Journal of BIMP-EAGA Regional Development Volume 3. No 2. 2017
ISSN 2232-1055

DEVELOPMENT OF AN ALTERNATIVE NATURAL DYE FROM PHILIPPINE TEAK LEAVES (*Tectona philippinensis*)

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ABSTRACT

This study focused on the development of an alternative natural dye from Philippine teak leaves *(Tectona philippinensis).* The leaves were boiled for one hour using tap water as the solvent for extraction of natural dye. The extracted dye was reddish in color. Quantitative determination revealed that 10.95g (1.095%) of powder dye was produced for every one kilogram of dye sample with 30 liters of water. Different shades of colors appeared when the dye was applied to cotton, linen, jusi, piña-seda and silk cocoon using different mordants. The dyed fabrics were subjected to colorfastness to washing, perspiration and sunlight using Launder-O-Meter, Incubator and Atlas Ci+3000 Xenon Weather-O-Meter. Results showed that it is acceptable to technical evaluators from Philippine Textile Research Institute (PTRI) in terms of Colorfastness to Laundering, Perspiration, and Light. It was concluded that the dye extracted from Teak leaves can be a good source of natural dye and can produce different shades of colors using different kinds of fabrics and mordant, and is useful as a substitute for synthetic dyes.

Key words: natural dye; *Tectona philippinensis*; Philippine teak

1. INTRODUCTION

Dye is a compound that can be adhered or fixed to a substance or material for purpose of coloring it in a more or less permanent state. Dye can be applied to various materials like textile, paper or cosmetics. The colors they yield vary and produce specific shades. The dyes are classified as either natural or synthetic, as discussed at Katutubong Kulay (1998).

According to Florece and Domingo (2005), throughout history, people are dying their textiles using common, locally available materials. The ancient people considered color as important as their food. Natural dyes are dyes or colorants derived from plants, invertebrates, or minerals. The majority of natural dyes are vegetable dyes from plant sources (roots, berries, bark, woods and leaves). The hue or shades of the color that a plant produces is dependent on the soil and weather conditions.

Synthetic dye is a man-made dye. It is widely used in textile since it is cheaper and superior in quality in terms of colorfastness, shades, and brilliancy. Some of the textile industries commonly use synthetic dye for a faster and easier dyeing process. However, most of the synthetic dyes are major waste in the industry due to their chemical content and structures. Disposal of inorganic dyes in water stream is aesthetically adverse and has serious environmental impact such as affecting the aquatic life and even the food chain.

Vankar (2013) stated that although mordanting and certain after treatments improved fastness, the inherent instability of the chromophores of the natural coloring matters resulted in low fastness to washing and light. Old textiles dyed with natural dyes have acquired an overall brownish hue. Greens were produced by over-dyeing indigo with higher light fastness of indigo component. These effects are readily observed in old tapestries.

In this study, Philippine teak was subjected to test its ability to produce natural dyes. This tree can be found in some places in Bataan, Batangas, Mindoro and Sulu Archipelago. The Philippine Teak or *Tectona philippinensis* is one of the three species in the genus Tectona, which includes the commercial teak *Tectona grandis*, one of the few tropical timbers successfully grown as a plantation crop. Philippine teak may have potential as a genetic resource for future teak breeding programme aimed at improving supplies of this highly popular wood *(http://www.globaltrees.org/tp_teak.htm).*

Similarly, teak is a species native to Southeast Asia rather than the Americas. It has been widely planted in Panama for various reasons. One of its advantages is that it grows quickly, and it provides an economical way to shade out the undesirable elephant grass that was brought in from Southeast Asia in the 1950s. Teak trees have large opposite, oval leaves with smooth margins. Leaves are 5.9 to 17.7 inches long and feature small glandular dots. Leaves grow from robust petioles that are 3/4 inch to 1 1/2 inches long (*http://www.thepanamanews.com/pn/v_09/issue_01/outdoors_01.html*).

This research study aims to prove that a natural dye can be extracted from Philippine Teak leaves (*Tectona philippinensis).* Likewise, the developed product can add to the economic growth of the country that may possibly be another aspiring product for local and international market for rural areas' sustainability. Furthermore, it can help protect the environment from harmful chemicals or substances unlike synthetic dyes.

1.1 Objectives of the Study

The general objective of the study is to develop a natural dye from Philippine Teak leaves (*Tectona philippinensis).*

Specifically, it aimed to:

1. Extract the natural dye
2. Determine the percent yield of the natural dye from Philippine teak leaves *(Tectona philippinensis)*
3. Apply the natural dye into selected fabrics such as:
    - 3.1 Silk Cocoon
    - 3.2 100% Cotton
    - 3.3 Piña-Seda
    - 3.4 Linen
    - 3.5 Jusi Barong
4. Identify the color produced on selected fabrics using different mordant such as:
    - 4.1 copper sulfate
    - 4.2 aluminum salt
    - 4.3 ferrous sulfate
5. Evaluate the dyed fabrics in terms of;
    - 5.1 colorfastness to laundering
    - 5.2 colorfastness to perspiration
    - 5.3 colorfastness to light

Figure 1 presents the conceptual model of the study. It includes the inputs, processes and output of the study. The input segment is the list of knowledge requirements needed for the project. The process segment consists of the extraction, formulation and testing for the desired output which is the development of Teak leaves (*Tectona philippinensis*) into natural dye.

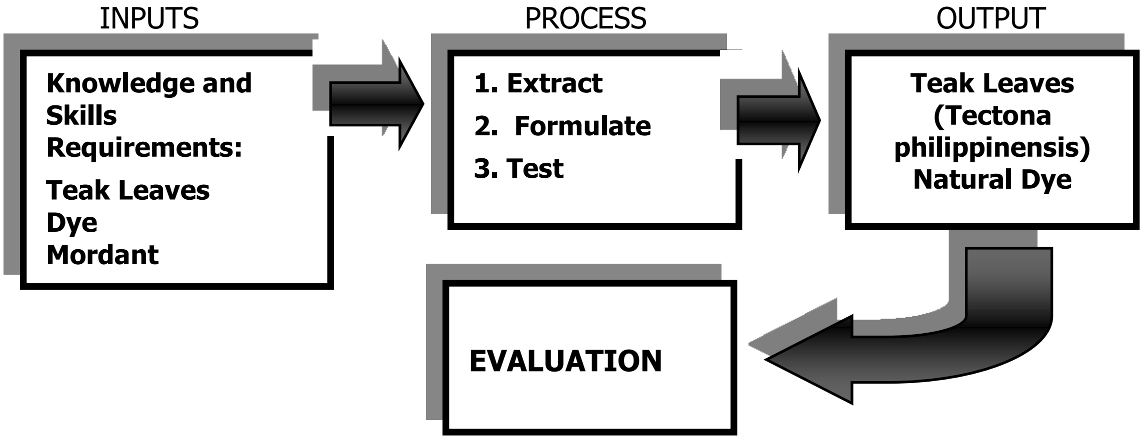

Figure 1: Conceptual Model of the Study

The conceptual model as illustrated in Figure 1 shows the different stages of the processes involved in order to achieve the objectives of the study.

2. RESEARCH METHODOLOGY

The leaves of Philippine Teak tree (*Tectona philippinensis)* from Mariveles, Bataan were used to develop an alternative or natural dye source.

Figure 2 shows the flow chart of the teak leave dye extraction, application and test. The natural teak dye was developed using tap water as solvent for extraction. The leaves underwent several process such as; extraction of dye, dyeing, testing and evaluation. The leaves were boiled for two hours for extraction process. The dye was applied to Silk Cocoon, 100% Cotton, Piña-Seda, Linen, Jusi Barong for dyeing. Technical grade copper sulfate, aluminum salt and ferrous sulfate were used as mordant. The dyed fabrics were evaluated in terms of colorfastness to laundering, perspiration and sunlight using Launder-O-Meter, Incubator, and Atlas Ci 4000 Xenon Weather-Ometer done in the Philippine Textile Research Institute. The tested fabrics were rated based on the AATCC Gray Scale for Color Change. Refer to Table 1.

The fabrics used were cotton, linen, silk cocoon, piña seda and jusi. Technical grade of hydrogen peroxide, sodium silicate, sodium hydroxide and detergent were used in scouring of cotton and linen fabric. Technical grade of copper sulfate, aluminum salt and ferrous sulfate were used for mordanting the pretreated and un-treated materials.

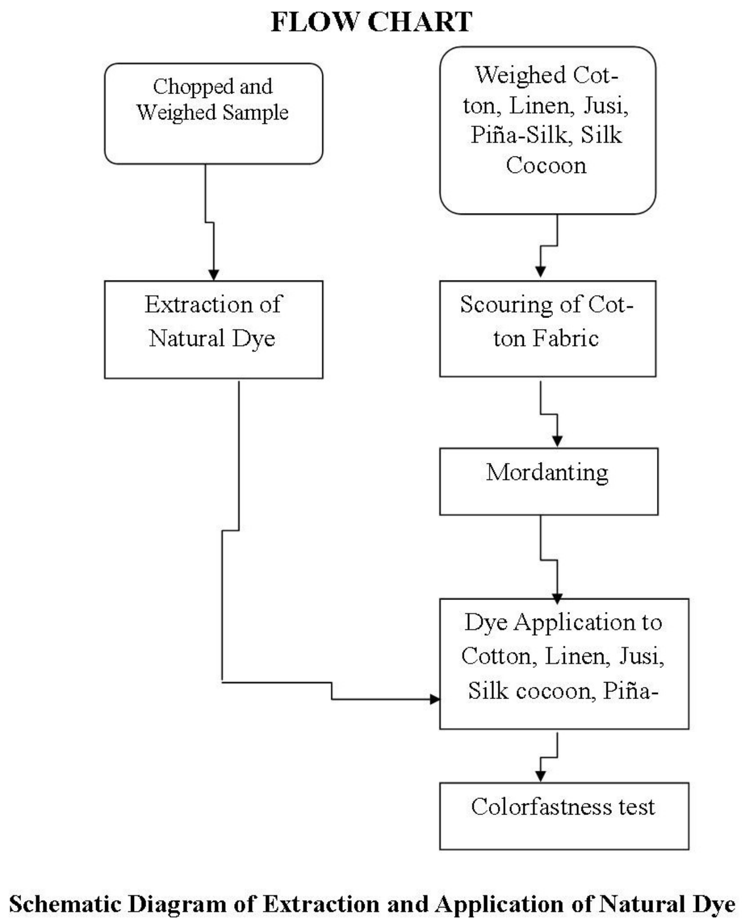

Figure 2: Schematic Diagram of Extraction and Application of Teak Leaves Dye

Table1: AATCC Description of Gray Scale Ratings

Grade	Change in color	Staining
5	Negligible or no change	Negligible or no staining
4	Slightly changed	Slightly stained
3	Noticeably changed	Noticeably stained
2	Considerably changed	Considerably stained
1	Much changed	Heavily stained

Beaker, stirring rod, tong, electric or gas stove, stainless cup and pot were used in scouring the fabric to remove the dirt, mordanting the fabric to retain its color and extracting the teak tree leaves to make a natural dye.

Launder-O-Meter, Weather-O-Meter and Atlas Ci 4000 Xenon Weather-Ometer are the instruments used in colorfastness test.

2.1 Preparation of the sample

One kilogram of Teak leaves were chopped and placed in stainless pot and extracted with thirty liters of tap water and boiled for two hours. It was filtered using a strainer and collected. Eighteen liters of filtered extract was placed in the spray drying machine for six hours at temperature of 120°C for powder production. The powder substance weighed 10.95g.

I Pretreatment of Material

Pretreatment processes include desizing, scouring, and bleaching which make subsequent dyeing and softening processes easy. Uneven desizing, scouring, and bleaching in the pretreatment processes might cause drastic deterioration in the qualities of the process products, such as uneven dyeing and decrease in fastness.

A. Scouring/Bleaching the cotton and Linen Fabric using aluminum salt and copper sulfate

In a pot, 12.35 grams of hydrogen peroxide, 6.176 grams of sodium silicate, 4.63 grams of sodium hydroxide and 1.54 grams of detergent were mixed and dissolved with 1.6 L of water. Some 52 grams of cotton and linen materials were immersed in the scouring solution and boiled for 30 minutes with frequent stirring. The scoured material was removed from the solution.

B. Scouring/Bleaching the cotton and Linen Fabric using ferrous sulfate

In a pot, 4.07 grams of hydrogen peroxide, 2.04 grams of sodium silicate, 1.52 of sodium hydroxide and 5.08 of detergent were mixed and dissolved with 500 ml of water. The study also used 17 grams of cotton and linen materials that were immersed in the scouring solution and boiled for 30 minutes with frequent stirring. The scoured material was removed from the solution. The pretreated material was rinsed thoroughly with tap water and air-dried.

II Mordanting of Materials

A. Pretreated cotton and linen

- 0.89 gram of aluminum salt was dissolved in 550 mL of water in stainless steel pots; 17.9 grams of pretreated materials were immersed in mordant solution and boiled for 30 minutes with frequent stirring. The mordanted material was cooled, squeezed and air-dried without rinsing.

- 0.89 gram of copper sulfate was dissolved in 550 mL of water in stainless steel pots; 17.9 grams of pretreated materials were immersed in mordant solution and boiled for 30 minutes with frequent stirring. The mordanted material was cooled, squeezed and air-dried without rinsing.

- 0.84 gram of ferrous sulfate was dissolved in 508.8 mL of water in stainless steel pots; 16.96 grams of pretreated materials were immersed in mordant solution and boiled for 30 minutes with frequent stirring. The mordanted material was cooled, squeezed and air-dried without rinsing.

B. Silk Cocoon, Jusi Barong and Piña-Silk

- 0.38 gram of aluminum salt was dissolved in 227.7 mL of water in stainless steel pots; 7.59 grams of materials were immersed in mordant solution and boiled for 30 minutes with frequent stirring. The mordanted material was cooled, squeezed and air-dried without rinsing.

- 0.37 gram of copper sulfate was dissolved in 222 mL of water in stainless steel pots; 7.59 grams of materials were immersed in mordant solution and boiled for 30 minutes with frequent stirring. The mordanted material was cooled, squeezed and air-dried without rinsing.

- 0.40 gram ferrous sulfate was dissolved in 240.9 mL of water in stainless steel pots, 8.03 grams of materials were immersed in mordant solution and boiled for 30 minutes with frequent stirring. The mordanted material was cooled, squeezed and air-dried without rinsing.

III Dyeing

Mordanted Linen and Cotton fabrics were boiled in 500 mL of crude extract of the teak leaves for 30 minutes while mordanted Jusi, Piña-Seda and Silk Cocoon were boiled in 300 ml of crude extract for 15 minutes not exceeding 70 to 80°C into a stainless pot. The dyed fabrics were taken out from the dye extract then rinsed with tap water and air dried.

IV. Colorfastness Test

Colorfastness is a term used in the dyeing of textile materials, meaning resistance of the material's color to fading or running. In general, clothing should be tested for colorfastness before using bleach or other cleaning products. Light fastness, wash fastness, and rub fastness are the main ones that are standardized. The light fastness of textile dye is categorized from one to eight and the wash fastness from one to five. The higher the number the better fastness is obtained.

A. Tests for Colorfastness to Laundering

7.4 grams of detergent was dissolved in two liters of distilled water. 200 mL of soap solution was filled to each stainless cylinder with 10 stainless balls inside. Each fabric with multi-fiber (to determine the possibility of dyed fabrics to stain) was soaked into the steel cylinder. A canister in the Launder-O-Meter Machine with the required temperature of 40°C for 45 minutes was used. The fabric was washed thoroughly with detergent and tap water and was air dried.

B. Tests for Colorfastness to perspiration

The study used 20g of sodium chloride, 2g of di-sodium hydrogen phosphate, 2g of Lactic acid, 50g of L-Histidine Monohydrochloride, and 2L of distilled water. The pH of Buffer Solution was determined before each sample fabric was prepared and soaked. The fabric was weighed again before putting it in the Perspiration Tester *(AATCC & ISO Perspiration Tests)*. It was then put inside the incubator with required temperature of 38°C for six hours.

C. Tests for Colorfastness to light

The purpose of this test is to determine how much the color will fade when exposed to a known light source. The proper test method is AATCC Test Method 16. Option A uses a Carbon Arc light source while Option E uses the more popular Xenon light source. The option used will depend on the equipment available. The test duration will be 10 AATCC fade units minimum for both colors and whites unless otherwise specified. Ten AATCC fade units are equivalent to 2.5 to 3 continuous 24 hour days of direct sunlight while 20 AATCC fade units are equivalent to 5-6 days of direct sunlight. The dyed sample was placed in an Atlas Ci+3000 Xenon Weather-O-Meter. The material was exposed to Xenon-Arc Lamp with continuous light for 20 hours. The change in color was compared to an exposed sample using AATCC Gray Scale for color change.

3. RESULTS AND DISCUSSION

Tap water was used as solvent to extract the dye from teak leaves. The filtrate was reddish in color. The extracted dye is processed in spray drying machine and turned into powder form by evaporation.

A total of 18 liters of crude dye was placed in spray drying machine for six hours at 120°C. The percentage yield of crude dye yield is 1.095%. Computation of the result is as follow.

Percentage yield = $\frac{\text{Weight of powder}}{\text{Weight of sample}} \text{x } 100$ $\text{PercentYield} = \frac{10.95 \text{ grams}}{1000 \text{ grams}} \text{ x } 100 = 1.095\%$

Where:
Weight of powder = 10.95 grams Weight of sample= 1000 grams

Table 2 shows the colors imparted by the extracted dye on cotton, Linen, Silk Cocoon, Jusi Barong and Piña-Seda materials using Aluminum Salt, Copper Sulfate and Ferrous Sulfate.

Table 2: Colors of extracted dye imparted on different kinds of fabric using different mordant

Fabric	**Mordant**	**Color**
Cotton	Copper sulfate	Shadow Green
	Ferrous sulfate	Pinkish Brown
	Aluminum salt	Pinkish Brown
Linen	Copper sulfate	Taupe
	Ferrous sulfate	Pinkish Brown
	Aluminum salt	Light Pink
Silk Cocoon	Copper sulfate	Light Fatigue
	Ferrous sulfate	Light Black
	Aluminum salt	Light pink
Jusi	Copper sulfate	Light Fatigue
	Ferrous sulfate	Black
	Aluminum salt	Mud
Piña-Seda	Copper sulfate	Light Fatigue
	Ferrous sulfate	Black
	Aluminum salt	Reddish B.

Table 2 shows that different colors appeared when the extracted dye was applied to cotton, linen, jusi, silk cocoon and Piña-Seda using different mordants. The imparted color in using copper sulfate was shadow green, taupe and light fatigue while in using ferrous sulfate, pinkish brown, light black and black and in using aluminum salt, pinkish brown, light pink, mud and reddish brown appeared. The best color imparted was jusi in fabric.

3.1 Capabilities and Limitations

The capabilities of the natural dye from Philippine teak leaves are as follows:

- It can extract reddish color.
- It can produce different shade of colors depending on the mordant applied; green for copper sulfate, pink for aluminum salt and black for ferrous sulfate.
- The crude extract from the Teak leaves can be transformed into powder form. See figure 3.

Teak Leaves **Powdered Teak Dye**

Figure 3: Teak Leaves and Powdered Form of Teak Dye

However, the natural dye from Philippine teak leaves has the following limitations:

- The young teak leaves produced more color rather than old teak leaves.
- Extracted powder from fresh teak leaves was hygroscopic (Readily absorbing moisture, as from the atmosphere).

3.2 Test Results

3.2.1 Colorfastness to Laundering

After the dyed materials were soaked in soap solution, some became lighter in color. The color change in cotton is 4.0 (Slightly changed), Linen is 3.0 (Noticeably changed) and in Silk Piña-Seda and jusi the color change is 4.5 (Noticeably changed).

3.2.2 Colorfastness to Perspiration

After the dyed materials were soaked in perspiration solution, some changed in color. The color change in cotton, Silk Piña-Seda and jusi is 4.5 (Slightly changed) and in linen the color change is 3.0 (Noticeably changed).

3.2.3 Colorfastness to Sunlight

The mordanted dyed fabrics were exposed for 20 hours to Xenon Arc Lamp using apparatus named Xenon Weather-Ometer, Atlas Ci +3000. Table 3 shows the results of the test.

Table 3: Colorfastness to Sunlight Rating

Fabric	Mordant	Light Fastness Rating	Description
Cotton	Copper Sulfate	4	Slight change in color
Jusi	Aluminum Salt	4-5	between Slightly
Silk	Ferrous Sulfate	1	much change in color
Jusi	Copper Sulfate	5	No change in color
Linen	Aluminum Salt	1-2	much change in color

Table 3 shows that the light fastness of dyed cotton fabrics which were mordanted with copper sulfate were given ratings of 4 (slight change in color) while for jusi fabrics which were mordanted with aluminum salt and copper sulfate were given ratings of 4-5 (between slightly) and 5 (no change in color) and Silk fabrics which were mordanted with ferrous sulfate and aluminum salt were given ratings of 1 (much change in color). Rated as 1-5, 1-3 rating is acceptable and 4-5 rating is not acceptable. The ratings were based from the AATCC Gray Scale for Color Change.

4. CONCLUSIONS

From the results obtained, it can be concluded that teak leaves is a good source of natural dye and it can produce different shades of colors in different kinds of fabrics and mordants. Teak leaves can be produced into powder form.

5. RECOMMENDATIONS

For further study about the effectiveness of the extract from dye source, the following studies should be explored.

- Application of the extracted dye in different fabrics like Beatrice and Lacoste.
- Different solvent such as ethanol and mixture of ethanol and water.
- Application of the extracted dye at different pH levels.
- Use of dry teak leaves as a source.

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