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NUTRITIONAL SUPPLEMENTATION OF AMINO ACID L-SERINE ON SILKWORM *BOMBYX MORI* (L.) LARVAE IN RELATION TO GROWTH RATE AND SILK PRODUCTION

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ABSTRACT: Nutritional requirement in food consumption have direct impact on the overall growth of silk worm and also increase the larval, pupae and cocoon weight with amount of silk production. Cocoon characters, both quantitative as well as qualitative, depend largely on the quality and quantity of mulberry leaves. Consumption of nutritional supplements enriched mulberry leaves to influence the silkworm larval body weight and influences the silk output. This study was to find out the pupal parameters and economic parameters such length, width and weight of cocoon, cocooning percentage, cocoon shell weight, cocoon shell ratio, silk filament length, Denier of silk filament of mori silk produced by V instar larvae of *Bombyx mori* fed the normal MR2 mulberry (*Morus sinensis*) leaves and different nutritional supplementary compound such as L-Serine, Aspartic acid, Arginine, Niacin, Retinol, Calciferol, Ascorbic acid and Glucose treated MR2 mulberry leaves. In the present study has been observed that the pupal, cocoon and economic parameters are enhanced by 0.25% L-Serine treated *Bombyx mori* V instar larval group than control and other treated groups. This study has been indicates that the amino acid L-serine reveal the presence of silk forming stimulant activity and also increase the silk yield in silkworm rearing with reference to sericulture industry.

KEYWORDS: *Bombyx mori*, L-Serine, Economic Parameters, MR2 Mulberry, Silk Production**.**

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1. INTRODUCTION

Nutrition of silkworm is sole factor which almost individually augment quality and quantity of silkworm [1]. In recent years, many researchers' attempts have been made in sericulture with nutrient such as protein, vitamin, carbohydrates, amino acids, etc., for better performance of good quality of cocoons [2]. Ascorpic acid (Vitamin C) [3], silver nanoparticles [4], Amoxicillin [5], natural dyes [6], *Spirulina* powder [7]. Amino acid Lysine, In addition to mulberry leaves feed supplements are also given to silkworm to enhance economic characteristics [8]. The enrichment of mulberry leaves with riboflavin at 77 ppm enhanced certain economic characters of silkworm, and improved silk production in north climatic conditions of Iran. Cocoon parameters such as cocoon weight, pupal weight and cocoon shell weight also showed significant decrease in all treatments [9]. Feeding of silkworm on mulberry leaves enriched with multi-vitamins from 4^{th} instar increased female cocoon shell weight in 2.5% concentration, while female pupal weight increased in 1% concentration [10]. Supplementation includes vitamins such as ascorbic acid, thiamine, folic acid and niacin multivitamins [11]. Supplemented fresh mulberry leaves with 3 levels of vitamin B complex by dipping them in 0.5, 1.0 and 1.5% solution, and fed the dried leaves to larvae of various *Bombyx mori* races: the 0.5% level increased the weights of larvae and cocoons, and the shell ratio [12]. Silk production basically depends on the *Bombyx mori* larval protein metabolism which in turn needs more energy generating events, spinning requires more muscular activity and silk is being produced by the silk gland. The quality of the leaves has a profound superiority of silk produced by the *B. mori* [13]. The effect of mulberry leaves enriched with amino acids on the growth of *B. mori* has been studied [14]. Nutritional supplements include vitamins, amino acids, protiens and probiotics when added to larval feed tend to increase nutritional efficiency and economic traits of silkworm [15]. The supplement feeds had been reported to enhance metabolic activity and a high protein production. The present study has been aimed to find out effective nutritional supplementary compound (glucose, some vitamins and some amino acids) which one to mostly enhance the pupal and economic parameter with regard to food utilization by larvae and ultimate impact on the silk production in selective concentration 0.25% [16].

2. MATERIALS AND METHODS

The first day of III instar of silkworm *Bombyx mori* $L \times NB_4D_2$ (Local Bivoltine) race were reared simultaneously both in control and experimental groups separately on mulberry leaves dipped in nutritional supplementary solution in the laboratory. Proper environmental conditions provided to the silkworms with photoperiod of 12:12 h light and darkness as recommended [17]. The first day of III instar larvae were placed at ambient temperature of 25 ± 27ºC and relative humidity of 70 to 80%. The larvae were reared in card board boxes measuring 22×15×5 cms covered with nylon net and placed in an iron stand with ant wells [18]. *Morussinensis* (MR2) is one of the varieties of

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mulberry. This mulberry plant branches are simple, vertical, grayish leaves are light green, unlobed, elliptic palmately veined, leathery / smooth / wrinkled. It has good agronomic characters like high rooting ability. The *Bombyx mori* larvae were divided into two experimental groups; those are Control and Treated. Group 1 serves as the control this group larva to fed normal MR2 mulberry leaves. Group 2 larva to fed different nutritional supplementary compounds such as L-Serine (T1), Aspartic acid (T2), Arginine (T3), Niacin (T4), Retinol (T5), Calciferol (T6), Ascorbic acid (T7) and Glucose (T8) treated MR_2 Mulberry leaves in the concentration of 0.25%.Economic parameters such as length, width and weight of pupae and cocoon were recorded for 6 larvae from control and nutritional supplementary compounds treated groups and mean values of 6 readings were recorded for observation. pupal and cocoon length, width and weight and cocoon shell weith were measured by using scales and digital balance respectively. The other economic parameters like cocooning percentage, shell ratio, filament length and denier were calculated by following appropriate formula. Average of cocoon parameters (length, width and weight) of 6 cocoons, selected randomly from control and nutritional supplementary compounds treated groups on 6^{th} day of spinning. The cocooning percentage (CP) was calculated by following formula.

$$CP = \frac{\text{Number of cocoons formed}}{\text{Total number of larvae kept for rearing}} \times 100$$

$$SR = \frac{\text{weight of shell}}{\text{weight of whole cocoon}} \times 100$$

Average shell weight of 6 cocoons, selected randomly from control and nutritional supplementary compounds treated groups (Pupae were removed from cocoons and only shell was weighed). The shell ratio (SR) was calculated by following formula. Six cocoons were taken randomly from control and nutritional supplementary compounds treated groups. The cocoon was socked in boiled water (after 6^{th} day of spinning) to soften the sericin content. Cocked cocoons were reeled on epprouvette. The total number of revolutions were recorded and converted into meters by using the following formula.

$$FL = R \times 1.125$$

Where, FL = Total filament length (m/cocoon), R= Number of revolutions,

1.125 = Circumference of Epprouvette.

Denier is defined as the strength of silk thread. The reeled silk thread is taken from the epprouvette. It was dried for 15 days and weight of reeled silk was recorded. The denier was calculated by following formula [19].

$$D = \frac{w}{L} \times 9000$$

Where, W = Weight of single cocoon reeled silk in grams, L= Total length of single cocoon reeled

filament in meters, 9000= Constant value.

All the data were analyzed by one way analysis of variance (ANOVA) followed by Duncan's multiple range test (DMRT) using a commercially available statistics software package (SPSS® for Windows, V. 16.0, Chicago, USA). Results were presented as mean ± standard deviation (SD). $P < 0.05$ was regarded as statistically significant [20].

3. RESULTS AND DISCUSSION

Table 1 shows that the Morphometric data analysis of length, width and weight of pupal parameters of *B. mori* fed with control MR2leaves and different nutritional supplementary compounds such as amino acids L-Serine (T1), Aspartic acid (T2), Arginine (T3), Vitamins Niacin (T4), Retinol (T5), Calciferol (T6), Ascorbic acid (T7) and Glucose (T8) treated MR2leaves in fed Vinstar larvae of *B. mori* produced pupae. The mean length, width and weight of Vinstar larvae of group 'C'were (2.216±0.127cm, 1.031±0.121cm and 1.218±0.116gm), respectively. The mean length, width and weight of Vinstar larvae of group T1were (2.986±0.263cm, 1.332±0.089cm and 1.546±0.287gm), respectively. The mean length, width and weight of Vinstar larvae of group T2were (2.475±0.271cm, 1.286±0.098cm and 1.390±0.211gm), respectively. The mean length, width and weight of Vinstar larvae of group T3were (2.476±0.187cm, 1.251±0.116cm and 1.321±0.275gm), respectively. The mean length, width and weight of Vinstar larvae of group T4were (2.386±0.196cm, 1.204±0.116cm and 1.283±0.246gm), respectively. The mean length, width and weight of Vinstar larvae of group T5were (2.389±0.186cm, 1.198±0.116cm and 1.289±0.137gm), respectively. The mean length, width and weight of Vinstar larvae of group T6were (2.486±0.169cm, 1.186±0.116cm and 1.259±0.131gm), respectively. The mean length, width and weight of Vinstar larvae of group T7were (2.386±0.109cm, 1.173±0.116cm and 1.290±0.127gm), respectively. The mean length, width and weight of Vinstar larvae of group T8were (2.298±0.169cm, 1.157±0.116cm and 1.246±0.119gm), respectively. In these nine observations, 0.25% amino acid L-Serine (group T1) treated Vinstar larvae produced pupae length, width and weight were significantly increased than the other eight groups ('C', T2, T3, T4, T5, T6, T7, T8).

Table 1. Morphometric data analysis of control and different nutritional supplements treated MR_2 mulberry leave fed *Bombyx mori* larvae produced pupae

Experimental Groups / Concentration	Pupal length (cm)	Pupal width (cm)	Pupal weight (gm)
Control (C)	2.216±0.127^{a}	1.031±0.121^{a}	1.218±0.116^{a}
L-Serine (T1 - 0.25%)	2.986±0.263^{c}	1.332±0.089^{b}	1.546±0.287^{c}
Aspartic acid (T2 - 0.25%)	2.475±0.271^{bc}	1.286±0.098^{ab}	1.390±0.211^{bc}
Arginine (T3 - 0.25%)	2.476±0.187^{bc}	1.251±0.116^{ab}	1.321±0.275^{bc}
Niacin (T4 - 0.25%)	2.386±0.196^{bc}	1.204±0.116^{ab}	1.283±0.246^{ab}
Retinol (T5 - 0.25%)	2.389±0.186^{ab}	1.198±0.116^{ab}	1.289±0.137^{ab}

Calciferol (T6 - 0.25%)	2.486±0.169^{ab}	1.186±0.116^{ab}	1.259±0.131^{ab}
Ascorbic acid (T7 - 0.25%)	2.386±0.109^{ab}	1.173±0.116^{ab}	1.290±0.127^{a}
Glucose (T8 - 0.25%)	2.298±0.169^{ab}	1.157±0.116^{a}	1.246±0.119^{a}

Values are Mean ± Standard Deviation of six observations. Values in the same column with different superscript letters (a, b & c) differs significantly at P<0.05 (DMRT).

Table 2. Morphometric data analysis of control and different nutritional supplements treated MR$_2$ mulberry leave fed *Bombyx mori* larvae produced cocoon

Experimental Groups/ Concentration	Cocoon length (cm)	Cocoon width (cm)	Cocoon weight (gm)
Control (C)	3.201±0.1547^{a}	2.183±0.1210^{a}	1.211±0.1006^{a}
L-Serine (T1 - 0.25%)	3.764±0.2600^{c}	2.441±0.2890^{b}	2.011±0.2631^{b}
Aspartic acid (T2 - 0.25%)	3.530±0.2464^{bc}	2.381±0.1983^{ab}	1.850±0.1963^{ab}
Arginine (T3 - 0.25%)	3.510±0.2301^{bc}	2.353±0.1660^{ab}	1.796±0.1715^{ab}
Niacin (T4 - 0.25%)	3.496±0.2097^{bc}	2.349±0.1514^{ab}	1.624±0.1179^{ab}
Retinol (T5 - 0.25%)	3.417±0.2012^{ab}	2.238±0.1425^{ab}	1.526±0.1605^{ab}
Calciferol (T6 - 0.25%)	3.389±0.1936^{ab}	2.229±0.1492^{ab}	1.403±0.1518^{ab}
Ascorbic acid (T7 - 0.25%)	3.316±0.1744^{ab}	2.219±0.1413^{ab}	1.392±0.1254^{ab}
Glucose (T8 - 0.25%)	3.300±0.1636^{a}	2.201±0.1321^{a}	1.384±0.1127^{a}

Values are Mean ± Standard Deviation of six observations. Values in the same column with different superscript letters (a, b & c) differs significantly at P<0.05 (DMRT).

Table 2 shows that the Morphometric data analysis of length, width and weight of cocoon parameters of *B. mori* fed with control MR2leaves and different nutritional supplementary compounds such as amino acids L-Serine (T1), Aspartic acid (T2), Arginine (T3), Vitamins Niacin (T4), Retinol (T5), Calciferol (T6), Ascorbic acid (T7) and Glucose (T8) treated MR2leaves in fed Vinstar larvae of *B. mori* produced cocoon. The mean length, width and weight of Vinstar larvae of group 'C'were (3.201±0.1547cm, 2.183±0.1210cm and 1.211±0.1006gm), respectively. The mean length, width and weight of Vinstar larvae of group T1were (3.764±0.2600cm, 2.441±0.2890cm and 2.011±0.2631gm), respectively. The mean length, width and weight of Vinstar larvae of group T2were (3.530±0.2464cm, 2.381±0.1983cm and 1.850±0.1963gm), respectively. The mean length, width and weight of Vinstar larvae of group T3were (3.510±0.2301cm, 2.353±0.1660cm and 1.796±0.1715gm), respectively. The mean length, width and weight of Vinstar larvae of group T4were (3.496±0.2097cm, 2.349±0.1514cm and 1.624±0.1179gm), respectively. The mean length, width and weight of Vinstar larvae of group T5were (3.417±0.2012cm, 2.238±0.1425cm and 1.526±0.1605gm), respectively. The mean length, width and weight of Vinstar larvae of group T6were (3.389±0.1936cm, 2.229±0.1492cm and 1.403±0.1518gm), respectively. The mean length, width and weight of Vinstar larvae of group T7were

(3.316±0.1744cm, 2.219±0.1413cm and 1.392±0.1254gm), respectively. The mean length, width and weight of Vinstar larvae of group T8were (3.300±0.1636cm, 2.201±0.1321cm and 1.384±0.1127gm), respectively. In these nine observations, 0.25% amino acid L-Serine (group T1) treated Vinstar larvae produced cocoon length, width and weight were significantly increased than the other eight groups ('C', T2, T3, T4, T5, T6, T7, T8).Economic characters like Cocooning Percentage (CP), Shell Weight (SW), Shell Ratio (SR), Silk Filament Length (SFL) and Denier (D-Silk filament Strength) data analysis of V instar larvae of *B. mori* fed with control MR2 mulberry leaves and different nutritional supplementary compounds such as amino acids L-Serine (T1), Aspartic acid (T2), Arginine (T3), Vitamins Niacin (T4), Retinol (T5), Calciferol (T6), Ascorbic acid (T7) and Glucose (T8) treated MR2leaves fed *B. mori* larvae produced cocoon and silk filament were presented in Table 3.Table 3 shows that the data analysis of control and different nutritional supplementary compounds treated MR2 mulberry leaves fed V instar larvae produced cocoon's cocooning percentage (CP). The cocooning percentage (%) of group 'C' larvae (82.274±0.251%), group T1 larvae (88.951±1.047%), group T2 larvae (86.428±0.965%), group T3 larvae (86.207±0.658%), group T4 larvae (85.761±0.492%), group T5 larvae (85.320±0.476%), group T6 larvae (84.490±0.410%), group T7 larvae (84.088±0.381%) and group T8 larvae (83.828±0.308%) respectively.In these nine observations, 0.25% amino acid L-Serine (group T1) treated Vinstar larvae produced cocoon's cocooning percentage (%) was significantly increased than the other eight groups ('C', T2, T3, T4, T5, T6, T7, T8).Table 3 shows that the data analysis of control and different nutritional supplementary compounds treated MR2 mulberry leaves fed V instar larvae produced cocoon's shell weight (SW). The shell weight (gm) of group 'C' larvae (0.601±0.141gm), group T1 larvae (0.803±0.805gm), group T2 larvae (0.747±0.651gm), group T3 larvae (0.712±0.620gm), group T4 larvae (0.700±0.402gm), group T5 larvae (0.686±0.380gm), group T6 larvae (0.661±0.318gm), group T7 larvae (0.643±0.257gm) and group T8 larvae (0.623±0.204gm) respectively.In these nine observations, 0.25% amino acid L-Serine (group T1) treated Vinstar larvae produced cocoon's shell weight (%) was significantly increased than the other eight groups ('C', T2, T3, T4, T5, T6, T7, T8).Table 3 shows that the data analysis of control and different nutritional supplementary compounds treated MR2mulberry leaves fed V instar larvae produced cocoon's shell ratio (SR). The shell ratio (%) of group 'C' larvae (18.070±0.615%), group T1 larvae (20.020±1.412%), group T2 larvae (19.453±0.898%), group T3 larvae (19.340±0.823%), group T4 larvae (19.217±0.788%), group T5 larvae (19.087±0.754%), group T6 larvae (18.495±0.712%), group T7 larvae (18.370±0.687%) and group T8 larvae (18.230±0.640%) respectively.In these nine observations, 0.25% amino acid L-Serine (group T1) treated Vinstar larvae produced cocoon's shell ratio (%) was significantly increased than the other eight groups ('C', T2, T3, T4, T5, T6, T7, T8).

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Table 3. Economic parameters data analysis of control and different nutritional supplements treated MR_2 mulberry leaves fed V instar larvae of *Bombyxmori* produced cocoon

Experimental Groups / Concentration	Cocooning Percentage (%)	Shell weight (gm)	Shell Ratio (%)	Silk filament Length (Meters)	Denier (%)
Control (C)	82.274±0.251^{a}	0.601±0.141^{a}	18.070±0.615^{a}	810.145±11.074^{a}	2.456±0.080^{a}
L-Serine (T1 - 0.25%)	88.951±1.047^{c}	0.803±0.805^{c}	20.020±1.412^{c}	964.272±12.841^{c}	3.015±0.198^{c}
Aspartic acid (T2 - 0.25%)	86.428±0.965^{b}	0.747±0.651^{bc}	19.453±0.898^{b}	942.210±11.749^{b}	2.820±0.189^{b}
Arginine (T3 - 0.25%)	86.207±0.658^{bc}	0.712±0.620^{b}	19.340±0.823^{b}	911.237±11.655^{bc}	2.763±0.173^{bc}
Niacin (T4 - 0.25%)	85.761±0.492^{bc}	0.700±0.402^{b}	19.217±0.788^{bc}	875.782±11.612^{bc}	2.701±0.171^{bc}
Retinol (T5 - 0.25%)	85.320±0.476^{bc}	0.686±0.380^{ab}	19.087±0.754^{bc}	867.127±11.566^{ab}	2.684±0.160^{bc}
Calciferol (T6 - 0.25%)	84.490±0.410^{ab}	0.661±0.318^{ab}	18.495±0.712^{ab}	849.576±11.548^{ab}	2.654±0.148^{ab}
Ascorbic acid (T7 - 0.25%)	84.088±0.381^{ab}	0.643±0.257^{ab}	18.370±0.687^{ab}	840.801±11.484^{ab}	2.508±0.123^{ab}
Glucose (T8 - 0.25%)	83.828±0.308^{ab}	0.623±0.204^{ab}	18.230±0.640^{ab}	832.785±11.330^{ab}	2.490±0.110^{ab}

Values are Mean ± Standard Deviation of six observations. Values in the same column with different superscript letters (a, b & c) differs significantly at P<0.05 (DMRT)

Table 3 shows that the data analysis of control and different nutritional supplementary compounds treated MR2 mulberry leaves fed V instar larvae produced cocoon's silk filament length (SFL). The silk filament length (meters) of group 'C' larvae (810.145±11.074mts.), group T1 larvae (964.272±12.841mts.), group T2 larvae(942.210±11.749mts.), group T3 larvae (911.237±11.655mts.), group T4 larvae (875.782±11.612mts.), group T5 larvae (867.127±11.566mts.), group T6 larvae (849.576±11.548mts.), group T7 larvae (840.801±11.484mts.) and group T8 larvae (832.785±11.330mts.) respectively.In these nine observations, 0.25% amino acid L-Serine (group T1) treated Vinstar larvae produced cocoon's silk filament length(meters) was significantly increased than the other eight groups ('C', T2, T3, T4, T5, T6, T7, T8).Table 3 shows that the data analysis of control and different nutritional supplementary compounds treated MR2 mulberry leaves fed V instar larvae produced cocoon's silk filament Denier (D). The silk filament Denier (%) of group 'C' larvae (2.456±0.080%), group T1 larvae (3.015±0.198%), group T2 larvae (2.820±0.189%), group T3 larvae (2.763±0.173%), group T4 larvae (2.701±0.171%), group T5 larvae (2.684±0.160%), group T6 larvae (2.654±0.148%), group T7 larvae (2.508±0.123%) and group T8 larvae (2.490±0.110%) respectively.In these nine observations, 0.25% amino acid L-Serine (group T1) treated Vinstar larvae produced cocoon's silk filament Denier (%) was significantly increased than the other eight groups ('C', T2, T3, T4, T5, T6, T7, T8).

DISCUSSION

The supplementation of silkworm with selected lower concentrations of amino acids at certain levels may be effective for improved growth, but a higher level of supplementations doesn't have a positive effect on silkworm growth and development. Supplementations of dietary nutrients with the aforementioned promising complementary additives increased content of leaf moisture that might have lead to higher consumption rate. This might have proportionately increased apparent digestibility that in turn resulted into enhanced digestion, absorption, assimilation and utilization of food energy in to larval bio-mass and cocoon. This might have induced upgrading economic parameters [21]. Further, conversion rate of leaf into silk was also found to be promising depicting higher silk content that represented superiority of silk quality as pointed out earlier [22]. However, found encouraging results with their higher concentration of amino acids aspartic acid and aspargine were not incorporated however, pectin and amino acid mixture were found to be promising; at their lower concentration, higher nutritional indices were found to be highest in Pectin (0.5 %) and Amino acid mixture (0.01 %) when compared with natural diet, which was pointed out the superiority over natural diet [23]. Also found that vitamin B complex significantly improved growth and development, with beneficial effects on the economic characteristics of the cocoon [24]. The improvement of cocoon and silk characters in this experiment may be attributed to improvement of the efficiency of conversion of dietary nitrogen into the cocoon shell. Increase in silk protein showed marked changes in silk percentage when larvae of *B. mori* fed by ascorbic acid. The increase protein or nitrogen in the silkworm diet causes the increase of total protein in the larval haemolymph [25]. Numerous studies have reported a repertoire of compounds for improving the economic traits of the larvae, such as body weight and cocoon weight [26]. The effect of different vitamins on the nutritional enrichment of mulberry leaves and it was found that all the vitamins showed a positive effect on *B. mori* growth and development [27]. Enriching the silkworm diet (mulberry leaves) with exogenous nutrients such as proteins, carbohydrates, amino acids, vitamins, minerals, hormones, antibiotics and assessing their impact on larval growth, metabolism and silk production has become the order of traditional research in sericulture. Ascorbic acid significantly increased the weight of *B. mori* larvae and pupae. Several authors suggested that the enhancement in larval weight was related to phagostimulation of ascorbic acid [28]. In higher doses of vitamin B or C in silkworm diet, the larval weight was considerably decreased. [29]. demonstrated that feeding of high concentrations of ascorbic acid decreased the silkworm larval weight due to hypervitaminosis [30]. Low concentrations of thiamine significantly reduced the developmental periods of silkworm [31]. The larval length, width and weight have been improved when the larvae fed with the supplementation of vitamin C treated mulberry leaves [32]. This observation derives support from the research findings of that feeding of silk worm on mulberry leaves enriched with multi vitamins from fourth instar increased female cocoon shell

weight at 2.5% concentration, while pupal weight got increased at 1% concentration [33]. The weight and the size of cocoon shell ratio and fibroin content of the shell increased with the supplementation of the amino acid, glycine, reported that administration of JH analogue, Methoprene, to fifth in star larvae of *B. mori* through hypodermic injection increased the shell weight by 16 percent over the control [34]. Different diets could alter the expression of proteins (amino acids) in relation to the immune system, digestion and absorption of nutrients, and energy metabolism in silkworms [35]. The weight and the size of cocoon shell ratio and fibroin content of the shell increased with the supplementation of the amino acid, glycine [36]. In the present study, 0.25% concentrated nutritional supplementary compounds treated MR2 mulberry leaves fed silkworm *Bombyx mori* larvae groups' pupal, cocoon and other economic parameters analysis enhanced by all aspects than control *Bombyx mori* larval group. Finally find out the effective nutritional supplementary compound is L-Serine amino acid treated group.

4. CONCLUSION

In the present study to be concluded that the pupal and cocoon morphometric analysis and economic parameters such as cocooning percentage, shell weight, shell ratio, silk filament length and silk filament denier was comparatively enhance by 0.25% concentration of amino acid L-Serine treated MR2 mulberry leave than the control and other nutritional supplementary groups such as Aspartic acid (T2), Arginine (T3), Vitamins Niacin (T4), Retinol (T5), Calciferol (T6), Ascorbic acid (T7) and Glucose (T8).

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CONFLICT OF INTEREST

The author declares no conflict of interest.

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