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Research Article

Effect of Fastness Properties Natural Indigo Dyed Cotton and Silk Fabrics from *Strobilanthes Cusia* (Nees) Kuntze

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Abstract

The quality of Mor Hom clothing, a well-known traditional fabric of Phrae Province, is diminished by the use of chemical indigo dyes. Increased understanding of how to prepare indigo paste and indigo dye as well as the utilization of *Strobilanthes cusia* (Nees) Kuntze, known as Hom, is necessary to raise the value of regional plant and community products. We discovered that soaking the harvested fresh leaves in 30°C water for 36 hours was the best condition for indigo paste preparation. The high-quality blue dye was created by mixing a kilogram of indigo paste with two liters of pH-14 alkaline water and 200 milliliters of tamarind sauce as a natural source of tartaric acid. This formulation provided the finished colored cottons with a high wash fastness scale.

The number of dye applications improved the fastness characteristics, with cotton fibers producing garments with richer colors than silk. Cotton and silk materials had color strength (K/S) values of 10.26–33.15 and 4.39–15.19, respectively. Both treated clothes scored 5 in color and staining at a 40°C laundry temperature, with no fading. On the other hand, increasing the washing temperature to 60°C made color fading on nylon materials more palatable. Additionally, natural mordants derived from the stem barks of *Oroxylum indicum* (L.) Vent., *Phyllanthus emblica* Linn., and Terminalia chebula Retz. as well as the leaves of *Psidium guajava L.*, *Senna siamea* (Lam.) H. S. Irwin & Barneby, and *Eucalyptus globules* Labill. demonstrated that mordanting and non-mordanting fabrics exhibited the same rate of wash fastness. This research helps local people make the best use of natural dye from Strobilanthes and supports local identity products.

Keywords: Hom, Indigo, Indigo paste, Production technology, *Strobilanthes cusia* (Nees) Kuntze

Introduction

The plant *Strobilanthes cusia* (Nees) Kuntze, commonly known as Hom in Thailand, belongs to the Acanthaceae family [1] and is divided into two categories based on their large leaves, which include the clones Phrae 1, Chiang Rai, Chiang Mai, and Phayao 1. And there are two types of small-leaf plant, *Strobilanthes* sp., Phrae 2 and Phayao 2 [2]. According to a study on the appropriate light intensity for plant growth, 70% shaded greenhouses and 60x50 cm of growing area were found to be the ideal environment for excellent production [3] Furthermore, the most productive harvesting period, which started nine months after planting, could be repeated every three months [2]. Because the yield was higher than at other times, the hours of 07.00-11.00 a.m. were excellent and ready to collect [4] Strobilanthes has long been used as a raw material for dyeing fabric, specifically Mor Hom.

The province of Phrae has consistently developed and promoted dyeing cloth products derived from Strobilanthes plant, leading to greater demand in both quantity and quality. The plant's leaves produced two distinct colors: indigo, a blue alkaloid, and indirubin, a red compound 6.8 times more potent than indigo [5] Indican, a colorless and water-soluble chemical, is found in the leaf. When Indican compounds react with hydrogen, they produce glucose and indoxyl. Indoxyl then reacts with oxygen in the air to form indigo, which is insoluble in water but soluble in alkali. Preparing indigo for dyeing requires balancing the conditions such as pH, temperature and amount of indigo. Under the right conditions, indigo is reduced to Leucoindigo or White indigo, which is yellow and water soluble. When exposed to air, Leucoindigo combines with oxygen to form blue and attach to the fabric fibers [6].

Natural dyes have no health risks, are easy to extract and purify, have mild dyeing conditions, and cause less environmental damage. It is a raw material that is available locally. The disadvantages associated with the use of natural dyes encompass poor color fastness properties and poor reproducibility of shades, which are mostly applicable to natural fibers [5]. The fermentation method calls for soaking fresh Strobilanthes leaves and stems in the cask to ferment them. The formation of foam on the water's surface necessitates careful shaking, indicating that the fermentation process is still in progress. The transformation of a plant part to red indicates that the fermentation process has been completed. Mash is most commonly used for direct coloring [7].

Materials and Methods

Effect Of Temperature and Soaking Time on the Quality of Indigo Paste

Fresh-cut leaves of *Strobilanthes cusia* (Nees) Kuntze were soaked in 30°C water for 12, 24, 36, and 48 hours, with a 48-hour soaking period at room temperature serving as a control treatment. Following the completion of the experiments, the fermented materials were extracted from the container and filtered through cotton cloth to collect the crude extract of indigo paste. The extracted indigo paste was weighed, and the indigo pigment was determined.

Indigo Dye Preparation

Six different therapies were tested, including alkaline water with pH levels of 12, 13, and 14, as well as tartaric acid in doses of 200 and 400 mL. The control treatment consisted of 200 mL of tartaric acid and lime water with a pH of 12. In a dye bath, one kilogram of indigo paste was completely blended with six liters of lime water to create an individual indigo dye vat. Tartaric acid was made by combining 100 g of tamarind with 200 ml of water and gradually adding it to the vat. The dark blue solution turns yellow after indigo has been converted to Leuco form and is ready to be colored. For one minute, thoroughly knead the 30x30 cm cotton clothes in the vat to allow the dye to properly permeate the fabric. Squeeze the colored objects to remove excess dye, then air dry for three minutes before hand washing them in water. After allowing the items to air dry for five minutes, dye them twice more. The color fastness to washing was evaluated using ISO 105-C01: 1989 and ISO 105-C03: 1989 methods.

Dye Count

Cotton and silk fabrics were colored in 1–9 repetitions. A kilogram of wet indigo, a liter of pH13–14 lime water, and 200g of tamarind sauce were used to make the dye vat. Wait until the mixture turns yellow, then gradually add 2 liters of lime water until the dye reaches 8 liters. The white cotton textiles were cut into 30x30 cm squares (144 total), hand washed, and air dried. Knead the prepared items in the vat for 2 minutes before removing excess dye solution and hanging for 3 minutes before hand washing in water. Following the set treatments, repeat the coloring. The finished items were tested for washing fastness and color measurement at Chiang Mai University.

Natural Mordanting

Stem barks from Indian trumpet (*Oroxylum indicum* (L.) Vent.), Indian gooseberry (*Phyllanthus emblica* Linn.), and chebulic myrobalan (*Terminalia chebula* Retz.) were used, as were leaves from common guava (Psidium guajava L.), Siamese cassia (*Senna siamea* (Lam.) H. S. Irwin & Barneby), and blue gum (*Eucalyptus globules* Labill.). Tannin compounds in all of the plants studied were analyzed prior to the experiments. A kilogram of individual mordant was boiled in 20L of water for 30 minutes and then filtered. Both fabrics were mordanted separately for an hour before being dyed three times in the indigo vat. The dye vat and the fabrics that were observed were prepared in the same manner as in the previous study. Fastness properties were investigated and the Hunterlab method was used to analyze dyed fabrics chosen at random.

Results

Effect of Soaking Time on The Quality of Indigo Paste

Table 1: Effect of water temperature and soaking time on the crude extract and indigo intensity.

Treatment	Crude extract (gram)	Indigo intensity (%)
30°C 12 hr.	77.9c	1.65a
30°C 24 hr.	159.4 b	0.79b
30°C 36 hr.	185.5a	1.00b
30°C 48 hr.	160.5ab	0.84b
Room temp., 48hr.	150.b	0.88b
Mean	146.8	1.03
CV(%)	11.2	15.7

The findings indicate that as the extraction period lengthened, the amount of crude extract rose. Soaking the leaves in 30 °C water for 36 and 48 hours produced the crudest extract (185.5 and 160.5g, respectively, which was not statistically different. The treatment with a 12-hour fermentation period yielded the least amount of wet indigo of (77.9g) (Table 1). The absorbance of the colored samples was determined at 414 nm. The 12-hour treatment in 30°C water produced the highest concentration of 1.65 percent indigo pigment, while the other treatments produced non-significantly different results. According to the data, the fermentation at 30°C for 12

hours produced the most indigo pigment but the least crude indigo extract. The optimal extraction time was determined to be 36 hours of soaking the Strobilanthes leaves in 30°C water to provide the ideal conditions for the wet indigo process by combining quality and quantity.

Indigo Dye Preparation

The extracts obtained at all designated pH levels were used for exhaust dyeing of cotton fabric under optimal dyeing conditions. It was discovered that increasing the extraction pH value to 14 and adding 200 tartaric acid resulted in a higher rate of washability on fabrics. Laundry temperatures at 40°C and 60°C yielded a fastness to washing scale of 4-5, indicating the observed items with barely faded in color (Table 2). Furthermore, the staining test to washing yielded a maximum scale of 5 with no staining on all tested types of fabrics. Except for the treatment of pH14 alkaline water and 200 ml tartaric acid, all treatments yielded the same score at 40 °C laundry temperature, whereas raising the temperature to 60°C yielded a score of 4 with slightly stained nylon fabric.

Table 2: Washing fastness of indigo dyed cotton fabric at 40°C and 60°C laundry temperatures.

	Washing Fastness Rating			
Condition	**Grey scale**	**40°C Color alteration**	**Grey scale**	**60°C Color alteration**
Alkaline water pH12+200 ml Tartaric	4	slightly faded	4	slightly faded
Alkaline water pH12+400 ml Tartaric	4	slightly faded	4	slightly faded
Alkaline water pH13+200 ml Tartaric	4	slightly faded	4	slightly faded
Alkaline water pH13+400 ml Tartaric	4	slightly faded	4	slightly faded
Alkaline water pH14+200 ml Tartaric	4-5	hardly faded	4-5	hardly faded
Alkaline water pH14+400 ml Tartaric	4	slightly faded	4	slightly faded

Dye Count

Table 3 shows the color characteristics of the dyed fabrics, including L*, a*, and b* values. The L* value indicates perceived darkness or lightness, with values ranging from 0 to 100 indicating color ranging from dark to white. The a* value represents redness (+a) and greenness (-a*), whereas the b* value represents yellowness (+b*) and blueness (-b*). The cotton and silk dyed color L* values were higher in the case of no dying samples, with 95.45 and 88.96, respectively, corresponding to lighter shades, whereas the L* values were lower in the case of 9 dying time samples, with 16.09 and 27, corresponding to darker shades. This meant that 9 dyeing times increased the darkness of the color on both cotton and silk fabric dyed, with silk fabric being lighter in color than cotton at the same treatment (Figure 1). The amount of kneading used during the dyeing process has a significant impact on the finished textile materials. Objects from W2 were handled by a skilled worker who carefully kneaded the tested items in the vat, as opposed to W1, which was handled by another operator. As a result, W2's end products are obviously darker than W1. Besides, the increasing dye count influenced the color strength of all treated cotton and silk, with cotton offering a higher K/S value than silk, ranging from 10.26 to 33.15 and 4.39 to 15.19, respectively (Table 3).

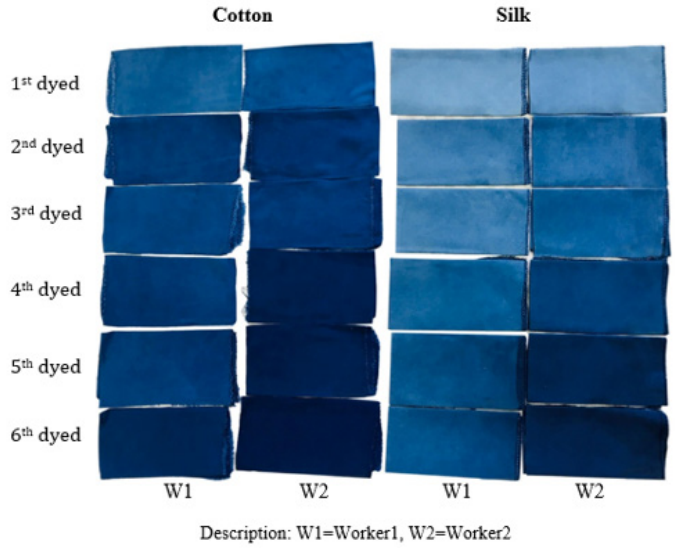

Figure 1: Cotton and silk dyed with natural indigo at various dye counts.

Table 3: CIE color coordinates and color strength (K/S) values of dyed cotton and silk fabrics.

Number of dyeing	Cotton				Silk			
	L*	a*	b*	K/S	L*	a*	b*	K/S
Untreated	95.45	0.43	-4.11	0	88.96	0.2	17.49	0.02
1st dyed	39.39	-2.75	-25.29	10	49.75	-6.1	-20.65	4.39
3rd dyed	34.14	-1.1	-25.79	15	42.33	-4.3	-22.46	7.62
5th dyed	29.63	0.22	-26.42	20	33.31	-1.3	-22.97	12.4
7th dyed	17.41	2.43	-17.92	31	30.88	-1.9	-17.67	12.3
9th dyed	16.09	2.64	-16.73	33	27	-0.6	-18.12	15.2

Color fastness testing at 40°C revealed that tested cottons were fast to washing on a scale of 5, which was reduced to 4-5 at 60°C. Unlike silk, the speed of washing at 40°C increased from 4-5 to 5 after three dye applications, but every treatment was 4-5 at 60°C. The light fastness was found to be fair (scale 4-5) after the first dyeing in both fabric materials when compared to untreated treatments that showed a 7-8 scale of light fastness. Cotton and silk had the same rate of fastness to light scale 5 after the third treatment (Table 4).

Table 4: Light fastness rating of cotton and silk fabrics dyed with *Strobilanthes cusia* (Nees) Kuntze.

Number of dying	Light fastness rating	
	Cotton	Silk
Untreated	7-8	7
1st dyed	4-5	4-5
3rd dyed	5	5
5th dyed	5	5
7th dyed	5	5
9th dyed	5	5

Natural Mordanting

Indian trumpet, Indian gooseberry, and chebulic myrobalan stem barks had tannin contents of 37.25 mg/g, 79 mg/g, and 725 mg/g, respectively. The leaves of Siamese cassia, common guava, and blue gum yielded 78.50, 161.25, and 172.25 mg/g, respectively.

We discovered that mordanted cotton and silk textiles displayed light-shaded colors of pink, yellow, and brown compared to untreated items (Figure 2). The dyed textiles with natural mordants produced different shades of blue depending on mordant type, as seen in the silk experiment (Figure 2). Besides that, three dye applications of cottons and silk after soaking for an hour in six observed natural mordants performed the same rate of fastness to washing in terms of color alteration and light fastness. All pre-mordanted dyed treatments of both studied garments exhibited blue shade in color that did not differ from dyed fabrics without mordanting and should not be washed with nylon clothes in warm laundry conditions (60°C) to avoid staining. Furthermore, the use of natural mordants reduced the blue shade color on finished products.

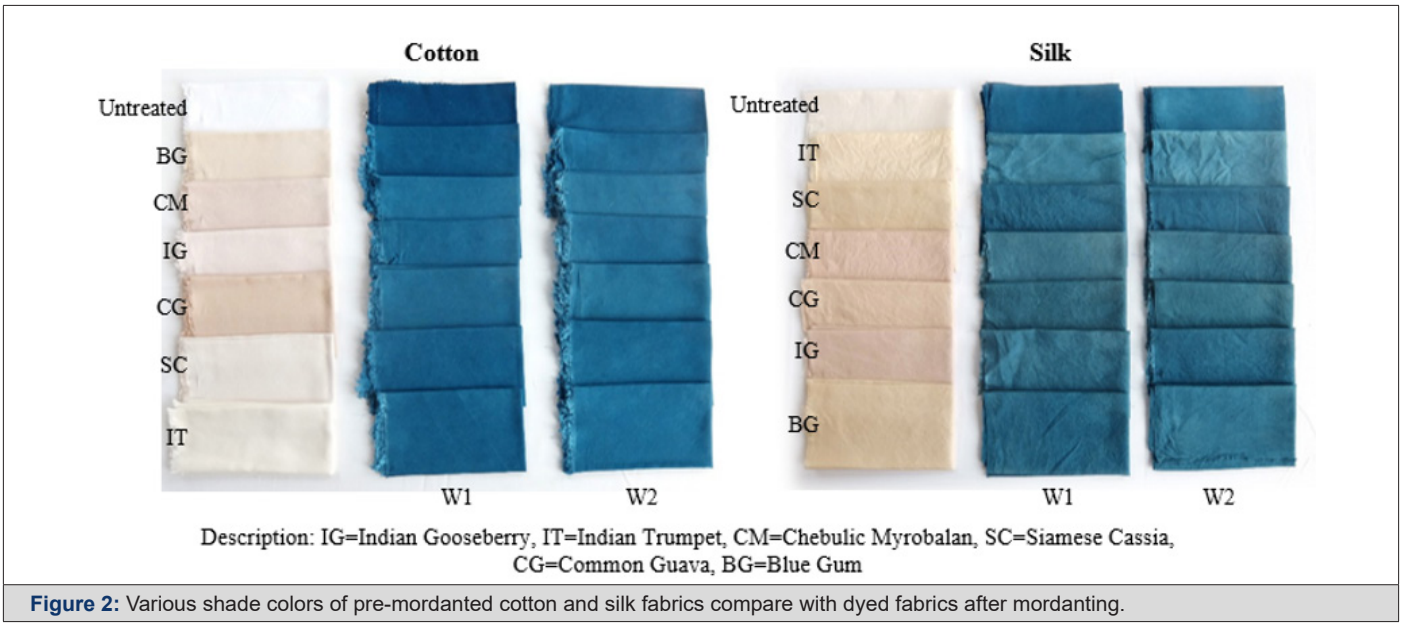

Figure 2: Various shade colors of pre-mordanted cotton and silk fabrics compare with dyed fabrics after mordanting.

Discussion

Tannin content was determined in all plants studied because it is an important component in improving the quality of natural-based coloring [8]. However, in our study, its use is not clearly different from that of non-mordanting items. The preparation of indigo paste or wet indigo, the vat condition, the number of dyes, the type of textile material, mordanting, and a skilled dyer all contribute to the quality performance of natural indigo dyed textiles. Our research identified the optimal conditions for producing wet indigo and the dye formulation for perfect qualitative coloring. Cotton fabric appears to be the best material for *Strobilanthes cusia* (Nees) Kuntze dye, and natural mordanting seems to be unnecessary in the manufacturing of indigo commodities [9,10].

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