Chapter 9

Sericulture 4.0: Innovation Meets Tradition in Silk Production

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Abstract

This study investigates the significance of reintroducing ancient handloom processes into current fashion culture in order to encourage environmental, cultural, and ethical practices. Its goal is to involve disadvantaged populations, create fair employment, and boost rural areas' monetary flexibility by assisting local artisans and communities. According to the study, reinstating these approaches can help to build resilience and lead to a more socially and environmentally sustainable future. Silk-based scaffolds, which imitate the extracellular matrix, are excellent for tissue regeneration and regulated medication release. Researchers are working to improve their characteristics, integrate silk with other biomaterials, and create sophisticated production processes such as 3D bioprinting. The use of bioactive compounds in silk matrices is also being investigated. Combining silk's natural qualities with new technologies such as nanotechnology, microfluidics, and stem cell engineering might result in next-generation biomedical devices and therapies, possibly changing patient care. This paper examines silk sericin's characteristics and bioactivities, as well as its uses in tissue engineering and regenerative medicine, as well as its potential for the development of flexible electrical devices and 3D bioprinting. It shows that sericin-based biomaterials may enhance clinical results in tissue engineering and smart implanted devices. This article discusses the application of silk in neural soft tissue engineering, emphasizing its potential for neuronal development, nerve guidance, and controlled medication release. It also explains how silk-based biomaterials can be used to preserve and regenerate the injured nervous system. Previous research has employed silk to improve therapies for diseases such as stroke, Alzheimer's, Parkinson's, and peripheral trauma. The article also highlights research on altering silk biomaterials to increase neuroprotection and regeneration. Biomaterial research has transformed healthcare by integrating natural biological macromolecules into high-performance, versatile materials. This has resulted in a search for low-cost, environmentally beneficial, and renewable biomaterials. Silk along with other bioinspired materials are becoming more popular because to their superior mechanical qualities, flexibility, bioactive component sequestration, controlled biodegradability, biocompatibility, and low cost. These materials have the ability to govern temporal, spatial, biochemical, and biophysical processes.

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Keywords

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1. Introduction

Craft history highlights variations in the evolution of a craft, yet the basic features and essence are maintained. Craftsmen, workmanship, customer requirements, and market trends all play an important role. Consumer requirements drive craft innovation, and lifestyle changes have resulted in considerable modifications in handloom silk weaving. In the midst of a crisis, weaving in locations with various materials and textures offers enormous profitability, popularity, and advertising opportunities for professionals [1]. Handloom textures include natural filaments and dyes, lowering the textile industry's environmental effect. The decentralized strategy decreases energy reliance on hardware and transportation while adhering to economic requirements. Reviving handloom skills assists civilizations in regaining their social identity, promoting happiness and continuity. It also has tremendous financial importance, since these techniques have served as the foundation for decades of employment. Restoring handloom skills involves marginalized populations, encourages fair employment, and increases rural communities' monetary flexibility [2]. To maximize the benefits of heterosis, sericulture globally concentrates on developing first-generation hybrids. One key problem is precisely sorting breeds for hybridization based on sex in order to achieve pure hybrids free of contamination. The current methods for classifying grenas, caterpillars, cocoons, pupae, and silkworm moths by sex are time-consuming and imprecise [3]. Sericulture, which combines agricultural and non-farm activities, provides many job options for both men and women. However, there is little information on the adoption trends and profitability of hybrid Bi-voltine silkworm rearing. Given sericulture's rising relevance in rural areas, the purpose of this study is to look into the amount of adoption and socio-economic features of farmers [4]. Intangible cultural legacy can greatly contribute to rural revival in the modern era. Scholars have explored non-sericulture's significance in rural regeneration from a macro viewpoint while ignoring its influence on local revitalization from a micro one. To achieve local economic development, theoretical assistance for other sericulture bases can be offered in order to strengthen the overall sericulture sector and so promote local economic growth [5]. To maintain the community's artistic heritage, it is critical to analyze the circumstances that led to its cultural and industrial growth, as well as improve preservation strategies. Sericulture theory, and sericulture farmhouse architecture are essential. Former farmhouses and their surrounding landscapes must be adapted for both industry and the environment. Plans for the preservation and rehabilitation of Sericulture Farm, its surroundings, and underlying concerns are presented, as well as a clear path for future preservation efforts [6]. To nurture, community-based sericulture, an old practice, requires modern technology as well as ongoing socialization. However, raw supplies, human resources, and marketing issues must be handled. To address these challenges, a community-based sericulture cluster based on a partnership approach is required. Active government participation, supportive institutions, and the entrepreneurial community are all critical to its success and long-term viability [7].

2. Sericulture 4.0: Innovation Meets Tradition in Silk Production

Silk, a natural fabric spun by spiders and silkworms, is used in the textile industry and healthcare settings to mend tissue and bind wounds. Its biocompatibility, mechanical performance, predictable degradation, and silk-based materials have made it a popular choice for regenerative medicine, neural soft tissue creation, and controlled drug release. Silk also helps in the encapsulation and implantation of therapeutic stem and progenitor cells [8]. Sustainable sericulture is a global challenge, necessitating environmentally benign, commercially successful, and culturally meaningful food production. Muga culture, a traditional silk production system in Assam, India, is a model of sustainable agriculture that incorporates indigenous traditions, biodiversity protection, minimal environmental effect, economic rewards, and cultural preservation. This approach exemplifies the power of combining old knowledge with contemporary ecological ideas [9]. Silk biomaterials, particularly those derived from Bombyx mori and spiders, are highly valued in biomedical engineering because to their remarkable mechanical characteristics, biocompatibility, and biodegradability. Tissue engineering, medication delivery, wound healing, and implanted devices all benefit from their resilience, flexibility, and strength. Silk-based scaffolds, which imitate the extracellular matrix, aid in cell adhesion, proliferation, and differentiation, making them helpful in repairing tissues such as bone, cartilage, skin, and nerve. Silk fibroin matrices permit regulated drug release, allowing for focused and long-term therapeutic delivery [10]. Silk is a valuable bio-sourced material due to its mechanical properties, flexibility, bioactive component sequestration, controlled biodegradability, biocompatibility, and low cost. It regulates temporal-spatial, biochemical, and biophysical processes, and its structural and functional characteristics are being studied as scaffolds. The objective is to explore the body's natural potential to regenerate by analyzing its biophysical properties and ability to meet tissue functional requirements [11]. Sericin, a natural biomaterial generated from silkworms, is gaining popularity due to its distinctive bioactivity and great compatibility. Silkworms are classified as wild-type or silk fibroin-deficient mutants, with the latter producing varied and high-quality sericin. This sericin has uses in cell culture, tissue engineering, medication delivery, and cosmetics [12]. Sericin, a biodegradable protein found in silk, has several uses in medications, textiles, and cosmetics. In India, degummed silk is discarded, yet its potential as a nutritional supplement remains untapped. Sericin's nanotechnology has resulted in advances in biomedicine and tissue engineering, notably pharmaceutical formulations and biomaterials. Sericin conjugated nano formulations are an example of a biocompatible, cost-effective, and bio-degradable substance [13]. Sericin, a protein derived from silkworm cocoons, has been considered a waste product for ages due to a lack of knowledge. Recent research has shown that sericin-based biomaterials have cytocompatibility, low immunogenicity, photoluminescence, antioxidant characteristics, and cell-function regulating activities, making them intriguing for biomedical applications [14]. Fibroin, a crucial component in silk, is a biomaterial that is both biocompatible and biodegradable. It's employed in medication delivery systems and the creation of three-dimensional tumor models to better understand cancer biology. Sericin, a cytotoxic drug, has been utilized as a nano-carrier for therapeutic medicines. Mulberry components, such as polyphenols and anthocyanins, have anticancer activity. Sericultural byproducts have been employed in cancer treatment, suggesting their potential for designing successful medication methods [15]. **Figure 1** below shows an image of Silk Sericin that can be utilized in bio-medicines. The documentation and distribution of cultural heritage is critical, and 3D models are becoming increasingly popular for this reason. Historical silk textiles are delicate and sophisticated, making documentation difficult owing to their precise geometries and weaving processes. A novel technology, Virtual Loom, is utilized to realistically represent and make 3D prints, making them more interactive and accessible [16]. Cordyceps militaris, an entomopathogenic fungus, is famous for its anti-cancer agent, Cordycepin. Despite its rarity, artificial culture is gaining worldwide popularity. After suffocating cocoons for raw silk manufacturing, the silkworm, a major economic participant in Asian food and silk industries, produces lifeless pupae. Sericulture waste in India has the potential to be utilized as a culture media for the Cordyceps industry, helping silk growers and tribal tribes. This might lead to future financial and social development [17]. The research identifies historical silks that have had degumming, a procedure that removes sericin, to

Figure 1. Silk Sericin for Bio-medicinal purposes.

differentiate between hard and soft silk. Non-invasive ATR-FTIR spectroscopy was used to evaluate samples of silk fabrics. The ER-FTIR approach, which is rapid, portable, and commonly utilized in cultural heritage research, was applied to solve data interpretation issues for firm silk, demonstrating the difference between hard and soft silk for informed conservation [18].

3. Recommendations

Based on our thorough literature review, we propose the following recommendations for the future.

- Silk scaffolds imitate the extracellular matrix, offering structural support as well as pharmacological signals for cell adhesion, proliferation, and differentiation. They are effective in tissue regeneration and controlled medication release, allowing therapeutic substances to be administered in a targeted and sustained manner.
- Sericin, a byproduct of silk fabrication, has both ecological and commercial importance, with potential applications in food and biology. Additional study must be conducted for assisting the silk industry produce value-added products.
- Mulberry's complex composition, high in bioactive compounds, has been shown in multiple studies to have anticancer properties, showing its potential as a viable alternative medicine for cancer treatment.

- Cordyceps militaris culture could promote resource efficiency, waste reduction, and energy efficiency by recycling and reusing silkworm pupae waste and researching alternate cultivation substrates.
- Advances in biotechnology, including as genetic engineering and tissue culture techniques, may increase the efficiency and productivity of Cordyceps militaris expansion utilizing silkworm pupae as artificial medium.
- Expectations and limitations for Cordyceps militaris and silkworm pupae cultivation may be required, since adherence to food safety, animal welfare, and environmental standards can raise operational complexity and expenses.
- The analysis suggests that indirect degumming extent assessment in the industrial environment might be a potential future trend, but it will require more research and chemo-metrics for effective management.
- The suggested approach for detecting hard silk is simpler than prior ATR-FTIR spectroscopy methods since it only evaluates one wide band. Visual comparison of spectra with reference textiles can aid in identification, however principal component analysis provides a more objective comparison that focuses on anomalies.

Conclusion

Sericulture, an appealing job option for farmers, generates waste from silkworm larvae and pupae during rearing and cocoon stifling. The efficient utilization of these byproducts can benefit a farm's profitability and sustainability. This study focuses on waste formation in sericulture, both mulberry and non-mulberry, and its collection, consolidation, and reutilization in agriculture and pharmaceutical sectors as prospective media for Cordyceps militaris fungal cultivation. Silk, a natural protein fiber, is an attractive choice for biomedical engineering because to its superior mechanical qualities, biocompatibility, and biodegradability. Its distinct molecular structure offers resilience, elasticity, and strength, making it suited for a variety of applications including tissue engineering, medication administration, wound healing, and implanted medical devices. Silk biomaterials have variable degradation rates, controlled mechanical characteristics, and promote cellular development and tissue regeneration, making them excellent for a wide range of biomedical applications. The case study recommends that sericulture bases create tourism goods and experiences to attract varied consumer groups, improve their relationship with local culture, and leverage multimedia and internet platforms for successful publicity. It suggests creating additional goods and services that complement local sericulture culture, expanding collaboration with tourism, culture, and education departments to promote silkworm culture, and using network media to increase brand visibility and market impact. Sericin, a valuable biopolymer with environmental advantages, has found commercial application in a variety of sectors, including cosmetics, medicines, food, and biomaterials. Its environmental benefits and diverse uses make it an important biopolymer. Sericin's anti-aging, antibacterial, anticancer, anticoagulant, hydrophilic, moisture-absorbing, antioxidant, biodegradability, cell compatibility, and UV-protection qualities make it ideal for cosmetic and biomedical uses. Nanoscience, with its tiny size, interaction with tissue, and high surface area, holds promise for biomedical and tissue engineering applications. However, sericin is frequently thrown as effluent due to a lack of understanding. Sericin, a useful biological component found in silkworms, has a variety of applications in cell culture, tissue engineering, medication delivery, cosmetics, and functional foods. Its biological activity and extraction process improvement have the potential to broaden its applications in a variety of industries. Sericin, which contains 18 amino acids, is very beneficial in silk fibroin-deficient silkworms, which have been researched for functional food. However, there has been little research on sericin's potential in functional food.

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References

1. Kumari P., Karolia A. Craftsman and Consumer: Need Driven Innovation for Handloom Silk of Bihar. *A treatise on Recent Trends and Sustainability in Crafts & Design*, *8*.
2. Goyal A., Choudhury J. (2024, October). Exploring the revival of traditional Handloom techniques in contemporary fashion trends in emerging technologies and sustainable finance. In *2nd International Conference on Emerging Technologies and Sustainable Business Practices-2024 (ICETSBP 2024)* (pp. 472–485). Atlantis Press.
3. Larkina E., Yakubov A., Daniyarov U., Abdikayumova N. (2024). Possibility of industrial use of silkworm breeds sex-tagged at the egg stage. In *E3S Web of Conferences* (*Vol. 563*, p. 03028). EDP Sciences
4. Jiragal I., Reddy M. S., Mahinsharif M., Naik R. G. (2019). Adoption Level of Bi-voltine Silkworm Rearing Practices among Farmers of Chitradurga District, India. *Int. J. Curr. Microbiol. App. Sci*, *8*(2), 2481–2488.
5. Kexi J., Mengling Z., Yuankai S., Peiyang H., Han Z., Lulu S. (2024). Research on the Path of Enabling Rural Revitalization by Intangible Cultural Heritage Industry: A Case Study of Zhouwang Temple in Haining City (Take the Sericulture Base of Yunlong Village as an Example). *Available at SSRN 4997790*.
6. Cheng S. Y., Ono S. (2020). Preservation and management of a World Heritage site Tajima Yahei Sericulture Farm and its buffer zone. *Built Heritage*, *4*(1), 13.
7. Agustarini R., Suharti S., Andadari L., Widarti A., Yuniati D., Sarwono K. A. (2023, December). Community-based development of Indonesian sericulture: An economic signification and defiance. In *AIP Conference Proceedings* (*Vol. 2972*, No. 1). AIP Publishing.
8. Yonesi M., Garcia-Nieto M., Guinea G. V., Panetsos F., Perez-Rigueiro J., Gonzalez-Nieto D. (2021). Silk fibroin: An ancient material for repairing the injured nervous system. *Pharmaceutics*, *13*(3), 429.
9. Hazarika S., Saikia B. MUGA CULTURE: A NOTABLE APPROACH FOR SUSTAINABLE DEVELOPMENT. *RECENT TRENDS IN ENTOMOLOGY*, *73*.
10. Attri K., Shruthi G. H., Gulabrao D. P., Teja K. S. S., Garai I., Pandey A. K., … Bharathi B. K. M. Silk Biomaterials: Applications and Future Prospects in Biomedical Engineering. *Biomedical Engineering*, *45*(16), 205-16.
11. Kumar Sahi A., Gundu S., Kumari P., Klepka T., Sionkowska A. (2023). Silk-based biomaterials for designing bioinspired microarchitecture for various biomedical applications. *Biomimetics*, *8*(1), 55.
12. Li Y., Wei Y., Zhang G., Zhang Y. (2023). Sericin from fibroin-deficient silkworms served as a promising resource for biomedicine. *Polymers*, *15*(13), 2941.
13. Sarangi A., Baral S., Thatoi H. N. (2023). Extraction and biological application of silk sericin: an over view. *Asian Journal of Biology*, *17*(2), 57–72.
14. Wang J., Liu H., Shi X., Qin S., Liu J., Lv Q., Wang L. (2024). Development and Application of an Advanced Biomedical Material-Silk Sericin. *Advanced Materials*, 2311593.
15. Baci G. M., Baciu E. D., Cucu A. A., Muscă A. S., Giurgiu A. I., Moise A. R., … Dezmirean D. S. (2023). Sericultural by-products: The potential for alternative therapy in cancer drug design. *Molecules*, *28*(2), 850.
16. Pérez M., Casanova-Salas P., Twardo P., Twardo P., León A., Mladenic D., … Portalés C. (2020). From historical silk fabrics to their interactive virtual representation and 3D printing. *Sustainability*, *12*(18), 7539.
17. Narzary P. R., Brahma D., Sarma J., Nath I., Dutta P. L., Bora N. R. (2024). Commercial Culture of Cordyceps militaris from Waste Products of Sericulture in India. *Journal of Advances in Biology & Biotechnology*, *27*(5), 73–80.
18. Geminiani L., Campione F. P., Canevali C., Corti C., Giussani B., Gorla G., … Rampazzi L. (2023). Historical silk: a novel method to evaluate degumming with non-invasive infrared spectroscopy and spectral deconvolution. *Materials*, *16*(5), 1819.