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Process of dyeing Chinese silk fabric using color of water betel nuts

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Abstract

The aims of this research are to study the process of dyeing Chinese silk fabric using color of water betel nuts. The extracts were prepared from the mixture of water betel nuts with water, 1:5 by ratio for 40 minutes. Water betel nuts were comprised of the various mixtures of betel nut seed, red lime, and Piper betel Linn (4:3:0.5, 8:6:1, and 10:8:1 respectively). Then the appropriated water betel nut mixtures were mixed with fixing agents, including, the concentration of salt at 10%, 20%, and 30%, the concentration of alum at 0.3%, 1.6%, and 3.3%, and the combination of concentration of salt and alum at ratio of 3.3% : 0.3%, 1.6% : 0.3% and 0.3% : 0.3% respectively for 40 minute. The research also study the appropriate of dyeing time at different of type and fixing agent concentration, time of dyeing were varied at 20, 40 and 60 minute. The result shows that the best propotional of water betel nut miture is 4:3:0.5. Besides the lowest L* is 55.800, and a*, b*, ΔE* and C* values identified at 19.550, 22.230, 45.340 and 29.600 respectively. In addition, the study reveals that the best fixing agent is 30% concentration of salt which show lowest L* value at 61.950, and a*, b*, ΔE* and C* highest values of 16.225, 27.425, 41.830 and 30.590 respectively. The best dyeing time is at 60 minute as results of the lowest of L* value at 69.020, and a*, b*, ΔE* and C* highest values of 9.585, 21.060, 31.190 and 23.150 respectively.

Keywords: betel nut, silk fabric, fixing agent

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1. Introduction

Natural colors gained from certain plants, animals, and some kinds of mineral are extracted from natural process. For many centuries, natural colors have been involving with human's way of life. People in the past usually use the natural colors for their activities used body painting, pottery painting, mural painting, clothes dyeing as well as using as a part of rites following a particular belief. Preparing natural colors is quite difficult. The color gained from those natural materials like plants, animals, and some kinds of mineral, is not colorful enough. Moreover, the dyeing is not consistent. There are some advantages, however. Natural colors don't lead to negative health and environment effects. Dyeing fabric or natural yarn is one of solution ways to help reduce pollution and environment problems. Crop rotation, moreover, can be done without losing of minerals in the soil [1]. Owing to the color extracted from natural materials has it charm with pretty dark shade, people nowadays, therefore, pay more attention to color extracted from natural materials than the past. Considering the process to gain silk fabric, the silk fabric is produced by larvae of silkworm from the insect named Bombyx mori which has a preference for only mulberry as its food. Life cycle of silkworm consists of four stages: age, worm, larvae, and butterfly [2]. Silkworm is known as "Queen of Silk". It is because silk has itself uniqueness and elegance. Apart from this, silk is lustrous and strong comparing to other natural fabrics. It is resistant to moths and dust mite and it can absorb 11% of its dry weight in moisture. There is also a translucency giving depth to the reflection. It dyes well. The colors take on a bright sparkle. These make it a comfortable year-round fiber to wear. Hence, silk has been popular among people for centuries. However, it was found that silk has the property of recovery from low wet resiliency. It is thus easily to wrinkle when getting wet or wash [3].

Recently, fabric dyeing from natural can be classified into 3 types, 1) Direct dyeing is occuring form natural material which is stainable without an agent, 2) Vat dyeing is an insoluble dyeing and 3) Mordant dyeing, this type is alleviated the color absorb into the fabric which is durability and less discoloration [4]. Coloration measurement by CIELab (L*, a*, b*) system is widely use lately, this newest system has developed the color identifying equation and this can be perfectly differentiat the color accordingly color space theory [5]. The color of betel nuts have potentially long lashing compare to other natural materials, this was noticed when the betel nuts stain into the clothes and it permanently, the

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researcher is interested in dyeing the chinese silk from betel nuts.

By the way, betel nuts or Areca catechu Linn in scientific name is monocotyledon grouped in palm family without taproots. But there are fibrous roots spreading around the stem, more or less, it depends on its age and soil abundance. Betel nut is a slender, single-trunked and monoecious plant with male and female flowers occurring on the same spadix. The diameter is typically around 5-6 inches. It is an oval-shaped fruit with a hard seed or nut inside. Each bunch will involve 10-150 fruits. Fresh fruit is green, whereas in the ripe fruit, the husk becomes yellow or orange. The more the fruit is ripe, the harder husk fiber is. In case of inside husk, it has slightly husk covering nut. The skin of betel nut is somewhat yellow or brown [6]. Piper betel Linn is an economic and important plant for exporting. Most of the countries importing the piper betel from Thailand are those from Middle East such as Pakistan and Afghanistan. However, it is still insufficient for consumers. Piper betel is normally grown in the central and northeastern parts of Thailand [7]. Historically, red lime is gained from hot burning shell and it could be mashed to get white lime Calcium Oxide (CaO). When it is cool, soak it with water and the lime will react with water to produce Calcium Hydroxide ($Ca(OH)_2$). When the lime is mixed with turmeric, it will produce orange color. The purpose of this study is thus to study the process of dyeing Chinese silk using natural color of betel nuts.

2. Materials and methods

In the experimental of this Chinese silk dyeing, the Chinese silk is normally boiled at approximately 60-70 degree celsius. Therefore, this method is easy and convenient, the processes can be devided into 4 steps following:

Pre-test: Step 1) the Chinese silk was boiled in betel nuts, then left them dry at room temperature, record the stainability.

Step 2) the Chinese silk was boiled in betel nuts mixed with fixing agent, salt and alum, respectively, then left at room temperature, record the stainability and compare the stainability from Step 1).

1st experiment: To study the proportion between young and fresh betel nut seed, red lime and fresh Piper betel Linn suitable for dyeing Chinese silk (commercial grade) is from local market (Songkhla store). The experiment process was Completely Randomized Design (CRD) by comparing the proportion between betel nut, lime, and piper betel suitable for dyeing Chinese silk. The betel nut was ascribed as the 3-6 months old betel nut seed likewise the Piper betel Linn was picked after 6 months old. Beside, red lime in this experiment was bought as a commercial grade. Chinese silk (commercial grade) and all those 3 main materials are from local market. The betel nuts were selected as young age or similar and then cut the fabric as 6x6 inches. After that extract it with water in the ratio of blend: water equivalent to 1:5 for 40 minutes. The fabric sample of Chinese silk was boiled with the mixture of betel nut seed, red lime and Piper betel Linn as various ratios for 40 minute then left the sample dried at room temperature. The proportion between betel nuts, red lime and Piper betel Linn was 4:3:0.5, 8:6:1 and 10:8:1. Thickness, length, weight and width of fabric before and after dyeing were recorded and analyzed. Handy Colorimeter with CIELab system was used to measure the color before and after dyeing to determine L* a* and b* values. By L* represents brightness, a* represents red-green colors, and b* represents yellow-blue colors. The total color differences (ΔE*) can be calculated from

$$\Delta E^* = (L^{*2} + a^{*2} + b^{*2})^{1/2}$$

and chroma (C*) can be calculated from

$$C^* = (a^{*2} + b^{*2})^{1/2}.$$

Color measurement values after that were estimated an average to be color value of fabric of each experiment. The data was then analyzed to find out the variance. Ducan's multiple rang test was also employed to compare the difference.

2nd experiment: To study types of fixing agent and concentration suitable for dyeing fabric with color from betel nut selected form the proportion of blend between betel nuts, red lime and Piper betel Linn suitable for dyeing fabric from the first experiment. Boil it for 40 minutes in order to use it with various types of fixing agent as followed: the proportion of suitable blend with concentrate salt 10%, 20%, 30%, alum 0.3%, 1.6%, salt 3.3% and concentrate alum 0.3%, salt 1.6% and alum 0.3% and salt 0.3% and alum 0.3%, respectively. Thickness, length, weight and width of fabric before and after boiling were recorded and analyzed following the calculation method in 1st experiment.

3rd experiment: To conduct suitable duration for dyeing Chinese silk from the color extracted from betel nuts with fixing agent by selecting types and concentration of the fixing agent from 2rd experiment which the color is lasting. The duration for dyeing was 20, 40, 60 minutes. Thickness, length, weight and width of fabric before and after dyeing and boiling were again recorded and analyzed following the calculation method in 1st experiment.

3. Results

3.1 The Suitable Ratio between Betel Nut: Red Lime: Piper Betel Linn for Dyeing Chinese Silk

The results revealed that the proportion between betel nut: red lime: Piper betel Linn for Dyeing Chinese Silk was the proportion of 0 before dyeing, proportion 1 was 4:3:0.5, proportion 2 was 8:6:1 and proportion 3 was 10:8:1, respectively.

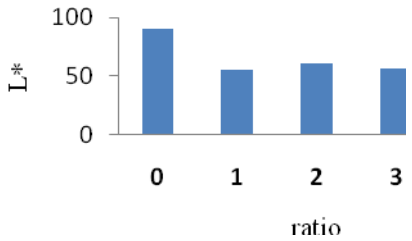
The results of the suitable ratio between betel nuts and lime for dyeing Chinese silk was displayed in the Table 1 and Figure 1.

According to Table 1 and Figure 1, it was found that the weight and thickness of three proportions was not difference and higher after being dyeing. Width of the three proportions was, moreover, not difference and lowers than after dyeing. Considering the length the three proportions, it was also not difference and not lower than after dyeing. Regarding the length before and after dyeing, it was not difference. The proportion of three L* value was lower than after dyeing. In other words, 1 and 3 proportions were considered as the lowest value, followed by 2. The a* all of the three proportions had higher value than before dyeing. The proportion 1 was at the highest value, followed by the 3 and 2 proportions, respectively. In case of the b*, the three proportion had higher value before dyeing. The proportion 2 had the highest value, followed by 1 and 3 proportions, subsequently.

Table 1 Physical properties and coloration of dyeing silk fabric with ratio betel nut: red lime: Piper betel Linn variation

ratio	weight	thickness	width	length	L*	a*	b*	ΔE*	c*
0	0.830b	0.080b	15.783a	15.122a	90.356a	-1.744d	1.174d		
1	0.883a	0.103a	15.143b	14.977a	55.800c	19.550a	23.227a	45.34a	29.60a
2	0.910a	0.103a	15.350b	15.140a	61.177b	15.697c	22.230b	38.07b	23.92ab
3	0.910a	0.100a	15.420b	15.047a	56.233c	17.567b	21.880c	39.26b	17.57b

Note: Mean with the different letter in same column is significantly $p < 0.05$



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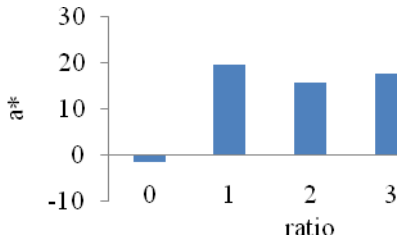

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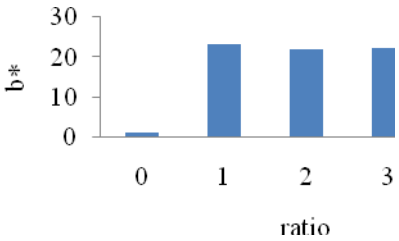


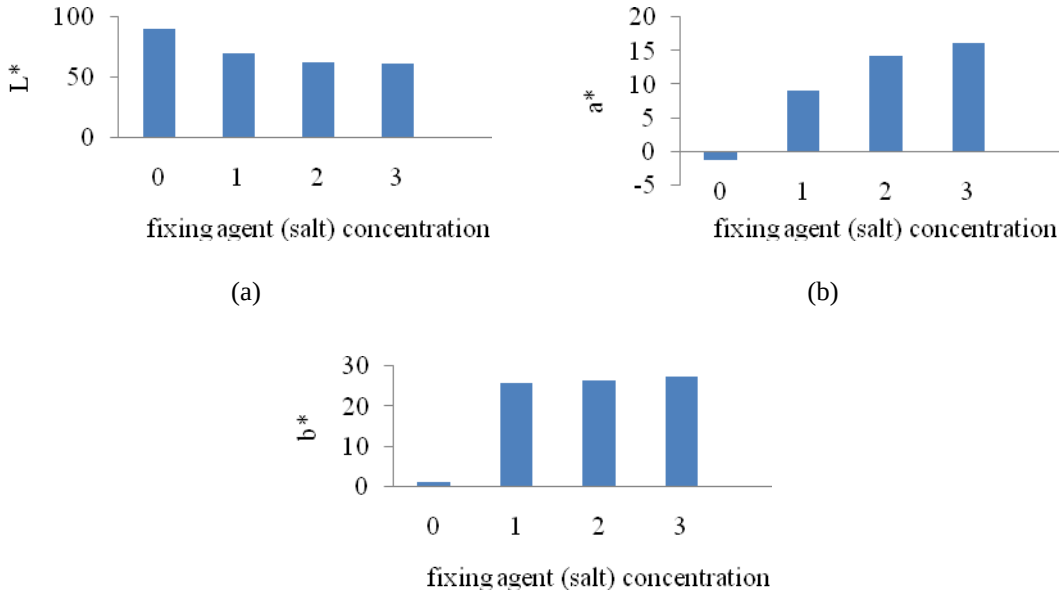
(c)

Figure 1 Coloration of dyeing silk fabric with ratio betel nut: red lime: Piper betel Linn variation. (a) L* (b) a* (c) b*

Table 2 Physical properties and coloration of dyeing silk fabric with fixing agent salt concentration variation

concentration	weight	thickness	width	length	L*	a*	b*	ΔE*	c*
0	0.818b	0.080b	15.857a	15.261a	90.533a	-1.242d	1.333d		
1	0.973a	0.108a	15.489ab	15.361a	70.295b	9.125c	25.925c	34.02c	28.91c
2	0.965a	0.103a	15.076b	15.118a	62.375c	14.250b	26.425b	40.79b	30.02b
3	0.978a	0.108a	15.622ab	15.119a	61.950c	16.225a	27.425a	41.83a	30.59a

Note: Mean with the different letter in same column is significantly $p < 0.05$



(a) (b)

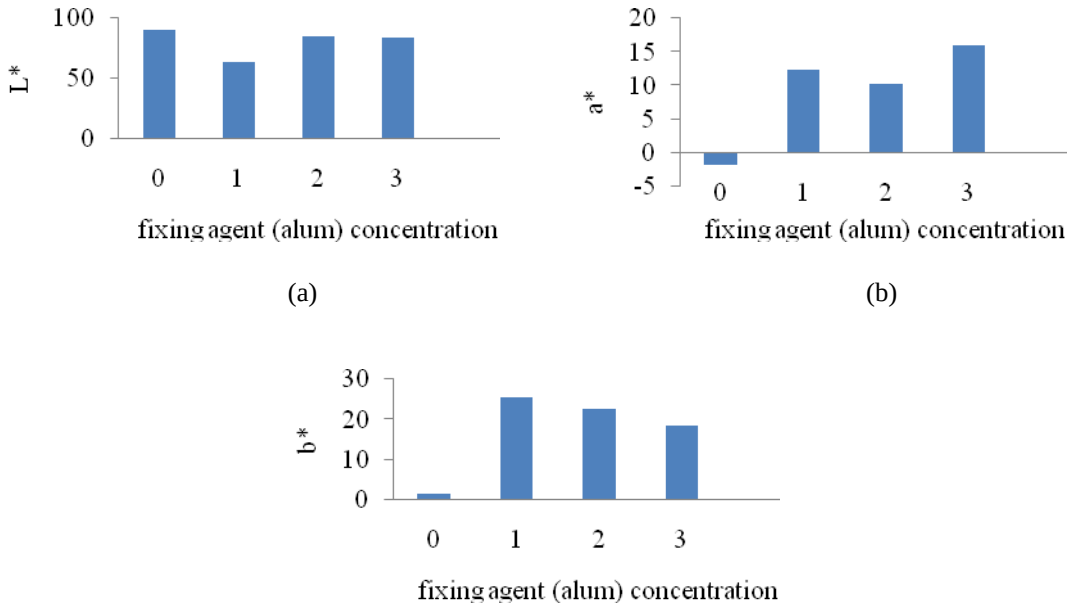
(c)

Figure 2 Coloration of time to dyeing silk fabric variation. (a) L* (b) a* (c) b*

Table 3 Physical properties and coloration of dyeing silk fabric with fixing agent alum concentration variation

concentration	weight	thickness	width	length	L*	a*	b*	ΔE*	c*
0	0.821bc	0.070b	15.482a	15.240a	90.633a	-1.717d	1.692d		
1	0.955a	0.105a	15.312a	15.082a	64.150d	12.350b	25.500a	38.30a	28.34a
2	0.860b	0.103a	15.093a	15.261a	85.250b	10.354c	22.600b	21.71b	22.87b
3	0.813c	0.108a	14.647a	15.187a	84.425c	15.998a	18.625c	18.87c	18.63c

Note: Mean with the different letter in same column is significantly $p < 0.05$



(a) (b)

(c)

Figure 3 Coloration of dyeing silk fabric with fixing agent alum concentration variation. (a) L* (b) a* (c) b*

Table 4 Physical properties and coloration of dyeing silk fabric with fixing agent salt and alum concentration variation

concentration	weight	thickness	width	length	L*	a*	b*	ΔE*	c*
0	0.780c	0.068c	14.817a	15.206a	90.742a	-1.7750d	1.800d		
1	0.830b	0.103b	14.461ab	14.997a	67.400c	13.100b	23.300b	35.08b	26.74b
2	0.815b	0.115a	14.201b	15.415a	71.475b	8.650c	19.125c	28.08c	21.00c
3	0.908a	0.105b	14.718a	15.159a	60.875d	16.15a	23.800a	41.06a	28.77a

Note: Mean with the different letter in same column is significantly $p < 0.05$

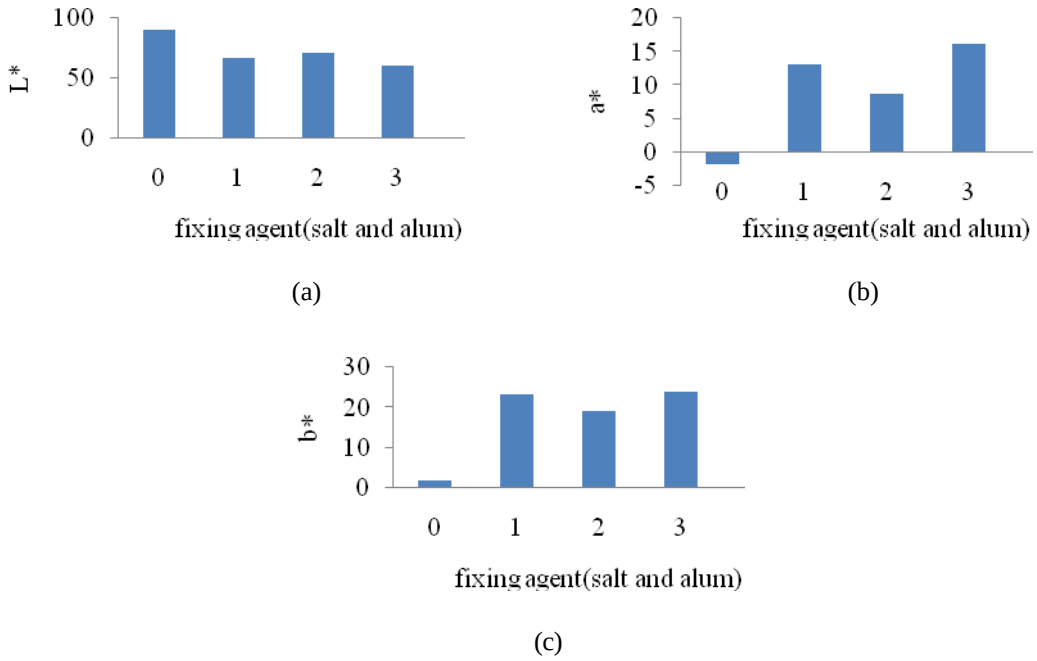


Figure 4 Coloration of dyeing silk fabric with fixing agent salt and alum concentration variation. (a) L* (b) a* (c) b*

3.2 Fixing Agent Suitable for Dyeing Silk Fabric

To be successful in this study three fixing agent: salt, alum, salt and alum were utilized.

1) Fixing Agent (salt)

The concentration of fixing agent (salt) for dyeing Chinese silk was set as followed: concentration 0 before dyeing, concentrate 1 salt 10%, concentrate 2 salt 20% and concentrate 3 salt 30%. The results were shown in the Table 2 and Figure 2.

According to Table 2 and Figure 2, it revealed that there was not difference between weight and thickness of the three concentrations and the value was higher than before dyeing. Considering the width of concentration 2, it had value less than before dyeing. The width before dyeing and after dyeing was not difference comparing the 1 and 3 concentration. The L* color of the three concentrations was lower than before dyeing. The concentration 2 and 3 was lowest, followed by the concentration 1. The a* color value all of the three concentrations was higher than before dyeing. The concentration 3 was highest followed by the concentration 2 and 1, respectively. In case of b* color value, all of the three concentrations were higher than before dyeing. The first concentration possessed the highest value, followed by the second and the third concentrations, subsequently.

2) Fixing Agent (alum)

The concentration of fixing agent (alum) for dyeing Chinese silk was set as followed: concentration 0 before dyeing, concentration 1 alum 0.3%, concentration 2 alum 1.6% and concentration 3 alum 3.3%. The results were shown in the Table 3 and Figure 3.

According to Table 3 and Figure 3, it was found that weight and concentration 1 and 2 had higher value than before dyeing, concentration 1 had the highest value. Thickness all of three concentration had the same value and higher than before dyeing. Width and length all the three concentrations was not difference between before and after dyeing. The L* color of the three concentrations was lower than before dyeing. The concentration 1 was lowest followed by the concentration 3 and 2, respectively. The a* color value all of the three concentrations was higher than before dyeing. The concentration 3 was highest followed by the concentration 1 and 2, respectively. In case of b* color value, all of the three concentrations were higher than before dyeing. The first concentration possessed the highest value, followed by 2 and 3 concentrations, subsequently.

3) Fixing Agent (salt and alum)

The concentration of fixing agent (salt and alum) for dyeing Chinese silk was set as followed: concentration 0 before dyeing, concentration 1 (salt 3.3% and alum 0.3%), concentration 2 (salt 1.6% and alum 0.3%) and concentration 3 (salt 0.3% and alum 0.3%). The results were shown in the Table 4 and Figure 4.

According to Table 4 and Figure 4, it was found that weight all concentration had higher value than before dyeing, concentration 3 had the highest value, follow by the concentration 1 and 2, respectively. Thickness all of three concentration had the same value and higher than before dyeing, concentration 2 had the highest value, follow by the concentration 1 and 3, respectively. A width concentration 2 was lower than before dyeing, a concentration 1 and 3 was not difference before dyeing. Length all the three concentrations was not difference between before and after dyeing. The L* color of the three concentrations was lower than before dyeing. The concentration 3 was lowest followed by the concentration 1 and 2, respectively. In case the a* color value and b* color value, all of the three concentrations was higher than before dyeing. The concentration 3 was highest followed by the concentration 1 and 2, respectively.

3.3 Study the duration of dyeing Chinese silk with fixing agent

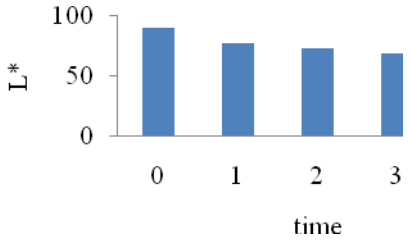
The duration of dyeing Chinese silk fabric with fixing agent was set as followed: Time 0 before dyeing, Time 1 (20 minute), Time 2 (40 minute) and Time 3 (60 minute). The results were shown in the Table 5 and Figure 5.

From Table 5 and Figure 5, it was found that there was not difference of the weight between before and after dyeing. Thickness of all the set time was not also difference and having value higher than of before dyeing. Considering the width of time 3, it was lower than before dyeing whereas time 1 and 2 had not difference of before dyeing. The length of before and after dyeing was not difference at time 3. The L* of three times was lower than before dyeing by time 1 was lowest followed by time 2 and 1 respectively. The a* and b* value of three time was higher than before dyeing by time 3 was highest value followed by time 2 and 1 respectively.

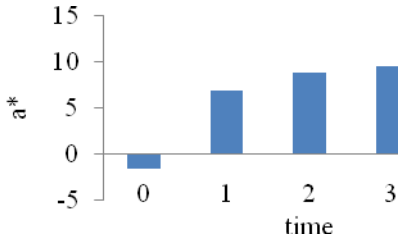
Table 5 Physical properties and coloration of time to dyeing Chinese silk fabric variation

time	weight	thickness	width	length	L*	a*	b*	ΔE*	c*
0	0.857a	0.080b	15.448a	15.109a	90.730a	-1.608d	1.667d		
1	0.877a	0.100a	15.163ab	15.147a	77.737b	6.860c	16.950c	21.80c	18.30c
2	0.860a	0.100a	15.200ab	15.103a	73.427c	8.903b	17.737b	25.84b	19.86b
3	0.833a	0.103a	14.757b	15.190a	69.020d	9.587a	21.060a	31.19a	23.15a

Note: Mean with the different letter in same column is significantly $p < 0.05$



(a)



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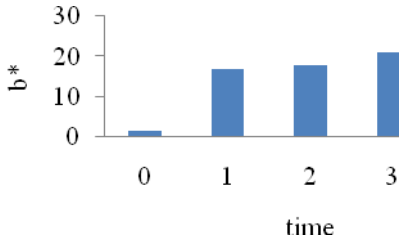

(c)

Figure 5 Coloration of time to dyeing silk fabric variation. (a) L* (b) a* (c) b*

4. Discussion and conclusions

The suitable ratio between betel nut: red lime: Piper betel Linn for dyeing Chinese silk.

In general, the brightness of Chinese silk sample before dyeing is in the range of 85-95 (L*=-100 is the darkness, L*=100 is the brightness). After dyeing the sample in the mixture of 4:3:0.5 of betel nut: red lime: Piper betel Linn. The result shows that the brightness (L*) is at 55.800 which is the lowest value from the experiment. Thus, the value of redness (a*), yellowness (b*), the total color differences (ΔE*) and chroma (c*) are highnest. All those values identified the most suitable dyeing of betel nut compare to the other natural materials.

Type of fixing agent suitable for dyeing Chinese silk.

According to the studied of appropriate betel nut propotion in dyeing Chinese silk, that reduced the brightness value (L*) and increase of the duration and increase an absorption. 30% of salt as fixing agent has a great influenced upon L* (lowest) and a*, b*, ΔE*, and c* comparing to the other agents.

The duration of dyeing Chinese silk with fixing agent.

The results of the duration for dyeing silk revealed that 60 minutes for dyeing silk could give Chinese silk with L* at the lowest value (69.020) and red value or a*, and yellow value or b* at the highest value (9.585 and 21.060, subsequently). When E* and C* values were analyzed, it revealed the highest value.

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