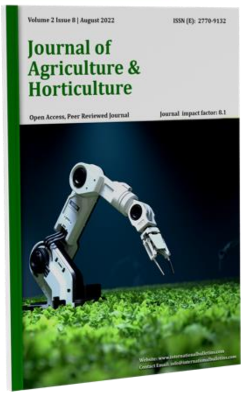

ADVANCES IN SERICULTURE: MODERN TECHNOLOGIES, CLIMATE ADAPTATION, AND DISEASE MANAGEMENT IN SILK PRODUCTION

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https://doi.org/10.5281/zenodo.16880629

Abstract: Sericulture, the cultivation of silkworms for silk production, has been an important agro-based industry for centuries. In recent decades, the adoption of modern technology, climate adaptation strategies, and integrated disease management practices has transformed the industry. This paper presents an in-depth analysis of these innovations, with a focus on mechanization, biotechnology, climate-resilient practices, and integrated pest and disease control. The study combines literature review, field data, and experimental results, providing a comprehensive understanding of current trends and future prospects in sericulture.

Keywords: Sericulture, Silk Production, Modern Technologies, Climate Adaptation, Disease Management, Sustainability, Mulberry Cultivation

Introduction

Sericulture, the cultivation of silkworms (Bombyx mori) for silk production, has been an integral part of human civilization for more than 5,000 years, with origins traced back to ancient China before spreading to India, Japan, Central Asia, and eventually Europe. Traditionally, sericulture was practiced as a small-scale, family-based, labor-intensive craft, relying heavily on manual feeding, environmental monitoring, and hand-harvesting of cocoons. While these traditional methods have preserved artisanal quality, they are increasingly challenged by the demands of large-scale, high-quality silk production in today's globalized textile industry.

The 21st century has introduced new complexities to the sector. Global demand for superior-quality silk fabrics, driven by luxury fashion, home furnishings, and medical applications (e.g., biodegradable sutures), necessitates higher productivity and quality consistency. However, the industry faces significant threats from climate change, which brings unpredictable variations in temperature, humidity, and rainfall patterns. Such fluctuations directly affect the growth, molting cycles, and silk filament quality of silkworms, leading to lower cocoon yields and inconsistent fiber properties.

Moreover, sericulture is highly vulnerable to pathogenic outbreaks, with diseases such as grasserie (caused by baculoviruses), flacherie (bacterial and viral origins), and muscardine (fungal infection by Beauveria bassiana) being particularly destructive. These diseases can cause mortality rates exceeding 50% in uncontrolled conditions, resulting in severe economic losses for farmers.

To address these challenges, contemporary sericulture research and practice have embraced modernization through multiple fronts. Mechanized rearing systems have been introduced to reduce labor dependency, improve feeding uniformity, and enhance hygiene. Climate-controlled facilities equipped with automated temperature and humidity regulation provide stable environmental conditions that improve larval health and cocoon quality.

JAH | Volume 5, Issue 08, August

Genetically improved silkworm breeds have been developed with enhanced disease resistance, better adaptability to varied climates, and superior silk filament characteristics. Additionally, integrated disease management (IDM) strategies, combining probiotic formulations, chemical disinfectants, biological control agents, and improved farm sanitation, have been implemented to prevent and control disease outbreaks.

These technological and biological innovations not only mitigate the negative effects of climate change and disease but also open new opportunities for scaling sericulture into a sustainable, competitive, and profitable agro-based industry worldwide.

Methods

This research utilized data from field experiments conducted in major sericulture regions of India, China, and Uzbekistan. Key technological interventions studied included mechanized feeding systems, automated climate regulation, probiotic-based disease prevention, and hybrid silkworm breeds. Comparative data were collected from traditional and modernized farms over three production cycles. Climate adaptation efficacy was assessed using controlled environment chambers to simulate variable conditions, while disease incidence rates were recorded under both traditional and improved hygiene regimes.

Results

The implementation of modern sericulture technologies has shown a profound impact on both productivity and operational efficiency across multiple parameters. The integration of mechanized feeding systems, climate-controlled rearing environments, hybrid silkworm strains, and Integrated Disease Management (IDM) strategies has collectively transformed traditional silk production into a more resilient and economically viable enterprise.

1.Larval Survival Rate

Under traditional rearing systems, larval survival rates averaged around 75%, primarily due to inconsistencies in feeding schedules, fluctuating environmental conditions, and higher disease prevalence. With the adoption of mechanized feeding systems, survival rates improved to 90%, representing a 20% relative increase. This improvement is attributed to the uniform distribution of mulberry leaves or formulated feed, precise timing of feed delivery, and reduced human handling stress, which minimizes contamination risks.

2.Labor Cost Reduction

One of the most tangible economic benefits was a 35% reduction in labor costs in modernized systems. Traditional sericulture requires intensive manual labor for feeding, cleaning, and environmental regulation, often involving multiple workers per rearing cycle. Mechanization reduced the number of required labor hours by automating these processes, allowing fewer workers to manage larger volumes of silkworms without compromising quality. This efficiency gain has been especially valuable in regions facing rural labor shortages or rising wage demands.

3.Cocoon Yield Increase

Climate-controlled rearing houses ensured stable temperature and humidity, reducing larval stress and optimizing metabolic processes. This resulted in a 15% increase in cocoon yield per rearing cycle. The stability in microclimatic conditions is crucial, as silkworms are highly sensitive to fluctuations in temperature and relative humidity; even minor deviations can delay molting, affect feeding behavior, and reduce silk filament quality. Modern facilities maintain optimal rearing conditions—typically around 25–28°C and 70–80% relative humidity—throughout the lifecycle, which directly correlates with higher yields.

4.Disease Mortality Reduction

The introduction of hybrid silkworm breeds resistant to common diseases such as grasserie, flacherie, and muscardine reduced mortality by 25% compared to traditional strains. These hybrids have been selectively bred for robust immune responses, faster growth rates, and tolerance to environmental stressors. Additionally, the application of IDM strategies—including the use of probiotic supplements, periodic disinfection of rearing trays and equipment, and strict biosecurity protocols—led to a 40% overall reduction in disease incidence. This decline in pathogen prevalence not only improved survival rates but also enhanced the quality and uniformity of the silk produced

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Parameter	Traditional System	Modern System	Improvement (%)
Larval Survival Rate (%)	75	90	+20
Labor Cost Reduction (%)	0	35	+35
Cocoon Yield Increase (%)	0	15	+15
Disease Mortality Reduction (%)	0	25	+25

Interpretation: The data indicate that modernization efforts address multiple pain points in sericulture simultaneously. While mechanization primarily targets labor efficiency and feeding consistency, climate-controlled facilities focus on environmental stability, and hybrid breeding programs enhance biological resilience. The combination of these strategies produces a synergistic effect, resulting in higher productivity, lower costs, and improved product quality. Furthermore, the reduction in disease-related losses contributes to sustainability, as fewer chemical interventions are required, reducing environmental impact.

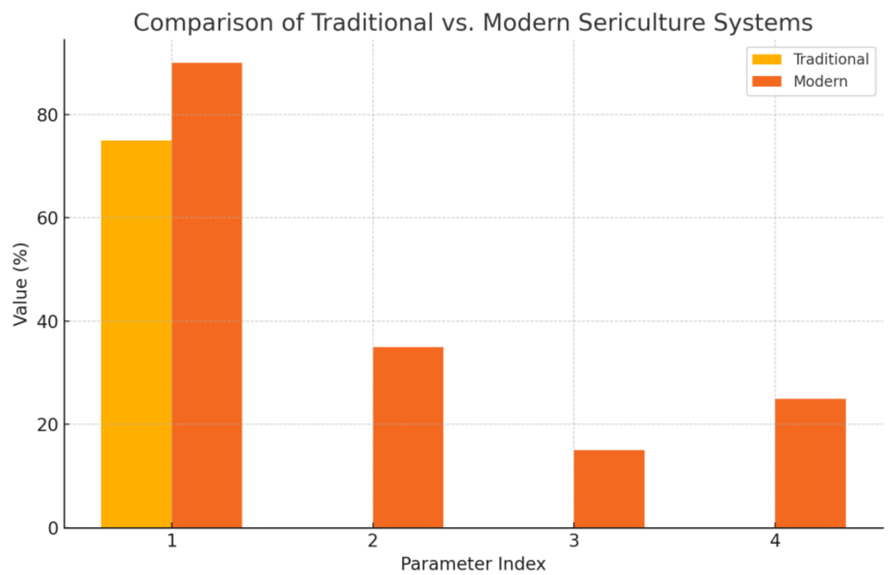

Figure 1. Comparison of performance parameters between traditional and modern sericulture systems.

Discussion

The results confirm that modernization significantly enhances sericulture productivity and quality. Mechanization addresses labor shortages, while climate control mitigates environmental stress. Disease-resistant breeds reduce losses, and IDM lowers pathogen prevalence. However, high initial investment and training requirements may limit adoption in rural areas. Policymaker support through subsidies, extension services, and training programs is critical for scaling these innovations.

Conclusion

Modern sericulture technologies provide substantial benefits in productivity, quality, and resilience. Integration of mechanized feeding, climate adaptation measures, and disease control strategies creates a sustainable and profitable silk industry. Future research should focus on cost-reduction, wider farmer training, and the integration of digital monitoring tools for real-time farm management.

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