EXPERIMENTATION OF MANGO LEAF EXTRACT (*MANGIFERA INDICA L.*) FOR NATURAL DYE MATERIALS FOR BATIK FABRICS

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ABSTRACT

The use of natural dyes is an effort to reduce the impact of environmental pollution on the production process of batik that uses synthetic colors. This experimental study aims to explore the stages and results of the natural color dyeing of mango leaf extract by using different fixator variables and batting processes. Batik cloth is dyed three times in a solution of mango leaf extract as a dependent variable, then fixed with a lime solution ($Ca(OH)_2$), an alum solution ($Al_2(SO_4)_3K_2SO_424H_2O$) and a ferrous sulfate solution ($FeSO_4.7H_2O$) as an independent variable. Results of the study: 1) The stages of the process of dyeing plain and patterned batik cloth with Mango Gedong Lip Batik leaf extract with a fixator of lime solution, alum, and ferrous sulfate solution are carried out through the following stages: processing the fabric and dye of mango leaf extract, writing motifs with canting caps, dipping batik fabric, fixing batik fabrics with fixators, and releasing wax from batik fabric; 2) The results of dyeing plain and patterned batik cloth with Gedong Gincu Mango leaf extracts with lime solution fixators tend to be brown; alum fixation produces original colors; and ferrous sulfate fixators produce colors that tend to be blackish-green. The dyeing results on plain batik fabrics have stronger color intensity than the dyeing results on patterned batik fabrics because they undergo the nglorod process (separation of batik wax from batik fabric) with hot water added with sodium carbonate auxiliary substances (Na_2CO_3). Research recommends that artisans utilize plant waste to promote the green industry.

KEYWORDS

Experimentation; Mango Leaf Extract; After-Mordanting; Natural Dyes; Batik Fabric; Green Industry.

INTRODUCTION

Pollution of batik wastewater produced by batik companies is one of the serious environmental problems in Indonesia [1] [2]. Water resources are very important for the development of a region because they function as the main source for drinking, agriculture, and industry. Water pollution caused by natural and antopogenic activities is a major threat to global public health [3]. More than 80% of the waste generated by human activities is dumped into rivers and oceans without any treatment, resulting in environmental pollution and more disease. 80% of diseases and 50% of child deaths worldwide are related to poor water quality [4].

Liquid waste from the batik production process usually contains colorful particles and has high levels of dissolved and suspended particles such as biochemical oxygen demand (BOD) and chemical oxygen demand (COD) [5]. To minimize this waste, several wastewater treatment efforts have been made at several batik companies through wastewater treatment plants (WWTPs), including using horizontal subsurface flows that are built into wetlands, using activated sludge processes, and using anaerobic biological treatment followed by wetlands as adsorbent media for batik waste [6] [7]. Efforts to reduce waste have also been carried out through filtration and nanofiltration processes so that they can reduce the concentration and increase the pH of liquid waste before filtration [8-10].

The waste generated by the batik industry consists of gas, liquid, and solid waste. Liquid waste in the batik industry is the most commonly produced waste and has the potential to pollute the environment if not managed properly [11]. One of these environmental problems is the emergence of liquid waste from the batik industry in large quantities [12]. With many batik fabric products made by batik companies, there is

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also a lot of waste generated from the manufacturing process [13].

Switching the use of synthetic dyes to natural dyes is one of the wisest solutions because the good use of natural ingredients will not have a bad impact on the environment [14]. The presence of natural dyes as a substitute material in the batik industry is a preventive solution to avoid environmental problems [15]. Natural dyes are more environmentally friendly and have been proven to produce lower emissions, so the use of natural dyes in the batik production process is highly recommended [16].

One of the ingredients that produces natural dyes for the dyeing process of batik fabrics is mango leaves from the Mango Gedong Gincu variety (*Mangifera indica var. Gedong*). This type of commodity is widely produced in Indramayu, Majalengka, and Cirebon Regencies, West Java Province [17]. The type of gedong variety of mango fruit has a half-mature maturity and a full-ripe maturity called Gedong Gincu Mango, which is one of the export fruit commodities from Indonesia. Gedong Gincu fruit is a type of fruit that is grouped at the level of full-ripeness [18].

Various studies on the use of mango leaves for food sources and medicines have been carried out by many researchers. In the food field, mango leaves are used in the development of active packaging to preserve food through chitosan film that has been enriched with mango leaf extract so as to physically protect food and actively resist oxidation [19] [20]. Furthermore, in the fields of health and pharmacy, it is known that mango leaves, as one of the tropical plants, can be used as the most important medicine in the world because they have effective bioactive substances [21]. Edible mango leaf extract has mangiferin content, which shows antioxidant, antiviral, anticancer, antidiabetic, immunomodulatory, hepatoprotective, and analgesic effects, and high polyphenolic compounds. It has a long history as a medicinal ingredient [22] [23]. Mango leaves with bioactive compounds have medicinal properties that have the potential to improve human health because they have phytochemical evidence as bioactive phenolic and contain flavonoids as anti-inflammatory, antioxidant, antidiabetic, and antitumor [24-27]. Clinically, mangiferin content can be used effectively to treat obesity in humans [28]. Mango leaf extract (*Mangifera indica* L. var. *gadung*) grown in Indonesia contains secondary metabolites that have the potential to be antibacterial agents [29]. Mango leaves also contain bioactive compounds that have the potential to be antibacterial, such as mangiferan, flavanoid, and saponin, which can be used to overcome skin disorders in the form of acne and have the potential to be an anti-Candida albicans formulation and ointment to protect the skin [30] [31].

Studies on mango leaves in agriculture relate to diseases and the maintenance of mango plants. Research related to mango leaf diseases includes the following: AI-based modeling research has been carried out to detect and classify mango leaf diseases effectively and efficiently [32]. The study of early mango leaf disease using feed-forward neural networks and hybrid metaheuristic feature selection showed that the results of the artificial neural network approach were better than the convolutional neural network that could be implemented by farmers using smartphones in the field [33]. Automated approach to diagnosing mango leaf disease using the improved and optimized DenseNet architecture [34]. Meanwhile, in the field of mango plant maintenance, studies have been carried out related to the balance of mineral nutrients in mango leaves during the flowering period, which affects mango trees and fruit production [35].

The results of studies related to the use of mango leaves have also been carried out in the fields of technology and environmental conservation. In the field of electrochemical and surface technology, the use of 1 M HCl solution with mango leaf ethanolic extract is known to inhibit the corrosion of light steel so that the rate of iron anodic solution and the rate of cathodic hydrogen evolution reaction decrease efficiently [36]. Mango leaf studies related to environmental conservation include the following: Juicy mango leaf extract is used as an agent for the biosynthesis of silver nanoparticles (AgNPs). Used catalytic and mercury detectors for wastewater management systems and activated carbon synthesis mango leaves are used for ultra-sensitive detection of toxic heavy metal ions and energy storage applications [37] [38]. Mango leaves as biochar derived from agricultural waste biomass are a cheap raw material for the complete removal of CV dyes in the concentration of toxic cationic textile dyes [39].

Various studies on mango leaves from various disciplines, such as those described above, have been carried out by many previous researchers, such as in the fields of food and medicine, agriculture, and plant maintenance, as well as in the fields of technology and environmental conservation. However, the author has not found many studies that specifically discuss the benefits of mango leaves, especially the Gedong Gincu Mango Leaf variety, as a natural dye for environmentally friendly batik fabric warming materials. For this vacancy, the researcher has conducted an exploration and will explain the benefits of leaf waste as one of the natural dyes in batik fabric that can be developed by batik craftsmen and entrepreneurs in Indonesia.

The objectives of writing the paper are: 1) to analyze the stages of the dyeing process of plain and patterned batik cloth with Batik Gedong Mango leaf extract with a fixator of lime solution, alum solution, and ferrous sulfate solution; 2) to find the difference between the dyeing results of batik cloth and the dyeing results on plain and patterned fabrics with

Gedong Gincu Mango leaf extract material with fixators of lime solution, alum solution, and ferrous sulfate solution. Research encourages batik artisans to utilize plant waste, especially mango leaves, as an alternative to environmentally friendly natural dyes. Further research is needed related to the difference in color intensity in plain fabrics and patterned fabrics with the process of bleaching (removing wax from batik fabrics).

MATERIALS AND METHODS

Materials and tools

The materials used in this study are natural leaf materials, primisima batik fabric, and several fixator materials. The natural dye used is the Mango Gedong Gincu leaves (Fig. 1). This mango variety grows a lot in Majalengka Regency and Indramayu Regency, West Java Province, Indonesia, as a superior product of the region.

In addition to using natural dyes from Gedong Gincu Mango leaves, in this experiment, the researcher used a "mori primissima" type of fabric medium whose specifications are presented in Table 1. This fabric is used as a medium to draw or write batik motifs by scratching or applying a barrier to the color of hot wax with canting tulis or a canting cap.

Table 1 above has informed the results of the Primisima fabric test with detailed data, as follows: a) fabric weight: 111.70 g/m^2; b) fabric thickness: 0.24 mm; c) fabric composition consists of: 80% cotton and 19.77% rayon; and d) known fabric construction: warp density: 42.52/cm; welf density: 30.91/cm; warp thread number: 14.37 tex; weft thread number: 13.75 tex; and face webbing: plain.

Some of the fixator materials used include: lime solution ($Ca(OH)_2$), aluminum solution ($Al_2(SO_4)_3K_2SO_424H_2O$), and ferrous sulfate solution ($FeSO_4.7H_2O$), which works for directors and color amplifiers or lockouts. In addition to the main ingredient, there are also auxiliary ingredients such as Turkey Red Oil (TRO) for the process of soaking the fabric before dyeing it in natural dyes so that the color absorbs optimally and soda ash/Sodium Carbonate (Na_2CO_3), which is used for the ngelorod process (the release of batik wax from batik fabric).

Figure 1. Natural color material of Mango Gedong Gincu leaves.

Research methodology

This study uses an experimental method to explore the natural color of Gedong Gincu Mango leaves. The variables in the study are differences in fixators and differences in the dyeing process of batik fabrics (some are dyed on plain batik cloth and some are dyed on fabrics that are already patterned with batik) using canting stamps.

The material exploration stage was carried out in Rajagaluh Lor Village, Rajagaluh District, Majalengka Regency. For the process of stamping batik cloth with the Mangga Gedong Gincu batik motif as a typical Majalengka batik motif, the researcher collaborated at the HertyElit Batik Gallery. The material of the solution of Gedong Gincu Mango leaf extract was the dependent variable, while the fixator was in the form of lime solution, alum solution, and ferrous sulfate solution as independent variables.

<u>Working procedure</u>

The steps taken by the researcher in this study are: a) cotton fabric processing (soaking cotton fabric with TRO solution); b) processing of natural dyes from Gedong Gincu Mango leaves by mashing them using a blender; c) boiling of natural ingredients of Mango Gedang Gincu leaves into an extract solution; d) the process of dyeing batik cloth with a solution of mango leaf extract of gedong lipc as much as 3 times each dyeing process; e) the color fixation process with lime solution, alum solution, ferrous sulfate solution; and e) the wax removal process using hot water added to a solution of soda ash/Sodium Carbonate. The steps of the work procedure are visualized in Fig. 2.

Table 1. Mori fabric test results.

No.	**Tests**		
	Type	**Method**	**Results**
1	Fabric weight [g/m^2]	SNI ISO 3801:2010	111.70
2	Fabric thickness [mm]	SNI ISO 5084:2010	0.24
3	Fabric composition (%)	SNI 08-0265-89	Cotton 80.23% Rayon 19.77%
4	Construction: - Warp density [1/cm] - Weft density [1/cm] - Warp thread number [tex] - Weft thread number [tex] - Face Webbing	 SNI ISO 7211-2:2010 SNI ISO 7211-5:2010 SNI ISO 7211-1:2010	 42.52 30.91 14.37 13.75 Plain

Source: Test results at the Bandung Textile Center [46].

Table 2. Results of dyeing mango leaf color extract on batik fabric

No	Dyeing Process	Types of Fixatives		
		Lime Solution ($Ca(OH)_2$)	**Alum Solution** ($Al_2(SO_4)_3K_2SO_424H_2O$)	**Ferrous sulfate Solution** ($FeSO_4.7H_2O$)
1.	Dyeing on fabrics without batik motifs (plain fabrics)			
2.	Dyeing on fabric using batik motifs (patterned fabrics)			

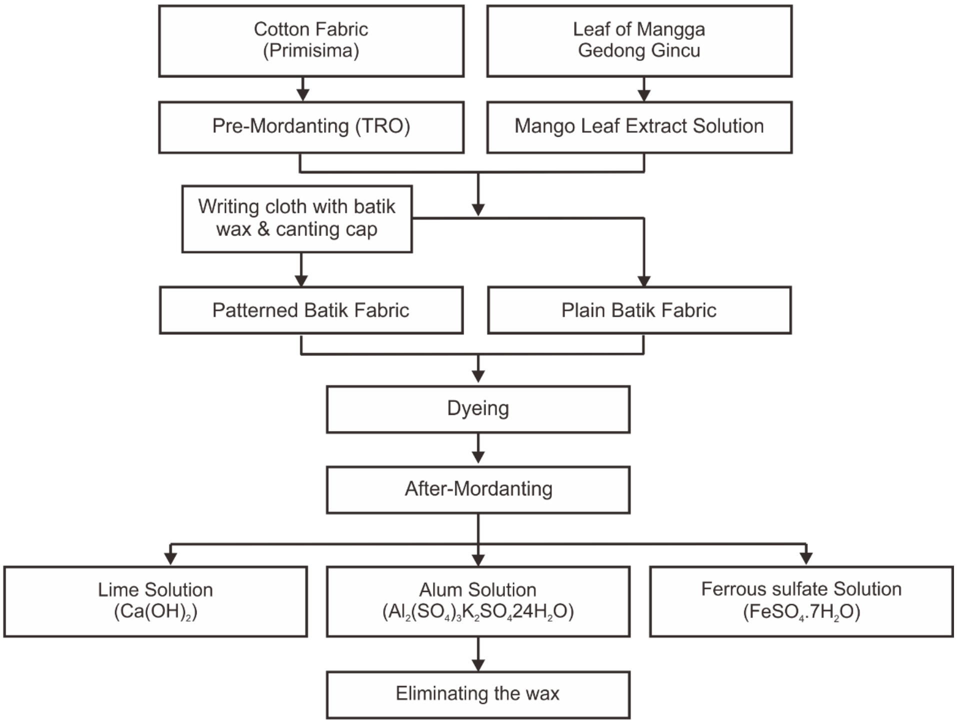

Figure 2. Experimental steps in research (adapted and developed from Sobandi et al., 2021) [40].

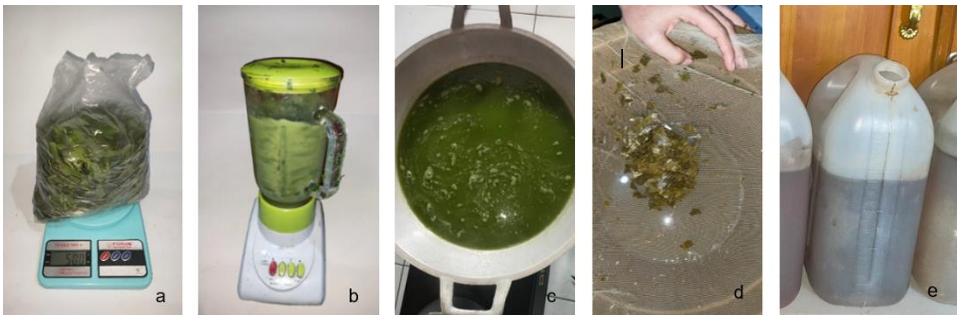

Figure 3. Mango leaf extract processing process.

Based on the experimental steps in the research presented in Fig. 2 above, it will be explained in detail as follows:

Preparation stage

In the preparation stage, there are two main steps consisting of fabric processing and natural dye processing: In the first step, the fabric to be used is first soaked with TRO solution (2 g/L) by soaking in cold techniques for 24 hours. After that, the Primisima batik cloth is rinsed with water and then dried. This stage aims to make the absorbency of the fabric to natural dyes more optimal. Furthermore, the curled batik fabric can be processed for stamping.

The second step is to make natural dyes from Gedong lip mango leaves. This natural color processing process is carried out through an extraction technique by boiling raw materials in a ratio of 1:10 (in this study using a ratio of mango leaf material of 0.5 kg to 5 liters of water).

Visually, Fig. 3 describes the stages of processing the natural color of mango leaves, with the following stages: a) preparing Gedong Gincu Mango leaves and weighing them as needed; b) smoothing the ingredients by cutting and blending so that the size becomes smaller; c) boiling the mango leaves until the amount of boiling water shrinks to half of the initial amount of water used; d) filtering the boiled liquid to separate the color extract from the rest of the pulp; d) storing the results of the extraction solution; this solution is ready to be used for the batik fabric dyeing process.

The process of writing fabric with canting stamp

The process of writing or applying batik motifs to batik fabric uses canting stamps. This process is carried out before the process of dyeing batik fabrics. In this study, the process of writing cloth was carried out on some batik fabrics (some other fabrics were not written with batik motifs, only plain fabric).

Dyeing process

The batik cloth that has been prepared in the previous process is then dipped in a solution of color extract from the leaves of Mango Gedong Gincu. The dyeing process is carried out gradually and repeatedly as needed, with the following stages: a) dip the batik cloth in a solution of mango leaf dye extract; b) lift the fabric from the dyeing solution, then drain the fabric until dry; c) the stages of the dyeing process are repeated again, like these stages. The dyeing process in this study was carried out three times with a predetermined dyeing time duration (about 30 minutes).

Fixation process

The fixation technique used in this study is final mordan fixation. This activity serves to determine the direction of the color and lock the color absorbed by the batik fabric so that it does not fade. In this study, the materials used were lime solution ($Ca(OH)_2$), alum solution ($Al_2(SO_4)_3K_2SO_424H_2O$), and ferrous sulfate solution ($FeSO_4.7H2O$) with a composition of 50 g/L of water each.

Wax removal process

The removal of the wax from the batik cloth is the final step of the batik process. The cloth that has been written or marked with batik wax using a canting stamp and dyed with natural dyes is boiled in boiling hot water on the stove at a temperature of 100 °C. The process of boiling batik fabric uses an auxiliary agent, sodium carbonate (Na_2CO_3) (5 g/L). This auxiliary substance serves to facilitate the removal of night candles from batik fabrics. After the process of ngloroding the batik cloth, clean the batik cloth with clean water and then dry it.

RESULTS AND DISCUSSION

Research results

The experimental process of dyeing batik fabrics has been carried out with two different treatments. The first process is carried out by dyeing on plain batik fabric, while the second process is carried out on batik fabric that already has batik motifs (see Table 2). Before the batik dyeing process in the second treatment, first the batik cloth that is still plain is written with a batik motif using a canting stamp with a Mangga Gedong Gincu motif (Fig. 4). The selection of canting caps with this motif aims to introduce and strengthen the identity of the typical batik motif that develops in Majalengka Regency, the district that produces the most Mangga Gedong Gincu.

The process of dyeing batik cloth using natural dyes made from Gedong Gincu Mango leaf extract. The results of dyeing plain fabrics and batik fabrics with the Mangga Gedong Gincu motif turned out to have different colors.

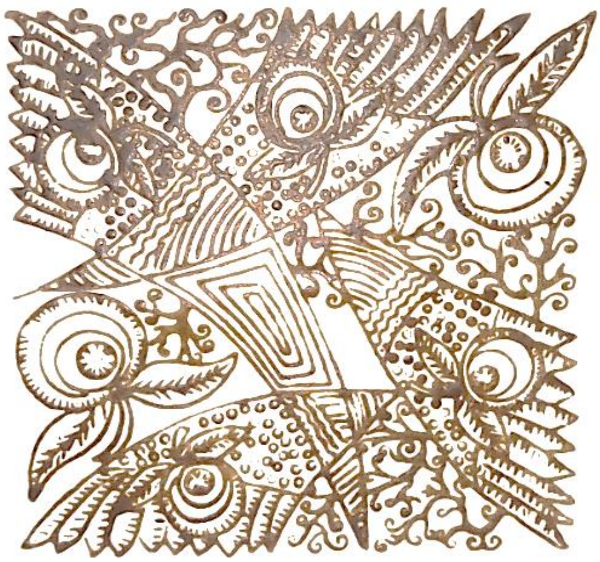

Figure 4. The result of the impression of the motif on the batik fabric using a canting stamp.

Table 2 above visualizes the comparison of the results of dyeing batik cloth with Gedong Gincu Mango leaf extract using different fixator materials, the dyeing results using lime solution fixators tend to be brown, the alum fixation produces a bright original color, and the ferrous sulfate fixator produces a color that tends to be blackish-green. Likewise, the results of dyeing colors on plain fabrics tend to have stronger color intensity than on batik fabrics that have been given batik motifs.

Based on the results of the color fastness to washing 40 °C and color fastness to rays: bright day, it is known that there are differences as presented in Table 3 below.

Table 3 displays the results of the test on the color fastness of Gedong Gincu Mango leaf extract on two types of fabrics, namely plain fabric and patterned fabric. This test was carried out on fabrics that were fixed with three different solutions, namely: lime solution ($Ca(OH)_2$), alum solution ($Al_2(SO_4)_3K_2SO_424H_2O$), and ferrous sulfate solution ($FeSO_4.7H_2O$). The test involved two main aspects: color fastness to washing at 40 °C and color fastness to bright light. The results of the color fastness test against washing at 40°C showed that plain fabrics generally showed a bad category (2–3) in fabrics that were fixated with lime solution and alum solution and a fairly good category (3). Meanwhile, the results of color fastness to washing at a temperature of 40 °C for patterned fabrics were found to be fabrics that were fixed with lime solution in the category of sufficient (3), fabrics that were fixed with alum solution in the category of good (3–4), and fabrics that were fixed with a solution of ferrous sulfate in the category of not good (2–3). Furthermore, the color staining value using fabric type medium (acetate, cotton, polyamide, polyester, acrylate, wool) showed that mango leaf extract provided a good category of color staining value (4–5), except for the cotton medium of patterned batik fabric dyed with lime solution and alum solution, which was better than plain fabric dyed with the same two solutions. Color-fading resistance to bright light during the day, light fastness values are known to have the same and different test results.

Table 3. Results of color testing of Gedong Gincu Mango leaf extraction on plain and patterned fabrics.

No.	Test Type	Test Results of Gedong Gincu Mango Leaf Extract						Test Method
		Plain Fabric			Patterned Fabric			
		Lime Solution ($Ca(OH)_2$)	**Alum Solution** ($Al_2(SO_4)_3K_2SO_424H_2O$)	**Ferrous sulfate Solution** ($FeSO_4.7H_2O$)	**Lime Solution** ($Ca(OH)_2$)	**Alum Solution** ($Al_2(SO_4)_3K_2SO_424H_2O$)	**Ferrous sulfate Solution** ($FeSO_4.7H_2O$)	
1.	Washing Resistance 40 ℃ Color Change Value Color Blemishes Value	2 - 3	2 – 3	3	3	3 – 4	2 - 3	SNI ISO 105-C06:2010 SNI ISO 105-A02:2010 SNI ISO 105-A03:2010
	- Acetate	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	
	- Cotton	4	3 – 4	3 – 4	4 – 5	4	3 – 4	
	- Polyamide	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	
	- Polyester	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	
	- Acrylate	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	
	- Wool	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	
2.	Color Resistance to Light: Day Light Ray - Resistant Value	3	4	3 – 4	3 – 4	3	3 – 4	SNI ISO 105 - B01:2010 SNI ISO 105 - A02:2010

Table 4. Comparison of the results of mango seed and mango leaf extraction dyeing on patterned fabrics.

No.	Test Type	Results of Natural Dyeing Test on Patterned Batik Fabric					Test Method
		Mango Seeds		Mango Leaf			
		Lime Solution ($Ca(OH)_2$)	**Ferrous sulfate Solution** ($FeSO_47H_2O$)	**Alum Solution** ($Al_2(SO_4)_3K_2SO_424H_2O$)	**Lime Solution** ($Ca(OH)_2$)	**Ferrous sulfate Solution** ($FeSO_47H_2O$)	
1.	Washing Resistance 40 ℃ Color Change Value Color Blemishes Value	4	4	3 – 4	3	2 - 3	SNI ISO 105-C06:2010 SNI ISO 105-A02:2010 SNI ISO 105-A03:2010
	- Acetate	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	
	- Cotton	4	3 – 4	4	4 – 5	3 – 4	
	- Polyamide	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	
	- Polyester	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	
	- Acrylate	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	
	- Wool	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	
2.	Color Resistance to Light: Day Light Ray - Resistant Value	3	3	3	3 – 4	3 – 4	SNI ISO 105-B01:2010 SNI ISO 105-B02:2010

Description: 1 = bad, 1-2 = bad, 2 = poor, 2-3 = not good, 3 = enough, good enough, 4 = good, 4-5 = good, 5 = very good

Patterned batik fabrics dyed with lime solution are known to be quite good (3–4) compared to plain fabrics; patterned batik fabrics dyed with alum are quite categorized (3) lower than plain fabrics (4); and there is a fairly good category similarity between fabrics dyed with ferrous sulfate solution on plain fabrics and patterned batik fabrics (3–4).

To see the contribution and significance of the research in this manuscript, it will be compared between the previous research (dyeing with mango seeds) and the results of the current mango leaf dyeing in terms of washing fastness and light fastness tests on patterned batik fabrics. The comparative data is presented in Table 4.

Table 4 above compares the results of color fastness testing on patterned fabrics dyed using extracts from mango seeds (previous research, which did not use alum solution fixators) [46] and Gedong Gincu Mango leaves. Testing was carried out using three types of solutions: lime solution ($Ca(OH)_2$), alum solution ($Al_2(SO_4)_3K_2SO_424H_2O$), and ferrous sulfate solution ($FeSO_4.7H_2O$). The test involved two main aspects: color fastness to washing at 40 °C and color fastness to bright light. The results of the color fastness test to washing at 40 °C in the color change value section showed that mango seed extract on patterned fabric had a color change value in category 4 with lime and ferrous sulfate solution fixators, compared to mango leaf extract, which only reached a value of 3 with lime solution fixator and a value of 2–3 with ferrous sulfate solution fixator. This shows that mango seed extract provides better color fastness for washing compared to mango leaf extract. Meanwhile, it was confirmed that the color staining value for all types of fabric mediums (acetate, cotton, polyamide, polyester, acrylate, and wool) was similar to the good category (4–5); even in the cotton medium, mango leaf extract with the lime solution fixator was better than mango seed extract.

Furthermore, from the results of the color fastness test to bright light during the day, the light fastness value was known: mango seed extract showed a fairly good light fastness value, namely 3 at the lime and ferrous sulfate.

Discussion

In general, the stages of dyeing batik cloth with natural dyes of Gedong Gincu Mango leaf extract are carried out in stages starting from: processing cotton fabrics, processing natural dyes from Gedong Gincu Mango leaves, making natural color extracts of Gedang Gincu Mango leaves, dyeing batik cloth with a solution of Gedong Gincu Mango leaf extract as many as 3 times each of the dyeing process, the color fixation process, and the wax removal process from the batik fabric (see Fig. 2). To produce natural color extracts from mango leaves, it is carried out through stages: preparing Gedong Gincu Mango leaf ingredients and weighing, smoothing the ingredients, making mango leaf extract, filtering the boiled liquid to separate the color extract from the rest of the pulp, and storing the results of the extraction solution (see Fig. 3).

Efforts to use and develop natural dyes derived from Gedong Gincu Mango leaves are considered appropriate to apply the 3R (Reduce, Reuse, Recycle) principle. Reduce means reducing the production of mango leaf waste that is widely produced by mango plants; reuse is meant to reuse mango leaf materials after their initial use; and recycle is intended as the process of converting waste materials into natural dyes to help reduce the use of natural resources and reduce negative impacts on the environment. This principle, in addition to aiming to reduce the amount of waste produced, also aims to reuse recyclable waste. In addition, mango leaves contain a lot of chlorophyll, which can produce color pigments for textiles that give them greenish-yellowish pigments with wavelengths of 540 nm and 640 nm [41].

The results of dyeing batik fabrics with different fixators and batik technique treatments have produced different color intensities. The data in Table 2 above informs us that the results of dyeing fabrics using a lime solution fixator ($Ca(OH)_2$) tend to produce colors that tend to lead to brownishness, the results of dyeing mango leaf natural dyes using an alum solution fixator ($Al_2(SO_4)_3K_2SO_424H_2O$) produce a more natural color that tends to be lighter in color, and the results of dye dyeing using a ferrous sulfate solution fixator ($FeSO_4.7H_2O$) tend to produce a darker fabric color, namely blackish-green color. The same thing was also found in the results of dyeing experiments using Gedong lip mango leaf extract on plain batik fabrics and motif fabrics that went through the process of batting with canting stamps. The color intensity of the dyeing results on plain fabrics (without batik motifs) appeared to be stronger than the dyeing results on patterned batik fabrics that underwent the nglorod process (the release of wax from the batik fabric), but the color intensity decreased. This condition is possible because it is boiled in hot water with the addition of soda ash / sodium carbonate (Na_2CO_3).

There was a color difference between the results of dyeing mango leaf extract on plain and patterned batik fabrics that were fixated with lime solution, alum solution, and ferrous sulfate solution. Through the color fastness test to washing at 40°C, the color change value showed that the results of dyeing mango leaf extract on patterned batik fabric fixed with lime and alum solution were better than plain fabrics. Different conditions were found in fabrics fixed with ferrous sulfate solution; the level of color fading resistance to washing at 40 °C was higher in plain fabrics than in patterned batik fabrics. Meanwhile, the color fastness test was conducted against bright light during the day, and the light fastness value is known to have various results. Patterned batik fabrics dyed with lime solution are known to be quite good compared to plain fabrics; patterned batik fabrics dyed with alum solution are in the sufficient category, lower than plain fabrics. The results of the fastness test to bright light in the day related to the light fastness value are known to have quite good category similarities between fabrics dyed with ferrous sulfate solution on plain fabrics and patterned batik fabrics (See Table 3). The findings from the results of this study need to be further studied.

The findings of the above study are in line with the results of previous studies, which stated that the potential of mangiferin yellow dye from mango leaves with the post-mordanting technique was confirmed as the best mordanting technique with the development of beautiful yellow to brown color gradation varieties with excellent fastness properties [42]. The dye extract material of Nigerian mango leaves (MLs) obtained from microwave extraction techniques (obtained through microwave-assisted and aqueous extraction techniques) confirms that mango leaf extract can be used to dye silk fabrics with various shades of yellow to brown as an abundant dyeing material, does not contain toxic materials, and can be sustainably used to dye silk fabrics on an industrial scale [43].

In general, the plant parts used as natural dyes for batik consist of tubers, roots, stems, leaves, and fruit peels [44]. The advantages of natural dyes include being cheaper, environmentally friendly, and producing distinctive colors [45]. Efforts to use natural colors for the dyeing process of batik fabric are an action that is not only healthy but also has added value in terms of economy, empowerment, and intergenerational inheritance efforts [46].

Mango is a fruit plant that grows widely and can be consumed. The quantity and quality of production are of utmost importance to meet the needs of the population [47]. The popularity of mangoes continues to increase due to their high nutritional and pharmaceutical value. Mangoes are unique because every part of the fruit, starting from the fruit, pulp, peel, seeds, leaves, and peel, can be used [48]. Dyes extracted from mango leaves produce more colorful ingredients than dyes derived from mango fruit extracts [49].

Based on the data in Table 4 above in the form of laboratory test results related to testing, namely color fastness to washing at a temperature of 40°C and color fastness to bright light in patterned batik fabrics (which have undergone the process of canting cap, color dyeing, and nglorod process), it is confirmed that the comparison is confirmed that mango seed extract provides better color fastness with lime and ferrous sulfate solution fixators with The value of 4 was compared to mango leaf extract using lime solution (value 3) and ferrous sulfate solution (values 2–3). The results of the color staining value test for all types of medium, such as acetate, cotton, polyamide, polyester, acrylate, and wool on batik fabric that uses mango seed extract and mango leaves in general, provide color staining values that have similarities, namely the good category (4–5). Meanwhile, the results of the color fastness test to bright light during the day confirmed the comparison that the quality of mango leaf extract resistance was better (value 3-4) than mango seed extract (value 3). The findings recommend that the two extract ingredients, namely mango seeds and mango leaves, with their advantages and disadvantages, can be used as dyeing materials for batik fabrics. The availability of mango leaf waste is more abundant because it is available throughout the year compared to the availability of mango seeds, which rely on by-products from mango fruit products. Thus, the author argues that mango leaf extract materials have more potential to be used and further developed in the dyeing process of batik fabrics in Indonesia.

The benefits of mango leaves are not only as an environmentally friendly natural dye for batik fabrics, but mango leaf extraction materials as a by-product of mango with the content of powerful antioxidant phenolic compounds such as mangiferin, flavonols, benzophenones, and gallotannis are highly appreciated in food, cosmetic, and pharmaceutical applications [50]. In addition, based on thermodynamic studies, it can be used as a green synthesis of silver nanoparticles carried out with mango leaf extract as a reducer, showing that the endothermic spontaneous reaction is an adsorbent suitable for development for textile wastewater treatment, with SDZA performing better than SZA [51].

CONCLUSION

Natural materials such as mango leaf waste in the surrounding nature can be used as a source of natural dye for dyeing batik fabrics. In addition to utilizing the diversity of natural potential flora, the use of Gedong Gincu Mango leaves as a source of natural dyes is also useful to foster awareness of life preservation and add economic value to the development of the green industry in the field of batik in a sustainable manner. The process of selecting natural color extraction materials and proper fixation can produce good colors that are environmentally friendly. The results of the experiment of dyeing Gedong Gincu Mango leaf extract on plain batik fabric are known to produce stronger color intensity than in patterned fabrics that undergo a wax removal process from batik fabrics. The findings of color reduction through the process of removing wax from batik fabric need further research. The research recommends the need to use natural dyes, such as those from Gedong Gincu mango leaves, through the extraction process in an effort to preserve the value of local wisdom and provide added value to batik craftsmen.

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