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Silkworm Pupa: A Valuable By-Product of Sericulture

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ABSTRACT: Silkworm pupae, a by-product of silk reeling, are increasingly valued for their nutritional richness, biological activity, and industrial applications. Traditionally discarded or used as animal feed, these insect-derived biomasses are now recognized for their potential in human nutrition, pharmaceuticals, cosmetics, and environmental sustainability. This paper explores the composition, applications, economic value, and future prospects of silkworm pupae (*Bombyx mori*), emphasizing their role in enhancing sericulture-based livelihoods and promoting circular economy principles.

Keywords: *Bombyx mori*, Silkworm pupae, animal feed, silk reeling.

INTRODUCTION

Sericulture is a vital agro-based industry in several Asian countries, particularly India and China. The primary focus of sericulture is the production of silk from the *Bombyx mori* silkworm. However, the process of silk reeling generates large quantities of silkworm pupae, which account for about 60–70% of the total biomass (Singh *et al.*, 2020). Historically considered waste, these pupae are now viewed as valuable resources due to their high protein and fat content, bioactive compounds, and industrial applicability. The nutritional, medicinal and economic value of silkworm pupa and the metabolites present are gaining recognition in recent times (Yang *et al*., 2009; Ratcliffe *et al.*, 2011). Use of silkworm pupa as food source as well as medicine is also practiced in many Asian countries (Zhou & Han 2006; Zhang & Zhang 2001). Most studies focus on the nutritional and therapeutic potential of silkworm pupa, but there is limited research on scalable, cost-effective, and environmentally sustainable processing methods for extracting and modifying SWP proteins and oils for diverse industrial applications. Additionally, the environmental impact of large-scale pupae disposal and the development of eco-friendly waste management strategies are underexplored. Addressing these gaps could enhance the valorization of SWP, contributing to sustainable sericulture and broader industrial applications. This review paper highlights these gaps and explore diverse strategies for expanding their utilization as a valuable by-product of sericulture.

COMPOSITION OF SILKWORM PUPA

Silkworm pupae are nutritionally dense and chemically diverse. On a dry weight basis, they contain approximately 50–70% protein, 10–30% lipids, and various vitamins and minerals (Longvah *et al.*, 2011). The major components include:

- **Proteins**: High biological value proteins with essential amino acids like lysine, methionine, and leucine.
- **Lipids**: Rich in unsaturated fatty acids, especially omega-3 and omega-6.
- **Chitin and Chitosan**: Derived from the exoskeleton, used in pharmaceuticals and biotechnology.
- **Micronutrients**: Zinc, iron, calcium, magnesium, and vitamin B-complex (FAO, 2013).

These properties make silkworm pupae an excellent candidate for use in various sectors beyond sericulture.

Applications of Silkworm Pupa

Human Nutrition. Silkworm pupae are consumed in several countries like China, Korea, and parts of India, especially in the northeastern regions. They are eaten boiled, fried, or fermented and are also incorporated into energy bars and protein powders. The high-quality protein and low carbohydrate content make them suitable for diabetic and high-protein diets (Singh *et al.*, 2020). A study by Kim *et al*. (2016) revealed that using flour from silkworm pupae can replace lean pork as a novel protein ingredient up to 10% as well as it improved cooking yield and toughness of emulsified sausages.

Animal Feed. Silkworm pupa meal is a protein-rich supplement for livestock, poultry, fish, and pets. Konwar *et al*. (2008) studied the effect of feeding silkworm pupa meal along with enzyme supplementation on indian broiler. Studies show that silkworm pupa meal can replace fish meal or soybean meal without compromising growth performance or feed conversion ratio (Reddy & Ramesh 2016). The feed is especially beneficial in aquaculture, where sustainable alternatives to fish meal are in high demand. Rahimnejad *et al*. (2019) used defatted *Bombyx mori* pupa instead of fish meal for pacific white shrimp.

Pharmaceutical and Cosmetic Use. The bioactive compounds in silkworm pupae have shown antioxidant, anti-inflammatory, and antimicrobial properties. These are utilized in skin creams, wound healing gels, and dietary supplements. Peptides derived from pupae also have potential applications in cholesterol reduction and anti-aging formulations (FAO, 2013). Hydrolysis peptide found in silkworm pupae shows antihypertensive property (Wu *et al.*, 2015; Wang *et al.*, 2014).

INDUSTRIAL AND ENVIRONMENTAL USE

Silkworm pupa oil is used in biodiesel production, soap manufacturing, and as a lubricant. Chitin and chitosan extracted from pupae shells are employed in biodegradable films, wound dressings, and wastewater treatment due to their binding and film-forming properties (Singh *et al.*, 2020).

Economic Importance. The value addition of silkworm pupae presents a significant economic opportunity for sericulture farmers and entrepreneurs. Instead of discarding them or selling at low cost, pupae can be processed into high-value products, generating additional income and employment. As awareness increases and demand for insect-based products grows, this by-product may become a central driver of rural bio-economy (Reddy & Ramesh 2016). There are numerous patents for silkworm pupa in countries like South Korea with uses ranging from the production of snacks to the refinement of silkworm powder ensuring the economic importance of silkworm pupa (Han *et al.*, 2017).

Challenges and Future Prospects. Despite the promising applications, several challenges limit the large-scale utilization of silkworm pupae:

- Lack of awareness and infrastructure at the grassroots level
- Social stigma and hesitancy around insect-based foods
- Inadequate regulatory frameworks and quality standards

Looking ahead, government support, research funding, and public-private partnerships can promote innovation in pupa processing and marketing. Moreover, integrating pupa-based products into food security, animal nutrition, and health care systems can significantly enhance their acceptance and utility (FAO, 2013).

CONCLUSIONS

Silkworms are reared in large scale for the production of commercial silk and after the silk is extracted from the cocoon, the spent pupa becomes a byproduct in sericulture industry which having high nutritional as well as commercial value. Silkworm pupae are no longer waste but a promising bioresource. Their nutritional, pharmaceutical, and industrial potential can significantly enhance the sustainability of sericulture. Encouraging scientific research, awareness programs, and policy support for pupa-based product development will create new income opportunities and reduce the environmental impact of sericulture.

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Conflict of Interest. None.

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