Effect of Pressurized Cooking & Low-Temperature Reeling of Cocoon on Qualitative & Quantitative Traits of Bivoltine Raw Silk

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Abstract: Cooking is known to be the heart of cocoon reeling. The chemistry & unique distribution of two proteins viz., Fibroin & Sericin have immense importance to decide the performance of reeling. Several cooking techniques with varying time-temperature profile are available. The techniques should be chosen according to the quality of cocoons and machines to be used in reeling. The Indian silk industry is lacking in considering the science behind handling the delicate silk fibre perceptively. This has proved to be one of the major hindrances in attaining the desired quality of raw silk grade apart from the socio-economic reasons. Sericin being the soluble protein and Fibroin being the fibre protein are to be handled with care. The target of reeling should always ensure unwinding of silk filament with maximum retention of sericin in it to produce a stronger yarn with maximum cohesiveness. Since Sericin is a gummy protein it acts as a sizing or binding material and protects the fibroin from the thrashing action of subsequent machineries. Present study aims at finding out the effect of pressurised cooking using Surface Active Agent and Wetting Agent and its effect on qualitative and quantitative characteristics of raw silk.

Key words: Denier, Denier Deviation, Evenness, Co-efficient of Variation

I. Introduction

Cooking is said to be the ‘heart’ of reeling. A little defect in cooking may increase the resultant defects manifold in the subsequent operations. Silk is a unique natural fibre that consists of two proteins viz., Fibroin and Sericin. Fibroin forms the core of the yarn and Sericin forms the sheath of the same. Thus, Sericin acts as a protective component of the original fibre part Fibroin. Hence, the object of reeling is to unwind the cocoon filament by retaining the maximum quantity of sericin in it. While swelling of sericin to a certain extent is enough to facilitate unraveling of filament, exposure of cocoons to higher water temperature for higher duration is unwarranted for both qualitative and quantitative point of view. The over-exposure of cocoons to hot water may cause low recovery of actual raw silk with higher wastage, more incidences of slubs, more cleanness defects, production of yarn with less cohesion and less tenacity. Similarly under-exposure of cocoons to hot water may cause poor reelability, low recovery of actual raw silk with higher wastage, more incidences of breaks, more cleanness defects, production of yarn with higher winding breaks and less tenacity. There should, therefore, have a balance between these two. However, the cohesion and tenacity of the yarn can be improved in two ways during reeling viz., by ensuring maximum possible retention of sericin with the filament after reeling and by using some chemicals followed by cold reeling. The present study is restricted to maximum possible retention of sericin by manipulating cooking and reeling techniques. A recent laboratory study reveals that the quantitative & qualitative attributes of raw silk can be improved by manipulating the cooking & reeling technique using some surface Active Agents (SAA) and Wetting Agents (WA) during cooking and reeling which has been able to improve the reelability to the extent of 7-13%. It is quite easy to understand that higher the no. of breaks, lower will be the reelability. The break in a cocoon has been brought down to a substantial extent by using those low-cost chemicals. Cooking parameters for semi-dried bivoltine hybrid cocoons to achieve better reeling performance and quality characteristics for raw silk by reeling it on CSTRI Multi-end Reeling Machine was suggested by Naik et al. It was observed that all the cocoon cooking parameters have a significant influence on reelability, raw silk recovery etc. Results indicate that the duration of high temperature treatment and steam cooking treatment play a dominant role with respect to the cleanliness, elongation and cohesion of raw silk, whereas the temperature profile of the adjustment treatment has a significant influence on all the quality characteristics of raw silk1 The cooking treatment is of extreme importance since it decides the quantity of water absorbed into the cocoon (semi/sunken/sunken system of reeling), waste production level, sericin swelling level adjustment and quality of raw silk reeled. Cooking technology was developed with a view to improve quality of raw silk and at the same time to reduce silk waste. A cooking technology involving pre-treatment, cooking at 98°C for about 2 mins with gentle boil followed by adjustment and finishing was developed. The adopted improved technique has been found to improve raw silk percentage and reduce the cleanness defects of raw silk2. A study reveals that degree of drying and cocoon-cooking conditions have significant influence on reelability, raw silk recovery, thread troubles and quality of raw silk. Results indicate
that drying of cocoons to the optimum degree of drying and better cocoon cooking conditions are essential for achieving better reeling performance and superior grade raw silk. Results also reveal that good quality raw silk (of international grade) can be produced from semi-dried cocoons provided cocoon cooking is good with suitable cocoon cooking conditions depending upon targeted raw silk recovery and quality. The influence of steam cooking temperature, duration of treatment and adjustment, time-temperature profile of cooking on reeling performance of bivoltine cocoons has been studied using pressurized circular cocoon cooking machine. It is observed that all the three factors i.e., steam cooking temperature, duration of treatment and adjustment, time-temperature profile have a significant influence on reelability, productivity (non broken filament length, raw silk recovery, waste percentage and raw silk%) and other qualitative and quantitative characteristics. The study was carried out with the locally available bivoltine hybrid cocoons to improve the cohesion and tenacity of yarn and to improve other properties of raw silk.

It is also observed that the cooking parameters have a significant influence on thread troubles during reeling. Based on the study, cooking parameters have been suggested with a view to achieving better results from semi-dried cocoons. Thorough investigations of the changes in sericin micro structure and shell structure of cocoons subjected to direct steaming, the mechanism of the process for improving raw silk neatness is studied. It is believed that the denaturing and deterioration of sericin will occur in direct steaming; causing higher dissolvability of sericin of dried cocoons at a higher temperature. Moreover, direct steaming will reduce the adhesion between cocoon layers, especially for loose-shell cocoons. The article also points out that vacuum direct steaming, in comparison with the conventional one, can obtain more evenly-cooked cocoons, resulting in better raw silk. Hence, the present study aims at maximising retention of sericin by manipulating cooking and reeling techniques.

II. Materials & Methods

In the present experimentation, only Bivoltine hybrid cocoons were taken. The cocoon samples have been subjected for cooking in three different treatments out of which one is the general conventional practice done by the reellers (T1). Other two are some modified cooking techniques that are subjected for pressurized cooking with 1gL Surface Active Agent and 1 mL Wetting Agent. These treatments were categorized as T2 & T3. The difference between T2 & T3 lies only in the cooking duration keeping other ingredients unaltered. Reeling was done on CSTRI Improved Cottage Basin. All the treatments were repeated for three times to get replicated values in order to minimize the errors. After reeling, the quantitative traits were recorded and compared. Raw Silk thus produced is also subjected for testing to have physical, mechanical & tensile properties. These include Denier, Denier Deviation, Co-efficient of Variation, Winding Breaks/Skein/hour, Cohesion, Evenness, Neatness, Cleanness, Tenacity and Elongation. The numerical values were recorded and compared. The lay-out was designed to conduct the experiment with Bi x Bi cocoons of silkworm Bombyx mori L. The detailed illustration has been given below:

- Type of cocoons: Bi x Bi
- The Bi x Bi hybrid cocoons were subjected for reeling under 3 separate treatments (including control)
- Each Treatment had 3 replications
- Each Replication requires 250 gms. of dry cocoons
- Pressurised cooking chamber fitted with 3-end test reeling machine was used for cooking
- CSTRI Improved Cottage Basin was used for reeling.
- Production, Reelability along with other quantitative & qualitative characteristics of raw silk have been tested & recorded.
- Effect of treatment on the qualitative and quantitative characteristics of raw silk have been recorded and analyzed.

The cocoons were taken to organise the work in following stages:

- For each treatment 750 gms (dry) of bi x bi hybrid cocoons was taken to utilise it in three replications with an apportionment of 250 gms. (dry) for each replication.
- Total number of treatments was three. Thus a total quantity of 2.250 kg. dry cocoons were required for carrying out the experiment
- Treated cocoons were utilised in CSTRI Improved Cottage Basin.
- Unravelling of yarn continued to the extent of availability of reealable length of raw silk.
- Productivity and other quantitative parameters were recorded.
- Physical, Mechanical and Tensile attributes were observed, recorded, analysed and compared.

The abbreviated codes of the cocoon varieties selected for the present study is Bivoltine X Bivoltine (Bi x Bi).

Ingredients Used:

1. Surface Active Agent during cooking & reeling 2. Wetting Agent during cooking & reeling

The equipments / apparatus used for the experimentation were:

Treatment Details:
TI (Control) = 3-5 minutes Boiling in Plain water + Reeling at 1000 C
T2 = 2-3 minutes pressurized cooking with 1 mlL-1 Wetting Agent & 1 gL-1 Surface Active Agent + reeling at 50-600 C
T3 = 4-5 minutes pressurized cooking with 1 mlL-1 Wetting Agent & 1 gL-1 Surface Active Agent + reeling at 40-500 C

The treatment effect on qualitative & quantitative parameters of cocoon and raw silk were observed. Standard Deviation of Size and Co-efficient of Variation was determined. Evenness variations by visuo-mechanical test were also carried out and compared. The equipments / apparatus used for the experimentation were Winding Machine, Epprouvete, Precision Electronic Balance, Seriplane Winder and Evenness Testing Apparatus. The raw silk samples were first unraveled in a winding machine to a 2-flanged bobbin at a winding speed of 120 metres per minute. The bobbins thus prepared were subjected to different tests for measuring and recording the required traits. Size (denier) deviation test determine the degree of size variation within the test pieces of sizing skeins of definite length of raw silk. Size is the linear density i.e., the weight of 9000 meters filament in gram. Mathematically it is represented as:

\[
\text{Denier} = \frac{W x 9000}{L} \text{ Where, } W = \text{ weight of filament (gms) and } L=\text{length of the filament (meters). Size Deviation can be determined by (SD) } = \sqrt{\frac{1}{n} \sum (x - \bar{x})^2} + n \text{ Where, x= Individual value of size, } \bar{x} = \text{ Average size n = No. of observation and Co-efficient of Variation (CV %) } = \frac{\text{SD} - \text{Mean}}{\text{Mean}} \times 100
\]

III. Results and Discussions

The present study is an attempt to improve the quantitative & qualitative characteristics of raw silk from the available raw materials by manipulating the cooking & reeling techniques within economic level. In this study productivity and quality of raw silk produced by applying different cooking techniques are observed. As is expected, a considerable difference between the treatments has been recorded. As far as quantitative traits are concerned, Production, Renditta, Raw Silk Recovery are the major parameters that are taken into consideration. It has been observed that by manipulating cooking technique, no significant increase in the production was observed. However, both T2 & T3 excel over the control (T1) by about 2% in terms of productivity improvement. When Renditta is considered, the minimum value (8.27) was recorded in T2 while maximum value was observed in the Control T1 (8.71). It reveals that there is a reduction of 440 gms. and 360 gms. of cocoon consumption in T3 & T2 respectively over control (traditional practice) T1 for production of 1 kg raw silk. Economically it is highly significant. Raw Silk Recovery is another important quantitative trait wherein T2 again excels over T1 & T3 to the tune of 4% & 1% respectively. So, T2 i.e., 2-3 minutes pressurized cooking with 1 mlL-1 Wetting Agent & 1 gL-1 Surface Active Agent + reeling at 50-600 C has recorded the best results in quantitative features. However by and large, the findings of the experiment corroborate that all the treatments from T2 to T3 are better than the control T1 in terms of all the quantitative parameters. Reelability is one of the important qualitative characters of cocoons that have direct bearing on reeling performance. In this study an attempt was made to improve this particular feature of the available cocoons by varying some cooking & reeling techniques. T3 has recorded the highest value of 93% followed by T2 (92%) and T1 (87%). In this case also both the treatments have an edge over the control. The physical properties of raw silk recorded in the present study include denier, denier deviation and co-efficient of variations. The target denier of resultant raw silk thread was 22d. It has been observed that the values are recorded as 22.9, 22.7 & 20.8 respectively for T1, T2 & T3. More importantly, the size deviation and co-efficient of variations of the raw silk have been found as 0.97 & 4.24 in T1, 0.99 & 4.36 in T2 and 0.54 & 2.60 in T3 respectively. Since silk cocoon is a biological material, inherent variation is an obvious event. But in this case the variation is well within the permissible limit for all the cases. T3 has been observed to produce most regular yarn followed by T1 and T2. As far as mechanical properties are concerned, winding breaks/skein/hour, cohesion, evenness, neatness and cleanness were considered in the present study. Winding break is the indicator for strength & load bearing capacity of the particular raw silk skein during transfer of yarn from skein to bobbin. In all the cases it fared well recording only a single break in T3 and no break in T2 & T3. Cohesion is the power of agglutination of individual thread in the resultant thread. It is analysed subjectively by counting the number of strokes required for splitting-off the individual thread from the resultant thread. The values recorded are 100, 123 & 121 respectively for T1, T2 & T3. It is well above the standard values in all the cases. The visuo-mechanical tests like evenness, neatness and cleanliness are also observed to be more than 90% in each case which reflect that the yarn quality is good enough to get a room for the international standard. Though there are no significant differences amongst the treatments and control, T1 (98% & 96%) seems to have fared well than the treatments in evenness and cleanliness property while T2 (93%) & T3 (93%) were superior in neatness property. But the variations amongst the treatments and control are very negligible. The tensile property of textiles is the fare indicator of deciding the quality of yarn for its performance in the subsequent operations. Raw silk is to combat the thrashing actions of heavy machineries to give a final shape of a finished fabric. Strength & elongation property are therefore very much important to decide its quality. In the present study, tenacity has been recorded as 2.65, 2.81 & 2.89 gd1 respectively for T1, T2 & T3.
while for same treatments elongation have been recorded as 16.13, 18.13 & 18.20%. The tabular and graphical presentations of the data recorded during the experimentations follow:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cohesion (g)</th>
<th>Denier</th>
<th>Renditta</th>
<th>Side Deviation (d)</th>
<th>CV%</th>
<th>Production (gms)</th>
<th>RSR%</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>22.7</td>
<td>8.2</td>
<td>8.3</td>
<td>0.47</td>
<td>0.00</td>
<td>123</td>
<td>87</td>
</tr>
<tr>
<td>T2</td>
<td>22.2</td>
<td>8.3</td>
<td>8.3</td>
<td>0.50</td>
<td>0.50</td>
<td>127</td>
<td>86</td>
</tr>
<tr>
<td>T3</td>
<td>21.1</td>
<td>8.4</td>
<td>8.2</td>
<td>0.40</td>
<td>0.40</td>
<td>121</td>
<td>86</td>
</tr>
</tbody>
</table>

The tabular and graphical presentations of the data recorded during the experimentations follow:
There is a school of thought who believes that production of cocoon is the only area which needs attention for quality improvement. The other school of thought perceives that by using improved machineries only, quality of raw silk can be improved. Quality of raw materials and type of machineries always play important role but not solely responsible in deciding the quality of the ultimate product. So, both these conceptions are either a misconception or a bad conception. A balance between the raw materials and the machines is required for techno-economic conversion of raw silk. For production of apparel, the silk fibres are to pass through innumerable machines and combat the thrashing action of each machine. Here lies the reason for quality improvement of raw silk which is not possible by paying attention to a particular discipline like seed production, cocoon production or raw silk production. The post cocoon sector is more important to create a demand for good quality raw silk which will ultimately help all the beneficiaries of sericulture. The present study is a secluded approach to interfere in the cooking & reeling operations only towards quantitative and qualitative gain. It has been confirmed that by manipulating the techniques the quality and quantity can be improved. Overall analysis of the results reveals that both T2 & T3 are almost at par but superior over the control i.e., existing practice. But since T2 (2-3 minutes pressurized cooking with 1 mL⁻¹ Wetting Agent & 1 gL⁻¹ Surface Active Agent + reeling at 50-60°C) requires less time and less fuel consumption than T3 (4-5 minutes pressurized cooking with 1 mL⁻¹ Wetting Agent & 1 gL⁻¹ Surface Active Agent + reeling at 40-50°C), T2 is recommended for practice keeping importance on the quality of cocoons because, inferior cocoons may not withstand the battering action of pressurized cooking.

Note: SD = Size Deviation; CV = Co-efficient of Variation

IV. Conclusion

References


