste from synthetic dyes is classified as hazardous and toxic waste. Compared to synthetic dyes, which are harmful to the environment, natural dyes offer several advantages, including being more environmentally friendly, non-toxic, and producing unique and beautiful colors.

On the other hand, data from the UNNES Conservation Development Agency recorded 5,170 Ketapang trees around the UNNES campus (Retnoningsih *et al*., 2022). This indicates that there is a large availability of Ketapang trees, which presents an opportunity for their utilization as a natural dye. The realization of UNNES's conservation vision can be achieved by using fallen Ketapang leaves as a dye source, thus avoiding harm or reduction to the existing tree population. Ketapang has potential as a dye source, with its color quality being well-tested.

Natural dyes often come from plants, such as indigo for blue shades or leaves, flowers, and bark for other color variations. Indigo plays a role in producing shades from light blue to dark blue (Martuti *et al*., 2019). The use of natural dyes is eco-friendly and does not harm the environment. Ketapang is a potential source of natural dye with well-tested color quality. Ketapang natural dye has good color fastness against washing and staining (Eriani & Purnama, 2017). Utilizing the natural color from Ketapang leaves in the shibori technique offers an environmentally friendly solution while preserving traditional cultural heritage. Shibori techniques can produce various tactile textures, influenced by fabric folding directions, binding distances, and the type and size of fillers used in fabric ties (Yusrina & Ramadhan, 2018).

The natural dyeing process requires an assisting agent called mordanting to strengthen and fix the color onto the fabric. Textile materials commonly dyed with natural dyes include cotton, silk, and rayon fibers due to their high absorbency (Dewi, 2018). In addition to mordants, textile materials made from cotton, silk, and rayon, which originate from plant fibers, are frequently used because of their excellent absorbency (Dewi, 2018). After washing, chemical testing is conducted to assess the durability of the fabric, determining how long it can withstand wear over time. To improve the weak color bonds on the fabric, color fixation is performed using alum, lime, and iron sulfate solutions. In the application of mordants, metal salts that bind to the fibers attract organic dye/pigment molecules, facilitating a bond between the dye molecules and the fibers by forming coordination complexes (Arora *et al*., 2017). Ketapang natural dye exhibits fair color fastness to washing and good color fastness to staining (Eriani & Purnama, 2017).

The dye extracted from the ketapang leaves contains tannins ranging from 11% to 23%, producing colors from yellow to brown, and exhibits good wash fastness (Eriani & Purnama, 2017; Faisal & Chafidz, 2019). Tests also indicate good colorfastness against washing (Wulandari, 2021). The ketapang tree contains anthocyanin pigments, which are a source of color (Irawati & Mardiana, 2018). The wash fastness against soap washing is rated as good, indicating satisfactory color retention during laundering (Wulandari, 2021). Additionally, ketapang can also be produced as a powdered dye for cotton fabrics (Krisnawati *et al*., 2022), confirming that the potential of ketapang as a natural dye has been well established.

Natural dye from the ketapang tree is processed through extraction methods using various solvents, such as water, ethanol, or methanol. Organic solvents yield better colors compared to water; however, high temperatures during boiling can affect color stability (Hernani *et al*., 2017). The extraction results in the highest tannin content from fresh leaf samples after soaking for 8 days, achieving a tannin concentration of 21.8 g/L for dry samples

(Purnama *et al*., 2019). Using the same leaves, the optimal extraction conditions for tannins using ethanol yielded a tannin concentration of 98.97% (Santi *et al*., 2020).

The potential of natural dye from the ketapang tree has been developed into products that are taught to the community. The processing of this natural dye is carried out through extraction methods using solvents, resulting in a liquid dye that can be used to color textile materials. Plant dye extraction is typically performed using boiling methods; however, high temperatures can damage the stability of anthocyanins and reduce color fastness. Nevertheless, the community is more familiar with water as a solvent in extraction, whereas organic solvents such as ethanol and methanol actually produce better colors (Hernani *et al*., 2017). It is also important for the community to understand that the addition of acid to organic solvents, whether ethanol or methanol, can increase the polarity of the solution and improve the extraction results.

Based on the potential of natural dye from the ketapang tree, this study will examine the utilization of ketapang natural dye applied using the shibori technique. The shibori technique involves manual processes such as tying, folding, twisting, or pinching the fabric to produce unique and unexpected patterns, depending on the technique used (Dwiguna & Hendrawan, 2020). The objective of this research is to assess the quality of fabric dyed with ketapang natural dye based on the aesthetics of the patterns and the resulting color directions. After the fabric is tied or folded according to the desired pattern, it is dipped into a solution of natural dye extracted from ketapang, dried, and then untied to reveal a variety of distinctive patterns.

## METHOD

This study employs an experimental approach to assess the quality of fabric dyed with natural dye extracted from ketapang leaves using the shibori technique. The following are the steps involved in the research methodology. The preparation of the natural dye begins with extracting the dye from ketapang leaves using boiling or organic solvents (ethanol or methanol) to obtain an optimal dye solution. The extraction process involves using 3 kilograms of ketapang leaves with 8 liters of water, subjected to heat for 1 hour of boiling.

The preparation of the fabric used in this study involves rayon fabric with thread number R12 1216, which has good absorption properties for natural dyes. The fabric is cut into several samples of uniform size. The mordanting process is carried out before dyeing, using alum as the mordant. The Shibori products utilize fixation with the following composition: 15 grams of lime, 14 grams of alum, and 3 grams of tunjung.

The Shibori technique is performed by binding, folding, twisting, or pinching each fabric sample using Shibori methods to create different pattern variations. This process is done manually to produce unique motifs, employing the Kanoko Shibori technique.

The dyeing process is carried out on the fabric that has been bound according to the pattern and then immersed in the natural dye solution made from the ketapang extract. The dyeing is conducted in several stages, lifting the fabric and allowing it to absorb the color evenly, repeating this to ensure optimal color absorption. The fabric is left for a specified duration before being lifted and dried. This drying process aims to set the color that has been absorbed by the fabric. The fabric is allowed to dry in a shaded area or under sunlight, but it should ideally avoid direct sunlight to prevent color fading due to UV exposure. This drying also ensures that the fabric is sufficiently dry before proceeding to the next stage.

After the dyeing process is complete, the bound fabric is immersed in a fixation solution.

This fixative is used to enhance the color absorption of the fabric, making the color more vibrant and long-lasting. The types of fixatives used can include alum to produce brighter colors, lime to create whiter or pastel shades, and tunjung to achieve darker hues.

The dyed fabric is soaked in the fixation solution for several minutes (usually around 15-30 minutes), depending on the type of fixative used and the thickness of the fabric. The fabric remains bound during the soaking process to ensure that the shibori pattern retains its shape and the motifs are not disrupted.

After the fabric has been soaked in the fixation solution (such as alum, lime, or tunjung) and rinsed with clean water, it also needs to be dried. This drying process is essential for locking in the color and ensuring that the fixative adheres to the fabric fibers. As before, the fabric can be dried in a shaded area or under indirect sunlight to preserve the quality of the colors produced. With both drying stages, the quality of the color and the durability of the shibori motifs can be maintained, resulting in a final product where the fixative and dye are better absorbed and the colors are securely locked into the fabric.

After drying, the fabric is unbound (opened) from its ties and analyzed to observe the resulting motifs and patterns. The patterns and colors produced are visually analyzed based on the aesthetics of the motifs and the direction of the colors obtained.

Fabric quality testing is conducted to evaluate colorfastness, wash durability, and resistance to sunlight and abrasion. The quality assessment of shibori in this study includes the aesthetics of the patterns and color direction, which is carried out by comparing the clarity and uniqueness of the patterns produced in each fabric sample.

The dyeing results are analyzed qualitatively based on the visual outcomes of the patterns and quantitatively using a colorfastness test scale. The data are analyzed to determine the success level of the natural dye from the ketapang leaf in producing diverse and high-quality patterns on fabric using the shibori technique. The collected data in the form of single figures are then described. The variable used in this study is a single variable. A single variable is one that only describes the elements and principles within each phenomenon of that variable. In this research, the variable is the quality of shibori produced from the natural dye of ketapang leaves with heat extraction. Based on this variable, research indicators are determined, namely the aesthetic aspects of the patterns and color direction. The indicators used in the testing are presented in the form of a grid of organoleptic test instruments, with the aesthetics of the patterns shown in Table 1.

The color quality in this study is determined through the parameter of color direction, which is measured using a color catalog as a standard reference. The color direction is evaluated visually through organoleptic testing, where the fabric samples are compared with the color catalog to assess the compatibility of the produced colors. This assessment helps ensure color consistency and accuracy of the dyeing results with the natural dye from ketapang leaves, as shown in Figure 1.

This study uses descriptive analysis techniques. This analytical technique is employed to analyze the sub-indicator of color direction through an observation sheet filled out by expert judgment using equation (1), with the notation P = the percentage value sought or expected, n = the total score obtained, and N = the total number of panelists.

$$P = \frac{n}{N} x100\% \quad (1)$$

The calculation of shibori quality using natural dye from ketapang leaves on rayon fabric is performed by referring to the range of percentage responses obtained from the observation sheet that has been prepared. Each observation result is analyzed and categorized based on specific percentage ranges, as shown in Table 2.

**Table 1.** Grid of Organoleptic Test Instruments for Pattern Aesthetics

| No | Indikator | Sub Indikator |
|---|---|---|
| 1 | Aesthetics | 1. Clarity of shape |
| | | 2. Alignment |
| | | 3. Comparison/Proportion |
| | | 4. Composition |
| 2 | Colour | Color direction |

**Table 2.** Percentage Range of Shibori Dyeing Quality on Rayon

| Percentage Range | Criteria |
|---|---|
| 84 - 100 % | Very good quality |
| 68 - 83 % | Good quality |
| 52 - 67 % | Quite good quality |
| 36 - 51 % | Not good quality |
| 20 - 35 % | Very bad quality |


**Figure 1**. Color Catalog as a Guide for the Results of Natural Dyeing with Ketapang Leaves

## RESULTS AND DISCUSSION

The results of the shibori experiment using natural dye from ketapang demonstrate interesting variations in the patterns and colors produced, as seen in Figure 2. In this study, shibori products were created using three types of fixatives: alum, lime, and tunjung. Each fixative imparts different color characteristics and durability, which affects the final outcome of the fabric, as illustrated in Figure 2.

Overall, the color characteristics of the three fixation agents show that alum as a fixative produces bright and sharp results, allowing the natural color of the ketapang to stand out more prominently. The fabric treated with alum demonstrates good washfastness when tested, making it an effective choice for textile applications that require high color durability.

The use of lime provides a more pastel and soft color tone. While the results may not be as bright as those obtained with alum, lime offers a unique quality to the aesthetics of the shibori motifs. The washfastness of fabrics treated with lime is also quite good, though it may be slightly inferior to that of alum. The tunjung fixation agent produces darker and deeper colors, imparting an elegant impression to the shibori fabric. This dyeing result demonstrates potential for applications in fashion or decoration that require a strong color palette. The color durability of the tunjung fixation agent has also been shown to be effective in wash tests. Similar results were observed in the extraction process of longan leaves using different mordant types, indicating variations in the color longevity of the fabrics, with alum yielding lighter tones, lime yielding slightly darker tones, and tunjung producing the oldest colors, which can influence the color direction of the resulting batik patterns (Amantika *et al*., 2021). The application of lime to the bark extract of *Rhizophora apiculata Bl.* yields a medium dark orange color, while a mixture of lime and tunjung results in a very dark orange (brown) hue (Basri, 2023).

### Esthetic of the Motif

The aesthetic testing of the shibori products dyed with natural ketapang dye was conducted by five experts who filled out observation sheets to provide objective and measurable assessments. Each expert assigned scores based on several criteria, including beauty, uniqueness, and pattern balance. The results indicated that the patterns produced varied depending on the shibori technique applied and the type of fixative used.

The resulting patterns tend to be brighter and more striking, receiving high scores from the experts. This indicates that alum as a fixative can enhance the visual appeal of shibori patterns, making it a suitable choice for fashion applications. Although the colors produced are softer, the patterns still possess a unique charm. The experts' scores suggest that the softness of the colors imparts an elegant feel, making it ideal for more casual products. The tunjung fixative produced deeper and more dramatic patterns, which received positive feedback from the experts. They noted that the depth of color added dimension to the designs, potentially making them more eye-catching in the context of art and decoration. The aesthetic testing of the patterns was conducted by 5 experts using observation sheets. The results of the aesthetic analysis are shown in Table 3.

From the aesthetic analysis, shibori using lime and tunjung fixatives achieved the highest scores, each with a 95% rating, categorized as "excellent quality." Meanwhile, alum fixative received the lowest percentage, at 89%, though it still fell within the "excellent quality" category. The high aesthetic value of the lime and tunjung fixatives is attributed to the clarity of the patterns, which were more visible against the darker background. In contrast, the alum fixative resulted in patterns with a fabric base color that was nearly the same, reducing the contrast and clarity of the design.

This rayon Kanoko Shibori product features circular patterns, consistent with the findings of Suantara *et al*. (2018). This technique, known as "tie-dye" in Indonesia, involves tying parts of the fabric with thread or rubber bands to create the desired pattern. In line with the preference test conducted by Izzati & Russanti (2018), shibori using tunjung fixation also received a very high score, demonstrating that the choice of fixative plays a crucial role in the aesthetics and appeal of the final product. These results highlight the importance of selecting the right fixative for achieving the desired outcomes in shibori dyeing techniques. Additionally, efforts to combine shibori techniques with embroidery have been made to enhance the aesthetic value and provide a unique texture (Setiowati & Widiastuti, 2022).

**Color Direction**

The color direction test was conducted by matching the background colors of the shibori results with a color catalog, based on organoleptic tests from five experts. The results showed that shibori treated with lime as a fixation agent produced 80% Dijon and 20% Hazelnut. For shibori treated with alum, the colors were 20% Flaxen, 60% Corn, and 20% Canarya. Shibori treated with tunjung resulted in 60% Seaweed and 40% Ash, as shown in Table 4.

The color direction test results show that each type of mordant produces different colors. Lime mordant produces the original color, alum results in a lighter shade, while tunjung gives a darker or deeper color. Fresh ketapang leaves typically yield colors ranging from yellow to brown (Eriani & Purnama, 2017). The pH difference in mordants also affects the resulting fabric color; the higher the pH, the lighter the color. Alum has a pH of 9, slaked lime has a pH of 11-12.5, and tunjung has a pH of 8.

Ketapang leaf dye can produce a range of colors, from light brown to black, depending on the choice of mordant used (Dwiguna & Hedrawan, 2020). A stable black color can be achieved using tunjung mordant. The color variation during the dyeing process with tunjung solution and indigofera extract shifts from ivory to light brown fabric, with dark blue motifs turning greenish-brown (Putri *et al*., 2021). Color direction is also prominent in batik patterns, like the Rifaiyahan style, which tends to feature dark, purplish-red tones (Kahdar *et al*., 2018). However, the washfastness of soap-washed fabric using alum and lime mordants shows good resistance to fading (Nirwana & Widhiastuti, 2022).

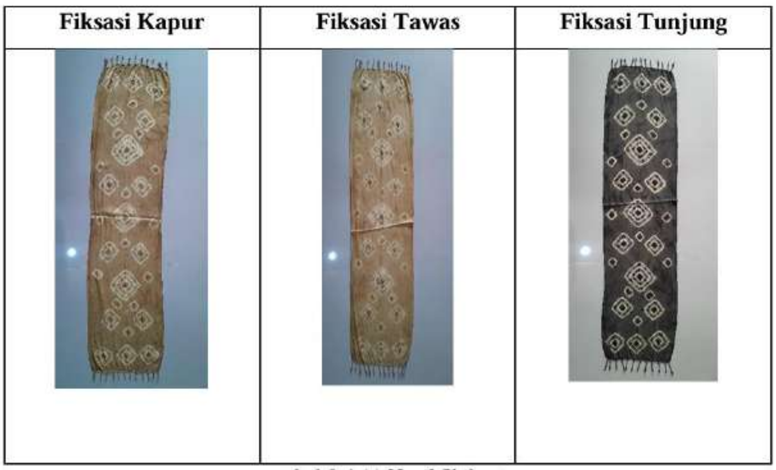
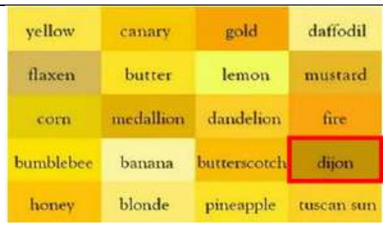
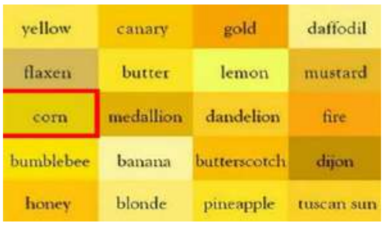



**Figure 2.** Shibori Fabric Products Dyed with Natural Dye from Ketapang with Variations of Fixatives.

**Table 3.** Aesthetic Analysis of Rayon Shibori Patterns with Three Fixatives

| No | Fixative Agent | Percentage | Criteria |
|---|---|---|---|
| 1 | Lime | 89 % | Excellent Quality |
| 2 | Tunjung | 95 % | Excellent Quality |
| 3 | Alum | 95 % | Excellent Quality |

**Table 4.** Color Direction of Shibori Products with Fixation

<table>
<tr><th>Fixator</th><th>Rayon Shibori Fabric</th><th>Color Guide</th></tr>
<tr><td>Lime</td><td></td><td>
</td></tr>
<tr><td>Alum</td><td></td><td>
</td></tr>
<tr><td>Tunjung</td><td></td><td>
</td></tr>
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## CONCLUSION

Natural dyes from ketapang leaves show high-quality results in the aesthetics of shibori motifs. The best results were achieved with shibori using lime and tunjung mordants, each reaching a percentage of 95%, categorized as excellent quality. Additionally, the natural dye from ketapang leaves produced color variations depending on the mordant used: lime produced a Dijon color, alum produced Corn, and tunjung produced Seaweed.

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