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Evaluation of various parameters of consumption indices of the silkworm hybrids administered with cholesterol content during 4th instar silkworms

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Abstract
In the present investigation an attempt has been made to study the various parameters of consumption indices in relation to the different concentration of cholesterol supplementation during 4th instar silkworm of FC_1XFC_2 and FC_4XFC_3 hybrids. The food consumption comprises the ingesta and digesta during 4th instar showed the level of ingesta was significantly higher compare to digesta in all the cholesterol treated batches in all 4 days, but on 4th day the rate of food consumption represents the highest rate of ingesta in the selected hybrids. Similarly the approximate digestibility was maintained ranging from 50-85% in cholesterol treated batches, whereas the efficiency of conversion of food ingested and efficiency of conversion of food digested were low ranging from 5-38% in FC_1XFC_2 and FC_4XFC_3 silkworm hybrids. The consumption index and coefficient of metabolism are the two nutritional parameters indicates the maximum attainment ranging from 0.8-0.9 ratio in all the days in all the cholesterol treatment concentration, whereas the growth rate was constantly maintained during 4th instar ranging from 0-0.05 throughout the instar in FC_1XFC_2 and FC_4XFC_3 hybrids. The pattern of changes in the ingesta and digesta of 5th instar silkworm, but cholesterol supplemented during 4th instar extended the above parameters ranging from 9-14g from first day to day seventh, whereas the digesta falls within a range of 9g during 5th instar in both the hybrids. The efficiency of conversion of food ingested, efficiency of conversion of food digested and approximate digestibility of 5th instar silkworm hybrids treated with three doses of cholesterol during 4th instar a showed the magnitude of changes above the level of 50% in FC_4XFC_3 hybrid, but the FC_1XFC_2 represents less than level of 50% except 5th day and 7th day during 5th instar. The consumption index, growth rate and co-efficient of metabolism were calculated during 5th instar the ratio was ranging from 0-1 in all the three parameters except consumption index and co-efficient of metabolism on 7th day ranging from 6-7 and 2-3 on respectively on the last day of 5th instar in FC_1XFC_2 and FC_4XFC_3 hybrids.

Keywords: consumption indices, silkworm hybrids, cholesterol content, late age silkworms

Introduction
Nutritional efficiency is considered as important to assess the cost benefit ratio of sericulture practices up to the level of cocoon production. The efficiency of converting the ingested and digested food into the body, cocoon and cocoon shell varies among silkworm races under the influence of season and mulberry varieties. Nutritional quality as well as environmental condition has greater impact on regulation over the quantum of ingesta, digesta and digestibility of food among silkworm. Recently new productive bivoltine double hybrids suitable for rearing throughout the year of Indian conditions have been evolved and introduced into the field with increase temperature 20-30 ^oC leaf silk conversion rate decreases. Studied the effect of temperature on nutritional efficiency of multivoltine and bivoltine silkworm larvae respectively. The present study has been taken up to assess the effect of different temperature and humidity conditions of feed conversion efficiency of elite bivoltine CSR double hybrids.

Cholesterol is a dominant sterol that accumulates in eggs regardless of dietary sterol components. Ichimasa (1976) [4] found that in the silkworm, the accumulation of sterol esters was higher in diapause than in non-diapause ovaries. Cholesterol is transformed from the fat body tissues to the eggs through lipophorin in a temperature dependent aqueous diffusion mode of action. 90% reduction in haemolymph cholesterol titers by dietary intervention brought about 10-20% reduction in egg production in adult female *Locusta migratotia*. In the eggs laid, ecdysteroid content varied and severe developmental abnormalities were observed. In view of the importance of the ecdysteroid derivatives in the larval growth the effects of

exogenous cholesterol on a number of nutritive parameters of consumption indices and economic traits of the silkworm hybrids are taken up in the present investigation

Materials and Methods

In the present study two productive double hybrids namely $FC_1 \times FC_2$ and $FC_4 \times FC_3$ were chosen and reared throughout the year under Indian conditions were utilized. Rearing was conducted as per the standard package and recommendation (Krishnaswamy, 1978) [6] by providing healthy fresh leaves of V_1 mulberry variety.

The feed utilization study was confined only to IV and V instar larva as 80-85% of the total leaf consumed in these instar. On consumption of IV instar silkworm larvae three replicates were separated from each batches of double hybrids and kept in normal temperature of 28-30 ºC and 80% humidity condition Known quantities of mulberry leaves were provided to silkworm thrice a day taking utmost care to maintain the leaf moisture content to the maximum possible extent.

Sample of mulberry leaves used for feeding was placed in separate tray as dummy for dry weight determination of Ingesta. Additional larval batches of each hybrids were maintained in parallel to determine the dry weight and subsequent determination of daily increment in larval weight. The healthy larvae were unhealthy and dead larvae were removed. The litter was selected carefully on subsequent days of feeding. The excreta and left over leaf in the litter were manually separated and dried in an oven to a constant weight. Observation on dry weight of left over leaf, excreta, larval weight gain, cocoon weight and shell weight were recorded for all the replications of each treatment.

From these data, nutritional indices like, ingesta, digesta, approximate digestibility percentage (AD %), efficiency of conversion of ingested food (ECI), efficiency of conversion of digested food into body substance (ECD), consumption index (CI), growth rate and coefficient metabolism of the selected bivoltine $FC_1 \times FC_2$ and $FC_4 \times FC_3$, a newly evolved productive double hybrids were utilized in the present investigation. The freshly moulted 4th instar silkworm larvae were grouped into four batches, each batch having three replication of 100 silkworm and maintained constant of temperature 25±1˚C and 70±5% Relative humidity during the silkworm rearing.

Cholesterol treatment

Cholesterol (Procured from Sisco Research laboratories Ltd., Mumbai, India) was dissolved in small quantity of chloroform and diluted with ethyl alcohol to 0.01, 0.1 and 0.5M concentrations. The mulberry leaf was smeared on the ventral surface with 1ml solution and after drying fed to 4th instars larval stage in separate batches. The cholesterol -smeared leaf was offered first on the day of treatment, and after the leaf was fed upon completely to the group of 100 larvae. The batch-I larvae are considered as carrier control as the larvae fed with normal mulberry leaf sprayed with ethyl alcohol aliquots. However, the other three batches containing 100 larvae each (in three replicates) were fed on the three doses of uniformly smeared cholesterol treated leaves on 1st, 3rd and 5th day. Cholesterol supplemented leaf was provided during the first feeding on the day of treatment. A total of three feeding are provided every day.

Nutritional indices

Fresh leaves of mulberry were cut through midrib into two symmetrical halves, one half was used to find out the moisture content of the leaves and the other half was weighed and smeared with known volume of cholesterol. Equal and known quantity of leaf was offered to all silkworm batches, taking into consideration the consumption level on each day of 4th instars larval development. The left over leaf of the excreta were dried in a hot air oven at 80 ˚C till constant weight and the values were recorded. The initial and final wet and dry weights of larvae were recorded every day. Daily food consumption and utilization were recorded by following the standard gravimetric method. The dry weights of leaf ingested and digested by each larva were calculated and the nutritional indices such as approximate digestibility (AD), efficiency of converting leaf ingested (ECI) and leaf digested (ECD) into larval body substance, consumption index (CI), growth rate (GR) and coefficient metabolism (COM) were calculated as per the empirical formulae provided by Waldbauer (1968) [8] are as follows.

Leaf ingested

Leaf ingested is the amount of leaf consumed by the larva for the specific period.

Leaf ingested = dry weight of the leaf offered - dry weight of left over leaf.

Leaf digested

Leaf digested is the amount of leaf assimilated by the larva for the specific period.

Leaf digested = dry weight of the leaf ingested -dry weight of excreta

Efficiency of conversion of ingested food (ECI)

Efficiency of conversion of ingested food into body substance is the percentage of ingested food contributing to weight gain the larva

$$\mathbf{ECI} = \frac{\text{Dry weight gained by larva}}{\text{Dry weight of food ingested}} \text{X } 100$$

Efficiency of conversion of digested food into body substance (ECD)

Efficiency of conversion of digested food into body substance is the percentage of digested food in dry weight contributing to weight gain the larva

$$\mathbf{ECD} = \frac{\text{Dry weight gained by larva}}{\text{Dry weight of food digested}} \text{X } 100$$

Approximate digestibility (AD %)

Approximate digestibility is the percentage of ingested food digested and absorbed

$$\mathbf{AD} = \frac{\text{Weight of food digested}}{\text{Weight of food ingested}} \text{X } 100$$

Consumption index (CI)

Consumption index is the quantity of food consumed for the observe increase in the larval

$$\mathbf{CI} = \frac{\text{Dry weight of food consumed}}{\text{Duration of feeding period x mean dry weight of larva during feeding period}}$$

Growth rate

Growth rate is the unit weight gain for the day

$$\mathbf{GR} = \frac{\text{Dry weight gain of larva during feeding period}}{\text{Duration of feeding period x Mean dry weight of larva during feeding period}}$$

Coefficient of metabolism

Coefficient of metabolism is the fraction of digested food required for metabolic activity of produce the observed weight gain for the day

$$\mathbf{COM} = \frac{\text{weight of food digested} - \text{increase in weight of larva}}{\text{Weight of food digested}}$$

Results and discussion

The consumption of food and utilization of all the essential energy metabolic resources to facilitate the biochemical and physiological events of the cells, it is mandatory programme in all the multicellular organism and eukaryotic system, so that a continuous supplementation of the food reservoir may be permitted and acquired a consistent growth, development, maturation and reproduction followed by the continuation of the life cycle, similarly in silkworm an attempt as been made to intricate the successive consumption indices parameter as well as the utilization index by providing recommended amount of mulberry as food soles source during 4th instar of selected silkworm hybrids namely, FC_1XFC_2 and FC_4XFC_3 for the evaluation of the consumption and nutritional indices. The silkworm rearing was conducted as per the standard procedure recommended by Krishnaswamy (1978) [6] with the available V_1 variety in the Department of Sericulture, University of Mysore. Three feeding schedules in order to achieve required stage and age of the silkworm especially 4th instar and experimental design was made during the 4th instar there are 3 different replications with 100 larvae each for the supplementation of different concentration of fortified cholesterol on 100 g mulberry leaves such as 0.01M, 0.1M and 0.5M of cholesterol smeared on the ventral surface of the leaves with the help of brush and allowed for drying under room temperature to percolate the cholesterol content into the cuticle and fed the mulberry leaf to the different batches of the silkworm during morning hours till the completion of development stage, but remaining feeding was only mulberry leaf is free from the cholesterol treatment. At the same time parallel control batches maintained for the comparative evaluation of the essential components of consumption similarly, the 5th instar silkworm chosen with 3 different replications with suitable control of 100 healthy silkworm larvae and assessed all the above parameters with regard to the cholesterol fortified mulberry leaves for the various parameters of consumption indices.

The economic characters of selected potential hybrids namely, FC_1XFC_2 and FC_4XFC_3 were evaluated and subjected for the statistical analysis to understand the performance and expression of quantitative and qualitative traits in cholesterol treated with different concentration and compared with untreated control. It is a most essential nutritive source for the silkworm in the manifestation of cellular and sub cellular functions during the course of development, lipogenesis, yolk synthesis, formation of excess of reserve food material in the fat body tissue, utilize further development of transformation from one stage to the another stage such as larval moulting, larval pupal transformation, pupal adult transformation as essential in the form of polyunsaturated fatty acids (PUFAS) in the present study with an objective of the consumption parameters, nutritional indices and enhancement and manifestation of economic characters in the selected productive hybrids.

The present findings consists the parameters, Ingesta, Digesta, ECI (Efficiency of conversion of food ingested), ECD (Efficiency of conversion of food digested), AD (Approximate digestibility), CI (Consumption index), GR (Growth rate), COM (Co-efficient of metabolism) were evaluated. The ingesta is invariably decreased in the order of different concentration of cholesterol treatment in all the days of 4th instar silkworm larvae and consistent over the control batches showed a maximum Ingesta, whereas the digesta also showed as a same pattern and trend among the treatment as well as in control, a negligible changes observed in both the parameters of the food consumption but proportionately different among the ingesta and digesta but maximum only the ingesta of all the days in control and cholesterol treated FC_1XFC_2 hybrid on the other hand food utilization namely ECI and ECD a greater level of ECI on day 2 at 0.5M concentration (18.467) but remaining days has a consistent but relatively low in ECI rate, whereas ECD is one of the food utilization parameter. There is a significant improvement in the 0.5M concentration. It is one of the sources for the better manifestation and improvement of economic traits, the 0.5M (8.66) on first day, 2nd day (35.76), 3rd day (23.45), 4th day (30.22). The comparison of ECD with a control batches boosting or enhanced 50 % of digestibility, efficiency in cholesterol treated batches. The Approximate digestibility percentage in FC_1 X FC_2 hybrid was significantly high among the control and treated batches of 1st day followed by 2nd, 3rd and 4th day were consistently decreased and 4th day it is lowest at 0.1 M (41.49) it is under subsequent moulting process and therefore it is reduced all most 50 % in approximate digestibility comparable to day first. The rate of consumption index is proportionately similar to approximate digestibility and maximum in control (0.82) and consistently reduced when the day advances up to the end of the 4th instar and it is lowest of 0.25 in 0.1 M on 4th day as far as the growth rate is concerned. It is the presented a consistent in all the concentration in all the days without much of differences as per the table values. A consistent coefficient of metabolism was recorded day 1 and 2 but the cholesterol treated concentration as relatively less compared to control whereas 3rd and 4th day has a consistent coefficient of metabolism and 0.787 is the lowest at 0.1M concentration in 4th day. The graphical representation indicated in fig.1 showed the total collective food consumption and utilization of FC_1XFC_2 hybrids subjected to the cholesterol supplementation with different concentration in all the four day during 4th instar.

The productive silkworm hybrid namely, FC_4XFC_3 also subjected for the study of food consumption parameters like Ingesta, digesta were significantly higher in untreated control in all the four days. On the other hand the cholesterol treated in different concentration of 0.01, 0.1 and 0.5 M showed a consistent observed values in the level of ingesta and digesta in the order of decrease in all the days of 4th instar except at 0.01 M on second day showed the highest level of ingesta and digesta it is important to note that influence as the growth promoting factor in the silkworm for the enhancement of the nutritional efficiency. The ECI and ECD were slightly decreased in untreated silkworm during 4th instar but in cholesterol administered silkworm at 0.5 M concentration on 2nd day and 3rd day as more of conversion of efficiency (18.46) ECI and (35.76) ECD as well as 15.14 and 23.45 respectively, but on 4th day at 0.1 M showed a relatively greater level of ECI of 16.20 and 39.04 of ECD compare to the other treated concentration. The approximate digestibility of FC_4XFC_3 during 4th instar showed the highest percentage of 92.96 and consistently decreased throughout the larval duration of 4th instar and lowest was recorded at 0.1 M concentration (41.49). The control batches of all the days representing a maximum approximate digestibility than the cholesterol fortified mulberry leaf fed to the silkworm. The same trend has been observed in consumption index and highest was recorded in the day1 and lowest on 4th day at 0.1 M (0.26) the food utilization parameters like ECI, ECD, AD, and CI collectively reflected on the growth rate was constant in 4th instar in all the 4 days as well as co-efficient of metabolism is attained maximum and the day 1 and decreased on remaining days of 4th instar in FC_4XFC_3 hybrid.

The application of different concentration of the aqueous cholesterol solution fortified on mulberry leaves and supplemented during 4th instar as well as the consumption and nutritional indices were evaluated in 5th instar. During the period of 5th instar cholesterol free mulberry leaves were fed (without cholesterol treatment) and adjudicated all the above parameters. The pattern of changes in the food consumption during all the 7 days were efficiently triggered the level of ingesta, digesta were maximized to possible extent in untreated silkworm represented as control subsequently in the treated silkworm a narrow decline in the rate of ingesta and digesta in developmental days of the 5th instar. The values of the ingesta and digesta showed a same trend of decrease compared to treatment and control respectively in all the days of development. The digesta was relatively lesser compare to ingesta. The food utilization parameters like ECI, ECD is in the order of increase as the concentration of the cholesterol level increased during the all the days of 5th instar compare to control batches and maintained throughout the 5th instar. The first and seventh day both ECI and ECD were drastically increased every day of development as and reach maximum of 80.80%, 912.06 ECD level on 7th day before day of spinning period and the lowest ECI is recorded on first day (13.66) of ECI and (17.40) ECD respectively. However the approximate digestibility is inversely proportional to ECI and ECD from the day 1 to 7 stating that the maximum digestibility was noticed on the first day and slowly declined when the age advances till the day of spinning in untreated control and cholesterol treated batches of the silkworm at the same time the consumption index also impinging in the same direction as a trend in approximate digestibility. Otherwise the approximate digestibility and consumption index are parallel in the order of the developmental events during the 5th instar. In all the days' maximum consumption index was 0.305 and day first and the lowest on 7th day 0.052. In FC_1XFC_2 hybrid also subjected for the determination of growth rate emphasizes the maturity especially in 5th instar. It is a significantly increased day to day consistently over a period of time it is reached the maximum growth rate 0.586 on 7th day starting from 0.055 growth rate on day 1st of 5th instar of FC_1XFC_2 hybrid. similarly co-efficient of metabolism is also determined in the investigation the level of the co-efficient of metabolism is relatively high on 1st day control and slowly decreased invariably in treated and control batches till the 6th day and on 7th day it is reverted again the maximum of 2.84 on the verge of 0.5 M of cholesterol administration. Thus the results are represented for the nutritional indices. The FC_4XFC_3 potential bivoltine hybrid was utilized to carry out the assessment of nutritional indices and it is better responded a consistent efficiency in the ingesta and digesta with a same trend as observed in ingesta and digesta of FC_1XFC_2 hybrids. The remaining parameters of ECI, ECD, and AD%, CI, GR and COM were represents a marginal differences in a daywise treatments and but the trend has been observed as most similar in maximum possibilities under the investigation of nutritional indices.

The *Bombyx mori* larval feeding behavior through continuous observations of throughout larval development. In addition to this analysis, the behaviours of starved larvae were also observed to determine how diet-deprivation affects feeding behaviour. Finally, the study examined defecation and physical stimulation in *Bombyx mori* larvae as possible triggers for feeding. Enrichment of mulberry leaves with vitamin E did not have significant effect on food consumption in silkworm larvae. The relationship between the environment and genes has considered bidirectional with food consumption efficiency on gene expression varies depending on the genetic background of an organism and expressed physiological or nutritional unit in gene regulation (Giacobino *et al*., 2003; Kang, 2008; 2009) [1, 5] has reported that dry matter consumed by silkworm was directly proportional to nitrogen contents of the leaves. Mahmood, (1989) has concluded that leaves dipped in 0.2% N solution produced the larvae with maximum weight as compared to the other doses Rehman, (1997) [7] has concluded that optimum doses of minerals in various combinations, when used enhanced silk production and silkworm growth to a greater extent than control. During the entire larval life, mean food was converted into body matter was 74.55%. Nutritional requirement in food consumption have direct impact on the overall genetic traits such as larval and cocoon weight, amount of silk production, pupation and reproductive traits. Silkworm nutrition refers the substances required by silkworm for its growth and metabolic functions and obtained from ingested food of mulberry/artificial diet and remaining other nutritional components are being synthesized itself through various biochemical pathways including protenaceous silk fiber of commercial interest (Hamano *et al*., 1986; Zhang *et al*., 2002) [3, 9].

The role of dietary sterols in nutrition and physiology of phytophagous insects like *B.mori* has been well documented (Hamamura, 1961; Bernay and Singer, 1998) [2]. The inability of the insect to synthesize sterols generates sterols auxotrophy, impairing insect growth and development on sterol deficient diets, insect posses' remarkable ability to convert dietary sterols into cholesterol. The nutritional value of sterols in the host plants depends on the ability of the insect to convert into cholesterol. The feeding behaviour in insects is therefore guided by the predominant sterol in the host plant. Hamamura *et al*., (1961) [2] reported that sitosterol stimulated

feeding response in *B. mori*. Also, sitosterol elicited better biting response than cholesterol and ergosterol in *B. mori*. Cholesterol provides indirect supports to silk biosynthesis in its precursor role towards ecdysteroids synthesis but is directly involved in egg development. Cholesterol is dominant sterol that accumulates in eggs. Cholesterol is esterifies and stored in higher quantities in diapauses eggs than in non-diapauses eggs. Cholesterol free diets do not significantly affect egg production in adult female *Locusta migratoria* but embryonic development and rate of hatching are severely altered by low ecdysteroids levels. Though cholesterol free diets may not affect egg production in lepidopteran insects, cholesterol supplemented diet has significantly improved the fecundity from in control of 0.1 and 0.01M cholesterol concentrations in *Bombyx mori.* Cholesterol is essential for normal embryonic development through its supports for ecdysteroid synthesis and its involvement in the formation of new membrane in association with phospholipids.

Table 1: Food consumption and utilization of FC_1 X FC_2 hybrid treated with three doses of cholesterol during fourth instar silkworm (Each value is mean of three observations±SD)

Days	Conc.	Fresh larval wt. (g)	Dry larval wt. (g)	Fresh left over leaf (g)	Dry left over leaf (g)	Fresh litter (g)	Dry litter (g)
		Mean ± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD
1	Control	0.184±0.003	0.420±0.010	23.817±0.035	11.363±0.067	0.264±0.005	0.580±0.010
	0.01 M	0.196±0.002	0.450±0.010	28.803±0.627	13.497±0.341	1.173±0.081	1.080±0.087
	0.1 M	0.198±0.006	0.460±0.026	28.433±0.887	12.293±0.794	1.117±0.021	1.007±0.038
	0.5 M	0.441±0.432	0.430±0.026	27.920±0.680	12.870±0.082	1.127±0.042	1.773±0.679
2	Control	0.364±0.006	0.600±0.010	28.770±0.114	12.943±0.465	3.057±0.136	2.767±0.199
	0.01 M	0.327±0.025 NS	0.597±0.006 NS	30.593±0.292	12.780±0.192	1.863±0.015 NS	1.487±0.006 NS
	0.1 M	0.341±0.020	0.600±0.010	30.530±0.659	13.410±0.341	2.260±0.261	1.810±0.165
	0.5 M	0.329±0.005	0.607±0.012	30.150±0.446	16.320±0.941*	1.887±0.045	1.590±0.036
3	Control	0.480±0.010	0.737±0.015	29.317±0.292	12.433±0.021	2.360±0.208	1.970±0.010
	0.01 M	0.520±0.046	0.740±0.020	30.297±0.794	13.963±0.110	2.037±0.025	1.877±0.025
	0.1 M	0.494±0.017	0.747±0.006	30.447±0.933	14.333±0.428	1.970±0.053	1.850±0.050
	0.5 M	0.501±0.029	0.757±0.021	30.933±0.232*	14.607±0.040	1.913±0.116 NS	1.773±0.178 NS
4	Control	0.546±0.002	1.030±0.010	18.230±0.256	10.810±0.223	4.100±0.020	3.617±0.015
	0.01 M	0.553±0.021	1.027±0.006 NS	21.303±0.302	12.293±0.344	4.587±0.116*	4.017±0.076*
	0.1 M	0.574±0.018*	1.053±0.015	20.150±0.391	13.107±0.367	4.253±0.142	3.803±0.144
	0.5 M	0.569±0.025	1.077±0.025*	18.463±0.289	12.243±0.266	4.307±0.125	3.800±0.040

*significant at (0.05%) of probability
NS=Non significant

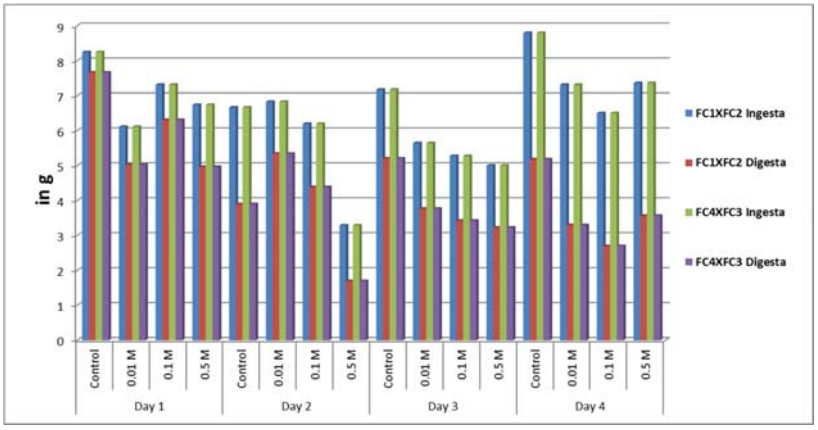

Fig 1: Changes in the food ingesta and digesta of selected hybrids treated with different doses of cholesterol during 4th instar silkworm

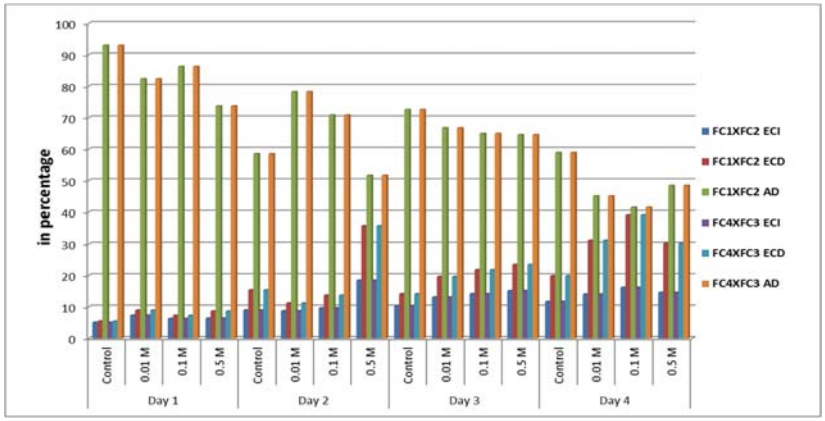

Fig 2: Changes in the efficiency of conversion of ingesta, efficiency of conversion of digesta and approximate digestibility of hybrids during 4th instar silkworm treated with different doses of cholesterol

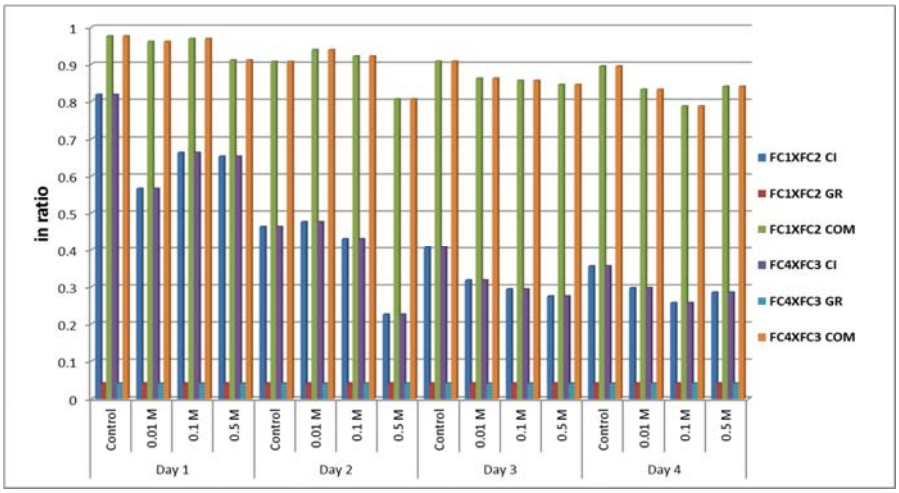

Fig 3: Changes in the consumption index, growth rate and coefficient of metabolism of hybrids during 4th instar silkworm treated with different doses of cholesterol

Table 2: Food consumption and utilization of FC_4 X FC_3 hybrid treated with three doses of cholesterol during fourth instar silkworm (Each value is mean of three observations±SD)

Days	Conc.	Fresh larval wt. (g)	Dry larval wt. (g)	Fresh left over leaf (g)	Dry left over leaf (g)	Fresh litter (g)	Dry litter (g)
		Mean ± SD	Mean ± SD	Mean± SD	Mean± SD	Mean ± SD	Mean± SD
1	Control	0.185±0.002	0.443±0.015	23.763±0.095	11.600±0.100	0.730±0.010	0.630±0.010
	0.01 M	0.200±0.011	0.473±0.032	28.027±0.662	12.343±0.713	0.893±0.067	0.830±0.050
	0.1 M	0.194±0.015	0.503±0.015	29.387±0.893	14.337±0.284	0.953±0.064	0.907±0.055
	0.5 M	0.216±0.018	0.523±0.015	25.720±0.433	13.827±0.961	1.053±0.040	0.967±0.021
2	Control	0.367±0.002	0.620±0.010	28.890±0.100	13.263±0.163	1.833±0.015	1.450±0.010
	0.01 M	0.343±0.022 NS	0.650±0.026	30.817±0.852	16.183±0.185*	1.933±0.015	1.243±0.557
	0.1 M	0.351±0.015	0.650±0.026	31.753±0.148	14.560±0.979	1.957±0.067	1.577±0.045
	0.5 M	0.369±0.017	0.673±0.006	29.670±0.282	13.460±0.324	2.240±0.036	1.807±0.040
3	Control	0.498±0.001	0.830±0.010	26.810±0.221	11.757±0.035	1.667±0.015	6.603±0.015
	0.01 M	0.533±0.022	0.857±0.025	29.523±0.366	12.497±0.015	1.977±0.015	1.553±0.032 NS
	0.1 M	0.515±0.052	0.870±0.017	30.803±0.832*	12.837±0.266	2.007±0.040	1.773±0.220
	0.5 M	0.527±0.006	0.850±0.010	30.410±0.546	12.610±0.062	2.063±0.161	1.837±0.275
4	Control	0.414±0.012	1.017±0.015	18.540±0.108	12.547±0.050	4.370±0.061	3.333±0.015
	0.01 M	0.602±0.023*	1.053±0.021	18.580±0.350	12.410±0.450	4.593±0.064*	4.293±0.021*
	0.1 M	0.595±0.044	1.057±0.025	19.667±0.519	12.647±0.543	4.367±0.038	4.140±0.314
	0.5 M	0.595±0.049	1.067±0.035*	20.033±0.403	12.090±0.598 NS	4.450±0.182	4.080±0.101

*significant at (0.05%) of probability
NS=Non significant

Table 3a: Food consumption and utilization of FC_1 X FC_2 5th instar silkworm hybrid treated with three doses of cholesterol during fourth instar (Each value is mean of three observations±SD)

Days	Conc.	Fresh larval wt. (g)	Dry larval wt. (g)	Fresh left over leaf (g)	Dry left over leaf (g)	Fresh litter (g)	Dry litter (g)
		Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD
1	Control	0.646±0.002	1.173±0.006	20.393±0.525	10.223±0.090	2.263±0.015	1.930±0.010
	0.01 M	0.651±0.052	1.250±0.020	23.313±0.085	10.557±0.401*	2.967±0.050	2.280±0.087
	0.1 M	0.664±0.036	1.327±0.110	25.517±0.126*	9.660±0.354	2.797±0.015	2.253±0.078
	0.5 M	0.603±0.021	1.370±0.010	22.437±0.415	9.443±0.168 NS	2.643±0.074	2.017±0.015
2	Control	1.044±0.006	3.367±0.012	16.310±0.036	7.827±0.735	5.890±0.168	4.440±0.498
	0.01 M	1.119±0.079	3.400±0.192	20.167±0.758	7.287±0.220 NS	5.523±0.078	3.867±0.194 NS
	0.1 M	1.037±0.020	3.350±0.010	22.930±0.044	7.920±0.364	5.600±0.236	4.047±0.045
	0.5 M	1.203±0.104	3.513±0.015 NS	21.573±0.064	7.857±0.059	5.367±0.083 NS	3.997±0.015
3	Control	1.372±0.003	3.773±0.021	9.863±0.015	6.943±0.068	6.707±0.083	5.870±0.010
	0.01 M	1.344±0.028	3.780±0.020	13.743±0.683	7.290±0.165	7.517±0.137	5.920±0.056
	0.1 M	1.361±0.073	3.770±0.026	14.283±0.146	7.093±0.654	7.513±0.012	5.910±0.036
	0.5 M	1.309±0.029 NS	3.863±0.025	16.237±0.362	8.967±0.214	6.643±0.612 NS	5.140±0.269 NS
4	Control	1.611±0.001	5.963±0.015	9.280±0.026	5.923±0.081	7.787±0.006	5.290±0.061
	0.01 M	1.818±0.134	6.067±0.076*	12.357±0.436	6.180±0.082	8.757±0.273*	6.093±0.121*
	0.1 M	1.856±0.063*	5.970±0.010	11.783±0.557	6.157±0.031	8.667±0.032	5.980±0.020
	0.5 M	1.710±0.061	6.063±0.090	12.473±0.491	6.227±0.076	8.047±0.186	5.450±0.096

*significant at (0.05%) of probability
NS=Non significant

Table 3b: Food consumption and utilization of FC_1 X FC_2 5th instar silkworm hybrid treated with three doses of cholesterol during fourth instar (Each value is mean of three observations±SD)

Days	Conc.	Fresh larval wt. (g)	Dry larval wt. (g)	Fresh left over leaf (g)	Dry left over leaf (g)	Fresh litter (g)	Dry litter (g)
		Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD
5	Control	1.927±0.006	6.577±0.015	13.200±0.100	7.033±0.015	8.067±0.521	6.407±0.124
	0.01 M	2.255±0.102	6.653±0.031	15.340±0.128*	8.013±0.457	9.867±0.189	7.077±0.131
	0.1 M	2.391±0.134	6.673±0.006	14.037±0.620	7.427±0.714	9.293±0.051	6.343±0.153
	0.5 M	2.063±0.033	6.640±0.036	15.093±0.232	7.607±0.059	9.137±0.227	6.297±0.145 NS
6	Control	2.327±0.023	7.877±0.015	11.723±0.015	6.867±0.021	10.517±0.059	6.903±0.765
	0.01 M	2.439±0.057	8.190±0.010	14.437±0.242	7.143±0.031	10.613±0.189	8.430±0.996
	0.1 M	2.697±0.088	8.213±0.015	14.353±0.950	7.197±0.162	13.163±0.999	10.833±0.061
	0.5 M	2.369±0.090	8.187±0.163	14.207±0.638	7.427±0.304	11.507±0.045	7.233±0.514
7	Control	2.401±0.062	8.700±0.100	11.963±0.015	6.963±0.015	13.313±0.021	10.847±0.117
	0.01 M	2.570±0.079	8.853±0.031*	11.050±0.650 NS	8.670±0.098	16.493±0.517	12.933±0.143
	0.1 M	2.727±0.095*	8.830±0.010	11.397±0.561	7.027±0.647	18.537±0.422*	14.473±0.363*
	0.5 M	2.474±0.055	8.830±0.010	13.060±0.953	8.710±0.485*	14.800±0.910	11.020±0.832

*significant at (0.05%) of probability
NS=Non significant

Table 3c: Food consumption and utilization of FC_4X FC_3 5th instar silkworm hybrid treated with three doses of cholesterol during fourth instar (Each value is mean of three observations±SD)

Days	Conc.	Fresh larval wt. (g)	Dry larval wt. (g)	Fresh left over leaf (g)	Dry left over leaf (g)	Fresh litter (g)	Dry litter (g)
		Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD
1	Control	0.689±0.002	1.253±0.015	20.840±0.226	10.437±0.115	2.340±0.026	1.967±0.015
	0.01 M	0.686±0.034	1.267±0.021	23.283±0.950	9.910±0.502	2.670±0.026	1.913±0.047 NS
	0.1 M	0.695±0.069	1.270±0.020	24.403±0.609*	10.570±0.165*	2.623±0.059	2.097±0.091
	0.5 M	0.676±0.023	1.277±0.006	22.827±0.831	9.190±0.857 NS	3.033±0.015	2.450±0.050
2	Control	1.037±0.023	3.340±0.026	16.210±0.185	6.950±0.069	5.827±0.045	4.043±0.021
	0.01 M	0.987±0.022 NS	3.400±0.020	24.207±0.547	8.850±0.137	4.540±0.269 NS	3.410±0.092 NS
	0.1 M	1.036±0.032	3.337±0.021	20.600±0.428	7.683±0.057	5.323±0.350	3.827±0.129
	0.5 M	1.028±0.044	3.383±0.015	21.537±0.497	7.960±0.295	5.067±0.042	3.767±0.023
3	Control	1.281±0.039	3.410±0.010	10.247±0.047	5.180±0.052	10.780±0.192	5.453±0.064
	0.01 M	1.418±0.059	3.527±0.021	18.850±0.927	8.727±0.145	6.410±0.159 NS	5.113±0.021 NS
	0.1 M	1.414±0.024	3.553±0.031	14.930±0.754	7.927±0.595	6.997±0.340	5.770±0.451*
	0.5 M	1.295±0.077	3.533±0.032	17.050±0.104	8.437±0.967	6.810±0.235	5.593±0.352
4	Control	1.610±0.011	5.960±0.020	9.340±0.142	5.583±0.585	7.887±0.095	5.420±0.092
	0.01 M	1.854±0.049*	6.093±0.083	12.360±0.182	6.153±0.074	8.243±0.438	5.300±0.270 NS
	0.1 M	1.841±0.129	5.917±0.361	13.260±0.173	7.113±0.878	8.397±0.585*	5.463±0.569
	0.5 M	1.767±0.026	6.147±0.035*	13.017±0.168	6.567±0.817	8.330±0.100	5.410±0.082

*significant at (0.05%) of probability
NS=Non significant

Table 3d: Food consumption and utilization of FC_4X FC_3 5th instar silkworm hybrid treated with three doses of cholesterol during fourth instar (Each value is mean of three observations±SD)

Days	Conc.	Fresh larval wt. (g)	Dry larval wt. (g)	Fresh left over leaf (g)	Dry left over leaf (g)	Fresh litter (g)	Dry litter (g)
		Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD
5	Control	1.901±0.012	6.277±0.032	12.720±0.128	6.170±0.053	8.510±0.026	5.103±0.015
	0.01 M	2.152±0.035	6.313±0.021	18.720±0.223*	7.213±0.419	9.593±0.344	6.667±0.378
	0.1 M	2.152±0.041	6.247±0.006	18.157±0.484	8.023±0.061	8.897±0.104	6.427±0.898
	0.5 M	2.236±0.043	6.287±0.042	18.697±0.148	8.780±0.017	9.173±0.440	5.950±0.554
6	Control	2.299±0.067	7.847±0.067	11.860±0.141	6.530±0.310	10.350±0.100	7.733±0.072
	0.01 M	2.344±0.098	7.933±0.031	18.643±0.080	8.340±0.771	10.790±0.053	8.280±0.036
	0.1 M	2.364±0.049	7.923±0.025	17.913±0.179	8.730±0.166	10.273±0.516	7.613±0.722
	0.5 M	2.444±0.033	7.980±0.030	19.497±0.087	8.960±0.201*	10.070±0.131 NS	7.133±0.042 NS
7	Control	2.401±0.070	8.823±0.025	11.530±0.436	7.427±0.751	13.233±0.051	8.920±0.053
	0.01 M	2.463±0.072*	8.837±0.006	15.470±0.214	7.177±0.353 NS	15.373±0.153	12.893±0.579*
	0.1 M	2.427±0.050	8.847±0.056	14.650±0.120	7.927±0.301	15.813±0.637*	12.187±0.554
	0.5 M	2.402±0.105	8.870±0.010*	15.753±0.601	7.880±0.110	14.450±0.470	11.373±0.562

*significant at (0.05%) of probability
NS=Non significant

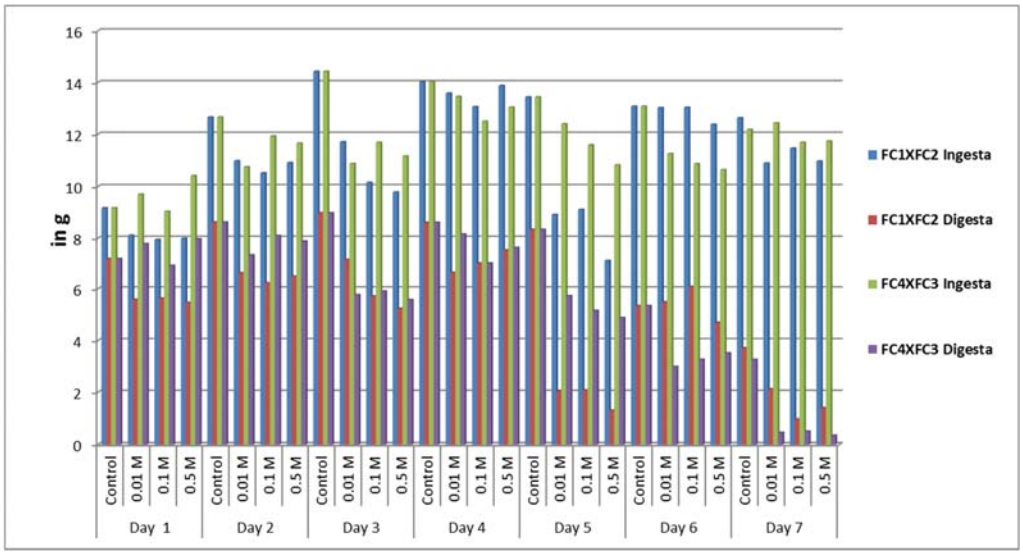

Fig 4: Changes in the food ingesta and digesta of 5th instar silkworm hybrids treated with three doses of cholesterol during 4th instar

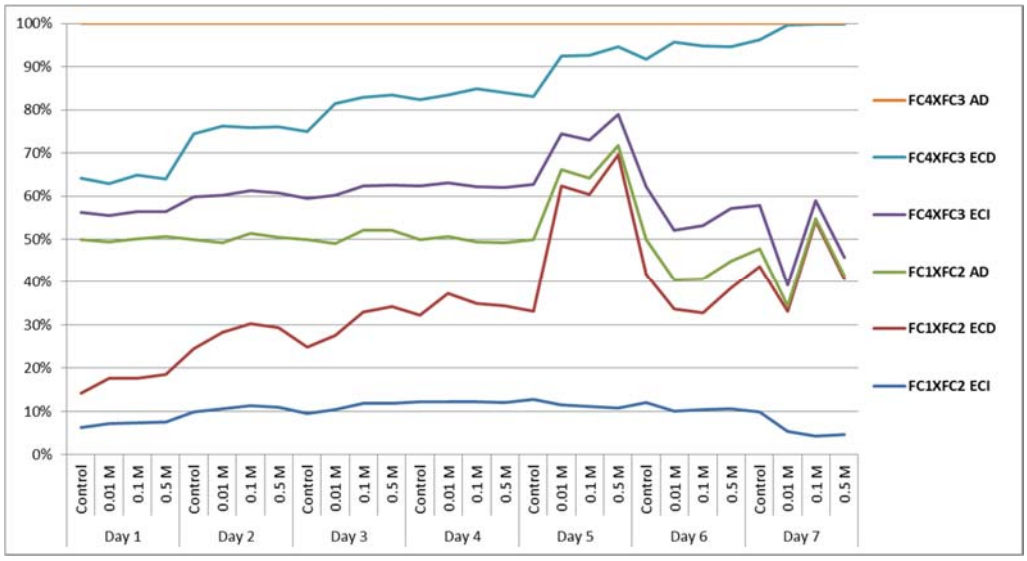

Fig 5: Changes in the efficiency of conversion of ingesta, efficiency of conversion of digesta and approximate digestibility of 5th instar silkworm hybrids treated with three doses of cholesterol during 4th instar

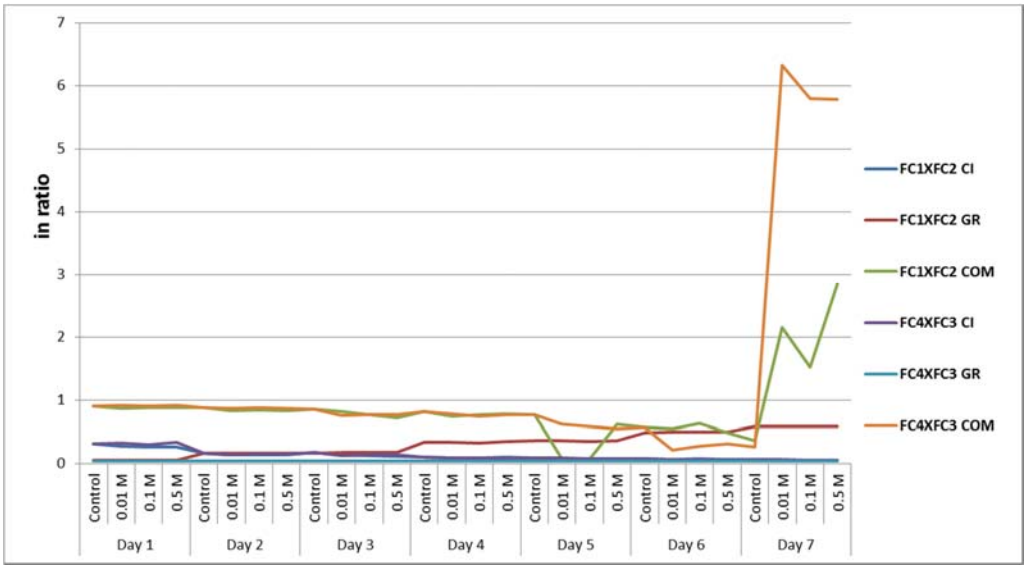

Fig 6: Changes in the consumption index, growth rate and coefficient of metabolism of 5th instar of silkworm hybrids treated with three doses of cholesterol during 4th instar

Conclusion

The food consumption comprises the ingesta and digesta during 4th instar showed the level of ingesta was significantly higher compare to digesta in all the cholesterol treated batches in all 4 days, but on 4th day the rate of food consumption represents the highest rate of ingesta in the selected hybrids. Whereas the efficiency of conversion of food ingested and efficiency of conversion of food digested were low ranging in FC_1XFC_2 and FC_4XFC_3 silkworm hybrids. The consumption index and coefficient of metabolism are the two nutritional parameters indicates the maximum attainment ranging from 0.8-0.9 ratio in all the days in all the cholesterol treatment concentration, whereas the growth rate was constantly maintained during 4th instar ranging from 0-0.05 throughout the instar in FC_1XFC_2 and FC_4XFC_3 hybrids. The pattern of changes in the ingesta and digesta of 5th instar silkworm, but cholesterol supplemented during 4th instar extended the above parameters ranging from 9-14g from first day to day seventh, whereas the digesta falls within a range of 9g during 5th instar in both the hybrids. The efficiency of conversion of food ingested, efficiency of conversion of food digested and approximate digestibility of 5th instar silkworm hybrids treated with three doses of cholesterol during 4th instar a showed the magnitude of changes above the level of 50% in FC_4XFC_3 hybrid, but the FC_1XFC_2 represents less than level of 50% except 5th day and 7th day during 5th instar. The consumption index, growth rate and co-efficient of metabolism were calculated during 5th instar the ratio was ranging from 0-1 in all the three parameters except consumption index and co-efficient of metabolism on 7th day ranging from 6-7 and 2-3 on respectively on the last day of 5th instar in FC_1XFC_2 and FC_4XFC_3 hybrids.

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