Silk Degumming with Dried Latex of Carica Papaya Linn

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Abstract

Degumming process is a fundamental finishing process for silk yarn and silk fabric. The main objective is scouring the substrate such as silk gum (sericin), wax and some impurities from silk fiber. The principle of degumming process is breaking the peptide linkage of amino acid in sericin structure into a small molecule, which is soluble in water. The hydrolysis reaction performed by acid and alkaline, but they have a big problem on the surface area of silk. Proteolytic enzyme be used to solve this problem but it has some disvantages such as it was using a specific condition and expensive. For this reason, this research chooses papain enzyme form dried latex of *Carica payapa* Linn. to degum the raw silk. The efficiency of degumming process was evaluated by determination of tensile strength and staining test with direct dyes (C.I. Direct Red 80). The result was revealed; the appropriate conditions for silk degumming with dried *Carica payapa* Linn.'s latex be recommended as follows: the amount of dried latex solution of 4 % owf at 75 degree Celsius for 30 minutes, in this condition was not harm to strength and fiber surface. The degummed fibers still had lustrous, soft and smooth surface.

Keywords : degumming, sericin, papain

1. Introduction

Silk is a protein fiber that consists with 2 main parts called fibroin (fiber part approximately 62.5 – 67.0 %) and silk gum called sericin (approximately 23. – 27.5 %). Sericin acts as an adhesive for the twin fibroin filaments and conceals the unique luster of fibroin. Sericin contains some impurities such as waxes, fats and pigments. Thus, need to remove sericin (degum) that cover on the fiber surface in order to obtain a luster, soft handle and the other desired properties for further process. Principle of silk degumming process is increasing the silk gum solubility by breaking the peptide linkage of sericin structure into small molecule such as amino acid and its oligomer with hydrolysis reaction. Silk degumming can be performed by various methods such as using alkaline and synthetic detergent. However, alkaline condition are harmful to silk fiber because silk has poor resistance to alkaline. Nowadays, proteolytic enzyme be used to solve this problem but it has some disadvantages about specific condition and high costs. For this reason, this research chooses papain prepared form dried latex of *Carica payapa* Linn. as proteolytic enzyme to degum the raw silk instead of conventional degumming agent. Thus, the main purpose of this work is to study about silk degumming with dry latex of papaya and its affective factor such as concentration and condition (temperature and time).

2. Experimental

2.1 Materials

Bombyx mori silk was selected as a material for degumming process with papain enzyme prepared from dried latex of *Carica papaya* Linn. Papain is obtained by cutting the skin of the mature papaya (approximately 2 - 3 months of age) 1/8 inch deep, then collecting the latex which flows from the cuts and left in the sun to evaporate some water. After that the latex was dried in the oven at 55 ^{O}C until the latex is crumbly and ground into a white powder. Hirus Supra Red 3BL 140% (C.I. Direct Red 80) donated by Phisit Intergroup**.** ECE Phosphate Reference Detergent FBA free (Union TSL Co., Ltd.) used soap for degumming. All other chemicals were of commercial grade and purchased from A.N.Y. Product Co., Ltd.

2.2 Degumming process

- Silk degumming with dried papaya's latex

Raw silk was degummed by using degumming liquor with various concentrations of dried latex of papaya fruit. Degumming liquor was comprised papaya's dried latex ranges 0%, 1%, 2%, 3%, and 4 % owf respectively. The liquor ratio of raw silk to degumming liquor was 1 : 25 (g : ml).

Specimens were degummed at the temperature ranges 55, 65, 75 and 85 and time 10, 20, 30 and 40 minutes, then rinsed with cool and hot water and dried at 60 ^{O}C

- *Silk degumming with soap and Sodium carbonate*

Specimens were subjected to degum in a boiled alkaline solution containing 12 % owf soap and 6 %owf sodium carbonate for 60 minutes at a liquor ratio of 1 : 30 (g : ml). Degummed silks were rinsed with cool and hot water and dried at 60 ^{O}C

2.3 Determination of tensile strength

Tensile strength of degummed silks fibers were performed according to TIS 121 Part 8-2518 (1975) : Method of test for textiles Part 8 Breaking load and extension of yarns and threads. A single fiber was measured at a gauge length of 200 mm on a tensile strength tester (Lloyd Instruments LR5K, Intro Enterprise Co., Ltd.)

2.4 Staining test with direct dyes

Hirus Supra Red 3BL 140% (C.I. Direct Red 80) was used to evaluate the remaining of sericin after degumming. The degummed silk samples were dyed in an dye liquor comprised Hirus Supra Red 3BL 140% 1 g/L with a liquor ratio of 1 : 200 (degummed silk : dye liquor) at 100 ^{O}C for 2 minutes. The color strength of dyed samples (K/S values) was measured by a spectrophotometer (Color Quest XE) under illuminant D65 with a 10^{O} standard observer. Color strength was calculated from the reflectance values using Kubelka-Munk equation as follows

$$K/S = \frac{(1-R)^2}{2R} \qquad (1)$$

Where R is the decimal fraction of the reflection of the dye fabric, K is the absorption coefficient and S is scattering coefficient.

2.5 Fiber surface morphology analysis

Scanning electron microscope (SEM) was used to study surface morphology of degummed silk. The samples were coated with gold by sputtering at room temperature. Scanning electron micrographs of fibers were taken by scanning electron microscope (JSM-5410LV). The instrument was operated at 15 kv.

3. Results and discussion

3.1 Fiber strength

The tensile strength of silk fiber can be indicating the results of degumming method because sericin act as reinforcement material for silk fiber when its was removed, the strength of fiber will also decreased. Several factors especially the amount of dried latex, was found to influence on tensile strength of degummed silk. Concentration of papaya's dried latex in degumming liquor related to efficiency of silk degumming due to papaya's latex was consist of papain enzyme that has ability to digest protein compound. At the high amount of dried latex and prolong degumming time, it would lead to the higher result in silk degumming. The tensile strength of silk fiber tend to be decrease when the amount of dry latex was increased and its become constant, when concentration of dry latex reach to 4 %owf. The average strength was 4.28 N

Considered the effect of temperature shows the tensile strength of silk fibers tend to be decrease when degumming temperature was increased. When the degumming temperature increased from 55, 65, 75 and 85 ^{O}C, the average tensile strength of fibers were 6.28 5.85 5.63 and 5.27 N respectively. The reduction in tensile strength was probably because of enzyme activity of papain. Effect of Temperature Papain has a temperature optimum range of 65 to 80 ^{O}C and temperatures above 90 ^{O}C rapidly inactivate the enzyme.

For the effect of degumming time to tensile strength of silk fiber, it was found slightly decreased in strength when degumming time increased from 10, 20, 30 and 40 minutes.

3.2 Result of staining test with direct dyes

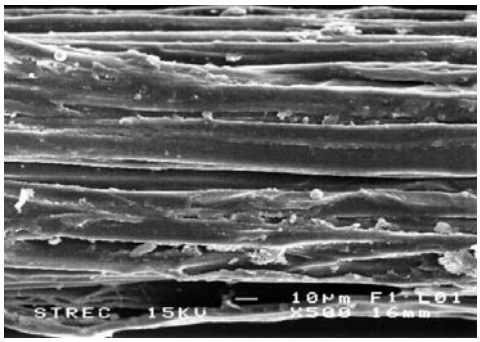
For the staining test by dyeing with C.I. Direct Red 80, raw silk was stained dark red color as a result of a large quantity of sericin present in the fibers. Soap and Sodium carbonate degummed silk at 100 ^{O}C appeared pale pink. Meanwhile, papain degummed silks were appeared pink. This indicating that there was a small amount of sericin remaining. Considered at the effect of temperature, time and amount of dried latex on the degumming efficiency by using K/S value was found color strength of silk fibers decreased when the temperature and time increased, except at 85 ^{O}C was increased. K/S value of raw silk, silk degummed with soap + sodium carbonate and papain degummed silks (55 – 85 ^{O}C) were 2.516, 0.163, 1.921, 0.279, 0.181 and 0.279 respectively.

Form the study variable result was revealed; the appropriate conditions for silk degumming with dried latex of *Carica payapa* Linn. was recommended as follows : the amount of dry latex solution of 4 % owf at 75 ^{O}C for 30 minutes at neutral condition

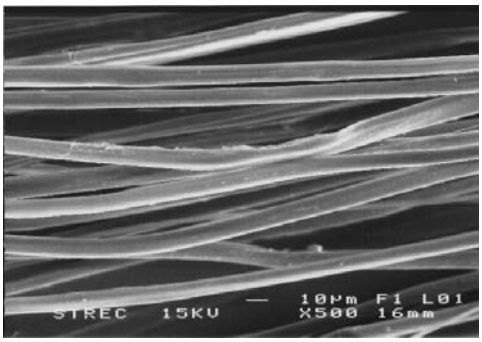
3.3 Fiber surface morphological

Different surface morphology and fiber damage of the raw silk fiber and degummed silk at various conditions were observed among the SEM micrographs of the fibers. Micrograph a in Figure 1 shows the surface characteristic of raw silk fiber that covered with large amount of sericin on fibroin. In micrograph b was shown surface of degummed silk fiber with soap and sodium carbonate at 100 ^{O}C, in this condition could almost completely remove sericin but some damage was observed on the fibers surface.

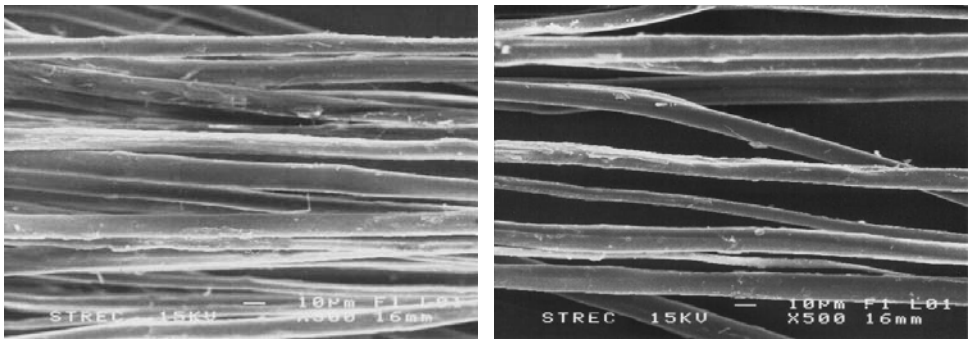
Micrograph c, d, e and f exhibited surface of silk fiber degumming with with 4% owf of dried latex solution at various temperature when the degumming time was 30 minutes. Degumming with papain enzyme 55 ^{O}C is not suitable condition because large amount of sericin still remained on fiber surface. The efficiency of silk degumming with papain enzyme was increased when increased temperature to 65 and 75 ^{O}C this condition could almost remove silk gum out off fiber surface (exhibited in micrograph d and e). At In 85 ^{O}C, degumming efficiency as same as65 and 75 ^{O}C However, some damage was observed and fibrillation of some fibroin threads occurred. (exhibited in micrograph f).



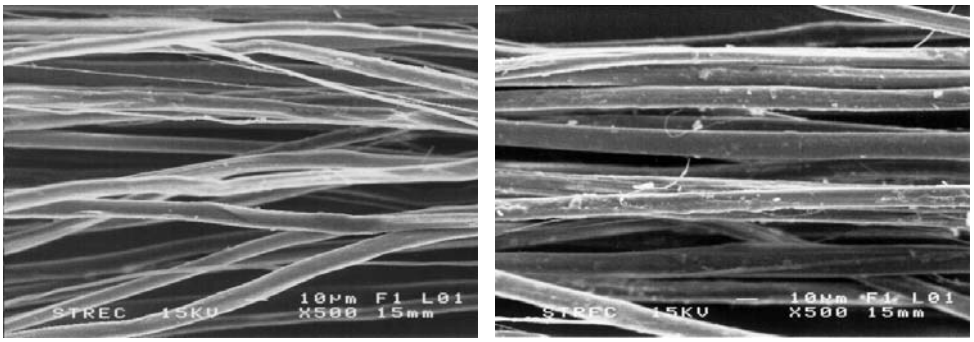
(a) raw silk



(b) Soap + Na_2CO_3



(c) 55 ^{O}C (d) 65 ^{O}C



(e) 75 ^{O}C (f) 85 ^{O}C

Figure 1 Scanning Electron Micrograph of degummed silk fiber

When comparison in appearance of fiber derived from 2 methods (Conventional deguming process with soap + Na_2CO_3 and deguming with dried latex 4 % owf at 75 ^{O}C) was found silk fibers obtained form conventional method has high bulky and some fiber was entangled with each other. Some fibril was observed on silk fiber of some threads occurred.

a. Raw silk b. Conventional deguming c. Deguming with papain

Figure 2 Appearance of silk fiber

4. Conclusions

Form the study about silk degumming wth dried latex of *Carica payapa* Linn. The appropriate conditions result was recommended as follows : the amount of dry latex solution of 4 % owf at 75 ^{O}C

for 30 minutes at neutral condition. In this condition was not harm to strength and fiber surface. The degummed fibers still had lustrous, soft and smooth surface. Result of staining test with direct dyes was appeared pink, indicating that there was a small amount of sericin remaining. This process can be used in stead of conventional degumming method with low cost and do not harm to environmental.

5. Acknowledgements

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