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Research Article

Assessing the Effects of Combined Industrial and Urban Sewage Water on Food Utilization in the Silkworm *Bombyx mori* L.

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ABSTRACT

Aim/Background: Sericulture is a crucial agro-based sector affected by environmental conditions, especially the quality of mulberry leaves, which serve as the principal food supply for silkworms (*Bombyx mori*). **Materials and Methods:** This study evaluates the effects of combined industrial effluents and urban sewage water on silkworm food utilisation and metabolic efficiency. Mulberry plants (*Morus alba*) were grown in pots utilising different concentrations (25%, 50%, 75% and 100%) of wastewater, while control plants were watered with borewell water. FC1×FC2 bivoltine silkworm larvae were cultivated under regulated laboratory conditions and their nutritional characteristics were assessed by gravimetric methods. **Results:** Findings demonstrate that moderate effluent exposure (75%) augmented eating and metabolic activity, resulting in improved food intake, absorption and conversion rates. At 100% effluent concentration, metabolic stress resulted in prolonged larval duration, diminished digestive efficiency and decreased conversion rates, signifying hazardous consequences. The diminishing efficiency of food conversion underscores possible threats to silk output and quality. **Conclusion:** The results highlight the necessity for pollution regulation in sericulture areas to alleviate environmental strain and guarantee sustained silk production. Implementing pollution management measures is essential for maintaining silkworm health and ensuring industrial sustainability.

Keywords: *Bombyx mori*, Food Utilization, Mulberry Plants, Sericulture.

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INTRODUCTION

Sericulture, a traditional agricultural industry in India, has significantly contributed to poverty reduction. Increasing the amount of cocoon production, in terms of quality and quantity, is expected to substantially enhance the sector's profitability and effectively meet production needs.[1] Food is essential in sericulture since it influences development, growth and silk output. Silkworm food intake and silk production are associated with nutritional parameters.[2,3] Silkworm consuming efficiency is critical in transforming mulberry leaves into silk. The nutritional content of the leaf determines the silkworms consumption rate, which varies cyclically in each instar.[1] The influence of industrial effluents and urban sewage water on sericulture is a developing issue, especially for silkworm cultivation and health. Sericulture strongly relies on the quality of mulberry leaves, which are silkworms primary food source. The silkworms may experience negative consequences when these mulberry plants are irrigated with industrial and urban sewage waste water. The silkworm is a vital insect for silk production and is especially susceptible to environmental changes, including major changes in food supply. Contaminants entered into natural water bodies may damage the silkworms primary food source, mulberry leaves. The silk industry and associated economies are threatened by this contamination, which also threatens the health and development of the silkworms and the overall quality and quantity of silk produced. The development of silkworms results from several physiological processes in which substance accumulates in the body. This accumulation is due to a balance between assimilation and dissimilation, during which complex phenomena occur.[4] The larva feeding requirements vary depending on its age. The nutritional status of the leaf is also said to play an essential role in determining the performance of different stages of silkworms.[5] Feed conversion efficiency is a critical physiological parameter for assessing the superiority of silkworm breeds or hybrids and influences the cost-benefit ratio of silkworm rearing either directly or indirectly.[6] Several factors add up to digestion and conversion efficiency within a breed, the most significant being eco-physiological status and morphological variation. The ability of a silkworm to digest, absorb and convert mulberry leaves into body mass is drastically altered on a large scale when

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animals are subjected to different environmental, feeding and nutritional conditions. The holistic knowledge of ethnobiology and physiology of insects would require detailed research in nutrition ecology.[7] In addition to its physiological significance, investigating nutritional parameters in sencigenous insects is a crucial area of research for enhancing the administration and advancement of the sericulture sector.[8] Given their food consumption and utilization, this study establishes the basis for viewing the impact of combined industrial effluents and urban sewage water on bivoltine silkworm hybrids. It is vital because the silk industry is of economic and ecological importance. Thus, the provided data will help understand how wastewater affects the health of silkworms and create measures to prevent undesirable effects while ensuring that sustainable silk is produced.

MATERIALS AND METHODS

The study was started by collecting samples of the combined industrial effluents and urban sewage water from Bhimasandra Pond near Tumakuru, Karnataka. This research consisted of cultivating V-1 mulberry plants in pots using different concentrations (25%, 50%, 75% and 100%) of a mixture of industrial effluents and urban sewage water for irrigation. Control plants received irrigation with borewell water to provide a basis for comparison. Silkworm larvae of the FC1×FC2 double hybrid bivoltine race were used in the experiment. The larvae were raised under controlled laboratory conditions (26±2°C and 75±2% RH)[9] and fed with mulberry leaves harvested from mulberry plants treated with different concentrations. A control set of silkworms is being fed with mulberry leaves that have been irrigated with borewell water. The experiment was performed in triplicates. Differing concentrations of treated mulberry leaves were fed twice daily to larvae from the I to V instar.

The gravimetric technique provided by Waldbauer (1968)[10] was used to assess food intake, considering modifications for water loss throughout the feeding period. The Maynard and Loashi (1962)[11] study used the sacrifice technique to assess the growth of silkworms by measuring the difference in weight between the larvae at the end and beginning of each instar. Before giving new leaves, leftover food and faeces were collected daily and dried at 100°C to a consistent weight.[10] The impact of the combined industrial effluents and urban sewage water on the food utilization of silkworms was determined using the IBP equation developed by Petrusewicz and Macfadayan in (1970).[12] The equation I=B+M+F represents the relationship between the food consumed (I), the Biomass Gained (B), the Faces generated (F) and the food Metabolised (M). Feeding, assimilation, metabolic and conversion rates were determined based on the mid-body weight at each instar and the duration of the instar. The data were analysed for statistical analysis and then compared between the treatments and the control group.

RESULTS

The results of this study add to the growing body of knowledge regarding how environmental pollutants affect silkworm physiology, especially when it comes to food utilization metrics. The significant increase in food consumption observed in all effluent treatments (Table 1) suggests a compensatory mechanism, possibly intended to counteract the altered nutritional composition or decreased nutrient availability of mulberry leaves exposed to effluents. Additionally, silkworms exposed to combined industrial effluents and sewage water irrigation showed increased eating behavior, which they attributed to nutritional stress brought on by contaminated foliage.

The larval duration exhibited notable variations across various effluent concentrations, indicating the impact of environmental stress on silkworm development. At a 75% effluent concentration, the larval duration decreased to 24.5 days, in contrast to the control period of 26.5 days, suggesting that rapid growth may be attributed to mild stress enhancing metabolic activity. At 100% effluent concentration, the period extended to 29 days indicating developmental delays attributed to elevated stress levels and toxicity. These results indicate that moderate effluent levels may promote development, but excessive exposure alters physiological systems, extending larval growth and perhaps affecting total production.

A disturbance in digestion and excretion processes, most likely caused by the negative effects of accumulated contaminants, is indicated by the decrease in fecal output at the highest effluent concentration (1439.98 mg at 100%) in comparison to the control (1713.87 mg). The increase of food assimilation and conversion at intermediate effluent concentrations (75%). At elevated effluent

Table 1: Impact of Treated *Morus alba* on Larval Duration and Nutritional Parameters of *Bombyx mori* (FC1×FC2) from Hatching to Pupation under controlled laboratory conditions. The values are given in milligrams of dry weight per day of larvae.

Parameters	Control	25%	50%	75%	100%
Larval Duration	26.5±0.5	26±0.4	26±0.3	24.5±0.6	29±0.7
Food Intake	5046.57±50	5101.03±55	5178.30±60	5382.73±65	5251.39±70
Faeces Defecated	1713.87±25	2086.71±30	2143.88±35	2484.45±40	1439.98±20
Food Assimilated	2957.16±40	3091.57±45	3332.70±50	3942.76±55	2766.94±60
Food Converted	931.52±15	1010.98±20	1190.47±25	1359.21±30	763.67±10
Food Oxidised	2003.26±30	2080.59±35	2401.20±40	2583.54±45	1766.69±25

Table 2: Impact of Treated *Morus alba* on Nutritional and Metabolic Rates in *Bombyx mori* (FC1×FC2) from Hatching to Pupation under Controlled Conditions. The values are expressed in mg dry weight per mg wet weight per larvae per day.

Parameters	Control	25%	50%	75%	100%
Feeding Rate	2.86±0.05	3.18±0.06	3.43±0.07	3.72±0.08	2.75±0.04
Assimilation Rate	2.67±0.04	2.99±0.05	3.22±0.06	3.43±0.07	2.60±0.03
Metabolicate	2.51±0.03	2.83±0.04	3.06±0.05	3.27±0.06	2.44±0.02
Conversion Rate	0.16±0.01	0.16±0.01	0.16±0.01	0.17±0.01	0.16±0.01

Table 3: Impact of Treated *Morus alba* on Nutritional efficiencies in *Bombyx mori* (FC1×FC2) from Hatching to Pupation under Controlled Conditions. The values are expressed in percent.

Parameters	Control	25%	50%	75%	100%
Food Assimilation Efficiency	82.22±1.0	79.55±1.1	79.81±1.2	82.69±1.3	79.21±1.4
Conversion Efficiency K1	18.07±0.5	14.23±0.6	12.83±0.7	10.69±0.8	16.20±0.4
K2	25.36±0.7	21.55±0.8	18.29±0.9	16.72±1.0	24.20±0.6

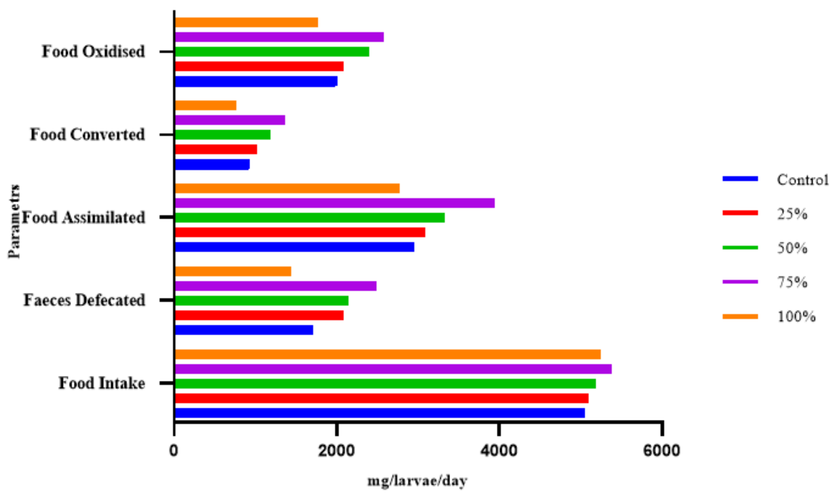

Figure 1: Impact of Treated *Morus alba* on Nutritional parameters of *Bombyx mori* (FC1×FC2) under controlled laboratory conditions.

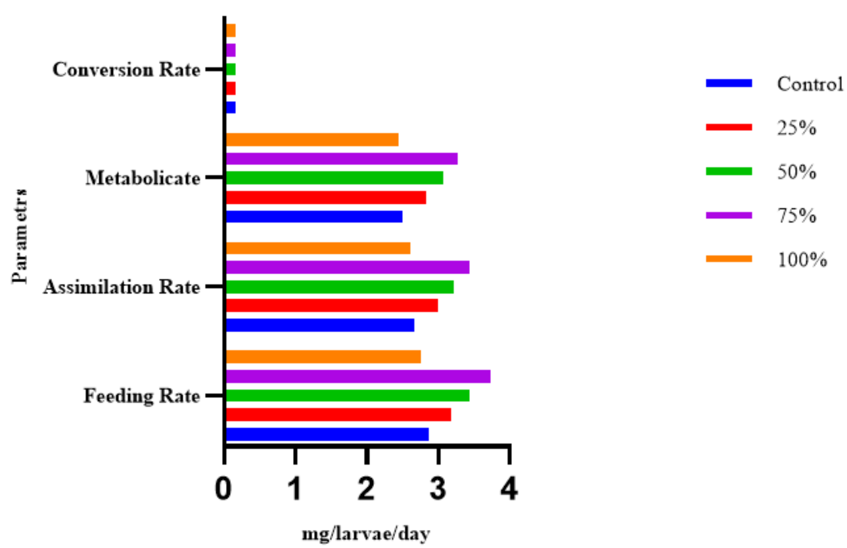

Figure 2: Impact of Treated *Morus alba* on Nutritional and Metabolic Rates in *Bombyx mori* (FC1×FC2) under controlled laboratory conditions.

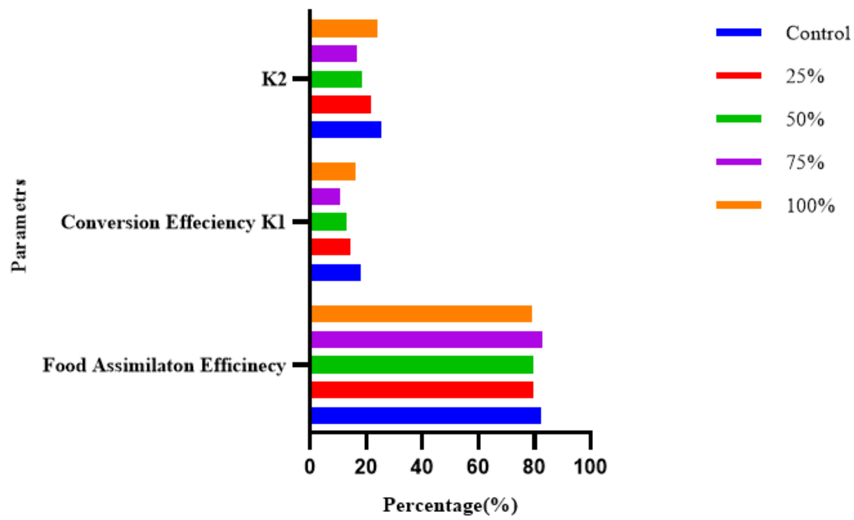

Figure 3: Impact of Treated *Morus alba* on Nutritional efficiencies in *Bombyx mori* (FC1×FC2) from Hatching to Pupation under Controlled Conditions.

concentrations, the noted reduction in these parameters (e.g., food assimilation decreased to 2766.94 mg at 100%) (Figure 1), signifies that the limit for advantageous metabolic stimulation has been surpassed, resulting in toxic effects that impede these processes in silkworms.

Likewise, the feeding rate, assimilation rate and metabolic rate all increased (Table 2 and Figure 2) at intermediate effluent levels but decreased at higher concentrations. These results suggest that silkworms can respond to moderate environmental stress by optimizing their feeding and metabolic strategies, but that under extreme stress, these processes are disrupted and less effective.

The efficiency of food assimilation and conversion efficiencies (K1 and K2) further illustrate the adverse impacts of effluent exposure. The decline in conversion efficiency across all effluent treatments (Table 3 and Figure 3) relative to the control suggests that contaminants disrupt the capacity of silkworms to transform ingested food into biomass and energy. The decline in energy and biomass conversion eventually undermines the production and quality of silk, creating questions over the long-term viability of sericulture in contaminated areas.

CONCLUSION

The findings demonstrate a dose-dependent impact of mixed industrial effluents and municipal sewage on silkworm food utilisation. Moderate effluent concentrations seem to enhance metabolic processes, improving feeding, absorption and conversion rates; while, higher concentrations hinder these activities, resulting in decreased efficiency and metabolic stress. These results underscore the dual function of pollutants as both stimulants and stressors, depending upon concentration levels. The findings emphasise the urgent need for pollution management measures to preserve silkworm health, sustain sericulture production and ensure the economic sustainability of the silk industry. Measures should prioritise the reduction of pollution loads in agricultural and sericulture environments, using evidence-based policies and sustainable practices to alleviate environmental stresses.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

SUMMARY

The study examines the impact of combined industrial and urban sewage water on the metabolism and food usage of silkworms (*Bombyx mori*). Silkworm larvae were raised under controlled conditions, while the mulberry plants were irrigated with different percentages of combined wastewater (25%-100%). The findings demonstrate that moderate wastewater exposure (75%) enhanced food consumption and metabolic efficiency, whereas 100% effluent induced metabolic stress, leading to decreased digestion and conversion rates. These findings highlight the need for pollution control measures in sericulture areas to protect silkworm health and ensure sustainable silk production.

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