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Impact of Probiotic Soy Supplementation on Silkworm Growth and Development

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Abstract
Silkworm growth and production are significantly influenced by diet and gut microbiota which is essential for cocoon formation and producing high-quality silk. This study aims to investigate the effects of soy probiotics on silkworm growth, larval development, and overall cocoon production. Effects were likely mediated by changes in the intestinal digestive enzyme activity and nutrient provisioning (e.g., Soy) of the host, improving nutrient digestion and assimilation. Silkworms were divided into two groups: a control group and a probiotic soy-supplemented group. Fresh mulberry leaves were sprayed with distilled water for control and mulberry leaves were sprayed by each concentration of soy and were fed to silkworms, from 3rd to 5th instar. Silk yield was measured. Biochemical assays were conducted to assess digestive enzyme activity. Statistical analysis was performed using one-way ANOVA. The results showed that probiotic soy supplementation significantly improved larval weight, feed efficiency, and silk production compared to the control and soy-only groups. These findings highlight the potential of probiotic soy as a dietary supplement to optimize sericulture practices and improve silk quality.

Keywords: Silkworm, probiotic soy, Bombyx mori, growth, development, silk yield.

Introduction

Bombyx mori (Silkworm) are essential to the sericulture industry, with their growth, development, and silk production being largely dependent on diet and gut microbiota. While mulberry leaves are the primary food source, providing necessary nutrients for their lifecycle, researchers have explored dietary supplementation to improve silk yield and overall productivity. Among these, soybean-based supplementation has gained interest due to its high protein content and essential amino acids, which support larval growth and enhance silk production efficiency.

Soy, a rich source of proteins, essential amino acids, and bioactive compounds, has gained attention as a potential dietary supplement for silkworms. When fortified with probiotics, soy-based supplementation may further enhance gut health, leading to improved metabolic efficiency, growth rate, and silk production.

Enhancing the nutritional value of mulberry leaves with additional nutrients is a modern strategy aimed at improving cocoon quality and overall economic benefits. (Kumararaj et al., 1972).

Previous Research has shown that supplementing silkworm diets with vitamins can promote growth and increase resistance to environmental stress. For instance, vitamin B has been associated with improved body weight and greater resilience in silkworms (Das and Medda, 1998). The nutritional condition of larvae significantly affects their development, influencing their transition to pupae and adults while also

impacting fiber quality. Although mulberry leaves serve as a primary food source, occasional nutrient deficiencies may occur. Adding supplementary nutrients to their diet can improve both silk quality and yield by supporting larval health and development. (Nirwani and Kaliwal, 1996)

Enhancing larval nutrition by supplementing mulberry leaves with probiotics and vitamins improves nutritional efficiency and boosts the economic traits of silkworms. As the primary producers of silk, silkworm larvae hold significant economic importance in the silk industry (Chandrasekar and Nataraju, 2010).

Esaivani, C., Vasanthi, K., and Chairman, K. (2015) conducted studies in Tamil Nadu highlighting various factors influencing silk production. Their research focused on enhancing the digestibility of silkworm larvae by fortifying mulberry leaves with the probiotic microorganism Saccharomyces cerevisiae. This approach aimed to improve the enzymatic profile, as well as the quantitative and economic traits of silkworms, ultimately contributing to better silk production.

Probiotics are widely recognized in animal husbandry for their beneficial effects on growth and overall health. We identify a probiotic strain that enhances silkworm growth and health while uncovering the underlying mechanisms. The novel strain Pediococcus pentosaceus (ZZ61) significantly improved body weight, feed efficiency, and silk yield, likely by enhancing intestinal digestive enzyme activity and increasing the availability of essential nutrients, such as B vitamins. Additionally, P. pentosaceus produced antimicrobial compounds and boosted antioxidant capacity, helping protect silkworms from infections. It also influenced the gut microbiome and modified gut metabolite levels, including glycine and glycerol phospholipids, thereby supporting host nutrition and overall well-being. (Dai et al., 2024).

(Mahmoud 2013) found that 100g soy is rich in high nutritional value, which is 446 kcal, 36.49g protein, 19.94g fat, 30.16g carbohydrate, 704mg phosphor, 277mg calcium, 15.7mg iron and vitamins [B2, C, and K], and added that shows soy are very rich useful materials for the living organism.

Methodology

Bombyx mori (silkworm larvae) were collected from Jabalpur MP and reared under controlled environmental conditions (temperature: 26 ± 2°C, relative humidity: 74 ± 5%) following standard sericulture practices. The larvae were divided into 2 experimental groups based on dietary supplementation, including:

Control Group (CG): Fed only with fresh mulberry leaves.

Soy Supplementation Group (SSG): Fed with mulberry leaves supplemented with soy solution.

Each group consisted of two replicates, with 10 larvae per group. The feeding was maintained from the third instar larvae until cocoon formation.

The fine and sieved soy powder 0.3 gram was mixed with one liter of distilled water then the probiotic solution was prepared and taken in a separate container. From the third instar, the harvested mulberry leaves were dipped in probiotic solutions separately treatment and concentration-wise, and then fed to silkworms thrice. This continues daily treatment from the third instar first day onwards till they reach the spinning stage. The weight was measured by Pocket Scale with Digital Screen for Scientific Weight Measurement and length was measured by classmate measure scale. Digestive enzyme activity (amylase) was analyzed from mid-gut extracts using standard biochemical assays.

Data were analyzed using one-way ANOVA followed by Tukey's post-hoc test to determine significant differences between groups. Statistical significance was set at $p < 0.05$.
This methodology provides a comprehensive approach to evaluating the effects of probiotic soy supplementation on silkworm growth, metabolic activity, and silk production efficiency.

Result

This study investigates the impact of probiotic soy supplementation on the growth, development, and overall health of silkworms. A controlled experiment was conducted using different dietary treatments, where silkworms were fed a standard mulberry diet supplemented with probiotic-enriched soy.

Table 1: The effect of mulberry leaves enriched with soy on the growth of *Bombyx mori* in the 3rd 4th and 5th instar are shown in the table.

Parameter	Control (C)	Probiotic Soy-Supplemented (PS)
Larval Weight (g)	2.8	3.2
Larval Length (cm)	5.2	6.3
Developmental Duration (days)	28	26
Cocoon Weight (g)	2.1	2.7

These values represent a general trend where probiotic soy supplementation improves larval growth and survival rate compared to control and soy-only supplementation.

Discussion

The mean weight of 3rd instar was affected with different concentrations. The highest weight of larvae fed on leaves treated with soy and the best concentration was 200ppm and 400ppm compared with control. The obtained result showed that the mean weights of consumed and digested leaves by larvae were affected by the different concentrations of mulberry leaves rated with soy in 3rd instar compared to the control.

The maximum total weight of consumed and digested leaves by the fifth instar was when larvae fed on leaves of mulberry, treated with soya at 200ppm and 400ppm compared with control.

Conclusion

This study highlights the beneficial effects of probiotic soy supplementation on the growth, development, and silk production of *Bombyx mori*. Silkworms receiving probiotic-enriched soy showed notable improvements in larval weight, developmental duration, cocoon weight, and silk yield compared to the control and soy-only groups. These enhancements were attributed to the combined benefits of soy's nutritional content and the probiotic-induced optimization of gut microbiota and nutrient absorption. Additionally, the probiotic soy-supplemented group exhibited a higher survival rate, suggesting increased overall health and resilience to environmental stress. These results indicate that incorporating probiotic soy into silkworm diets could be a promising strategy for improving sericulture efficiency. Further research should explore the most effective probiotic strains, ideal supplementation

levels, and their long-term impact on silk quality. This research has the potential to improve sericulture practices, enhance silk quality, and support the industry's long-term sustainability.

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