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STUDIES ON THE EFFECT OF PLANT SEED POWDERS SUPPLEMENTATION ON FEED EFFICIENCY AND ECONOMIC PARAMETERS OF SILKWORM *BOMBYX MORI* LINN

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Abstract:

Sericulture depends on rearing of silkworm on mulberry leaves. Silk production has direct relationship with larval growth. One of the alternative ways of improvement of larval growth and cocoon production is enrichment of mulberry leaves with supplementary nutrients. The present study has been aiming to find out the feed efficacy of five different plant seed powders treated V1 mulberry leaves with regard to food utilization by larvae and ultimate impact on the economic parameters of silkworm, *Bombyx mori* Linn. Fresh mulberry leaves were treated with five different plant seed powders such as *Cucurbita pepo*, *Cicer arietinum*, *Phaseolus vulgaris*, *Vigna radiate* and *Vigna mungo* at different concentrations such as 50 mg, 100 mg and 150 mg for third, fourth and fifth instar larvae of silkworm respectively. Group sixth served as control. The results indicate a significant difference among the six groups. The economic parameters and the nutrient efficacy were significantly increased in plant seed powders treated groups when compared to the control. The present study revealed that group III fed with *Phaseolus vulgaris* plant seed powders have shown a significant increase in the food consumption, food assimilation, percent of approximate digestibility, percent of efficiency of conversion of digested food and percent of efficiency of conversion of ingested food, percent of shell ratio, percent of raw silk, silk filament length, silk filament weight and denier in each larval stage followed by other experimental groups when compared with the control. Since silkworms are the only source for producing silk. Plant seed powders supplementation has significantly induced food consumption, utilization and superior cocoon characters by maintaining a balance in the gut flora. Thus, it has been inferred that silkworm larvae fed with plant seed powders supplementation beneficially influence the energy and economic parameters of *Bombyx mori*, which could be exploited in commercial cocoon production.

Keywords: Silkworm, Digestive parameters, Economic parameters, Plant seed powders.

1. Introduction:

Sericulture is the development of silkworm to produce silk. Among the couple of beneficial types of the silkworm, *Bombyx mori* Linn is the most broadly utilized and seriously considered silkworm for sericulture, as sericulture activity in India helps rural people for the socio-economic development, women empowerment, increase children's education and social activities developments (International Sericulture Commission, 2014). The aim of the present study was to analyses the feed efficiency characters and economic parameters of silkworm *Bombyx mori* Linn.

Nutrition plays a vital role in sericulture by improving the commercial characters of silkworm. Silkworm is a monophagous, deriving almost all the constituent required for its growth from the mulberry leaf. Mulberry (*Morus sp*) is the only food plant and it plays an important role in the growth and development of silkworm and subsequently the production and productivity of silk. Leaf quality and quantity influence the growth and development of silkworm as well as cocoon production and quality of raw silk produced. It is true that, nearly 70% of silk protein produced by mulberry silkworm is derived from protein of mulberry leaves in optimum quality for successful cocoon production (Bhaskar *et al*., 2008; Narayanan *et al*., 1967). The supplementation or fortification of mulberry leaves is the recent techniques in sericulture research (Murugan *et al*., 1998).

Feeding of nutritionally enriched leaves provided better growth and development of silkworms as well as gain in economic characters of cocoons (Krishnaswami, 1978). A wide range of chemicals including vitamins, minerals, amino acids, soyatose protein, hormones and plant extract have been used as supplements for enrichment of mulberry leaf to improve cocoon characters including reproductive potential of silkworm (Khan and Saha, 1997 and Nirwani *et al.*, 1998). In recent years, several attempts have been made to fortify the leaves with different beneficial nutrients and combination of nutrients (Rajegowda, 2002) to enhance the quality of cocoon crop. Extracts of various medicinal plants such as *Aloe vera*, *Moringa oleifera*, *Ocimum sanctum* etc has been elicited various response on silkworm and was shows influence on economical characters such as body weight, cocoon weight, shell weight, shell ratio, thread length in *Bombyx mori* (Sujatha, 2015). The dietary supplementation of tender coconut water can be used to improve economical performance of silkworm, *Bombyx mori* Linn (Kalyankar *et al*., 2015)

2. Materials and Methods:

2.1. Collection of silkworm larvae

The silkworm races PM x CSR2 of *Bombyx mori* Linn have been taken for the present study (Fig.1). The III instar larvae were collected and the silkworms were reared at Narasingapuram Village, near Walajapet, situated at Ranipet District, Tamilnadu, India as per the standard procedure of Krishnaswami (1978).

2.2. Collection of mulberry leaves

Mulberry leaves -V1 variety have been collected from Narasingapuram Village, to feed the silkworm larvae (Fig.2).

2.3. Collection of the plants

A wide range of indigenous plants of Ranipet zone were screened for its feeding acceptability as a supplementary diet along with mulberry leaves. The seeds of the plants *Cucurbita pepo* (Pumpkin), *Cicer arietinum* (Chick pea), *Phaseolus vulgaris* (Red kidney beans), *Vigna radiate* (Mung bean) and *Vigna mungo* (Black gram) were chosen for supplementation. The plant identification have been done in the Department of Botany, Arignar Anna Govt. Arts College for Women, Walajapet, Ranipet district, Tamilnadu, India.

2.4. Seed powder preparation

All the five plant seeds each 500 g have been taken washed in running water, shade dried, and powered separately using mortar and pestle. All the five seed powder was kept safely for the supplementation of mulberry leaves to the silkworm larvae.

2.5. Feeding silkworm larvae with supplementation of mulberry leaves

Six groups of III instar larvae of *B. mori* L. each group containing 20 larvae were taken for the present study (Fig.3).

Group I: Larvae fed with mulberry leaves dusted with 50 mg of *Cucurbita pepo* seed powder

Group II : Larvae fed with mulberry leaves dusted with 50 mg of *Cicer arietinum* seed powder

Group III : Larvae fed with mulberry leaves dusted with 50 mg of *Phaseolus vulgaris* seed powder

Group IV : Larvae fed with mulberry leaves dusted with 50 mg of *Vigna radiata* seed powder

Group V: Larvae fed with mulberry leaves dusted with 50 m of *Vigna mungo* seed powder

Group VI : Control group have been fed with normal mulberry leaves.

The silkworm larvae were kept inside the rearing room at 27 ± 2°C and 70 ± 15% as per the recommended rearing practice and relative humidity have been maintained. Every day feeding was done, first feeding of the larvae have been mulberry leaves dusted with seed powders, subsequent feedings were accomplished with normal mulberry leaves. After 3 days the IV instar larvae have been fed with mulberry leaves dusted with 100 mg concentration of all the five different seed powders. The V instar larvae have been fed with mulberry leaves dusted with 150 mg concentration of all the five seed powders and feeding was done for 6 days continuously till the cocoon formation.

2.6. Feed efficiency characters of III, IV and V instar larvae

The energy parameters of silkworm were analyzed based on the methods developed by Waldbauer (1968). The beds of the larvae were cleaned regularly in the morning and the observations on left over leaf, excreta, and larval weight gain were recorded. To study the feed efficiency, character the food utilization pattern has been calculated from Food consumption, Food Assimilation, Tissue growth, Percent of approximate digestibility, Percent of efficiency of conversion of digested food and Percent of efficiency of conversion of ingested food.

2.7. Economic parameters of the cocoon

The cocoons were harvested on the fourth day after spinning and the cocoon characters were recorded for five experimental groups and the control group. Based on the methods of Sonwalker, 1993 assessment of various cocoon parameters was done. To study the economic parameters of the cocoons, cocoons were assessed for cocoon weight, shell weight, pupal weight and shell cocoon weight ratio for all groups. Non - breakable filament length and denier were measured at Sericulture Grainage Centre in Vaniyambadi, Vellore District.

2.8. Statistical analysis

The experiments were repeated thrice and the data collected were subjected to statistical analysis. Mean and standard deviations were calculated by using Graphpad prism software version 4.50.

3. Results:

3.1. Digestive parameters

Feed efficacy characters like Food Consumption (FC), Food Assimilation (FA) Approximate Digestibility (AD), Efficiency of Conversion of Digested Food (ECD), Efficiency of Conversion of Ingested Food (ECI) data of III instar larvae, IV instar larvae, V instar larvae of *Bombyx mori* fed with V1- variety mulberry leaves with five seed powders *Cucurbita pepo, Cicer arietinum, Phaseolus vulgaris, Vigna radiate, Vigna mungo* Groups I to V and Control Group VI fed with mulberry leaves alone were given in table 1 - 3.

Figure 4 shows feed efficacy characters of III instar larvae of *B. mori*. L. Group I to V fed with mulberry leaves and five different seed powders (50 g) and control Group VI. Food Consumption (g) was found to be highest in Group III (0.64 ± 0.04 g) when compared with the control (0.51 ± 0.07 g) followed by other Groups V (0.55 ± 0.05 g), Group IV (0.55 ± 0.05 g), Group I (0.53 ± 0.03 g) and Group II (0.52 ± 0.03 g). Food Assimilation (g) was found to be highest in Group III (0.58 ± 0.07 g) when compared with the control (0.37 ± 0.06 g) followed by other Groups V (0.47 ± 0.04 g), Groups IV (0.45 ± 0.05 g), Group I (0.44 ± 0.04 g) and Group II (0.44 ± 0.04 g). Approximate Digestibility (%) was found to be highest in Group III (89.97 ± 4.76 %) when compared with the control (72.54 ± 4.14 %) followed by other Groups V (85.29 ± 4.73 %), Group IV (83.50 ± 3.65 %), Group I (82.05 ± 3.56 %) and Group II (73.07 ± 3.55 %). Efficiency of conversion of digested food (ECD %) was found to be highest in Group III (86.20 ± 3.64 %) when compared with the control (73.12 ± 3.63 %) followed by other groups V (85.10 ± 4.14 %), Group IV (82.22 ± 3.41%), Group I (79.54 ± 3.44 %) and Group II (78.40 ± 2.56 %). Efficiency of conversion of ingested food (ECI %) was found to be highest in Group III (78.12 ± 3.67 %) when compared with the control (58.82 ± 4.02 %) followed by other groups V (72.72 ± 3.15 %), Group IV (67.27 ± 4.26 %), Group I (66.36 ± 3.87 %) and Group II (66.03 ± 3.51%) (Table 1).

Figure 5 shows feed efficacy characters of IV instar larvae of *B. mori*. L. Group I to V fed with mulberry leaves and five different seed powders (100 g) and control Group VI. Food Consumption (g) was found to be highest in Group III (0.68 ± 0.05 g) when compared with the control (0.57 ± 0.12 g) followed by other Groups V (0.61 ± 0.07 g), Group IV (0.61 ± 0.07 g), Group I (0.60 ± 0.06 g) and Group II (0.59 ± 0.08 g). Food Assimilation (g) was found to be highest in group III (0.49 ± 0.06 g) when compared with the control (0.31 ± 0.06 g) followed by other Groups V (0.38 ± 0.05 g), Groups IV (0.36 ± 0.04 g), Group I (0.34 ± 0.04 g) and Group II (0.33 ± 0.02 g). Approximate Digestibility (%) was found to be highest in Group III (72.15 ± 5.36 %) when compared with the control (54.38 ± 4.87 %) followed by other Groups V (62.29 ± 5.40 %), Group IV (59.01 ± 3.14 %), Group I (56.66 ± 4.51 %) and Group II (55.93 ± 4.85 %). Efficiency of Conversion of Digested Food (ECD %) was found to be highest in Group III (173.46 ± 3.79 %) when compared with the control (151.57 ± 4.65 %) followed by other Groups V (171.05 ± 3.25 %), Group IV (166.66 ± 3.75 %), Group I (161.76 ± 3.18 %) and Group II (157.57 ± 5.78 %). Efficiency of Conversion of Ingested Food (ECI %) was found to be highest in Group III (139.34 ± 5.46 %) when compared with the control (81.96 ± 4.73 %) followed by other Groups V (112.06 ± 4.62 %), Group IV (105.26 ± 4.12 %), Group I (98.36 ± 3.89 %) and Group II (91.66 ± 3.67 %) (Table 2).

Figure 6 shows feed efficacy characters of V instar larvae of *B. mori*. L. Group I to V fed with mulberry leaves and five different seed powders (150 g) and control Group VI. Food Consumption (g) was found to be highest in Group III (0.82 ± 0.06 g) when compared with the control (0.72 ± 0.03 g) followed by other Groups V (0.77 ± 0.06 g), Group IV (0.76 ± 0.04 g), Group I (0.75 ± 0.05 g) and Group II (0.74 ± 0.04 g). Food Assimilation (g) was found to be highest in group III (0.43 ± 0.05 g) when compared with the control (0.33 ± 0.02 g) followed by other Groups V (0.35 ± 0.06 g), Groups IV (0.34 ± 0.04 g), Group I (0.34 ± 0.04 g) and Group II (0.34 ± 0.04 g). Approximate Digestibility (%) was found to be highest in Group III (53.82 ± 5.68 %) when compared with the control (44.15 ± 4.06 %) followed by other Groups V (47.42 ± 3.56 %), Group IV (45.94 ± 2.87 %), Group I (45.33 ± 4.09 %) and Group II (44.73 ± 4.53 %). Efficiency of Conversion of Digested Food (ECD %) was found to be highest in Group III (267.44 ± 5.06 %) when compared with the control (235.94 ± 3.45 %) followed by other Groups V (264.87 ± 4.79 %), Group IV (264.70 ± 4.75 %), Group I (257.14 ±4.34 %) and Group II (250 ± 2.65 %). Efficiency of Conversion of Ingested Food (ECI %) was found to be highest in Group III (140.24 ± 4.57 %) when compared with the control (111.11 ± 4.07 %) followed by other Groups V (118.42 ± 4.89 %), Group IV (116.88 ± 3.28 %), Group I (114.86 ± 3.75 %) and Group II (112.48 ± 4.69 %) (Table 3).

3.2. Economic parameters

Economic parameters like Cocoon weight (g), Shell weight (g), Silk filament (g), Pupal weight (g), Shell ratio (%), Silk filament length (m), Filament weight (g), Raw silk (%), Number of cocoons (kg), Denier (D- silk filament strength) data of control and experimental Groups I to V have been given in table 4, 5 and Figure 7.

Table 4 shows pupal parameters of experimental groups I to V and control group. Cocoon weight of Group III fed with *Phaseolus vulgaris* (1.75 ± 0.03 g) was found to be more than the control fed with mulberry leaves alone (1.05 ± 0.03 g) followed by other experimental Groups IV (1.55 ± 0.04 g), Group V (1.39 ± 0.04 g), Group II (1.24 ± 0.03 g) and Group I (1.19 ± 0.02 g). Shell weight of Group III fed with *Phaseolus vulgaris* (0.46 ± 0.02 g) was found to be more than the control fed with mulberry leaves alone (0.25 ± 0.03 g) followed by other experimental Groups IV (0.39 ± 0.03 g), Group II (0.30 ± 0.03 g), Group V (0.24 ± 0.01 g) and Group I (0.21 ± 0.04 g). Pupal weight of Group III fed with *Phaseolus vulgaris* (1.83 ± 0.05 g) have been significantly more than the control fed with mulberry leaves alone (0.80 ± 0.07 g) followed by other experimental Groups IV (1.16 ± 0.03 g), Group V (1.15 ± 0.03 g), Group I (0.98 ± 0.02 g) and Group II (0.94 ± 0.05 g). Number of cocoon per Kg in Group III (558.65 ± 7.48) when compared to the control where it is (952.63 ± 5.67).

Table 5 shows reeling parameters of control and experimental groups I to V. Group III larvae fed with *Phaseolus vulgaris* shell ratio (25.71 ± 2.66 %) and silk filament length (1033 ± 6.11 m), silk filament weight (2.93 ± 0.03 g) and raw silk (167.42 ± 3.12 %) have been more, when compared to control, where shell ratio (17.64 ± 1.50 %), silk filament length (799 ± 3.60 m), silk filament weight (1.87 ± 0.03 g) and raw silk (159.04 ± 2.22 %) followed by other experimental groups, group IV shell ratio (25.16 ± 2.53 %), silk filament length (912 ± 4.16 m), silk filament weight (2.51 ± 0.03 g) and raw silk (161.93 ± 3.08 %), group II shell ratio (24.19 ± 2.20 %), silk filament length (840 ± 4.04 m), silk filament weight (2.02 ± 0.02 g) and raw silk (162.90 ± 2.52 %), group I shell ratio (23.80 ± 1.26 %), silk filament length (769 ± 4.50 m), silk filament weight (2.07 ± 0.02 g) and raw silk (173.94 ± 8.32 %), group V shell ratio (17.26 ± 1.26 %), silk filament length (946 ± 2.64 m), silk filament weight (2.18 ± 0.02 g) and raw silk (156.83 ± 3.50 %). In the present study Denier was calculated for the silk filament produced by the control and the experimental groups. Denier was found to be maximum in Group III (2.52 ± 0.05 %) silkworm fed with *Phaseolus vulgaris* when compared with the control (2.10 ± 0.03 %) followed by other experimental groups, group IV (2.47 ± 0.02 %), group I (2.34 ± 0.03 %), group II (2.16 ± 0.02 %) and group V (2.07 ± 0.03 %).

4. Discussion:

The silkworm, *Bombyx mori* L. is an economically beneficial insect and survives only on Mulberry leaves (*Morus* spp). The quality of Mulberry leaves play an important role in the nourishment of silkworm and in turn cocoon/silk production for the success of sericulture industry (Choudhary *et al*., 1999). Silkworms, voracious eaters of mulberry leaves during its larval stage and around 80 % leaves were consumed in last two instars (Fakuda, 1960).

The results of the present investigation shows that the utilization of plant seed powders during silkworm rearing is one of the better options for the integrated improvement in economic traits of the silkworm *Bombyx mori* L. In sericulture silkworm feeding with nutrients, minerals and botanicals for better performance to get higher yield, quantity and quality of cocoons have been studied (Sannappa, 2002). Various researches have been carried out on the diet supplementation of mulberry leaves fed to silkworm (Etebari *et al*., 2004). Studies of Maribashetty *et al*., 2010 shows botanicals, being a better and cheaper supplement, can improve the quality and yield of cocoons.

Feed efficiency characters of III, IV and V instar larvae fed V1 Mulberry leaves fortified with 50 mg, 100 mg and 150 mg of 5 different plant seed powders respectively have been given in table 1-3. The results of the present study revealed that group III fed with *Phaseolus vulgaris* plant seed powders have shown a significant increase in the food consumption, food assimilation, percent of approximate digestibility, percent of ECD and percent of ECI in each larval stage followed by other experimental groups when compared with the control.

The increase in digestibility and ingestibility of the present study may be due to increased metabolic activities resulting in enhanced larval growth and early pupation. Hiware (2008) stated that the increase in ingestion and digestion of the treated silkworms over the control suggests the possibility of increased accumulation of organic constituents such as carbohydrates, proteins, lipids etc., in the body tissues.

The cocoon quantitative parameters like cocoon weight (g), shell weight (g), pupal weight (g), silk filament length (m) and shell ratio (%) were given in table 4 and 5. Single cocoon weight (1.75 ± 0.03 g), single shell weight (0.46 ± 0.02 g), single pupal weight (1.83 ± 0.05 g) of group III larvae of *Bombyx mori* fed with *Phaseolus vulgaris* was found to be more effective and increased drastically when compared with the control. It is therefore understood that the ingested food has been properly converted to the body matter. The body weight may go up to a certain extent and further get converted to the pupal and shell weight. These findings are comparable with that of Grimaldi and Engel (2005), who investigated that the quantity of cocoon and silk produced, is directly related to the pupation rate and larval weight. Other experimental groups also showed the increase in the yield of cocoons when compared to the control, which is in accordance with the studies of Santoshkumar *et al*., (2000) and Kumar *et al*., (2009) who observed increase in cocoon weight.

The significantly increased nutritional and economic parameters of the present study have been strongly correlated with the study of Thangapandiyan and Dharanipriya (2019) and suggest that feed efficacy of *Bombyx mori* was comparatively more when the silkworm fed with 25% Silver nanoparticles treated MR2 Mulberry leaves than the control MR2 leaves and other groups. Venkatesh Kumar *et al*., (2009) stated that single cocoon weight, single shell weight, pupal weight and silk filament length are significantly higher on spirulina treated silkworm, *B. mori* L. at 300 ppm concentration compared to control, 100 ppm and 200 ppm. The amino acids treated mulberry leaf fed silkworm larvae shows significantly higher in terms of body weight, cocoon weight, shell weight and yield/100 DFLs (Kg) when compared with control. It is also found that silk filament length (m) significantly increased in amino acid treated when compared with control (Shivkumar *et al*., 2020).

Good cocoon and pupation percentage is a positive sign for cocoon reeling performance as well as silk production. These are generally influenced by rearing environment and other a biotic factor. The post cocoon parameters like shell ratio (%), raw silk (%), silk filament length (m), silk filament weight (g) and denier contribute to the commercial value of silk (Malik *et al*., 2006). The nutritional fortification of nanoparticles of alanine an aminoacid significantly enhanced the growth of silkworm larvae, silkgland weight and cocoon parameters when compared to control (Kamala and Karthikeyan, 2019).

In the present study high values of group III larvae fed with *Phaseolus vulgaris* 25.71 ± 2.66 % of shell ratio, 167.42 ± 3.12% of raw silk, 1033 ± 6.11 m of silk filament length, 2.93 ± 0.03 g of silk filament weight, 2.52 ± 0.05 of denier when compared to control could have been due to the fact that dusting of plant seed powders supplementation increased the protein synthesis particularly the fibroin synthesis in the posterior silk gland which in turn influences the increased filament length and weight of the silk. These findings are in accordance with the fortification studies of Sannappa *et al.*, (2002) using *Arachis hypogaea* and *Acacia indica* respectively. Significant improvement in the filament length could be attributed to improvement in shell ratio with the application of the supplementation.

Denier represents the thinness or thickness of the filament and it was found to be maximum for Group III larvae fed with *Phaseolus vulgaris* (2.52 ± 0.05). Denier being genetically controlled trait and as such it may not have significant correlation with other parameters. The results are in close conformity with those reported by Murthy *et al*., (2013). The Lepidopteron insect (*B. mori*) is highly specialized for rapid growth, primarily achieved by higher rate of consumption. Food consumption has a direct relevance on the weight of larvae, cocoon, pupae and shell (Shivakumar, 1995). Leaf consumption rate directly influences the silk producing capacity and body weight of the silkworm. It was reported that cocoon weight and pupal weight were directly proportional to the concentration of Juvenile hormone and the feeding period (Chowdhary *et al*., 1990).

The supplementation of extra nutrients along with mulberry leaves results higher yield because the production of superior quality and quantity of silk depends mainly on nutritional status and healthiness of the larva (Rahmathulla *et al.,* 2005). In this study, it is evident that the supplementations of mulberry leaves with five different plant seed powder have shown good quality and yield of cocoon crop. This study is in confirmity with that of Bohidar and Manita (2005), who observed that the supplementation of mulberry leaves with plant extracts of *Trianthema portulacastrum, Trianthema procumbens, Sesamum indicum, Ocimum basilicum, Leucas aspera, Lantana camara* and *Crotalaria pallida* to silkworm resulted in great improvement of all the cocoon parameters. Geetha *et al*. (2017) conducted the combined foliar spray of micronutrients (ZnSo4, FeSo4, MnSo4 and citric acid) on 5th instar larvae and reported that the significant increase might be due to increased DNA synthesis in the silkgland or may be due to the general growth stimulatory effect of those chemicals on silkgland. Several reports containing the positive effects of nutritional supplementation of the economic traits of silkworms have been in support of the present study. In the present study the growth promoting effect of proteins and vitamins are found in the plant seeds powders treated on silkworm to enhance the larval and cocoon length, weight, cocoon shell and pupal weight.

5. Conclusion:

The present study evidenced significant increase in the plant seed powders treated group in the feed efficacy and economic parameters of silkworm *B. mori* L. Fortification of Mulberry leaves with supplementary nutrients could give the good quality and quantity of the cocoon and silk. So, this supplementation could be prescribed to the farmers to get more quantity and good quality of silk.

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Conflict of interest:

The authors have no conflict of interest.

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Fig.1: Larvae race PM × CSR2 *Bombyx mori* Linn

Fig.2: Mulberry plant –V1 variety

Fig.3: Experimental groups

Fig.4: Photograph showing 3th instar larvae feeding on mulberry leaves fortified with different seed powder

Group 1 have fed with mulberry leaves dusted with 50 mg seed powder *Cucurbita pepo*

Group 2 have fed with mulberry leaves dusted with 50 mg seed powder *Cicer arietinum*

Group 3 have fed with mulberry leaves dusted with 50 mg seed powder *Phaseolus vulgaris*

Group 4 have fed with mulberry leaves dusted with 50 mg seed powder *Vigna radiata*

Group 5 have fed with mulberry leaves dusted with 50 mg seed powder *Vigna mungo*

Group 6 have control group has fed with normal mulberry leaves

Fig.5: Photograph showing 4th instar larvae feeding on mulberry leaves fortified with different seed powder

Group 1 have fed with mulberry leaves dusted with 100 mg seed powder *Cucurbita pepo*

Group 2 have fed with mulberry leaves dusted with 100 mg seed powder *Cicer arietinum*

Group 3 have fed with mulberry leaves dusted with 100 mg seed powder *Phaseolus vulgaris*

Group4 have fed with mulberry leaves dusted with 100 mg seed powder *Vigna radiata*

Group5 have fed with mulberry leaves dusted with 100 mg seed powder *Vigna mungo*

Group 6 have control group has fed with normal mulberry leaves

Fig.6: Photograph showing 5th instar larvae feeding on mulberry leaves fortified with different seed powder

Group 1 have fed with mulberry leaves dusted with 150 mg seed powder *Cucurbita pepo*

Group 2 have fed with mulberry leaves dusted with 150 mg seed powder *Cicer arietinum*

Group 3 have fed with mulberry leaves dusted with 150 mg seed powder *Phaseolus vulgaris*

Group4 have fed with mulberry leaves dusted with 150 mg seed powder *Vigna radiata*

Group5 have fed with mulberry leaves dusted with150 mg seed powder *Vigna mungo*

Group 6 have control group has fed with normal mulberry leaves

Group –I Group -II

Group –III Group -IV

Group –V Group –VI Control

Fig.7 : Cocoon formation on plastic mountage of group I to V and control - VI

Table 1: Feed efficacy characters (Digestive parameters) of III instar of *B. mori* L. larvae fed with V1-mulberry leaves fortified with 50 mg of plant seed powders of experimental Group I to V and control Group VI

Parameters	Food consumption (mg)	Food Assimilation (mg)	Approximate Digestibility (%)	ECD (%)	ECI (%)
Group I	0.53 ± 0.03	0.44 ± 0.04	82.05 ± 3.56	79.54 ± 3.44	66.36 ± 3.87
Group II	0.52 ± 0.03	0.44 ±0.04	73.07 ± 3.55	78.40 ± 2.56	66.03 ± 3.51
Group III	0.64 ± 0.04	0.58 ±0.07	89.97 ± 4.76	86.20 ±3.64	78.12 ± 3.67
Group IV	0.55 ± 0.05	0.45 ± 0.05	83.50 ± 3.65	82.22 ± 3.41	67.27 ± 4.26
Group V	0.55 ± 0.05	0.47 ± 0.04	85.29 ± 4.73	85.10 ± 4.14	72.72 ± 3.15
Group VI (Control)	0.51 ± 0.07	0.37 ± 0.06	72.54 ± 4.14	73.12 ± 3.63	58.82 ±4.02

Values are Mean ± S. D. Group I- *Cucurbita pepo;* Group II- *Cicer arietinum;* Group III- *Phaseolus vulgaris;* Group IV- *Vigna radiate;* Group V- *Vigna mungo*

Table 2: Feed efficacy characters (Digestive parameters) of IV instar of *B. mori* L. larvae fed with V1-mulberry leaves fortified with 100 mg of plant seed powders of experimental Group I to V and control Group VI

Parameters	Food consumption (mg)	Food Assimilation (mg)	Approximate Digestibility (%)	ECD (%)	ECI (%)
Group I	0.60 ± 0.06	0.34 ± 0.04	56.66 ± 4.51	161.76 ± 3.18	98.36 ± 3.89
Group II	0.59 ± 0.08	0.33 ± 0.02	55.93 ± 4.85	157.57 ± 5.78	91.66 ± 3.67
Group III	0.68 ± 0.05	0.49 ± 0.06	72.15 ± 5.36	173.46 ± 3.79	139.34 ± 5.46
Group IV	0.61 ± 0.07	0.36 ± 0.04	59.01 ± 3.14	166.66 ± 3.75	105.26 ± 4.12
Group V	0.61 ± 0.07	0.38 ± 0.05	62.29 ± 5.40	171.05 ± 3.25	112.06 ±4.62
Group VI (control)	0.57 ±0.12	0.31 ± 0.06	54.38 ± 4.87	151.57 ± 4.65	81.96 ± 4.73

Values are Mean ± S. D. Group I- *Cucurbita pepo;* Group II- *Cicer arietinum;* Group III- *Phaseolus vulgaris;* Group IV- *Vigna radiate;* Group V- *Vigna mungo*

Table 3: Feed efficacy characters (Digestive parameters) of V instar of *B. mori* L. larvae fed with V1-mulberry leaves fortified with 150 mg of plant seed powders of experimental Group I to V and control Group VI

Parameters	Food consumption (mg)	Food Assimilation (mg)	Approximate Digestibility (%)	ECD (%)	ECI (%)
Group I	0.75 ± 0.05	0.34 ± 0.04	45.33 ± 4.09	257.14 ± 4.34	114.86 ± 3.75
Group II	0.74 ± 0.04	0.34 ± 0.04	44.73 ± 4.53	250 ± 2.65	112.48 ± 4.69
Group III	0.82 ± 0.06	0.43 ± 0.05	53.82 ± 5.68	267.44 ± 5.06	140.24 ± 4.57
Group IV	0.76 ± 0.04	0.34 ± 0.04	45.94 ± 2.87	264.70 ± 4.75	116.88 ± 3.28
Group V	0.77 ± 0.06	0.35 ± 0.06	47.42 ± 3.56	264.87 ± 4.79	118.42 ± 4.89
Group VI (control)	0.72 ± 0.03	0.33 ± 0.02	44.15 ± 4.06	235.94 ± 3.45	111.11 ± 4.09

Values are Mean ± S. D. Group I- *Cucurbita pepo;* Group II- *Cicer arietinum;* Group III- *Phaseolus vulgaris;* Group IV- *Vigna radiate;* Group V- *Vigna mungo*

Table 4: Effect of plants seed powder supplementation on pupal parameters Group I to V and the control of Silkworm, *B. mori* L.

Parameters	Cocoon Weight (g)	Shell Weight (g)	Pupa Weight (g)	No. of Cocoon (Kg)
Group I	1.19 ±0.02	0.21 ±0.04	0.98 ±0.02	840.45 ±5.35
Group II	1.24 ±0.03	0.30 ±0.03	0.94 ±0.05	806.45 ±5.28
Group III	1.75 ±0.03	0.46 ±0.02	1.83 ±0.05	558.65 ±7.48
Group IV	1.55 ±0.04	0.39 ±0.03	1.16 ±0.03	645.16 ±5.47
Group V	1.39 ±0.04	0.24 ±0.01	1.15 ±0.03	716.42 ±2.68
Group VI (control)	1.05 ±0.03	0.25 ±0.03	0.80 ±0.07	952.38 ±5.67

Values are Mean ± S. D. Group I- *Cucurbita pepo;* Group II- *Cicer arietinum;* Group III- *Phaseolus vulgaris;* Group IV- *Vigna radiate;* Group V- *Vigna mungo*

Table 5: Effect of plants seed powder supplementation on reeling parameters Group I to V and the control of Silkworm, *B. mori* L.

Parameters	Shell Ratio (%)	Raw Silk (%)	Silk Filament Length (m)	Silk Filament Weight (g)	Denier (%)
Group I	23.80 ± 2.26	173.94 ± 8.32	769 ± 4.50	2.07 ± 0.02	2.34 ± 0.03
Group II	24.19 ± 2.20	162.90 ± 2.52	840 ± 4.04	2.02 ±0.02	2.16 ± 0.02
Group III	25.71 ±2.66	167.42 ± 3.12	1033 ± 6.11	2.93 ±0.03	2.52 ±0.05
Group IV	25.16 ± 2.53	161.93 ± 3.08	912 ± 4.16	2.51 ±0.03	2.47 ±0.02
Group V	17.26 ± 1.26	156.83 ± 3.50	946 ± 2.64	2.18 ±0.02	2.07 ±0.02
Group VI (control)	17.64 ± 1.50	159.04 ± 2.22	799 ± 3.60	1.87 ±0.03	2.10 ±0.03

Values are Mean ± S. D. Group I- *Cucurbita pepo;* Group II- *Cicer arietinum;* Group III- *Phaseolus vulgaris;* Group IV- *Vigna radiate;* Group V- *Vigna mungo*