



# Impact of Leaf-age on Economic Traits of Mulberry Silkworm (*Bombyx mori* L.)

Vallapu, S.N<sup>a\*</sup>, Nalwandikar, P.K.<sup>a</sup>, Bhamare, V.K.<sup>a</sup>,  
Darapureddy, N.S.S.S<sup>a</sup> and S.K.Meena<sup>a</sup>

<sup>a</sup> Department of Entomology, College of Agriculture, Latur, Vasanttrao Naik Marathwada Krishi Vidyapeeth, Parbhani, India.

## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

## Article Information

DOI: <https://doi.org/10.9734/jabb/2024/v27i81259>

## Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/120833>

Original Research Article

Received: 05/06/2024

Accepted: 07/08/2024

Published: 13/08/2024

## ABSTRACT

**Aims:** This study aimed to investigate the impact of feeding mulberry leaves of different maturity stages—tender, medium, and coarse—on the economic traits of bivoltine silkworms (*Bombyx mori* L.), with the goal of enhancing sericulture practices by identifying the most beneficial leaf types for feeding.

**Study Design:** The experiment utilized seven treatments comprising various combinations of mulberry leaf ages: tender (T1), medium (T2), coarse (T3), and their combinations (T4-T7). Each treatment was replicated three times, following a randomized block design.

**Place and Duration of Study:** The experiment was conducted during the monsoon season of 2020-21 at the Department of Agricultural Entomology, College of Agriculture, Latur, under Vasanttrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra.

**Methodology:** Disease-free layings of FC<sub>2</sub> X FC<sub>1</sub> bivoltine double hybrid silkworms were reared on different maturity mulberry leaf combinations (variety V-1), and parameters such as larval weight,

\*Corresponding author: E-mail: [vallapusowjanyanarayana2109@gmail.com](mailto:vallapusowjanyanarayana2109@gmail.com);

**Cite as:** S.N, Vallapu, Nalwandikar, P.K., Bhamare, V.K., Darapureddy, N.S.S.S, and S.K. Meena. 2024. "Impact of Leaf-Age on Economic Traits of Mulberry Silkworm (*Bombyx Mori* L.)". *Journal of Advances in Biology & Biotechnology* 27 (8):1359-72. <https://doi.org/10.9734/jabb/2024/v27i81259>.

cocoon weight, single shell weight, cocoon shell ratio, cocoon yield, filament length, filament weight, denier, disease incidence, and effective rate of rearing were measured.

**Results:** Feeding silkworms with tender leaves (T1) resulted in the highest values for larval weight (38.82 g), cocoon weight (1.94 g), single shell weight (0.37 g), cocoon shell ratio (19.21%), cocoon yield (18.68 kg per 10,000 larvae), filament length (922.33 m), filament weight (0.28 g), denier (2.76), effective rate of rearing (98.40%), and lower disease incidence (1.30%). Conversely, feeding coarse leaves (T3) led to the lowest values across these parameters.

**Conclusion:** The study highlights the significance of mulberry leaf quality, particularly tenderness and moisture content, in optimizing economic traits in sericulture. Tender leaves consistently supported superior economic traits compared to medium and coarse leaves. These findings suggest that managing leaf quality can significantly enhance silk production and quality in *Bombyx mori* L., highlighting the nutritional advantages of tender mulberry leaves. Future research could explore additional factors affecting leaf quality and their specific impacts on silkworm development and silk characteristics.

**Keywords:** *Mulberry leaf maturity; Bombyx mori; sericulture; silk production; cocoon yield; filament length; leaf quality.*

## 1. INTRODUCTION

The silkworm *Bombyx mori* is essentially monophagous and relies exclusively on mulberry leaves (*Morus* spp.) for nutrition, which is crucial for its growth, development, and silk production. Mulberry is a highly heterozygous and vegetatively propagated species with a prolonged juvenile period. The quality and maturity of mulberry leaves are vital for the healthy growth of silkworms and maximizing cocoon production [1].

*Bombyx mori* exhibits a preference for mulberry leaves at various maturity levels—tender, medium, and mature—depending on its larval stage [1]. Chemical analysis show significant differences in crude protein, total sugar, starch, reducing sugar, total carbohydrates, fiber, ash, and moisture content among these leaves [2]. Studies indicate that silkworm larvae prefer leaves with high moisture content and lower dry matter [3]. Top tender leaves are nutritionally richer compared to medium, mature, and over-mature leaves and have less density of pubescence with a blunt tip [4,5,6,7].

Feeding highly moisture content tender leaves may help farmers to harvest quality cocoon crops [8,9,10,2]. The quantity and quality of these leaves play a pivotal role in silk productivity, with a direct correlation to environmental factors [11]. Matsumura et al. [12] highlighted that mulberry leaf quality is the most critical factor for successful cocoon crops, accounting for 38.2% of the success, followed by climate, rearing techniques, silkworm race, silkworm eggs, and other factors. Nearly 70% of the silk protein

produced by silkworms comes directly from the protein in mulberry leaves [13]. Thus, selecting the right mulberry leaves, containing essential chemical constituents and favorable physical features, is crucial for sericulture [14].

Considering these factors, the present study was undertaken to understand the impact of leaf age on the economic traits of bivoltine silkworm (*Bombyx mori* L.).

## 2. MATERIALS AND METHODS

The experiment was conducted during monsoon 2020-21 at the Department of Agricultural Entomology, College of Agriculture, Latur under Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra to study the effect of mulberry (Variety V-1) leaves of different ages on the biology and economic traits of bivoltine silkworm (*B. mori* L.). It was conducted in randomized block design with seven treatments and three replications using disease free layings of FC<sub>2</sub> X FC<sub>1</sub> bivoltine double hybrid silkworm. Mulberry variety V-1 is identified as a one of the best mulberry varieties in this area. One hundred silkworm larvae were reared in each replication under environmental conditions of 28°C, 85 per cent relative humidity in the rearing room. For defining different age groups of leaves mulberry branches were divided into three regions, namely top tender (high moisture 75-80%), middle medium (moisture content 65-75%), and bottom coarse leaves (low moisture 60-65%). The treatments included were T<sub>1</sub> with the larval feed of tender leaves, T<sub>2</sub> with the larval feed of medium leaves, T<sub>3</sub> with the larval feed of coarse leaves, T<sub>4</sub> with the larval feed of tender +

medium leaves, T<sub>5</sub> with the larval feed of medium + coarse leaves, T<sub>6</sub> with the larval feed of tender + coarse leaves, and T<sub>7</sub> is with the larval feed of tender + medium + coarse leaves.

The equipments which were used during rearing programme are listed below.

**Rearing trays:** The plastic trays having size 36" x 24" x 3" mainly used for keeping the silkworm larvae during rearing programme.

**Rearing stand:** The rearing stand made of the iron frames on which the rearing trays were placed.

**Chopping board:** The chopping board was made-up of soft wood of size 36.6" x 36.6" with thickness 3.0" and used for chopping the mulberry leaves during chawki rearing of silkworms.

**Chopping knife:** The chopping knife was an iron blade knife of 6" size with wooden handle used for chopping the mulberry leaves.

**Bamboo sticks:** The bamboo sticks were sticks about 8" long, thin in diameter and tapering at one end; they were used for giving space to the worms in rearing bed and picking the young stage larvae.

**Feather:** Clean white bird feather was used for brushing newly hatched worms and cleaning the beds in younger stages.

**Cleaning nets:** The cotton thread and nylon nets were used to clean the beds in different stages of worms.

**Collapsible plastic mountages:** The collapsible plastic mountages of size 2 x 0.95 sq m. were used to keep the ripe new worms for spinning the cocoons.

**Paraffin papers:** The paraffin papers were used to cover the bed from upper and lower side in order to maintain the required humidity in the rearing beds.

**Foam pads:** The foam pads were used for maintaining optimum humidity in the rearing beds.

**Rearing method:** The disease-free layings of the Double Hybrid silkworm (FC<sub>2</sub> X FC<sub>1</sub>) were kept for hatching in the laboratory. Upon hatching, the chawki (the neonate) worms were

brushed onto the rearing trays as per the treatments, each with three replications. The mulberry leaves as per the treatments were chopped and sprinkled over the worms. The size of the bed varies with the stage of the larva. The improved technology of silkworm rearing described by Krishnaswami [15] was followed in the present investigation. The quantity of food, spacing, and cleaning were done as per the stage of worms. The disinfectants used were formalin 2% solution, Bleaching Powder 0.3%, Lime Powder, and Vijetha Powder @ 4 kg/100 DFLs (1kg powder contains 100 gm vetcare vijetha powder and 900gms of lime powder). Based on the stage of the larvae, a predetermined uniform quantum of feed was provided to the larvae across the treatments. The chopped and whole mulberry leaves were fed to the chawki worms and mature larvae respectively, three times a day at 8.00 am, 2.00 pm, and 6.00 pm. The size of the chopped leaves was regulated according to the larval instar. During moulting periods, the worms were not fed with any food and they were not disturbed. After the completion of each moult, a bed disinfectant Vijetha @ 4 kg/100 DFLs was dusted as per recommendation for the prevention of diseases and feed was given after half an hour. After each moulting, bed cleaning was done by removing waste material from the tray with the help of cleaning nets. The quantity of food was increased as per the growth of the silkworm, which is uniform among all the treatments and replications. After the full development of the worms, they were released on mountages for spinning cocoons. Treatment-wise harvesting of cocoons was made on the fifth day of releasing worms on the mountages. Three lots of 10 cocoons from each treatment and replication were randomly selected and used for recording cocoon parameters. The first lot was used for recording cocoon weight. The second lot was used for determining the single filament length and the third lot was used to observe the emergence of moths and fecundity.

The maximum larval weight in grams was recorded by taking the weight of 10 matured larvae just before the onset of spinning, the cocoon weight was recorded on the 6<sup>th</sup> day of spinning when the cocoon weights are assumed to be maximum. The average of 10 cocoons was taken as single cocoon weight and expressed in grams. The cocoons were cut open at one end, and the shell weight was recorded after removing the pupae. The average of 10 shells was taken as single shell weight and expressed in grams.

The cocoon shell ratio was calculated using the formula: Cocoon shell weight / Cocoon weight X 100. Yield of cocoon/ 10,000 larvae brushed (kg) was calculated as: Randomly selected 100 cocoons were weighed and the cocoon yield per 10,000 larvae brushed was computed. The disease incidence was calculated as: Number of diseased larvae / Total number of larvae released X 100. The effective rate of rearing was calculated as: No. of cocoon harvested / No. of larvae released X 100. Ten cocoons were boiled in water and reeled for measurement of cocoon filament length, using a scale. The filament weight was recorded by taking the weight of randomly selected 10 reeled silk filaments, expressed in grams. The denier (density of fibres) was calculated using the formula: Filament weight (g) / Filament length (m) X 9000 [16].

### 3. RESULTS AND DISCUSSION

**Larval weight (g):** Table 1 data reveals that feeding with tender leaves (T<sub>1</sub>) resulted in the highest larval weight of 38.82 g, while coarse leaves (T<sub>3</sub>) led to the lowest larval weight of 21.47 g (Fig. 1). Rahmathulla et al. [17] documented that larvae fed tender leaves attained the highest larval weight of 13.42 g per ten larvae by the end of the 4<sup>th</sup> instar, compared

to 11.07 g for medium leaves, 10.24 g for coarse leaves, and 11.56 g for mixed feeding. By the end of the 5<sup>th</sup> instar, larvae fed tender leaves reached the highest larval weight of 65.65 g, whereas those fed medium leaves weighed 54.86 g, coarse leaves 47.93 g, and mixed feeding resulted in 56.97 g. Sarkar et al. [18] reported significantly higher larval weights for larvae fed tender leaves (50.02 g) compared to medium leaves (49.08 g), with over-mature leaves showing the lowest weight (45.16 g) for the N x NB<sub>4</sub>D<sub>2</sub> race. Kale et al. [16] observed that treatment T<sub>1</sub>, exclusively fed tender leaves, resulted in the highest larval weight recorded (38.28 g), while treatment T<sub>3</sub>, fed with coarse leaves only, showed the lowest weight (18.66 g). Furthermore, Sarkar et al. [1] noted that larvae fed tender shoots exhibited the highest larval weight (53.29 g), whereas those fed mixed shoots during late larval instar exhibited the lowest weight (48.78 g). Overall, the consistent findings across these studies underscore the significant influence of leaf maturity on the larval weight and development of *Bombyx mori* L. larvae. Tender leaves consistently support higher larval weights compared to middle and mature leaves, indicating their nutritional superiority for larval growth and development. These results highlight the importance of leaf quality in optimizing the economic traits of *Bombyx mori* L.

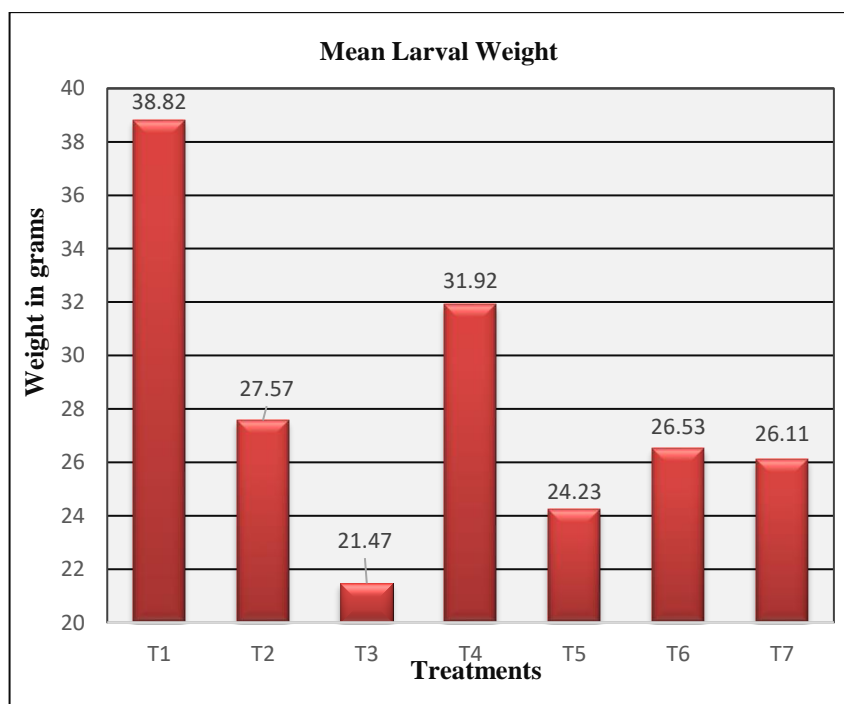


Fig. 1. Impact of leaf-age on larval weight of bivoltine silkworm (*Bombyx mori* L.)

**Table 1. Effect of feeding different maturity leaves of mulberry on the economic traits of bivoltine silkworm ( *Bombyx mori* L.)**

Treatment No.	Treatment details (Leaf age)	Larval weight (g)	Cocoon weight (g)	Shell weight (g)	Cocoon shell ratio (%)*	Cocoon yield (kg)	Mean filament length (m)	Mean Filament weight(g)	Mean denier	Mean disease incidence (%)*	Mean ERR (%)*
T <sub>1</sub>	Tender leaves	38.82	1.94	0.37	19.21 (25.98)*	18.68	922.33	0.28	2.76	1.30 (6.54)*	98.40 (82.73)*
T <sub>2</sub>	Medium leaves	27.57	1.63	0.30	18.65 (25.57)	16.04	853.33	0.23	2.46	2.40 (8.90)	97.33 (80.68)
T <sub>3</sub>	Coarse leaves	21.47	1.29	0.22	17.35 (24.59)	12.80	755.00	0.21	2.47	5.07 (13.00)	94.57 (76.59)
T <sub>4</sub>	Feeding with tender + medium leaves	31.92	1.81	0.32	17.85 (24.98)	17.81	883.33	0.25	2.54	1.67 (7.41)	98.07 (82.02)
T <sub>5</sub>	Feeding with medium + coarse leaves	24.23	1.43	0.26	18.18 (25.22)	14.95	821.67	0.21	2.34	3.57 (10.88)	96.27 (78.85)
T <sub>6</sub>	Feeding with tender + coarse leaves	26.53	1.57	0.28	18.26 (25.28)	15.37	844.00	0.22	2.31	2.57 (9.21)	97.27 (80.61)
T <sub>7</sub>	Feeding with tender +medium + coarse leaves	26.11	1.63	0.30	18.68 (25.59)	15.92	870.67	0.23	2.34	3.27 (10.41)	95.97 (78.54)
	S.E. ±	0.374	0.020	0.005	0.231	0.210	9.694	0.005	0.051	0.123	0.929
	C.D. at 5%	1.152	0.062	0.014	0.719	0.647	29.869	0.015	0.157	0.378	2.896
	C.V. (%)	2.30	2.15	2.69	1.58	2.28	1.98	3.60	3.58	2.247	2.013

\*figures in parentheses are angular transformed values

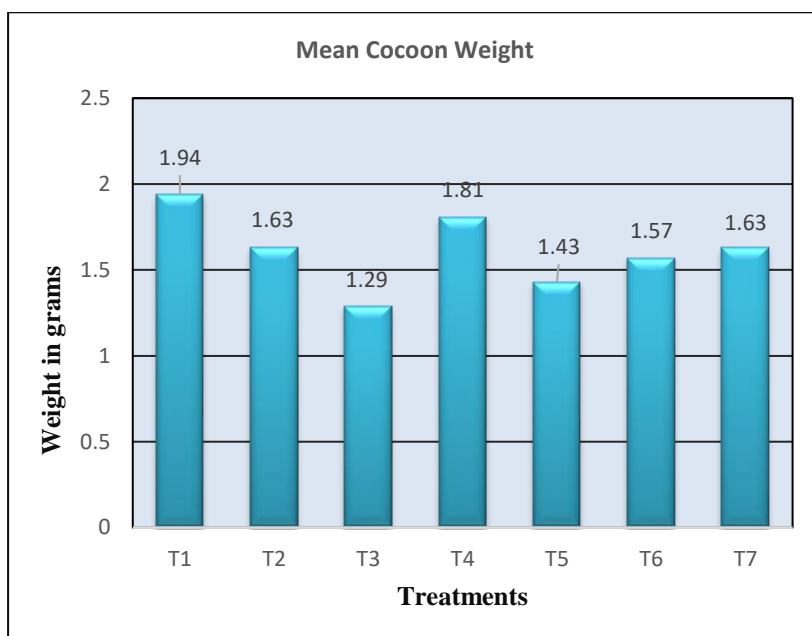


Fig. 2. Impact of leaf-age on single cocoon weight of bivoltine silkworm (*Bombyx mori* L.)

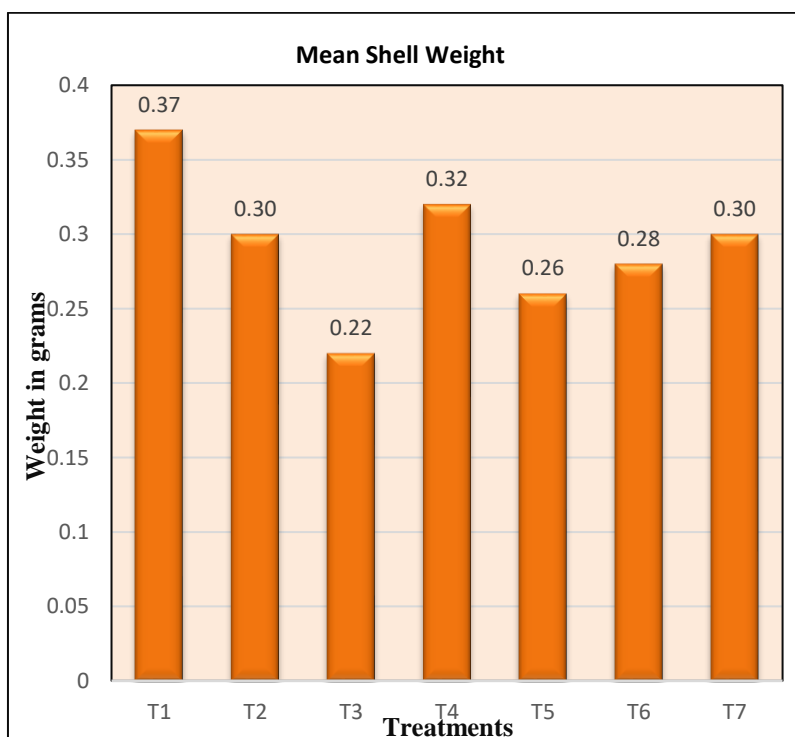


Fig. 3. Impact of leaf-age on shell weight of bivoltine silkworm (*Bombyx mori* L.)

**Cocoon weight (g):** Table 1 shows that larvae fed on tender leaves (T<sub>1</sub>) achieved the highest single cocoon weight of 1.94 g, whereas larvae fed on coarse leaves (T<sub>3</sub>) exhibited the lowest single cocoon weight of 1.29 g (Fig. 2). These findings are consistent with multiple previous studies. Krishnaprasad et al. [19] recorded a higher cocoon weight of 13.31 g per 10 cocoons

in silkworms fed tender leaves. Rahmathulla et al. [2] reported cocoon weights of 2.50 g for tender leaves, 2.11 g for medium leaves, and 1.84 g for coarse leaves. Sarkar et al. [18] found that larvae fed tender leaves including the apical bud had the highest cocoon weight (1.79 g), significantly higher than mature (1.54 g) and over-mature leaves (1.48 g) for the N x NB<sub>4</sub>D<sub>2</sub>

race. Adeduntan SA [20] observed the highest cocoon weight of 1.33 g in larvae fed tender leaves, followed by middle leaves (1.22 g), and base leaves (1.16 g). Kale et al. [16] also observed significantly higher single cocoon weight (1.90 g) in larvae fed tender leaves exclusively, compared to the lowest weight of 1.23 g in larvae fed coarse leaves. Krishnaswami [21] similarly reported that succulent mulberry leaves, especially from tender twigs, resulted in superior cocoon weight. Li and Sang (1984) investigated that cocoon weight of mulberry silkworms increased when larvae were fed tender leaves during their larval stage. Sarkar et al. [1] also noted the highest single cocoon weight (1.806 g) in larvae fed tender shoots during the late larval instar of the N x NB<sub>4</sub>D<sub>2</sub> race. Quraiza et al. [22] reported a maximum cocoon weight of 1120 ± 55.41 mg when *Bombyx mori* larvae were fed tender leaves.

These collective findings underscore the significant influence of leaf quality, particularly the tenderness of leaves, on enhancing cocoon weight in *Bombyx mori* L. larvae. Tender leaves consistently support higher cocoon weights compared to medium and coarse leaves, highlighting their nutritional superiority and the importance of leaf quality management in optimizing economic traits in sericulture.

**Shell weight (g):** Table 1 illustrates the influence of feeding different maturity leaves on the single shell weight of bivoltine silkworms. Larvae fed tender leaves (T<sub>1</sub>) exhibited the highest single shell weight at 0.37 g, whereas those fed coarse leaves (T<sub>3</sub>) showed the lowest at 0.22 g (Fig. 3). These findings are supported by previous studies. Krishnaprasad et al. [19] noted higher shell weights of 1.82 g per 10 cocoons in silkworms fed tender leaves, and Rahmathulla et al. [17] found a significant positive correlation between leaf moisture content and single shell weight, with larvae fed tender leaves achieving a peak shell weight of 0.36 g. However, Paramasiva et al. [23] reported the highest shell weight of 0.39 g with medium mature leaves, contrasting with Sarkar et al. [1], who recorded 0.32 g for larvae fed tender leaves. Kale et al. [16] observed significantly higher single shell weights of 0.36 g in larvae exclusively fed tender leaves. Similarly, Sarkar et al. [1] reported higher shell weights in larvae fed tender shoots throughout the 4th and 5th instars compared to those fed mature shoots without tender leaves. Quraiza et al. [22] highlighted a maximum shell weight of 200 ± 18.66 mg when *Bombyx mori*

larvae were fed tender leaves. These findings collectively underscore the significant impact of leaf maturity on single shell weight in *Bombyx mori* L. larvae, emphasizing the importance of optimizing leaf quality for enhanced economic traits in sericulture.

**Cocoon shell ratio (%):** Table 1 presents data on the cocoon shell ratio, ranging from 17.35% to 19.21%. The highest cocoon shell ratio of 19.21% was observed in treatment T<sub>1</sub>, where larvae were fed tender leaves, while the lowest ratio of 17.35% occurred in treatment T<sub>3</sub> with larvae fed coarse leaves (Fig. 4). These results align consistently with previous research findings. Rahmathulla et al. [2] demonstrated that tender leaves yielded a higher cocoon shell ratio of 26.82% compared to medium leaves (25.21%) and coarse leaves (23.39%). Elumalai et al. [24] also noted increases in the cocoon shell ratio with medium and coarse leaves, albeit not to the extent seen with tender leaves. Talebi et al. [25] emphasized the relationship between leaf moisture content and cocoon shell ratio, suggesting higher moisture levels enhance shell formation. Sarkar et al. [18] found a higher cocoon shell ratio of 18.25% in larvae fed tender leaves compared to other leaf types, and Kale et al. [16] reported significantly higher ratios (18.94%) in larvae fed exclusively tender leaves. Similarly, Sarkar et al. [1] observed a peak cocoon shell ratio of 18.34% in larvae fed tender shoots during late instar stages. Quraiza et al. [22] reported a maximum cocoon shell ratio of 17.85 ± 1.01% when *Bombyx mori* larvae were fed tender leaves. These findings collectively underscore the significant impact of leaf quality, particularly tenderness, on enhancing the cocoon shell ratio in *Bombyx mori* L. larvae, highlighting the importance of optimizing leaf quality for maximizing economic traits in sericulture.

**Cocoon yield (kg):** Table 1 presents data on cocoon yield per 10,000 larvae, showing that treatment T<sub>1</sub>, with larvae fed tender leaves, achieved the highest yield of 18.68 kg, whereas treatment T<sub>3</sub>, fed coarse leaves, had the lowest yield of 12.80 kg (Fig. 5). These findings are consistent with previous research. Rahmathulla et al. [2] reported a cocoon yield of 24.95 kg per 10,000 larvae for those fed tender leaves, which was higher compared to medium leaves (19.81 kg) and coarse leaves (17.05 kg). Kale et al. [16] reported significantly the highest cocoon yield (18.52kg) was obtained in treatment T<sub>1</sub> i.e. feeding the tender leaves only. The significantly lowest cocoon yield (12.39 kg) was obtained by

treatment T<sub>3</sub> i.e. larvae fed on coarse leaves only. Sarkar et al. (2012) observed a cocoon yield of 55.72 kg when silkworms were fed tender leaves, while larvae fed over-mature leaves yielded 39.91 kg for the N x NB<sub>4</sub>D<sub>2</sub> race. Similarly, Sarkar et al. [1] reported the highest cocoon yield of 57.09 kg with tender leaves for

the same race. These findings underscore the significant impact of leaf quality, particularly tender leaves, on maximizing cocoon yield in *Bombyx mori* L. larvae. Optimizing feeding practices with tender leaves can enhance economic outcomes in sericulture by maximizing cocoon production.

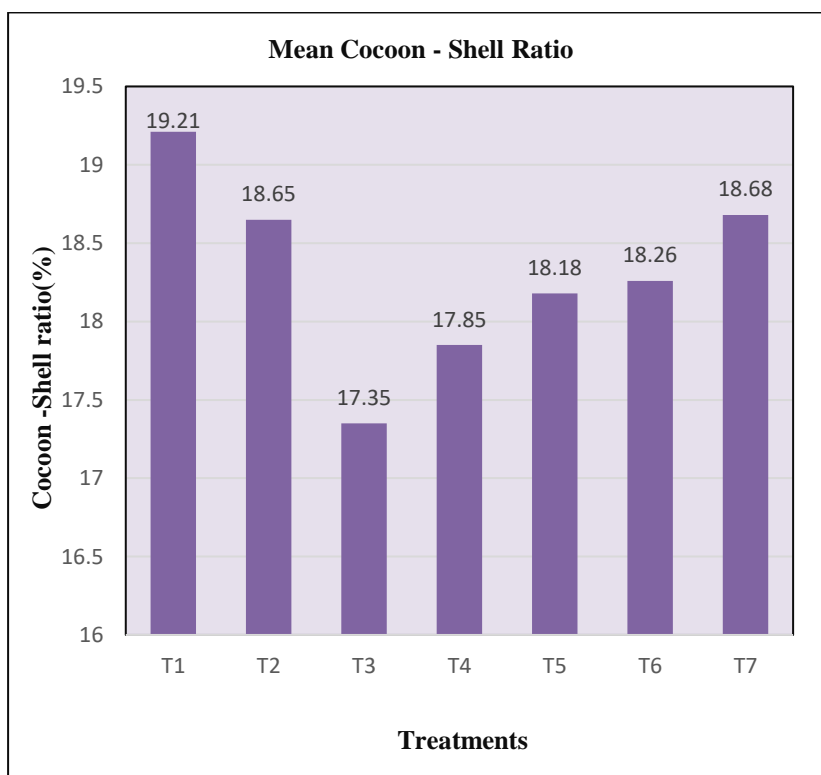


Fig. 4. Impact of leaf-age on cocoon shell ratio of bivoltine silkworm (*Bombyx mori* L.).

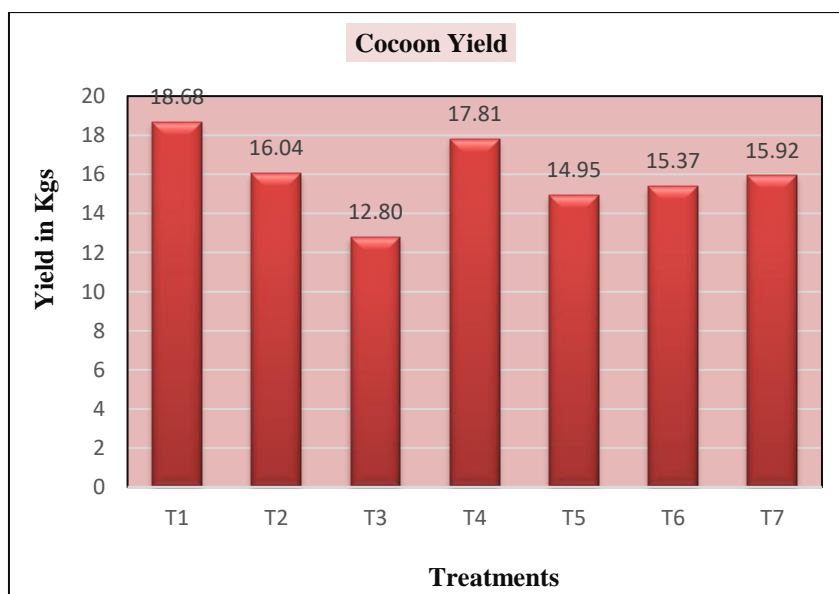


Fig. 5. Impact of leaf-age on cocoon yield per 10,000 larvae of bivoltine silkworm (*Bombyx mori* L.)



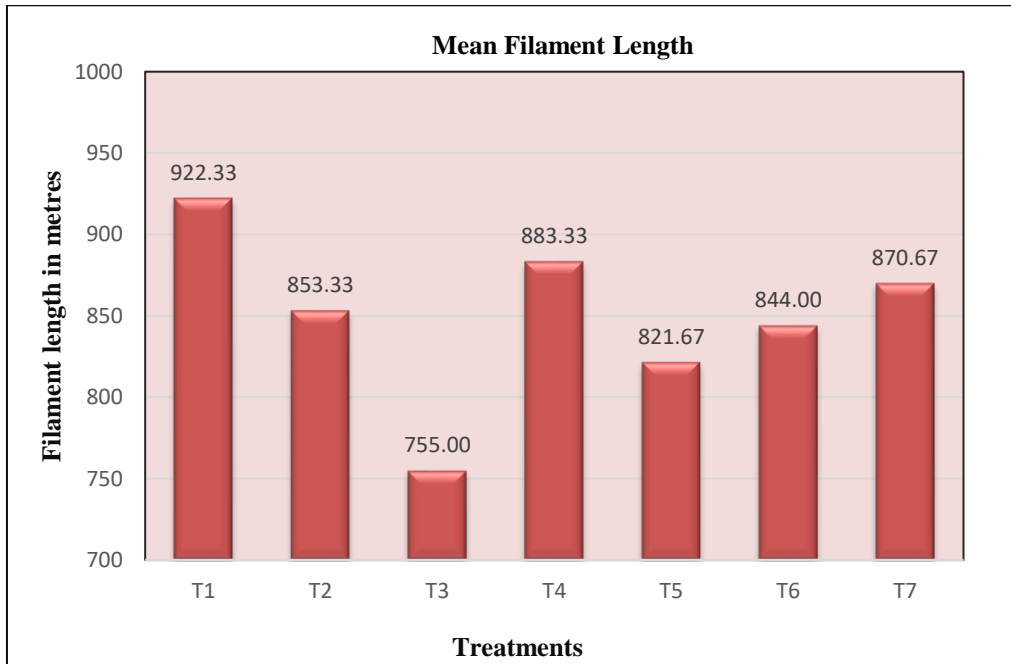


Fig. 6. Impact of leaf-age on filament length of bivoltine silkworm (*Bombyx mori* L.)

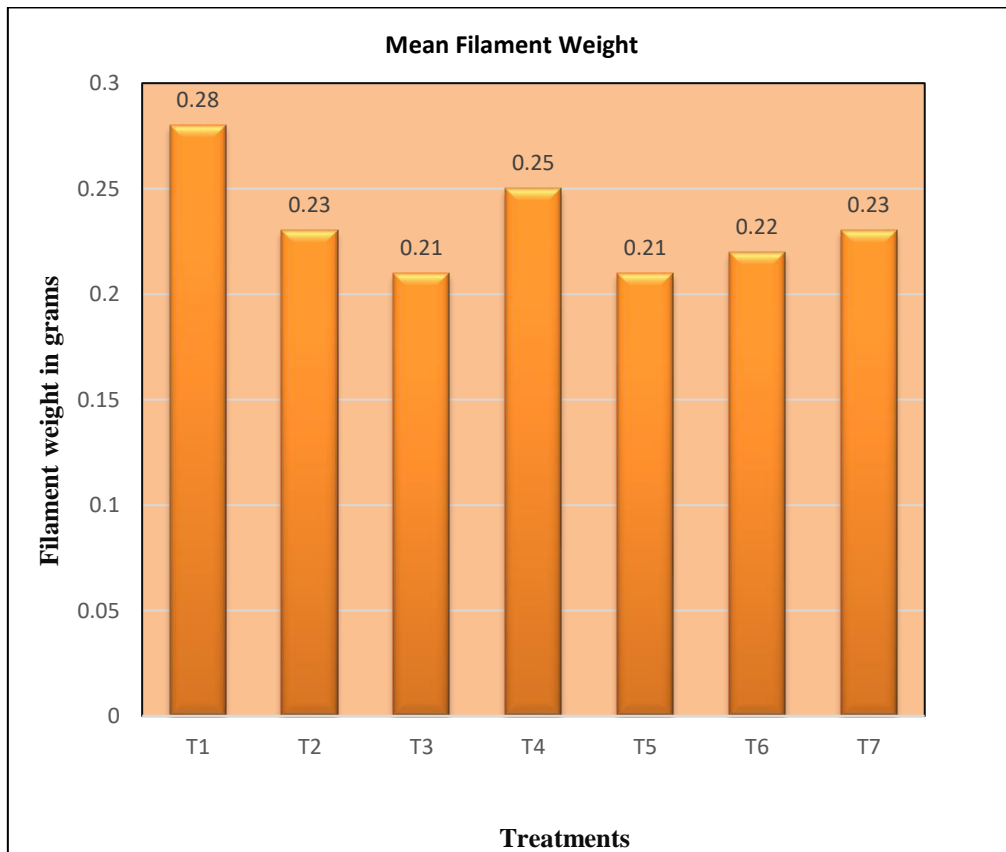


Fig. 7. Impact of leaf-age on filament weight of bivoltine silkworm (*Bombyx mori* L.)

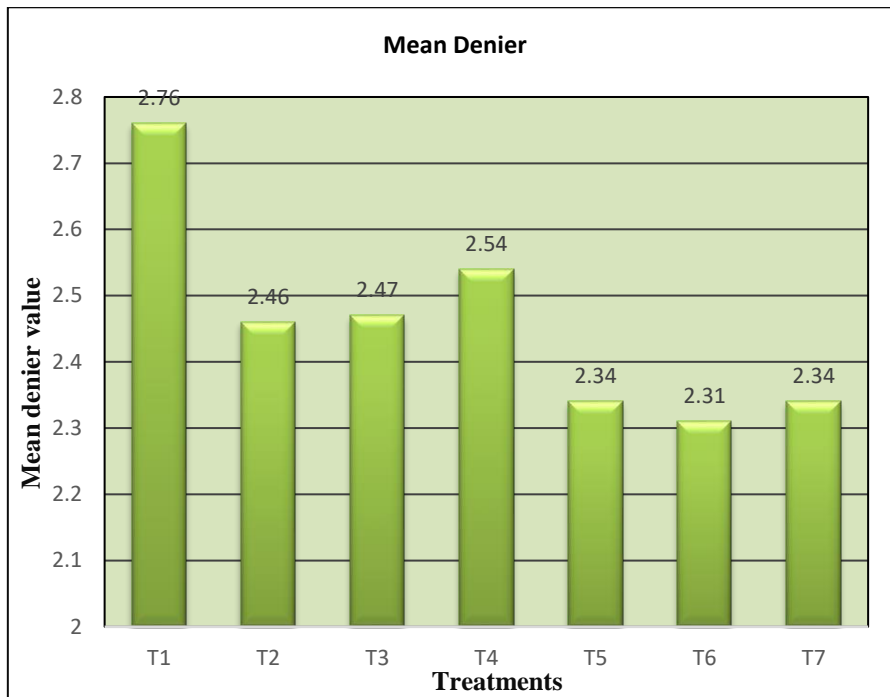


Fig. 8. Impact of leaf-age on denier of bivoltine silkworm (*Bombyx mori* L.)

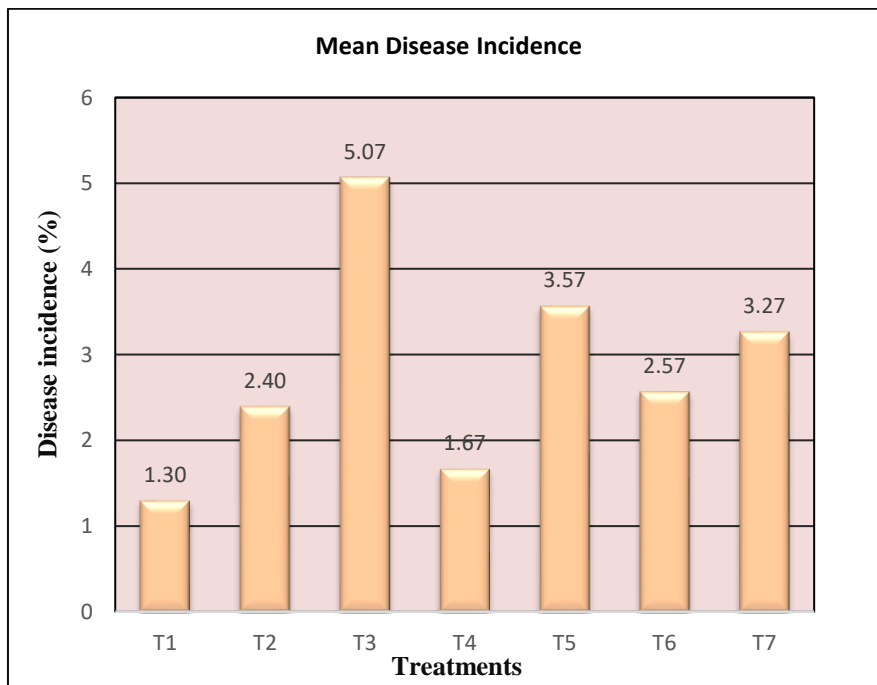


Fig. 9. Impact of leaf-age on disease incidence of bivoltine silkworm (*Bombyx mori* L.).

**Mean filament length (m):** Table 1 reveals that larvae fed tender leaves (T<sub>1</sub>) produced the longest filaments, measuring 922.33 meters, whereas those fed coarse leaves (T<sub>3</sub>) yielded the shortest filaments at 755 meters (Fig. 6). These results are consistent with prior studies indicating that tender leaves promote longer filament

lengths. Rahmathulla et al. [2] found that larvae fed tender leaves attained an average filament length of 1467 meters, surpassing medium leaves (1256 meters) and coarse leaves (946 meters), with moisture content in tender leaves correlating positively with filament length. Similarly, Sarkar et al. (2012) reported the

longest average filament length of 748.83 meters in larvae fed tender leaves compared to medium leaves (688.52 meters) and mature leaves (550.76 meters). Kale et al. [16] also observed longer filaments (898 meters) in larvae fed tender leaves. Sarkar et al. [1] confirmed these findings, noting that tender shoot feeding throughout the fourth and fifth instar stages resulted in an average filament length of 774.27 meters. These findings collectively emphasize the critical role of leaf quality, specifically tenderness and moisture content, in maximizing filament length and thus enhancing silk quality and economic outcomes in *Bombyx mori* L. larvae for sericulture.

**Mean filament weight (g):** The data presented in Table 1 reveal that silkworms fed on tender leaves (T<sub>1</sub>) had the highest filament weight, measuring 0.28 g. In contrast, silkworms fed on coarse leaves (T<sub>3</sub>) exhibited the lowest filament weight at 0.21 g. (Fig. 7). These findings align with previous research. Rahmathulla et al. [17] reported the highest filament weight of 0.472 g when larvae were fed tender leaves, compared to 0.385 g for medium leaves and 0.340 g for coarse leaves. Similarly, Kale et al. [16] observed that tender leaf feeding resulted in the highest filament weight of 0.254 g, while medium and coarse leaves resulted in

lower filament weights of 0.217 g and 0.198 g, respectively. The current study's results are consistent with these earlier observations, confirming that tender leaves lead to the highest filament weights in silkworms, while coarse leaves and mixed leaf diets result in lower filament weights.

**Denier:** The data in Table 1 show that the highest denier value (2.76) was observed in treatment T<sub>1</sub>, where silkworms were fed on tender leaves. Rahmathulla et al. (2003) reported the highest denier value of 2.91 for silkworms fed on tender leaves, compared to 2.76 for medium leaves and 2.82 for coarse leaves. Sarkar et al. [1] reported the highest denier value of 2.11 for silkworms fed tender leaves, compared to 2.08 for medium leaves and 2.02 for mature leaves. Similarly, Kale et al. [16] observed a significantly higher denier value of 2.55 in larvae fed tender leaves. Sarkar et al. [18] also noted a higher denier value of 2.16 in silkworms fed tender shoots during the late larval instar. The current study's findings are consistent with these earlier observations, indicating that feeding silkworms tender leaves results in the highest denier values, while a combination of tender and coarse leaves or coarse leaves alone results in lower denier values.

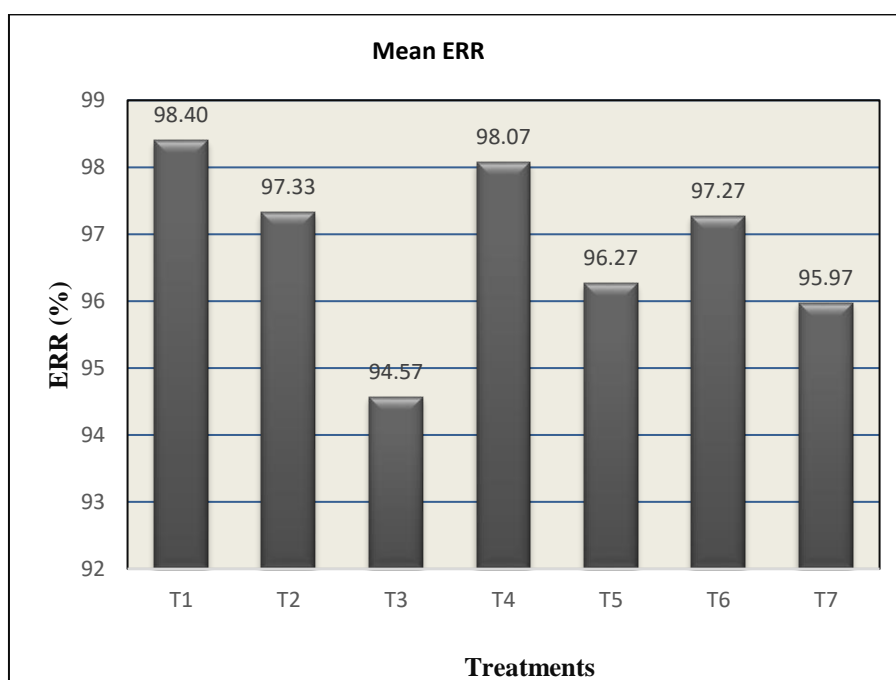


Fig. 10. Impact of leaf-age on ERR of bivoltine silkworm (*Bombyx mori* L.)

**Disease incidence (%):** Table 1 presents data on disease incidence of flacherie among *Bombyx mori* L. larvae, highlighting that treatment T<sub>1</sub>, with larvae fed tender leaves, exhibited the significantly lowest incidence at 1.30%. Conversely, treatment T<sub>3</sub>, fed with coarse leaves, showed the highest incidence at 5.07%, indicating a greater susceptibility to disease incidence (Fig. 9). These findings are consistent with previous research demonstrating the impact of leaf maturity on disease susceptibility. Hu Shi Ye et al. [26] observed higher occurrence, disease, and mortality rates in silkworms fed old mulberry leaves compared to those fed leaves of appropriate maturity, with occurrence rates 1.85 times higher, disease rates 2.08 times higher, and mortality rates 1.81 times higher. Kale et al. [16] similarly reported lower disease incidences in larvae fed tender leaves compared to medium and coarse leaves. However, Sarkar et al. [1] suggested no significant relationship between feeding tender leaves and the occurrence of grasserie disease in silkworms during dry summers, contradicting earlier observations by Sivaprakasam [27], Basarajappa and Savanurmth [28], and Elumalai et al. [24]. These findings underscore the importance of leaf quality in disease management strategies for optimizing silk production in sericulture, highlighting tender leaves as beneficial for reducing disease incidence and promoting healthier larval development.

**Effective rate of rearing (%):** Table 1 presents data on the Effective Rate of Rearing (ERR) in *Bombyx mori* L. larvae, showing that treatment T<sub>1</sub>, where larvae were fed tender leaves, achieved the highest ERR at 98.40%. This was at par with treatments T<sub>2</sub> (97.33%), T<sub>4</sub> (98.07%), and T<sub>6</sub> (97.27%) (Fig. 10). In contrast, treatment T<sub>3</sub>, fed with coarse leaves, exhibited the lowest ERR at 94.57%. These results are consistent with previous research indicating the influence of leaf quality on ERR. Rahmathulla et al. [2] reported a significantly higher ERR of 98.49% in silkworms fed tender leaves compared to those fed medium (91.14%) and coarse leaves (92.19%). Similarly, Sarkar et al. [18] found that ERR was highest in batches fed tender leaves (8276.33) for the N x NB<sub>4</sub>D<sub>2</sub> race, contrasting with significantly lower ERRs in batches fed mature (7774.86) and over-mature leaves (7617.16). Sarkar et al. [1] further supported these findings, reporting the highest ERR of 8347 in silkworms fed tender shoots throughout the 4<sup>th</sup> and 5<sup>th</sup> instar stages, while the lowest ERR of 7789 was recorded in those fed mature shoots

without tender leaves throughout the same stages. These findings underscore the critical role of leaf tenderness and quality in maximizing ERR and optimizing sericulture outcomes, emphasizing the importance of selecting suitable leaves to enhance productivity and economic viability in silk production.

#### 4. CONCLUSION

Based on the study's findings regarding the influence of mulberry leaf maturity on bivoltine double hybrid silkworms FC<sub>2</sub> X FC<sub>1</sub>, it is evident that feeding tender mulberry leaves, specifically variety V-1, accelerates silkworm growth, reducing both larval and pupal durations while significantly improving economic traits such as larval weights, cocoon weights, shell weights, cocoon shell ratios, cocoon yields, filament lengths, filament weights, denier values, and effective rates of rearing compared to coarse leaf-fed larvae. These findings underscore the nutritional superiority of tender leaves, attributed to their higher moisture content and nutrient profile, which optimize silk production outcomes. The study recommends prioritizing the cultivation and management of tender and succulent mulberry leaves through frequent irrigation to sustainably enhance sericulture productivity and profitability. Efforts towards leaf quality management are crucial for advancing sustainable practices in the silk industry, ensuring efficient resource utilization and economic viability. Further research could explore additional factors influencing silk production and evaluate the scalability of these findings across diverse sericulture environments.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have been used during writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

#### Details of the AI usage are given below:

1. The AI tool Chat GPT was used in this manuscript to rephrase the sentences and no artificial data was generated using the AI tool.

#### COMPETING INTERESTS

The authors have declared that no competing interests exist.

## REFERENCES

- Sarkar K. Studies on the effect of different types of feeding on the commercial characters of mulberry silkworm (*Bombyx mori*) in West Bengal: A review. *Int J Agric Environ Biotechnol.* 2020;13(3):305-21.
- Rahmathulla VK, Tilak Raj, Himanthraj MT, Vindya GS, Geetha Devi RG. Effect of feeding different maturity leaves and intermixing of leaves on commercial characters of hybrid silkworm (*Bombyx mori* L.). *Int J Ind Entomol.* 2003;6(1):15-19.
- Benchamin KV, Jolly MS. Principles of silkworm rearing. In: Mahalingam S, editor. *Proceedings of Seminar on Problems and Prospects of Sericulture.* 1986.63-108. Vellore, India.
- Rangaswami S, Narasimhanna MN, Kasiviswanathan K, Sastry CR, Jolly MS. *Sericulture manual-1 mulberry cultivation.* FAO Agric Serv Bull. 1976;15/1:150.
- Sinha AK, Srivastava PP, Brahmachari BN. Variation of chemical constituents in relation to maturity levels in mulberry varieties S1 and K2 under the agro-climatic conditions of Ranchi District. *Indian J Seric.* 1993;32(2):196-200.
- Bongale UD, Chaluvachari M, Malikarjunappa RS, Narahari BV, Anantharaman MN, Dandin SB. Leaf nutritive quality associated with maturity levels in fourteen important varieties of mulberry (*Morus* spp.). *Sericologia.* 1997;37(1):71-81.
- Trivedi S, Sarkar K, Bhattacharya DK, Chattopadhyay SK, Ghoshal S. Study of pubescence in different maturity levels of leaves in different mulberry varieties. *J Environ Sociobiol.* 2008;5(1):49-53.
- Narayanan ES, Kasivishanathan K, Iyengar MNS. Preliminary observations on the effect of feeding leaves of varying maturity on the larval development and cocoon characters of *Bombyx mori*. *Indian J Seric.* 1967;1:109-13.
- Krishnaswami S, Ahsan MM, Sriharan TP. Studies on quality of mulberry leaves and silkworm cocoon production, Part-2. Quality difference due to maturity. *Indian J Seric.* 1970;9:11-17.
- Vage MN, Ashoka J. Effect of tender shoot feeding on silkworm technological parameters of *Bombyx mori* L. *Sericologia.* 2000;40:79-89.
- Nagaraju J. Application of genetic principles in improving silk production. *Curr Sci.* 2002;83:409–15.
- Matsumara S, Tanaka S, Kosaka, Suzuki S. Relation of rearing condition to the ingestion and digestion of mulberry leaves in the silkworm, *Sanshi*. *Shikenjo Hokokou Tech Bull.* 1958;73:1-40.
- Fukuda T, Sudo M, Matuda M, Hayashi T, Kurose T, Horiuchi MF. Formation of silk protein during the growth of the silkworm larvae, *Bombyx mori* L. In: *Proceedings of the 4th Instar Cong Biochemistry.* 1959;12: 90-112.
- Rajan RK, Himantharaj MT. A text book on silkworm rearing technology. Central Silk Board; 2005.
- Krishnaswami S. New technology of silkworm rearing. Bull No. 2, CSRTI, Mysore, India. 1978;4-5.
- Kale AD, Nalwandikar PK, Bhamare VK, Badgire BB. Effect of different maturity leaves of V-1 mulberry variety on life-cycle and economic traits of silkworm (*Bombyx mori* L.). *Trends Biosci.* 2017;10(23):4613-17.
- Rahmathulla VK, Tilak R, Rajan RK. Influence of moisture content of mulberry leaf on growth and silk production in *Bombyx mori* L. *Caspian J Environ Sci.* 2006;4(1):25-30.
- Sarkar K, Bhattacharya DK, Chattopadhyay SK, Baur G, Ray SK. Effect of feeding of different maturity level of mulberry leaves on the commercial characteristics of *Bombyx mori* L. during late larval stage in dry summer. In: *Proceedings of the UGC Sponsored State Level Seminar on "Advancement of Biological Science Towards Sustainable Development"*. 2012. 129-41.
- Krishnaprasad NK, Sannappa B, Dharma Naik BC. Effect of feeding mulberry leaves of variable maturity on cocoon traits of *Bombyx mori* L. *J Environ Ecol.* 2003;21(1):112-16.
- Adeduntan SA. Nutritive effect of leaf position of mulberry plant *Morus alba* on silkworm *Bombyx mori* L. performance. *Adv Life Sci.* 2013;3(2):23-27.
- Krishnaswami S. Silkworm feeding trials for evaluating the quality of mulberry leaves as influenced by variety, spacing and nitrogen fertilization. *Indian J Seric.* 1971;19(1):79-89.

22. Quraiza MT, Selin CD, Raja VKS. Studies on the impact of tender, middle and mature leaves on the mandible size and economic traits of *Bombyx mori* L. Annals RSCB. 2021;25(4):10212-17.  
Available: <http://annalsofscb.ro>
23. Paramasiva I, Rajendra P, Prasad, Eswara Reddy NP. Effect of leaf maturity and shade drying time on cocoon parameters of *Bombyx mori* larvae infected with bacterial flacherie. J Res SKUAST-J. 2006; 5(1):71-77.
24. Elumalai K, Ekambaram E, Rajalakshmi S, Sundaram D, Raja N, Jaykumar M, Jeyasankar A. Influence of age of mulberry (*Morus alba*) leaves on economic traits of silkworm, *Bombyx mori* L. Uttar Pradesh J Zool. 2001;21:159-61.
25. Talebi MR, Bahreini, Tajabadi N. Effect of mulberry leaves moisture on some traits of silkworm. Sericologia. 2002;42(2):1-5.
26. Hu Shi Ye, Zhang Anchen, Li Kai Lin, Wang Wen Xue, Luo Chao. Effect of leaf maturity degree on vital energies and F1 egg quality of Dongting silkworm. J Guizhou Agric Sci. 2009;11:139-41.
27. Sivaprakasam N, Jayrani S, Rabindra RJ. Influence of certain physical factors on the grasserie disease of silkworm, *Bombyx mori* L. Indian J Seric. 1996;35(1):69-70.
28. Basarajappa S, Savanurmamath CJ. Effect of feeding of mulberry (*Morus alba* L.) leaves of variable maturity on the economic characters in some breeds of silkworm, *Bombyx mori* L. Bull Seri Res. 1997;8: 13-17.

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the publisher and/or the editor(s). This publisher and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

© Copyright (2024): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:  
The peer review history for this paper can be accessed here:  
<https://www.sdiarticle5.com/review-history/120833>