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## Analysis of Natural Mordant to B. mori Silk Fabrics Dyeing with Tea Extract

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# Analysis of Natural Mordant to *B.mori* Silk Fabrics Dyeing with Tea Extract

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**Abstract.** Tea pigments as biological materials were extracted in this paper. Applications of turmeric and tannic acid during the silk dyeing with tea extract were studied. By changing mordant dyeing methods, concentration of mordant, dye solution pH value and dyeing concentration, we tried to study the effect of natural mordant. The results showed that two kinds of mordant were more suitable for pre-mordant. When the tannic acid was 5 g/L, the turmeric was 0.025 g/L, and the dye solution pH value was 5, the dyeing effect was optimal. Furthermore, when the dyeing concentration was diluted 5 times, the dyed fabric color was fuller. With the optimum mordant dyeing process conditions, the colors fastness to washing were acceptable.

## 1. Introduction

Tea has a long history and many uses. Usually we drink it or eat it. But it can be used as a natural biological material in many application areas more and more. Such as extracting catechins from tea leaves, tea polyphenols and others[1-3]. At the same time, Tea contained a variety of pigments, so many researchers had tried to extract pigment from tea as a dye for dye for textiles. The study also found that when dyeing silk with tea pigments, the mordant were needed. Furthermore, the use of mordant could improve the color fastness of the fabric [4-5]. So many kinds of metal mordant were often applied, such as aluminum ion, copper ion, and iron ion. But the extensive use of metal mordant could cause certain pollution to the environment. So the research about natural mordant becomes more and more important.

Turmeric could be used as a yellow dye, and there was few research on turmeric used as mordant currently [6]. While turmeric and tannic acid were selected as natural mordant in the dyeing of silk on tea, which provided a reference for natural environmental protection of dyeing.

## 2. Experimental

### 2.1. Materials

Silk: crepe satin plain (71g/m<sup>2</sup>), black tea (saled), turmeric (saled);

Reagent: 95% ethanol (chemically pure); tannic acid (analytically pure);

Equipment: R-201 rotary evaporator, RUC-5200 ultrasonic machine, BHS-4 digital homoeothermic water bath, PHS-3C meter, SW-12J Wash fastness tester, Y571B Rubbing fastness tester, Datacolor-check3 analyzer, Q-SUN B02 Color fastness test chamber, FA1C04 electronic balance.



## 2.2. Method

**2.2.1.Extraction of Tea Pigments.** Accurately a certain concentration of tea leaves were weighed, then were dipped in the 95% ethanol at room temperature; and with ultrasonic extraction. Furthermore, the tea leaves with ethanol were filtered and concentrated. Finally the tea extract were prepared. The tea extract were diluted to 5, 10, 30 and 50 times.

**2.2.2.Mordant Method.** The silk samples were immersed in pure water for 5 minutes before experiment.And all liquor ratio was 50:1 in this paper. After mordant, the treated silk were washed with water, soap solution and air-dried.

- Pre-mordant: silk fabrics were immersed in mordant solution, and oscillated at 50°C for 30 min. Next, the fabrics were put into tea extract diluted at 5. Then oscillated at 80°C for 30 min.
- Bath mordant: The silk fabrics were put into tea extract diluted at 5 mixed with turmeric or tannic acid. Then oscillated at 80°C for 30 min.
- Post-mordant: silk fabrics were put into tea extract diluted at 5 and oscillated at 80°C for 30 min. Next, took out silk fabrics and dropped them into mordant solution. Furthermore kept oscillating gently at 50°C for 30 min.

**2.2.3.Variety in the Concentration of mordant and Dye pH.** When the optimal mordant process was selected, we tried to change the concentration of mordant and changed the dye pH from 3,4,5,6,to 7.5.

### 2.2.4Performance Testing:K/S Value Testing and Testing of Color fastness

The K/S value was the depth of fabric surface. It could show ability of tea extract to the silk fabrics. K/S value was tested by color analyzer at D65 light source, 10 ° standards, and fabric was folded 4 layers, while each sample was tested 4 times. The maximum absorption wavelength tested within 400-700 nm was corresponding to K/S value, L value, a value and b value.

Color Fastness to Washing: according to GB/T 3921-2008; Color fastness to rubbing: according to GB/T3920-2008; Color Fastness to Artificial Light: according to GB/T8427-2008; Color fastness rating: according to GB250-2008 and GB251-2008.

## 3. Results and Discussion

### 3.1. Effect of Mordant Method

The dyeing solution was diluted 5 times with tea extract, the turmeric was 0.05g/L, and the tannic acid was 10g/L.

**Table 1.** The treated fabrics under different mordant methods

| Mordant method |              | K/S  | L     | a*    | b*    |
|----------------|--------------|------|-------|-------|-------|
| Non- mordant   |              | 4.56 | 65.06 | 9.81  | 29.86 |
| Turmeric       | Pre-mordant  | 7.77 | 59.09 | 10.22 | 35.66 |
|                | Bath mordant | 7.10 | 59.50 | 10.51 | 33.79 |
|                | Post-mordant | 6.25 | 61.17 | 10.43 | 32.95 |
| Tannic acid    | Pre-mordant  | 6.58 | 60.16 | 10.41 | 32.36 |
|                | Bath mordant | 4.30 | 65.19 | 8.62  | 28.41 |
|                | Post-mordant | 5.75 | 62.78 | 9.46  | 31.84 |

Table 1 showed that K/S of the dyed fabric treated by turmeric and tannic acid were higher than non-mordant silk, while pre-mordant dyeing process were mostly better than bath mordant and post-mordant. The colors of dyed fabrics were deeper, indicating that turmeric and tannic acid could improve tea extract dyeing silk. The reasons may be, at the beginning of mordant, there were more vacancies of fiber, and turmeric was easy to adsorb and infiltrate; when dyed in the bath mordant, the

turmeric was easier to combine with the fiber than tea extract; when dyed in the post-mordant, the tea extract had already been adsorbed to the fiber, the turmeric was difficult to complex with fiber.

### 3.2. Effect of Different Concentration of Mordant

Table 2 showed that when the concentration of turmeric was 0.1g/L, K/S of the fabric was the maximum, and the fabric had a yellow-green tendency. When the concentration of turmeric was 0.025 g/L, the K/S value of the dyed fabric was relatively high, a value and the b value were relatively stable, therefore the fabric mainly presented color of tea basically. While the turmeric played a role as mordant. When the concentration of tannic acid was 5g/L, the K/S value of the dyed fabric was the maximum and the dyeing effect was better.

**Table 2.** The treated fabrics under different concentration of mordant

|             | Concentration of mordant | K/S  | L     | a*    | b*    |
|-------------|--------------------------|------|-------|-------|-------|
| Turmeric    | 0.0125                   | 6.29 | 61.15 | 8.91  | 32.51 |
|             | 0.025                    | 7.65 | 59.81 | 10.32 | 35.75 |
|             | 0.05                     | 7.21 | 61.42 | 8.82  | 38.23 |
|             | 0.1                      | 8.62 | 60.29 | 8.99  | 42.52 |
| Tannic acid | 2                        | 5.86 | 63.00 | 9.14  | 31.67 |
|             | 5                        | 6.28 | 63.02 | 11.08 | 33.83 |
|             | 10                       | 5.15 | 63.78 | 8.82  | 30.06 |
|             | 20                       | 4.57 | 64.98 | 8.17  | 29.04 |

### 3.3. Effect of pH Value

Generally, mordant was sensitive to variety of pH, while turmeric presented different colors at different pH [7]. Tea extract was diluted at 5. Turmeric was 0.025 g/L, and tannic acid was 5 g/L.

**Table 3.** The treated fabrics under different pH solution

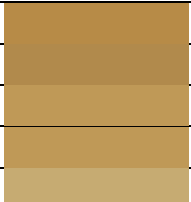
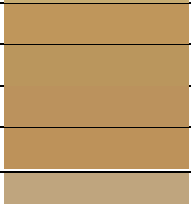
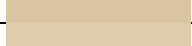
|             | pH value | K/S  | L     | a*    | b*    | Color of the treated silk                                                             |
|-------------|----------|------|-------|-------|-------|---------------------------------------------------------------------------------------|
| Turmeric    | 3        | 8.36 | 59.8  | 12.17 | 38.72 |  |
|             | 4        | 7.87 | 59.16 | 10.82 | 36.39 |                                                                                       |
|             | 5        | 7.04 | 60.65 | 12.23 | 35.47 |                                                                                       |
|             | 6        | 5.66 | 63.84 | 9.20  | 36.59 |                                                                                       |
|             | 7.5      | 2.93 | 68.89 | 4.72  | 29.93 |                                                                                       |
| Tannic acid | 3        | 6.32 | 63.28 | 10.81 | 33.66 |  |
|             | 4        | 6.29 | 62.70 | 11.20 | 33.71 |                                                                                       |
|             | 5        | 6.26 | 62.26 | 11.89 | 32.69 |                                                                                       |
|             | 6        | 5.94 | 61.96 | 11.52 | 30.92 |                                                                                       |
|             | 7.5      | 2.90 | 66.99 | 6.65  | 21.30 |                                                                                       |

Table 3 showed that K/S values of the dyed fabric were different under different pH environments. The higher pH, the smaller K/S value of treated fabrics. Generally, it was not conducive to the role of mordant under alkaline condition. When turmeric used, color of the fabric shifted from yellowish brown to light yellow as the pH increased. When tannin used, color of the fabric shifted from yellowish brown to light brown as the pH increased. When pH of the dye solution was 5, the apparent depth and color stability of the dyed fabric could be balanced.

### 3.4. Optimize Mordant to Different Tea Extract

The turmeric was 0.025 g/L, and the tannic acid was 5 g/L. Pre-mordant was fixed, to adjust pH of the dye solution to 5, and original tea extract were diluted by different multiples. Table 4 showed the smaller concentration of tea extract, the smaller K/S value of treated fabrics, mainly caused by pigment of tea. Under different concentrations of tea extract, the color were obviously different, which also provided actual color requirements for people. When the tea dye liquor was diluted 5 times, the dyed fabric could get more full color appearance.

**Table 4.** The treated fabrics under different tea extract

| Tea extract | Dilution multiple | K/S  | L     | a*    | b*    | Color of the treated silk                                                           |
|-------------|-------------------|------|-------|-------|-------|-------------------------------------------------------------------------------------|
| Turmeric    | 5                 | 7.76 | 59.67 | 10.03 | 36.00 |  |
|             | 10                | 4.83 | 65.63 | 8.78  | 34.80 |  |
|             | 30                | 1.96 | 76.86 | 3.36  | 31.32 |  |
|             | 50                | 1.28 | 80.23 | 1.87  | 26.39 |  |
| Tannic acid | 5                 | 6.37 | 61.34 | 10.38 | 32.20 |  |
|             | 10                | 3.97 | 67.20 | 7.55  | 28.54 |  |
|             | 30                | 1.52 | 77.09 | 5.35  | 19.18 |  |
|             | 50                | 1.21 | 79.55 | 4.67  | 16.70 |  |

### 3.5. Test of Color Fastness

Table 5 showed that the fabrics dyed with turmeric and tannic acid had good color fastness to rubbing, the color fastness to washing was improved, and color fastness to artificial light was good. It could be speculated that the use of the mordant made the tea extract bonded to the fiber more firmly, thereby improved the color fastness to washing.

**Table 5.** Testing of color fastness under optimize mordant

|              | Color fastness to rubbing | Color Fastness to Washing       |                             | Color fastness to artificial light |
|--------------|---------------------------|---------------------------------|-----------------------------|------------------------------------|
|              | Dry/wet                   | Change in color of the specimen | Staining of adjacent fabric |                                    |
| Non- mordant | 4                         | 2-3                             | 4                           | 3-4                                |
| Turmeric     | 4-5                       | 3-4                             | 4-5                         | 4                                  |
| Tannic acid  | 4-5                       | 3                               | 4-5                         | 4                                  |

## 4. Conclusion

- The tea extract could be used as natural dye by mordant. The optimal process of turmeric was: pre-mordant, 0.025g/L, pH at 5; The optimal process of tannic acid was: pre-mordant, 5g/L, pH at 5. Furthermore when tea extract was diluted 5 at times, the color of fabric was more full.
- After dyeing by turmeric and tannic acid, the color fastness of the silk dyed with tea extract were: the color fastness to rubbing was 4-5, and the color fastness to soap was 3 or above. The light fastness was good and basically met people for the color of silk fabrics. The mordant: The silk fabrics were put into tea extract diluted at 5 mixed with turmeric or tannic acid. Then oscillated at 80°C for 30 min.
- Turmeric and Tannin acid themselves had no pollution to the environment and improved the dyeing effect of tea dye liquor on silk. It was an environmentally friendly mordant dyeing process, which helped the dyeing of natural dyes in fabrics.

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