Evaluation of different methods of solid waste disposal in silk reeling industry

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The different methods of basin refuse separation practiced in reeling industry have been evaluated in terms of recovery and quality of bisu fibres. It is observed that there is an urgent need to handle this valuable waste by appropriate and efficient processing method in order to preserve the fibre quality and improve fibre recovery for further utilization.

Keywords : Basin refuse, Bisu waste, Bisu separating machine, Silk reeling, Whiteness index

1 Introduction

The innermost layer of the cocoon, referred to as pelade layer, is left out in the reeling process along with the pupa as basin refuse. The pupa which constitutes the major portion of the cocoon weight is an inevitable byproduct generated in very large quantity.

The pelade layer poses difficulties in its separation from pupa. In sericulturally advanced countries, basin refuse treating machines separate fibre waste (normally referred to as bisu waste) and pupa effectively, whereas in India, manual separation not being effective, bisu waste is not utilized fully.

The methods of handling basin refuse vary considerably depending upon the reeling process. These are depicted in flowcharts 1-3 and described below.

Conventional Charaka and Cottage Basin Method (Method A1)

This process is practiced in the majority of traditional reeling clusters in India. The basin refuse is separated manually by shaking the entangled mass in a cold standing bath. The efficiency of separation and the quality of the solid waste is not at all satisfactory. Bisu waste and pupae are dried under sun on mud floor. Delay in drying is observed to deteriorate the quality of fibre waste.

Conventional Filature Method (Method A2)

In this method, the process till the separation of bisu and pupa is same as in method A1. The basin refuse is separated using steam and chemical in a cement tank. Even with this method, the efficiency of separation and the quality of bisu fibre is not satisfactory.

Chart 1—Conventional charaka and cottage basin method (A1) and conventional filature method (A2)
Hot air drying of cocoons
(Batch process—cottage type drier)
↓
Storage
(long period)
↓
Cocoon cooking by cocoon boiling machine
(with vacuum permeation)
↓
Multiend/Automatic reeling machine
↓
Bisu separating machine—separation
(by centrifugal force)
(in hot water with the aid of soda)
↓
Wet bisu waste
↓
Dehydration
↓
Sun drying
↓
Storage
(Warehouse)
↓
Powdered pupae
packing

Chart 2—Modern filature method ([Chinese method](B1)).

Modified Filature Method (Chinese Method) ([Method B2])

The separation of basin refuse is carried out on a bisu separating machine. The bisu fibre and pupa are separated by the opening action of the cylinder and centrifugal force. Bisu fibre waste that gets wrapped onto the cylinder is removed as fibrous sheet by cutting. The bisu waste is sun dried and stored. The bisu waste is in good condition without any pupa fragments and cast off skin.

Modern Filature Method (Japanese Method) ([Method B2])

The separation of bisu and pupa is carried out on a bisu separating machine, where the basin refuse is subjected to teasing action. A small quantity of sodium carbonate is added to the bath to facilitate separation. Water is circulated to reduce the concentration of effluents. The bisu sheet is further subjected to the shaking action by a vibrating lever. The fibre sheet obtained from this process is free from pupa fragments and cast off skin. The wet bisu fibre is dehydrated, dried under sun and stored.

In the present study, the different methods of handling basin refuse, described above, have been compared with respect to the recovery of silk fibre and fibre quality obtained.

2 Materials and Methods

The silk fibre waste (Bisu) from different methods of separation practiced in India was collected from the field. Samples A1 and A2 from conventional charaka and basin method and conventional filature method contained a lot of foreign matter, cast off skin, fragments of pupa, etc. when compared to samples B1 and B2 obtained from Chinese and Japanese methods. Degumming was carried out as per IS:1582-1968 (Method for determination of scouring loss in silk textile materials) as follows:

I Bath— Soap (Neutral) : 10 g/l
Duration : 1 h
Material-to-liquor ratio : 1:30
Temperature : Boil

II Bath— Sodium Carbonate : 10 g/l
Duration : 30 min
Material-to-liquor ratio : 1:30
Temperature : Boil
Degummed fibres were bleached with sodium hydroxide (4g/l) at boil for 1h. The fibre waste obtained was opened in a hand opener in both undegummed and degummed state. The fibres were then tested on a stelometer at zero gauge length to find out the effect and severity of separating processes on the tenacity of the fibres. Undegummed, degummed and bleached fibres were evaluated for whiteness index on a Milton Roy computer colour matching system to examine the effect of different methods of separation and treatments.

3 Results and Discussion

3.1 Fibre Recovery

Fibre recovery from bisu waste obtained from different methods of separation is shown in Table 1. Fibre recovery from bisu waste after opening and degumming is also shown in Table 1. The results of analysis of variance are shown in Table 2. The recovery percentage of fibre useful for further utilization is observed to be different for different methods of separation. An increase in fibre recovery is observed from methods A1 to B2. The difference in recovery is attributed to the differences in the efficiency of handling the bisu waste by different methods as detailed in charts 1-3 and discussed earlier.

An analysis of the results clearly indicates that the recovery of the fibre is influenced by the method of stiffing/drying. Steam stiffing of cocoons coupled with pan cooking results in high degumming loss, whereas hot air drying of cocoons (B1 and B2), particularly by employing conveyor type of dryers, results in low gum loss and high fibre recovery.

3.2 Tenacity of Bisu Fibre

The tenacity values for bisu fibres obtained from different methods of separation as well as for fibres after degumming are given in Table 3. ANOVA results (Table 2) show no significant difference with respect to the tenacity (Mean of ten samples) of bisu fibres obtained from different methods of separation.
as well as between the undegummed and degummed fibres. It may be inferred from the ANOVA results that the different methods employed in the separation of basin refuse have not affected the tenacity of bisu fibres. Even after degumming, the bisu fibres from different methods show no significant difference in tenacity.

3.3 Whiteness Index

The whiteness index values of undegummed, degummed and bleached bisu fibres obtained from different methods of separation are given in Table 4 and the ANOVA results are given in Table 2. It is observed that the whiteness index values of fibres obtained from different methods of separation are statistically significant. The whiteness index values for degummed and bleached fibres are also statistically significant. From Table 4, it is clear that the whiteness index values of samples A1 and A2 are negative in undegummed state and that there is substantial increase in the whiteness index values of these samples compared to samples B1 and B2 due to degumming and bleaching. However, the whiteness index values of degummed and bleached fibres are still lower than those for samples B1 and B2. This may be attributed to the fact that if the pupa entangled with the fibre is not separated, it will stain the fibres and it will be difficult to obtain good whiteness in the fibre. The staining of the fibres is severe in the methods A1 and A2 as reflected by poor (negative) whiteness index values in undegummed state. It appears that steam stifling of cocoons achieves the killing of the pupa only\(^1\), whereas hot air drying besides killing the pupa dries the body fluids and prevents staining of the fibre. It is also observed that steam stifling results in breaking of pupa body during handling of basin refuse, whereas hot air drying keeps the pupal body intact and assists in effective separation. This is an important observation since the fibre is to be utilized for the production of spun silk yarns.

The \(L, a, b\) and \(c\) values for the bisu waste obtained from different methods of processing were obtained from Milton Roy computer colour matching system by different modes (D65, A and WF). The results (Table 5) for undegummed, degummed and bleached bisu fibres are in line with the observations made on whiteness index with respect to samples B1 and B2.

### Table 4—Whiteness index values

<table>
<thead>
<tr>
<th>Fibre type</th>
<th>Whiteness index</th>
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<tbody>
<tr>
<td></td>
<td>A1</td>
</tr>
<tr>
<td>Undegummed</td>
<td>-5.675</td>
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<tr>
<td>Degummed</td>
<td>17.409</td>
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<tr>
<td>Bleached</td>
<td>31.213</td>
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### Table 5—\(L, a, b\) and \(c\) values

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<tr>
<th>Mode</th>
<th>UD</th>
<th>D</th>
<th>BL</th>
<th>UD</th>
<th>D</th>
<th>BL</th>
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<tbody>
<tr>
<td>D65</td>
<td>A1</td>
<td>71.29</td>
<td>77.14</td>
<td>79.40</td>
<td>75.73</td>
<td>83.78</td>
<td>84.24</td>
<td>74.85</td>
<td>83.70</td>
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<tr>
<td>B1</td>
<td>59.81</td>
<td>67.57</td>
<td>70.14</td>
<td>61.27</td>
<td>69.12</td>
<td>71.68</td>
<td>66.00</td>
<td>70.23</td>
<td>71.72</td>
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<tr>
<td>B2</td>
<td>61.52</td>
<td>69.04</td>
<td>71.56</td>
<td>62.87</td>
<td>67.00</td>
<td>71.12</td>
<td>65.03</td>
<td>70.32</td>
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<th>BL</th>
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<tbody>
<tr>
<td>B1</td>
<td>72.94</td>
<td>77.85</td>
<td>79.82</td>
<td>76.87</td>
<td>84.42</td>
<td>84.78</td>
<td>75.68</td>
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<td>84.78</td>
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<tr>
<td>B2</td>
<td>76.54</td>
<td>80.76</td>
<td>83.59</td>
<td>77.56</td>
<td>85.28</td>
<td>85.80</td>
<td>81.36</td>
<td>85.04</td>
<td>85.61</td>
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<table>
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<th>WF</th>
<th>UD</th>
<th>D</th>
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<th>D</th>
<th>BL</th>
<th>UD</th>
<th>D</th>
<th>BL</th>
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</thead>
<tbody>
<tr>
<td>B1</td>
<td>72.50</td>
<td>79.65</td>
<td>79.65</td>
<td>76.45</td>
<td>84.18</td>
<td>84.60</td>
<td>75.36</td>
<td>84.05</td>
<td>84.61</td>
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<tr>
<td>B2</td>
<td>76.88</td>
<td>81.02</td>
<td>83.70</td>
<td>78.00</td>
<td>85.50</td>
<td>86.01</td>
<td>83.68</td>
<td>85.20</td>
<td>84.97</td>
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has not been possible for our spun silk mills to utilize this waste effectively. In fact, the fibres obtained from the bisu waste are fine in denier and their addition to the product mix would be beneficial in the spinning of finer counts of yarns. It may, therefore, be inferred that effective utilization of bisu waste would benefit both reellers and spun silk mills. It is in this context that an indigenous bisu separating machine has been designed and fabricated. The machine works on the principle of teasing action of sharp metal spikes. The efficiency of bisu fibre separation on the above machine is found to be in between the available Indian methods and the Chinese and Japanese methods. The machine has been found to be particularly efficient in bisu details and performance of the bisu separating-separation of steam stifled cocoons. The design machine would be discussed later in another paper.

5 Conclusions
The bisu fibre waste, generated as an inevitable byproduct during the reeling of raw silk, is valuable. Appropriate and efficient processing, as seen in methods B1 and B2, with respect to fibre recovery and whiteness index is needed to preserve the quality of bisu fibre. The fibres obtained from methods A1 and A2 do not possess the required quality parameters for further utilization.

References