Coffee bean skin waste extraction for silk dyeing

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Abstract. Coffee bean skin waste has been used as a coloring agent in the process of dyeing silk threads by varying the concentration of coffee bean extract extracts in 4 treatment stages, each 50 g/l, 100 g/l, 150 g/l and 200 g/l and varying the fixation solution lime also in 4 levels of treatment each 25 g/l, 50 g/l, 75 g/l and 100 g/l to obtain 16 kinds of silk thread colors. The parameters tested included color aging, color fastness to washing, rubbing, sweat and light. The aim of the study was to obtain the best treatment from the coloring process carried out, while the overall test results met the SNI quality requirements for how to test color fastness for washing, sweat and rubbing (BSN, 1989), except the results of the test for color fastness to light. The best treatment was obtained at the extraction concentration of 150 g/l coffee beans and the concentration of lime fixation solution 75 g/l produced a color aging K/S 20.93, color fastness to washing value 3-4 (enough) for discoloration and 4 (good) for color staining, color fastness to rubbing value 4 (good) for dry rubbing and 3-4 (enough) for wet rubbing, color fastness to perspiration value 4-5 (good) for acid and base rubbing as well as resistance color fastness to light values 2-3 (less).

1. Introduction

Indonesia is the third coffee producing country in the world after Brazil and Vietnam, currently coffee products are one of the leading commodities in Indonesia and in 2015 Indonesia was able to produce 639,412 tons or 6.6% of the world's coffee products. This coffee is produced from coffee plantations covering an area of 1,230,001 hectares [1].

According to [2] in the processing of coffee produced 55-60% coffee beans and 40-45% coffee bean skins consisting of pulp (the mesocarp), skin (the exocarp), mucilage and parchment (the endocarp). Utilization of coffee bean husk waste in Indonesia can be said to be not optimal and is only used for animal feed and as fertilizer in plantations where the economic value produced is still low, even in some areas the coffee bean shell waste is left and is a source of spread of pests and plant diseases. The development of coffee plantations which is carried out indirectly will also increase the amount of coffee bean waste produced, therefore it needs a new breakthrough to process coffee waste so that it can be utilized and not wasted.

Coffee bean skin contains 14.4% sugar, tannins 8.6%, pectin 6.50%, chlorogenic acid 2.6%, caffeic acid 1.6% and caffeine 1.3% of its dry weight [3]. Tannin is an organic compound consisting of a mixture of complex polyphenol compounds are built from elements C, H and O and often form large molecules with larger molecular weights. Tannins are widely obtained from plants and can also be obtained from minerals, tannins from plants are also called tannic acid with the empirical formula C₁₄H₂₀O₉, [4].

The presence of tannin content in the coffee bean skin is a potential that waste coffee bean skin can be used as one source of natural dyes for textiles, according to [5] Tannin can be colorless to yellow and light brown, if exposed to sunlight will hydrolyze into dark brown, if reacted with metal ions will give a bluish black color. Silk fiber is hydrophilic because it contains a lot of OH, in the process of coloring the OH gum it will play an important role in the bond between fibers and dyes [6].
Silk fiber consists of 76% fibroin, 1.5% wax and 1.5% salt 0.5% mineral salt. Fibroin is a protein that is insoluble in weak alkalis and soap which is a chain molecule formed by a combination of amino acids that form a polypeptide chain having the formula \( \text{NH}_2\text{CHRCOOH} \) [7][8].

Textile staining is basically the event of absorption of dyes into fibers consisting of several stages, namely the transfer of dyestuff molecules from solution to the fiber surface, adsorption of dyestuff molecules on the fiber surface and diffusion of dyestuff molecules from the surface into or on the axis of the fiber [9].

In order to obtain a dye with good color fastness properties, it is necessary to have a strong bonding force between the dyestuff and the fiber; in this case there are 4 types of bonding force between the fiber and the dye, namely hydrogen bonding, forces that are ions or electrovalent, van der Waals forces and covalent bonds [10].

The process of dyeing textiles with natural dyes simply includes mordanting, coloring, fixation, weaving and drying [11]. Mordanting is the initial treatment of textile materials that will be colored so that the fat, oil, starch, and dirt left in the weaving and spinning process can be eliminated. In this process the textile material is put into the alum solution which will be heated to boiling, the coloring process is done by dipping the textile material in the dye, while the fixation process is a process of locking the color, can be done with several materials, such as alum, lime, etc. other. The fixation process aims to generate dyes that have entered into the textile fiber, with fixation, the dye will be difficult to return after entering the fiber [12].

The purpose of this research is to get the best formula in the process of dyeing silk thread by using coffee bean skin waste as a coloring material that has color aging, color fastness to washing, sweat rubbing and light can be used to make woven cloth.

2. Methods
2.1. Material
The material used consists of silk thread Nm 140/2, Robusta coffee bean skin waste obtained from Muaraenim Regency, South Sumatra, laundry soap, TRO, alum and lime.

2.2. Equipment
Equipment used include heaters/stoves, pans, measuring cups, filters, Waskom, Spectrophotometer, Grey Scale (standard color change scale), Staining Scale (color staining scale standard) and Crock meter (fabric rubbing test equipment).

2.3. Research method
This experiment studies the relationship between the concentration of coffee bean skin dye solution (A) and the concentration of lime color fixation (B) on color aging and color fastness to washing, rubbing, sweating and light produced.
The concentration of the coffee bean skin coloring solution consists of four levels, namely 50 g/l (A1), 100 g/l (A2), 150 g/l (A3) and 200 g/l (A4), and the concentration of lime color fixation solution Tough also consists of 4 levels, namely 25 g/l (B1), 50 g/l (B2), 75 g/l (B3) and 100 g/l (B4). The process of yarn coloring by using coffee bean skin as a coloring agent is carried out with the following procedure:

2.3.1. Cooking process.
Degumming/cooking silk threads are soaked in a washing solution of 20 g/l at 90°C for 1 hour. then washed clean.

2.3.2. Mordanting process.
The silk threads are soaked in alum solution of 50 g/l, at 90 °C for one hour, the heater is turned off, the yarn is allowed to stand for 24 hours, then washed clean and aerated until it dries.

2.3.3. Making dyes.
Coffee bean skin is extracted/boiled with water in accordance with a predetermined concentration until the boiling water is only half. The colored cooking water is filtered and the solution is then used to dye silk.

2.3.4. Colorization process.
The obtained dye solution is put into a Waskom/plastic bucket, then the cooked and twisted silk thread is soaked in the dye solution for 15 minutes at room temperature, the yarn is then removed and hung in a shady place. Each color drop is collected again in a dip bucket, then the yarn soaked again in the dye solution that was accommodated earlier, removed and dried in a shady place, the process takes place repeatedly until 5 times.

2.3.5. Color fixation process.
In this process the coffee bean skin dye that has existed in the yarn, fixed with a solution of lime with a predetermined concentration, this process is done by soaking the yarn that has been colored in the solution of the lime for 15 minutes at room temperature.

2.3.6. Weaving process.
After the coloring process and color fixation, the yarn is then soaped into the solution for 30 minutes at 80 °C and then washed and dried/aired to dry.

2.3.7. Testing.
The results of the experiments were tested for color aging, color fastness to washing, rubbing, sweat and light.

3. Results and discussion

3.1. Color assembly
The results of color aging test or K/S values that have been done using a spectrophotometer show that increasing the concentration of natural dye solution of coffee bean skin and increasing the concentration of lime fixation solution in the process of coloring silk material obtained by older silk thread colors (K/S value higher) from light golden yellow to dark golden yellow.
Figure 2. Histogram of color aging.

The color aging histogram in Figure 2 can be seen that at the concentration of a coffee bean skin dye solution A1 (50 g/l) and the concentration of lime (25 g/l) fixation obtained a color aging with a K/S value of 12.56. At the concentration of a coffee bean skin dye solution A2 (100 g/l) and the concentration of color fixation solution B2 (50 g/l) the color aging increases with a K/S value of 15.66. At the concentration of the coffee bean skin dye solution A3 (150 g/l) and color fixation concentration B3 (75 g/l) the color aging increases again with the K/S value of 20.93. At the concentration of the coffee bean skin dye solution A4 (200 g/l) and color fixation concentration B4 (100 g/l) color aging does not increase anymore or tends to continue to reach K/S value of 20.92. The increasing value of color aging has to do with the number of dyestuff molecules that hold bonds with fibers, the greater the concentration of dyes in solution, the more the number of dyestuff molecules in the solution, thus the number of dyestuff molecules entering, absorbed and attached to the surface of the fiber also more and more so that the color of the yarn obtained will get older or the value of K/S will be even greater.

Meanwhile, by increasing the concentration of color lime fixation will also increase the color aging, because the function of the color fixation solution is to help the binding of dye molecules so that they can be firmly attached to the fiber/yarn [13]. Lime contains compounds that cause alkaline conditions which cause the fiber to become more bulging so that the fiber pores are more open, when the pore condition of the open fibers the dye will get more leverage into the fibers will bind with lime. The more bonds that occur will produce an older color, therefore the fixation process is carried out after the coloring process where the particles of the dye have been absorbed optimally on the fiber [14].

The histogram in Figure 2 can be seen that the coloring process at the concentration of the coffee bean skin dye solution A3 (150 g/l) and the concentration of lime color fixation B3 (75 g/l) produces maximum color aging with a K/S value of 20.93. Increasing the concentration of the dye solution and the concentration of the color fixation solution subsequently turned out to not be able to increase the color brightness, the color brightness value (K/S) tends to remain. This means that the number of dyestuff molecules attached to the surface and fiber axis has reached its saturation point.

3.2. Color fade resistance to washing
The results of color fastness testing for washing as can be seen in Table 1 shows that increasing the concentration of natural dye solution of coffee bean skin and enlarging the concentration of lime fixation solution to the color fastness tends to remain constant, both in color changes and in color staining, namely the value 3-4 (enough) for color changes and 4 (good) for color stain while the
minimum value is 3 [15]. Color fastness assessment is done by seeing the changes in the original color as there is no change, there is a slight change, enough to change and change at all. The standards used are Gray Scale (color change) and Staining scale (color stain).

| Table 1. Silk color fastness to washing. |
|----------------------------------------|
| Fixation (g/l)                         |
| Pigment | B1 | B2 | B3 | B4 | |
| (g/l)   | RW | NW | RW | NW | RW | NW | RW | NW |
| A13      | 4  | 3-4 | 4  | 3-4 | 4  | 3-4 | 4  | |
| A23      | 4  | 3-4 | 4  | 3-4 | 4  | 3-4 | 4  | |
| A3       | 3-4 | 4  | 3-4 | 4  | 3-4 | 4  | |
| A4       | 3-4 | 43-44 | 3-4 | 4  | 3-4 | 4  | |

Information:
RW = Color change, NW = Color staining

In the Gray Scale, an assessment of color fastness and color change is done by comparing the differences in the samples that have been tested with the original samples, to the corresponding differences from the standard sequence of changes described by the Gray scale. While on the Staining Scale, the assessment of staining on white cloth in color fastness testing is done by comparing the color differences of the stained and undefiled white cloth, against the differences described by the Staining Scale [16].

The value of color fastness to washing tends to be permanent or permanent, both color changes and color staining caused during the coloring process takes place containing tannin can enter the fiber which is a process of imbibiption and certain attractive forces and binds to silk fibers containing OH groups, although the bonds formed are only hydrogen bonds, but the lime fixator can lock and coat the tannins so they don't come out of the fiber easily. This is why tannins that have bonded to the fibers are not easily separated and run the test material when it is tested. color fastness to washing. Another cause is the process of lathering/washing carried out after the coloring process causes the remaining dye molecules and attached to the surface of the thread/fiber will be reduced or completely lost, so that when the process of testing the color fastness to washing the value tends to remain good color changes as well as color staining [17] as can be seen in Table 1.

The results of research that have been carried out from all treatments, the value of color fastness to washing on silk material both for color changes and color staining is higher than the SNI requirements, which is a minimum of 3.

3.3. Color fade resistance to rubbing
The results of the color fastness to rubbing test show that the value of color fastness to dry rubbing is higher than the wet rubbing as can be seen in Table 2. Color fastness is 4 (good) for dry rubbing and 3 (sufficient) for wet rubbing, while the minimum standard value is 3 [18].

| Table 2. Silk color fastness to rubbing. |
|----------------------------------------|
| Fixation (g/l)                         |
| PigmentB1 | B2 | B3 | B4 | |
| (g/l)     | GK | GB | GK | GB | GK | GB |
The high value of color fastness in dry rubbing compared to wet rubbing is caused by the weaving process, where all the dyes are only attached to the surface of the yarn, so that during the testing process the rub resistance of the dyes inside the yarn will be difficult to detach. Wet rubbing the presence of water causes the fibers or threads to swell and the pores of the fibers will open, causing the dye in the thread to get out easily and with the existence of friction or direct mechanical movement of the test equipment resulting in some of the bonded dye will be detached and attached to the scouring cloth [19].

The color fastness assessment for rubbing is the same as the color fastness assessment for washing, that is the value of color fastness tends to be permanent or permanent both color changes and color staining is done by seeing the original color changes as there is no change, there is little change, enough change and changed completely. The standard used is the standard Gray Scale (color change) and Staining scale (color stain).

The results of research that have been carried out from all treatments, the value of color fastness to rubbing both dry rubbing and wet rubbing on silk material meets SNI requirements, namely at least 3.

### 3.4. Color fade resistance to sweat

The results of the color fastness test against acidic sweat and alkaline sweat as shown in Table 3 and Table 4. shows the value 4 (both) for color changes and color staining while the minimum standard value is 3 [20]. In the process of testing the color fastness to sweat, a weak acid solution, lactic acid and a weak base, sodium carbonate, is used. It is possible that the weak acids and bases used do not affect the color fastness of the fabric resulting from the natural dye process of coffee bean shells with lime color fixation [21].

**Table 3.** Silk color fastness to acid sweat.

| Fixation (g/l) | PigmentB1 (g/l) | B2 | B3 | B4 |
|---------------|-----------------|----|----|----|
|               | RW  NW | RW  NW | RW  NW | RW  NW |
| A1             | 4      | 4      | 4      | 4      |
| A2             | 4      | 4      | 4      | 4      |
| A3             | 4      | 4      | 4      | 4      |
| A4             | 4      | 4      | 4      | 4      |

Information:

RW = Color change, NW = Color staining
The results of research that have been done from all treatments, the value of color fastness to acid sweat and alkaline sweat both on the yarn is higher than the SNI requirements, which is a minimum of 3.

**Table 4. Silk color fastness to alkaline sweat.**

| Pigment (g/l) | Fixation (g/l) | B1 | B2 | B3 | B4 |
|--------------|---------------|----|----|----|----|
| RW | NW | RW | NW | RW | NW | RW | NW |
| A1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| A2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| A3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| A4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

Information:
RW = Color change, NW = Color staining

3.5. **Color fastness to light**

The results of testing the color fastness to light on silk thread as can be seen in Table 5, shows a value of 2-3 (less), while a minimum value of 3 [22]. Color fastness to light is a weakness/deficiency of natural dyes [23], sunlight with certain wavelengths will decompose or damage the molecular structure of coffee bean skin dyes so that the color of fabric staining results quickly fade and turn younger than its original color so the value of the color fastness to light is less.

**Table 5. Silk color fastness to light.**

| Pigment (g/l) | Fixation (g/l) |
|--------------|---------------|
| (g/l) | B1 | B2 | B3 | B4 |
|-----------------|---|---|---|---|
| A1 | 2-3 | 2-3 | 2-3 | 2-3 |
| A2 | 2-3 | 2-3 | 2-3 | 2-3 |
| A3 | 2-3 | 2-3 | 2-3 | 2-3 |
| A4 | 2-3 | 2-3 | 2-3 | 2-3 |

4. **Conclusion**

Coffee bean skin waste can be used for dyeing silk thread, the greater the concentration of the coffee bean skin dye solution and the concentration of lime fixation solution, the color of the fabric is older, while the color fastness against washing, rubbing, sweat and light tends to remain.

The best results were obtained at a concentration of 150 gr/l coffee bean skin dye solution and 75 gr/l lime fixation solution concentration resulting in K/S color aging of 20.93, color fastness to washing values of 3-4 (sufficient) for color changes and 4 (good) for color staining, color fastness to rubbing values 4 (good) for dry rubbing and 3-4 (sufficient) for wet rubbing, color fastness to sweat values 4-5 (good) for acidic and basic sweat, meet SNI quality standards. 0285-89-A, SNI 0287-89-A
and SNI 0288-89-A, while the color fastness to light value of 2-3 (less) does not meet SNI quality standards. 0289-89-A.

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