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Biopigment Tracing of Mangrove *Rhizophora mucronate* Leaf an Bark Waste and Its Application for Batik Dyeing by Multiple Fixations

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Abstract – The purpose of this research is to determine the pigments in the bark and leaves of mangrove (Rhizophora mucronata), to analyze rate of color fastness in batik, level of consumer interest, and most effective pricing for the resulting batik products. The research was conducted between June 2015 and February 2016, and took place in Mangunharjo village, Tugu district, Semarang city, Indonesia. The pigment identification tests were performed in Laboratorium Terpadu Universitas Diponegoro, Indonesia. This research focused on the leaves and barks of mangrove plants. The leaves and barks were extracted to be used as dyeing agents, after which the batik fabrics were fixated using alum, limestone and lotus. This descriptive research employed UV-Vis spectrophotometry to identify pigment and Adobe Photoshop computer program to perform color fastness analysis. The result showed that chlorophyll is a pigment which contributes to the color green in leaves. Photochemical test results also show that the pigment associated to the blackish-green hue was tannin, andthat which was associated with red was flavonoid and quinone. The various colors were applied in batik dyeing process, which resulted in a range of color from yellow to dark brown. Color fastness test of batik dyed with mangrove-derived pigments on wash air dry, wash press dry, and wash sun dry using calico as fabric showed that alum and limestone fixated fabric had the least color fastness, while conversely, lotus-fixated fabric displayed good color retention. Levels of consumer interest naturally-dyed batik fabric by alum fixation was 20%. Of all the respondents, 46.67% showed interest in limestone-fixated batik, whereas 40% responded well with the lotus-fixated batik. Consumer acceptance levels for the mangrove-dyed batik fixated by alum, limestone, and lotus were 6.67%, 16.66% and 13.33% respectively. High consumer interest in fabric fixated by limestone and lotus was attributed to darker and stronger hues. The most effective price point suggested per 2.1 x 1 m of fabric was between IDR 200,000 to IDR 350,000.

Key words: Bio pigment, mangrove waste, fixation, batik

1. INTRODUCTION

The cycle in recent cycle has developed so advanced in that it demands designers and academics in the field to continuously produce creative, innovative, and marketable clothing. Many fashion products nowadays, particularly batik, use synthetic dye with chemical additives. Among the advantages of synthetic dye usage are guaranteed stock, wide range of color options, and practical in its application. However, the usage of synthetic dye can be harmful for people and environment due to its strong carcinogenetic characteristics, which is often attributed to severe dermal allergic reaction, skin cancer, and environmental pollution [1]. An alternative to synthetic dye is natural dye, most of which are derived from plants. Within the tissue of plants is pigment which give distinctive colors based on its chemical structure. Such chemical structures include chlorophyll, carotenoid, tannin or anthocyanin [2].

Fashion and batik fabric design using natural dye have added retail value because they are artistic, have unique colors, and are environmentally friendly, adding the impressions of ethnicity and exclusiveness. One of the most viable natural dye materials, which is also proven to be environmentally friendly, is mangrove waste. For example, different colors can be obtained by processing leaf, twig, and root waste of mangrove trees. Colors resulted from such processing are in the hue range of yellow, red and brown [3].

The quality of naturally-dyed batik is one of the determining factors in consumer satisfaction after the purchase of said batik products. Therefore, it is important that the planning of these batik products to take account consumer needs. In addition, the products must reflect good craftsmanship. This is crucial so that the products will cater the need of the consumers, will be well-received in the market, and can meet consumer expectations and demands. This perception towards quality is an indicator of consumer perception towards a product, and negative consumer perception most likely to result in poor market reception and unsustainable business. On the contrary, positive consumer perception can indicate good market reception when the products are used by consumers, with the assumption that product quality determines the satisfaction in using the product.

The importance of information of pigments on mangrove (*Rhizophora mucronata*) natural dye which is used as treatment for batik and consumer interest as well as ideal pricing for naturally-dyed batik from mangrove waste. Providing the importance of such information, this study aims to: identify the pigment contained in the leaf and bark of mangrove waste; determine the color fastness of batik fabrics treated with mangrove-based dye; identify the consumer preference or interest on batik with mangrove-based natural dye; determine ideal price point for batik fabrics with mangrove natural dye.

2. METHODS

2.1 Sampling

Samples of mangrove leaves and barks were collected from Mangunharjo village, Semarang city. Dried mangrove leave and bark samples were then extracted. Respondents were sampled using snowball sampling method. In this method, a small number of initial respondents were interviewed, after which the researchers asked the respondents to refer to other prospective respondents of their choice, until the ideal number of respondent samples was met. The batik consumer study was performed on 30 respondents.

2.2 Execution of Research

The study focused on 18 colors extracted from mangrove leaves and barks as natural dye for batik fabrics, fixated by alum, limestone and lotus with three repetitions.

2.3 Extraction Process of Mangrove (*Rhizopora mucranata*) Leaves and Barks

The extraction of mangrove (*Rhizopora mucranata*) leaves and barks was carried out in two parts in this research. The first part was synthesizing natural dye from mangrove waste [4] and extraction by ethanol 95% solution [5] [6]. The second part included several processes, namely: batik painting, batik dyeing, fixation, *nglorot* (batik wax removal by repeatedly boiling) and fabric drying. Before the fabrics were ready to use, fabrics having gone through the *nglorot* process were cold-rinsed and air dried in a prepared space protected from direct sunlight exposure.

2.4 Pigment Identification Using UV-Vis Spectrophotometer

Pigment identification using UV-Vis spectrophotometer was carried out by observation of absorbance spectrum pattern, maximum wavelength (λ_{max}), and percentage of the difference in height between the 3rd and the 2nd peaks (%III/II) [7].

2.5 Phytochemical Screening

Ethanol extracts of mangrove leaves and barks were put into phytochemical screening to determine the secondary metabolites compounds [8].

2.6 Color Fastness Test for Batik Fabrics

This test was performed to determine the color quality of batik fabrics with three treatments: wash and air dry, wash and iron dry, wash and sun dry. Obtained image data were coded in accordance to the treatment used for each fabric sample, after which the said fabric was scanned under Canon scanner. Data from fabric scanning were then processed using photoshop to obtain RGB (Red/Green/Blue) [9].

The color fastness test was performed to gauge the color quality obtained from each fixation process using fractional factorial design (3x2) experimental method in SPSS 10 where the first factor was fixation compound (alum, lotus, limestone) and the part of mangrove (leaves and barks). Research data were analyzed with F test on 5% significance.

Laboratory experimental method is a research which is conducted to determine the impact of a treatment on a subject studied, in other words the experiment aims to establish causal relationship.

2.7 Consumer Preference and Price Perception Test

Consumer preference and price perception test were performed using descriptive method. The consumer preference test was carried out by handing out Likert scale-based questionnaires as seen in Table 1 below:

Table 1. Level of Consumer's Preference and Price Perception Test

Research Variable	Operational Definition	Measurement
Ideal Price Point	Perception price is the trend of consumer to indicate price in giving judgement to suitability of product's benefits.	IDR / fabric
Consumer Preference	Attractiveness of the colors and motifs of the product are the appeals of the product to draw attention of consumer's interest to such product.	Index of Preference
Color fastness test	Quality of the product is the potential of the product performing its function and to indicate bad or good level of the product.	Color fastness Index (pixel)

The consumer preference above was measured in Likert scale with 1-5 score for each answer, with each score number represent the following answer in inclination: Strongly Disagree (STS), Disagree (TS), Neutral (N), Agree (S), Strongly Agree (SS).

Similar method was also used in determining the ideal price perceived by consumers, in which the questionnaire was designed to identify the best price range based on competition both on highest to lowest price point.

3. RESULTS AND DISCUSSION

Phytochemical screening is one of the methods in determining the contents of secondary metabolites contents of a plant species. This is useful in determining the main group of bioactive compounds. The screening in this research showed that the mangrove leaves and barks contained several distinct secondary metabolite compounds as listed in Table 2.

Table 2. Result of Leaf and Skin Phytochemical Test

Types of Mangrove Waste	Class of Secondary Metabolite Compound						
	Tannin	Saponin	Steroid	Terpenoid	Alkaloid	Flavanoid	Quinon
Leaf	+ +	-	-	-	-	-	-
Bark	+ +	-	-	-	-	+	+
Note	Greenish-black	-	-	-	-	Red	Red

Note: (-) = not detected (+) = positive (++) = strong positive

Phytochemical screening on the mangrove leaves and barks in this study showed positively strong result toward tannin. The screening of the barks also showed positive results towards quinone. Saponine, steroid, terpenoid, alkaloid, and flaovonoid were not detected on the leaves and barks of the mangrove. Tannin screening in the leaf and bark samples of the mangrove showed positive results, marked by the occurrence of blackish green coloration after 5 drops of 1% $FeCl_3$ were added. Quinone screening on the mangrove bark samples resulted in red coloration after 5 drops of NaOH solution was used. Flavonoid screening showed positive test after 1 gram of powdered Mg and 5 drops of viscous HCl were used. The appearance of red coloration was attributed to flavonoid.

3.1 Batik Natural Dye from Mangrove (*Rhizopora mucranata)* Waste

Natural dye is a viable alternative to artificial dye in textile production. The use of artificial dye has been linked to environmental damage and can cause cancer when the fabrics come into contact with skin. The study of mangrove plant (*Rizophora*) waste in the form of leaves and barks as source of natural dye, fixated with alum, limestone and lotus, resulted in various colors, which are listed in Table 3.

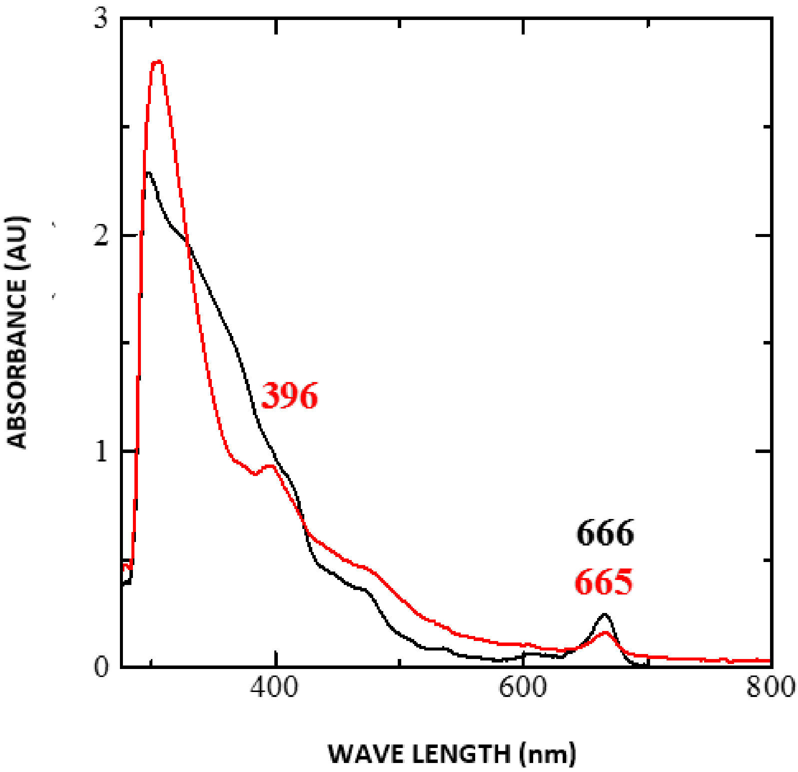
Table 3. Colors from Mangrove Natural Dye with Different Fixations

Sample	Fixation								
	Alum			Limestone			Lotus		
	U.I	U.II	U.III	U.I	U.II	U.III	U.I	U.II	U.III
Leaves									
Bark									

Fixation by alum resulted in light brown color, which appeared faded and pale. Fixation by limestone resulted in light brown with more brightness, whereas fixation by lotus resulted in dark brown color.

3.2 Pigment Identification by UV-Vis Spectrophometer

The identification of pigment in mangrove leaves and bark in this study was accomplished by the use of UV-Vis Spectrophotometer. The results of UV-Vis Spectrophotometer, shown in Figure 1, showed the existence of a and b chlorophyll. Chlorophyll a was detected in mangrove leaves, with 666 nm wavelength in peak I and an absorbance rate of 2.29. Chlorophyll b was detected in mangrove barks, having 396 nm wavelength in peak I and 665 nm wavelength in peak II and an absorbance rates of.



2,80.

Figure 1. Chlorophyll a and b spectra on leaves and barks of mangrove.

3.3 Batik Color Fastness Test

The color fastness test of batik fabrics in this study was devised by way of wash-air dry, wash-iron dry, and wash-sun dry. Image data obtained were coded in accordance to the treatment of the fabric sample. The images were then processed using photosop program to extract the RGB (red/green/blue) data. The results of batik color fastness test for all treatments are presented in Figure 2 below.

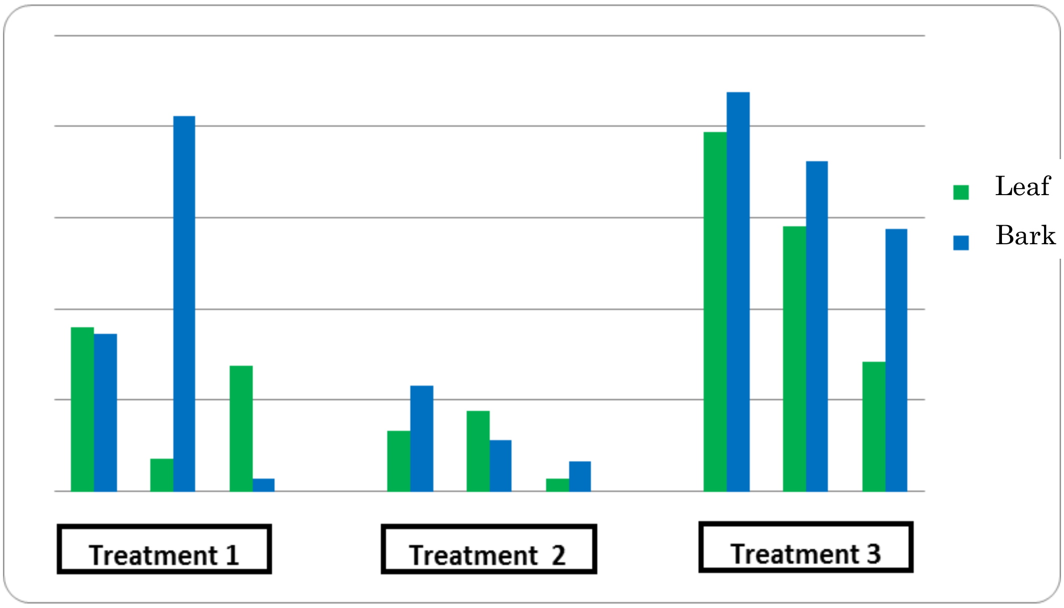


Figure 2. Color Fastness Value of Batik with Mangrove-based Natural Dye

The graphic shows that treatment I (wash-air dry) resulted in a significant discoloration of the batik fabric fixated with limestone. Treatment II (wash-iron dry) and III (wash-sun dry) showed significant discoloration of the batik fabric fixated with alum. The test also showed that wash-sun dry treatment caused the most significant discoloration to the fabrics of all fixation methods.

3.4 Color Fastness Test of Batik with Mangrove Leaf-based Dye

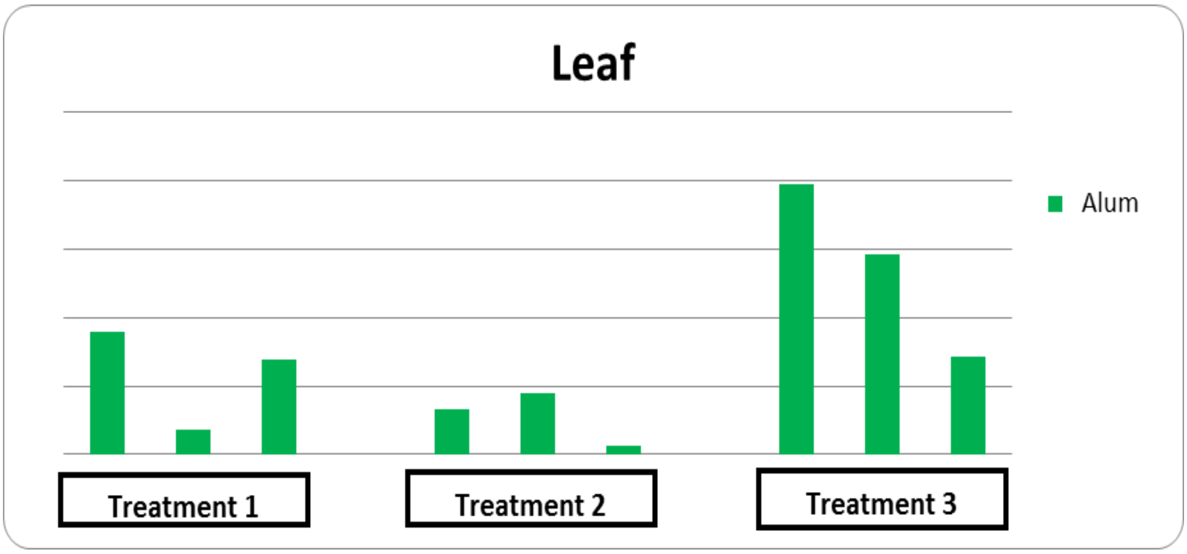


Figure 3. Color Fastness Values of Batik with Mangrove Leaf-based Dye

Figure 3 presents the color fastness of batik fabric with mangrove leaf-based dye fixated with alum, limestone and lotus. The results showed distinct color retention for each treatment. Fabrics fixated with alum on wash-air dry treatment showed significant discoloration. The second treatment, wash-iron dry, resulted in significant discoloration on fabric with limestone fixation. The third treatment, wash-sun dry, was particularly damaging to the colors of fabric with alum fixation, compared to that with the other fixation treatments.

3.5 Color Fastness Test of Batik with Mangrove Bark-based Dye

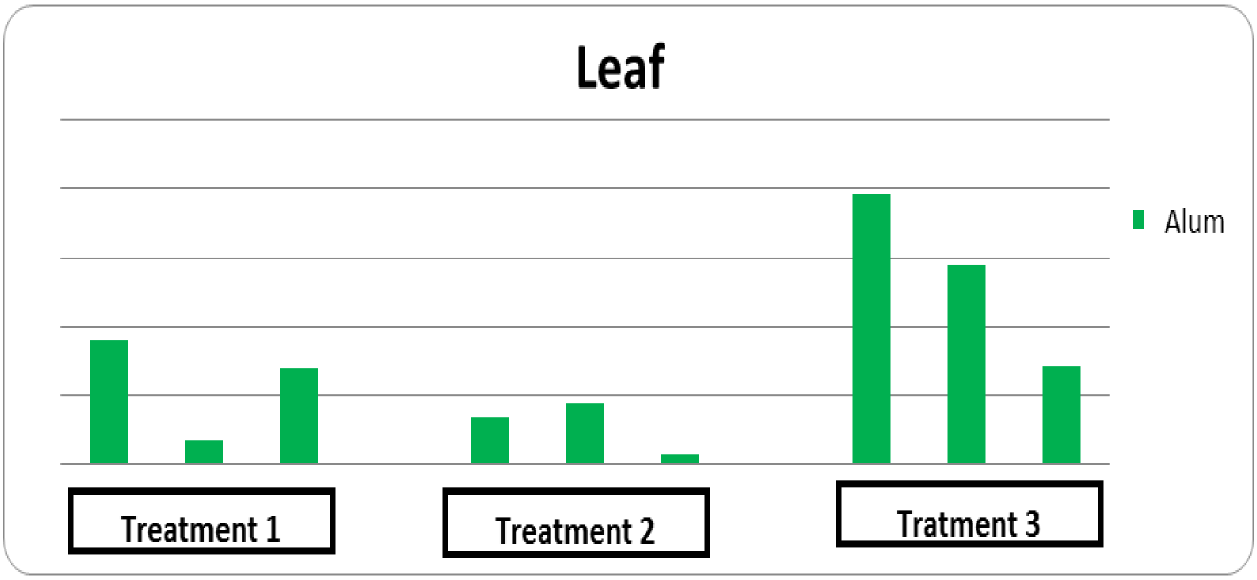


Figure 4. Color Fastness Values of Batik with Mangrove Bark-based Dye

The bar chart above showed that the first treatment, wash-air dry on fabrics fixated with limestone resulted in significant discoloration. The most significant discoloration found on fabrics with the second treatment, wash-iron dry, was observed in fabrics with alum fixation. Alum-fixated fabrics also showed the most significant rate of discoloration in the third treatment, wash-sun dry. Additionally, wash-sun dry treatment resulted in the most significant overall discoloration on fabrics with all fixation, compared to the other two treatments.

3.6 Consumer Interest in Batik Fabrics with Mangrove-based Natural Dye

The color quality resulted by the application of mangrove leaves and barks for batik dye may vary greatly due to the difference in pigment content compositions. In addition, usage of different fixers also contributes to the variation of color in such application. The report of respondent ratings is presented in the Table 4 below.

Table 4. Respondent Rating to Colors of Batik Fabric

No	Sample	Rating (%)				
		1 (Strongly Dislikes)	2 (Dislikes)	3 (Neutral)	4 (Likes)	5 (Strongly Likes)
1.	Leaf-based with Alum Fixation	6.67%	16.67%	40%	20%	16.67%
2.	Leaf-based with Limestone Fixation	10%	6.67%	13.33%	46.67%	23.33%
3.	Leaf-based with Lotus Fixation	10%	10%	20%	40%	20%
4.	Bark-based with Alum Fixation	23.33%	40%	23.33%	6.67%	6.67%
5.	Bark-based Limestone Fixation	23.33%	16.67%	26.67%	16.67%	16.67%
6.	Bark-based Lotus Fixation	33.33%	23.33%	16.67%	13.33%	13.33%

Consumer interest ratings in Table 4 showed that 20% of the respondents liked the fabrics with leaf-based dye and alum fixation, which resulted in light brown color. On the other hand, the same fabric fixated with limestone obtained the preference of 46.67% of the respondents, with strong-hued light brown. The fabrics with lotus fixation were liked by 40% of the respondents, with dark brown or darker color compared to the same fabric dye from other fixation treatments.

Batik fabrics with mangrove bark-based dye with alum fixation methods gained a very low consumer preference, 6.67%, due to its resulting faded colors that the respondents viewed to be detrimental to characteristics of the batik pattern. The fabrics fixated with limestone was preferred by 16.67% of the respondents due to their brighter colors (light brown), and the fabrics fixated with lotus were preferred by 13.33% of the respondents because of their darker colors when compared to fabrics with other fixers. Batik fabrics with mangrove leaf-based natural dye fixated with limestone and lotus obtained the highest preference rating of all.

3.7 Perceived Ideal Price of Batik with Natural Dye Made from Mangrove (Rhizopora mucranata) Leaves and Barks

The object of this study were consumers in the vicinity of Semarang proper, numbering 30 people in total. The demographics of the respondents were dominated by females (63.3%) as opposed to males (36.7%) as seen in Table 5. Respondents aged 40-50 made up the majority of the samples, compared to those under the age of 20 (Table 6). In terms of education, more than half of the respondents graduated from undergrad school or academy (56.7%) (Table 7). Half of the respondents worked as civil servants or as entrepreneurs (50%) (Table 8). The highest monthly spending of the majority of the respondents were between IDR 3,001,000 to IDR 4,000,000 (40%) (Table 9).

Table 5. Sex of Respondents

No.	Sex	Frequency	Percentage
1.	Male	11	36.7%
2.	Female	19	63.3%
	Total	30	100%

Table 6. Age of Respondents

No.	Age Range	Frequency	Percentage
1.	< 20	0	0 %
2.	21-30	3	10 %
3.	31-40	10	33.3 %
4.	41-50	11	36.7 %
5.	< 50	6	20 %
	Total	30	100%

Table 7. Education of Respondents

No.	Level of Education	Frequency	Percentage
1.	Grammar School	0	0 %
2.	Junior High School	0	0 %
3.	Senior High School	5	16.7 %
4.	Diploma/Bachelor	17	56.7 %
5.	Master/Doctor	8	26.7 %
	Total	30	100%

Table 8. Profession of Respondents

No	Occupation	Frequency	Percentage
1.	Students/College Students	0	0 %
2.	Civil Servant/ Private Employee	15	50 %
3.	Housewife	8	26.7 %
4.	Entrepreneur	6	20 %
5.	Others	1	3.3 %
	Total	30	100%

Table 9. Respondents Monthly Spending

No.	Range of Monthly Spending	Frequency	Percentage
1	< IDR 2,000,000	2	6.7 %
2	IDR 2.001,000 to IDR 3,000,000	7	23.3 %
3	IDR 3,001,000 to IDR 4,000,000	12	40 %
4	IDR 5,001,000 to IDR 6,000,000	5	16.7 %
5	>IDR 6,000,000	4	13.3 %
	TOTAL	30	100 %

Table 10. Price Perception of Batik Fabric Per 2.1x1 m Assumption

No.	Sample	Reasonable Price	Highest Price
1.	Leaf-based with Alum Fixation	IDR 193,333	IDR 266,666
2.	Leaf-based with Limestone Fixation	IDR 323,333	IDR 383,333
3.	Leaf-based with Lotus Fixation	IDR 350,000	IDR 433,333
4.	Bark-based with Alum Fixation	IDR 173,333	IDR 250,000
5.	Bark-based with Fixation	IDR 193,333	IDR 266,666
6.	Bark-based with Fixation	IDR 210,000	IDR 300,000

Note: Rates are based on average of 30 respondents

The perceived ideal price point for batik with mangrove-based natural dye showed considerable variations. The perceived ideal price for batik with mangrove leaf-based natural dye, fixated with alum, limestone, and lotus were IDR 193,333, IDR 323,333, and IDR 350,000 respectively (Table 10). On the other hand, the perceived ideal price for batik with mangrove-bark based natural dye, fixated with alum, limestone, and lotus were IDR 173,000, IDR 193,333, and IDR 210,000 respectively.

Batik with mangrove leaf-based natural dye, fixated with limestone and lotus had the highest perceived ideal price point of IDR 383,333 and IDR 433,333 respectively. The results highly correlated with the fact that female respondents showed higher preference to batik with mangrove leaf-based natural dye, fixated with limestone, and that the male respondents showed the highest preference to mangrove leaf-based natural dye, fixated with lotus.

3.8 Discussion

Secondary metabolites in plants generally consist of mixtures of many chemical classes such as alkaloids, flavonoids, tannin and polyphenol compounds, anthraquinone, terpenoids, and steroids compounds. Therefore, the mangrove leaves and bark samples in this study were put through phytochemical screenings to determine the compounds. Phytochemical screening results on leaves and barks of mangroves in this study showed positive findings of tannins, alkaloids, flavonoids, and quinones.

Tannin screening on the mangrove leaves and barks samples showed positive results after the addition of 5 drops of 1% $FeCl_3$, which was identified by blackish green coloration. Alkaloid screening on the samples did not show positive results after the addition of dagrendrof reagent. Orange to bright red coloration after the addition of dagrendrof reagent shows positive result in alkaloid compound screening, as opposed to the brown coloration on leaves and yellow coloration on barks samples [5]. Flavonoid test on mangrove bark samples came out positive by the occurrence of pink coloration after the addition of H_2SO_4. Flavonoids the most commonly found phenol compounds in nature. These compounds give red, purple, blue and yellow hues in plants. The quinon screening with NaOH addition showed positive results, by the occurrence of red coloration. Quinon gives distinct and strong coloration in plants, covering hues of visible colors, albeit that the coloration contributed by quinon are mostly found in the internal parts of the plants, making coloration by quinon often unobservable on the plant exteriors. Quinon is derived from *benzoquinone, naphthoquinone* or *anthraquinone* structures.

Phytochemical screening of mangrove leaves and barks with $FeCl_3$ showed strongly positive results on tannin by opaque, blackish green coloration. Phytochemical screening is a viable qualitative tool to determine the tannin contents in mangrove barks [10]. Phytochemical screenings, such as the one employed in this study, is carried out by adding reagents to sample extracts. The screening is a classical method to determine simple phenol compounds, done by adding 1% $FeCl_3$ dissolved in water, upon which positive results will be shown by distinct green, red, purple, blue or black coloration [5]. The blackish green coloration from the screening results was caused by the complex reaction between tannin and Fe^{3+} ions. Tannin is defined scientifically as a polyphenol compound with high molecule mass and possesses hydroxyl and other clusters (such as carboxyl), making complex formation with proteins and other macro molecules under specific environmental conditions.

Mangrove contains tannin, phthalate, and furfural which act as media for dye [11]. There is a recurring interest in developing natural dye in many industrial nations recently owing to the fact that it is environmentally friendly and safer to use, in keeping with many clean production and products policies. As secondary metabolites, tannin have a number of uses such as for insecticides and fungicides for plants, for antiseptic due to its protein-controlling properties, for alkaloid poisoning antidote, for a reagent in detecting gelatin, alkaloid, and protein as well as for preservative agents in leather products.

Based on the results in Table 3, various fixations resulted in different colors. In this study, the natural dye made of mangrove based and leaves were fixated using alum, limestone and lotus. Batik color from mangrove leaf-based natural dye resulted in pale brown color with alum fixation, strong-hued light brown with limestone fixation, and dark brown with lotus fixation. The use of lotus in mangrove leaf-based fixation resulted in the best motif visibility in this study. The brightest color was found in leaf-based natural dye with lotus fixation. Batik color from mangrove bark-based natural dye resulted in pale brown, bleached color with alum fixation, slightly pale light brown with limestone fixation, and dark brown with limestone fixation.

Based on the results from this study, the application of *Rhizopora mucranata* mangrove leaves and bark in the production of natural dye resulted in a range of color from pale to dark brown. The application of leaves and barks of *Sorenasia alba*, *Rizophora* sp, *Avecenia* sp, *Ceripos decandra*, and *Lumicera* sp showed relatively similar range of dominant colors, namely pale to dark brown [3]. Producing natural dye from several mangrove species resulted in various colors [12]. *Sonneratia Caseolaris* yielded greenish brown, the fruit of *Cerbera Manghas* resulted in light brown, the leaves of *Cerbera Manghas* resulted greenish yellow. Natural colors are derived from natural pigments produced by plants and animals [13]. Natural colors produced by mangrove plants have been identified as greenish brown, light brown and yellowish green.

The degree of the hues and the resulting dye colors are determined by the base ingredient, fixation agents, and the number and duration of dipping during the fabric dyeing process. In this study, barks were obtained from a relatively juvenile mangrove trees (aged between 3 and 4 years old), which affected the resulting colors. Fixation agents used in the fabric dyeing process also contributed to the colors; alum would bring up natural colors, limestone resulted in darker colors and lotus gave out darker colors or stronger hues. These different results were attributed to the reaction between tannin and Fe^{2+}metal, which results in complex salt (ferric tannate) appearing brown in color. Ferric sulphate reacts with oxygen to form another ferric formation, resulting in darker colors. Cotton fabric fixated using lotus resulted in the darkest coloration, brownish green, compared to those fixated with alum and limestone [14]. Complex potassium and aluminum sulfate from the reaction between tannin and lotus fixer tend to result in darker colors albeit not with the fibers, blocking out the dye and reducing interaction with the fabric.

Pigment identification was carried out to determine the pigment contents on mangrove leaves and barks used as the base ingredients for the natural dye in this research. The identification was performed by utilizing a UV Vis spectrophotometer device. The results of the analysis observed from the pattern line, as seen in Figure 3, showed the identification of chlorophyll a and b. Chlorophyll a was identified in the mangrove leaves with 666 nm wavelength at peak I and 2.29 absorbance rate. Mangrove barks were shown to contain chlorophyll b with 396 nm wavelength at peak I, 665 nm wavelength at peak II, with 2.804 absorbance rate.

Chlorophyll belongs to photosynthetic pigments in plants, which absorbs red, blue and violet light and reflects green light, from which its distinct color comes. It exists in chloroplasts and utilizes the absorbed lights as an energy source to power the photosynthesis processes. Chlorophylls have been identified as chlorophyll a, b, c and d. Chlorophyll a is the most important one for photosynthesis process. Chlorophyll an absorbs light with maximum wavelength ranging from 430 nm to 662 nm. Chlorophyll b also plays an important role in photosynthesis, with light absorbance capacity between the maximum wavelength of 453 nm and 642 nm. Chlorophyll is a light-sensitive chemical, especially towards purple, orange or red colors. The two dominant chlorophylls found in plants are chlorophyll a and b. Chlorophyll a has a dominant green coloration, expressed in $C_{55}H_{72}MgN_4O_5$, whereas chlorophyll b has a dominant color of blue and expressed in $C_{55}H_{70}MgN_4O_6$. These chlorophylls are housed within storage organelles called chloroplasts.

Chlorophyll gives out the color green because it is ineffective in absorbing the colors, reflecting most of it back. The reflection of green light spectrum is caught by human eye, which in turn creates the color sensation of green to the viewer. In other words, when white polychromatic light shines on leaves, the green light is transmitted and reflected making the chlorophyll look green in color. The absorbance spectra of chlorophyll a and b are different due to the distinct chemical structure between the two.

The color fastness test in this study was performed to determine the color quality as a result of the use of various fixers in the fixation processes. The color fastness rate was concluded by RGB value, obtained from photoshop image data processed through experimental factorial pattern statistics (3x2) using SPSS 1.8.

The mean of RGB value found for mangrove leaf and bark-based batik was measured by using Levene's test, resulting in Sig. 0.46 (>0.05) which indicated that all of the fixation treatments had insignificant impact in color fastness, with wash-sun dry treatment. The mean of RGB data also showed different color fastness rate resulting from the use of each fixer. Mangrove leaf-based dyed batik, fixated with alum under the treatment of wash-air dry, showed a very significant color bleaching. It was suspected that during the fixation process, alum did not allow maximum absorbance of tannin in mangrove by the fabric.

The batik with mangrove bark-based natural dye, fixated with limestone did not result in maximum absorbance of the dye molecules in fabric due to the severed bond between the fabric and the acrosome, resulting in low dye absorbance and surface colorization. The result of color fastness test in multiple wash treatments using Grey Scale rating showed the values between 3 to 4 [15]. However, dyed fabrics were tolerated or are usable as dyeing material.

Analysis of the RGB data values of mangrove leaf-based natural dye colors resulted, with wash-iron dry treatment, showed a Levene's sig, 0.30 (>0.005). This indicated that there was no significant color bleaching in the use of this dye with all fixation methods under the aforementioned fabric treatment. The use of different fixers also resulted in different color fastness rate, with limestone fixation showing the most sensitive towards color bleaching in mangrove leaf-based dyed fabric under wash-iron dry treatment, and alum fixation showing the least color fastness in mangrove bark-based dyed fabric under similar treatment. These results were possibly caused by the intense heat applied during the iron dry treatment, which prevented color bond between the tannin and the fabric from properly forming.

The color fastness analysis of mangrove leaf and bark-based natural dye, each fixated with alum and limestone showed significantly low color fastness under three treatments (wash-air dry, wash-iron dry, and wash-sun dry). Low color fastness rate is attributed to the severance of bond between the acrosome and the fabric, significantly lowering the dye absorbance rate of the fabric, resulting in surface coloring [9]. On the other hand, the usage of lotus as a fixer resulted better color fastness for the end product, since lotus increased the color fastness rate of the dyed fabric by locking the dye molecules with the fabric. This proved that the contents of mangrove leaves and barks were viable as fabric natural dyeing materials. Tannin, which is capable of forming strong bonds with fabrics, contributed to the best results in this study. Tannin as a compound falls into mordant coloring agent, which combines easily with metal oxides to form lasting dye. These mordant compounds possess good capacity in forming bonds between the fabrics and the dye used, increasing the affinity of the dye to the fabric. The fixation process performed after the dyeing process is finished, is meant to reinforce the dye to the fabric, which will make better lasting colors.

The treatment which caused the most significant color bleaching found in this study for all mangrove-based dye with all fixation methods was the wash-sun dry treatment. It was suspected that sunlight posed significantly adverse impact towards color stabilization during the drying process. The impact of sunlight toward the pigment of red yeast rice, in which lowered colorization intensity was observed due to the damage in active pigments [16]. This decline of color intensity was represented by lower spectrum absorbance rate from the kinetic energy caused by the damage. Ultraviolet light and the energy from sun exposure attacked chains of color molecules and could cause breakdown in the bonds. The damage in color molecule chain contributed to lower color fastness rate because the color carrier cluster in the fabric became inactive. The most significant factor contributing to the color fastness in the molecule stability of the dye material under sunlight exposure.

Mangrove leaf-based dye with alum fixation in batik fabric obtained 20% consumer preference rating, of which color characteristic was light brown. Limestone fixation of the same dye obtained 46.67% consumer preference rating, of which the characteristic was light brown color, whereas limestone fixated, rating dark brown in color, fabric of the same dye obtained 40% consumer preference.

For fabrics with mangrove-bark based dye, fixated with alum, a 6.67% consumer preference rating was obtained, with those in favor stated that the color light brown blurred the batik motif. The same fabric with limestone fixation resulting in slightly faded, light brown color obtained 16.67% consumer preference rating. The same fabric with lotus fixation resulting in dark brown color, darker when compared to the results of the other two fixations, garnered 13.33% consumer preference rating.

The interview of respondents indicated that the interviewees tended to prefer batik with mangrove leaf-based natural dye fixated with limestone and lotus. The most dominant reason given by the respondents for this preference was the dark brown color which they perceived to be more exclusive. The respondents showed lower interest towards other batik, with the most dominant reason being the lighter colors which they perceive to blur out the batik motif.

Textile products with natural dye was preferred more by consumers from abroad, with comfort and less allergic-triggering properties of the natural dye [3]. Natural dye, especially in developed countries, has practically deprived of its economical values. However, with the recent resurgence of "back to nature" movement, along with the concern of environmental and health hazard from the use of artificial dye, and the desire to create or possess uniqueness in fashion, breathed new life to the use of natural dye [17].

The study for ideal price points of mangrove-based natural dye batik showed varying results. Batiks with mangrove leaf-based natural dye fixated with alum, limestone, and lotus were perceived ideally at IDR 193,333, IDR 323,333 and IDR 350,000 respectively. On the other hand, batiks with mangrove bark-based natural dye fixated with alum, limestone, and lotus were perceived ideally at IDR 173,000, IDR 193,000 and IDR 210,000 respectively. The highest ideal perceived price point by consumers were given to batiks with mangrove leaf-based natural dye fixated with limestone and lotus, with the highest ideal perceived prices at IDR 383,333 and IDR 433,333 respectively.

The perceived ideal price points found in this study were given by consumers based on their experience in purchasing similarly colored and compared quality batiks in the market. In addition to the use of natural base materials of mangrove leaves and barks, batiks with natural dye were perceived to be environmentally friendly and to pose less allergic reaction. Consumers also perceived the batiks in this study to require long hours and meticulous production process, resulting in exclusive products that were not widely available. Batik with natural dye gained better consumer preference abroad due to it being less allergic-triggering nature. Batiks with natural dye were more prominent from its artistic side, making the appropriate target market as middle to higher end consumers from abroad with higher price points [18].

4. CONCLUSIONS

Based on the research, it can be concluded as follows:

1. The content of pigment in mangrove leaves and barks by spectrophotometer UV-Vis indicated the existence of chlorophyll a and b. In mangrove leaves, it was indicated the content of chlorophyll a, while in mangrove bark it indicated the content of chlorophyll b.
2. Fabrics fixated with alum and limestone showed resulted in the least color fastness, after three post fixation treatments of wash-iron dry, wash-air dry and wash-sun dry. Batik fabrics fixated using lotus showed the best color retention in all post-fixation treatments. It was also found that wash-sun dry treatment caused the most color fading.
3. Batik with mangrove leaf-based natural dye, fixated with limestone obtained the highest consumer preference rating (46.67%), fabric with similar dye, fixated with lotus (40%).
4. The perceived ideal price point for batik with mangrove leaves and barks-based natural dye, 2.1 x1 m per unit assumed, ranged between IDR 200.000 to IDR 350.000.

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