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Reed Dyeing from Color Plants in Khao Phluang Forest and Neighborhood of Chai Badan Phiphat College, Chai Badan District, Lopburi Province

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Abstract This research investigated 1) a dyeing method for reeds, and 2) types of color plants found in Khao Phluang Forest, Chai Badan District, Lopburi Province, and mordants affecting shade (CIEL*a*b*) and color fastness. The tool for color measurement was a Chroma meter: Konica Minolta CR – 400. The measurements of color were performed after airing; then the dyed reed was washed with distilled water. Next, it was aerated for seven days before the remeasurements of the color values.
The reed dyeing process involved soaking the reed in warm water for an hour, followed by soaking it in a mixture of alum, sodium bicarbonate, and lukewarm water for 30 minutes. After aeration, the reed was boiled in the dyeing water for 20 minutes. Color measurements revealed that reeds dyed with turmeric and neem barks, and neem leaves resulted in shades of yellow, red, and brown, respectively. The reed dyed with turmeric, using tamarind juice as the mordant, exhibited the strongest color (CIEL*a*b* = 48.68, 15.01, 41.56). Meanwhile, reeds dyed with neem barks appeared in a shade of red. The use of neem leaves as the dyeing plant did not yield any significant difference from the undyed reed at a significance level of .05.

Keywords Reed; Dyeing; Color plants; Mordant; Khao Phluang forest

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Introduction

Phranakhon Rajabhat University has implemented a local development strategy in Chai Badan District, Lopburi Province, where the Chai Badan Phiphat Campus is located and falls under the university's responsibility. In the fiscal year 2022, Phranakhon Rajabhat University participated in the Royal Project on Plant Genetic Conservation, initiated by Her Royal Highness Princess Maha Chakri Sirindhorn. The Princess established this project to conserve and utilize resources within a 50-kilometer radius of Chai Badan Pipat College, Phranakhon Rajabhat University. Chai Badan District is rich in natural resources, culture, and wisdom, with its administrative area divided into 17 sub-districts and 136 villages. The area is home to the biodiversity of Khao Phluang forest, housing various plant and animal species. One noteworthy cultural aspect discovered during a survey in Tambon Tha Din Dam, Village Moo 1, is the reed mat weaving group. This group, known as the "Tha Din Dam Reed Mats Weaving Group", utilizes reeds from a public community area to weave reed mats, a traditional skill passed down through generations. Additionally, the group creates other items such, as hats and water bottle holders, using this technique. However, the group faces challenges related to dyeing the reeds. They use expensive chemical dyes, leading to water pollution and health risks. Research by Thongthummachat et al. (2011) found that chemical dyes used for reed dyeing were contaminated with heavy metals, specifically lead and chromium. Lead content in the reed dyes ranged from 0.8926 µg/kg (yellow shade) to 0.8374 µg/kg (purple shade). Chromium content in synthetic reed dye averaged 0.5642 µg/kg, while in natural red and purple dyes, it was 0.3966 µg/kg and 0.3161 µg/kg, respectively.

Due to these issues, the group is interested in using natural dyes from plants found in the Khao Phluang forest to color reeds to solve this issue and broaden the range of products. The study of plants that can be used for dyeing techniques for dyeing reeds from plants and the use of various types of mordants for enhanced fastness and diverse shades were motivated by this problem. Silk and cotton dyeing are the main subjects of most research on natural dyeing. There have been few studies on reeds that have been naturally dyed. A study by Thongthamtham et al. (2011) examined the shades of reeds dyed with distilled water and vinegar with turmeric, neem bark, and butterfly pea flowers. The measured values showed that dyeing reeds with natural colors produced light tones. It was found that turmeric and neem bark, produced similar shades when used with distilled water and 1% vinegar. However, butterfly pea flowers gave a blue hue with distilled water and turned purple when 1% vinegar was used. The color of the reeds dyed with natural dyes from turmeric, neem bark, and butterfly pea flowers faded after being exposed to sunlight for 10 days. Pimchan (2021) conducted a study on the production and development of natural reed dyes using three types of plants: Luk Wa, Fang, and Turmeric. The study also investigated the effects of three types of mordants: Sodium Hydroxide, Potassium, Aluminum Sulphate, and Acetic acid. After extraction, it was found that the Luk Wa, Fang, and Turmeric, extracts when extracted with water at 80 °C, yielded purple, red, and yellow colors, respectively. The color of the dyed reeds was analyzed using a Chroma meter: Konica Minolta CR-400. Namakorn et al. (2020) investigated the factors of dye types, dyeing methods, and concentrations of mordants affecting the color hue (CIE Lab*), color intensity (K/S), and color fastness of the reeds. The study found that Potassium and Aluminum Sulfate affected the color shade. Reeds dyed with shellac exhibited a reddish hue; the optimum concentration was 2 g/L. The use of shellac improved the colorfastness when exposed to light, but it did not affect the residual fastness from abrasion. According to the findings of these investigations, choosing color plants and using mordants are crucial for color retention and shading effects in plant-based reed dyes. Therefore, this study used previously researched plants to dye reeds with natural colors for the reed mat weaving group in Moo 1, Tha Din Dam Sub-district. Different plant parts, were employed, including the bark, rhizome, and leaves. Locally accessible mordants were chosen including, red lime, tamarind, and banana ash. This research on dyeing reeds with natural colors will produce distinctive, environmentally friendly, and health-

friendly products by lowering health hazards, environmental difficulties, and production costs. Furthermore, it acts as a social capital database and increases community understanding of the importance of local natural resources. This database can be used as a guideline to ensure the persistence and sustainable development of cultural resources and traditional knowledge.

Research objectives

1. To study the process of dyeing reeds using color plants from the Khao Phluang forest and the vicinity of Chai Badan Pipat College, Lopburi Province.
2. To investigate the impact of dyeing reeds with color plants from the Khao Phluang forest and the vicinity of Chai Badan Pipat College, Lopburi Province.

Research hypothesis

Colors obtained from different plants and mordants had different shades at a significance level of .05.

Research method

This research was an experiment on the dyeing process and the color of dyeing reeds by using natural dyes from color plants found in the Khao Phluang forest and Chai Badan Phiphat college area, namely turmeric, neem bark, and neem leaves and using 3 types of mordants as follows: red lime, banana ash, and tamarind. Plants for color were collected in March 2022.

Reed dyeing process

This study utilized color plants primarily sourced from the Khao Phluang forest and the Chai Badan Phiphat College area, turmeric, neem bark, and neem leaves. The dyeing process, modified from the method outlined by the Office of Community Technology (Jindawutkul, 2019), involved the following steps:

1. Cleaning the reeds: Soaking them in warm water for 1 hour, then soaking them in slightly boiling water mixed with 10 grams of alum and 10 grams of sodium bicarbonate per 500 ml of water for 30 minutes, then air drying them.

Figure 1 The method for cleaning reeds

2. Preparation of dye solution from color plants: turmeric rhizomes are washed, cleaned and pounded thoroughly, neem barks are chopped into small pieces, and neem leaves are cleaned. Then,

prepared plants are boiled in 5 liters of boiling water for an hour and taken out. Then 10 grams of salt is added to this dye solution.

Figure 2 The preparation of dye solution from color plants

3. Preparation of mordants: This study utilized locally available mordants, such as banana ash, tamarind, and red lime, by adding the mordants during the dyeing process. This method saves more time than soaking reeds with mordants before or after dyeing. In this process, 20 g of mordants are added to 500 ml of water for 1 hour.

4. Dyeing: The reeds prepared in step 1 are immersed in the pot of boiling dye solution from step 2 for 20 minutes. Then, the mordants prepared in step 3 are added. The pot containing the dye solution and reeds is removed from the stove and left to stand for 1 hour. After that, the dyed reeds are taken out and air-dried.

Color testing

The colors of the dry-dyed reeds are measured using a Chroma meter: Konica Minolta CR-400. The color fastness is evaluated by washing them with distilled water for about 3 minutes and then air drying them for 7 days before measuring the color. Three locations on each reed strand are measured for colors.

Results and discussion

Effect of dyeing

The reed dyeing process consists of the following steps: 1) Cleaning the reeds: Soaking the reeds in warm water for 1 hour, then immersing them in slightly boiling water mixed with 10 g of alum and sodium bicarbonate each per 500 ml of water for 30 minutes, and finally air drying them. 2) Preparation of the dye solution: Boil 1 kg of color plants in 5 liters of water for 1 hour and add 10 g of salt. 3) Preparation of the mordants: Dissolve 20 g of mordants in 500 ml of water. Next, add the mordants to the boiling dye solution and let them simmer for 1 hour. According to Apichart Sonthisombat (2002), combining mordants with the boiling dye solution simultaneously for the cotton

dyeing process can save time and energy. However, this method prevents the reuse of the dye solution. Therefore, preparing the dye solution meticulously is as crucial as it cannot be stored for future use. For dyeing, immerse the reeds in the colored water and boil them for 20 minutes. Afterward, remove them from the heat and let them soak in the colored water for 1 hour before air drying. Previous research by Pimchan (2013) involved dyeing reeds with turmeric, heating them at 70^{o}C for 1.30 hours, and allowing them to cool at room temperature for 1 hour. However, this method made brittle reeds that were prone to breaking, making them unsuitable for weaving into mats. To address this issue, the dyeing method was adjusted by reducing the reed boiling time to 20 minutes.

The effect of dyeing using color plants such as turmeric, neem bark, and neem leaves, and employing mordants like red lime, banana ash, and tamarind, is shown in Table 1.

Table 1 Coloring on reeds from plant-based dyes and mordants

Color plants	**Mordants**		
	Red lime	**Banana ash**	**Tamarind**
Not Dyed			
Turmeric			
Neem bark			
Neem leaves			

From Table 1, it was found that turmeric made the reeds yellow. The tamarind gave the darkest yellow color. The neem bark gave a reddish- brown color. This result was consistent with Thongthammachat et al. (2011). They also found that turmeric gives yellow and the neem bark gives reddish hue. The three types of mordants gave a little difference in color hues, but the differences were not noticeable. Color from neem leaves with 3 mordants did not attach on reeds. Figure 3 shows products that are dyed with turmeric and neem bark.

Figure 3 Reed mats and wicker products are dyed with turmeric and neem bark.

Color hue analysis and color fastness of reeds measured by Chromameter: Konica Minolta CR-400.

Reeds were dyed with turmeric, neem bark, and neem leaves using mordants such as red lime, banana ash, and tamarind, after aeration until dry and washed with distilled water and left for 7 days. The results of the study are shown in table 2.

Table 2 Colors of reeds with dyes from different color plants and mordants.

Color Plants	Mordants	Colors of reeds					
		L*		a*		b*	
		1 Day	7 Days	1 Day	7 Days	1 Day	7 Days
Not dyed	-	63.10	54.46	10.55	9.81	24.08	21.36
Turmeric	Red lime	50.68	55.79	10.00	10.33	33.93	32.89
	Banana ash	51.25	52.39	13.01	12.18	37.65	38.06
	Tamarind	48.68	59.55	15.01	13.54	41.56	55.99
Neem bark	Red lime	37.51	42.88	10.95	12.52	18.75	21.05
	Banana ash	39.87	41.29	10.67	12.63	18.13	21.06
	Tamarind	40.56	41.56	11.80	10.93	20.13	20.42
Neem leaves	Red lime	42.41	43.33	11.28	9.85	23.47	22.61
	Banana ash	42.83	48.17	10.02	10.01	21.94	22.28
	Tamarind	44.56	51.21	11.15	9.92	25.19	23.12

Note: The color values presented are the average values obtained from the three measurements.

L* indicates luminance value, a* indicates red value, b* indicates yellow value.

From Table 2, it was found that the average L* values of undyed reeds were more significant than those of dyed reeds. The average a* values on the first and 7 days of reeds dyed with turmeric/tamarind were the highest (15.01, 13.54) and turmeric/lime gave the lowest a* value (10.00). When washed with distilled water and left for 7 days. The undyed reeds had the lowest a* value (9.81). The average b* values on the first and 7 days of reeds dyed with turmeric/ tamarind were the highest (41.56 and 55.99).

In addition, it was found that the L* brightness of the undyed reeds was greater than that of the dyed reeds. The red a* value of the turmeric/tamarind-dyed reeds was the highest (15.01, 13.54) and the turmeric/ red lime gave the lowest (10.00), but when washed with distilled water and left for 7 days, undyed reeds was the least (9.81). The b* values of turmeric/tamarind-dyed reeds were the highest (41.56 and 55.99). When washed with distilled water and left to dry for 7 days, it was found that the values of L*, a*, and b* increased, consistent with the study of Thongthamtham et al. (2011), which found that turmeric and neem bark in distilled water and acetic acid gave yellow and brown colors, respectively. When the dyed reeds were washed with distilled water and dried for 10 days and 20 days in the sun, it was found that the L* brightness increased in all samples, the red a* and b* values decreased, but the yellow colors faded which indicates that the color intensity has decreased.

Hypothesis test results

The colors produced with various mordants exhibited shades at a significance level 0.05. As indicated in Table 3, the color difference of the reed utilized with each mordant was determined using ANOVA and Bonferroni.

Table 3 The comparison results of color shades classified by the types of color plants and mordants

	SS	**df**	**MS**	**F**	**p-value**
Turmeric					
L*	385.301	3	128.434	34.003	0.000*
a*	48.394	3	16.131	11.918	0.003*
b*	505.632	3	168.544	21.315	0.000*
Neem bark					
L*	1288.599	3	429.533	266.500	0.000*
a*	2.893	3	0.964	0.642	0.609
b*	64.350	3	21.450	10.412	0.004*
Neem leaves					
L*	893.449	3	297.816	149.395	0.000*
a*	3.045	3	1.015	0.604	0.631
b*	16.534	3	5.511	1.319	0.334

*P < 0.05

From Table 3, it was found that the L* and b* values of the undyed reeds and the turmeric-dyed reeds were significantly different at .05. Turmeric-dyed reed/lime red and turmeric/tamarind dyed reeds were significantly different at .05. For neem bark dyed reeds, the color of the dyed reeds, L* and b* were significantly different from the neem bark-dyed reeds. In contrast, the a* values were not significantly different at .05. The L* values of the undyed reeds and the reeds dyed with neem leaves were significantly different at the .05 level.

Table 4 Comparison of shade values of reeds dyed with different types of color plants and mordants when dried and washed with distilled water for 7 days with undyed reeds

Shade values	Color plants/ Mordants	Mean	T	df	Sig. (2-tailed)
L*	Turmeric/Tamarind	-10.86333	-12.714	2	0.006*
b*	Turmeric/Tamarind	-14.42667	-9.356	2	0.011*
a*	Neem bark/ Red lime	-1.57667	-6.264	2	0.025*
b*	Neem bark/ Red lime	-2.30000	-9.082	2	0.012*
L*	Neem leaves/ Banana ash	-5.34000	-11.029	2	0.008*

*P < 0.05

According to Table 4, there were no variations in L* brightness, a* reddish hue, and b* yellowish hue between reeds colored with turmeric and red lime, tamarind, and banana ash, and reeds dyed with neem bark and red lime. However, it was discovered that after washing with distilled water and drying for 7 days, reeds dyed with turmeric and tamarind had differing impacts on L* brightness and b* yellow shade. The color had faded. The L* brightness of reeds dyed with neem leaves and banana ash dramatically altered after washing with distilled water and aerating for seven days, as shown in Table 4. Worachetwarawat & Worachetwarawat (2018) researched how slowing down the fastness of the process of dyeing silk with nipa palm fruits and ash. The resistance to color fastness after washing was also provided by red lime. According to Pimpraphon (2015) and Patranich (2013), the dyeing procedure for silk using natural color extracts from Litsea glutinosa (Lour) leaves was compatible with tamarind and red lime and increased the fastness. Each species of colored plant, though, responds best to a particular mordant. The dyeing of cotton fabric with turmeric extract solution is an experimental method. Rahman et al., (2020) found that mordant can enhance the color fastness properties of cotton fabrics dyed with turmeric extract, comparatively better than without mordant.

Conclusion

Cleaning the reeds, preparing the dye solution, preparing the mordants, and dying are the four processes of the color plant dyeing procedure. The attachment of color to different plants varies when using them to dye reeds with mordants and color plants. Using tamarind as a mordant, for instance, intensifies the color of turmeric, which lends a yellow hue. A reddish hue can be seen in neem bark. The color value is consistent between mordants. Neem leaves are not ideal for dying reeds since they do not adhere effectively. The shade values decrease after washing with distilled water and being left for 7 days, demonstrating how weakly the dyes from color plants are.

Suggestions

1. Like fabric dyeing, reed dyeing is inappropriate for heat dyeing. The reeds will become brittle if left in boiling water for an extended period. Because they break too easily during weaving, the products manufactured from these reeds are short-lasting Regarding cold dyeing, the reeds will not retain the color. Therefore, it is not suggested to use procedures that do not include soaking the reeds in boiling water or soaking them in any water. The dye solution and soaking water must be moderately hot and cold. The appropriate procedure is to bring the dye solution to a boil, then remove it from the stove, switch off the heat, and soak the reeds in hot water. Longer dye solution soaking times will aid in improved color absorption for the reeds, albeit data on this point were not gathered for this study. It is necessary to conduct additional research on the length of time the reeds are soaked in the colored water, as this impacts their color.

2. This study was conducted within a limited timeframe, making it impossible to assess color fastness by collecting color shade values at different intervals. In future studies, color fastness should be examined over various durations. Additionally, the tensile strength of dyed and undyed reeds should be investigated to determine the suitability of the dyeing method and assess how the quality of the reed's changes over time.

3. For dyeing trials, other local plants should be considered for dyeing experiments. This could maximize the utilization of available local resources by revealing a larger spectrum of colors obtained from plants. These results could be useful models for upcoming research on reed dying.

4. Dyeing with natural dyes is a more intricate and time-consuming process compared to using chemical dyes. Studying consumer preferences and promoting environmentally friendly products might be essential for understanding color attachment and stimulating demand.

5. This study did not determine ΔE. In the next study of color attachment, the color difference should be determined by ΔE values for each condition.

6. The use of mordants effects the coloration of plants on reeds. Therefore, the use of mordants in terms of types and the appropriate amount of mordants should be experimented with to provide more variety.

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