

Characterisation of the Polarity

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Characteristic and quality of silk fabric colored using natural dyes

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Characteristic and quality of silk fabric colored using natural dyes

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Abstract. Environmental issues have become important nowadays, and there is a trend to reduce polluting materials used. As in the textile industry, consumers prefer to choose the natural dyes fabric than synthetic dyes. The aim of this study is to find out the natural dye materials from henna leaves (*Lawsonia inermis* L.), sappan wood (*Caesalpinia sappan*), and dragon fruit peel (*Hylocereus costaricensis*) on silk fabrics and to analyze the quality of silk that colored using natural dyes. The natural dyes were then applied to the silk and then performed testing quality of silk color. The results showed that the natural dyes mostly produce the pastel colors, where henna leaves performed a pastel green color, peel of dragon fruit performed baby pink color, and the sappan wood performed dusty pink. According to the quality test, all-natural dyes showed a bad resistance toward washing at 40°C and a bad fade resistance to acid sweat, but on the contrary, they perform a good resistance to bases sweat. It can be concluded that all the silk that has been colored by natural dyes indicated higher tensile strength compared to the silk without dye.

1. Introduction

Silk is one of the leading national Non-Timber Forest Products (NTFPs) in Indonesia [1]. Silk is a protein fiber produced by silkworm and can be woven into textiles. The most common type of silk is originating from a cocoon produced by mulberry silkworm larvae (*Bombyx mori*). Silk has a smooth texture, soft, easily tangled, less resistant to ironing, and has a high luster [2–4]. Currently, in the market, there are many silks with various attractive colors and motifs. Silk colors give a special appeal to consumers because they have beautiful colors.

Silk color is determined by the material and coloring process, which is one of a series of processes in producing silk cloth. There are two kinds of textile dyes namely the dyes derived from natural materials, generally derived from animals or plants, and another one is a synthetic coloring agent, which is an artificial color with a synthetic chemical reaction with materials from coal or petroleum resulting from aromatic hydrocarbon compounds such as benzene, naphthalene, and anthracene. However, synthetic dyes can cause environmental pollution because it is non-biodegradable compounds. It can cause groundwater pollution, a carcinogen, and expensive [5]. On the other hand, natural dyes possess some advantages such as high economic value and price, environmentally friendly, non-allergenic, easily obtained, and renewable. Textiles that use natural dyes provide a more distinctive and softer color compared to the



synthetic dyes, and therefore they perform a high aesthetic value. Even so, natural dyes still have some disadvantages compared to synthetic dyes, such as its coloring is weak, less stable in various conditions, applications are less extensive and tend to be more expensive, the natural dyes are still used today [6–9].

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2. Materials and method

2.1. Materials

The material used in this research is silk fabric obtained from Sengkang, South Sulawesi Province, Indonesia. Natural dyes, such as henna leaves (*Lawsonia inermis* L.) and sappan wood (*Caesalpinia sappan*), were obtained from Bone Regency, South Sulawesi and dragon fruit peel (*Hylocereus costaricensis*) were obtained from fruit sellers in Makassar City.

2.2. Preparation of Natural Coloring Extracts

Preparation of natural dyes extracts by immersing the coloring agent in a water solvent at a ratio of 1:10 (weight/volume) for 24 hours. All the coloring agent were prepared differently depending on their characteristics. Dragon fruit peel is cut into small pieces, and henna leaves are separated from the stem, meanwhile for the sappan wood is made flakes and then ground in a hammer mill, and all the material weighed prior extraction. Furthermore, each substance is blended with water according to the ratio obtained before and then filtering to obtain their extract.

2.3. Immersion in Natural Dyes

There are several preparatory processes are required before silk fabric is dipping in the dye solution, as follows:

2.3.1. Mordanting process. The silk fabric must be mordant in advance to increase the attractiveness of the dye and to produce good color evenness and sharpness. Materials used as mordants are lime juice and hot water in various concentrations such as 2.5%, 5%, 7.5, and 10%. Determination of these concentrations is based on the results of a previous study conducted by Subekti *et al.* (2015) [10], which shows that these concentrations performed the best results. The silk cut with a size of 30 cm x 30 cm, then washed using detergent and rinsed with clean water and dried in the room. Furthermore, the silk then immersed in a mordant solution for 2 hours, washed, and dried in the room [2].

2.3.2. Coloring Process. The dyes extract were weighed, then dissolved using water in a ratio of 1: 5 and 1:10. The mordant silk is dipped in the dye solution for 30 minutes, gently removed and squeezed, then air-dried. Furthermore, the fabric is dyed again with the same process [9].

2.3.3. Preparation and dipping in fixer solution. The color must be locked in order to have a high fastness so that the silk that has been dyed then dipped in a fixer solution. In this study fixer material used was alum with a concentration of 10% as has been used in several previous studies [10–12]

2.4. Dying Quality Testing

2.4.1. Fade Resistance. The quality of natural colorfastness testing was carried out at the Textile Center in Bandung, which consists of two types of testing, namely:

- 1) Colorfastness test for washing at 40°C based on SNI ISO 105-C06: 2010 method
- 2) Test the colorfastness to acid and base sweat based on the method of SNI ISO 105-E04: 2010

2.4.2. *Silk Fiber Tensile Strength Testing*. Silk tensile strength testing based on the ASTM method D638-02a-2002 was carried out at the Center for Plantation Product Industries, Makassar.

3. Result and discussion

3.1. Results of Silk Fabric Staining

The natural dyes that have been applied to the silk fabric provided the pastel colors, as described below. Pastel colors are the colors that are preferred by consumers because they are soft and relatively neutral, so they are almost suitable for use by all skin tones and all scenes [13–16]. Pastel colors and floral motifs are one of the six categories of style characteristics, which are the Feminine-Romantic category or styles with soft, delicate, sweet, and beautiful appearance [17].

3.1.1. Henna leaves (*Lawsonia inermis* L).



Figure 1. Henna leaves color results of 1:10 and 1: 5 concentrations

Based on the picture above, henna leaves produced the yellowish-green color, both of the concentrations of 1:10 and 1: 5, and the concentrations did not show significant color differences.

3.1.2. Peel of the dragon fruits (*Hylocereus costaricensis*)



Figure 2. Dragon fruit peel color result of 1: 5 concentration

Figure 2 above showed the color resulted from the dragon fruit peel with a concentration of 1: 5 was the baby pink or light pink color. The color mention above only resulted from a concentration 1:5, whereas the 1:10 concentration resulted from there was no color on the silk, so there is no color change occurs on the silk fabric.

3.1.3. Sappan wood (*Caesalpinia sappan*)



Figure 3. Sappan wood color results of 1:5 and 1:10 concentrations

Sappan wood gives attractive color results, namely dusty pink and dark pink, from both with 1:5 and 1:10 concentrations. It can be seen that from 1: 5 concentration provided an older color compared to 1:10 concentration.

3.2 Staining Tests

3.2.1. Silk Color Fade Resistance

3.2.1.1. Silk Color Fade Resistance to 40°C Washing Temperature

Table 1. Silk Color Fade Resistance to 40°C Washing Temperature

Natural Dyes	Washing Tests		
	Color Change	Color staining	
		Wool	Rayon
Peel of dragon fruits (1:5)	1	4	4-5
Sappan wood (1:5)	1-2	4-5	4
Sappan wood (1:10)	1-2	4	3-4
Henna leaves (1:5)	2	4	4
Henna leaves (1:10)	1-2	4-5	4

* according to ISO 105-C06: 2010 Note: 1 (bad); 2 (less); 3 (enough); 4 (good); 5 (very good)

According to Table 1 above, the natural coloring agents used showed a color change due to washing temperature at 40°C which is based on SNI ISO 105-C06: 2010 classified as bad to less category (1-2) that is to dragon fruit peel with a concentration of 1: 5, sappan wood concentration of 1: 5 and 1:10, and henna leaves with a concentration of 1: 5. For the indicator of color staining to wool cloth, all the coloring agents were classified into good to very good quality (4-5), while for rayon, which was classified into sufficiently to very good (3-5). Meanwhile, for rayon desecration, almost the coloring agents included in good category (4), except for dragon fruit peels, which belong to good to very good category (4-5) and sappan wood with 1:10 concentration was including to sufficiently to good category (3-4). Therefore, it can be concluded that based on SNI ISO 105-C06: 2010, all the natural dyes used have a poor quality of fastness

to 40°C washing temperature. On the other hand, for color staining due to washing temperature of 40°C for wool, sappan wood with 1:5 concentration and henna leaves with 1:10 concentration performed the best fastness, while for rayon desecration, dragon fruit peel with 1:5 concentration showed the best fastness.

3.2.1.2. Silk Color Fade Resistance To Acid and Base Sweat

Table 2. Silk Color Fastness Test Against Acid Sweat

Natural Dyes	Leaching Test		
	Color change	Color Staining	
		Wool	Rayon
Peel of dragon fruits (1:5)	1-2	4-5	4
Sappan wood (1:5)	2	3-4	3
Sappan wood (1:10)	2	4	4
Henna leaves (1:5)	2	3-4	4
Henna leaves (1:10)	2	3-4	4

* according to ISO 105-E04: 2010, Note: 1 (bad); 2 (less); 3 (enough); 4 (good); 5 (very good)

Based on Table 2 above, it can be seen that based on SNI ISO 105-E04:2010, all-natural coloring agents showed a color change due to acid sweat which is classified into lack category (2), while for dragon fruit peel at the 1: 5 concentration classified into poor - less (1-2). Another aspect is the desecration of wool, all the natural dyes provided a pretty good quality (3-4), even for dragon fruit peels classified as very good category (4-5). Meanwhile, for rayon desecration, almost all-natural dyes are classified into a good category (4), except for sappan wood with 1: 5 concentration classified into sufficient (3). Therefore it can be concluded that based on SNI ISO 105-C06:2010, all the natural dyes perform a lack of quality of fastness against acid sweat. The dragon fruit peel with a concentration of 1: 5 shows the best fastness against color staining due to acidic sweat on wool, while for rayon staining, all dyes are classified into good category, except the sappan wood with a 1: 5 concentration is including in fairly good.

Table 3. Silk Color Fastness Test Against Base Sweat

Natural Dyes	Leaching Tests		
	Color Change	Color Staining	
		Wool	Rayon
Peel of dragon fruits (1:5)	1	4-5	4
Sappan wood (1:5)	2-3	3-4	3-4
Sappan wood (1:10)	2	4	4
Henna leaves (1:5)	3-4	4	4
Henna leaves (1:10)	3	3-4	3-4

* according to ISO 105-E04: 2010, Note: 1 (bad); 2 (less); 3 (enough); 4 (good); 5 (very good)

Table 3 above mention that based on SNI ISO 105-E04:2010, almost natural dyes performed a color change due to base sweat which was classified as sufficient category (3) except dragon fruit peel with a 1:

5 concentration was classified into the poor category (1) and sappan wood with a concentration 1:10 is classified as less category (2). All the coloring agents classified into good quality (4), even for dragon fruit peel classified into the very good category (4-5), against color staining due to base sweat against wool. For rayon desecration, almost all dyes are in good category (4). Accordingly, it can be concluded that based on SNI ISO 105-C06:2010, almost natural dyes have sufficient fastness to alkaline sweat. For color staining due to alkaline sweating on wool, dragon fruit peel with a concentration of 1: 5 shows the best fastness, while for rayon staining, all-natural dyes are of good quality.

3.2.2. Results of Silk Fiber Tensile Strength Test

Table 4. Tensile strength testing results of silk fiber colored by natural dyes

No	Treatments	Test Results		
		Tensile Load (N)	Tensile Strength (N/mm ²)	Elongation (mm)
1	Original Silk	86.10	25.00	6.23
2	Peel of dragon fruits (1:5)	52.45	24.17	6.07
3	Sappan wood (1:5)	68.00	33.94	5.57
4	Sappan wood (1:10)	91.38	45.35	8.17
5	Henna leaves (1:5)	56.17	27.21	7.45
6	Henna leaves (1:10)	74.11	28.62	8.15

*ASTM D638-02a-2002.

In Table 4 above, the silk, which is colored with sappan wood with a 1:10 concentration, provided the best tensile strength indicated with the highest tensile load and tensile strength. In addition, the silk, which was given a 1:10 concentration of sappan wood dyes, also has a high elongation, which means that the stretching strength of the silk with this dye is very good. Nevertheless, it can be concluded that almost silk fabrics that have been colored by natural dyes have higher tensile and elongation strength values than silk without dyes. Otherwise, silk fabrics that were dyed with dragon fruit peels performed a tensile strength slightly below the value of silk without coloring. It means that the natural dyes provide good tensile and stretching strength for silk fabrics.

4. Conclusions

4.1. Natural dyes

Used in this study provided the pastel colors, such as green pastel by henna leaves, dragon baby pink from dragon fruit peel, and sappan wood produces dusty pink.

4.2. a. All-natural dyes possess a poor quality of fastness against 40°C leaching;

- b. sappan wood and henna leaves show the best fastness for color staining due to washing temperature of 40°C against wool
- c. dragon fruit peels show the best fastness for blemishes and poor quality of fastness against acid sweat
- d. dragon fruit peels show the best fastness for color staining due to acidic sweat on wool,
- e. all dyes are in the good category for staining of rayon, only sappan wood is classified as sufficient.

4.3. In general

Silk fabrics that have been colored natural dyes showed higher tensile and elongation strength values compared to silk fabrics without dyes.

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