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Effect of nutraceutical on economic characters of grasserie inoculated mulberry silkworm *Bombyx mori* L.

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Abstract
In Jammu & Kashmir, sericulture is practised in both temperate and sub-tropical zones. The socioeconomic environment, climate and land availability of the valley encourage the development of bivoltine sericulture, which yields extraordinarily high-quality cocoons. Economic features are the main elements for rearing of silkworm to produce superior quality of cocoons, mulberry leaves, silkworm health, rearing conditions, etc are some of the major factors that influence the amount and quality of cocoons. The cocoons generated during rearing are the raw material for the cottage-based industry, so it is imperative to improve the silkworm (*Bombyx mori* L) economic characteristics in order to create high-quality cocoons and booster the country's economy. The current study evaluated the use of nutraceuticals at three different concentrations (2%, 4%, and 6%) resulting in the growth of following parameters like: the average weight of 10 mature larvae (49.61 g), the duration of the fifth instar (163 h), the total larval duration (626 h), average cocoon weight (2.16 g), single shell weight (0.39 g), shell percentage (18.05%) and the filament length (1035 m) compared to the standard check (Normal rearing). According to this study, in addition to boosting silkworm immunity, which will help farmers increase their profits. Nutraceuticals also have the added benefits of being affordable, easily accessible and environmentally friendly. Additionally, the study has made room for even more concentration.

Keywords: Kashmir, bivoltine, rearing, growth, nutraceutical

1. Introduction
In India, silk is a way of life; without it, no ceremony is complete. It is an essential component of Indian customs and culture. Traditionally, people in India have lived in rural areas and the country's economy is largely dependent on the success of agriculture and related farm activities, with over 70 percent of the population depending on these sectors for their security of livelihood. Sericulture, an agro-based enterprise, plays a significant role in determining the economic destiny of these people; out of 6,38,588 villages in India, sericulture is practiced in about 52,360 of them, employing about 7.52 people, thus providing a means of subsistence for 9,47,631 families (Savithri *et al.*, 2013) [11]. The rural masses can find profitable work by pursuing sericulture. Being a labour-intensive rural industry, it provides a qualitative and quantitative shift in the reduction of poverty by creating a chain of employment that starts with unskilled farm workers and extends to all segments of rural people. India has a robust and expanding domestic market that is predicted to last for a very long time. About 85 percent of the silk produced in India is consumed domestically, with the remaining percentage being exported. However, the amount of raw silk produced domestically is insufficient to fulfil the growing demands for both domestic and export markets (Savithri and Sujathamma, 2012) [10]. However, domestic raw silk production is insufficient to fulfil growing export and domestic demand. In 2010–11, India produced about 21,005 metric tonnes; however, the country actually consumed about 29,000 metric tonnes (Varmudy, 2011) [13]. The depth of the matter lies in the cocoon economic characters. The economic parameters such as larval duration, larval weight, cocoon weight, shell percentage, filament length are crucial for the cocoon economic development of the sericulture industry in order to increase the production of raw silk (Jyothi, *et al.*,2010) [3].

2. Materials and Methods

The research was carried out at KVK, Ganderbal, SKUAST-K. During the study test, nutraceutical was evaluated for increasing the economic characters of the silkworm in order to increase their raw silk production. Prior to silkworm rearing, rearing room and equipments were subjected to disinfection with 2.5 percent sanitech (chlorine dioxide) in 0.5 percent slaked lime. The rearing room was kept closed for 24 hours for effective diffusion of sanitech. One day before brushing of eggs, the rearing room was opened to remove accumulated gases.

2.1 Preparation of Nutraceutical solution

The test nutraceutical was obtained in the form of capsules, the capsules were cut open and paste obtained was collected in a petri plate. The required concentrations of nutraceutical (2 percent, 4 percent and 6 percent were prepared by dissolving 2, 4 and 6 grams of nutraceutical paste in 100 ml of double distilled water respectively, composition of nutraceutical are as follows:

Table 1: Composition of Nutraceutical

Nutritional Information (Approximate Values)	Per Capsule (1727.06 Mg)
Energy	4.23 Kcal
Carbohydrate	0.10 G
Protein	0.02 G
Fat	0.38 G
Vitamin A	2000 Iu
Vitamin B1	1.39 Mg
Vitamin B2	1.8 Mg
Vitamin B3	12 Mg
Vitamin B5	9.66 Mg
Vitamin B6	0.99 Mg
Vitamin B12	1 Mcg
Vitamin C	40 Mcg
Vitamin D3	350 Iu
Vitamin E	5.92 Mg
Folic Acid	0.2 Mg
Calcium	76.9 Mg
Phosphorus	59.43 Mg
Iron	5.73 Mg
Zinc	10.29 Mg
Magnesium	3.13 Mg
Potassium	2.07 Mg
Manganese	0.53 Mg
Copper	0.52 Mg
Iodine	0.11 Mg

3.2 Test insect and treatment details

The nutraceutical was evaluated at three different concentrations viz., 2, 4 and 6 percent against *Bm*NPV. The silkworm race (CSR4) procured from germplasm bank of College of Temperate Sericulture Mirgund, SKUAST-K was selected for the experiment. Five replications were maintained for each treatment with 250 larvae in each replication. Besides all, a normal rearing which was kept as standard check was carried out. The experiment was laid out in a Completely Randomized Design (CRD). Different concentrations of nutraceutical were sprayed on mulberry leaves. The treated leaves were shade dried to evaporate the excess water from the leaf surface and were fed to silkworms on the alternate days of 3rd, 4th and 5th instar. Residual effect of nutraceutical was determined by comparing the larval heath and cocoon quality of nutraceutical treated worms with standard check (normal rearing). The following parameters were recorded:

- **5th instar larval duration (hours):** It was recorded as number of hours taken by 5th age silkworms from zero hour of 5th age till the Seri position.
- **Total larval duration (hours):** It was recorded as the total number of hours taken by the larvae from the date of brushing till Seri position.
- **Average weight of 10 mature larvae (g):** Ten mature larvae were randomly picked from each replication on 5th day of 5th instar and weighed on digital balance to determine the average larval weight.
- **Average cocoon weight:** 10 cocoons (5 male and 5 female) were selected from each replication on 7th day of spinning to determine average cocoon weight.
- **Single shell weight**: The cocoons used for determining average cocoon weight were also used to calculate single shell weight. The resultant shells were weighed to determine the average shell weight.
- **Shell percentage**

  It was calculated by using following formula:

$$\frac{\text{Single shell weight}}{\text{Single cocoon weight}} \times 100$$

- **Average filament length:** Ten cocoons were randomly selected from each replication, stifled and reeled individually to determine the average filament length.

3. Result and Discussion

3.1 Fifth instar larval duration (hours)

Minimum fifth instar larval duration (163 h) was shown by treatment with nutraceutical at 6 percent concentration followed by 4 percent (165 h) and 2 percent (165 h). However, 6 percent nutraceutical solution (163 h) was found at par with 4 percent (165 h) and 2 percent (165 h). The fifth instar larval duration (165 h) in standard check was also at par with all the three concentrations of nutraceutical used which clearly proved that there is no side effect of nutraceutical on the health and commercial characteristics of silkworm larvae (Table 2).

Table 2: Effect of nutraceutical on 5th instar larval duration (hours).

Treatment	5th Instar Larval Duration
T_1 2% nutraceutical solution	165^b
T_2 4% nutraceutical solution	166^b
T_3 6% nutraceutical solution	163^c
Standard Check (normal rearing)	165^b
C.D. ($p \leq 0.05$)	2.56

3.3 Total larval duration (hours)

The minimum total larval duration (626 h) was recorded in treatment with nutraceutical at 6 percent concentration followed by 4 percent (629 h) and 2 percent (630 h). However, 6 percent nutraceutical solution (626 h) was found at par with 4 percent (629 h) and 2 percent (630 h). The fifth instar larval duration (626 h) in standard check (normal rearing) was also at par with all the three concentrations of nutraceutical used which clearly proved that the nutraceutical used has no side effect (Table 3). The results are in conformity with Islam *et al.,* 2020 [2] who fed silkworm larvae with egg albumin fortified leaves and recorded the shortest larval duration in case of T_5 (Egg albumin 20%) due to the increased availability of amino acids in the larval food and larval haemolymph which in turn led to shortening of larval duration.

Table 3: Effect of nutraceutical on total larval duration (hours).

Treatment	Total Larval Duration
T_3 2% nutraceutical solution	630[b]
T_4 4% nutraceutical solution	629[b]
T_5 6% nutraceutical solution	626[b]
Standard Check (normal rearing)	626[b]
C.D. ($p \leq 0.05$)	5.35

3.4 Average weight of ten mature larvae (g)

In the three concentrations of nutraceutical used for the study, highest (49.61 g) average weight of ten mature larvae was recorded by 6 percent solution followed by 4 percent (48.43 g) and 2 percent (48.22 g). However, nutraceutical concentrations viz., 2 percent (48.22 g) and 4 percent (48.43 g) were found at par. Average weight of ten mature larvae in standard check (48.71 g) was found at par with 6 percent solution (49.61 g) and also with 4 percent solution (48.43 g) Table 4. The results are in conformity with Jyothi *et al*. 2002 who have reported that phyto-juvenoid omega-formyl longifolene oxime propargyl ether (NL 13) extracted from *Pinus longifolia* increased larval weight. The findings are conformity with Deb *et al.*, 2021, mature larval weight was found to be higher in dusting 1 (Tricodermin, Paraformaldehyde and Lime 30: 20: 950) (1.77 g), dusting 3 (1,3-Dibromo 5,5 Dimethylhydantonin, Paraformaldehyde and Lime 30:20:950) and dusting 2 (Paraformaldehyde and Lime 20:980) (1.65 g).

Table 4: Effect of nutraceutical on weight of 10 mature larvae (grams)

Treatment	Larval Survival
T_3 2% nutraceutical solution	48.22[b]
T_4 4% nutraceutical solution	48.43[ab]
T_5 6% nutraceutical solution	49.61[a]
Standard Check (normal rearing)	48.71[a]
C.D. ($p \leq 0.05$)	1.21

3.5 Average cocoon weight (g)

The results of the study revealed that highest average cocoon weight (2.16 g) was recorded in nutraceutical solution at 6 percent concentration which is found at par with 4 percent (2.13 g) and 2 percent nutraceutical solution (2.12 g). The average cocoon weight (2.13 g) in standard check (normal rearing) was found at par with different nutraceutical concentrations viz., 2 percent (2.12 g), 4 percent (2.13 g) and 6 percent (2.16 g) which affirms that there is no side effect of nutraceutical on the silkworm in general and cocoon weight in particular (Table 5). The study is in conformity with Kumar *et al.* (2000) [9] who dusted 2 days old 5th instar larvae of pure Mysore silkworm breed with *Lantana camara* and observed an increase in cocoon weight (10.33 g).

Table 5: Effect of nutraceutical on single cocoon weight (grams).

Treatment	Total Larval Duration
T_3 2% nutraceutical solution	2.12[a]
T_4 4% nutraceutical solution	2.13[a]
T_5 6% nutraceutical solution	2.16[a]
Standard Check (normal rearing)	2.13[a]
C.D. ($p \leq 0.05$)	0.048

3.6 Single shell weight (g)

In comparison with other concentrations of nutraceutical used for the study, the single shell weight in 6 percent concentration (0.39 g) was found higher than 4 percent (0.36 g) and 2 percent (0.35 g) nutraceutical solutions, however, all the three treatments were found at par. In standard check (0.37 g) performance with reference to single shell weight was found at par with all the three concentrations of the nutraceutical under test which asserts that there is no negative effect of nutraceutical on the health of silkworms (Table 6). The results are supported by Krishnaprasad *et al*. (2000) [4] where they found significant increase in shell weight (0.27 g) as compared to control (0.229 g) after the supplementation of mulberry leaf with potato leaf extract at growth stage.

Table 6: Effect of nutraceutical on single shell weight (grams).

Treatment	Total Larval Duration
T_3 2% nutraceutical solution	0.35[b]
T_4 4% nutraceutical solution	0.36[b]
T_5 6% nutraceutical solution	0.39[a]
Standard Check (normal rearing)	0.37[ab]
C.D. ($p \leq 0.05$)	0.02

3.7 Shell percentage

Maximum shell percentage (18.05) was recorded in nutraceutical solution at 6 percent concentration followed by 4 percent (16.90) and 2 percent (16.51). The treatments at 2 percent (16.51) and 4 percent (16.90) nutraceutical solutions were found at par. All the three concentrations of nutraceutical were statistically found at par (17.30) with standard check (normal rearing) (Table 7). The effect of nutraceutical on shell percentage was also observed by Padmalatha, 2016 [7] where he fed silkworms with the mulberry leaves applied with Amway nutraceutical on the first day of 4th instar larvae L×CSR_2 silkworm breed and recorded an increase in shell percentage (28.41%) in 6 percent nutraceutical concentration. The present investigation is supported by the findings of Krishnaprasad *et al.* (2000) [4] where they found significant increase in shell percentage (15.98%) compared to control (14.01%) after the supplementation of mulberry leaf with potato leaf extract at growth stage. The findings were also conformity with Kumar *et al*., 2022 [5] and recorded that the highest shell ratio was recorded in the treatment where chloroform extract of *Psoralea corylifolia* (1000 ppm) was given.

Table 7: Effect of nutraceutical on shell percentage.

Treatment	Total Larval Duration
T_3 2% nutraceutical solution	16.51[b]
T_4 4% nutraceutical solution	16.90[b]
T_5 6% nutraceutical solution	18.05[a]
Standard Check (normal rearing)	71.30[ab]
C.D. ($p \leq 0.05$)	0.87

3.8 Filament length (m):

Longest filament length (1035 m) was recorded in treatment in which nutraceutical was applied at 6 percent concentration followed by 4 percent (1006 m) which is at par with 2 percent nutraceutical solution (1001 m). The filament length (1026 m) in standard check (normal rearing) has been found at par with all the three concentrations of nutraceutical used in the study which has proven that there is not any negative impact of nutraceutical on filament length (Table 8). The study is again in conformity with Padmalatha (2016) [7] who has reported that the mulberry leaves fortified with Amway nutraceutical at 2 percent, 4 percent and 6 percent showed improvement of cocoon and reeling parameters of L×CSR2 when fed to silkworms. The results are also supported by Sujatha and Rao, 2003 who have reported that with increase in concentration of *C. longa* extract up to 25 percent, silk filament length also increased.

Table 8: Effect of nutraceutical on average filament length (m).

Treatment	Total Larval Duration
T_3 2% nutraceutical solution	1001[b]
T_4 4% nutraceutical solution	1006[b]
T_5 6% nutraceutical solution	1035[a]
Standard Check (normal rearing)	1026[ab]
C.D. ($p \leq 0.05$)	26.31

4. Conclusion

In case of commercial characters fifth instar duration, total larval duration, average weight of ten mature larvae, single cocoon weight, single shell weight, shell percentage and average filament length there was not found any significant statistical difference among the treatments in which nutraceutical was applied and the standard check (normal rearing). This proved that the nutraceutical has no adverse effect on the health of silkworms and quality of cocoons/silk. The present study has revealed that the nutraceutical has an ability to build immunity in the silkworms which helped them to coup the loss caused by disease. Management with nutraceutical is eco-friendly and can be acceptable to the farmers because of low cost and easy availability at farmers' level.

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