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USE OF BEE POLLENS AS A NUTRITIONAL DIET TO IMPROVE THE QUALITY AND QUANTITY OF SILK PRODUCTION

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ABSTRACT

To meet the increasing demand of silk, different research studies have been designed to give silkworms (Bombyx mori L.) (Lepidoptera: Bombycidae) the mulberry leaves fortified with natural and synthetic food additives to increase the production, quality and quantity of silk. The objective of this study was to investigate the effect of bee pollens coated mulberry leaves on the biological and economic parameters of silkworm. Different concentrations of bee pollens (0.5%, 1% and 2%) coated fresh mulberry leaves were given to 5th instar larvae while unfortified mulberry leaves were fed to control group. The results of the present study showed that there was significant ($P<0.05$) increase in the larval weight of treatment group as compared to control group. Highest increase in larval weight (1.047 g ± 0.028) and % ratio of silk gland weight to body weight (30.306 ± 0.430) was observed in the group treated with 1% BP. Furthermore, the cocoon weight, cocoon length and cocoon width was also significantly higher in treatment groups as compared to control group. A comparable pattern was observed in the % shell ratio and % fibroin content. Moreover, the highest cocoon weight (0.654 ± 0.017), cocoon length (31.96 ± 0.217), cocoon width (17.55 ± 0.060), % shell ratio (52.968 ± 2.008) and % fibroin content (76.8 ± 0.335) was found in the group treated with 1% BP. The outcomes of the current experiment have illustrated that silkworm has good adaptability for artificial nutritional diet. By enhancing the protein content in the silkworm feed, the biological and economical parameters of silkworms can be improved. It is conferred from the current study that the use of bee pollens has positive impacts on the productivity of silk.

INTRODUCTION

Different arthropod like spiders, bees, mites produce silk but silkworm is the major contributor of silk production in the world (Shahzadi et al., 2022). Silkworm is known for its sleek and luxurious silk thread which is recognized as Queen of textile industry (Souyma et al., 2017; Gautam et al., 2022; Shahzadi et al., 2022). Sericulture is an agricultural based industry which involve rearing of silkworm (Bombyx mori L.) to get silk. Sericulture is a profitable business that is practiced in more than 60 countries in the world but China and India are major contributor of silk and provide a handsome source of income with low investment to poor people living in rural areas (Sharma and Kapoor, 2020; Jaiswal et al., 2021). China is producing 84% of total world silk with 15% production in India (Natikar et al., 2023). The domestication of silkworm from its wild habitat started 5000 to 1000 years ago in China (Li et al., 2023; Sashina and Yakovleva, 2023).

Silkworm is monophagous insect that only eats mulberry leaves. B. mori has short reproductive cycle of 6-8 weeks with four different developmental stages that are eggs, larvae, pupa and adult moth. Within 10 days, eggs hatch to larva that undergoes complete metamorphosis (Soumya et al., 2017; Altman and Farrell, 2022). At 5th instar, larvae spin to produce silk cocoon and pupa goes inside and turn out with adult moth (Soumya et al., 2017; Ikeya et al., 2023). Idea condition for better larval growth and development include 25-28°C temperature and 60-70% humidity, However, high temperature and humidity also effect the characteristics of cocoon i.e. length, color and rigidity (Offord et al., 2016). Silk is a fibrous protein which consist of two thread like filaments clinked together by sericin protein (Altman and Farrell, 2022). Fibroin protein is produced by posterior silk gland while sericin is synthesized by middle silk gland (Dong et al., 2019). Two type of silk is produced worldwide i.e. Mulberry Silk and Non-Mulberry silk. Mulberry silk is produced by Bombycidae family while non-mulberry silk is produced by family Saturniidae and family Lasiocampidae (Jasmine and Mandal, 2014). Many crops of silk are obtained in a year depending upon the type of silkworm specie i.e. univoltine, bivoltine, and multivoltine (Gautam et al., 2022). Every year, the demand of silk for both domestic and export purpose is increasing which is still not fulfilled (Holland et al., 2019). The estimated quantity of natural silk produced in the world is 83393 tons every year while the required demand is 92742 tons in each year, showing a massive deficit (Tenriawaru *et al.,* 2021). Sericulture industry is playing an importance role in sustaining the economy of many developing countries but in last few decades, silk industry is facing many problems like decrease in demand and supply proportion, economic crisis in farmers, poor economic strategies, lack of trained persons, conventional infrastructure for silkworm rearing and better jobs opportunities in other industries than sericulture (Popescu, 2013). Many other concerns and obstacles are arising in silkworm industry including management of mulberry, preservation of genetic resources, high equipment prices and lack of labor force (Gautam *et al.,* 2022; Habeanu *et al.,* 2023).
Nutrition plays a crucial role in health, growth and development of larvae, quality, and quantity of silk of *B. mori*. Characteristics of silk fibers produced by silkworm depend on the intake of protein content along with mulberry leaves (Sharma *et al.,* 2022). A number of research activities demonstrated improvements in physiological and biochemical properties of silkworm when fortified mulberry leaves with different nutrients are given *i.e.* amino acids, vitamins, juvenile hormones, minerals, honey, royal jelly, and propolis (Helaly *et al.,* 2021; Mohanny *et al.,* 2022). Bee pollens are products of bee-hive rich in protein content, carbs, lipids, dietary fibers and many vitamins. Due to nutrient rich composition, bee pollens have been used in many research studies as food for insect (Ghouizi *et al.,* 2023). The current study has been planned to demonstrate the effect of bee pollens on the physiological characteristics of silkworm. Mulberry leaves are coated the with three different concentrations (0.5%, 1%, and 2%) of bee pollen and 5th instar larvae are fed with them (Moise *et al.,* 2020; Mohanny *et al.,* 2022).

MATERIAL AND METHODS

The experiment was performed in Applied Entomological and Toxicology Lab, Department of Zoology, Government College University Lahore and Sericulture Wing; Forestry, Wildlife and Fisheries Department, Ravi Road Lahore. Mulberry leaves coated with different concentrations (0.5%, 1% and 2%) of bee pollen were given to silkworm larva at 5th instar. The biological and economical parameters of silkworm were observed (Mohanny et al., 2022).

Source of Silkworm Eggs

Sericulture Wing; Forestry, Wildlife and Fisheries Department, Ravi Road Lahore provided us eggs of silkworm (Bombyx mori L.) of Chinese Race.

Eggs Hatching and Rearing Technique

Silkworm eggs were hatched in 8 days under optimal laboratory conditions having temperature (25-28°C), humidity (70-75%) (Helaly et al., 2021). Neonate larvae were kept in disinfectant rearing room. Disinfection was administered by using 3% formalin and equipment was sterilized by 0.05% spray of Asthra liquid

possessing active chlorine (Aruna and Murugesh, 2021). Fresh mulberry leaves were minced and fed to larva till 4th molting. The newly hatched larvae were kept on cotton trays for rearing with 20 larvae in each tray. At 5th instar, experiment was performed on randomly selected larva and fed with mulberry leaves augmented by bee pollens solution five times a day. The neonate beds were cleaned daily to remove dry leaves and larval feces.

Experimental Design

A batch of 60 larvae of silkworm was randomly divided into four groups, each group containing 15 larvae. One group was taken as control group which was treated with normal fresh mulberry leaves. Other three groups were designated as treatment groups that fed on mulberry leaves fortified with 0.5%, 1% and 2% of bee pollen.

Preparation of experimental solutions

Different concentrations of bee pollen (0.5%, 1% and 2%) were prepared by individually dissolving 0.5 gm, 1 gm and 2 gm of bee pollens in 100 ml distilled water. Furthermore, fresh mulberry leaves were soaked in prepared solutions for 20-30 seconds and fed experimental groups (Table 1).

Sr. No.	Groups	Treatment
1	Control Group	Larvae fed with non-coated mulberry leaves
2	Group 1	Larvae fed with 0.5% bee pollen concentration coated mulberry leaves
3	Group 2	Larvae fed with 1% bee pollen concentration coated mulberry leaves
4	Group 3	Larvae fed with 2% bee pollen concentration coated mulberry leaves

Table 1. Detail of control and experimental groups.

Analysis of Biological parameters of silk cocoon

Larval weight

From day one to pupation, increase in larval weight of all molts were measured by using electric weighing balance and noted on daily basis under laboratory conditions.

Silk gland weight

Before the start of silk formation, 5 silkworms were taken from each group and dissected them and weigh their silk glands to check the effect of bee pollen coated mulberry leaves on them. Electric weighing balance was used for this purpose.

Analysis of Quantity of silk cocoon

Cocoon Weight

Silkworm larva at 5th instar started forming cocoon with speed 65 revolutions per minute. As cocoon formation completed, cocoons were kept in sun light to kill adult moth inside the cocoon. Cocoons produced by experiment and control group larvae were weight by using electric weighing balance. Cocoons length and width was also measured by using Vernier caliper.

Shell weight/Shell ratio

From each group, 5 cocoons were selected and cut them to remove adult dead moth inside cocoon. In order to know the production of silk by experimental and control groups, shell weight and shell ratio of both groups were found by using the given formula:

Shell weight Formula

Shell weight = cocoon weight ─ pupa weight

Shell ratio Formula

$$\text{Shell ratio (\%)} = \frac{\text{Shell weight (gm)}}{\text{Cocoon weight (gm)}} \times 100$$

(Rahman, 2018; Fathy and Gad, 2022)

Analysis of Quality of silk cocoon

Sericin and Fibroin content in cocoon

Few cocoons were taken and cut them into small pieces and autoclaved them in particular concentrations for 2 hours at 121°C temperature. After autoclaving, the liquid was filtered by using filter paper and filtrate was dried at room temperature for 24 hours. Dried filtrate was weighed which gave fibroin content in the cocoons. Sericin content was determined by following formula:

Sericin content (gm) = Initial dry weight of shell − dry weight of the filtrate after filtration

Fibroin content(gm) = Dry weight of the shell − Sericin content

Statistical Analysis

Normality of the variables was assessed by employing Shapiro-wilk test. Biological aspects (% ratio of silk gland weight) and economical aspects including cocoon weight, cocoon length, cocoon width and % shell ratio were found by applying One-way ANOVA (Analysis of Variance) following Turkey's test and comparison was done between groups. The increase in larval weight was measured by applying repeated measure ANOVA. The significant value considered during Turkey's test was $P<0.05$ (Shahzadi *et al.,* 2022).

RESULTS

Analysis of weight of Silkworm Larvae

The gradual increase in the weight of 5th instar larvae of silkworms was observed from day 1 to day 5 in both treatment and control groups (Table 2). The larvae fed with 1% bee pollen fortified mulberry leaves had shown significant increase in larval weight (Table 3) (Figure 6). At day 5, the average gain in weigh of larvae was highest in treatment group with 1% bee pollen (1.047g ± 0.028) as compared to control group (0.884g ± 0.062).

Analysis of Percentage ratio of Silk gland weight

In all the treatment groups, the significant increase in % ratio of silk gland weight to larval body weight was observed as compared to control group ($F_{3, 16} = 4.669$; $P<0.05$) (Table 4). Maximum increase in the % shell gland weight was observed in the group fed with 1% bee pollen coated mulberry leaves (30.306 ± 0.430) followed by 2% bee pollen coated mulberry leaves (28.606 ± 0.978) and 0.5% bee pollen coated mulberry leaves (27.674 ± 0.553) (Figure 7).

Cocoon weight, Width and Length

The significant difference between the cocoon weight of all treatment groups were observed as compare to control group ($F_{3, 16} = 3.630$; $P<0.05$). There were increase in cocoon width of all treatment groups as compared to control group ($F_{3, 16} = 4.255$; $P<0.05$). Similar trend was observed in the cocoon length ($F_{3, 16} = 11.047$; $P<0.05$). The highest increase in cocoon weight, cocoon width and cocoon length was shown by the silkworms fed with 1% bee pollen fortified mulberry leaves followed by silkworms fed with 2% bee pollen fortified mulberry leaves and silkworms fed with 0.5% bee pollen fortified mulberry leaves (Table 5).

Cocoon Shell Ratio

The cocoon shell ratio was increased in all the treatment groups as compared to control group. Moreover, the significant difference in cocoon shell ratio was observed in the treatment group fed with 1% bee pollen fortified mulberry leaves as compared to control group ($F_{3, 16} = 4.693$; $P<0.05$). All other groups were showing non-significant difference in cocoon shell ratio as compared to control group. Furthermore, the best result was shown by the silkworms fed with 1% bee pollen fortified mulberry leaves (52.968 ± 2.008) followed by treatment group fed with 0.5% bee pollen fortified mulberry leaves (51.198 ± 1.052) and treatment group fed with 2% bee pollen fortified mulberry leaves (49.664 ± 1.236) (Table 5).

Analysis of % Fibroin and % Sericin Content

There was significant difference in percentage fibroin content of all treatment groups as compared to control group ($F_{3, 16} = 25.893$; $P<0.05$). However, the maximum % fibroin content was shown by the silkworms fed with 1% bee pollen coated mulberry leaves (76.8 ± 0.335), followed by treatment group fed with 0.5% bee pollen coated mulberry leaves (74.8 ± 0.335) and treatment group fed with 2% bee pollen coated mulberry leaves (74.6 ± 0.219) (Table 5).

In case of percentage sericin content, the control group gave the maximum percentage of sericin content ($F_{3, 16} = 25.893$; $P<0.05$). The highest % sericin content was present in control group (27.6 ± 0.3580) while the treatment group fed with 1% bee pollen coated mulberry leaves gave least % sericin content (23.2 ± 0.335) (Table 5).

Table 2. Results of AVOVA followed by Tukey's Test showing multiple comparison of increase in larvae weight.

No. of days	ANOVA	Tukey's Test
Day1	($F_{3, 56} = 6.678$; $P<0.05$)	
Day2	($F_{3, 56} = 5.078$; $P<0.05$)	The increase in larval weight from day 1 to day 5 varied significantly as compared to control group.
Day3	($F_{3, 56} = 3.678$; $P<0.05$)	
Day4	($F_{3, 56} = 4.139$; $P<0.05$)	
Day5	($F_{3, 56} = 3.252$; $P<0.05$)	

Table 3. Increase in Larval weight (g) in control and experimental groups.

Treatments	Day 1	Day 2	Day 3	Day 4	Day5
Control	0.145^{a} ± 0.009	0.329^{a} ± 0.015	0.550^{a} ± 0.025	0.712^{a} ± 0.017	0.884^{a} ± 0.062
0.5% BP	0.203^{b} ± 0.016	0.391^{ab} ± 0.016	0.603^{ab} ± 0.026	0.791^{ab} ± 0.046	0.943^{ab} ± 0.019
1% BP	0.236^{b} ± 0.012	0.431^{b} ± 0.017	0.660^{b} ± 0.023	0.923^{b} ± 0.064	1.047^{b} ± 0.028
2% BP	0.209^{b} ± 0.019	0.402^{b} ± 0.025	0.613^{ab} ± 0.017	0.892^{b} ± 0.044	0.986^{ab} ± 0.020

Note: Values in column with same superscripts showed non-significant difference while values with different superscripts showed significant difference. The values after ± are representing Standard Error.

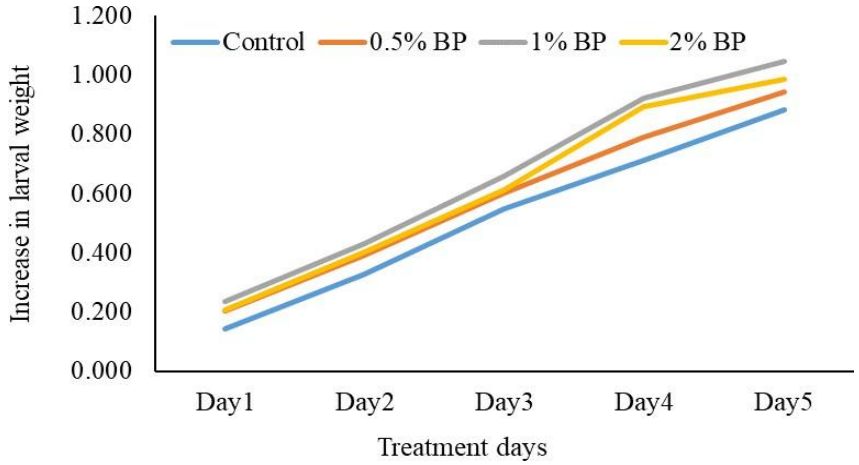

Figure 6. Mean plot of larvae weight (g) of treatment and control groups in 5th instar larva.

Table 4. Comparison of % ratio of silk gland weight to body weight in treatment and control group.

Groups	% ratio of silk gland weight
Control	$26.196^{a} \pm 0.765$
0.5% BP	$27.674^{ab} \pm 0.553$
1% BP	$30.306^{b} \pm 0.430$
2% BP	$28.606^{ab} \pm 0.978$

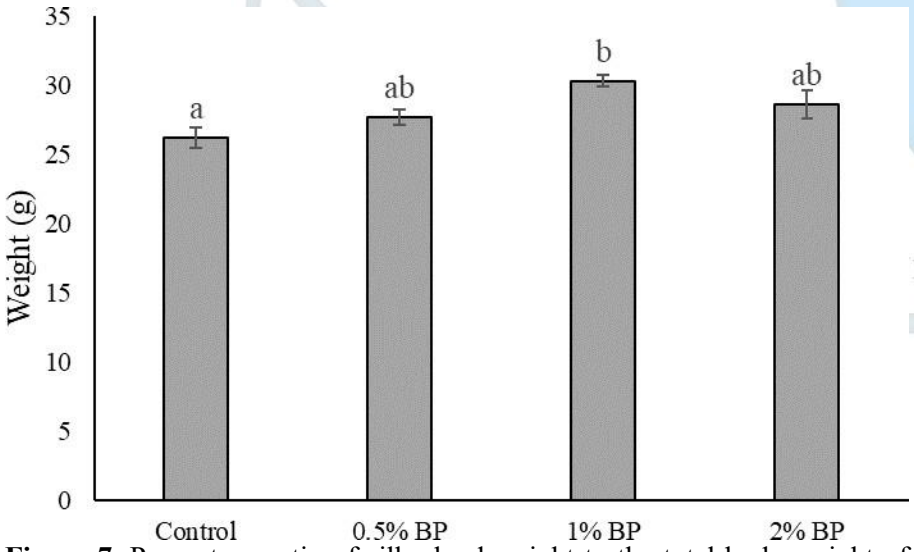

Figure 7. Percentage ratio of silk gland weight to the total body weight of larvae in control and treatment groups.

Table 5. Comparison of economic traits in experimental groups and control group.

Groups	Cocoon weight (g)	Cocoon length (mm)	Cocoon width (mm)	% Shell ratio	% Fibroin content	% Sericin content
Control	0.552^{a}	30.07^{a}	16.45^{a}	45.09^{a}	72.4^{a}	27.6^{c}

	± 0.007	± 0.185	± 0.220	± 1.049	± 0.358	± 0.358
0.5% BP	0.622^{ab}	31.742^{bc}	17.194^{ab}	51.198^{ab}	74.8^{b}	25.2^{b}
	± 0.034	± 0.347	± 0.271	± 1.052	± 0.335	± 0.335
1% BP	**0.654^{b}**	**31.96^{c}**	**17.55^{b}**	**52.968^{b}**	**76.8^{c}**	**23.2^{a}**
	± 0.017	**± 0.217**	**± 0.060**	**± 2.008**	**± 0.335**	**± 0.335**
2% BP	0.644^{ab}	30.7^{ab}	17.16^{ab}	49.664^{ab}	74.6^{b}	25.4^{b}
	± 0.020	± 0.166	± 0.184	± 1.236	± 0.219	± 0.219

Note: Values in column with same superscripts showed non-significant difference while values with different superscripts showed significant difference. The values after ± are representing Standard Error.

DISCUSSION

Sericulture is profitable agro-farming that is providing a source of income to rural and poor farmers. From the last few decades, the demand of silk is increasing globally. To meet the global demand of silk, researchers are improving the feed of silkworm in order to increase its production. Different nutritional elements such as probiotics, protein, honey, multi-vitamins, royal jelly, pollen, cow milk, egg albumin and glycine are used as a supplement in the feed of silkworm to enhance the production of silk (Etebari and Matindoost, 2005; Saad et al., 2019; Helaly et al., 2021). The nutritional value of mulberry leaves is crucial in promoting the larval growth and development of silkworms. Beside this, nutrient rich diet also influences the economic aspects of silkworm cocoon (Muhammed and Ayoub, 2023). Sharma et al. (2023) reported that the growth parameters of silkworm larvae were significantly increased when they were given with enriched mulberry leaves containing additional proteins such as protinex powder, drone brood. The present study was conducted to increase the productivity, quality and quantity of silk by giving bee pollen fortified leaves to silkworm.

In the present study, the highest increase in larval weight was observed in the treatment group fed with 1% BP fortified mulberry leaves (1.047g ± 0.028) as compared to control group (0.884g ± 0.062). Similar results were also reported by Saad et al. (2019), who fed silkworm larvae with 1% glycine dipped mulberry leaves and observed significant increase in the larva weight of silkworm. The use of Multi-vitamins in silkworm feed resulted 10.2% weight increase in treatment group as compared to control group (Etebari and Matindoost, 2005).

The results of our study showed that the significant increase in % ratio of silk gland weight to larval body weight were observed when larvae consumed mulberry leaves fortified with 1% BP. Comparable findings were reported by Esaivani et al. (2014) with increase in % shell ratio and % ratio of silk gland weight to body weight of silkworm when larvae were given with probiotics (Saccharomyces cerevisiae). Similar increase in % shell ratio was also reported by Prihatin et al. (2023) when Eri silkworms were fed with cassava leaves soaked in 1.5% glycine. Mulberry leaves treated with 1% cinnamon showed similar increase in % shell ratio of cocoon (Fathy and Gad, 2022). The major constituents of the silk gland are proteins, predominantly fibroin, which constitutes the main element of silk fibers (Cui et al., 2018). A protein-rich diet supplies the essential components for silk protein synthesis, resulting in increase
in % ratio of silk gland weight to body weight (Lattala et al., 2014). Furthermore, the increase in nutrients such minerals, vitamins, availability also fosters the development of silk gland, resulting in its weight gain (Muhammed and Ayoub, 2023).

The results of our study showed that the significant increase was observed in cocoon length, cocoon width and cocoon weight in the experimental group fed with 1% BP coated mulberry leaves as compared to control group. Hossain et al. (2022) reported that treatment group fed with 0.75% sericin coated mulberry leaves showed maximum increase in the cocoon length, width of cocoon and cocoon weight. Similar increase in the cocoon length, width of cocoon and cocoon weight were reported by Muhammed and Ayoub, (2023) when

larvae were fed on mulberry leaves enriched with vitamin C, probiotic and honey. The productivity of silk is associated with the nutritional value of mulberry leaves. The major portion of mulberry leaves is composed of essential amino acids i.e. glycine, alanine, serine (Borah and Boro, 2020). Bee pollen contains a diverse range of nutrients, comprising proteins, carbohydrates, enzymes, antioxidants, beneficial fats and essential vitamins like B-complex and vitamin C (Sanyal et al., 2023). This nutritional diversity makes BP a valuable supplement for silkworm larvae and result significant difference among biological and economical traits of silkworm.

The food supplements are source of vital vitamins, minerals and proteins that might be deficient in the mulberry leaves. By enhancing their nutritional supplements, silkworms become healthier and stronger, leading to an increase in silk production (Borah and Boro, 2020; Mahanta et al., 2023). Furthermore, their immune system gets stronger which enable them to show resistance against illnesses and microbes (Kunz et al., 2016; Shahzadi et al., 2022). As a results, the rate of mortality of silkworm larvae decreases and increases the silk production and brings better economic conditions for sericulture farming and silkworm farmers (Muhammed et al., 2023). The fortification of mulberry leaves with bee pollen increases the essential amino acids in silkworm feed which resulted improvements in quality and quantity of silk. But, these improvements are observed up to a particular limit of bee pollen in mulberry leaves (Moise et al., 2020). Fortification of mulberry leaves with 5% BP gave significant improvements in economic characteristics of silkworm as compared to 2% and 10% concentration of BP (Mohanny et al., 2022). Moreover, a higher concentration of BP would disturb silkworm growth by creating toxicity, digestive issues, stress and allergic reactions (Vegh et al., 2021). As the concentration of BP increases, different minerals and vitamins in BP accelerate the metabolism of nutrients which in turn increase more energy generation within body and effect negatively in further feed absorption (Attia et al., 2011).

Conclusion

The results of the present study represented that silkworm larvae showed significant improvement in larval weight, cocoon weight, cocoon length, cocoon width, % shell ratio, % ratio of silk gland weight to body weight and fibroin content of cocoon of silkworm (B. mori L.) when they were given with 1% BP coated mulberry leaves as compared to control. It is concluded that diet supplements in silkworm feed can improve the sericulture farming and results in generation of more revenue and uplifting the economy of a country.

REFERENCES

Abdel-Rahman, Y. A. (2018). Effect of the whey protein on economic traits for mulberry silkworm, Bombyx mori L. Journal of Plant Protection and Pathology, 9(4), 273-276.

Agarwal, R., Bansal, A., Saini, A. S., Raj, A., Kumar, A., & Gharde, S. K. (2023). Bee nutrition and artificial food. The Pharma Innovation Journal, 12(6), 1635-1641

Algethami, J. S., El-Wahed, A. A. A., Elashal, M. H., Ahmed, H. R., Elshafiey, E. H., Omar, E.

M., Naggar, Y. A., Algethami, A. F., Shou, Q., Alsharif, S.M., Xu, B., & El-Seedi, H. R. (2022). Bee pollen: Clinical trials and patent applications. Nutrients, 14(14), 2858.

Alshallash, K. S., Abolaban, G., Elhamamsy, S. M., Zaghlool, A., Nasr, A., Nagib, A., Abd El- Hakim, A. F., Zahra, A. A., Hamdy, A. E. & Taha, I. M. (2023). Bee pollen as a functional product–chemical constituents and nutritional properties. Journal of Ecological Engineering, 24(2), 173–183.

Altman, G. H., & Farrell, B. D. (2022). Sericulture as a sustainable agroindustry. Cleaner and Circular Bioeconomy, 2(2022), 100011.

Andadari, L., Yuniati, D., Supriyanto, B., Suharti, S., Widarti, A., Steven, E., Sadapotto, A., Winarno, B., Agustarini, R., Muin, N. Isnan, W., & Narendra, B. H. (2022). Lens on Tropical Sericulture Development in Indonesia: Recent Status and Future Directions for Industry and Social Forestry. Insects, 13(10), 913.

Arnott, R. (2022). Crossing Continents: Between India and the Aegean from Prehistory to Alexander the Great. Crossing Continents, 1-160.

Aruna, R., & Murugesh, K. A. (2022). Modulating the metabolic activity of silkworm, Bombyx mori l. with the supplementation of honey and protein sources. Madras Agricultural Journal, 108 (7-9), 1.

Asakura, T. (2021). Structure of silk I (Bombyx mori silk fibroin before spinning)-type II β-turn, not α-helix. Molecules, 26(12), 3706.

Asakura, T., & Williamson, M. P. (2023). a review on the structure of Bombyx mori silk fibroin fiber studied using solid-state nuclear magnetic resonance (NMR): An antipolar lamella with an 8-residue repeat. International Journal of Biological Macromolecules, 245(2023), 125537.

Assemie, A., & Abaya, G. (2022). The effect of edible mushroom on health and their biochemistry. International Journal of Microbiology, 2022, 7.

Attia, Y. A., Al-Hanoun, A., Tag El-Din, A. E., Bovera, F., & Shewika, Y. E. (2011). Effect of bee pollen levels on productive, reproductive and blood traits of New Zealand White (NZW) rabbits. Journal of Animal Physiology and Animal Nutrition, 95(3), 294-303.

Baruah, M. B., & Kalita, P. (2023). Muga silk: Sustainable materials for emerging technology.

In Advanced Materials from Recycled Waste, 2023, 295-316. Elsevier.

Basavanna, H., Kaur, J., Rasane, P., Singh, J., & Bhadariya, V. (2023). An overview of the health effects of bee pollen: A functional food ingredient. The Pharma Innovation Journal, 12(6), 4146-4150

Bhat, A. (2021). Management of white muscardine disease of silkworm (Bombyx mori L.) and improvement of economic characters by using botanicals: a review. Journal of Entomological Research, 45(2021), 1012-1019.

Biswal, B., Dan, A. K., Sengupta, A., Das, M., Bindhani, B. K., Das, D., & Parhi, P. K. (2022). Extraction of silk fibroin with several sericin removal processes and its importance in tissue engineering: a review. Journal of Polymers and the Environment, 30(6), 2222- 2253.

Blamires, S. J., Rawal, A., Edwards, A. D., Yarger, J. L., Oberst, S., Allardyce, B. J., & Rajkhowa, R. (2023). Methods for silk property analyses across structural hierarchies and scales. Molecules, 28(5), 2120.

Borah, S. D., & Praban, B. (2020). a review of nutrition and its impact on silkworm. Journal of Entomology and Zoology Studies, 8(3), 1921-1925.

Bu, C., Zheng, R., Huang, G., Wu, J., Liu, G., Donald, M. L., Dong, T. & Xu, X. (2022). The differences in cocoon and silk qualities among sex-related mulberry and silkworm feeding groups. Plos One, 17(6), 0270021.

Bucciarelli, A., & Motta, A. (2022). Use of Bombyx mori silk fibroin in tissue engineering: From cocoons to medical devices, challenges, and future perspectives. Biomaterials Advances, 139(2022), 212982.

Cao, T. T., & Zhang, Y. Q. (2016). Processing and characterization of silk sericin from Bombyx mori and its application in biomaterials and biomedicines. Materials Science and Engineering, 61(2016), 940-952.

Carissimi, G., Baronio, C. M., Montalbán, M. G., Víllora, G., & Barth, A. (2020). On the secondary structure of silk fibroin nanoparticles obtained using ionic liquids: an infrared spectroscopy study. Polymers, 12(6), 1294.

Chand, S., Chand, S., & Raula, B. (2023). Usage of silkworm materials in various ground of science and research. Journal of Natural Fibers, 20(1), 2139328.

Chanotra, S., Bali, S., & Gandotra, R. (2022). Popularization of bivoltine sericulture among tribal folk of Jammu and Kashmir with special reference to Poonch District. Emergent Life Sciences Research, 8(1), 43-49.

Chanotra, S., Verma, S., Bhat, M. A., Angotra, J., Verma, G. R., Langer, S., & Azam, M. (2022). Studies on vermicomposting of sericultural wastes: an eco-friendly approach for effective management of seri-wastes. Journal of Experimental Agriculture International, 44(12), 146-156.

Chelucci, E., Chiellini, C., Cavallero, A., & Gabriele, M. (2023). Bio-functional activities of tuscan bee pollen. Antioxidants, 12(1), 115.

Chen, X., Ye, A., Wu, X., Qu, Z., Xu, S., Sima, Y., Wang, Y., He, R., Jin, F., Zhan, P., Cao, J.,

& Zhou, W. (2022). Combined analysis of silk synthesis and hemolymph amino acid metabolism reveal key roles for glycine in increasing silkworm silk yields. International Journal of Biological Macromolecules, 209(2022), 1760-1770.

Chiome, T. J., & Srinivasan, A. (2022). Silk fibroin-based drug delivery systems. In Advanced Porous Biomaterials for Drug Delivery Applications, 23-47. Chemical Rubber Company (CRC) Press.

Chithrashree, G., Kumar, M., & Sharada, A. (2021). Sericin from the silk worm cocoons is an outstanding protein by possessing biological activities. Shanlax International Journal of Arts, Science and Humanities, 8(1), 6-11.

Chutia, B. C. (2022). Wild silk moth diversity in north-eastern region of India: a potential source for novel silk. Souvenir-cum-Compendium, Biotic Science Congress, 2022, 40-41.

Clarke, D., Morley, E., & Robert, D. (2017). The bee, the flower, and the electric field: electric ecology and aerial electroreception. Journal of Comparative Physiology A, 203(2017), 737-748.

Coombs, G., Dold, A. P., & Peter, C. I. (2011). Generalized fly-pollination in Ceropegia ampliata (Apocynaceae–Asclepiadoideae): the role of trapping hairs in pollen export and receipt. Plant Systematics and Evolution, 296(2011), 137-148.

Cui, Y., Zhu, Y., Lin, Y., Chen, L., Feng, Q., Wang, W., & Xiang, H. (2018). New insight into the mechanism underlying the silk gland biological process by knocking out fibroin heavy chain in the silkworm. BMC genomics, 19(2018), 1-10.

Czaplicki, Z., Gliścińska, E., & Machnowski, W. (2021). Natural silk–an unusual fibre: origin, processing and world production. Fibres & Textiles in Eastern Europe, 5(149), 22-28

Dan, A. K., Aamna, B., De, S., Pereira-Silva, M., Sahu, R., Paiva-Santos, A. C., & Parida, S. (2022). Sericin nanoparticles: future nanocarrier for target-specific delivery of chemotherapeutic drugs. Journal of Molecular Liquids, 368(2022), 120717.

Das, P. (2022). A review on physicochemical, structural and biomedical properties of silk worm sericin. Current Trends in Pharmaceutical Research, 8(2) 82-93.

Das, S., Soundar, S., & Gunaseelan, N. P. (2022). Colored cocoon silk. Journal of Natural Fibers, 19(16), 14067-14076.

Denisow, B., & Denisow-Pietrzyk, M. (2016). Biological and therapeutic properties of bee pollen: a review. Journal of the Science of Food and Agriculture, 96(13), 4303-4309.

Dong, Z., Guo, K., Zhang, X., Zhang, T., Zhang, Y., Ma, S., Chang, H., Tang, M., An, L., Xia,

Q. & Zhao, P. (2019). Identification of Bombyx mori sericin 4 protein as a new biological adhesive. International Journal of Biological Macromolecules, 132(2019), 1121-1130.

El Ghouizi, A., Bakour, M., Laaroussi, H., Ousaaid, D., El Menyiy, N., Hano, C., & Lyoussi, B. (2023). Bee pollen as functional food: insights into its composition and therapeutic properties. Antioxidants, 12(3), 557.

Esaivani, C., Vasanthi, K., Bharathi, R., & Chairman, K. (2014). Impact of probiotic Saccharomyces cerevisiae on the enzymatic profile and the economic parameters of silkworm Bombyx mori L. International Journal of Advanced Biological and Biomedical Research, 1(1), 1-7.

Etebari, K., & Matindoost, L. (2005). Application of multivitamins as supplementary nutrients on bio economical characteristics of Bombyx mori. Journal of Asia-Pacific Entomology, 8(1), 1-6.

Fambayun, R. A., Agustarini, R., & Andadari, L. (2022, April). Cultivation and breeding techniques for increase silk productivity in Indonesia. In IOP Conference Series: Earth and Environmental Science 995(1), 012055. IOP Publishing.

Fatahian, R., Hosseini, E., Fatahian, A., Fatahian, E., & Fatahian, H. (2022). a review on potential applications of sericin, and its biological, mechanical, and thermal stability characteristics. International Journal of Engineering Technology and Sciences, 9(1), 1-9.

Figueroa, L., Sadd, B., Tripodi, A., Strange, J., Colla, S., Adams, L., Duennes, M., Evans, E., Lehmann, D., Moylett, H., Richardson, L., & Inouye, D. W. (2022). Endosymbionts that threaten commercially raised and wild bumble bees (Bombus spp.). Journal of Pollination Ecology, 32(2), 14-36.

Gad, R. S. (2022). Effect of adding chamomile and cinnamon oils to larval diet of silkworm Bombyx mori L. on its biological parameters. Journal of Plant Protection and Pathology, 13(2), 55-58.

Gadad, H., Bhagat, A., Naqvi, A. H., & Kutala, S. (2022). Host instar susceptibility and stage specific predatory potential of stink bug Eocanthecona furcellata on tasar silkworm Antheraea mylitta. Journal of Environmental Biology, 43(5), 702-708.

Gamrat, R., Puc, M., Gałczyńska, M., Bosiacki, M., Witczak, A., & Telesiński, A. (2022). Differences in the pollen content of varieties of polish honey from urban and rural apiaries. Acta Universitatis Cibiniensis. Series E: Food Technology, 26(1), 109-122.

Gautam, M. P., Singh, D. K., Singh, S. N., Singh, S. P., Kumar, M., & Singh, S. (2022). a review on silkworm (Bombyx mori linn.) an economic important insect. In Biological Forum–an International Journal 14(4), 482-491.

Ghonmode, S. V. (2023). Influence of covid-19 peak period on sericulture farmers, reelers, weavers and traders. Current Agriculture Research Journal, 11(1), 212-218.

Ghorpade, K., Netam, V., Desai, N., & Shewale, V. (2022). Ascertaining role and importance of artificial diet and botanicals mediated serifeed for the strengthening of sericulture industry. Uttar Pradesh Journal of Zoology, 43(22), 46-54.

Giora, D., Marchetti, G., Cappellozza, S., Assirelli, A., Saviane, A., Sartori, L., & Marinello, F. (2022). Bibliometric analysis of trends in mulberry and silkworm research on the production of silk and its by-products. Insects, 13(7), 568.

Gupta, S., Alrabaiah, H., Christophe, M., Rahimi-Gorji, M., Nadeem, S., & Bit, A. (2021). Evaluation of silk-based bioink during pre and post 3D bioprinting: a review. Journal of Biomedical Materials Research Part B: Applied Biomaterials, 109(2), 279-293.

Hăbeanu, M., Gheorghe, A., & Mihalcea, T. (2023). Silkworm Bombyx mori—Sustainability and economic opportunity, particularly for romania. Agriculture, 13(6), 1209.

Hao, J., Gao, Y., Xue, J., Yang, Y., Yin, J., Wu, T., & Zhang, M. (2022). Phytochemicals, pharmacological effects and molecular mechanisms of mulberry. Foods, 11(8), 1170.

Helaly, W. M., Mohsen, A., Elyamani, E. M., & Helaly, S. (2021). Influence of royal jelly and palm pollen on biological, technological and physiological characters of silkworm, Bombyx mori L. Journal of Plant Protection and Pathology, 12(8), 507-513.

Herman, R. A., Yan, C. H., Wang, J. Z., Xun, X. M., Wu, C. K., Li, Z. N., Ayepa, E., You, S.,

Gong, L.C. & Wang, J. (2022). Insight into the silkworm pupae: Modification technologies and functionality of the protein and lipids. Trends in Food Science & Technology, 129(2022), 408-420.

Holland, C., Numata, K., Rnjak-Kovacina, J., & Seib, F. P. (2019). The biomedical use of silk: past, present, future. Advanced Healthcare Materials, 8(1), 1800465.

Hossain, M. S., Uddin, M. A., Islam, M. S., & Alim, M. A. (2015). Effect of cow milk on the growth and economic traits of silkworm, Bombyx mori L. Int. J. Scientific & Engineering Res, 6(3), 517-520.

Hossain, S., Ali, R., & Hasan, T. (2022). Sericin as a nutritional supplement to enhance cocoon, pupal parameters and grainase properties of silkworm Bombyx mori L. European Journal of Agriculture and Food Sciences, 4(6), 72-78.

Ikeya, Y., Wakkary, R., & Barati, B. (2023, July). Metamorphonic: A reflective design inquiry into human-silkworm relationship. In Proceedings of the 2023 ACM Designing Interactive Systems Conference, 808-819.

Isidorov, V. A., Maslowiecka, J., Pellizzer, N., Miranda, D., & Bakier, S. (2023). Chemical composition of volatile components in the honey of some species of stingless bees. Food Control, 146(2023), 109545.

Islam, T., Bhat, S. A., Malik, F. A., Wani, S. A., Khan, F. A., Mir, S. A., & Nazir, N. Feeding of different mulberry varieties and its impact on silk gland of silkworm, Bombyx mori L. Biological Forum –An International Journal, 15(1), 488-492.

Islam, T., Khan, I. L., Gora, M. M., Khan, M. Y., Bhat, T. A., & Jan, N. (2020). Influence of egg albumen supplemented mulberry leaf on some reeling parameters of silkworm, Bombyx mori L. The Pharma Innovation Journal, 9(11), 19-22.

Jaiswal, K. K., Banerjee, I., & Mayookha, V. P. (2021). Recent trends in the development and diversification of sericulture natural products for innovative and sustainable applications. Bioresource Technology Reports, 13(2021), 100614.

Jasmine, S., & Mandal, B. B. (2014). Types and properties of non-mulberry silk biomaterials for tissue engineering applications. In Silk Biomaterials for Tissue Engineering and Regenerative Medicine, 275-298. Woodhead Publishing.

Jaya Prakash, N., Wang, X., & Kandasubramanian, B. (2023). Regenerated silk fibroin loaded with natural additives: a sustainable approach towards health care. Journal of Biomaterials Science, Polymer Edition, 34(10), 1453-1490.

Jelen, Š., & Krajnc, A. U. (2023). Composition of proteins and phenolics in the leaves of different mulberry species (Morus alba L., M. alba× rubra, M. australis Poir., M. nigra L.). Agricultura Scientia, 20(1), 23-33.

Jha, A., Mishra, D. K., & Kumar, S. (2022). Bombyx mori: Life cycle and as a model organism in life science research. Journal of Entomological Research, 46(2), 378-384.

Joseph, B., & Raj, S. J. (2012). Therapeutic applications and properties of silk proteins from Bombyx mori. Frontiers in Life Science, 6(3-4), 55-60.

Kalagi, A., Raghavan, D., Raghavendra, C. G., Bajannavar, S., & Bhavani, V. S. (2022, April). Sericulture technology towards sustainable management. In 2022 IEEE International Conference on Distributed Computing and Electrical Circuits and Electronics (ICDCECE), 1-5. Institute of Electrical and Electronics Engineers.

Kaleka, A. S., Kaur, N., & Bali, G. K. (2019). Larval development and molting. Edible Insects, 560(2019), 17.

Kanoujia, J., Dubey, R., Debgharia, S., Sisodia, P., Mohanalakshmi, S., Bhatt, S., Parashar, P. & Kishore, A. (2023). Mini-review on analytical methods applied for analysis and characterization of sericin. Current Analytical Chemistry, 19(2), 119-129.

Khan, S. A., Khan, K. A., Kubik, S., Ahmad, S., Ghramh, H. A., Ahmad, A., Skalicky, M., Naveed, Z., Malik, S., Khalofah, A. & Aljedani, D. M. (2021). Electric field detection as floral cue in hoverfly pollination. Scientific Reports, 11(1), 18781.

Konwar, P., Saikia, M., & Saikia, S. (2022). Impact of bed disinfectants in mulberry silkworm rearing. The Pharma Innovation Journal, 11(3), 1613-1617.

Konwarh, R. (2019). Can the venerated silk be the next-generation nanobiomaterial for biomedical-device designing, regenerative medicine and drug delivery? Prospects and hitches. Bio-Design and Manufacturing, 2(4), 278-286.

Kumar Sahi, A., Gundu, S., Kumari, P., Klepka, T., & Sionkowska, A. (2023). Silk-based biomaterials for designing bioinspired microarchitecture for various biomedical applications. Biomimetics, 8(1), 55.

Kunz, R. I., Brancalhão, R. M. C., Ribeiro, L. D. F. C., & Natali, M. R. M. (2016). Silkworm sericin: properties and biomedical applications. BioMed Research International, 2016, 19.

Lakra, O., Kerketta, A., Tomar, R. K. S., Verma, S. K., Chaure, N. K., & Awasthi, A. K. (2022). Biology of mulberry silkworm (Bombyx mori L.) in laboratory at Bilaspur (Chhattisgarh). The Pharma Innovation Journal, 11(7), 4219-4222.

Lattala, G. M., Kandukuru, K., Gangupantula, S., & Mamillapalli, A. (2014). Spermidine enhances the silk production by mulberry silkworm. Journal of Insect Science, 14(1), 207.

Li, H., He, Y., Lu, J., Jia, L., Liu, Y., Yang, D., Shao, S., Lv, G., Yang, H., Zheng, H. & Peng, Z. (2023). A pilot study of stable isotope fractionation in Bombyx mori rearing. Scientific Reports, 13(1), 6643.

Li, J., Chen, C., & Zha, X. (2022). Midgut and head transcriptomic analysis of silkworms reveals the physiological effects of artificial diets. Insects, 13(3), 291.

Li, K., Li, P., & Fan, Y. (2019). The assembly of silk fibroin and graphene-based nanomaterials with enhanced mechanical/conductive properties and their biomedical applications. Journal of Materials Chemistry B, 7(44), 6890-6913.

Li, Y., Zhao, H., Li, T., Shang, D., Wu, L., Guan, N., & Wu, S. (2023). Quaternary ammonium salts functionalized cotton fibers with highly effective and durable antibacterial performances for daily healthcare textile applications. Industrial Crops and Products, 202(2023), 117100.

Lukas, C. (2021). Determinants of the use of silk in fashion industry. International Journal of Fashion and Design, 1(1), 31-39.

Mahanta, D. K., Komal, J., Samal, I., Bhoi, T. K., Dubey, V. K., Pradhan, K., Nekkanti, A., Gouda, M. R., Saini, V., Negi, N., Bhateja, S., & Jeengar, D. (2023). Nutritional aspects and dietary benefits of "Silkworms": Current scenario and future outlook. Frontiers in Nutrition, 10(2023), 1121508.

Mallick, P., & Sengupta, M. (2022). Prospect and commercial production of economically important plant mulberry (Morus sp.) towards the upliftment of rural economy. In Commercial Scale Tissue Culture for Horticulture and Plantation Crops, 2022, 219-
243. Singapore: Springer Nature Singapore.

Matran, I. M., Matran, C., & Tarcea, M. (2022). Sustainable prebiotic dessert with sericin produced by Bombyx mori worms. Sustainability, 15(1), 110.

Matuszewska, E., Plewa, S., Pietkiewicz, D., Kossakowski, K., Matysiak, J., Rosiński, G., & Matysiak, J. (2022). Mass spectrometry-based identification of bioactive bee pollen proteins: evaluation of allergy risk after bee pollen supplementation. Molecules, 27(22), 7733.

Maxwell, R., Costache, M. C., Giarrosso, A., Bosques, C., & Amin, S. (2021). Optimizing interactions between soluble silk fibroin and capryl glucoside for design of a natural and high-performance co-surfactant system. International Journal of Cosmetic Science, 43(1), 68-77.

Mohanny, K. M., Abdelkarim, S. I., & Mohamed, G. S. (2022). Effect of pollen a bee-hive product on some physiological, biochemical and economical characteristics of silkworm, Bombyx mori L. South Valley University(SVU)-International Journal of Agricultural Sciences, 4(4), 79-89.

Moise, A. R., Pop, L. L., Vezeteu, T. V., Agoston, B. D., Pasca, C., & Dezmirean, D. S. (2020). Artificial diet of silkworms (Bombyx mori) Improved with bee pollen-biotechnological approach in global centre of excellence for advanced research in sericulture and
promotion of silk production. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Animal Science and Biotechnologies, 77(1), 51.

Mondal, M., Trivedy, K., & Nirmal, K. S. (2007). The silk proteins, sericin and fibroin in silkworm, Bombyx mori Linn., -a review. Caspian Journal of Environmental Sciences, 5(2) 63-76.

Montaseri, Z., Abolmaali, S. S., Tamaddon, A. M., & Farvadi, F. (2022). Composite silk fibroin hydrogel scaffolds for cartilage tissue regeneration. Journal of Drug Delivery Science and Technology, 79(2023) 104018.

Motamed, M. K., & Ghorbani Piralidehi, F. (2021). Analysis of the sustainability of sericulture industry in guilan province. Iranian Agricultural Extension and Education Journal, 17(1), 85-99.

Muhammed, H. A. W., & Ayoub, Z. N. (2023). Effect of supplemental feeding on the weight of silk glands and larval development of mulberry silkworm (Bombyx mori). Journal of Duhok University, 26(1), 183-189.

Mushtaq, R., Qadiri, B., Lone, F. A., Raja, T. A., Singh, H., Ahmed, P., & Sharma, R. (2023). Role of sericulture in achieving sustainable development goals. Problemy Ekorozwoju, 18(1), 199-206.

Mwchahary, H., & Brahma, D. (2023). Microbial partnerships in sericulture: a review on the gut bacteria of silkworms. International Journal of Entomology Research, 8(6), 44-49.

Nasirillaev, B., Rajabov, N., Abdukadirov, M., & Fozilova, K. (2023). History and development prospects of silk farming in Uzbekistan. In E3S Web of Conferences, 376(2023). EDP Sciences.

Natikar, P., Sasvihalli, P., Halugundegowda, G. R., & Sarvamangala, H. S. (2023). Effect of global warming on silk farming: a review. The Pharma Innovation Journal, 12(3), 3714- 3719.

Nicodemo, D., Oliveira, J. E., Sedano, A. A., Marconcini, J. M., & Tonoli, G. H. (2014). Impact of different silkworm dietary supplements on its silk performance. Journal of Materials Science, 49(2014), 6302-6310.

Nurkomar, I., Trisnawati, D. W., & Tedy, M. H. (2022). Effect of different diet on the survivorship, life cycle, and fecundity of Eri silkworm Samia cynthia ricini Boisduval (Lepidoptera: Saturniidae). The Canadian Entomologist, 154(1), 25.

Offord, C., Vollrath, F., & Holland, C. (2016). Environmental effects on the construction and physical properties of Bombyx mori cocoons. Journal of Materials Science, 51(2016), 10863-10872.

Oroian, M., Dranca, F., & Ursachi, F. (2022). Characterization of Romanian bee pollen—an important nutritional source. Foods, 11(17), 2633.

Ozkavruk Adanir, E., İleri, B., Can, F., & Ulasli, B. (2022). An ethical approach to sericulture: production of peace silk in Hatay/Turkey. TEXTILE, 1-11.

Paladini, F., & Pollini, M. (2022). Novel approaches and biomaterials for bone tissue engineering: a focus on silk fibroin. Materials, 15(19), 6952.

Paudel, A., Panthee, S., Hamamoto, H., & Sekimizu, K. (2020). A simple artificial diet available for research of silkworm disease models. Drug Discoveries & Therapeutics, 14(4), 177- 180.

Poline, M. E. (2022). Studies on identifying various diseaeses affecting the Silkworm Bombyx mori under rearing. MVM Journal of Research, 8(2022), 59-68.

Pop, L. L., Mărghitaş, L. A., Bobiş, O., Moise, A. R., & Dezmirean, D. S. (2020). Analysis of market trends within the romanian silk industry. Bulletin of the University of Agricultural Sciences & Veterinary Medicine Cluj-Napoca. Animal Science & Biotechnologies, 77(1), 23-34.

Popescu, A. (2013). Trends in world silk cocoons and silk production and trade, 2007- 2010. Scientific Papers: Animal Science & Biotechnologies/Lucrari Stiintifice: Zootehnie Si Biotehnologii, 46(2), 418-423.

Popescu, A. (2020). A. silk trade in the European union: trends in the period. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 20(3), 443-454.

Popkova, M. A., Budnikova, N. V., & Brandorf, A. Z. (2023, June). Indicators of pollen quality during its stabilization. In AIP Conference Proceedings, 2817(1), 20017. American Institute of Physics (AIP) Publishing.

Prihatin, J., Savira, N. I. I., & Dewi, S. S. (2023). Impact of glycine fortification of cassava leaves on the late instar larvae of Eri silkworm (Samia cynthia ricini D.). Journal of Central European Agriculture, 24(2), 464-469.

Qadir, J., Gupta, R. K., Bali, K., Sharma, M., & Gupta, S. K. (2022). Impact of Sericin fortified mulberry leaves on the cocoon traits of silkworm Bombyx mori L. The Pharma Innovation Journal, 11(10),1519-1522.

Rahimpour, S., Jabbari, H., Yousofi, H., Fathi, A., Mahmoodi, S., Jafarian, M. J., Shomali, N. & Shotorbani, S. S. (2023). regulatory effect of sericin protein in inflammatory pathways; A comprehensive review. Pathology-Research and Practice, 243(2023), 154369.

Rani, G. A., Padmalatha, C., Raj, R. S., & Singh, A. R. (2011). Impact of supplementation of amway protein on the economic characters and energy budget of silkworm Bombyx mori

L. Asian Journal of Animal Sciences, 5(3), 190-195.

Rasuljonovich, K. R. (2022). An economic analysis of sericulture in the republic of Uzbekistan and development of its competitiveness. Journal of Pharmaceutical Negative Results, 13(6), 3820-3827.

Rather, B. A., Nozari, J., Mir, M. M., & Iqbal, U. (2023). Integrated pest management of temperate nuts. In Temperate Nuts, 351-385. Singapore: Springer Nature Singapore.

Ravi Kumara, R., & Kumar, H. (2022). The Fagara Silkworm (Attacus atlas L.): An underutilized Vanya Silkworm of India. Journal of Biodiversity, 8(5), 1-11.

Roy, C. (2022). a review on genesis, growth and development of Bengal artisanal silk industry in India. Integrated Journal for Research in Arts and Humanities, 2(4), 27-37.

Saad, M. S., Helaly, W. M., & El-Sheikh, E. S. A. (2019). Biological and physiological effects of pyriproxyfen insecticide and amino acid glycine on silkworm, Bombyx mori L. Bulletin of the National Research Centre, 43(2019), 1-7.

Sai, U. P., Tomar, R. K. S., Awasthi, A. K., Nirmalkar, V., Chaure, N. K., & Kerketta, A. (2022). Studies on varietal performance of mulberry on growth and development of silk worm (Bombyx mori L.). The Pharma Innovation Journal, 11(8), 987-990.

Saini, P., Rohela, G. K., Kumar, J. S., Shabnam, A. A., & Kumar, A. (2023). Cultivation, utilization, and economic benefits of mulberry. In The Mulberry Genome, 2023, 13-56. Cham: Springer International Publishing.

Sanyal, A., Ghosh, A., Roy, C., Mazumder, I., & Marrazzo, P. (2023). Revolutionizing the use of honeybee products in healthcare: a focused review on using bee pollen as a potential adjunct material for biomaterial functionalization. Journal of Functional Biomaterials, 14(7), 352.

Sarangi, A., Baral, S., & Thatoi, H. N. (2023). Extraction and biological application of silk sericin: an over view. Asian Journal of Biology, 17(2), 57-72.

Sashina, E. S., & Yakovleva, O. I. (2023). The current state and prospects of recycling silk industry waste into nonwoven materials. Fibers, 11(6), 56.

Seo, S. J., Das, G., Shin, H. S., & Patra, J. K. (2023). Silk sericin protein materials: Characteristics and applications in food-sector industries. International Journal of Molecular Sciences, 24(5), 4951.

Shabbirahmed, A. M., Sekar, R., Gomez, L. A., Sekhar, M. R., Hiruthyaswamy, S. P., Basavegowda, N., & Somu, P. (2023). Recent developments of silk-based scaffolds for tissue engineering and regenerative medicine applications: a special focus on the advancement of 3 dimensional (D) printing. Biomimetics, 8(1), 16.

Shahzadi, N., Tahir, H. M., Azizullah, M. F. B., Ali, S., Summer, M., & Chaudhary, F. A. (2022). Effect of sericin and honey on economical and biological traits of silkworm, Bombyx mori (L.) (Lepidoptera: Bombycidae). Punjab University Journal of Zoology, 37(2), 155-161.

Sharma, A., Bandral, R. S., Sharma, P., Gupta, R. K., Bali, K., Shankar, U., Sharma, S. & Pandey, R. K. (2022). Effect of drone brood and protinex fortification on feeding indices of silkworm, Bombyx mori L. The Pharma Innovation Journal, 11(8), 285-289.

Sharma, A., Sharma, P., Bandral, R. S., Gupta, R. K., & Bali, K. (2023). Influence of protein fortification on larval growth parameters of silk. The Pharma Innovation Journal, 12(3), 2978-2982.

Sharma, A., Sharma, P., Thakur, J., Murali, S., & Bali, K. (2020). Viral diseases of mulberry silkworm, Bombyx mori l.-a review. Journal of Pharmacognosy and Phytochemistry, 9(2), 415-423.

Sharma, K., & Kapoor, B. (2020). Sericulture as a profit-based industry—a review. Indian Journal of Pure and Applied Biosciences, 8(4), 550-562.

Sharma, V., Rattan, M., & Chauhan, S. K. (2022). Potential use of sericultural by products: a review. Pharma Innovation, 11(8), 1154-1158.

Silva, A. S., Costa, E. C., Reis, S., Spencer, C., Calhelha, R. C., Miguel, S. P., Ribeiro, M. P., Barros, L., Vaz, J. A. & Coutinho, P. (2022). Silk sericin: a promising sustainable biomaterial for biomedical and pharmaceutical applications. Polymers, 14(22), 4931.

Sime, D., & Siraj, Z. (2020). Sericulture in Ethiopia: Production status, opportunities, challenges and potential areas. a review. Journal of Entomology and Zoology Studies, 8(6), 01-10.

Smirnov, A., Smolokurov, E., Bolshakov, R., & Parshin, V. (2022). Current problems in developing the new silk road from China to Europe. In E3S Web of Conferences, 363(2022), 1014. Edition Diffusion Presse (EDP) Sciences.

Soliyeva, M. B., & No'monov, N. N. (2022). Processes for obtaining quality silk raw materials from industrial silkworm cocoons. Central Asian Journal of Theoretical and Applied Science, 3(6), 88-92.

Sorlini, M., & Menato, S. (2020). From textile to pharmaceutical and cosmetic industry: circular economy applied to silk manufacturing wastes. In Silk-based Drug Delivery Systems, 205-224. The Royal Society of Chemistry.

Soumya, M., Reddy, H., Nageswari, G., & Venkatappa, B. (2017). Silkworm (Bombyx mori) and its constituents: A fascinating insect in science and research. Journal of Entomology and Zoology Studies, 5(5), 1701-1705.

Ssemugenze, B., Esimu, J., Nagasha, J., & Wandui Masiga, C. (2021). Sericulture: Agro-based industry for sustainable socio-economic development: a review. International Journal of Scientific and Research Publications, 11(9), 474-482.

Sudha, S. R., Vasanthi, K., Usha, B., & Arumugavel, S. (2023). Biochemical and enzymatic study of the silkworm hemolymph, silk gland and gut analysis in different nutrients. Journal of Experimental Zoology India, 26(1), 749-757.

Sulaymonov, S., Abdurahmanov, A., & Parpiyev, S. (2023, June). Obtaining high-quality silk raw by excluding various factors insufficient to protect the raw material of the cocoon. In AIP Conference Proceedings, 2789(1). AIP Publishing.

Syamaladevi, S. (2022). Employment and income generation in cocoon production-a study.

International Journal of Multidisciplinary Educational Research, 11(7), 150-166.

Taba, M., & Gogoi, H. (2022). Structure of the silk gland of Eri silkworm Samia cynthia ricini boisduval and its secreted proteins. International Journal of Tropical Insect Science, 42(2022), 1-15.

Tahir, H. M., Jabeen, J., Raza, R., & Ali, S. (2019). Silk of spider and Bombyx mori: an overview. Punjab University Journal of Zoology, 34(2), 170-179.

Tarafder, N. (2022). Different types of fibre used in silk fabric manufacturing-a review. Journal of Recent Trends in Mechanics, 7(3), 22-28.

Tassoni, L., Cappellozza, S., Dalle Zotte, A., Belluco, S., Antonelli, P., Marzoli, F., & Saviane,

A. (2022). Nutritional composition of Bombyx mori pupae: A systematic review. Insects, 13(7), 644.

Tayal, M. K., & Chauhan, T. P. S. (2017). Silkworm diseases and pests. Industrial Entomology, 265-289.

Tenriawaru, A. N., Fudjaja, L., Jamil, M. H., Rukka, R. M., & Anisa, A. (2021, July). Natural silk agroindustry in Wajo Regency. In IOP Conference Series: Earth and Environmental Science, 807(3), 032057. IOP Publishing.

Thakur, J., & Bali, R. K. G. K. (2022). Innovations for reviving sericulture in Jammu and Kashmir. The Pharma Innovation Journal, 11(7), 1126-31.

Thakur, M., & Nanda, V. (2020). Composition and functionality of bee pollen: a review. Trends in Food Science & Technology, 98(2020), 82-106.

Tran, H. A., Hoang, T. T., Maraldo, A., Do, T. N., Kaplan, D. L., Lim, K. S., & Rnjak-Kovacina,

J. (2023). Emerging silk fibroin materials and their applications: New functionality arising from innovations in silk crosslinking. Materials Today, 65(2023), 244-259.

Unban, K., Klongklaew, A., Kodchasee, P., Pamueangmun, P., Shetty, K., & Khanongnuch, C. (2022). Enterococci as dominant xylose utilizing lactic acid bacteria in Eri silkworm midgut and the potential use of Enterococcus hirae as probiotic for Eri culture. Insects, 13(2), 136.

Urbanek Krajnc, A., Bakonyi, T., Ando, I., Kurucz, E., Solymosi, N., Pongrac, P., & Berčič, R.

L. (2022). The effect of feeding with central european local mulberry genotypes on the development and health status of silkworms and quality parameters of raw silk. Insects, 13(9), 836.

Urge, B., Dechassa, N., Keneni, G., Terefe, M., Shifa, K., Bediye, S., Tadesse, M. & Jemal, J. (2022). A technical guide for producing improved dairy heifers and multiplying sericulture technologies. Ethiopian Institute of Agricultural Research, ENARESS (Enabling Next-generation Researchers through Engaging Seasoned Scientists) Project.

Vaishnav, S. R., & Singh, S. A. (2023). Sericin, a by-product of the silk industry: extraction and applications. In Value-Addition in Agri-food Industry Waste Through Enzyme Technology, 199-208. Academic Press.

Végh, R., Csóka, M., Sörös, C., & Sipos, L. (2021). Food safety hazards of bee pollen–a review. Trends in Food Science & Technology, 114(2021), 490-509.

Vidya, M., & Rajagopal, S. (2021). Silk fibroin: a promising tool for wound healing and skin regeneration. International Journal of Polymer Science, 2021, 1-10.

Vishaka, G. V., Nadaf, H., Chandrashekharaiah, M., Rathore, M. S., & Sathyanarayana, K. (2021). New vistas of value addition in tasar sericulture through utilization of co- products. The Pharma Innovation Journal, 10(12), 388-392.

Wang, H. Y., Zhang, Y. Q., & Wei, Z. G. (2021). Dissolution and processing of silk fibroin for materials science. Critical Reviews in Biotechnology, 41(3), 406-424.

Wang, J., Chen, Y., Zhao, L., Zhang, Y., & Fang, X. (2022). Lipidomics reveals the molecular mechanisms underlying the changes in lipid profiles and lipid oxidation in rape bee pollen dried by different methods. Food Research International, 162(2022), 112104.

Wani, M. Y., Ganie, N. A., Wani, D. M., Wani, A. W., Dar, S. Q., Khan, A. H., A Khan, N., Manzar, M. S. & Dehghani, M. H. (2023). The phenolic components extracted from mulberry fruits as bioactive compounds against cancer: a review. Phytotherapy Research, 37(3), 1136-1152.

Widiawati, H., Sukirno, S., Sumarmi, S., Purwanto, H., Soesilohadi, R. H., & Sudaryadi, I. (2022, May). UV protectant ability of Attacus atlas L. (Lepidoptera: Saturniidae) sericin extract to increase nucleopolyhedrovirus effectiveness against Beet army worm, Spodoptera exigua (Hübner) (Lepidoptera: Noctuidae). In 7th International Conference on Biological Science. Advances in Biological Sciences Research, 22(2022), 2282-89. Atlantis Press.

Wood, T. J., Cross, I., & Baldock, D. W. (2020). Updates to the bee fauna of Portugal with the description of three new Iberian Andrena species (Hymenoptera: Apoidea: Anthophila). Zootaxa, 4790(2), 201-228.

Wu, G. (2023). Mapping Byzantine sericulture in the global transfer of technology. Journal of Global History, 2023, 1-17.

Yang, Y., Chen, J., Migliaresi, C., & Motta, A. (2020). Natural fibrous protein for advanced tissue engineering applications: focusing on silk fibroin and keratin. Bioinspired Biomaterials: Advances in Tissue Engineering and Regenerative Medicine, 1249(2020), 39-49.

Yesenia, S., & Nielsen, R. K. Forecast the trend of future silk production in India. Journal of Research in Science and Engineering (JRSE), 4(2), 38-44.

Yilmaz, O., Erturk, Y. E., Coskun, F., Wilson, R. T., & Ertugrul, M. (2015). History of sericulture in Turkey. Asian Journal of Agriculture and Food Sciences, 3(02), 237-242.

Zambrano, T. Y. M., Joza, J. M. A., Cobeña, G. V. S., Anchundia, S. E. P., & Zambrano, Y. D.
M. (2022). Honey, pollen and propolis in therapeutic treatments for COVID- 19. International Journal of Health Sciences, 6(1), 196-213.

Zanier, C. (2022). The migration of silk production from China to Europe and its subsequent developments. Textiles and Clothing Along the Silk Roads: Thematic Collection of the Cultural Exchanges along the Silk Roads, 1(2022), 297.

Zhang, Y., Lu, L., Chen, Y., Wang, J., Chen, Y., Mao, C., & Yang, M. (2019). Polydopamine modification of silk fibroin membranes significantly promotes their wound healing effect. Biomaterials science, 7(12), 5232-5237.

Zhou, Y., Wang, D., Zhou, S., Duan, H., Guo, J., & Yan, W. (2022). Nutritional composition, health benefits, and application value of edible insects: a review. Foods, 11(24), 3961.