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Application of natural dyes in the woven pandan leaf: experimental study on craft products in Tipang village

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ABSTRACT

Natural dyes come from natural sources through certain processes used in several arts and crafts to produce environmentally friendly products. This research aims to conduct experiments on applying natural dyes to woven pandan products in Tipang Village, North Sumatra Province. This aim was to develop sustainable methods for woven pandan leaf products. The research method uses an experimental process with a practice-led research approach to applying natural dyes in the context of arts and crafts. Experimental samples were obtained by staining using a type of mordant group, namely *tegeran* and *tingi* wood extraction, as well as a container group from fermented *tarum* leaves (Indigofera). The number of samples used was 6, with 1 sample without color, two with tegeran wood dye, two with tingi wood, and 1 with arum leaves. The analysis and evaluation process uses visual analysis assisted by greyscale image assessment via the Matlab application. The findings show that the application of natural dyes of the mordant group with fixation using lime has a more intense and even color quality with an R.G.B value of around 0.5 - 0.6 or an index value of around 135 -143. Meanwhile, natural dyes in the vessel class have uneven colors, so further experiments must be conducted to produce good colors. Thus, natural dyes from the mordant group can be applied to woven products made from pandan leaves.

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1. Introduction

The abundant natural resources of the Indonesian archipelago offer significant potential for its various communities to engage in diverse craft production activities. Craftsmen who are skilled at using locally available materials to create products and generate income are called pre-industrial craftsmen [1]. Weaving constitutes a significant aspect of Indonesian craft traditions. This process involves the interlacing of fibers to create rigid structures, typically forming products such as baskets, bags, or furniture. Woven artifacts are predominantly characterized by their utilization of natural fibers derived from plant matter, including leaves and stems. The advantages of natural fiber as a material in industry are that it is cheaper and environmentally friendly [2]. The weaving technique is done by intertwining materials that form ribbon knots so that they reinforce each other and create a repeating pattern. Woven products are categorized as craft because of their process, which requires hand-skilled techniques to create both functional and aesthetic values. Craft is inherently aesthetic, making it a valid art form. Its strong focus on visual and tactile aspects greatly enhances its artistic value [3]. Crafts such as self-expression can be found in cultural forms such as traditional art [4]. Craftspeople must ensure that the objects they create have aesthetic values [5]. Techniques and materials in craft can use all types of materials and produce various forms of work [6].

Several regions in Indonesia use plants as woven materials, one of which is Tipang Village, North Sumatra province. The people there, especially in Tipang Village, use thorned pandan leaves (Pandanus Tectorius) to make woven crafts in various shapes, such as baskets, woven bags, and other types of containers. In the Batak language, woven pandan thorns are called "baion" and grow abundantly in Tipang village. Woven pandan leaf products can have a high selling value if managed well [7]. However, one of the weaknesses of the woven pandan leaf products produced by the people in Humbang Hasundutan is that they do not apply coloring to the products. This can mean that their products do not have variations in colors and motifs, hindering product development. So, there is an opportunity to increase product innovation by applying new coloring techniques while improving quality and producing a wide variety of woven products. Innovation relies on reusing existing knowledge in new ways [8]. Especially because the value of craft works of art is seen based on compositional experiments, design principles, and artistic elements [9]. Although previous studies have applied natural dyes to woven products, little research has discussed the application of natural dyes to woven products made from pandan leaves. Based on this, the aim of this research is to apply natural dyes to woven pandan leaf products in Tipang Village, Humbang Hasundutan Regency, North Sumatra. This study also aims to contribute to providing inspiration for innovation and creativity in creating innovative craft products [10], especially in making woven pandan leaf crafts. In addition, collaboration between researchers as industrial designers and craftsmen groups can stimulate the development and preservation of local crafts through sustainable concepts [1]. Several studies have explained that natural dyes can be applied to woven products. For example, research conducted by Palilati *et al.* explains that natural dyes can be applied to woven products using the eco-print technique and produce various colors according to the type of color and mordanting [11]. Research by Lipikuni & Silla (2024) explains that okomama woven crafts have the basic material of palm leaves with natural dye from indigo leaves or tarum (indigofera) [12]. Then Nuwa *et al*. explained that ginger can be used as a natural dye in woven rattan products and gives an attractive color to the rattan that is made into woven material [13].

Natural dyes are color solutions obtained from nature, such as from plant or animal parts [14]. Natural dyes can be found in several parts of plants, such as stems, leaves, fruit, roots, and flowers [15], [16]. Natural dyes have been used since ancient times to color craft materials. Natural dyes are one of the oldest techniques used by ancient civilizations [17]. Over time, the use of natural dyes in Indonesia began to shift from 1960 to the use of synthetic dyes [18]. In fact, synthetic dyes have a dangerous impact on the environment. Many industries use synthetic dyes, which cause environmental pollution [19]. Synthetic dyes used in the woven industry are a potential chemical hazard and pose a risk of causing irritation, shortness of breath, and coughing, so natural dyes are an alternative to reduce this impact [20]. Exploring environmentally friendly dye resources helps increase environmental awareness and reduce synthetic chemical use [21]. So, applying natural dyes to woven products can help improve product quality and increase the use of environmentally friendly resources. Natural dyes are harmless and non-toxic, so they are safe for both the health of the people and the environment [22]. The environmentally friendly aspect of woven crafts has the potential to add value to the industry [1]. Apart from that, natural dye raw materials also have the potential to be planted around the industry and utilized by the industry itself [23].

2. Method

This research uses an experimental method with a practice-based research approach. The experiment was carried out in the form of a one-shot case study pre-experiment. The experimental method is used to obtain results from the effects of certain treatments under controlled conditions. The use of a one-shot case study is a limitation of research because it focuses on samples that are given treatment, and then the results are analyzed at the post-test stage. The treatment process in this research is the application of natural dyes to woven pandan leaves with experimental samples obtained by dyeing using a type of mordant group, namely tegeran and tingi wood extraction, as well as a container group from fermented *tarum* leaves (Indigofera). The number of samples used was 6, with 1 sample without dye, two with tegeran wood dye, two with tingi wood, and 1 sample with tarum leaves. For jemis mordant dye, a

fixation process is carried out using alum and lime. The analysis and evaluation process uses visual analysis assisted by greyscale image assessment via the Matlab application. In practice-based research, the results are implemented into new craft products in the sense that the research becomes the basis for practice. Practice-led research uses visual skills in communicating and applying concepts, interpretation, and evaluation, so this will occur in collaborative research to share information, get feedback, and generate new ideas [24], [25]. In the research process which is guided by practice, researchers explore ways information can be processed into works of art and text form [26]. This research exploration focuses on natural dyes and their application to woven materials made from pandan duri leaves in Tipang Village, Humbang Hasundutan Regency.

The data collection procedure uses a naturalistic approach with participant observation, where everything is seen, heard, and recorded in field notes [27]. Primary data sources were collected from the process of making natural dyes, coloring pandan leaves, and making woven crafts. The secondary data source comes from literature studies, which are data taken from books, journals, and previous research. The research design as an experimental will be carried out as follows: (a) Applying dyeing dry pandan leaves using natural dyes based on mordant and vessel groups with the same soaking time of 24 hours. The mordant class of dyes used is the extraction of Tingi wood (Ceriops tagal) and tegeran wood (Cudrania javanensis) with lime (Ca(OH)2) and alum (K2Al2O4) fixation. The mordant process functions as a binder between the dye and the fiber [15]. Meanwhile, the vessel group uses fermentation from tarum (Indigofera) leaves; (b) Samples that have been colored through immersion are dried in the sun until dry. Then, a concentration test process was carried out using a grayscale image using the Matlab application to obtain the color intensity value produced by the natural dye solution; (c) Apply colored pandan woven material to the woven product, and the color results are analyzed visually. Can be depicted in Fig.1.

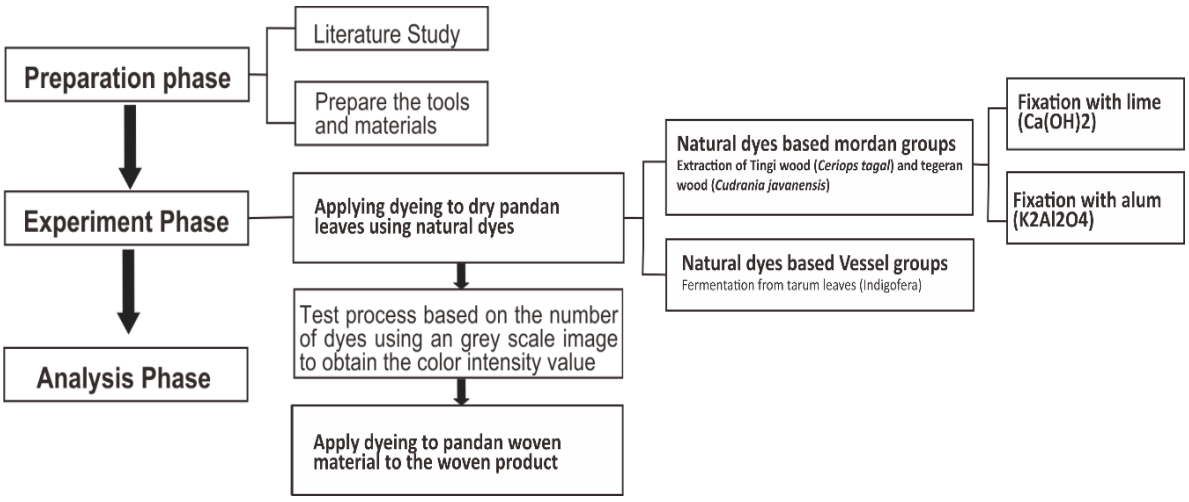

Fig. 1.research flow chart

3. Results and Discussion

3.1. The Process Of Making Natural Dye Solutions and Their Application

Based on the use of natural dyes, two processes for making dye solutions are carried out, namely the extraction technique for the mordant class and the fermentation technique for the vessel class. Natural dyes of the mordant type are obtained from the extraction process. The coloring materials used in this group are tingi wood and tegeran wood extraction. Each dye uses 2 kg of material, which is boiled in 10 liters of water. The vessel group is obtained from glucosides' fermentation and air oxidation processes. Vessel dye is usually obtained from fermented tarum plants (indigofera). The following is Table 1 of the process for making natural dye solutions, extraction, and fermentation techniques.

Table 1. Process of making natural dyes solution

Extraction Process	Fermentation Process
Tingi and tegeran wood materials were sorted and collected separately in quantities of 2 kg each. Put each ingredient in a pan and mix with 10 liters of water. Boil the wood at a temperature of 950 - 100 0 Celsius for 2 hours until half the water remains or until the solution thickens. After the boiling process is complete, the solution is filtered until it separates from the wood parts, then the solution is ready to use.	Fermentation involves soaking 2 kg of leaves and twigs in 10 liters of clean water. The soaking process is carried out for 24 hours until the solution is dark blue. The reduction process is mixing 30 grams of quicklime dissolved in 5 liters of water. Then, the solution is stirred until the blue foam appears to turn greenish-yellow Oxidation process, namely the boiling process for 60 minutes or until the foam or froth disappears The sedimentation process involves settling the solution for 30 minutes until the solution in the form of a paste settles and separates from the water. Then, separate the paste solution with water. After that, the paste solution is ready to use.

After making the natural dye solution, the next process is applying it to the pandan leaf material. The process of staining the mordant group and the vessel group has a different method. Mordant natural dyes require a mordant process in which the position of the hydrogen element is replaced by a metal element that functions as an acceptor while the dye acts as an electron donor (ligands). Meanwhile, the vessel group in the form of indigofera paste needs to go through a reduction process using glucose. For the mordant process, this research uses a solution of lime and alum; for the vessel class, the reduction process uses brown sugar. Before dying, the woven material in the form of pandan leaves is cleaned off the prickly edges and dried. The following is the coloring process for each type of dye in Table 2.

Table 2. Stages of pandan leaf coloring

Coloring Using Mordant group	Coloring Using Vessel Groups
Clean and dry pandan leaves are soaked in a solution of tingi and tegeran with 1 kg of pandan leaves each. Then, put a weight on it so that the leaves can be completely submerged and let it sit for 24 hours. After soaking, the pandan leaves are dried in the sun for 3 hours until dry. Drying is done in a shady place and avoids direct sun exposure. The next stage is the mordant process, which involves soaking the pandan leaves in the mordant solution for 1 hour. Soaking is separated into two parts, namely, a lime solution and an alum solution. Lime solution mordant with the following measurements: 50 grams of lime (Ca(OH)2) dissolved in 1 liter of water, then stirred and left for 24 hours. Alum solution mordant with the following measurements: 70 grams of alum (K2Al2O4) dissolved in 1 liter of water, then stirred and left for 24 hours. The mordanted pandan leaves are then washed clean and dried in the shade until dry.	The reduction process, namely 2 kg of indigofera paste, is dissolved in 10 kg of water and mixed with 2 kg of brown sugar, which has been dissolved in 2 liters of water. After that, the solution is stirred until mixed with the brown sugar. After that, 1 kg of dry pandan leaves are put into the solution and weighed so that they are completely submerged. Then, the marinade is left for 24 hours. The next stage is to dry the soaked pandan leaves in the shade and away from the sun.

After coloring the woven material as a sample, the color density test process is carried out by identifying the color intensity using a grayscale image with the help of the Matlab application. This process is carried out to see the intensity of color density that occurs from each sample that has undergone a different dyeing process and type of fixation. In a grayscale image, the R.G.B. value for white is presented with a value of 12 and perfect black with a value of 0, while the index value for perfect white is presented with a value of 255 and perfect black with a value of 0. The higher the R.G.B. and index values, the lower the color density intensity. Conversely, the lower the index value, the higher the color intensity. The highest score is taken as the assessment result. The following Table 3 shows the results of the staining and color density assessment.

Table 3. Coloring results of woven pandan leaf material

Coloring	Visual	Information
Not through coloring		The natural color of dried pandan leaves is pale gray.
Coloring uses tegeran wood extraction with lime fixation.		The lime fixation reaction produces a yellow color. R.G.B value: 0.6 Index: 143
Coloring uses tegeran wood extraction with alum fixation.		The alum fixation reaction produces a pale yellow color. R.G.B value: 0.7 Index: 156
Coloring uses Tingi wood extraction with lime fixation.		The lime fixation reaction produces a reddish-brown color. R.G.B value: 0.5 Index: 135
Coloring uses Tingil wood extraction with alum fixation.		The alum fixation reaction produces a light brown color. R.G.B value: 0.6 Index: 140
The coloring uses tarum (Indigofera) tree fermentation without fixation.		Tarum (Indigofera) Produces blue and greenish-yellow colors, but the color is not perfectly even R.G.B value: 0.5 Index: 132

After carrying out coloring experiments, the next process is applying colored woven material into a woven product. Application is carried out by combining several colors with uncolored woven material. This aims to see the visual form of woven pandan leaf products that are given natural dyes. The following are the results of applying natural dyes to woven pandan leaf products, as in Fig 2.

Fig. 2. Results of applying natural dyes to woven pandan leaf products

The application of natural dyes to woven products produces more visible colors in contrast to uncolored woven materials. The results of applying natural dyes to woven pandan leaf products show that natural dyes can add color composition and motifs to make product colors more diverse and attractive. This shows that woven pandan leaf material that has been given natural coloring can be applied to woven products made from pandan leaves.

3.2. Analysis of color results on woven products

Based on the coloring results, it can be seen that the mordant dyes in the woven pandan leaf material can absorb the color more completely and evenly. Assessing color density, it can be seen that the yellow wood extraction mordant dye with lime fixation has an R.G.B value of 0.6 and an index value of 143, while alum fixation has an R.G.B value of 0.7 and an index value of 156. For high wood extraction dyes with fixation, lime has an R.G.B. value of 0.5 and an index value of 135, while alum fixation has an R.G.B. value of 0.6 and an index value of 140. These values show that natural dyes from the mordant group of yellow wood and tingi wood can produce quite deep colors. The results of the assessment for the mordant group show that lime fixation has a higher value, so lime fixation has a better concentration than alum fixation. This aligns with research by Palilati et al., which explains that natural dyes in woven fabric with lime fixation produce a more intense color than alum fixation [10]. The same opinion from research by Oetopo et al. states that lime fixation produces better color density than other fixations [28]. Natural dye from tingi wood extract (Ceriops tagal) produces a brown to reddish color on the woven pandan leaf material. In line with the opinion of Manohar *et al.* that the tannins of Soga tingi wood are of the procyanidin type, resulting in a reddish brown color [29]. Tingi wood has quite high tannin levels, so it is very good for use as a natural dye [30], [31]. Meanwhile, the natural dye for tegeran wood (Cudrania javanensis) produces a yellow color on the woven pandan leaf material. The natural dye of tegeran bark produces a yellow color [32].

Based on the most intense color, the Indigofera dye in pandan leaves has an R.G.B. value of 0.5 and an index value of 132. This value shows that the Indigofera dye produces a fairly dense color. In contrast to the mordant group, the woven pandan leaf material is difficult to absorb in the Indigofera fermentation type of the Vessel group, so it is not absorbed well, and the color is uneven. The coloring process produces blue spots, and the evenness of the blue color only appears on the edges of the leaves, while in the middle, it produces a greenish-yellow color. This is in line with the opinion of Avinc et al., who state that sometimes natural dyes are not completely absorbed, so some only stick to the surface [33]. However, in Lipikuni & Silla's research, the indigo or tarum (indigofera) plant actually produces a black color because the process does not go through fermentation, and the colored material is palm leaves [12]. This shows that making colors and materials can influence the results of natural dye from Indigofera plants. The results of applying natural dyes from the three materials used show that natural dyes produce distinctive colors and are not too strong like synthetic dyes. Basically, the colors produced by natural dyes produce distinctive colors that tend to be paler [14]. Apart from that, the use of mordant is not only a color binder, but also helps in generating color [17]. The appearance of the color produced by natural dyes is also influenced by the binding or fixing agent [34]. The mordant process can change or enhance the color [15]. So, this type of mordant can also be an alternative when choosing colors when people want to make woven products made from pandan leaves.

4. Conclusion

Based on the experimental results of applying natural dyes to woven pandan leaves in Tipang Village, Humbang Hasundutas Regency, it was found that local pandan leaves can be colored with natural dyes such as mordant and vessel. The mordant groups that can be used are tegeran wood extraction and tall wood extraction, which have good color quality results. Meanwhile, the vessel group fermented with tarum leave (indigofera) produces poor and uneven color. The assessment results in the mordant group showed that lime fixation had a higher value in each type of color environment, so lime fixation had a better concentration than alum fixation. However, each fixation produces a different color. Therefore, applying natural dyes to woven pandan leaves can be adjusted to suit your creativity and desires for the colors used. Through this research, craftsmen have new innovations in making woven products with natural dyes, especially using natural dyes such as mordant and vessel. As a pre-experimental research method of the one-shot case study type, the research results are limited to samples that used direct treatment without a controlled sample. Therefore, in future research, it is hoped that controlled experimental tests can be carried out, such as the amount of material or the amount

of dyeing tested by assessing the strength of color fastness. Natural dye in woven pandan leaves. So that the use of natural dyes in industry can be developed more optimally.

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Declarations

Author contribution	:	FP: research idea, analyzing data, and writing articles; AM: analyzing data, translating articles, and writing articles; FA: data collection, data reduction, and writing articles
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