New techniques for improving the quality of cotton yarn using natural dyes from teak leaves (Tectona grandis), ketapang leaves (Terminalia catappa), and tender skin (Lannea coromandelica)

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Abstract. Sade village woven fabric is one of Lombok's superior woven fabrics. The process of producing this woven fabric is traditional by using yarn spun from cotton. The purpose of this study is to obtain the optimal strength of cotton yarn using natural dyes. Mordan stage and fixation using alum solution. The coloring stage uses teak leaves, ketapang leaves, and banten skin. All three ingredients are dissolved in water with concentrations 1:10, 1:8, and 1:5. In the mordan stage, 8 grams of alum is dissolved in 1 liter of water. While at the fixation stage, 50 grams of alum is dissolved in 1 liter of water. Teak leaves produce a dark brown color, ketapang leaves produce turmeric yellow color, and banten skin produces a brick red color. After going through the coloring process, the yarn is tested using Tensilon RTG. The result show that the yarn strength increase during the coloring process. In addition, differences in the concentration of the solution also affect the strength of the yarn produced. Solution with a concentration ratio of 1: 8 produces optimal tensile strength of 0.3450 cN/dtex on teak leaves, 0.3369 cN/dtex on ketapang leaves, and 0.2450 cN/dtex on banten skin.

1. Introduction

The tourism sector is one of the main income sectors for the island of Lombok. Sade village is one of the Lombok tourism villages. This village is famous for its strong customs, such as coloring woven fabrics using traditional methods. Before doing the coloring, the local community does a sizing process on the cotton threads that have been spun with the rice soaking method. This process can increase the tensile strength of the yarn [1]. Besides that, the coloring process utilizes the plants around the home environment. The plants used include teak leaves, ketapang leaves, and banten bark. This type of plant is abundant and easy to live in dry areas [2].

Every plant has a source of natural dyes because they contain natural pigments. The potential sources of color produced depend on the type of dye present in the plant [3]. We can obtain dye from plants by extraction and fermentation. Extract of roselle petals (Hibiscus sabdariffa L) provides red, orange, purple, and blue pigments [4]. Mangosteen rind extract produces a red color [5]. Teak leaf extract produces colors whose color stability changes with changes in pH. At high pH, it is blue, then violet. At low pH, it will turn red [6]. Kesumba seed extract can provide colors from yellow to red and dissolve in organic solvents [7]. From research conducted by Titiek [8], mango leaves produce a
yellow pigment, while according to Seran and Hana [9], tarum leaves produce a blue color. As for getting the red color, we can take advantage of the banten plant by using the skin.

The coloring stage is carried out through three processes: mordanting, dyeing, and fixation. The fixation process is the most critical because it is a step where the color is locked so that it does not fade quickly. The best fixation treatment was measured in an alum fixator with a 10% concentration and a lime fixator 20% [10]. The alum fixator contains $\text{Al}^{3+}$ and $\text{Ca}^{2+}$ lime. These ions will bind to tannins (hydroxyl groups) in the fibre and bind to other fibres so that the dye molecules become more vigorous and do not fade quickly [11]. From several fixation materials such as alum, chalk, and tipped, alum is the best fixator because it provides the highest fastness [12].

Apart from fastness resistance, yarn quality can also be seen from the physical properties of the yarn's color and tensile strength. Increasing the strength of the yarn will significantly affect the quality of the weaving produced. Therefore, it is essential to analyse the physical properties of the yarn from natural dyes. The strength of the yarn and the resulting color affected by pH level, the concentration of the solution, the type of plant, and the extraction method. In this study, the measurement of yarn quality improvement using natural dyes was carried out at different pH, concentration, and plant species.

2. Methods

The natural dyes used are teak leaves, ketapang leaves and banten skin. Preparation is done by cutting it into sizes 1 cm x 2 cm. The cotton thread preparation was carried out by separating the threads per strand and cutting them to a size of 15 cm. Then, the threads are tied together.

The coloring process is carried out in three main stages: mordant, dyeing, and fixation. The mordant stage uses 8 grams of alum. Alum is dissolved in 1 liter of distilled water. Cotton threads are soaked for 12 hours in this solution. After soaking, the threads are dried in the sun to dry. The next stage is coloring using natural ingredients. The dyeing is carried out in two processes: the manufacture of dyes and the dyeing of the yarn. The dyeing process was carried out by the extraction method. The dye was added to distilled water with a mass ratio of 1:10, 1:8, and 1:5. Each material was heated to half its initial volume. After the solution is ready, the next process is dyeing the yarn. The yarn was dyed with two variations of treatment, namely for 30 minutes and 12 hours. Furthermore, the threads are dried in the sun to dry. Then the final stage is fixation. The fixation solution is made with 50 grams of alum in 1 liter of distilled water. The threads are soaked for 5 minutes then dried.

The Analysis of the quality of the cotton yarn is then viewed from some aspect: the colors, the tensile strength in each dyeing stage, and the tensile strength influenced by the acid-base properties of the dye solution. Yarn strength analysis was tested using Tensilon RTG 1310 with the ASTM D2256 standard. Meanwhile, the pH of the dye solution was tested using a pH meter. From the results, we can recommend the appropriate treatment in the coloring process.

3. Results and discussion

In this study, the dyeing process was carried out by two methods, namely immersion, for 30 minutes and 12 hours. These two methods produce different colors. However, the resulting color difference was not significant. The 30 minutes immersion results had the characteristics of the color fading faster when fixed than the 12 hours immersion. This phenomenon occurs due to the acidic nature of alum as a fixator. In general, the results show that the teak leaves produce a dark brown color, the ketapang leaves produce a turmeric yellow color, and the banten skin produces a brick red color.

In this study, teak leaves produced a dark brown color. This pigment arises due to the presence of anthocyanin content in teak leaves. From the image (Figure 1), in 30 minutes of immersion, it is shown that the teak leaves produce milo brown color (concentration 1:10) before fixation and milk brown color after fixation. At concentrations of 1:8 and 1:5, the pigment was dark brown before fixation and milo brown after fixation. Otherwise, in 12 hours of immersion, there was a change in color before and after fixation. Before fixation, a purple-colored thread is obtained, and after fixation, it becomes dark brown.
Figure 1. Coloring result using Teak leaves in different concentration and soaking time

The result of dyeing the threads with the color pigment from ketapang leaves gives a turmeric yellow color. This yellow pigment appears due to the carotenoid content in ketapang leaves. In the 30 minutes immersion treatment (Figure 2), the yarn produced a golden yellow color (1:10 and 1:8 concentrations), while the 1:5 concentration produced a turmeric yellow color before fixation. After fixation using alum, the color of the threads turned golden yellow slightly faded at all concentrations. At 12 hours of immersion, all concentration treatments produced medium yellow thread before fixation and saffron yellow after fixation.

Figure 2. Coloring result using Ketapang leaves in different concentration and soaking time

The brick red color of the yarn is produced by dyeing it with the skin of the banten. This brick red color appears because the skin of the offering contains anthocyanin. Rose baby color (Figure 3 in 30 minutes of immersion) on the yarn was produced at all concentrations of the solution before fixation. However, after the fixation process, the rose baby color started to fade. The brick red color (Figure 3 in 12 hours of immersion) was produced before fixation, and the brick red color was medium after fixation at all concentrations.

Of the three types of plants, the color produced at 12 hours of immersion was better. This phenomenon happened in all treatments before and after fixation. In general, the color results do not
fade quickly when going through the fixation process. Soaking the yarn in the dye for 12 hours is recommended to be applied to the weaving yarn.

![Image](https://via.placeholder.com/150)

**Figure 3.** Coloring result using Banten skin in different concentration and soaking time

The yarn tensile strength test was carried out on the yarn with a 12-hours immersion treatment. Based on the data in Table 1, the tensile strength of the yarn is higher than before the mordant. The tensile strength of the yarn after dyeing and fixation tends to increase. This result happens because the fibres in the cotton thread are getting closer together. Besides that, the difference in solution concentration also affects the strength of the resulting yarn. A solution with a concentration ratio of 1:8 produces optimal tensile strength, namely 0.3450 cN/dtex on teak leaves, 0.3369 cN/dtex on ketapang leaves, and 0.2450 cN/dtex on banten skin (Figure 4).

**Table 1.** Tensile strength in three step of coloring with 12 hours soaking time

| Natural Dyes | Concentration | pH  | Before | Mordan | Dyeing | Fixation |
|--------------|---------------|-----|--------|--------|--------|----------|
| Teak leaves  | 1:10          | 6.5 | 0.1083 | 0.1392 | 0.2690 | 0.2790   |
|              | 1:8           | 6.5 | 0.1083 | 0.1392 | 0.3434 | 0.3450   |
|              | 1:5           | 6.5 | 0.1083 | 0.1392 | 0.3483 | 0.2951   |
| Ketapang leaves | 1:10   | 6.3 | 0.1083 | 0.1392 | 0.3379 | 0.2413   |
|              | 1:8           | 6.3 | 0.1083 | 0.1392 | 0.3379 | 0.2413   |
|              | 1:5           | 6.4 | 0.1083 | 0.1392 | 0.4186 | 0.3369   |
| Banten skin  | 1:10          | 6.9 | 0.1083 | 0.1392 | 0.2831 | 0.3239   |
|              | 1:8           | 6.8 | 0.1083 | 0.1392 | 0.0378 | 0.2450   |
|              | 1:5           | 6.9 | 0.1083 | 0.1392 | 0.1235 | 0.1708   |

The highest tensile strength occurs in threads colored using teak leaves. Besides the type of dye and the concentration, the pH also affects the strength of the yarn. The higher the pH of the solution, the smaller or lower the tensile strength. The decrease in the quality of the yarn is due to the acid-base nature of the dye solution.
4. Conclusion
Teak leaves, ketapang leaves, and banten skin can be used as sources of natural dyes that are environmentally friendly. The treatment of yarn immersion in natural dye solution for 12 hours has a better color quality than soaking for 30 minutes. Besides that, each dyeing process can increase the tensile strength of the yarn. The optimum tensile strength was found at a concentration of 1:8 for all tested plant species. Of the three types of plants, teak leaves produced the maximum tensile strength, namely 0.3369 cN/dtex. Apart from the plant type and solution concentration, the solution's pH also affects the yarn strength.

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