Sericin as a Nutritional Supplement to Enhance Cocoon, Pupal Parameters and Grainase Properties of Silkworm *Bombyx mori* L.

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**ABSTRACT**

During the raw silk degumming process, the water-soluble natural protein sericin is discarded as waste material in the sericulture industry of Bangladesh. In this study, various amount of sericin (as nutritional supplement) treated mulberry leaves was fed to three different silkworm groups and its effect on cocoon, pupal parameters as well as grainase properties of the silkworms was evaluated. The results indicated that fecundity increased with the decrease of the concentration of sericin for all treatment groups. There was no significant difference among the treatment groups and the control group for fecundity value, but in the case of hatching percentage (%), all the treatment groups showed the reverse trend with fecundity. Cocoon production was increased by 23.91% when silkworm was fed with 0.50% sericin-treated mulberry leaves at chawki stage (first to the third instar) compared to the control group.

**Keywords:** Cocoon and pupal parameters, Grainase properties of silkworm, Nutritional supplement, Sericin, Silkworm (*Bombyx mori* L.).

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I. INTRODUCTION

Silkworm rearing is conducted to produce cocoons. Silkworm is a cold-blooded animal. Its larval growth and cocoon characteristics are highly influenced by the nutritional parameters of mulberry leaves, as it is a monophagous insect. It is a fact that the quality of mulberry alone contributes 38.2% of successful cocoon production. Mulberry leaf being the only source of nutrition for silkworms, the growth rate of silkworm larvae and subsequent silk production depends on the nutrient contents of mulberry leaves [1]. The nutrition of the silkworm *Bombyx mori* L. is the primary importance in sericulture for their larval growth and survival and also for cocoon and egg production, which is influenced by the nutritive value of mulberry leaves.

Food supplementation with required micronutrients is one of the best techniques to enhance silkworm growth and yield parameters. One of the essential characteristics of the silkworm *Bombyx mori* L. is its ability to switch plant protein to silk protein. A number of research groups conducted research to enhance silkworm growth and productivity with different types of vitamins, proteins, amino acids, and micronutrients. Larval development and production of high-quality silk by silkworms depend mainly on various nutrients and the quality of mulberry leaves [2]. The silkworm larvae utilize the amino acids obtained from the leaf for body growth, development, and cocoon formation [3].

Adult female silkworm needs protein to mature their ovaries and eggs. It is crucial to successfully secrete a juvenile hormone (JH) required for ovary and egg development. Male silkworm usually does not require protein to mature their sperm when they become adults. Generally, optimal nutritional requirements change with age, sex, and physiological stress [4].

Moths deficient in fatty acids can be defects in wing formation, and their scales adhere to the pupal case on emergence. A trace amount of lipids or sterols in a diet may positively influence growth and development [5]. An increase of 15.34% in the experimental group’s average weight of cocoons compared to the control was reported when silkworm was fed honey-treated mulberry leaves [6].

The growth, cocoon quality, and reproductive performance of fifth instar larvae of silkworms fed on mulberry leaves saturated with different concentrations (0.01, 0.1, 1, and 10%) of lactic acid were studied, and the results showed that 0.01, 0.1, and 1% lactic acid supplementation positively affects growth and female cocoon quality, with increased larval weight and female cocoon shell weight compared to the control group [7].

The silk fiber collected from the silk cocoon produced by silkworms (*Bombyx mori* L.) is mainly composed of two cores of fibroin surrounded by a glue-like layer of sericin [8]. Somashekarappa et al. reported that silk fibroin is a semi-crystalline polymer [9] of a natural fibrous protein. It is
mainly divided into two important phases: (1) One is well known by the highly β-sheet crystals [10], and (2) The other is a non-crystalline form consisting of micro voids and amorphous structures [11]. However, sericin is amorphous and acts as an adhesive binder to maintain the fibroin core’s fine filaments and the cocoon’s overall structural integrity [12]. Fibroin is the structural protein of the silk fiber, whereas sericin is the water-soluble proteinaceous glue that works as a binder of the fibers together [13]. During the raw silk degumming process, the water-soluble natural protein sericin is discarded as waste material in the sericulture industries of Bangladesh. Sericin consists of 18 different types of amino acids, with 33% of the serin part. Therefore, this study was undertaken to evaluate the effect of sericin as a nutrition supplement on the cocoon characteristics and grainase properties of silkworms.

II. MATERIALS AND METHODS

A. Sericin Extraction and Treatments

Sericin was extracted from fresh cocoons through high temperature and high pressure (HTHP) method and three different concentrations of sericin solution were used as three different treatments viz., T-1 (0.75%), T-2 (0.50%) and T-3 (0.25%).

B. Silkworm Rearing

This experiment was carried out at Bangladesh Sericulture Research and Training Institute (BSRTI), Rajshahi, Bangladesh from March 2022 to April 2022 (Fig. 1). The disease-free laying of native popular hybrid silkworm race BSR 85/22 was supplied by the silkworm section of BSRTI and the rearing was maintained at Rearing house No-01 of BSRTI.

Rearing was conducted as per the BSRTI recommended standard silkworm rearing technique by providing fresh leaves of a selected mulberry variety BM-11. The hatching schedule with BSRTI recommended temperature, light, and humidity were followed for the hatching of the eggs.

After hatching of eggs, the top two full-blown leaves of mulberry below the growing bud were picked up and chopped into small pieces (0.5 to 1.0 cm²) and sprinkled over the newly hatched young larva, which crawled on the leaves and started feeding from cut edges. Subsequently, after 30 minutes the freshly hatched larvae and mulberry leaves were transferred into the rearing trays with the help of feathers and spread on the bed with the use of chopsticks. Mass rearing was followed during the first instars. The food, spacing, and cleaning were done as per the larval stages and requirements. An equal quantity of food was given every time, which was thoroughly chopped as per the requirement before feeding. Four feedings of chopped mulberry leaves were given in a day. The timing of feedings was fixed at 10.00 a.m., 4.00 p.m., 10.00 p.m., and 4.00 a.m. in a day. The size of the chopped leaves was regulated according to conditions and the size of the larvae. During molting the larvae were not provided with any food and were not disturbed. The quantity of food was increased as per the growth of the silkworm.

The silkworm larvae were divided into four different groups viz.

Group 1 (G1): supplied sericin-treated mulberry leaves at only the chawki stage (1st to 3rd instar level).
Group 2 (G2): supplied sericin-treated mulberry leaves at only the late age (4th to 5th instar level).
Group 3 (G3): supplied sericin-treated mulberry leaves during their whole larval period (1st to 5th instar level).
Group 4 (control group): supplied only fresh mulberry leaves of the same mulberry variety during the whole rearing period.

All treatment groups of silkworms were a set of 150 silkworm larvae with three replications. Sericin-treated mulberry leaves were offered to the different treatment groups of silkworms once a day (at 10:00 a.m.). The length, width and weight of cocoon and pupae, fecundity, hatching %, and yield/100 dfls were evaluated.

C. Length, Width, and Weight of Cocoon

Ten nos. of randomly selected cocoons were taken from each replicate and treatment. An average of three individual readings from the first end, last end, and middle part of the cocoon were recorded in cm using slide calipers. Randomly selected ten cocoons from each replicate, treatments were cut, opened, and pupae were separated. Each cocoon was weighed (g) using a four-digit analytical balance.

D. Length, width, and weight of Pupae

The length and width of 10 pupae, separated from each replicate and treatment, were recorded in cm using slide calipers with the same procedure followed for cocoons. Ten pupae separated from each replicate and treatment were weighed (g) using a four-digit analytical balance individually.

E. Fecundity and Hatching%

A total number of eggs laid by a single female moth in three nights is its fecundity.

\[
\text{Hatching (\%) = \frac{\text{Number of eggs hatched}}{\text{Number of eggs kept for brushing}} \times 100}
\]

III. RESULT AND DISCUSSION

The effect of sericin as a nutritional supplement on cocoon parameters, i.e., cocoon length, cocoon width and cocoon weight of three different silkworm groups were investigated with three different treatments. The results obtained were listed in Table I, II and III. The photos of different cocoons and pupae were displayed in Fig. 2 and Fig. 3, respectively.

Table I showed the length of the cocoon of the silkworm *Bombyx mori* L., with different treatment and control groups.
In Table I, using different treatments T-1, T-2, and T-3, group 1 (G1) showed the maximum length of cocoons 2.74, 2.88, and 2.88 cm, and the minimum length of cocoons 1.98, 2.05, and 2.22 cm; group 2 (G2) showed the maximum length of cocoon 2.76, 2.82, and 2.83 cm, and the minimum length of cocoons 2.49, 2.55, and 2.54 cm; group 3 (G3) showed the highest cocoon lengths 3.05, 2.83, and 2.88 cm and the minimum cocoon length 2.63, 2.44, and 2.65 cm, respectively. The control group showed the maximum and the minimum cocoon length 2.35 cm and 2.05 cm, respectively. The top length of cocoon 3.05 cm was observed in treatment group G3 (T1), whereas least length of cocoon 1.98 cm was observed in treatment group G1 (T1) among the other treatment groups.

Using T-1, T-2 and T-3 treatments, the mean length of cocoons observed were 2.63, 2.56, and 2.55 cm for group 1 (G1), 2.70, 2.67, and 2.66 cm for group 2 (G2) and 2.78, 2.69, and 2.78 cm for group 3 (G3), respectively. On the other hand, the control group showed the mean length of cocoon 2.24 cm. The highest mean length of cocoon 2.78 cm was observed in treatment group G3 (T-1), whereas the least mean length of cocoon 2.55 cm was observed in treatment group G1 (T-3).

In Table II, the results of the effect of sericin as supplement on width of the cocoon are listed. Using T-1, T-2 and T-3 treatments, group 1 (G1) showed the maximum width of cocoon 1.72, 1.68, and 1.63 cm, and the minimum width of cocoon 1.27, 1.09, and 1.14 cm; group 2 (G2) showed the maximum width of cocoon 1.32, 1.57, and 1.43 cm, and the minimum width of cocoon 1.28, 1.46, and 1.31 cm; group 3 (G3) showed the maximum cocoon width 1.62, 1.36, and 1.43 cm and the minimum cocoon width 1.37, 1.20, and 1.35 cm, respectively. The control group showed the maximum and the minimum cocoon width 1.33 and 1.21 cm, respectively.

The largest width of cocoon 1.72 cm was observed in treatment group G1 (T-1), whereas the least length of cocoon 1.09 cm was observed in treatment group G1 (T-2) among the other treatment groups.

The mean width of cocoon observed were 1.44, 1.33, and 1.41 cm for group 1 (G1); 1.42, 1.38, and 1.30 cm for group 2 (G2) and 1.83, 1.32, and 1.40 cm for group 3 (G3) with treatments T-1, T-2 and T-3, respectively. But the control group showed the mean width 1.25 cm. The highest mean width of cocoon 1.83 cm was observed in treatment group G3(T-1), whereas the least mean width of cocoon 1.30 cm was observed in treatment group G2 (T-3).

These data exhibit a significant difference among different sericin concentrations on the width of the cocoon for all treatment groups. The highest concentration of sericin as supplement showed the most increased width of the cocoon for all treatment groups. Almost similar trend of the results was also reported when the silkworms were treated with amino acid L-serine as supplement [14].

### Table I: Effect of Sericin on Cocoon Parameter (Length of Cocoon) of a Selected Silkworm Bombyx mori L...

<table>
<thead>
<tr>
<th>Treatment</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-1</td>
<td>1.98±0.03</td>
<td>2.49±0.08</td>
<td>2.63±0.05</td>
</tr>
<tr>
<td>T-2</td>
<td>2.05±0.02</td>
<td>2.55±0.09</td>
<td>2.44±0.12</td>
</tr>
<tr>
<td>T-3</td>
<td>2.22±0.17</td>
<td>2.83±0.09</td>
<td>2.88±0.09</td>
</tr>
<tr>
<td>Control</td>
<td>2.05±0.11</td>
<td>2.35±0.11</td>
<td>2.35±0.11</td>
</tr>
</tbody>
</table>

**LS**: Each value presents the Mean±STD (standard deviation) of three separate observations. Min=Minimum, Max=Maximum, means with different superscissions are significantly different from each other for various treatments (as indicated by Tukey’s HSD test), LS-Level of significance **(p<0.05), and *** (p<0.01).

### Table II: Effect of Sericin on Cocoon Parameter (Width of Cocoon) of a Selected Silkworm Bombyx mori L...

<table>
<thead>
<tr>
<th>Treatment</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-1</td>
<td>1.27±0.06</td>
<td>1.28±0.10</td>
<td>1.37±0.07</td>
</tr>
<tr>
<td>T-2</td>
<td>1.09±0.05</td>
<td>1.46±0.03</td>
<td>1.20±0.05</td>
</tr>
<tr>
<td>T-3</td>
<td>1.14±0.15</td>
<td>1.31±0.04</td>
<td>1.35±0.03</td>
</tr>
<tr>
<td>Control</td>
<td>1.21±0.05</td>
<td>1.21±0.04</td>
<td>1.21±0.04</td>
</tr>
</tbody>
</table>

**LS**: Each value presents the Mean±STD (standard deviation) of three separate observations. Min=Minimum, Max=Maximum, means with different superscissions are significantly different from each other for various treatments (as indicated by Tukey’s HSD test), LS-Level of significance **(p<0.05), and *** (p<0.01).

### Table III: Effect of Sericin on Cocoon Parameter (Weight of Dry Cocoon) of a Selected Silkworm Bombyx mori L...

<table>
<thead>
<tr>
<th>Treatment</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-1</td>
<td>0.14±0.01</td>
<td>0.18±0.02</td>
<td>0.19±0.01</td>
</tr>
<tr>
<td>T-2</td>
<td>0.10±0.03</td>
<td>0.16±0.01</td>
<td>0.17±0.01</td>
</tr>
<tr>
<td>T-3</td>
<td>0.11±0.06</td>
<td>0.17±0.01</td>
<td>0.16±0.01</td>
</tr>
<tr>
<td>Control</td>
<td>0.11±0.11</td>
<td>0.17±0.01</td>
<td>0.15±0.11</td>
</tr>
</tbody>
</table>

**LS**: Each value presents Mean±STD (standard deviation) of three separate observations. Min=Minimum, Max=Maximum, Means with different superscissions are significantly different from each other for various treatments (as indicated by Tukey’s HSD test), LS-Level of significance **(p<0.05), and *** (p<0.01). +/- was calculated by increase or decrease compared to the control.
In Table III, the results of the effect of sericin as supplement on weight of dry cocoon are listed. Using T-1, T-2 and T-3 treatments, group 1 (G1) showed the maximum weight of dry cocoon 0.18, 0.19, and 0.32 gm, and the minimum weight of dry cocoon 0.14, 0.10, and 0.11 gm; group 2 (G2) showed the maximum weight of dry cocoon 0.20, 0.20, and 0.17 gm, and the minimum weight of dry cocoon 0.14, 0.18, and 0.15 gm; group 3 (G3) showed the maximum weight 0.20, 0.18, and 0.18 gm and the minimum weight 0.18, 0.15, and 0.15 gm, respectively. The control group showed maximum and minimum weight 0.15 and 0.11 gm, respectively. The heaviest weight of a dry cocoon 0.32 gm was observed in treatment group G1 (T-3), whereas the least weight of a cocoon 0.10 gm was observed in treatment group G1 (T-2) among the other treatment groups.

The mean weight of the dry cocoon observed were 0.17, 0.15, and 0.16 gm for group 1 (G1); 0.18, 0.16, and 0.17 gm for group 2 (G2) and 0.19, 0.17, and 0.16 gm for group 3 (G3) with different treatments T-1, T-2, and T-3, respectively, but 0.13 gm for control group. The highest mean weight of dry cocoon 0.19 gm was observed in treatment group G3(T-1), whereas the least mean weight of dry cocoon 0.15 gm was observed in treatment group G1 (T-2).

For all treatment groups, the highest increase in weight was observed with T-1 (i.e., the highest concentration of sericin) among the three treatments. The highest increase in cocoon weight was found to be 46.1% in treatment group G3 (T-1) compared to the control group. The mean weight of dry cocoon increased by about 46% when the silkworms were fed sericin-treated mulberry leaves during their whole larval period. A. M Tahir et al. also reported that honey-treated larvae increased by 15.34% in average weight of cocoons of the experimental group compared with the control [6].

**TABLE IV: EFFECT OF SERICIN ON PUPAL PARAMETER (LENGTH OF PUPAE) OF A SELECTED SILKWORM Bombyx mori L.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-1</td>
<td>1.07</td>
<td>1.09</td>
<td>1.18</td>
</tr>
<tr>
<td>T-2</td>
<td>1.22</td>
<td>1.32</td>
<td>1.29</td>
</tr>
<tr>
<td>T-3</td>
<td>1.31</td>
<td>1.40</td>
<td>1.39</td>
</tr>
<tr>
<td>Control</td>
<td>1.07</td>
<td>1.18</td>
<td>1.16</td>
</tr>
</tbody>
</table>

Each value presents the Mean ± Standard deviation of three separate observations. Min=Minimum, Max=Maximum, means with different superscripts are significantly different from each other for various treatments (as indicated by Tukey’s HSD test), LS-Level of significance *** (p<0.01).

**TABLE V: EFFECT OF SERICIN ON PUPAL PARAMETER (WIDTH OF PUPAE) OF A SELECTED SILKWORM Bombyx mori L.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-1</td>
<td>1.07</td>
<td>1.09</td>
<td>1.18</td>
</tr>
<tr>
<td>T-2</td>
<td>1.22</td>
<td>1.32</td>
<td>1.29</td>
</tr>
<tr>
<td>T-3</td>
<td>1.31</td>
<td>1.40</td>
<td>1.39</td>
</tr>
<tr>
<td>Control</td>
<td>1.07</td>
<td>1.18</td>
<td>1.16</td>
</tr>
</tbody>
</table>

Each value presents the Mean ± Standard deviation of three separate observations. Min=Minimum, Max=Maximum, means with different superscripts are significantly different from each other for various treatments (as indicated by Tukey’s HSD test), LS-Level of significance *** (p<0.01).

**TABLE VI: EFFECT OF SERICIN ON PUPAL PARAMETER (WEIGHT OF DRY PUPAE) OF A SELECTED SILKWORM Bombyx mori L.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-1</td>
<td>0.24</td>
<td>0.30</td>
<td>0.27</td>
</tr>
<tr>
<td>T-2</td>
<td>0.22</td>
<td>0.41</td>
<td>0.30</td>
</tr>
<tr>
<td>T-3</td>
<td>0.28</td>
<td>0.37</td>
<td>0.33</td>
</tr>
<tr>
<td>Control</td>
<td>0.17</td>
<td>0.26</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Each value presents the Mean ± Standard deviation of three separate observations. Min=Minimum, Max=Maximum, means with different superscripts are significantly different from each other for various treatments (as indicated by Tukey’s HSD test), LS-Level of significance ** (p<0.05), and *** (p<0.01). +/- was calculated by increase or decrease compared to the control.
In Table IV, the results of the effect of sericin as supplement on length of pupae are listed. Using different treatments T-1, T-2, T-3, group 1 (G1) showed the maximum length of pupae 2.59, 2.71, and 2.90 cm, and the minimum length of pupae 2.49, 2.52, and 2.67 cm, respectively; group 2 (G2) showed the maximum length of pupae 2.32, 2.71, and 2.93 cm, and minimum length of pupae 2.29, 2.67, and 2.87 cm, respectively; group 3 (G3) showed the maximum pupal length 2.77, 2.49, and 2.62 cm and minimum pupal length 2.70, 2.40, and 2.57 cm, respectively. The control group showed the maximum and minimum pupal length 2.35 and 2.22 cm, respectively.

The longest length of pupae 2.93 cm was observed in treatment group G2 (T3), whereas least length of pupae 2.29 cm was observed in treatment group G2 (T1) among the other treatment groups.

The mean length of pupae observed were 2.53, 2.63, and 2.79 cm for group 1 (G1); 2.31, 2.69, and 2.89 cm for group 2 (G2); and 2.73, 2.46, and 2.60 cm for group 3 (G3) with different treatments T-1, T-2 and T-3, respectively, but 2.24 cm for control group.

The longest mean length of pupae 2.89 cm was observed in treatment group G2(T-3), whereas the least mean length of pupae 2.31 cm was observed in treatment group G2 (T-1). From these data, it can be stated that there was a significant difference among sericin concentrations on the length of pupae for all treatment groups. The lowest concentration of sericin showed the highest length of pupae for all treatment groups.

In Table V, the results of the effect of sericin as supplement on width of pupae are summarized. Using different treatments T-1, T-2, T-3, group 1 (G1) showed the maximum width of pupae 1.29, 1.32, and 1.40 cm, and the minimum width of pupae 1.20, 1.22, and 1.31 cm; group 2 (G2) showed maximum width of pupae 1.20, 1.32, and 1.48 cm, and minimum width of pupae 1.16, 1.25, and 1.41 cm; and group 3 (G3) showed maximum pupal width 1.54, 1.21, and 1.31 cm and minimum pupal width 1.32, 1.16, and 1.22 cm, respectively. The control group showed the maximum and minimum pupal width 1.18 and 1.07 cm, respectively.

The largest width of pupae 1.54 cm was observed in treatment group G3 (T-1), whereas the least length of pupae 1.16 cm was observed in both treatment groups G2 (T-1) and G3 (T-2) among the other treatment groups.

The mean width of pupae was observed 1.28, 1.29, and 1.39 cm for group 1 (G1); 1.18, 1.29, and 1.46 cm for group 2 (G2) and 1.36, 1.20, and 1.28 cm for group 3 (G3) with different treatments T-1, T-2 and T-3, respectively, but the control group showed the mean width 1.16 cm.

The highest mean width of pupae 1.46 cm was observed in treatment group G2 (T-3), whereas the least mean length of pupae 1.18 cm was observed in treatment group G2 (T-1). Data from Table V showed significant differences among the treatments on the width of pupae for all treatment groups. These data revealed that the lowest concentration of sericin showed the highest length of pupae for all treatment groups except group 3 (G3).

In Table VI, the results of the effect of sericin as supplement on weight of dry pupae are summarized. Using different treatments T-1, T-2, T-3, group 1 (G1) showed the maximum weight of dry pupae 0.30, 0.41, and 0.37 gm and the minimum weight of dry pupae 0.24, 0.22, and 0.28 gm; group 2 (G2), showed maximum weight of dry pupae 0.27, 0.33, and 0.38 gm, and minimum weight of dry pupae 0.22, 0.26, and 0.29 gm; group 3 (G3) showed maximum weight of dry pupae 0.36, 0.28, and 0.33 gm and minimum weight of dry pupae 0.28, 0.22, and 0.28 gm, respectively. The control group showed the maximum and minimum weight of dry pupae 0.26 and 0.17 gm, respectively.

The heaviest weight of dry pupae 0.41 gm was observed in treatment group G1 (T-2) among the other treatment groups and the least weight of dry pupae 0.22 gm was observed in treatment groups G1 (T-2), G2 (T-1) and G3 (T-2).

The mean weight of dry pupae observed were 0.27, 0.30, and 0.33 gm for group 1 (G1); 0.25, 0.30, and 0.32 gm for group 2 (G2) and 0.30, 0.26, and 0.30 gm for group 3 (G3) with different treatments T-1, T-2 and T-3, respectively, but mean weight of dry pupae was 0.24 gm for control group.

The highest mean weight of dry pupae 0.33 gm was observed in treatment group G1 (T-3), whereas the least mean weight of dry pupae 0.25 gm was observed in treatment group G2 (T-1).

For all treatment groups, it was observed that the lowest concentration of sericin (0.25%) showed the highest increase in pupal weight. The highest 37.5% increase in pupal weight was found in treatment group G1(T-3), and the second highest 33.4% was in treatment group G2 (T-3). The highest pupal length and width recorded were 2.986 and 1.332 cm, respectively, when the silkworm was fed with amino acid L-serine treated mulberry [14], which are very relevant with the result from Table IV, V and VI.

In Table VII, the results of the effect of sericin as supplement on grainase properties of a selected silkworm Bombyx mori L. are listed. The fecundity values were...
observed 513±12.00, 529±4.10 and 534±2.84 for group G1; 529±1.52, 538±4.58, and 542±12.35 for group G2; 535±2.64, 535±1.20, and 538±7.23 for group G3 with different treatments T-1, T-2, and T-3, respectively. The control group showed the fecundity value of 535±6.11.

The value of hatching% were recorded 95.52±0.69, 95.41±0.31, and 93.3±0.76 for group G1; 96.43±0.13, 95.84±0.51, and 95.17±1.57 for group G2; 96.54±0.33, 94.94±1.11, and 95.37±0.92 for group G3 with different treatments T-1, T-2, and T-3, respectively. The control group showed the value hatching% 82.48±4.38.

The results (from Table VII) indicated that fecundity was increased with the decrease of the concentration of sericin as supplement for all treatment groups. No significant difference was observed between the treatment groups and the control group for fecundity value. In the case of hatching%, all the treatment groups showed the reverse trend with fecundity. Though the control group showed very similar fecundity but there was a mentionable variation in hatching% with all treatment groups.

**Effect of sericin on cocoon production**

![Fig. 4: Effect of sericin on yield performance of selected silkworm race Bombyx mori L.](image)

Overall, the cocoon productivity of silkworms was expressed in kg per 100 DFLs (disease-free laying’s). The results obtained are plotted in Fig. 4. The highest yield was 57 kg/100 DFLs in treatment group G1(T-2), and the second highest cocoon productivity was 54 kg/100 DFLs for both treatment groups G2 (T-2) and G3 (T-1), whereas the control group showed the cocoon productivity 46 kg/100 DFLs. The production of cocoon was increased by 23.91% in treatment group G1(T-2) and 17.39% in both groups G2 (T-2) and G3 (T-1) compared to the control group.

The above results revealed that when the sericin was used as a nutritional supplement with mulberry leaves, the cocoon and pupal parameters, fecundity, and hatching% were significantly enhanced like the previous research reports [15]–[17].

**IV. CONCLUSION**

In the sericulture industries of Bangladesh, sericin is a waste material during reeling. There are a lot of scopes to use this waste material to boost up cocoon productivity and grainase properties. In this study, different amount of sericin 0.75%, 0.50% and 0.25% (T1, T2 and T3) was used as a nutritional supplement with mulberry leaves and applied to feed to four different silkworm groups (G1, G2 and G3) and a control group. It was observed that sericin increased pupal weight by 37.5% in treatment group G1(T-3) and 33.4% in treatment group G2(T-3). The fecundity and hatching% data revealed that healthy pupae have the highest fecundity, but the lowest concentration of sericin exhibited the highest hatchability. Yield per 100 DFLs was increased by 23.9% in treatment group G1(T-2). It is suggested that silkworms can be fed 0.50% sericin-treated mulberry leaves once daily at chawki stage (first to the third instar) to increase the cocoon productivity considering overall performances.

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**CONFLICT OF INTEREST**

Authors declare that they do not have any conflict of interest.

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