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Digitized Identification of Indigo Natural Dyeing on Batik and Non-Batik Fabrics

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Abstract: Natural coloring in textiles has regained favor as the sustainable fashion movement grows. Along with that, the need for digital repository of Indonesia's natural dyed textiles color data is necessary for the continuation of the regeneration of Indonesian natural dyed textiles' knowledge which will be useful for textile design creative process. Fabric color digitization can help with data repository of natural dyed textiles because digital data could endure longer than physical sample artifacts. This paper focuses on the problem of identifying the colors produced by indigo natural dyeing on cotton fabrics with batik and non-batik treatment to obtain the color discrete data in RGB values. The experimental method was applied on the different variable of the dyeing process, which is three, six, and nine times. The obtained RGB values will be used for the purpose of fabric color digitization. The RGB color data was obtained by analyzing each pixel from fabric samples' image which was captured and then dented into 64 pixels x 64 pixels. The result is a clustered group of color consists with 21 different shades of blue and 3 other light colors which were less relevant with indigo dyeing. Experimental results from this research could be applied as an inventory content for digital media.

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Keywords: indigo natural dye, batik and non-batik fabric, color identification, color digitization, RGB color value.

INTRODUCTION

Natural dyed textiles are regaining popularity, as is the eco-fashion trend, which prioritizes sustainable and environmentally friendly fashion design concepts, as well as the slow textile trend, which reintroduces traditional techniques and manual methods into the textile design process. Natural dyes are unique in both the color product and the color generating method. The uniqueness of these colors is obtained in accordance with the geographical and environmental conditions that produce natural dyes, as well as the traditional techniques of the local area's cloth dyeing process, so that the processing and color results vary from one area to the next (Hasanudin, 2001). Natural dyeing is also noted for having less stable color results. According to Suprapto (2014), while standardizing natural dyeing, various variables must be considered, including the length of dyeing, the concentration of the solution, temperature, the amount of dyeing, the material or materials to be dyed, and the dye composition itself. Because natural textile dyeing is unique, samples of natural dyeing results must be collected in order to collate the resulting differences for standardization reasons.

Unfortunately, as stated by Hasanudin (2001), the storage of original textile artifacts as a source of natural color information cannot be relied on since textile artifacts have an unavoidable obsolescence period, and the actual fabric can be degraded due to weather and moisture disruption. Because of Indonesia's unfavorable environmental conditions for fabric preservation, it is challenging to find archaeological remnants of old textiles there. The fact that an artifact's hue may eventually fade owing to the effects of time, cleanliness, weather, and sunshine raises additional concerns about the veracity of identifying data derived from artifacts (Milner, 1992). Digital visual data of textile items dyed naturally is therefore valuable. Fabric color data is one type of digital visual data that can be acquired and utilized in digital media.

In order to offer digital visual data of natural dyed textiles, textile samples must be digitized to acquire discrete data. The fabric samples must first be standardized before the digitization process can begin. This is because, when textiles are naturally dyed, various settings, circumstances, and dyeing techniques might produce finished products with varying standards.

The indigo plant, or Indigofera tinctoria, is the source of the natural dye utilized in this investigation because Indigofera tinctoria is massively produced in Indonesia, and batik maker often used Indigofera tinctoria as the source of indigo blue color (Arista, Azis, & Kurniawati, 2024). Many traditional Indonesian fabrics, like Classical Batik of Yogyakarta, Batik Lasem, Sumba Woven Fabric, Ulos Fabric, Lurik cloth, and others, are made with indigo dye. These days, natural indigo dyes are also frequently utilized in the production of modern textiles. It is commonly utilized because it is considered as one of of Indonesian natural dye which has a high success rate for coloring clothes than other natural dyes, such as those created from sappan wood and turmeric (Sarwono, Darwoto, & S P Adi, 2022). In order to access the color material of the indigo plant, it must first be removed by fermentation and used to dye clothes and other textile products.

In this research, an observation and interview with natural dyed batik maker from Batik Bixa, the belated Hendri Suprapto and his craftsmen team, was conducted to find out more about traditional indigo dyeing for batik. The experimental method was applied on different variable of the natural dyeing process methods, similar with the amount of traditional indigo dyeing process that is often practiced on Batik Bixa batik workshop. Indigo natural dyeing was applied with three, six- and nine-times dyeing variations. Quicklime (Calcium Oxide) was used as both the initial and final mordant in the fixation process. The fabric that was used to create samples is plain white Prima cotton fabric, both with and without the treatment of batik technique. By using modifications in the fabric sample-making process, researchers hope to be able to recognize color variances resulting from different sample-making procedures and categorize colors based on the category of techniques used.

The literature research findings reveal that color values expressed in RGB notation are the discrete data needed for digital media requirements. The RGB color index is better suited for digital applications since it allows colors to be displayed contextually, whereas the CMYK color index is better suited for ink-based printing (Suyoto, Dasuki, & Prasetya, 2012). The measuring of image pixel color values is the technique used to acquire discrete values of fabric samples. The fabric samples were photographed using a digital camera in an attempt to digitize the image, and after that, the image was compressed. Pixel color value measurement software programs can be used to measure each picture pixel's RGB color value after the image has been compressed. Additionally, the RGB notation results for the maximum, minimum, average, and median colors will be obtained. In order to identify and organize colors, the acquired color value data is required. The process of color identification in this research is similar with the one applied by Kim, Bae, & Lee (2007) and Cocco, Ceré, Xanthos, & Brandt (2018) who assign the most comparable color from a palette of colors they defined to each pixel in an image to certain color coordinate value, which in Kim, et al. (2007) and Cocco, et al. (2018) are using the Munsell color system.

The growing demands of society for information technology drive technological advancements. Historically, oral culture gave way to written culture, then to printing culture, and now to electronic culture (Lim, 2008). The decision to use digital media and information technology is made at both the individual and community levels. Communication exchanges that facilitate information exchange might bring in knowledge from outside the community, hastening the process of disseminating the intended message. Because of this shift in communication, new innovations are more likely to arise in response to the demands of changing social and technological contexts, which call for the replacement of antiquated practices with cutting-edge ones.

Hartley (2010) mentioned that because of their ability to spread information quickly and in large quantities, new media technologies facilitate the globalization process. The main feature of communication technology is digitization, which allows it to compress a huge amount of information into a small size and then restore it to its original size when the information data is required. The impact of information digitization is the transfer of information that can be done through many media with a clear program, both from traditional media such as printed newspapers and magazines to modern electronic media such as computers and digital mobile devices. Content inventory is one of the essential elements in designing a digital media user experience. According to Pannafino (2012), content inventory is the overall process of taking stock of information on a web site with content audit as a tool for storing information. The audit content command process can be done by accessing each web page according to the web site structure.

Digital color data from batik and non-batik fabrics using natural dyes, particularly indigo natural dyes, is the novelty idea presented in this study. The acquired digital color data can be used to suggest content inventory for digital media that wishes to provide details on the natural dyes used in Indonesian textiles. Natural dye data can be conserved, made widely available, and reintroduced as a suggestion for traditional Indonesian textile design approaches that are still pertinent to the demands of the design creation process or the textile business in the modern period, thanks to this digital color data.

METHODS

Materials

Indigo Natural Dye

Natural dyes according to Dean (2009) are divided into three types, namely substantive dyes, vat dyes, and adjective dyes. Substantive dyes are natural dyes that contain a lot of tannin substances, such as bark, leaves, or fruit from certain tree species. Vat dyes are dyes that require a fermentation process in the coloring process, such as indigo and tyrian dyes or imperial purple obtained from shellfish. While adjective dyes are a class of dyes that require mordant additives in the coloring. In general, most types of natural dyes are included in the adjective dyes group. Color penetration with textile fibres is mediated by the absorbency ability of the fibre that brings the dye closer to the fibre. However, each fibre has a different absorption capacity, which can cause different colors to appear because the color absorption capacity of each fibre is not the same (Hasanudin, 2001).

Indigo (*Indigofera tinctoria*) is a natural blue dye whose natural color is obtained from the indigo plant. Indigo plant can be found in several regions in Indonesia, such as Java, Sumatra, Sumba and Flores. These areas make indigo as signature dye for their traditional local fabrics, such as Ulos cloth in North Sumatra and various traditional woven fabrics typical of Baduy, Sumba, Flores, and others.

Figure 1. Indigo paste.

Indigo grows close to the ground, in the sense that indigo plant are not trees that grow tall. The indigo plant is approximately three metres tall. The plant has many branching twigs, opposite compound leaves, and purple compound flowers near the base of the beginning of the petiole. The indigo plant also produces pod-shaped fruits of six to eight seeds. The part of the plant used to produce the dye is the entire plant, but some only use the leaves. Indigo natural dye is extracted by fermentation.

Table 1. Taxonomy of Indigo Plants.

Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Fabales
Family	Fabaceae
Genus	*Indigofera* L.
Species	*Indigofera tinctoria* L.
Synonim	*Indigofera sumatrana* Gaertn. *Peltophorum inerme* (Roxb.) Naves & Villar

Source: Lemmens and Wulijarni-Soetjipto (1992), USDA (2014), and PROHATI (2014).

Quicklime Mordant

The term "mordant" comes from the French word, *mordre*, which means to bite. The definition of mordant is mentioned by Dean (2009) as a substance that has affinity to both the dyeing material and the dyed material, acting as a color binder in the dyed material and to fix the color in the material fibre. The use of mordant will also affect the final result of the dyeing color, so that if each material is given a different mordant, it will produce a different color. The functions of mordant are also expressed by Robertson (1973) who states that mordant chemicals are needed when dyeing with natural dyes for color binding in dyed materials. In addition to being a color binder, mordants are also useful for strengthening the color of the dyeing results and for providing color variation when using different types of mordants.

Quicklime is the result of burning raw limestone at a temperature of ± 90°C with most of the composition in the form of Calcium Carbonate ($CaCO_3$). Quicklime, also known as burnt lime, has the chemical formula CaO (Calcium Oxide). Quicklime is alkaline, so its use in dyeing with natural dyes is to increase pH levels and alkalinity. In the natural coloring process, quicklime is also used as an additive in the fermentation process of indigo plants to bind indigotin so that the decaying material becomes indigo paste.

Figure 2. Quicklime.

Quicklime will produce heat when splashed with water, then turn into Calcium Hydroxide (CaOH). When the quicklime is hot, it will be yellowish in color, but will turn white when it cools. The storage period of quicklime is quite short, which is about 60 days. Storage that is too long will cause quicklime to change shape into white powder because it reacts with water vapour in the air.

Table 2. Chemical Composition of Quicklime.

Molecular weight 56,08 gram			
Potassium	71,47% Ca	100,00%CaO	
Oxygen	28,53% O		
	100,00%	100,00%	= TOTAL OXIDE

Source: Barthelmy (2014).

Standardization of Fabric Sample Dyeing Method

Indigo Fermentation as Natural Dye Extraction

The process of taking natural dyes from plants in general is by extraction, namely boiling the plant for a while and then taking the extraction solution. Whereas specifically for indigofera plants, the process of taking the color is by fermentation and then continued with the pembejanaan stage. The fermentation stage is the stage of making indigo paste where the indigofera plant is decomposed with the help of an additional substance in the form of quicklime which is useful for binding indigotin so that the decomposed material becomes paste. The stages of taking indigo dye that begins with the fermentation process according to Suprapto, et al. (2010), are as follows:

1. Indigofera leaves were cut into pieces;

2. The leaves were soaked in water for 24 hours;
3. The leaves were taken from the soaking solution that already contained indigotin, then the solution water was boiled for 2 hours while adding quicklime;
4. The solution was allowed to stand for 24 hours until a sediment formed;
5. The solution that has been allowed to stand for 24 hours is filtered and the sediment is collected in an earthenware jug, the sediment is the indigo paste.

After taking the paste from the fermentation process, indigo paste still needs to be processed through the process of *pembejanaan* to become a ready-to-use dye. In this process, indigo paste is dissolved in Javanese sugar water solution and then allowed to stand for one day until it becomes a ready-to-use indigo solution. The following are the stages of indigo paste coloring in more detail:

1. Weigh 1 kg of indigo paste;
2. Weigh 1 kg of brown sugar and quicklime, then dissolve in 8 liters of water;
3. Dissolve the weighed indigo paste into the brown sugar solution until it is completely dissolved and homogeneous;
4. Allow the mixture to stand for 24 hours;
5. The indigo solution is filtered and ready to be used for the fabric color dyeing process.

Figure 3. Indigo natural dye solution at Hendri Suprapto's "Batik Bixa" workshop.

Fabric Dyeing

After the dye collection process is complete, the sample-making activity continues with the color dyeing stage. The variable number of color dyeing in the making of this fabric sample is three times, six times, and nine times, similar with the amount of traditional indigo dyeing process. Thus, the division of the coloring category is divided into three types of dye combinations only, namely indigo dye three times, six times, and nine times. The following are the fabric dyeing stages for the samples:

1. Cut the fabric to the desired size;
2. Mordant the fabric with quicklime solution;
3. Dye the fabric in indigo dye solution, the amount of each dyeing is adjusted to the variable amount of dyeing, namely three times, six times, and nine times;
4. Mordant the fabric again with quicklime solution;
5. Rinse the fabric thoroughly and then dry it in shady place until dry.

In the sample fabric with batik technique treatment, the stages that distinguish it are the batik stage when the fabric has been given the initial mordant and the batik wax decay stage after the fabric has been given the final mordant fixation. In the batik cloth samples for this research, the batik technique used is the stamp batik technique. The following are the stages of dyeing the fabric sample fabric with the application of batik technique:

1. Cut the fabric to the desired size;
2. Mordant the fabric with a solution of quicklime;
3. Apply batik wax onto the fabric using batik stamp;
4. Dye the fabric in indigo dye solution;
5. Covered some parts of the decorative motifs using batik *canting*;
6. Dye the cloth again with the total amount of each dyeing adjusted to the variable number of dyes, namely three times, six times, and nine times;
7. Mordant the fabric again with quicklime solution;
8. Rinse the fabric until clean;
9. Remove the wax with *lorod* technique;
10. Dry the fabric in shady place until dry.

Figure 4. *Lorod*, or wax removal activity.

Image Digitization and RGB Color Values Identification

Image digitization is the first stage that needs to be done in the digital color measurement method with the help of software tools. The sample object in this method is documented into digital format using a digital camera with a shooting angle of approximately 90 degrees and using natural light. The digitized image was then cropped to a size of 20 cm x 20 cm, followed by a reduction in the image pixel size to 64 pixels x 64 pixels as shown on Figure 5 below, and then blocked according to the pixel size.

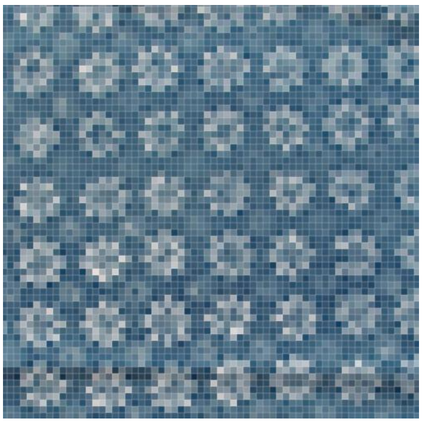


Figure 5. Example of blocked 64 pixels x 64 pixels image on fabric sample A1.

After the sample objects were dented to 64 x 64 pixels, the sample images were uploaded to Adobe Photoshop to analyze the image color. Color scanning is done in order from left to right and from top to bottom. The results obtained are in the form of RGB values of each pixel. To obtain the conclusion of RGB color data from image digitization, the "Image Color Summarizer" tool is used. From the summary results using "Image Color Summarizer" will be obtained average color data, median color, maximum color, and minimum color in RGB notation. On the work of Kim, et al. (2007) and Cocco, et al. (2018), the palette of colors they using to associate each pixel in an image is based on the Munsell color system, while in this research's color identification process the pixels were associated directly with RGB color coordinates.

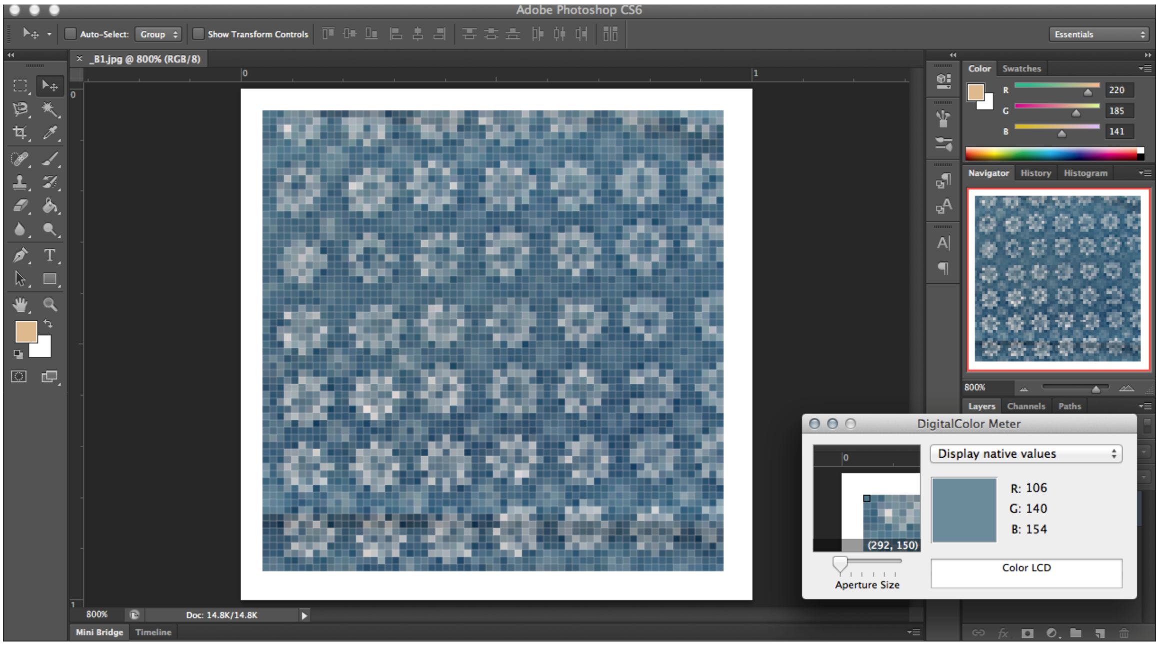


Figure 6. RGB color identification using Adobe Photoshop.

RESULTS

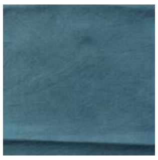
In this section, we present the experimental results of standardized indigo dyeing fabric samples method and the color identification which was assessed by the method as described on the previous section.

Fabric Samples Result

The fabric sample making produced six kinds of samples consisting of three samples with batik techniques and three types of plain samples without batik motifs. For the variable number of dyeings, each dye was dyed with variations in the number of dyeings three times, six times, and nine times.

Table 3. Fabric Samples.

Sample Code	Fabric Sample	Textile Technique	Dyeing Process Amount	Mordant	
				Initial	Final

A1		Batik	Three times	Quicklime	Quicklime
A2		Without batik	Three times	Quicklime	Quicklime
B1		Batik	Six times	Quicklime	Quicklime
B2		Without batik	Six times	Quicklime	Quicklime
C1		Batik	Nine times	Quicklime	Quicklime
C2		Without batik	Nine times	Quicklime	Quicklime

Color Identification Results in RGB Notation

With a sample size of 64 pixels x 64 pixels, the amount of color identification data obtained for each sample is 4096 colors, and for a total of six sample objects there are 24576 colors. The data presented is listed in the notation R=xxx, G=xxx, B=xxx. R represents the red color component, G represents the green color component, and B represents the blue color component value. From the color scan of the sample fabric using the "Image Color Summarizer", there is data on the average color (AVG), medium color (MED), minimum color (MIN), and maximum color (MAX). All color data is expressed in RGB (Red, Green, Blue) color notation. The number of colors obtained for the six samples tested is 24 colors with detailed identification results of different RGB values.

Table 4. Example of RGB Color Value Detail Based on Digitization Method for Sample A1.

	AVG	MED	MIN	MAX
R	**93.7** (93.7, 0, 0)	**86** (86, 0, 0)	**7** (7, 0, 0)	**238** (238, 0, 0)
G	**119.13** (0, 119, 0)	**114** (0, 114, 0)	**51** (0, 51, 0)	**224** (0, 224, 0)
B	**135.35** (0, 0, 135)	**131** (0, 0, 131)	**80** (0, 0, 80)	**217** (0, 0, 217)
RGB	**93.7, 119.13, 135.35** (93, 119, 135)	**86, 114, 131** (86, 114, 131)	**7, 51, 80** (7, 51, 80)	**238, 224, 217** (238, 224, 217)

Table 5. The Average, Median, Minimum and Maximum RGB Color for Fabric Sample A1 – C2.

Sample	RGB Value			
	AVG	MED	MIN	MAX
A1 	**93.7, 119.13, 135.35** (93.7, 119.13, 135.35)	**86, 114, 131** (86, 114, 131)	**7, 51, 80** (7, 51, 80)	**238, 224, 217** (238, 224, 217)
A2	**82, 127, 141** (82, 127, 141)	**82, 128, 142** (82, 128, 142)	**46, 78, 93** (46, 78, 93)	**110, 156, 168** (110, 156, 168)

				
B1 	**90, 119, 137** (90, 119, 137)	**81, 113, 133** (81, 113, 133)	**81, 113, 133** (81, 113, 133)	**229, 224, 220** (229, 224, 220)
B2 	**82, 112, 119** (82, 112, 119)	**80, 111, 118** (80, 111, 118)	**47, 66, 73** (47, 66, 73)	**126, 155, 160** (126, 155, 160)
C1 	**90.77, 114.23, 128.38** (90.77, 114.23, 128.38)	**79, 106, 122** (79, 106, 122)	**0, 21, 42** (0, 21, 42)	**252, 247, 243** (252, 247, 243)
C2 	**70, 105, 119** (70, 105, 119)	**71, 106, 121** (71, 106, 121)	**19, 38, 52)** (19, 38, 52)	**100, 144, 159** (100, 144, 159)

Table 6. Sequence of Color Identification Results from Sample A1 – C2.

Color	RGB Value (R, G, B)	Sample Source
	(252, 247, 243)	C1
	(238, 224, 217)	A1
	(229, 224, 220)	B1
	(126, 155, 160)	B2
	(82, 128, 142)	A2
	(110, 156, 168)	A2
	(100, 144, 159)	C2
	(82, 127, 141)	A2
	(90, 119, 137)	B1
	(79, 106, 122)	C1
	(10, 105, 119)	C2

	(90.77, 114.23, 128.38)	C1
	(86, 114, 131)	A1
	(93.7, 119.13, 135.35)	A1
	(81, 113, 133)	B1
	(80, 111, 118)	B2
	(82, 112, 119)	B2
	(71, 106, 121)	C2
	(46, 78, 93)	A2
	(15, 48, 72)	B1
	(7, 51, 80)	A1
	(47, 66, 73)	B2

	(19, 38, 52)	C2
	(0, 21, 42)	C1

In the RGB color results obtained from image digitization process in this research, there are some colors that are less relevant to include as color content data from dyeing with natural dyes, namely the maximum values obtained in A1, B1, and C1. These colors are considered less relevant because visually they are closer to white, which is impossible to achieve when dyeing with natural dyes. The reason these colors can appear in the color identification results based on digitization is because the samples contain batik ornaments that are not exposed to the dyeing process because they are covered with wax. The part covered with wax gives a color finish that tends to be white. After eliminating the less relevant colors, the result of identified color digitization for batik and non-batik natural indigo-dyed fabrics is a group of color consists with 21 blue colors with different shades.

Figure 6. Conclusion of Color Digitization Results for Batik and Non-Batik Fabrics.

CONCLUSION

During this research, the color analyzing process was limited to utilizing "Image Color Summarizer" tool on Photoshop to obtain the RGB color data from manual documented fabric sample images. The manual documentation might affect the accuracy of the colors due to several circumstances, for example the lighting that was used during documentation process, because natural light is prone to change with the weather or other natural changes in the surrounding environment in a short period of time. The wrinkle and shadow on the surface of the fabric might be a noise from the image which may disrupt the color perception from the image itself. The "Image Color Summarizer" tool itself is not the most efficient tool to obtain the RGB values because the researcher needs to collect data from each pixel manually. For future research, researcher could use spectrophotometry to obtain discrete color values from fabric samples, and researcher could also use other software tool that is more efficient in the process on obtaining RGB color values.

On color identification result, researcher decided to eliminate three colors from color identification sequence due to the colors were less relevant to be included in color data result. Even though the colors were less relevant, but it was part of the research process resulted from the batik textile treatment process. Researcher needs to be aware of these less relevant colors existence as they should not be included on the result color group.

This research is a response to the need for non-analogue documentation for the results of Indonesian natural dyes, especially indigo natural dyes. Identifying and compiling the non-analogue data are the main activities of this research, the results of which can be applied to digital media because the discrete color value data obtained has been adjusted to the needs of the medium, namely the color value in RGB notation. The result implementation of this research can be developed into further research, for example research on designing digital repository of Indonesian natural dye, or designing mobile applications about natural dyes, or other potential new media design research which related to Indonesian natural dye. Apart from the digital medium aspect, further research can include variations of other Indonesian natural dyes, such as *soga* brown dye which is a mixture of *tingi* wood (*Ceriops candolleana*), *jambal* wood (*Pelthophorum ferrugineum*), and *tegeran* wood (*Cudrania javanensis*), or other natural dyes from Indonesia.

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