THE DEVELOPMENT AND ANALYSIS OF ECO-PRINT AND SCREEN PRINTING COMBINATION USING NATURAL DYES

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ABSTRACT

Natural dye is one of the solutions to alleviate environmental damage caused by the textile industry. Existing synthetic dyes have been proven to adversely affect the environment and human. Hence, revisiting natural dyes becomes a correct decision to alleviate existing environmental problems. Eco-print is one of the natural dyeing methods done by using plants typically found in the surroundings. This method has become the subject of various developments, both in its mordanting and making processes. Its visual aesthetics should also receive attention to avoid stagnation. Further development and innovation are necessary. The purpose of this study was to develop the visual aesthetic aspect of the eco-print method. It particularly focused on developing the design and production technique in terms of concepts, materials, and working techniques. This work also adopted a screen printing technique to enrich the motifs and colors. The method utilized in this research was art-based research with the premise of adapting artistic creativity to social research using an artistic practice approach because both are holistic and dynamic. The result showed that eco-print and screen printing methods could be combined, as the latter significantly enhance the eco-print product's visual aesthetics. However, the result of this combination exhibited poor color fastness, implying the need for further study.

KEYWORDS

Eco-print; Screen printing; Natural dye.

INTRODUCTION

The majority of industries utilize synthetic textile dyes [1], and almost 800,000 tons of dyes are used each year globally. There are more than 10,000 dyes used in the textile industry, of which 70% are synthetic [2]. Before synthetic dyes were first introduced in 1858, natural dyes were the primary component in textile dyeing. The introduction of synthetic dyes has substantially reduced the usage of natural dyes [3] because synthetic colors are brighter, cheaper, and allow mass production [4]. Despite these benefits, however, synthetic dyes are detrimental to human health, cause substantial environmental pollution [5, 6], and damage ecosystems [7]. Synthetic dyes generate industrial waste, the largest contributor to water pollution. [8]. For this reason, many countries worldwide have outlawed the use of synthetic colors such as the poisonous benzidine [9].

The use of natural dyes is one of the measures to lessen the environmental impact of industrial pollution. Natural dyeing process is a coloring technique that utilizes natural materials [10]. It is safe for the environment and provides soft, delicate hues, hence regaining popularity in recent years [11, 12].

Natural dyes can be made from many different materials, such as animals, insects, bacteria, fungi, minerals, and different parts of plants, such as roots, bark, leaves, flowers, and fruits [13]. Natural dyes could be used in various methods, one of which is the eco-print method [14]. Eco-print is a technique to transfer leaf and flower motifs to fabrics [15, 16]. Eco-print application produces environmentally friendly wastes, as the textiles and dyes used are made from natural materials [17].

Eco-print was reintroduced by India Flint in 2006 and since then has expanded rapidly worldwide, including in Indonesia. Since 2016, eco-print centers in Indonesia have expanded, notably in Jakarta, Bandung, Yogyakarta, Kudus, Surakarta, and Surabaya, with technological improvements and breakthroughs in the natural dyeing process from diverse plants and the mordanting process on fabrics as fashion materials. However, if the visual aesthetics and techniques of eco-print fail to keep up with the development, it will eventually become extinct due to stagnation. Therefore, ongoing development and innovation are necessary. This study focuses on the creation of design and production procedures, both in terms of concepts, materials as a medium of work,

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and processing techniques, as well as the use of screen printing techniques to enrich the color and patterns.

METHOD

The method utilized in this research was an art-based research [18]. It adopted art creativity in social study using artistic practice approach, as both are holistic and dynamic. This research included reflection, description, problem formulation, and problem resolution, identification and explanation of intuition and creativity made during the research process. The artistic process employed a three-step experimental framework: the discovery stage, the design stage, and the embodiment stage. The eco-print method was combined with the screen printing method because these two methods had comparable printing technique. The screen printing technique could enrich the motifs of the finished works and accentuate the point of interest, preventing the work from looked flat. The work quality was evaluated using several parameters, including colorfastness to wash 40° C, sweat (acid), daylight, and ironing.

Materials

Primissima cotton fabric used in this study possessed the following material characteristics: material (warp 56/60 dtex, weft 50/56 dtex), density (warp 42/50 threads/cm, weft 42/50 threads/cm), and 100% pure primissima cotton. Weight 190 g/m^2.

The basic pre-mordant materials were alum, iron (tunjung), and chalk, (30 g/L of water each). Raw coloring materials: Terminalia bellerica, Ceriops candolleana, and mahogany (250 g/3L of water). Fixator: alum and chalk (30g/L). The screen printing materials (synthetic pigments): rubber, pigments (water-based) 0. 25 ml / 250 g of rubber, and binder (Polyurethane) 50 ml / 250 g of rubber.

The natural pigment used for eco-print was chlorophyll ($C_{55}H_{72}O_5N_4Mg$). The natural binders used were alum and chalk. The pigment used for the screen printing was a water-based synthetic dye usually used in printing ink. It was selected due to its easily-soluble nature, making it more environmentally friendly. The binder used was polyurethane. Equipment: scales, stainless steel pan, buckets, filters, motif-printed screen printing, and squeegee.

Procedure

Several stages were performed, including the pre-mordant stage, extraction stage, the eco-print stage, the fixation stage, and the screen printing stage.

Pre-mordant: Before the pre-mordant step, the fabric was washed using detergent and dried. It was done to remove the wax material from the fabric, allowing it to absorb color effectively. The pre-mordant stage began with dissolving alum, iron, and chalk in boiled water (the dosage information is presented in table 1). The fabric was soaked for 30 minutes in hot mordant water, then squeezed and sun-dried.

Extraction stage: this phase began by boiling 255 grams of natural dyes (i.e., Terminalia bellerica, Ceriops candolleana, and mahogany) in 3 liters of water until a 1/4 of the water shrinks and color was extracted. After 10 minutes of soaking in the natural dye solution, the mordanted fabric was filtered to remove any remaining natural dye particles. The wet fabric was squeezed, and sun-dried.

Eco-printing stage: eco-printing is the process of creating motifs on textiles using tannin-containing leaves and flowers. The eco-printing was done using the steam method. The first step in this stage was to soak the fabric in water, and the fabric was then half-dried. The fabric was put over the plastic, and after that, leaves and flowers were then arranged over the fabric. After that, the fabric was covered with a half-dampened fabric and plastic. The material was firmly rolled and tied with rope. The fabric was placed in a steamer with hot water and steamed for three hours. After that, the cloth was left to cool. The fabric was unrolled and hung up to dry in the air. This process creates flower and leaf motifs on the fabric.

Fixation stage: The fixation phase is a color-locking phase utilizing alum and chalk as the fixator. Each fixator was dissolved in hot water to initiate this step. The eco-print fabric was then soaked for two hours after being boiled. The fabric was then squeezed and sun-dried.

Screen printing stage: This was the final stage, which was done by combining eco-print and screen printing techniques using screen printing ink.

RESULT

Coloring result

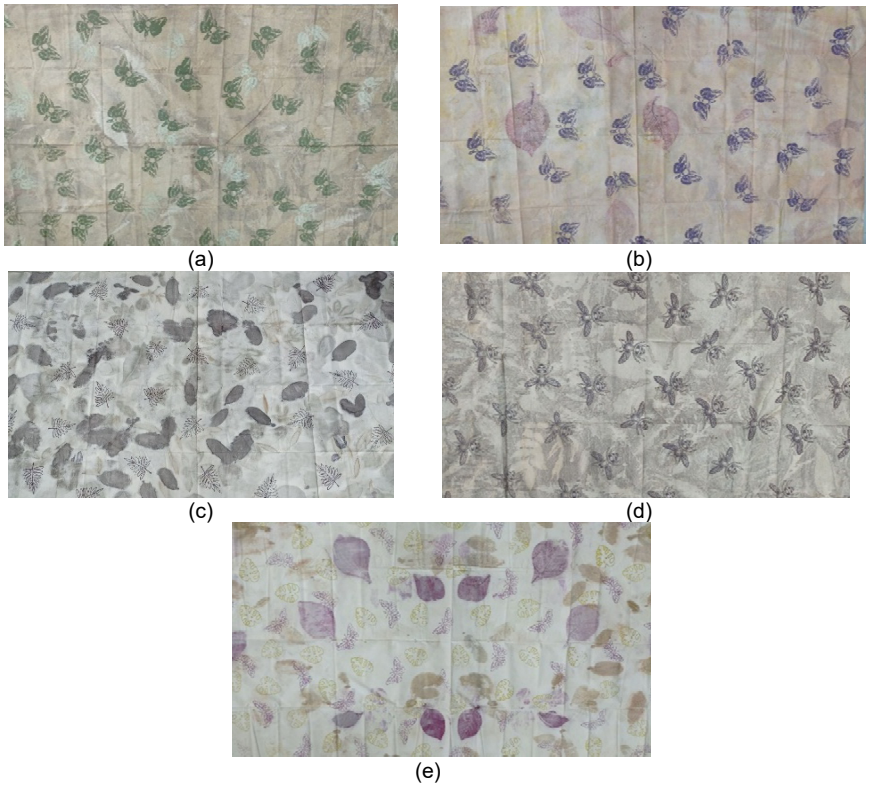
There were five eco-print and screen-printing combinations in this study (Fig. 1-5). Table 2 shows the comparison of dyeing results based on mordants, natural dyes, fixators and screen-printing motifs. Two combinations did not use the natural dyeing stage and only processed through the mordant, eco-print, fixation, and screen-printing stages. The other three combinations were dyed using natural dyes before the eco-print stage. Overall, the result was predominantly dark colors.

Table 1. Materials and dosage.

Mordant (30 g/L)	Natural Dye (85 g /L)	Fixator (30 g/L)	Screen Printing
Alum	*Terminalia bellerica*	alum	√
Chalk	*Ceriops candolleana*	alum	√
Chalk	-	alum	√
Iron	Mahogany	Chalk	√
Iron	-	Chalk	√

Table 2. Comparison of eco-print-screen printing combinations.

Pre-mordant	Natural Dye	Fixator	Coloring Result
Alum	*Terminalia bellerica*	Alum	
Chalk	*Ceriops candolleana*	Alum	
Chalk	-	Alum	
Iron	Mahogany	Halk	
Iron	-	Chalk	



(a) (b) (c) (d) (e)

Figure 1. Eco-print and screen printing combinations: (a) Alum - *Terminalia bellerica* - alum, (b) Chalk - *Ceriops candolleana* - alum, (c) Chalk - alum (no natural dye), (d) Iron – mahogany – chalk, (e) Iron - Chalk (no natural dye).

Table 3 Colorfastness test.

Score	Reading
5	Excellent
4-5	Good
4	Good
3-4	Good
3	Fairly good
2-3	Fair
2	Poor
1-2	Poor
1	Very poor

Based on the result of the eco-print, color selection and screen-printing motifs were adjusted to the eco-print motifs on the fabric. There were several forms of objects created, including butterflies, insects and leaves. The eco-print effect of each sample was intentionally made differently. The faint eco-print was used as the background to accentuate the screen-printing motifs. Meanwhile, the motif was made to accentuate the eco-print itself. The mordant-pre-mordant-fixator variations also significantly affect the eco-print result, which accounts for the highly diverse results in each sample.

Colorfastness test

Four colorfastness tests were conducted following Indonesian National Standard-abbreviated SNI (Standar Nasional Indonesia) to evaluate the product's colorfastness to 40°C wash, sweat (acid), daylight, and ironing. The test result was presented in 1-5 scale of discoloration score.

Colorfastness to 40 °C wash

Colorfastness to 40 °C wash was tested following the SNI ISO 105-C06:2010 test method. The lowest score was found in iron -chalk combination with a score of 1-2 (poor). Combinations with or without the natural dyes showed similar result. The combination with alum as fixator exhibited scores of 2-3 and 3 (fair), which was better than those using chalk as fixator. All in all, eco-print - screen-printing combination had a poor colorfastness to 40 °C wash.

Colorfastness to sweat (acid)

The colorfastness to sweat (acid) was tested following SNI ISO 105-B01:2010 test method. The result in Table 4 shows that colorfastness score was at 3-4 and 4 (good). The combination of alum - Terminalia bellerica-alum exhibited a score of 4 (good). Similarly, the combination of chalk-Ceriops candolleana-alum also exhibited a score of 4. These combinations exhibited a higher score than other three combinations. Therefore, it could be concluded that eco-print-screen printing combination have a good colorfastness to sweat (acid).

Colorfastness to daylight

The colorfastness to daylight was tested following SNI ISO 105-B01:2010 test method. All combinations showed good colorfastness (4 and 4-5). The scores lead to a conclusion that eco-print and screen-printing combination has a good colorfastness to daylight.

Colorfastness to ironing

Colorfastness to ironing was tested following SNI IS0 105-XII: 2010 test method. The scores showed the best result among the other colorfastness tests (4-5). In other words, the eco-print – screen printing combination product's colorfastness to ironing can be categorized as good.

Based on the results of the four tests, the colorfastness to 40°C wash exhibited the lowest score (1-3), while colorfastness to sweat (acid), light (daytime), and iron heat were in the good category.

DISCUSSION

In terms of visuals, the development of eco-print by adopting screen printing to enrich patterns and colors can be considered successful. Applying the screen printing technique to the eco-print method exhibited significant impacts, as the eco-print product looks more compelling and varied. Screen printing adds a point of interest and emphasis through the presented motifs, preventing the work from looking flat. However, the quality of this combination still cannot be categorized as good for a 40°C wash. Several factors were possibly responsible for poor colorfastness to 40°C wash, including short dyeing duration, too early fixation process, and insufficient dyeing processes.

First of all, the natural dyeing duration. The process of dyeing fabrics in natural dyes was done for only 10 minutes. This short time caused the dyes not to soak properly on the fabrics. Second, the dyeing was done only once, causing only a few amounts of natural dyes to be absorbed. Repeated dyeing of fabrics in natural dyes would produce rich and strong colors. Third, the eco-print result was fixed too early. In the process, the fabric was aerated for 8 hours after the eco-print steaming process until it was fixed. The fabric airing process was too fast. Hence the eco-print and natural dyes were not fully absorbed into the fabric.

Table 4 Colorfastness test resut

Process	Test Result			
	Colorfastness to 40°C wash	*Colorfastness to sweat (acid)*	*Colorfastness to daylight*	*Colorfastness to Ironing*
Iron - chalk (no natural dye)	1 - 2	3 - 4	4 - 5	4 - 5
Iron - mahogany- chalk	1 - 2	3 - 4	4 - 5	4 - 5
Chalk – alum (no natural dye)	3	3 - 4	4 - 5	4 - 5
Alum - *Terminalia bellerica* - alum	3	4	4 - 5	4 - 5
Chalk - *Ceriops candolleana* - alum	2 - 3	4	4	4 - 5

CONCLUSION

The combination of eco-print and screen printing done in this study was built on previous works on eco-print. This development was carried out to prevent eco-print from stagnant and as an initiative to use natural dyes to reduce the use of synthetic dyes—one of the causes of environmental pollution.

This study concluded that the screen printing technique plays a significant visual aesthetic role in eco-print. Screen-printing makes eco-print appear to have more patterns and be colorful. Moreover, screen-printing also becomes the point of interest when combined with eco-print, making the final work more compelling and not plain. However, the colorfastness of the eco-print and screen-printing combination cannot be categorized as completely good. The low score of colorfastness to wash may be accounted for by fading of natural dyes and screen-printing ink. Therefore, further research is required.

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