Effect of degumming followed by sequential oxidative and reductive bleaching on mulberry and tasar silk fabrics

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The effect of degumming followed by sequential oxidative and reductive bleaching on physical properties, such as tenacity, thickness, fabric weight, bending length, crease recovery, flexural rigidity and air permeability, of mulberry and tasar silk fabrics has been studied. It is observed that tenacity, thickness, fabric weight, bending length, crease recovery and flexural rigidity decrease whereas air permeability increases after degumming and bleaching.

Keywords: Bombyx mori, Bleaching, Degumming, Fibroin, Sericin, Silk fabric, Wild silk

1 Introduction

Silk is an unique natural fibre produced by sericogenous insects. It is one of the world’s most exclusive and luxurious fibres. The various kinds of silk available in nature can be classified into two reversal groups. The cultivated silk variety is mostly produced by species Bombyx mori. There are other less cultivated species called wild silk, such as tasar, eri and muga. Among the commercially important varieties of wild silk, tasar is the most popular. The genetic, diet and agroclimatic variations along with the cultural practices are responsible in providing tasar with its characteristic ecru to dark brown colour. It is difficult to remove the natural colouring matter held tenaciously by the fibroin.

Tasar silk differs from mulberry silk in the composition of various amino acids in the fibroin structure. The tasar fibroin constitutes about 75-80% by weight of the raw fibre and the remainder is mostly sericin. Microscopic studies show that tasar silk is comparatively broader than the mulberry silk and has longitudinal striations representing minute filaments called fibrils.

Degumming and bleaching are the important treatments of silk processing. The presence of gum makes the silk harsh and stiff, and masks its natural lustre. Tasar silk is more difficult to degum than mulberry silk because the tasar silk fibre contains more mineral matter and the gum is harsher and more resistant to the action of chemicals. The sericin is embedded in the strongly fibrillated fibres and is difficult to remove completely. Tasar silk cannot be freed from inherent fawn colour through degumming and even after intensive bleaching treatment. The degumming of silk is carried out by different methods. As the soap is relatively mild in action and its permeability is also high, there are less chances of overdegumming. Also, the whiteness, lustre and feel are excellent in the fabric with amount of softening effect. Tsunokaye has postulated that the degumming action of soap solution is due to the alkali formed on hydrolysis of soap.

Silk can be bleached by both oxidation and reduction methods. Reduction bleaching is generally carried out with sodium hydrosulphite. Hydrogen peroxide is the preferred oxidizing bleaching agent for silk. Studies on oxidative and reductive bleaching are available in the literature. However, it is still difficult to obtain a pure white colour without damaging the fibre. Hence, delicate shades cannot be attained with the same brightness as in single bleaching for both tasar and mulberry silk. This can also lead to the problems with pure white discharge prints. In this paper, the effect of degumming followed by sequential oxidative and reductive bleaching on physical properties of mulberry and tasar silk fabrics has been studied.

2 Materials and Methods

2.1 Materials

Three samples each of tasar and mulberry silk were used. The constructional details of these fabrics are given in Table 1.

Sodium stearate solution (non-ionic soap) of high degree of hydrolysis was used for degumming.
Bleaching using the following specifications:

- **Treatment - 1**
  - Material - to - liquor ratio: $= 1 : 50$
  - Soap conc.: $= 34 - 45%$
  - Duration: $= 1 - 3 h$
  - Temperature: $= 95^\circ C$

- **Treatment - 2**
  - Material-to-liquor ratio: $= 1 : 50$
  - Soap conc.: $= 15-20%$
  - Duration: $= 30 - 45$ min.
  - Temperature: $= 95^\circ C$

### 2.2.2 Bleaching

Bleaching was carried out using the following two methods:

- **Oxidative Bleaching**
  - Material - to - liquor ratio: $= 1 : 40$
  - Hydrogen peroxide: $= 15 - 20$ ml/L

- **Reductive Bleaching**
  - Stabilizer (sodium silicate): $= 0.5$ g/L
  - Non-ionic surfactant: $= 2$ g/L
  - pH: $= 9$
  - Temperature: $= 90^\circ C$
  - Duration: $= 1$ - 2 h, wash

### 2.2.3 Tests

The testing of samples was carried out as per the standard procedures laid down in ASTM, B.S. Handbook, etc. Before testing, the fabric samples were conditioned for 24 h in an atmosphere of $27 + 2^\circ C$ and $65 + 2%$ RH.

Fabric thickness was measured by the R & B cloth thickness tester (James H. Heel and Co. Ltd, Hailf returning, England) with a pressure foot of 5 g/cm². Bending length and flexural rigidity were measured by Shirley stiffness tester according to ASTM D : 1388 - 557. The tensile strength was measured on the Goodbrand’s tensile strength tester according to BS : 2576-1967. Crease recovery was determined by the Shirley crease recovery tester as detailed in IS : 4681.

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<table>
<thead>
<tr>
<th>Sample No</th>
<th>Warp Yarn</th>
<th>Weft Yarn</th>
<th>Linear density ends/in.</th>
<th>Picks/in.</th>
<th>Weight Cover factor</th>
<th>Ends/in.</th>
<th>Picks/in.</th>
<th>Weight/cm²</th>
<th>Ends/in.</th>
<th>Picks/in.</th>
<th>Weight/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mulberry (single)</td>
<td>Mulberry (spun yarn)</td>
<td>20-22</td>
<td>130</td>
<td>100</td>
<td>5.88</td>
<td>15.59</td>
<td>105</td>
<td>86</td>
<td>5.70</td>
<td>103</td>
</tr>
<tr>
<td>2</td>
<td>Korea tasar filament yarn</td>
<td>China tasar filament yarn</td>
<td>33-37</td>
<td>60-65</td>
<td>80</td>
<td>64</td>
<td>4.38</td>
<td>12.06</td>
<td>82</td>
<td>62</td>
<td>4.01</td>
</tr>
<tr>
<td>3</td>
<td>Mulberry (plied)</td>
<td>Mulberry (single)</td>
<td>22-22/2</td>
<td>20-22</td>
<td>128</td>
<td>108</td>
<td>4.18</td>
<td>15.71</td>
<td>128</td>
<td>116</td>
<td>4.00</td>
</tr>
<tr>
<td>4</td>
<td>Korea tasar filament yarn</td>
<td>Taras waste filament yarn</td>
<td>33-37</td>
<td>164</td>
<td>88</td>
<td>68</td>
<td>6.61</td>
<td>16.14</td>
<td>89</td>
<td>69</td>
<td>5.74</td>
</tr>
<tr>
<td>5</td>
<td>Mulberry (single)</td>
<td>Mulberry filament yarn</td>
<td>20-22</td>
<td>20-22</td>
<td>120</td>
<td>120</td>
<td>4.43</td>
<td>15.63</td>
<td>124</td>
<td>123</td>
<td>4.20</td>
</tr>
<tr>
<td>6</td>
<td>Korea tasar filament yarn</td>
<td>Taras waste (mill spin)</td>
<td>33-37</td>
<td>157</td>
<td>100</td>
<td>90</td>
<td>3.16</td>
<td>13.61</td>
<td>107</td>
<td>95</td>
<td>3.10</td>
</tr>
</tbody>
</table>

**Table 1—Constructional details of grey fabrics and effect of degumming and bleaching on constructional factors of these fabrics**
3 Results and Discussion

3.1 Thickness

Table 2 shows that the thickness decreases on degumming and that the decrease in thickness is marginally increased further on sequential bleaching. This may be attributed to the removal of sericin. The extent of decrease is less in case of fabric having spun weft in comparison to that in fabric having both weft and warp filament. However, the difference between the thickness of mulberry and tasar silk is not significant.

3.2 Fabric Weight

The loss in weight due to degumming alone is sufficiently high which slightly increases further on bleaching. No definite trend of decrease in weight of the two varieties of silk is observed. The amount of gum or sericin may vary from 22% to 30% and its complete removal will result in a corresponding loss in weight.

3.3 Bending Length

The bending length also decreases after degumming and sequential bleaching (Table 2). This may be due to the decrease in stiffness of the fabric. The removal of waxes and sericin makes the fabric less stiffer. During the course of degumming, the reagents not only remove the sericin and free the parallel filaments of fibroin but they also penetrate the filaments and hence there is possibility of separating the fibrillae. This may be the reason for the decrease in stiffness of fabric\textsuperscript{16}. There is no significant difference between bending length of mulberry and tasar silk fabrics.

3.4 Flexural Rigidity

The flexural rigidity of silk fabric decreases after degumming and sequential bleaching (Table 2) which may be due to the increase in flexibility of fabric by the removal of pigments, fats and sericin. The reagents used in the degumming not only remove the sericin and lead to parallelization of filaments but also penetrate the filaments, leading to decrease in stiffness of fabric\textsuperscript{16}. As the bending length of mulberry and tasar silk fabrics is almost equal, these fabrics have almost the same flexural rigidity.

3.5 Tenacity

Table 3 shows that the tenacity decreases to a greater extent after degumming followed by sequential bleaching, indicating that it is the bleaching which mainly affects the strength. The action of bleaching agent on amino acid of silk leads to degradation of fabrics but the degradation is less in comparison to that with permanganate.\textsuperscript{16} The tenacity of mulberry and tasar silk fabrics is found to be almost equal.

3.6 Crease Recovery

Crease recovery of fabric decreases significantly after degumming followed by sequential bleaching (Table 3). This may be due to the removal of sericin, waxes and colouring materials which leads to the flexibility of silk fabrics. The removal of sericin makes the fabric softer and, therefore, less resistant towards creasing. There is a marginal difference between the crease recovery of mulberry and tasar silk fabrics.

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Table 2—Thickness, weight, bending length and flexural rigidity of grey, degummed and bleached silk fabrics

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Thickness, mm</th>
<th>Weight, g/m²</th>
<th>Bending length, cm</th>
<th>Flexural rigidity, mg.cm⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grey</td>
<td>Degummed</td>
<td>Bleached</td>
<td>Grey</td>
</tr>
<tr>
<td>1</td>
<td>0.25</td>
<td>0.20</td>
<td>0.20</td>
<td>58.87</td>
</tr>
<tr>
<td>2</td>
<td>0.22</td>
<td>0.20</td>
<td>0.18</td>
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</tr>
<tr>
<td>3</td>
<td>0.18</td>
<td>0.16</td>
<td>0.13</td>
<td>40.83</td>
</tr>
<tr>
<td>4</td>
<td>0.26</td>
<td>0.25</td>
<td>0.26</td>
<td>64.22</td>
</tr>
<tr>
<td>5</td>
<td>0.17</td>
<td>0.16</td>
<td>0.16</td>
<td>42.14</td>
</tr>
<tr>
<td>6</td>
<td>0.19</td>
<td>0.17</td>
<td>0.11</td>
<td>31.65</td>
</tr>
</tbody>
</table>
3.7 Air Permeability

Table 4 clearly shows that the air permeability of spun weft fabrics increases and that of filament silk fabrics decreases. This may be due to the fact that filament yarn is subjected to a greater loss of surface material due to degumming followed by sequential bleaching. Hence, due to the change in the cover factor of the filament weft fabric, lower air permeability is observed. The level of air permeability is found to be almost equal for both mulberry and tasar silk fabrics.

4 Conclusions

4.1 The fabric thickness, weight, bending length, flexural rigidity, tenacity and crease recovery decrease after degumming and sequential bleaching. However, there is no significant difference in the above fabric properties of mulberry and tasar silk fabrics.

4.2 Air permeability of weft filament silk fabric decreases and that of spun weft fabric increases after degumming and sequential bleaching. However, the air permeability of mulberry and tasar silk fabrics is found to be almost equal.

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References