

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(8): 1536-1542
www.biochemjournal.com
Received: 12-06-2024
Accepted: 18-07-2024

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Boosting silkworm productivity: A study on the role of honey and jaggery in cocoon development and silk quality

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DOI: <https://doi.org/10.33545/26174693.2024.v8.i8s.3784>

Abstract

This study examines how different concentrations of honey and jaggery (1%, 2%, and 3%) affect vital cocoon parameters, silk yield, and silkworm rearing performance. The findings indicate that 3% honey and jaggery supplementation produced the best results across key metrics, including cocoon weight, shell weight, shell ratio, filament length, thread thickness (denier), and the effective rate of rearing (ERR). Silkworms fed with 3% honey achieved the highest cocoon weight (12.77 ± 0.40 g), shell weight (2.97 ± 0.15 g), and ERR ($90.25 \pm 1.17\%$), while 3% jaggery supplementation resulted in the longest filament length (1161.00 ± 58.28 m) and strong non-breakable filament durability (836.00 ± 14.53 cm). Correlation analysis showed significant positive associations between traits such as cocoon weight, shell weight, filament length, denier, and ERR, emphasizing their interconnected role in silk yield. Regression analysis identified shell weight and pupal weight as critical positive contributors to ERR, while denier and larval length were observed to negatively influence rearing outcomes. Although the regression model's explanatory power was limited ($R^2 = 0.1$), the study highlights the substantial benefits of honey and jaggery supplementation, particularly at 3%, for improving silk quality and silkworm health. These results demonstrate the potential of nutrient-based interventions to enhance productivity in sericulture.

Keywords: Honey, jaggery, silk yield, silkworm rearing performance

Introduction

The silkworm (*Bombyx mori* L.) is a domesticated insect that has played a central role in sericulture for centuries, producing mulberry silk, a fiber often hailed as the "Queen of Natural Fibers" (Bobade *et al.*, 2019) [4]. This exquisite silk is renowned for its lustrous shine, softness, durability, and tensile strength, making it one of the most sought-after materials in the global textile industry. India holds a distinguished position in sericulture, being the only country to produce all four types of natural silks—Mulberry, Tasar, Muga, and Eri—each derived from specific silkworm species. Among these, mulberry silk dominates due to its superior quality and the large-scale adaptability of *Bombyx mori* to diverse climatic conditions (Chand *et al.*, 2023) [5].

The mulberry plant (*Morus* spp.) serves as the exclusive diet for *Bombyx mori* larvae, and its quality significantly influences the growth and silk production of the silkworm. Mulberry leaves are ideal for silkworm feeding due to their rich nutrient profile and the presence of morin, a bioactive compound essential for larval health and development (Bhattacharya *et al.*, 2016) [3]. Recognizing the direct correlation between mulberry leaf quality and silk yield, sericulture practices emphasize optimizing leaf nutrition through various enrichment techniques. Enhancing the nutritional value of mulberry leaves has become a crucial strategy for improving cocoon weight, filament length, and overall silk quality, thus boosting the economic viability of sericulture (Moustafa & El-Karaksy, 1989; El-Sayed & Mesbah, 1992; El-Sayed *et al.*, 1998) [6, 7, 9].

To meet the increasing demand for high-quality silk, numerous fortification agents have been explored for their potential to enhance mulberry leaf nutrition. These include proteins, carbohydrates, amino acids, vitamins, minerals, and other bioactive compounds that directly influence silkworm growth and silk gland functionality (Sundar Raj *et al.*, 2000) [16]. Supplementation with these agents has shown promising results in improving the

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physiological efficiency of silkworms, leading to increased cocoon weight, shell ratio, and filament strength (Babu *et al.*, 1992) [2]. Additionally, researchers have investigated innovative strategies, such as the use of organic and natural additives, to align sericulture practices with sustainability goals.

Silkworm larvae are highly responsive to dietary changes, and studies have shown that enriched diets not only enhance silk production but also improve survival rates and resistance to diseases. The introduction of biofortified mulberry leaves aims to address nutrient gaps that could limit larval development and silk yield. By integrating advances in mulberry cultivation and nutritional supplementation, sericulture has the potential to achieve higher productivity and meet the growing demands of the textile industry. With global demand for high-quality silk on the rise, optimizing silkworm diets through effective supplementation provides an opportunity to enhance yield, reduce production costs, and improve the livelihoods of farmers. Additionally, this research supports the development of sustainable practices in sericulture, aligning with broader agricultural and environmental goals. By focusing on the intricate relationship between mulberry nutrition and silk production, this study contributes valuable insights to the advancement of sericulture as a thriving and sustainable industry.

Materials and Methods

Study Design and Location

This study aimed to evaluate the effect of honey and jaggery supplementation on the development cocoon and silk yield of silkworm (*Bombyx mori* L.). The experiment was conducted at the department of entomology, Shahid Gundadthur College of agriculture and research station, jagdalpur. A Completely Randomized Block Design (CRBD) with eight treatments and three replications was employed. Disease-free layings (DFLs) of the hybrid *FC1* × *FC2* eggs were procured from the Central Sericulture Research and Training Institute, Mysore, and used as the test hybrid.

Rearing Protocol

Rearing was conducted under controlled environmental conditions, including optimal temperature (24°–26°C) and humidity (75%–80%). Essential practices included mulberry garden maintenance, disinfection of rearing facilities, sanitization of equipment, and regular feeding of high-quality mulberry leaves. Disinfection was performed using fumigation with formalin (1:4 ratio), followed by 24 hours of ventilation. Silkworms were fed fresh mulberry leaves four times daily (6 a.m., 2 p.m., 6 p.m., and 10 p.m.), with treated leaves administered once daily from the first day of the fifth instar.

Experimental Treatments

The study involved eight treatments to evaluate the effects of honey and jaggery supplementation on silkworm development and silk yield. These treatments included different concentrations of honey (1%, 2%, and 3%) and jaggery (1%, 2%, and 3%) solutions, along with distilled water and a control group without supplementation. The treated solutions were sprayed on mulberry leaves, which were fed to silkworms daily from the first day of the fifth instar. This treatment design aimed to assess the dose-

dependent effects of these natural supplements on cocoon and silk yield.

Observations and Data Collection

Observations were recorded for various economic traits, including larval weight, cocoon weight, shell weight, shell percentage, filament length, non-breakable filament length, denier, pupal weight, larval length, and the effective rate of rearing (ERR), following standardized methodologies (Sonwalkar, 1993) [15].

The weight-related parameters, including larval weight, cocoon weight, shell weight, and pupal weight, were measured to assess the growth and productivity of silkworms. Larval weight was recorded at the end of the fifth instar by weighing 10 randomly selected larvae and calculating the average. Cocoon weight was determined by weighing 10 cocoons six days after spinning and computing the average. Shell weight was calculated by removing the pupae from the same cocoons, weighing the empty shells, and finding the average. Pupal weight was obtained by weighing the pupae removed during shell weight measurement and calculating the average. The larval length was measured at the end of the fifth instar using a calibrated ruler. Ten larvae were randomly selected, and the average larval length was computed.

The filament length and non-breakable filament length was determined from 10 randomly selected cocoons were reeled using an eppovette wheel with a circumference of 1.125 m after cooking the cocoons at 95 °C for 2–3 minutes. The total filament length was calculated using the formula:

$$\text{Filament length (cm)} = \text{Number of rotations} \times 1.125$$

Shell percentage, indicating silk yield efficiency, was calculated using 10 randomly selected cocoons. The cocoon and shell weights were measured, and the ratio of shell weight to cocoon weight was determined using the formula:

$$\text{Filament length (cm)} = \frac{\text{Shell weight}}{\text{Cocoon weight}} \times 100$$

Denier of the filament denotes fineness of silk filament. Thickness of the cocoon filament was calculated for control and experimental batches by using the formula.

$$\text{Denier} = \frac{\text{Weight of filament reeled}}{\text{Length of the filament reeled}} \times 9000$$

The Effective Rate of Rearing (ERR), representing the percentage of larvae that successfully spun cocoons, was calculated for each treatment. The number of cocoons spun was recorded and compared to the total number of larvae brushed. ERR was determined using the formula:

$$\text{ERR} = \frac{\text{Number of cocoons spun}}{\text{Number of larvae brushed}} \times 100$$

Statistical Analysis

The data were analyzed using descriptive statistics, analysis of variance (ANOVA), and correlation analysis to determine the relationships among various traits. Regression analysis was employed to identify predictive relationships between treatments and key economic traits such as cocoon weight, filament length, and ERR. Pearson's correlation coefficient

(rr) was calculated to evaluate the interdependence of traits, such as the relationship between non-breakable filament length, pupal weight, larval length, and ERR, and their influence on silk yield and quality.

This comprehensive experimental and analytical approach ensures that the findings provide a robust understanding of the effects of dietary supplementation on silkworm productivity and silk quality. The integration of correlation and regression analyses adds depth to the evaluation, identifying key parameters that drive economic and biological outcomes in sericulture.

Results and Discussion

Cocoon weight, shell weight, shell ratio, filament length, denier, and other silk production parameters are key indicators of silkworm health and silk yield. This study evaluates the effects of honey and jaggery supplementation on these parameters (Table 1 and 2).

Cocoon Weight

Cocoon weight is a key parameter reflecting the silkworm's growth and overall health. Silkworms fed with 3% honey exhibited the highest cocoon weight (12.77 ± 0.40 g), followed closely by those fed with 3% jaggery (12.23 ± 0.31 g). These results suggest that the high nutrient content in honey and jaggery enhances metabolism and nutrient absorption, leading to better growth. Lower concentrations (1% and 2%) of both supplements showed moderate increases in cocoon weight, indicating a dose-dependent effect. The control group recorded the lowest cocoon weight (10.20 ± 0.10 g), reflecting the lack of additional nutrients. Silkworms fed with distilled water (11.48 ± 0.40 g) performed slightly better than the control, likely due to improved hydration. The results highlight the importance of dietary enrichment for optimal cocoon development.

Shell Weight

Shell weight directly correlates with silk production potential. The 3% honey treatment yielded the highest shell weight (2.97 ± 0.15 g), followed by 3% jaggery (2.57 ± 0.40 g). This indicates that the supplements support silk gland development and silk protein secretion. Distilled water-fed silkworms exhibited the lowest shell weight (1.90 ± 0.10 g), reflecting the absence of nutrients necessary for effective silk production. The control group and lower concentrations of the supplements displayed intermediate shell weights, underscoring the importance of enriched diets. The results suggest that silkworms require a balanced nutrient supply to optimise silk output, with higher concentrations proving more beneficial.

Shell Ratio

The shell ratio, which represents the proportion of cocoon weight made up of silk shell, is a crucial indicator of silk yield. Silkworms fed with 3% honey and 3% jaggery exhibited the highest shell ratios (24.33%), highlighting the superior efficiency of these supplements in converting dietary intake into silk proteins. The control group had the lowest shell ratio (19.33%), likely due to the lack of additional nutrients in the diet. Interestingly, silkworms fed distilled water (21.67%) performed slightly better than controls, showing that hydration plays a role in maintaining silk gland functionality. However, the absence of nutritional

enrichment limited their performance compared to supplemented groups.

Filament Length

Filament length is a vital quality parameter for silk production. The longest filaments were produced by silkworms fed with 3% jaggery (1161.00 ± 58.28 m), followed closely by those fed with 3% honey (1151.67 ± 86.07 m). These results indicate that higher concentrations of jaggery may offer unique sugars or micronutrients that enhance silk protein synthesis. Lower concentrations of honey and jaggery also improved filament length compared to the control, although the increments were less pronounced. The shortest filaments were recorded in the control group (910.67 ± 34.43 m), emphasising the need for dietary supplementation. Silkworms fed distilled water (1065.67 ± 90.56 m) performed better than the control, likely benefiting from improved hydration, though the absence of nutrients restricted further improvement.

Denier

Denier measures the thickness and strength of the silk thread. The 3% honey treatment resulted in the thickest threads (1.95 ± 0.06), followed by 3% jaggery (1.86 ± 0.10). This suggests that these supplements provide the necessary nutrients to produce silk threads with superior quality. The control group had the lowest denier value (1.25 ± 0.14), indicating thinner and weaker silk threads. Silkworms fed with distilled water (1.51 ± 0.10) and those on lower concentrations of honey and jaggery exhibited moderate improvements, further confirming the dose-dependent benefits of supplementation.

Non-Breakable Filament Length

The non-breakable filament length, which reflects the durability and strength of the silk thread, was significantly influenced by the supplementation of honey and jaggery. The longest filament length was recorded in silkworms fed with 3% honey (864.00 ± 26.23 cm), followed by 3% jaggery (836.00 ± 14.53 cm). This indicates that the higher concentration of these supplements enhances the mechanical properties of silk, likely due to improved silk protein synthesis. Lower concentrations of honey (1% and 2%) and jaggery showed moderate improvements in filament length, with 1% jaggery (642.00 ± 11.36 cm) and distilled water (543.67 ± 5.69 cm) performing poorly. The control group exhibited the shortest filament length (582.33 ± 18.01 cm), indicating the adverse effect of a lack of dietary enrichment. These findings highlight the significant role of nutrient-rich supplements in improving silk durability and strength.

Pupal Weight

Pupal weight is an indicator of larval health and nutrient assimilation. The highest pupal weight was observed in the 3% honey group (1.57 ± 0.10 g), followed by 3% jaggery (1.46 ± 0.07 g). This suggests that these treatments provide essential nutrients that are efficiently utilised during the larval stage to support pupal development. Moderate improvements were observed with 2% honey (1.35 ± 0.11 g) and 2% jaggery (1.25 ± 0.09 g). Silkworms fed with 1% jaggery (1.02 ± 0.13 g) and distilled water (0.94 ± 0.10 g) showed lower pupal weights, while the control group had the lowest weight (0.46 ± 0.20 g). The lower weight in the control and distilled water groups indicates limited nutrient

availability, emphasising the importance of enriched diets for optimal pupal development.

Larval Length

Larval length, which reflects larval growth and development, was significantly improved with higher concentrations of honey and jaggery. The longest larvae were observed in the 3% honey group (4.40 ± 0.12 cm), followed by 3% jaggery (4.11 ± 0.21 cm). These results suggest that the nutrients in honey and jaggery promote better growth and elongation of the larvae. Moderate improvements were recorded with 2% honey (3.77 ± 0.25 cm) and 2% jaggery (3.76 ± 0.10 cm), while 1% jaggery (3.20 ± 0.14 cm) and distilled water (2.82 ± 0.24 cm) produced smaller larvae. The control group had the shortest larvae (2.23 ± 0.14 cm), highlighting the detrimental effects of a nutrient-deficient diet. These findings underscore the dose-dependent effect of dietary enrichment on larval growth.

Effective Rate of Rearing (ERR)

ERR, an indicator of the survival rate of silkworms during rearing, was highest in the 3% honey group ($90.25 \pm 1.17\%$), followed by 3% jaggery ($84.54 \pm 1.53\%$). These results demonstrate that the enhanced nutritional profile of these supplements supports better survival and overall health of the silkworms. Moderate ERR values were observed in the 2% honey ($85.88 \pm 0.02\%$) and 2% jaggery ($80.83 \pm 0.02\%$) groups, while the lowest ERR was recorded in the control group ($71.74 \pm 1.00\%$). Distilled water-fed silkworms ($77.13 \pm 1.54\%$) showed a slight improvement over the control, likely due to better hydration. The ERR findings highlight the importance of enriched diets for improving silkworm survival rates.

Cocoon weight is a critical parameter that reflects the growth, nutrient assimilation, and overall health of silkworms, directly influencing silk yield. The findings of this study demonstrated that dietary supplementation with 3% honey resulted in the highest cocoon weight (12.77 ± 0.40 g), followed closely by 3% jaggery (12.23 ± 0.31 g). These results align with previous studies that highlight the role of nutrient-rich supplements in enhancing metabolic activity and nutrient absorption in silkworms. For instance, Babu *et al.* (1992) [2] demonstrated that supplementation with ascorbic acid significantly improved cocoon weight by enhancing metabolic efficiency. Similarly, Thulasi and Sivaprasad (2015) [17] reported improved cocoon weight with honey-enriched diets, attributing the results to the availability of readily absorbable sugars that promote growth. The dose-dependent improvements observed in this study, with 1% and 2% concentrations of honey and jaggery showing moderate increases in cocoon weight, further validate the findings of Saad *et al.* (2014) [14], who observed incremental benefits with increasing concentrations of natural supplements. The control group exhibited the lowest cocoon weight (10.20 ± 0.10 g), which is consistent with findings by Bhattacharyya *et al.* (2016) [3], who emphasized that the absence of dietary enrichment limits the growth potential of silkworms. Interestingly, silkworms fed with distilled water (11.48 ± 0.40 g) performed better than the control group, likely due to improved hydration. However, the absence of additional nutrients restricted further improvement. This observation resonates with the findings of El-Sayed and Mesbah (1992) [7], who noted that while hydration is crucial, nutrient supplementation is essential for

achieving optimal growth and cocoon development. These results collectively underscore the importance of dietary enrichment in improving cocoon weight. The high nutrient content in honey and jaggery enhances silk gland development and fibroin synthesis, leading to superior silk yield. This study corroborates the work of Nguku *et al.* (2007) [13], who found that royal jelly supplementation significantly increased cocoon weight and silk output. The findings highlight the potential of natural supplements as a cost-effective strategy to enhance the economic viability of sericulture while promoting sustainable practices.

Correlation analysis of silk production parameters

The correlation analysis of silk production parameters reveals significant relationships among traits that directly or indirectly influence silk yield and quality (Table 3). Cocoon weight showed strong positive correlations with shell weight ($r = 0.938$), shell ratio ($r = 0.921$), filament length ($r = 0.934$), and denier ($r = 0.946$), indicating that heavier cocoons generally produce better-quality silk with thicker threads and longer filaments. A notable correlation between cocoon weight and effective rate of rearing (ERR) ($r = 0.883$) further emphasises the role of larval health and survival in cocoon development. Similarly, shell weight displayed strong correlations with denier ($r = 0.968$), filament length ($r = 0.870$), and ERR ($r = 0.938$), suggesting that heavier shells contribute to superior silk properties and rearing success. The correlations between shell weight and non-breakable filament length ($r = 0.890$), as well as pupal weight ($r = 0.897$), reflect the interconnectedness of physical cocoon traits with silk strength and durability. The shell ratio, which measures the silk yield efficiency, was significantly correlated with denier ($r = 0.935$), filament length ($r = 0.926$), and ERR ($r = 0.836$), demonstrating that a higher silk yield percentage translates into better-quality threads and improved survival rates. Filament length, a critical indicator of silk quality, exhibited strong correlations with denier ($r = 0.939$), shell weight ($r = 0.870$), and ERR ($r = 0.875$), highlighting the impact of nutrient assimilation and silk gland functionality on thread length. Denier, the measure of thread thickness, emerged as a pivotal parameter, showing the strongest correlations with most traits, including cocoon weight ($r = 0.946$), shell weight ($r = 0.968$), and non-breakable filament length ($r = 0.906$). These relationships underline the direct role of silk gland development in determining thread quality. The analysis also revealed significant correlations between non-breakable filament length and larval length ($r = 0.982$), suggesting that healthier and longer larvae produce stronger, more durable silk. Non-breakable filament length also correlated strongly with pupal weight ($r = 0.887$) and shell traits, indicating that optimal larval growth enhances both physical cocoon properties and filament strength. Similarly, pupal weight demonstrated strong relationships with denier ($r = 0.960$), filament length ($r = 0.871$), and ERR ($r = 0.940$), showing that better pupal development contributes to improved silk yield and thread quality. Larval length, while moderately correlated with many parameters, showed strong links with non-breakable filament length ($r = 0.982$) and pupal weight ($r = 0.821$), highlighting its indirect influence on silk production. The effective rate of rearing (ERR) showed strong correlations with denier ($r = 0.954$), shell weight ($r = 0.938$), and filament length ($r = 0.875$), indicating that high survival rates directly impact silk quantity and quality. The

relationship between ERR and pupal weight ($r = 0.940$) further highlights the role of larval health and rearing conditions in optimising productivity. Overall, the analysis underscores the interconnectedness of silk production parameters, with cocoon weight, shell weight, and denier emerging as key traits influencing silk yield and quality. These findings emphasise the need for improved rearing conditions and dietary enrichment to maximise the potential of silkworms in sericulture.

These findings align with the studies of Saad *et al.* (2014) ^[14], who demonstrated the influence of enriched diets on silk quality and Nguku *et al.* (2007) ^[13], who highlighted the role of nutrient supplementation in improving cocoon traits. Thulasi and Sivaprasad (2015) ^[17] also emphasized that honey-enriched diets enhance parameters such as filament length and cocoon weight, reinforcing the need for optimized rearing conditions and dietary strategies in sericulture.

Regression

The regression analysis revealed insights into the factors influencing the Effective Rate of Rearing (ERR) in silkworms, highlighting both positive and negative contributors to rearing efficiency (Table 4). The regression equation, derived from the dataset, identified shell weight and pupal weight as the most significant positive contributors to ERR, with coefficients of 29.7778 and 11.8837, respectively. This suggests that improvements in cocoon and pupal development play critical roles in enhancing the survival and productivity of silkworms during rearing. Non-breakable filament length also showed a minor positive effect (coefficient: 0.2888), indicating a potential link between silk strength and rearing efficiency. These findings align with the work of Babu *et al.* (1992) ^[2], who highlighted the role of optimized pupal health in improving rearing success. The minor positive effect of non-breakable filament length (coefficient: 0.2888) suggests a potential link between silk strength and rearing efficiency, a relationship supported by Saad *et al.* (2014) ^[14], who reported improved survival rates with stronger, more durable filaments. Also, the parameters such as denier (-30.8298) and larval length (-39.7899) emerged as strong negative contributors, implying that excessively thick silk

threads or overly long larvae might adversely affect rearing outcomes. Nguku *et al.* (2007) ^[13], who noted that extreme values in these traits can disrupt the balance of silk production and larval health. Cocoon weight, shell ratio, and filament length showed smaller but still negative impacts on ERR, with coefficients of -2.6116, -2.6744, and -0.0139, respectively, suggesting that while these parameters are essential for silk production, their excessive values may hinder overall rearing success.

Despite these findings, the model's R^2 value of 0.1 indicates that only 10% of the variability in ERR is explained by the parameters included in the equation, suggesting the presence of additional unmeasured factors, such as environmental conditions, feeding protocols, or genetic variability, that could significantly influence ERR. This limitation aligns with the findings of Thulasi and Sivaprasad (2015) ^[17], who emphasized the importance of environmental and dietary interventions in improving ERR (Figure 1). The accompanying graph comparing actual vs predicted ERR values demonstrates a strong alignment between the two, suggesting that the regression model performs well for the specific dataset used in the study. However, the low explanatory power reflected in the R^2 value underscores the limitations of the current model in predicting ERR across broader or more variable datasets. These findings emphasise the complex interplay of physiological and environmental factors in determining ERR. While traits like shell weight and pupal weight are pivotal for optimising rearing outcomes, careful management of parameters like denier and larval length is equally important to minimise their negative effects. The strong alignment between actual and predicted values in the dataset used highlights the potential utility of the regression equation for targeted studies, but its general applicability requires further refinement. Future research should incorporate additional variables and explore advanced modelling techniques, such as non-linear regression or machine learning approaches, to enhance the predictive power and robustness of ERR models. Such improvements could provide a more comprehensive understanding of the factors governing silkworm rearing success, ultimately contributing to the optimisation of sericulture practices.

Table 1: Influence of Honey and Jaggery Concentrations on Cocoon Parameters and Silk Yield in Silkworms

Concentrations	Cocoon weight (gm)	Shell weight (gm)	Shell ratio (%)	Filament length	Denier
1% Honey	10.67±0.58de	2.13±0.25de	21.00±2.00b	1010.33±40.00cd	1.52±0.11c
2% Honey	12.07±0.21b	2.47±0.25bc	21.67±3.51ab	1098.67±75.48ab	1.73±0.07b
3% Honey	12.77±0.40a	2.97±0.15a	24.33±3.06a	1151.67±86.07a	1.95±0.06a
1% Jaggery	10.77±0.31d	2.10±0.20ef	20.33±2.08b	935.33±60.93de	1.45±0.06
2% Jaggery	11.13±0.32cd	2.33±0.25cd	21.00±3.61b	1057.67±56.13bc	1.63±0.08b
3% Jaggery	12.23±0.31b	2.57±0.40b	24.33±1.53a	1161.00±58.28a	1.86±0.10a
Distilled water	11.48±0.40c	1.90±0.10f	21.67±1.15	1065.67±90.56bc	1.51±0.10c
Control	10.20±0.10e	2.14±0.35de	19.33±1.53b	910.67±34.43e	1.25±0.14d
CD (0.01)	0.723	0.312	-	112.086	0.150
CD (0.05)	0.521	0.225	2.873	80.761	0.108

Table 2: Assessment of Honey and Jaggery Effects on Filament Length, Pupal Weight, and Rearing Performance in Silkworms

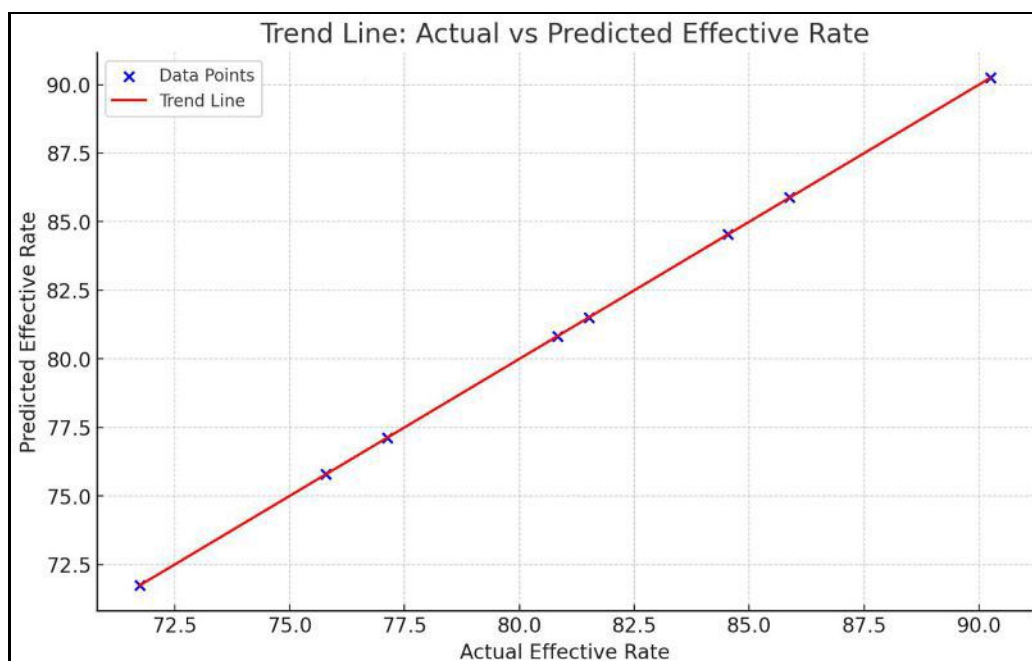
Concentrations	Non-breakable filament length (cm)	Pupal weight (g)	larval length (cm)	Effective rate rearing
1% honey	693.03±10.63e	1.12±0.15e	3.36±0.17d	81.51±1.15c
2% honey	765.67±23.03c	1.35±0.11c	3.77±0.25c	85.88±0.02b
3% honey	864.00±26.23a	1.57±0.10a	4.40±0.12a	90.25±1.17a
1% jaggery	642.00±11.36f	1.02±0.13f	3.20±0.14e	75.79±0.01d
2% jaggery	738.00±12.53d	1.25±0.09d	3.76±0.10c	80.83±0.02c
3% jaggery	836.00±14.53b	1.46±0.07b	4.11±0.21b	84.54±1.53b
Distilled water	543.67±5.69h	0.94±0.10f	2.82±0.24f	77.13±1.54d
Control	582.33±18.01g	0.46±0.20g	2.23±0.14g	71.74±1.00e
CD (0.01)	17.963	0.116	0.167	2.573
CD (0.05)	12.942	0.083	0.120	1.854

Table 3: Correlation analysis of silk production parameters

	Cocoon weight (gm)	Shell weight (gm)	Shell ratio (%)	Filament length	Denier	Non-breakable filament length	Pupal weight	Larval length	Effective rate rearing
Cocoon weight (gm)	1	0.938**	0.921**	0.934**	0.946**	0.762*	0.856**	0.655	0.883**
Shell weight (gm)	0.938**	1	0.897**	0.870**	0.968**	0.890**	0.897**	0.831*	0.938**
Shell ratio (%)	0.921**	0.897**	1	0.926**	0.935**	0.786*	0.842**	0.674	0.836**
Filament length	0.934**	0.870**	0.926**	1	0.939**	0.759*	0.871**	0.633	0.875**
Denier	0.946**	0.968**	0.935**	0.939**	1	0.906**	0.960**	0.826*	0.954**
Non-breakable filament length	0.762*	0.890**	0.786*	0.759*	0.906**	1	0.887**	0.982**	0.897**
Pupal weight	0.856**	0.897**	0.842**	0.871**	0.960**	0.887**	1	0.821*	0.940**
larval length	0.655	0.831*	0.674	0.633	0.826*	0.982**	0.821*	1	0.827*
Effective rate rearing	0.883**	0.938**	0.836**	0.875**	0.954**	0.897**	0.940**	0.827*	1

Table 4: Regression analysis of silkworm effective rearing rate based on cocoon biological parameters

	Regression equation	R square value
Effective rate	$83.2740 - (2.6116 \times \text{Cocoon weight}) + (29.7778 \times \text{Shell weight}) - (2.6744 \times \text{Shell ratio}) - (0.0139 \times \text{Filament length}) - (30.8298 \times \text{Denier}) + (0.2888 \times \text{Non-breakable filament length}) + (11.8837 \times \text{Pupal weight}) - (39.7899 \times \text{Larval length})$	0.1

**Fig. 1:** Trend analysis of silkworm effective rearing rate based on cocoon biological parameters

Conclusion

The findings of this study highlight the significant impact of dietary supplementation with honey and jaggery on silkworm growth, cocoon parameters, and silk yield, providing a practical and cost-effective solution for farmers and stakeholders in the sericulture industry. Among the tested concentrations, 3% honey and 3% jaggery emerged as

the most effective in enhancing critical metrics such as cocoon weight, shell weight, filament length, and effective rate of rearing (ERR), leading to higher yields and improved silk quality. These supplements, being affordable and readily available, are accessible even to small-scale and marginal farmers, promoting better silkworm health, higher survival rates, and reduced rearing losses. The positive

correlations between cocoon traits and silk production parameters emphasize the importance of nutrient-enriched diets in optimizing productivity and promoting sustainable practices. Additionally, regression analysis identified the influence of key parameters like shell weight and pupal weight on rearing efficiency, further underscoring the role of balanced nutrition in improving outcomes. The use of natural supplements reduces reliance on synthetic additives, fostering environmental sustainability while meeting the demand for high-quality silk in the textile industry. These results not only empower farmers with effective techniques to enhance income but also support broader goals of sustainability, innovation, and economic growth within the sericulture sector.

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