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Effect of Supplementation of Food Spirulina on Food Utilization in Silkworm *Bombyx Mori* L.

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Abstract
The effect of Supplementation of food especially Spirulina on food intake and utilization was studied in Cross Breed race of Silkworm *Bombyx mori* (Linnaeus) in IV and V instar larvae, when fed with *ad libitum* Mulberry leaves *Morus alba* treated with three different concentrations of food Spirulina at 26°±2°C with a relative humidity of 80±10%. The food utilization parameters like food intake, feces defecation, assimilation, food converted, oxidation, feeding rate, assimilation rate, conversion rate, metabolic rate, assimilation efficiency, conversion efficiency (K1 and K2) were studied. It has been observed that the 2% Spirulina treated group plays a significant role with an increase in growth and better food intake which averages 14422.41 mg/mg/day compared to control group i.e., 3185.366 mg/mg/day and also other two Spirulina treated groups i.e., 1% and 1.5% concentrations.

Keywords
Bombyx mori, Food utilization parameters, *Morus alba,* Spirulina.

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INTRODUCTION
Living organisms obtain energy from organic and inorganic sources mostly from carbohydrates, fats, and proteins. The study of Bioenergetics is a very important fundamental aspect in Life Science which is concerned with molecular, biochemical and physiological aspects of Bioenergetics in insects [1]. Among invertebrates extensive studies have been made on the Bioenergetics of insects, the contribution [2] on *Bombyx mori* L. is the most complete study of food utilization budget in insects. Silkworm *Bombyx mori* L. is an important economic insect in silk production and also an important tool to convert leaf protein into silk. The leaf of *Morus alba* is an important source of food for *Bombyx mori* L. and the nutritional quality of leaf plays a vital role in determining the yield and growth of the larva [3]. Spirulina is a cyanobacteria which can be consumed by human and other animals. It is a very important dietary supplementary food. In recent years attempt are made in Sericulture with nutrients such as proteins, carbohydrates, amino acids, vitamins, sterols, hormones, antibiotics etc., for better performance and to get higher yield of cocoons [4]. Since Spirulina has a high nutritive value as it is rich in carbohydrates, fats, proteins, vitamins, minerals. Hence Spirulina was selected as a supplementation of food in food utilization of *Bombyx mori* L. in CB race in two penultimate instars (IV and V instar).

MATERIALS AND METHODS
The disease-free laying of Cross Breed race of *Bombyx mori* L. were obtained from chawki rearing center Tumbadi, a village in Koratagere taluk,

Tumkur district, Tumakuru. After a period of 10 days freshly hatched larvae were transferred to enamel trays (36 x 26 x 4 cm) covered with paraffin paper to prevent loss of water from the leaf bed. The experiment is conducted with freshly moulted larvae belonging to IV instar, continued till pupation, arranged in triplicate. The larvae fed *ad libitum* mulberry leaves (*Morus alba*) with the different concentration of Spirulina at room temperature of 26°±2°C with a relative humidity of 80%±10%. In the present study Spirulina tablets were used. The larvae of experimental group was fed with mulberry leaves treated with different concentrations of Spirulina four times at 6.A.M, 11.A.M, 3.P.M and 8.P.M. Simultaneously, the larvae were reared under control condition without Spirulina concentration at 26°±2°C with a relative humidity of 80%±10%. Its effect on Spirulina concentration and food utilization were studied by using IBP formula and technology [5]. Sacrificial method described by [6] for accessing the growth of laboratory mammals and fishes [7, 8, 9] and insects [10] was employed in the present study. The difference between the final weight and initial weight is the growth of insect in each instar. The data were analysed by using mean and standard deviation.

RESULTS AND DISCUSSION

Studies on food consumption, digestion, and utilization of food in insects are the fundamental important basis for the proper understanding of nutrition of insects. Lepidopteran insects specially the larvae of silkworm *Bombyx mori* L. consume more than 90% of food during penultimate two instars [11, 12]. The quality of food consumed by *Bombyx mori* L. has direct effect on growth, development, and performance of the individual from fourth instar to pupation (Table1). The larval period had no variation depending on concentration of Spirulina fed with mulberry leaves *Morus alba*. The control batch of Cross breed race completed its two instars (IV and V instar) for 10 days and it was same for the three different concentrations of Spirulina. The food intake was highest at 2% concentration ranged to 14422.41 mg dry weight and decreasing from 1% and 1.5% fed concentration of Spirulina. The food assimilation and food oxidation were significantly higher in those silkworms treated with 2% concentration compared to that of control groups (Table 2). However, the gross conversion efficiency (K1) increases in control group i.e., it averages 12.72% compared to Spirulina treated groups which averages 1.085%, 1.117% and 1.455% in 1%, 1.5% and 2% Spirulina concentration respectively (Table 3). The total food intake, feeding rate, assimilation efficiency registered a slight increase over the control feed at 26°±2°C and with relative humidity 80±10%.

From the data, it is evident that Spirulina plays a key role in silkworm physiology and that this role changes according to the development stage. Feeding trials conducted by several workers proved that the level of nutrients in different varieties of mulberry leaves has significantly influenced on growth and development of silkworm and cocoon production [13, 14]. Feeding rate in the silkworm *Bombyx mori* L. decreased with increase in the body weight or age irrespective of the factors like food quality, Scotoperiod or photo period [2, 15]. Further it can be concluded that improvement in the quality of mulberry leaves by fortification methods with different concentration of Spirulina can improve the economic parameters of *Bombyx mori* L.

Table 1: Effect of Supplementation of food Spirulina on the total food intake, faeces defecated, assimilation, conversion and food oxidized in IV and V instar larvae up to pupation in Silkworm *Bombyx mori* L. [Cross Breed Race], fed *ad libitum Morus alba* at 26°±2°C and 80%±10% RH at different concentrations. The control worms were maintained at room temperature. All the values are expressed as mg dry weight per instar.

	Control	**1%**	**1.5%**	**2%**
Life span	10	10	10	10
Food Intake	3185.366 ± 15.521	12159.99 ± 1277.18	14334.22 ± 2599.42	14422.41 ± 997.43
Faeces defecated	1633.596 ± 374.675	475.21 ± 301.36	3079.08 ± 795.52	3123.96 ± 384.16
Food assimilated	1551.79 ± 172.47	6706.50 ± 3926.96	11210.23 ± 549.35	11301.01 ± 5552.3
Food converted	369.316 ± 33.136	490.19 ± 23.54	519.32 ± 26.83	592.26 ± 63.88
Food oxidized	1182.46 ± 145.058	8780.48 ± 1493.48	11136.03 ± 1760.6	11313.54 ± 4713.61

Table 2: Effect of Supplementation of food Spirulina on the total feeding rate, assimilation rate, conversion rate and metabolic rate in IV and V instar larvae up to pupation in Silkworm *Bombyx mori* L. [Cross Breed Race], fed *ad libitum Morus alba* at 26°±2°C and 80%±10% RH at different concentrations. The control worms were maintained at room temperature. All the values are expressed as mg dry weight/ mg wet weight/ insect / day.

	Control	1%	1.5%	2%
Feeding Rate	0.2828 ± 0.0086	1.4644 ± 0.2329	2.0694 ± 0.1905	2.10916 ± 0.4414
Assimilation Rate	0.1426 ± 0.0126	1.1615 ± 0.2180	1.5828 ± 0.4391	1.6968 ± 0.2603
Conversion Rate	0.0354 ± 0.0014	0.01896 ± 0.0052	0.02186 ± 0.0012	0.0502 ± 0.0375
Metabolic Rate	0.1072 ± 0.0112	2.2504 ± 1.2482	2.7361 ± 1.6397	3.1736 ± 0.1855

Table 3: Effect of Supplementation of food Spirulina on the Assimilation efficiency, Gross Conversion Efficiency (K1) and Net Conversion Efficiency (K2) in IV and V instar larvae up to pupation in Silkworm *Bombyx mori* L. [Cross Breed Race], fed *ad libitum Morus alba* at 26°±2°C and 80%±10% RH at different concentrations. The control worms were maintained at room temperature. All the values are expressed in percent.

	Control	1%	1.5%	2%
Assimilation efficiency	50.686 ± 4.441	78.9198 ± 4.9999	81.914 ± 5.2852	81.924 ± 2.3875
Gross Conversion Efficiency (K1)	12.7256 ± 0.9002	1.0856 ± 0.3886	1.1178 ± 0.1186	1.45566 ± 0.2093
Net Conversion Efficiency (K2)	25.0348 ± 1.6834	1.3118 ± 2.3856	1.41144 ± 0.2463	1.81702 ± 0.1883

CONCLUSION

In the present study it is evident that the Spirulina with different concentration affects the biological characteristics of silkworm by significantly increased body weight, where the growth is enhanced. This confirms by adding supplementation of food like Spirulina along with mulberry leaves resulted in the increase of yield and silk production which can be practiced by farmers in Sericulture, and it is beneficial in Sericulture industry.

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