

Impact of vermiwash on G4 mulberry leaves in some post cocoon parameters of on silkworm *Bombyx mori* L

Ravikiran KM^{1*}, Simi Simon¹, Roopa KB², Asiya Nuzhat FB¹

¹ Department of Studies and Research in Zoology, Tumkur University, Tumakuru, Karnataka, India

² Department of Biotechnology, Siddaganga Institute of Technology, Tumakuru, Karnataka, India

Abstract

Silkworm *Bombyx mori* L. is a monophagous creature mainly feed on mulberry leaves obtained all the nutrients from the mulberry leaves, diet plays a vital role in sericulture enlightening the economic traits. Another way for the enhancement of growth and development of silkworm is adding additional supplementary nutrients with mulberry leaves. The present experiment was under taken to know the influence of the supplementation of vermiwash on post cocoon parameters in Bivoltine double hybrid (FC1XFC2) during experiment G4 mulberry leaves was used. Treating of G4 mulberry leaves vermiwash for cocoon parameters analysed are cocoon weight, shell weight, shell ratio, pupa weight, silk filament length, silk filament weight, denier, silk productivity, renditta, sericin and fibrin content. The One-way ANOVA describe among the treated groups 100% vermiwash recorded maximum cocoon parameters, cocoon weight is (9.77gm), shell weight (3.16gm), shell ratio (21.6%), pupa weight (8.13gm), silk filament length (1253.15mtr), silk filament weight (0.45gm), Denier (3.00d), silk productivity (7.5cg/day), renditta (6.00gm), sericin (0.71gm) and fibrin (0.65gm). The study specified that there is insightful increase due to treatment of vermiwash on cocoon characters than the control which improved the quality of silk production.

Keywords: *Bombyx mori* L., vermiwash, G4 mulberry, cocoon parameters, one-way ANOVA

Introduction

Sericulture in India is land based practice; labour oriented and suit to rural peoples with high employment and economic benefit. India clamps the second largest creator of silk and also the largest user of silk in the world [13]. The mulberry silkworm is a monophagous insect which feed only on the mulberry leaves for growth and development. Success in the sericulture mainly depends on quality and quantity of the mulberry leaves, genetic traits of silkworm race and best rearing technology. Mulberry leaves quality impact on the advance and improvement of silkworm as well as cocoon production and quality of raw silk generated [16]. Silkworms are reared for their cocoons from which the pure silk is obtained. Commercial parameter plays a crucial role in silkworm production because they directly impact on they profitability and efficiency of sericulture operations [26]. Mulberry leaves as the main feed of silkworms which directly influences the amount of feed consumption and subsequently affects the growth, production and quality of cocoon [14]. Lack in the quality of nutrition in mulberry leaves caused a negative impact on cocoon production. One of the substitute way for the improvement of enrichment in nutrition of mulberry leaves with the fortification of additional nutrients is fundamental condition for improvement of *Bombyx mori* growth and development, hence its suitable the commercial profit [14, 8, 27]. The superiority of mulberry leaf depends on many aspects such as leaf moisture, protein, carbohydrates, amino acid, nitrogen, chlorophyll [9]. Previous studies have been made by many researchers with supplementation of nutrients such as protein carbohydrates, vitamins and amino acids to get good quality cocoons [24]. Recent studies have made on fortify mulberry leaves with botanical extracts to increase the mulberry leaf quality and feed competence of silkworm, which in turn benefits to increase cocoon production and silk excellence [15]. Impact of probiotic (*Lacto bacillus*, *S.*

cervisiae and effective microorganism) treatments on mulberry leaves to improve the economic parameters of fifth instar larvae *B.mori*. Vermiwash is the liquid extract from vermicompost produced in the presence of many earthworms and contains several micro and macro nutrients which improve the growth and productivity of crops [10]. The research on effect of vermiwash fortification with mulberry leaves with is tiniest. So, the present study aim to determine the effect of vermiwash fortified with mulberry leaves on some post cocoon parameters.

Materials and method

Silkworm Strain: In the present analysis 1st instar larvae of Bivoltine double hybrid (FC1× FC2) silkworm strain were collected from Beldhara chawki rearing centre, Tumakuru. Silkworms were reared in research laboratory, DOSR in Zoology, Tumkur University, Tumakuru.

Silkworm rearing: Silkworms were reared at room temperature (RT) 26±2°C and relative humidity (RH) 75±2% The larvae were reared by using standard protocol [11].

Preparation of vermiwash: Vermiwash of earthworm (*Eudrilus eugeniae*) was collected from Durgadahalli, Tumakuru, and various concentrations of vermiwash were prepared by distilled water.

Experimental Group: After 3rd moult IV instar larvae were divided in to five experimental groups, each groups consists of 30 larvae (T₀) Control, (T₁) 25% (T₂) 50% (T₃) 75% (T₄) 100% Fresh G4 mulberry leaves were dipped in different concentrations of vermiwash for 20 minutes, later leaves were air dried for 10 minutes before feed to silkworm, (T₀) groups were feed with G4 leaves treated with distilled water (Two times per day 9:00am and 4:00pm) until silkworm start spinning.

Post cocoon parameters: Weight of Cocoon (g): Five cocoons were collected randomly from every experimental groups and weight of cocoon were recorded by digital balance.

Weight of Shell (g): Five cocoons were casually selected to know the weight of shell cocoons were cut open pupae and exuviae were removed, shell weight was recorded by using electronic balance. [32].

Shell ratio (%): The shell ratio was findout by using formula

$$\text{Shell ratio} = \frac{\text{Weight of Shell}}{\text{Weight of Cocoon}} \times 100$$

Pupa weight (g): Cocoon from five experimental groups was cut open by using sharp blade and pupae were collected and weight by using electronic balance.

Silk filament length: Cocoons of five experimental groups were collected deflossed by hand and cocoons were dipped in hot water bath at 90°C for 20 minutes, the length of silk filaments was recorded by using formula.

$$L = R \times 1.125$$

L= Filament Length in meter

R= Numbers of revolution of epprouvette

1.125= Epprouvette Circumference

Weight of Silk filament: Reeled silk filaments were kept in hot air oven at 60°C until dry and weight was obtained by digital balance.

Denier: It denotes the stiffness of silk filaments [1] and calculated by using formula.

$$\text{Denier} = \frac{\text{Silk filament Weight}}{\text{Silk filament Length}} \times 100$$

Silk productivity: Silk productivity was calculated by using formula.

$$SP = \frac{\text{Shell weight}}{\text{Larval duration of fifth instar (days)}} \times 100$$

Renditta: Number of cocoons required to produce 1kg of raw silk and calculated by using formula.

$$\text{Renditta} = \frac{\text{Weight of cocoon}}{\text{Weight of raw silk}} \times 100$$

Sericin = Primary weight of shell- Dry weight of the shell followed by alkali treatment

Fibrin = Dry weight of shell after alkali treatment - Sericin content

Statistical investigation: The data were examined by using One-way ANOVA for the Post cocoon parameter with Dunnett's multiple comparison test, by using graph pad prism 8.3.0. All the value are in Mean ±SD were expressive *P< 0.05, **P<0.01 and *** P<0.001.

Results

The silkworm *B.mori* is an economically valuable insect and mainly feed on mulberry leaves. The success in sericulture industry depends on the superiority of mulberry leaves plays a significant function on the nourishment of silkworm for good cocoon and silk production. The results in the present study shows that the use of vermiwash during silkworm rearing is one of the better options for the combined enhancement in economic traits of the silkworm *B. mori* healthy larvae were collected from each group to analyse the post cocoon parameters like Weight of cocoon, Weight of pupa, Weight of Shell, Shell ratio, length of silk filament, Weight of silk filament, Denier, Silk productivity, Renditta, Sericin content and Fibrin content.

Table 1: Effect of vermiwash on Cocoon parameters of silkworm *B.mori*

Economical parameters	T ₀	T ₁	T ₂	T ₃	T ₄
Cocoon Weight (g)	5.88±0.14	6.93±0.04*	8.66±0.22*	9.17±0.13**	9.77±0.38**
Shell Weight (g)	1.46±0.026	2.33±0.096**	2.64±0.132***	2.75±0.085***	3.16±0.103***
Shell Ratio (%)	18.95±0.031	20.57±0.085**	21.25±0.163**	21.35±0.115**	21.6±0.316**
Pupa weight (g)	4.81±0.061	5.40±0.051***	7.18±0.146**	7.50±0.131**	8.13±0.198**

T₀-Control, T₁-25%, T₂- 50%, T₃-75%, T₄- 100%

Weight of Cocoon: The study revealed that supplementation of vermiwash at different concentration on silkworm (FC1XFC2) exhibit significant difference. The data on Table-1 and Fig-1 shows that One-way ANOVA exhibit highly significant difference between silkworm treated with vermiwash at T₄ concentration recorded high value of cocoon weight 9.77±0.38gm (p<0.01) followed by 9.17±0.13gm (p<0.01), 8.66±0.22 (p<0.05), 6.93±0.04 (p<0.05) at concentration of T₃, T₂ and T₁ respectively the T₀ shows 5.88±0.44gm of cocoon weight.

Weight of Shell: Silkworms were fed with mulberry treated with difference concentration of vermiwash identified remarkable influence on weight of shell. The data present in Table-1 and Fig-1 shows significant increase in the shell weight comparing with control. It was observed that vermiwash at concentration of T₄, T₃, T₂ and T₁.The T₄

exhibit higher shell weight 3.16±0.10gm (p<0.001), followed by 2.75±0.08gm (p<0.001), 2.64±0.13gm (p<0.001) and 2.33±0.09gm (p<0.01) however in T₀ group it was found to be 1.46±0.026gm respectively.

Shell ratio: Data presented in Table-1 revealed that such shell weight, the result of shell ratio exhibit the same trend, the shell ratio increased significant by silkworm feed with mulberry leaves were enriched with vermiwash compared with control which shows any significant difference among different concentration as shown in Fig-1 shell ratio at concentration of T₄ found to be the higher 21.6±0.316% (p<0.01) and significantly decrease in the shell ratio followed by T₃, T₂, T₁ and T₀ was 21.35±0.11, (p<0.01) 21.25±0.16 (p<0.01), 20.57±0.08 (p<0.01), and 18.95± 0.03 respectively.

Pupa weight: The result obtained proved that silkworm feed with mulberry leaves enriched with vermiwash of all concentration have a progressive effect on pupa weight assessed with control. The maximum and significant pupae

weights were gained 8.13±0.69gm (p<0.01) at T₄ concentration of vermiwash followed by T₃ 7.50±0.13gm (p<0.01), T₂ 7.18±0.10gm (p<0.01), and T₁ 5.4±0.03gm (p<0.01) when compared with T₀ 4.81±0.06 respectively.

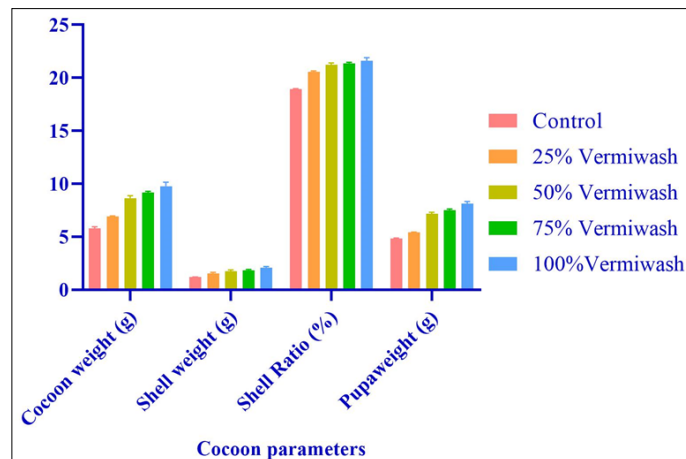


Fig 1: Effect of vermiwash on cocoon parameters of silkworm *B.mori*

Silk filament length: The length of silk filament of bivoltine double hybrid in present study has positive correlation with shell weight and shell ratio is an indication of improved in the filament length with the increased concentration of vermiwash fortified with different concentration on mulberry leaves fed with silkworm that data from Table-2 and Fig-2a. The higher filament lengths were recorded as 1253.15±4.59 (p<0.01) at T₄ concentration followed by 1166.51±3.91 (p<0.01) at T₃, 1153.57±4.4 (p<0.01) at T₂, 1147.57±3.12 (p<0.01) at T₁, 1038.15±1.01 in T₀.

Filament weight: The filament weight is the qualitative parameter of filament characters based on filament length, The data present in the Table-2 and Fig-2c the increase in the filament weight by 0.17±0.021, 0.26±0.025 ns, 0.32±0.21 (p<0.05), 0.37±0.026 (p<0.01) and 0.45±0.04

(p<0.01) with concentration of T₄, T₃, T₂, T₁ and T₀ respectively.

Denier: Denier is the qualitative of filament characters which indicates the thickness of silk filament. The data present in the Table-2 and Fig-2b show that the treated groups shows higher denier in T₄, 3.00d followed by 2.94d in T₃, 2.35d in T₂, 2.04d in T₁ and minimum denier was observed in the T₀ 1.58d respectively.

Silk Productivity (Cg/day): Silk productivity is also another filament character which indicates amount of centigram of silk produce per day, The data present in the Table-2 and Fig-2c showed that the treated groups shows higher silk productivity in T₄ 7.5±0.26 Cg/day (p<0.01), followed by T₃ 5.91±0.08 Cg/day (p<0.05), T₂ 5.66±0.13 Cg/day (p<0.05), in T₁ concentration does not show any significant in silk productivity 4.08±0.08 Cg/day ns, T₀ 2.85±0.39 Cg/day respectively.

Table 2: Effect of vermiwash on Cocoon parameters of silkworm *B.mori*

Economical parameters	T ₀	T ₁	T ₂	T ₃	T ₄
Silk Filament Length (m)	1038.15±4.01	1147.57±3.12**	1153.57±4.45**	1166.51±3.91**	1253.15±4.59**
Silk Filament Weight (g)	0.17±0.021	0.26±0.025 ns	0.32±0.021*	0.37±0.026*	0.45±0.049**
Denier (d)	1.58±0.018	2.04±0.004*	2.35±0.007**	2.94±0.009**	3.00±0.005***
Silk Productivity (Cg/day)	2.85±0.39	4.08±0.08 ns	5.66±0.13*	5.91±0.08*	7.5±0.26**
Renditta (g)	8.33±0.13	7.27±0.21*	6.37±0.10**	6.19±0.06**	6.00±0.10***
Sericin Content (g)	0.36±0.13	0.51±0.10**	0.66±0.03**	0.70±0.03***	0.71±0.01***
Fibrin Content (g)	0.43±0.027	0.45±0.052 ns	0.51±0.007*	0.52±0.007*	0.65±0.086***

Renditta: The data in Table-2 and Fig-2c represent the renditta of silkworm fed with mulberry fortified by vermiwash of all concentration have a positive effect on renditta. The lowest renditta was observed in T₄ vermiwash 6.00±0.10 (p<0.001) and increased in T₃ 6.11±0.10,(p<0.01) followed by 6.37±0.10 in T₂ (p<0.05), 7.27±0.21 in T₁ (p<0.05), and 8.32±0.13 in T₀ respectively.

Sericin: The data present in the Table-2 and Fig-2d show that the treated groups shows higher Sericin content in T₄ 0.71±0.01 gm (p<0.001), followed by T₃ 0.70±0.03gm

(p<0.05), T₂ 0.66±0.03gm (p<0.05), in T₁ concentration does not show any significant in sericin content 0.51±0.10gm ns, T₀0.36±0.13gm respectively.

Fibrin: The data in Table-2 and Fig-2d represent the fibrin of silkworm fed with mulberry fortified by vermiwash of all concentration have a positive effect on fibrin The highest fibrin was observed in T₄ vermiwash 0.65±0.10 gm (p<0.001), and decreased in T₃ 0.52±0.07gm (p<0.05) followed by 0.51±0.07gm in T₂, 0.45±0.05gm (p<0.05) in T₁, 0.43±0.027gm in T₀ respectively.

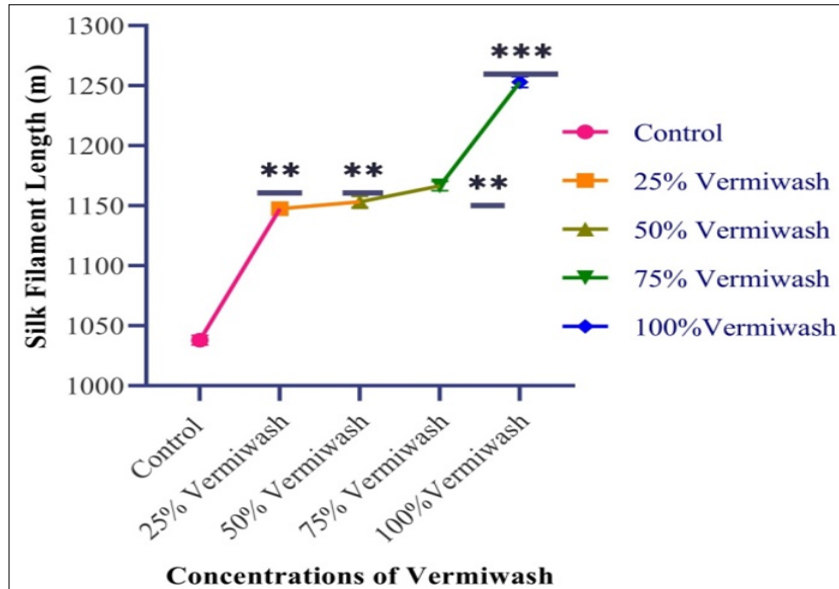


Fig 2a: Effect of vermiwash on Denier of silkworm *B.mori*

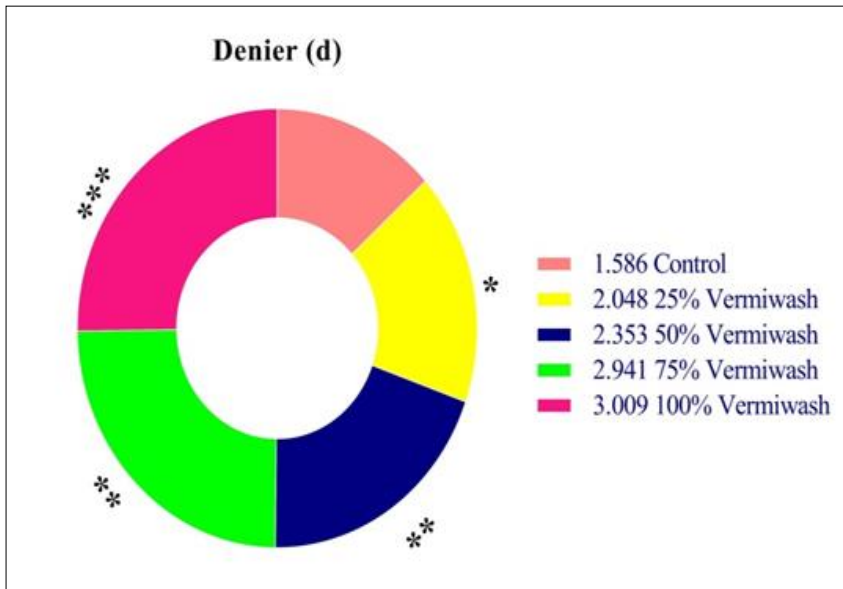


Fig 2b: Effect of vermiwash on Denier of silkworm *B.mori*

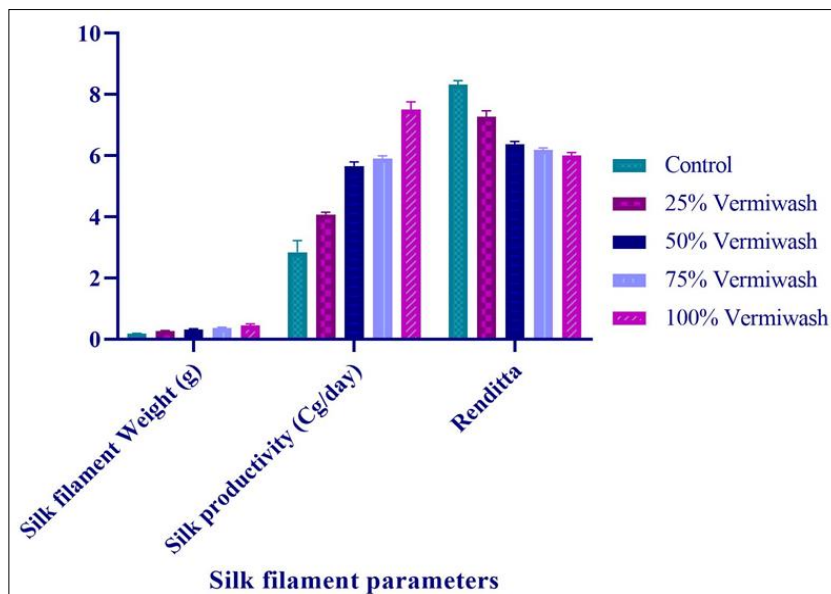


Fig 2c: Effect of vermiwash on Filament weight, Silk Productivity and Renditta of silkworm *B.mori*

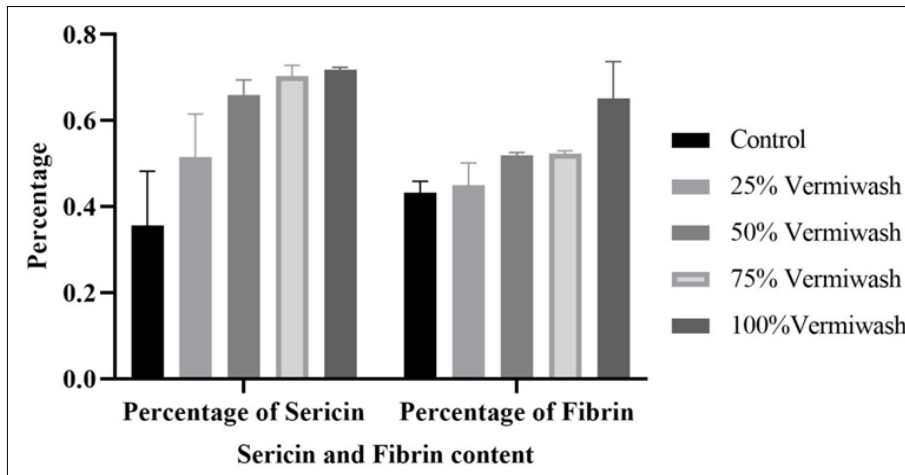


Fig 2d: Effect of vermiwash on Sericin and Fibrin of cocoon *B.mori*

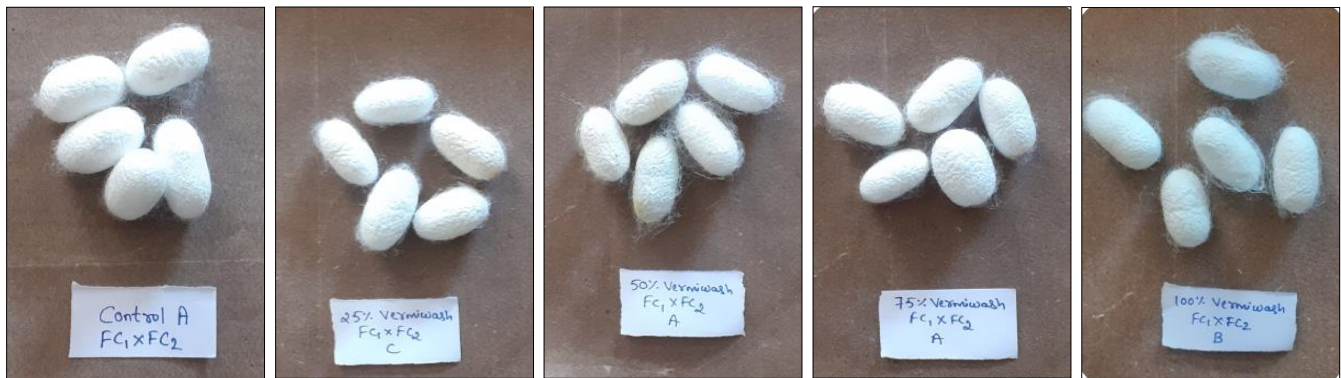


Plate 1: Effect of vermiwash on Cocoon of silkworm *B.mori*



Plate 2: Effect of vermiwash on Pupa of silkworm *B.mori*

Discussion

The life activity of silkworm is highly dependent on feed that has a harmony of nutrients to regulate metabolic process [14]. The attempt of rearing better quality hybrid silkworm races, conservation of eggs, bed cleaning, number of feeding to worm per day, type of leaves fed to worms, during different stages and caring during moutage for successful high silkworm yield [28]. Several supplementation of studies on different mulberry genotypes helps in improving the growth and cocoon parameters. In the present result were in conformity with earlier findings reported by [29] fortified mulberry leaves of gosherami supplemented with egg albumen recorded maximum silk filament length of 1252.36mtrs denier of 3.19d and raw silk percentage 19.92% in 20% of egg albumin. The present findings also shows confirmed by [19] oral feeding of folic acid during 5th instar silkworm expressively influences the weight of cocoon 1.92gm, weight of shell 0.4gm, shell ratio 25.52% of bivoltine hybrid of CSR2X CSR4 using V1 mulberry

variety. The impact of different plants powder mix supplementation on kanva-2 as cocoon weight 1.47gm, pupa weight 1.118gm, shell weight 0.356gm, shell ratio 2.44% [7]. Effect of vermiwash enriched with MR2 mulberry variety on mulberry silkworm the cocoon weight was 1.374gm with 50% vermiwash the pupa weight was 1.059gm and shell weight was 0.315gm was observed by [18]. Supplementation of amino acid to Chinese Japanese hybrid silkworm with shin ichinise variety of mulberry have cocoon weight of 1.24gm at 0.2%, pupa weight 0.945gm, shell weight 0.296gm and shell ratio 23.81% in male where as in female the cocoon weight 1.514gm, weight of pupae 1.219gm, weight of shell 0.302gm and shell ratio 20.24% [22]. Silkworm of PM X NB4D2 variety supplemented with corticosterone effective increase in the weight of cocoon, weight of shell, shell ratio, silk filament length, denier, renditta, fibroin, sericin, [21]. According to [3] effect of some medicine plant *S.media* and *P. ovate* extracts on economic parameters like weight of cocoon, weight of shell and shell

ratio. ^[30] As feed supplement of honey as protein source to FC₁×FC₂ were found to be effective in increase in weight of cocoon, weight of shell, shell ratio and silk filament length. According to ^[1] application of coconut water as supplement for improvement of economic as well as feasibility wise. Similar result were obtained by ^[12] who reported that feeding the silkworm with fungicide of cocoon weight was (11.80gm), pupa weight (8.6gm), shell weight (3.15gm) and shell ratio was 26.69%. ^[23] Reported that *S.gallinarum* and *S.arlettae* significantly promoted on in cocoon characters. ^[5] Reported that commercial charters of the silkworm such as cocoon charters. Weight of cocoon, weight of shell, shell ratio, silk filament length, denier, reelability were boosted by *S. cerevisiae* the mean cocoon weight on KG race and CSR2 races of silkworm fed with mulberry variety supplemented with vermiwash 1.652gm and 1.706gm and silkfilament length was KG race was 185.2mtrs CSR2 races was 926mtrs. ^[17]. According to ^[20] treating of the mulberry leave with aqueous mixture of aloe herbal formulation and feeding them to the fifth instar larvae of silkworm (PM XCSR2) *B.mori*(L.) resulted in elicitation better answer of growth and cocoon yield ^[6] deduce the influence of different mulberry varieties and rearing seasons on growth and cocoon traits of *B mori* fed with S1 mulberry varieties, Azolla has proteinaceous source can enhance the cocoon and shell weight ^[31, 25] The current investigation emphases on the fortified supplement of vermiwash enhance the cocoon parameter helps in the economic improvement in sericulture industry.

Conclusion

Diet is the important factors that affect the progress and development of silkworm. Additional supplementary products to mulberry leaves by fortification increase the post cocoon characteristic. It is clearly evident after the observation of present study that additional of various concentrations of vermiwash, significantly promotes the growth of silkworm which reflects on quantitative and qualitative improvement in coon parameters based on above study it can be conclude that the use and application of vermiwash as supplement show superior performance in economic traits.

Acknowledgements

The authors are grateful to Karnataka Science and Technology promotion Society (KSTePS), for offering funding support through the DST-Ph.D., scholarship program (Order No. DST/KSTePS/Ph.D., Fellowship/LIF16:2022-23/1240 Dated 27-Jan-2023). We Thank Nagaraju for providing the seed of silkworm FC₁×FC₂ strain. We also thank Dr. Gowrishankar, Department of Biotechnology, Siddaganga Institute of Technology, Tumkur, Karnataka, for allowing us to use his laboratory facilities for carrying out experiments.

Authors Contribution

Ravikiran, K.M and Simi Simon performed the experiments and wrote the manuscript. Roopa, K.B. Framed research proposal and draft corrections. Asiya Nuzhat, F.B. conceptualization and manuscript correction.

Conflict of interest

The authors does not have any conflict of interest.

References

1. Amit S kalyankar, Hugar I I, govind V murkute. Influence of tender coconut water on the economic parameters of silkworm *Bombyx mori* L, Journal of global bioscience,2015:4(9):3325-3329
2. Anilkumar M N. Application of tryptophan as supplementary nutrient on dehydrogenase activities and economic parameters in *Bombyx mori* L., Journal of pharmaceutical, chemical and biological sciences,2018:6(3):209-217
3. Anju Baera, Srivastava R R. Effect of some medicinal plant extracts on feeding growth, development and economic parameters of mulberry silkworm *Bombyx mori* L, Indian journal of applied entomology,2009:23(1):5-8.
4. Buhrooz Bhat M, Kamili A S, Ganai N A, Bali G K, Khan I L, Aziz A. Trends in development and utilization of sericulture resources for diversification and value addition, Journal of entomology and Zoology studies,2018:6(4):601-615.
5. Esaivani C, Vasanthi K, Bharathi R, Chairman K. Impact of probiotic *Saccharomuces cerevisiae* on the enzymatic profile and the economic parameter of silkworm *Bombyx mori* L, Advance in biology and biomedicine,2014:1(1):01-07.
6. Harendra kumar, Yuvana satya priya, Mukesh kumar, Vadamali elangovan. Effect of different mulberry varieties and seasons on growth and economic traits of Bivoltine silkworm *Bombyx mori* L Journal of entomology,2013:10(3):147-155.
7. Hassan S J, Rateb S H, Mohann K M, Hussein M H. Efficiency of some plants powder mix as dietary supplement of silkworm *Bombyx mori* L, International journal of Agriculture science,2020:2(2):378-383.
8. Jaiswal K K, Banerjee I, Mayookha V P. Recent trends in the development and diversification of sericulture natural products for innovative and sustainable application, Bio resource technology reports,2020:13:100-114.
9. Joythi M, Pratap M, Seenaiiah R, Thimma Naik S. Biochemical analysis and protein profile through SDS-PAGE in leaves of four (RC-1,RC-2, G2 and G4) mulberry (*Morus alba* L).cultivars, International journal of recent scientific research,2016:7(4):10296-300.
10. Karuppasamy Karthikairaj, Lourdu Isaiarasu. Effect of vermiwash on the growth of mulberry cuttings, world journal of agricultural science,2013:9(1):69-72.
11. Krishnaswami S. New technology of silkworm rearing, Bulletin, Central sericulture research and training institute, CSRTI, Mysore,1978:2:1:24.
12. Manjunatha S E, Sanatha kumar V B, Kiran kumar N. Toxicological studies of mulberry powdery mildew effective fungicide residues on growth and development of silkworm *Bombyx mori* L, cocoon and silk quality parameter, International journal of current microbiology and applied science,2017:6(11):708-716.
13. Manu H N, Prashanth J, Chaitra S, Jagadeesh Kumar T S. Evaluation of economic traits of selected FC₁×FC₂ and FC₄×FC₃ double hybrid treated with different doses of cholesterol during IV and V instar Silkworm,2020:9(3):129-137.
14. Norry thalineke wuntu, Maxtulung, Jantje pelealu Bernal tulung. The effect of plam sugar supplementation on feed consumption and percentage

- of silkworm (*Bombyx mori* L.) in the end of instar V, Scientific paper series management, economic engineering in agriculture and rural development,2019:19(4):377-381.
15. Padmashree Vidya Devi P, Ramani Bai M. Effect of *O.Sanctum* Plant extract on the economic parameters of silkworm *Bombyx mori* (L.), Journal of Entomology and Zoology studies,2015:3(2):62-64.
 16. Poonguzali J, Porkodi E, Vimala G. Studies on the effect of plant seed powders supplementations on feed efficiency and economic parameter of silkworm *Bombyx mori* Linn, journal of emerging technologies and innovative research,2021:8(11):504-523.
 17. Priyadarshini P Maddi, Yathessh K Rawgol. The influence of vermiwash sprayed mulberry on some growth and silk parameters of silkworm *Bombyx mori* L. MJS,2008:7(2):52-69.
 18. Purusothaman S, Murthuvelui S, Balasubramanian U, Murugesan P. Biochemical analysis of mulberry leaves (*Morus Alba*) and silkworm *Bombyx mori* L enriched with vermiwash, Journal of entomology, 1-7.
 19. Rahamathulla VK, Priyabrata Das, Ramesh M, Rajan K K. Growth rate pattern and economic traits of silkworm, *Bombyx mori* L under the influence of folic acid administration, Journal of applied science and environmental management,2007,11(4):81-84.
 20. Rajkumar Bapuro Deshmuku, Vithalrao B Khyade. Utilization of Aloe vera (L) herbal tonic for treating mulberry leaves before feeding the fifth instar larvae of silkworm *Bombyx mori* L,(Race: PMX CSR2) International journal of Bioassays,2013:2(1):281-285.
 21. Rao C N, Prasad R S, Doss PJ. Effect of corticosterone on silkworm larvae *Bombyx mori* L with special reference to economic parameters, Bioscience biotechnology research Asia, 2009, 6(1).
 22. Rouhollah Radjabi. Effect of mulberry leaves enrichment with amino acid supplementary nutrients on silkworm, *Bombyx mori* L at North of Iran, Academic journal of entomology,2010:3(1):45-51.
 23. Saranya M, Krishnamoorthy S V, Muruges K A. Fortification of mulberry leaves with indigenous probiotic bacteria on larval growth and economic traits of silkworm *Bombyx mori* L, Journal of entomology and Zoology studies,2019:7(4):780-784.
 24. Sekar P, Kalpana S, Ganga S. George john, Kannadasan N, and Krishna moorthy R, Studies on the growth parameters (Length and Weight) and cocoon production in *Bombyx mori* on mulberry leaves fortified with a putative probiont *Lactobacillus cassei*, International journal of current research,2016:8(4):29127-132.
 25. Simi Simon, Ravikiran KM, Asiya Nuzhat F B, Gowrishankar B S. A study on economical parameter of silkworm , *Bombyx mori* L supplemented with azolla, International journal of research culture society,2024:8(1):164-168.
 26. Simi Simon, Ravikiran KM, Gowrishankar B S, Asiya Nuzhat F B. Evaluation of economic traits of three selected mulberry silkworm races for commercial purpose, International journal of advanced research,2024:12(3):108-114.
 27. Soliman A M. The impact of fortification of mulberry leaves with the yeast *Saccharomyces cerevisiae* and blue green algae *Spirulina platensis* on some quantitative parameters of silkworm *Bombyx mori* (L.), Journal of plant protection and pathology,2021:12(1):55-59.
 28. Sunday Adeniyi Adeduntan, Infulence of different varieties of mulberry leaves (*Morus alba*) on growth and cocoon performance of Bivoltine strain of silkworm (*Bombyx mori* L), International journal of biological and chemical science,2015:9(2):751-757.
 29. Tajamul islam, Irfan latif khan, Mahrem manzoor gora, Mohd younis khan, Tariq A Bhat and Nayeena jan, Influence of egg albumen supplemented mulberry leaf on some reeling parameter of silkworm, *Bombyx mori* L, The pharma innovation journal,2020:9(11):19-22.
 30. Tamil selvi, Muruges K A Mangammal P, Krishna moorthy S V. Effect of different honey and protein sources on economic characters of silkworm *Bombyx mori* L, International journal of chemical studies,2020:4(9):3325-3329.
 31. Vijay kumar A, patil G M, Kavita M B. Effective concentration of azolla supplementation to grown up silkworm, Advance in life science,2016:5(10):04029-4038.
 32. Waktole sori, Bhaskar R N. Effect of bio inoculants applied to M5 mulberry under Rain fed condition on growth and cocoon traits performance of silkworm, *Bombyx mori* L. Momona Ethiopian journal of science,2012:4(2):29-32.