Natural batik dyes from *Terminalia bellirica*, *Ceriop condoleanea*, *Cudrania javanensis* and *Pelthopherum pterocarpum*

Sarwono¹, Darwoto¹ and S Mataram²

¹ Textile Craft Study Program, Faculty of Fine Art and Design, Universitas Sebelas Maret, Surakarta, Indonesia
² Visual Communication Design Study Program, Faculty of Fine Art and Design, Universitas Sebelas Maret, Surakarta, Indonesia

Corresponding author: Sarwono59@staff.uns.ac.id

Abstract. This study aims to apply *Terminalia bellirica*, *Ceriop condoleanea*, *Cudrania javanensis*, and *Pelthopherum pterocarpum* as textile dyes to cotton and silk fabrics. The experimental method was carried out to utilize the waste of *Terminalia bellirica*, *Ceriop condoleanea*, *Cudrania javanensis*, and *Pelthopherum pterocarpum* as natural dyes using alum, lime, and ferrous sulphate fixations. The fixation values of alum, lime, and ferrous sulphate using natural dyes were at level 3 (good) on cotton and level 4 (very good) on silk.

1. Background

The use of natural dyes is preferred because it can reduce waste in the surrounding environment. Natural dyes are environmentally friendly, so they can be used repeatedly in the dyeing process of textile products [1]. Natural colors are found in plant parts such as leaves, stems, bark, flowers, fruits, roots, sap, seeds, and so on. Each part of the plant has different types of coloring matter and content levels. In using natural dyes, color locking process needs to be carried out to maintain the color and obtain a variety of desired colors. This can be done using several fixators and varying the intensity of the solution. The color variations produce a colorful display that is not monotonous. Natural dyes have beautiful color effects and characteristics that are difficult to imitate by synthetic dyes. This is the main attraction of the naturally dyed textile products. Natural dyes have artistic value and their own market segments [2]. Plants that can be used as natural dyes are rarely known in the community. This is because many of these plants have no direct social and economic values. Some examples of plants that are commonly used as natural dyes are *Putri mahu* (*Mimosa Pudica L.*), shallot (*Allium Ascanicum L.*), *Stachytarpha Jamaicensis L.*, *Jolawe* fruit (*Terminalia bellirica*), and tree barks of tingi (*Ceriop condoleanea*), *jambal* (*Cudrania javanensis*), and *tegeran* (*Pelthopherum pterocarpum*). Beside functioning as medicinal plants, these plants can also produce natural dyes [3,4]. Every region in Indonesia recognizes *jolawe* (*Terminalia bellirica*), *tingi* (*Ceriop condoleanea*), *jambal* (*Cudrania javanensis*), and *tegeran* (*Pelthopherum pterocarpum*) plants with various local names. [5]

There are four basic aspects that need to be considered in the dyeing process using natural dyes, namely: the mordanting process, the extraction process with water solvents, the fixation process (dyeing the fabric into the solution and repairing the dye on the fabric fiber), and the washing process [6].
Natural dyes are commonly obtained by extracting or boiling the plants that are widely available in the environment around the community. Sources of natural dyes are wood, bark, twigs, leaves, roots, fruit, and seeds or sap. In addition, there are also natural dyes obtained from animals in the form of waste sap (Lac dye). The part of the plant that is the source of natural dyes is not the same for each plant. This depends on various factors such as the type of plant, where it grows, soil fertility, climate, age and time of harvest, and the preparation method or process of making the dyes. Some natural dyes will fade without pretreatment (mordanting) with certain chemicals as the medium. Before the mordanting process is carried out, it is necessary to weigh the fabric in dry conditions to adjust it to the weight of the metal elements used. The mordanting process is a process to expose metal elements (alum, ferrous sulphate or others) into fabric fibers to trigger reactions with various types of natural dyes [7]. Natural dyes from plants, trees or roots are generally obtained through extraction process (both at high and low temperatures) of the plant parts that are used as the dye source (flowers, leaves, seeds, tree bark, roots, grasses, weeds, grapes, and fungi) using water solvent [8]. Dyeing is the process of imparting color evenly to textile materials. The dyeing process is principally a process of combining fiber and dye. Natural dyes are used by craftsmen in some remote areas because it is difficult to obtain commercial synthetic dyes. Therefore, they get their dyes from plants found in gardens, forests, and along roadsides. Although only using simple materials, the craftsmen are able to find the unique characteristics of the natural dyes that they use [9]. Fabrics that have been dyed with natural dyes should not be washed immediately, because the existing colors still need to be strengthened through the oxidation process so that they do not fade. This refinement process is called fixation. Washing is carried out after the fixation process to remove the dye adhering to the fiber surface and even out imperfect fiber absorption [10]. The amino acid bond in the dye is called allin which can turn into allicen [5].

Although natural dyes from Terminalia belirica and barks of Ceriop condolleana, Cudrania javanensis, and Pelthopherum pterocarpum are still rarely used in textile products, the colors they produce are interesting to develop. The purpose of this study was to utilize Terminalia belirica and barks of Ceriop condolleana, Cudrania javanensis, and Pelthopherum pterocarpum as natural dyes for silk and cotton fabrics with alum, lime, and ferrous sulphate fixation.

2. Methods
This research study was directed at the original conditions in which the research subjects were located. Thus, there was no single phenomenon that can be understood outside of time and the context that supports and shapes it [11]. This research was a single case study with comprehensive action research. Various factors that were seen as interrelated and interacting were investigated. However, factors other than the main problems were not the focus and were not widely discussed [12]. The sources of data used in this study are the work of experimental results as data for direct observation and experimental results from actors, events, archives, and documents. These various data sources require certain data collection methods. In this study, the data collection strategies used were grouped into two ways, namely interactive and non-interactive methods [13]. Direct observation is also known as participatory observation, where the researcher plays various roles in various situations or even directs the events being studied with the aim of interacting with informants. This qualitative research used a "purposive sampling" technique, and the validity of the data was tested using "data triangulation" method, according to Sutopo [14]. The analysis process was carried out in a sequential manner using the staining scale and gray scale.

3. Discussion
The followings are the process of utilizing Terminalia belirica, and the barks of Ceriop condolleana, Cudrania javanensis, and Pelthopherum pterocarpum as textile dyes using alum, lime and ferrous sulphate as fixation materials:
3.1. Preparation stage

The preparation stage in using natural coloring consists of the mordanting process, coloring/extraction process, and fixation process. Each stage is interrelated and important for the next process.

The purpose of the mordanting process is to increase the absorption level of the fabric to natural dyes. The equipment used in the mordanting process are a scale, aluminum pan, stirrer, stove, bucket, rope for drying cloth, thermometer, litmus paper (used to test the acidity/alkalinity of water). The extraction process is the process of obtaining natural dyes. The tools used for the extraction process are: aluminum pan, stove, clock/stopwatch, measuring cup, stirrer, and filter. The fixation process is the process of perfecting the dyeing of natural dyes using alum, lime, and ferrous sulphate to obtain a color that does not fade easily.

3.2. Application process

3.2.1. Mordanting process using hot water. The followings are the steps taken in the mordanting process using hot water. First, the standardization of the mordant process for silk fabrics is carried out with the formula of "500 grams of cloth, 100 grams of alum, and 17 liters of water". Second, the cloth material that had been soaked overnight is put into the boiling alum solution in a wet state. Third, the cloth material is boiled for 1 hour at a temperature of 60 degrees Celsius. All parts of the fabric must be completely submerged. Fourth, after 1 hour, the cloth is left to soak overnight. Fifth, the soaked cloth is then rinsed clean and air dried. Sixth, fabrics can then be processed to the next stage.

3.2.2. Extraction stage. The followings are the steps taken in making natural dyes from Terminalia Bellirica, and the tree barks of Ceriop condolleana, Cudrania javanensis, and Pelthopherum pterocarpum. First, boil 500 grams of Terminalia bellirica fruit, and the tree barks of Ceriop condolleana, Cudrania javanensis, and Pelthopherum pterocarpum in 5 liters of water for 1 hour. Second, strain to separate the pulp of Terminalia bellirica, and the tree barks of Ceriop condolleana, Cudrania javanensis, and Pelthopherum pterocarpum from the dye solution. Third, putting the cloth that had gone through the dyeing process into the dye solution for about 15 minutes. Fourth, drain and dyeing again according to the desired color intensity. Fifth, after the dyeing process is complete, it was continued with the fixation process.

3.2.3. Fixation stage. The followings are the steps taken in making fixation solutions. First, weigh the alum metal salt at a rate of 70 grams / liter, lime 50 grams / liter, ferrous sulfate 20 grams / liter, then dissolve it in water (for alum can be heated to quickly dissolve). Second, put in the dry cloth into the desired metal salt/fixation for about 5 minutes. Third, then drain and wash the cloth with clean water. Fourth, dry the cloth in a shady place.

3.2.4. Mordanting process with cold water. The followings are the steps taken in mordanting process using cold water. First, dissolve 100 grams of alum with 2 liters of fresh water and heat to boil. After boiling, remove the solution from the stove and add 3 ml of TRO and 8 liters of fresh water. Soak 250 grams of batik cloth for 15 minutes, and drain for immersion extract. Second, soak 1000 grams of dried shallot peel with 10 liters of fresh water until it boils or becomes half of the previous water content. Cool and separate the dye from the extraction solution by filtering. The solution is ready to use. Third, put the cloth into the extraction solution, stir it over until smooth and soak it for 15 minutes. Then, dry in a shady place by spreading the cloth on a clothesline until it is dry or semi-dry. Repeat dyeing and drying until getting the desired color.

3.2.5. Fixation process. The followings are the steps taken in fixation stage using cold water. First, prepare 70 grams of alum and dissolve it in 500 ml of hot water, then add 500 ml of cold water. Keep the solution for 24 hours and take the clear part of the solution. Prepare 50 grams of lime and dissolve it with 500 ml of hot water, then add 500 ml of cold water. Store for 24 hours, then take the clear solution.
Add 20 grams of ferrous sulfate and dissolve it into 500 ml of hot water and add 500 ml of cold water. Store the solution for 24 hours and take the clear part of the solution. The solution can be used directly to give color to fabrics that use natural dyes. In the next process, put the cloth in a solution of alum, lime, or ferrous sulphate for ± 3 minutes. Take a cloth from the solution of alum, lime, or ferrous sulfate, and rinse with fresh water until clean then drain. Next, boil 10 liters of water, then add 100 grams of starch, and mix well. Then remove wax from the batik cloth. After that, remove the cloth and put it in cold water, then rinse and dry in a shady place.

4. Conclusion
From the explanation regarding the use of natural dyes from the fruit of *Terminalia bellirica*, and the barks of *Ceriop condolleana*, *Cudrania javanensis*, and *Pelthopherum pterocarpum* above, the following conclusions can be drawn:

4.1. Alum fixation
The yield values of the use of natural dyes from *Terminalia bellirica*, and the barks of *Ceriop condolleana*, *Cudrania javanensis*, and *Pelthopherum pterocarpum* on silk fabrics using alum fixation are:

4.1.1. Fastness test. Based on the fastness test, the change in color value on silk fabrics using natural dyes from *Terminalia bellirica*, and the barks of *Ceriop condolleana*, *Cudrania javanensis*, and *Pelthopherum pterocarpum* with alum fixation is very good. Changes in color values on cotton fabrics using natural dyes from *Terminalia bellirica*, and the barks of *Ceriop condolleana*, *Cudrania javanensis*, and *Pelthopherum pterocarpum* with alum fixation are 3–4 (good).

4.1.2. Color staining. Color staining on silk fabrics using natural dyes from *Terminalia bellirica*, and the barks of *Ceriop condolleana*, *Cudrania javanensis*, and *Pelthopherum pterocarpum* with alum fixation is very good in the fastness test. The value of color staining on cotton fabrics using natural dyes from *Terminalia bellirica*, and the barks of *Ceriop condolleana*, *Cudrania javanensis*, and *Pelthopherum pterocarpum* with alum fixation is 3 (good).

4.2. Ferrous sulphate fixation
The assessment result of silk fabric dyeing using natural coloring from *Terminalia bellirica*, and the barks of *Ceriop condolleana*, *Cudrania javanensis*, and *Pelthopherum pterocarpum* with ferrous sulphate fixation are: the changes in color values of cotton fabrics using natural colors from *Terminalia bellirica*, and the barks of *Ceriop condolleana*, *Cudrania javanensis*, and *Pelthopherum pterocarpum* with ferrous sulphate fixation are very good in the fastness test. The changes in the color value of silk fabrics using natural dyes from *Terminalia bellirica*, and the barks of *Ceriop condolleana*, *Cudrania javanensis*, and *Pelthopherum pterocarpum* with fixation of ferrous sulphate are 3–4 (good).

Thus, the changes in cotton fabrics dyeing using natural dyes from *Terminalia bellirica*, and the barks of *Ceriop condolleana*, *Cudrania javanensis*, and *Pelthopherum pterocarpum* with fixation of ferrous sulphate are quite good.

References
[1] Prawirohartonono S and Sasas K 1999 Seminar Dekranas, Bangkitnya warna-warna alam Yogyakarta
[2] Sarwono 2019 Biodiversitas journal of Biological Diversity 20 2475–9
[3] Lestari K 1999 Seminar Dekranas Bangkitnya warna-warna alam Yogyakarta
[4] Lestari W F K 2005 Teknologi Pewarnaan Alam untuk Komoditas Tekstil, Kriya Tekstil dan Benang (Yogyakarta: BPKB Departemen Perindustrian Republik Indonesia)
[5] Wibowo S 1992 Budidaya Bawang: Bawang Putih, BawangMerah, Bawang Bombay (Jakarta: Penebar Swadaya)
[6] Saunders K J 1997 *Contemporary Tie and Dye Textiles of Indonesia* (USA: Oxford University Press)
[7] Suprapto H 2005 *Pengetahuan Mordanting* (Yogyakarta: Batik Natural “BIXA”)
[8] Phillys G T 1978 *Understanding Textiles* (USA: Collier Macmillan Canada)
[9] Adrosko R J 1971 *Natural Dyes & Home Dyeing* (New York: Dover Publications, Inc)
[10] Hasanudin M, Widjiyati, Sumardi, Mudjini, Setioleksono H and Pamungkas W 2001 *Penelitian Penerapan Zat Warna Alam dan Kombinasinya pada Produk Batik dan Tekstil Kerajinan* (Yogyakarta: Balai Besar Penelitian Dan Pengembangan Industri Kerajinan Dan Batik)
[11] Lincoln Y S and Guba E G 1985 *Naturalistic Inquiry* (Baverly Hill: Sage Publications)
[12] Yin R K 1987 *Case Study Research* (Baverly Hills: Sage Publication)
[13] Goetz J and Allen J 1984 *Qualitative Research for Education* (Athens: University of Georgia)
[14] Sutopo H B 2002 *Metodologi Penelitian Kualitatif (Dasar Teori dan Terapannya dalam Penelitian)* (Surakarta: Sebelas Maret University Press) pp 25–30