INTRODUCTION

Nutrition involves various chemical, physiological and biochemical activities, which transform food elements into body elements. Nutrients are the major components of the food that leads to growth and increase the body volume. Hence, food plays main role in growth, fattening, silk secretion, or other reproductive functions however, a substantial part of its food is used for supporting body processes, which must go on whether or not any new tissue or product is being formed.

This demand for food is referred to as the maintenance requirement, as it comprises the amount needed to keep intact the tissues of an animal, which is not growing, working, or yielding any product. If this need is not met, which is commonly revealed by a loss in weight and which leads to various undesirable consequences. This destruction of body tissue is referred to as the fasting metabolism, and it can be measured in terms of the waste product eliminated through the various parts of excretion. Most of the breakdown is for energy, which occurs in response to the demand of the fasting organism. An animal, which is receiving sufficient protein and energy to permit growth of its tissues and organs, show an increase in size and weight.

The growth of the body as a whole is most commonly measured as an increase in weight. An animal may increase in weight though the deposition of fat without any increase in the structural tissues and organs, which characterize growth. An animal, which receives insufficient protein and energy to permit growth of its organs and tissues, may still show an increase in size due to skeletal growth. In nutritional studies normal growth is referred to as the state of nutrition and health and in descending growth and reproductive performance. Growth retardation is reduced by
malnutrition, either in calories or in some specific essential nutrients. The nature and extent of the effect on growth are dependent upon the character and severity of the deficiency and upon the period involved. A deficiency of energy, for example, will immediately check growth in mass while lack of calcium may not, as its primary effect is upon bone structure rather than its size. A deficiency of certain other nutrients such as phosphorus or Vitamin-B exerts an indirect influence on increase in size by decreasing appetite, as well as causing direct physiological effects. Restriction in diet up to 800 days of age in rats resulted in many animals which somewhat less skeletal size, but improved health, female fertility and longevity and delayed the onset of degenerative disease (Benjamin, 1960 and Benjamin and Simms, 1960). Tonge and McCance (1965) exhibited that growth retardation is due to food restriction in pigs.

Study of various nutritional parameters such as food consumption, excretion, food assimilation and oxidation give an idea regarding growth and energy. The silkworm, Bombyx mori L. feeds on the food mulberry leaves from which it ingests various nutrients to support physiological activities. The nutrients include protein, carbohydrate, fat, vitamin, inorganic salt and water. Food preference of silkworm largely depends upon the physical and chemical components of the food. It was reported that the appetizing factor, biting factor, swallowing factors and repellent substances play a key role in accepting in diet (Hanamura et al., 1962). The appetizing factors include many volatile substances such as alcohol, citric aldehyde and linalol influence the larval appetite and feeding reaction. Whereas biting factors like beta sito sterol, isoquercertrin and flavinin cause the larval biting motion. Continuous feeding of the larvae is kept by the swallowing factors such as cellulose, sucrose, inositol, phosphate, silicate, Vitamin-c and sulphur amino acids etc.

Food ingestion by the larvae of Bombyx mori L. varies during its different instars. The intake of mulberry leaves into oral cavity is "Ingestion". Active feeding occurs only during IV and V instars and 97% accounts for of total ingestion. The larval feeding is discontinuous and initial feeding time is different among various instars. This quiscentrest before feeding helps the newly moulted larvae in hardening of new cuticle and the continuous developing of internal organs (Naik, 1985 and Radhakrishna 1989). The duration of feeding is only about 27 percent of the larval
feeding period. Each time of feeding lasts for 12-16 minutes. Delvi (1972) described the cessation of the appetite considerable 20-30 hours prior to moult in many insects as pre-moult starvation period. The complex organic nutrients in mulberry leaves are covered by cell wall of cellulose hence are insoluble, impermeable and are not utilized by the silkworm directly and silkworm needs to convert the macro, complex insoluble and impermeable substances into simple, permeable products, those actions are called “Digestion”.

Food in the buccal cavity is digested, primarily by the saliva and lubricated and expelled to midgut, which is the main region for digestion and assimilation. The goblet cells of midgut play a key role in digestion by secreting digestive juices and absorb nutrients into the haemolymph through cylindrical cells of midgut. The remains are combined with the secretions by the Malpighian tubules, the mixtures are pressed by the colon into the hexagonal excrements is reabsorbed and the faecal matter is pressed further and excrete the undigested matter as solid faecal pellets. During rearing, the larvae exhibited serious poisoning symptoms such as decreased appetite, retarded growth and development of silkworm larvae on exposure to fluoride at 32 mgF/kg (Yun-gen et al., 2004).

RESULTS

The data on the various nutritional parameters like food consumption, faecal excretion, assimilation, food conversion and oxidation in V instar silkworm Bombyx mori L. exposed to sub lethal doses of fluoride in groups 2, 5 and 8 and to sub-sub lethal doses of fluoride to the groups 3, 6 and 9 at 2nd, 3rd and 4th days of exposure period besides controls (groups 1, 4 and 7) are shown in table 4.1, and figure 4.1. The differences obtained in relation to controls in nutritional parameters at the above said exposure periods of sub lethal and sub-sub lethal doses were converted as percent change of corresponding controls and these percent change values were also given in the table 4.1 and plotted against exposure periods in figure 4.1 for comparative assessment.

Food consumption

The data presented in table 4.1 and figure 4.1 showed that the total amount of food consumption at 2nd, 3rd and 4th days exposure of V instar silkworms in groups
2, 5 and 8 to sub lethal dose of fluoride was significantly (P>0.05) decreased. Depending on the percent change the percent decrease in the food consumption in sub lethal dose was progressed gradually from the 2nd day to 4th days of exposure period studies and was in the order 2<3<4 days. Whereas in the sub-sub lethal dose (groups 3, 6 and 9), the amount of food consumption also decreased from the 2nd to 3rd and on 4th day, the food consumption increased and was in the order 2<3>4. However, this decrease/increase was significant (P>0.05).

**Faecal out put**

Corresponding to the decrease in food consumption in sub lethal dose of fluoride in groups 2, 3 and 4, the excretion of faecal matter also decreased significantly (P>0.05) in relation to control groups 1, 4 and 7 at all exposure periods studies and was in the order 2<3<4. Based on percent change values, it is observed that the percent decreased in the faecal out put of silkworm exposed to sub lethal dose of fluoride, progressed gradually from 2nd to 4th day. In sub-sub lethal dose exposed to groups of 3, 6 and 9 exhibited a significant decrease in faecal out put at 2nd, 3rd and 4th days of exposure periods studied indicating the enhanced food assimilation due to increased oxidation. However, the decrease of excretion of faecal matter at 4th day is less when compared to 2nd and 3rd days, and the decrease was in the order 2<3>4.

**Food assimilation, oxidation and conversion**

In relation to the decrease in food consumption and faecal out put of the 5th instar silkworm exposed to sub lethal dose of fluoride in groups 2, 5 and 8, the nutritional parameters, such as food assimilation, conversion and oxidation exhibited a significant (P>0.05) decrease at all exposure periods i.e., 2nd, 3rd and 4th days. Based on percent change values the percent decrease progressed gradually and was in order 2<3<4. In sub-sub lethal dose of fluoride treated groups i.e., 3, 6 and 9 the above nutritional parameters exhibited a significant (P>0.05) decrease at 2nd, 3rd and 4th days of exposure. However, the decrease at 4th day was less when compared to 3rd and 2nd days and it was in order 2<3>4.
DISCUSSION

Successful sericulture depends on increased production of mulberry leaves with high nutritive values (Krishnaswamy, 1978 and Adolkar et al., 2007). Cocoon production or yield can be seriously reduced if the fluoride content of dried mulberry leaves exceeds 40 mg/kg (Chen, 1993). Food utilization parameters have been studied in many insects (Rath et al., 2003) and there is a direct correlation between nutritional indices and silk production. Further the nutritive value of mulberry leaves depends on various agro-climatic factors, because of its long history of its domestication some varieties have become extremely sensitive to environmental pollution, especially to atmospheric fluoride emitted from brick kilns and coal-burning power plants (Chen, 1993; Chen and Wu, 1994 and Tong, 1988). Further its food source, the mulberry tree, Morus is a high Fluoride-accumulating plant (Chen and Lu, 2002). As a result heavy loss of cocoon production often occurs in main sericultural regions. Many researchers worked on harmful effects of fluoride on silkworm growth and the mechanism of the action of fluoride (Chen and Wu, 1995; Chen and Li, 1996 and Chen et al., 1996) and Chen and Wu, 1998). Earlier research work was carried out in different varieties of insects near fluoride pollution sources and found variations in tolerance to fluoride.

Food ingestion, digestion, gain in food weight and efficiencies of utilization significantly decline following fluoride exposure. Chen and Gu (2006) exhibited that activation of DNA synthesis in gland cells during the middle stages of the last larval instar is nutrition-dependent, with starvation of day 3 inhibiting DNA synthesis. Therefore, there is direct correlation between nutritional indices and silk production. Therefore, studies on nutritional aspects are important economically. As the silkworm is a monophagous herbivore and depends mainly on the quality of mulberry leaves and environmental conditions for its development, nutritious leaves play an important role in the silkworm growth and overall silk cocoon production (Adolkar et al., 2007). Hence, attempt has been made to study the fluoride toxicity in relation to nutritional parameters, on the whole the fluoride at sub-lethal and sub-sub-lethal doses caused inhibiting effect on the nutritional parameters. However a recovery was observed on prolonged exposure to fluoride due to detoxification mechanism in silkworm.
Table 4.1: Estimation of Nutritional Parameters (mg / kg. body weight / day / larva) at 2nd, 3rd and 4th days in V instar of Silkworm fed on Mulberry leaves treated with Sub lethal and Sub-sub lethal doses of Fluoride

<table>
<thead>
<tr>
<th>Days exposed</th>
<th>Dosage</th>
<th>Consumption</th>
<th>Excretion</th>
<th>Assimilation</th>
<th>Conversion</th>
<th>Oxidation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd day</td>
<td>Control</td>
<td>c 475.00 ± 4.899</td>
<td>c 256.37 ± 6.410</td>
<td>c 218.93 ± 5.307</td>
<td>c 22.160 ± 0.1793</td>
<td>c 196.77 ± 5.430</td>
</tr>
<tr>
<td></td>
<td>SL</td>
<td>a 355.33 ± 14.290 (-25.26)</td>
<td>a 215.54 ± 5.405 (-15.90)</td>
<td>a 136.903 ± 7.649 (-37.46)</td>
<td>a 18.120 ± 0.1674</td>
<td>b 165.26 ± 68.07</td>
</tr>
<tr>
<td></td>
<td>SSL</td>
<td>b 405.00 ± 5.715 (-14.73)</td>
<td>b 224.59 ± 6.107 (-12.37)</td>
<td>b 179.62 ± 3.070 (-17.94)</td>
<td>b 25.907 ± 0.1674</td>
<td>a 153.71 ± 2.920</td>
</tr>
<tr>
<td>3rd day</td>
<td>Control</td>
<td>c 625.00 ± 7.483</td>
<td>c 304.23 ± 6.814</td>
<td>c 323.09 ± 6.556</td>
<td>c 25.687 ± 0.3027</td>
<td>c 297.41 ± 6.255</td>
</tr>
<tr>
<td></td>
<td>SL</td>
<td>a 386.33 ± 6.548 (-38.24)</td>
<td>a 249.55 ± 9.929 (-17.89)</td>
<td>a 72.14 ± 7.838 (-77.67)</td>
<td>a 20.050 ± 0.1918</td>
<td>a 52.09 ± 7.666</td>
</tr>
<tr>
<td></td>
<td>SSL</td>
<td>b 438.33 ± 4.921 (-29.92)</td>
<td>b 275.86 ± 5.059 (-9.32)</td>
<td>b 166.10 ± 9.415 (-48.59)</td>
<td>b 24.667 ± 0.3307</td>
<td>b 141.44 ± 9.461</td>
</tr>
<tr>
<td>4th day</td>
<td>Control</td>
<td>c 696.00 ± 3.742</td>
<td>c 353.08 ± 7.267</td>
<td>c 345.10 ± 7.228</td>
<td>c 29.903 ± 0.1696</td>
<td>c 315.03 ± 7.640</td>
</tr>
<tr>
<td></td>
<td>SL</td>
<td>a 339.00 ± 4.899 (-51.29)</td>
<td>a 249.97 ± 9.352 (-29.20)</td>
<td>a 89.85 ± 2.873 (-73.97)</td>
<td>a 16.810 ± 0.19791</td>
<td>a 73.040 ± 3.019</td>
</tr>
<tr>
<td></td>
<td>SSL</td>
<td>b 656.33 ± 5.439 (-5.74)</td>
<td>b 328.96 ± 2.500 (-6.83)</td>
<td>b 325.80 ± 8.265 (-5.62)</td>
<td>b 28.273 ± 0.5658</td>
<td>b 297.53 ± 8.828</td>
</tr>
</tbody>
</table>

± Standard Deviation
* Each value is a mean of eight estimates
** Percent change (increase/decrease) over control is given in parenthesis
*** Means within a column followed by the same letter are not significantly different (p ≥ 0.05) from each other according to Duncan’s Multiple Range tests.
Fig. 3.1: Estimation of Nutritional Parameters (mg/kg body weight/day/ larva) at 2\textsuperscript{nd}, 3\textsuperscript{rd} and 4\textsuperscript{th} days in V instar of Silkworm fed on Mulberry leaves treated with Sub lethal and Sub-sub lethal doses of Fluoride

% Change

Days exposed