Chapter 7

Redefining Silk Farming: A New Age with Sericulture 4.0

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Abstract

Silk farming, also known as sericulture, has a 5,000-year history. It promotes employment opportunities, economic growth, and well-being by raising mulberry trees for a variety of purposes. The industry produces high-quality silk thread and high-protein foods for both humans and animals. It relies on a multipurpose plant to improve human health and soil conservation. A sustainable silk derivatives sector might replace petrochemicals with fibroin molecules found in common health items, biopharmaceuticals, and implants. Sericulture is an agricultural-based business that produces food plants and breeds silkworms. Common silkworm species include Bombyx mori caterpillars, Eri, Muga, and Tasar for 'wild silks'. India has a long history of silk manufacture, extending back to the 14th century. It is the world's only country that produces muga silk. Silkworms go through four stages in their life cycle: egg, larva, pupa, and adult. Filaments from numerous cocoons are wrapped together to form a single raw silk thread. The genome of the Bombyx mori silk moth was sequenced in 2004, a significant step forward in insect genomics research. This finding has uncovered crucial genes involved in silk manufacture, development, immunology, and other biological processes. This information has applications in agricultural enhancement, silk quality, disease resistance breeding, and molecular breeding techniques. Advances in genetics and analytical technologies point to new discoveries in silkworm study and sericulture. Sericulture, a traditional agribusiness, exploits mulberry silkworms to generate natural silk in cocoons. However, synthetic fertilizers can degrade leaf quality and soil health, posing a threat to silkworm health. Natural or organic alternatives to mulberry leaf improvement include farmyard manure, compost, vermin compost, green manures, and bio-fertilizers. These solutions seek to increase the industry's success. This chapter investigates the environmental implications of collecting natural or synthetic fibers including cotton, wool, silk, polyester, nylon, rayon, and acrylic. It focuses on water and air pollution, solid waste creation, freshwater usage, dangerous toxic compounds, and wastewater generation. The manufacture of textile fibers requires enormous volumes of fresh water, harmful chemicals, and wastewater, emphasizing the importance of sustainable textile industry approaches.

Keywords

Seri-Compost, Organic Mulberry Production, Silk Fibroin, Bombyx Mori, Sericin, Genome Sequencing

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1. Introduction

Sericulture is a rural enterprise that includes separating silk filaments from cocoons and winding them onto reels to produce raw silk. This agro-based economy provides more revenue and distributes funds from the wealthy to the poor, making it ideal for small and marginal farmers. Waste generated by sericulture operations, especially silk worm litter and mulberry leaves, is collected and turned into beneficial seri-compost using appropriate equipment. Sericulture activities in villages discourage people from migrating to cities to find work [1]. Sericulture is an important cash crop since it requires minimal investment, has a short gestation time, has significant employment potential, and yields a good return. It is appropriate for all socioeconomic groups, including wealthy farmers and those without land. It necessitates limited technology and generates employment and revenue in rural and semi-urban environments, particularly among low-income and socially marginalized communities [2]. Silk cocoons from foothill plantations had stronger technical indicators, implying that developing mulberry plants on recently recovered soil in the foothills improves sericulture feed and preserves agricultural crops from erosion. This demonstrates the significance of strategic planning and sustainable land use methods in agricultural growth. Policymakers can boost silk production, contribute to environmental conservation, and conserve agricultural areas by concentrating on appropriate places such as foothills [3]. Silkworm larvae go through four moults and five instars, chawki and late-age, before spinning cocoons. They get their nourishment from mulberry leaves, but their needs change as they become older. Chawki Rearing Centers (CRCs) help to sustain cocoon crop yield in sericulture by providing controlled settings, boosting silkworm health, promoting uniform development, and raising survival rates. These facilities are critical to the sector's success and long-term existence [4]. Fibers are utilized in fashion and textile manufacturing and can be sourced from natural or petroleum resources. Traditional natural fibers, such as cotton, require a lot of water and pesticides, whereas synthetic fibres are non-renewable and non-biodegradable. Given their end-of-life status, the extraction and usage of these fibers are not sustainable, rendering them unsuitable for sustainable production. As a result, it is critical to examine the longevity of these basic materials [5]. The demand for high-quality mulberry leaf for silkworm breeding has resulted in the adoption of natural or organic alternatives including farmyard manure, compost, vermi-compost, green manures, and biofertilizers. Organic mulberry production is seen as essential for reviving the world silk industry. Awareness of the damaging effects of toxic chemicals, and the necessity for eco-friendly natural resource management, has resulted in a new lifestyle that has the potential to substantially enhance the sericulture business, including leaf, cocoon, and silk production [6]. Sericulture, a historic rural agro-based sector, has greatly improved social and economic conditions in emerging nations. Tasar sericulture, with its on-farm and off-farm operations, has a high employment potential. It directly employs people in tasar nursery and seed production, silk worm raising, spinning, weaving, and waste processing, as well as indirectly trading silk goods. Tasar sericulture has also benefited the rural economy by providing income-generating entrepreneurship options [7].

2. Redefining Silk Farming: A New Age with Sericulture 4.0

Sericulture is a sustainable enterprise that manufactures high-quality silk thread and protein-rich foods for people and animals. It is based on a versatile plant called silk fibroin, which is biodegradable and flexible like plastic. With advancements in bio-harvesting technology, markets may now get silk fibroin on a big scale, benefiting human health and soil conservation. Sericulture is a unique end-to-end sustainable sector with a low environmental effect [8]. New materials for the food, water, and agricultural

industries must exceed performance standards while also addressing biodegradability, circular life cycle, and sustainable sourcing. Regenerated silk fibroin is a structural biopolymer recovered from Bombyx mori cocoons via a water-based technique. Silk fibroin is harmless, natural, and competitively orientated. Although it degrades slowly in the human body, it is both ecologically stable and biodegradable, giving it a viable alternative to conventional materials [9]. Genome sequencing and public databases have combined molecular technologies with traditional breeding methods to create silkworm hybrids with greater production, quality, and long-term yields. Researchers discovered genes and proteins related with illness resistance and tolerance, which led to the formation of Bombyx mori breeds. Molecular diagnostic tools for silkworm illnesses have enhanced precision and innovation in characteristics such as silk productivity, disease tolerance, high temperature, and relative humidity [10]. The Bombyx mori mulberry silkworm, which is infected with the Bombyx mori nucleo-polyhedro virus (BmNPV), produces grasserie disease and considerable economic losses in the silk industry. Despite the introduction of diagnostic kits, they are rarely employed. The best emerging methods include antibody-based biosensors and lateral flow assays, which have great specificity and sensitivity. Disease-resistant silkworm breeds or natural silkworm resistance may be the most cost-effective method of preventing grasserie disease. A comprehensive investigation of host gene responses to BmNPV infection is also expected [11]. Silkworm genetic variety is a cause for worry since it can make them more susceptible to pests and illnesses. Maintaining genetic variety is critical for long-term genetic improvement management techniques, as silkworms are domesticated all over the world for their glossy silk. Studies based on quantitative qualities, biochemical and genetic markers, and factors contributing to biodiversity loss should be investigated [12]. Recent biotechnology advances, especially recombinant DNA methods, genetic engineering, and stem cell research, have transformed plant and animal sciences. However, their influence on sericulture is restricted due to a lack of practice in industrially developed nations, which impedes the development of biotechnological methods to sericulture [13]. Sericulture is an agricultural cottage enterprise that promotes long-term growth through social interaction. Muga silk, an organic fiber composed of fibroin and sericin, is a flexible, long-lasting material excellent for emerging technologies. Sericin, a globular protein, is suitable for biological purposes. Muga silk is known for its applications in textiles, clothing, biomaterials, pharmaceuticals, dietary additives, and biofuel synthesis. Its adaptability makes it a viable alternative for a variety of sectors [14]. Eri silk, a darker and thicker variety of silk, is recognized for its thermal characteristics, keeping it warm in winter and cool in summer. It consists mostly of fibroin and sericin, with minor paraffin components, mineral salts, and coloring materials. Its distinctive features, including as fineness, density, and surface, make it ideal for commercial usage in the production of high-quality blankets, sweaters, and suiting fabrics. Eri silk is extremely popular in eco-friendly items since it does not disrupt the silkworm's normal life cycle [15]. Silkworm genomics has had a tremendous influence on sericulture, exposing the genetic basis of silk production and other biological processes. This has resulted in the development of molecular breeding methodologies for more effective silkworm trait improvement. Engineers can reduce economic losses by discovering resistance genes in silkworm breeds. This understanding has implications for agricultural development, allowing researchers to create silk of higher quality and quantity, breed silkworms with better disease resistance, and investigate novel molecular breeding strategies [16].

3. Recommendations

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

- New concepts and technology are increasing the application and value of silk fibroin in consumer products and healthcare, making sericulture a greener, more sustainable alternative to petrochemical manufacturing. It also provides low-impact farming, making for an exciting future.
- Sericulture, a worldwide, sustainable, and safe alternative to petrochemicals, is gaining appeal across a variety of sectors. Sustainable cultivation techniques can assure the long-term viability of this natural technology, both in production and utilization.
- Sericulture enriches soil fertility, avoids erosion, and promotes sustainable forest management. It maintains wild flora and animals, controls precipitation, cleanses the air, and prevents pollution. Promoting sericulture activities is critical to preventing soil erosion and preserving biodiversity in the Ecosystems.
- Sericulture, a simple and accessible technique, helps all segments of society, including farmers and landless people, and has offered employment and income in rural and semi-urban regions, notably for low-income and socially under-privileged groups.
- Due to its multifunctional capabilities, the sericulture sector is a very useful agro-based venture, particularly for socio-economic development. According to studies, it is the best agro-based industry for current and future socioeconomic progress.
- Silkworms from Asian nations have the potential to produce medicinal proteins, vaccines, and nano-materials. Understanding the host protein process can aid in the development of further commercial uses for this species.
- Genome editing technology may be employed to create innovative commercial B. mori variants with higher silk production, quality, and virus resistance. The silk gland of B. mori is suitable for creating useful proteins, and while expression methods have been devised, further work is needed to optimize the silk protein-encoding genes.
- Improving silkworm resistance to BmNPV is critical for minimizing economic losses and promoting sericulture advancement. Identifying grasserie disease-predisposing variables and functionally evaluating potential genes can contribute to the development of novel treatments, improving sericulture output, and protecting farmers' interests.

Conclusion

Sericulture, a historic and important aspect of society's past, may be utilized in environmentally conscious and responsible ways. Sericulture, as an integrated agricultural production system, is a low-capital, high-yield technique with advantages on a small scale. It's flexible to climate change, sustainability, and fair trade. Silk fibroin, a fundamental component of the silk production supply chain, is being employed in consumer products and healthcare owing to new concepts and technology. This chapter investigates the environmental and social consequences of textile fiber production for fashion and textiles. It highlights the difficulties in collecting traditional natural textile fibers, as well as the significant environmental effect of synthetic fibers including cotton, wool, silk, polyester, nylon, rayon, and acrylic. The chapter also discusses how these fibers pollute the environment. Silkworm genetic variety is critical for developing long-term management techniques to increase silk quality. Greater homogeneity might make you more vulnerable to pests and illnesses. Seri-biodiversity conservation seeks to save various ecotypes from extinction and use them in breeding operations for commercial silkworm advancement. Promoting sericulture activities can help to minimize soil erosion and preserve the Biosphere's unique biodiversity. Millions of people worldwide rely on silkworms to produce beautiful silk, the Queen of Textiles. The sericulture industry, which was once primarily focused on silk fiber for textiles, has evolved into a

multi-purpose agro-based industry that contributes to socioeconomic development by providing jobs, food security, income generation, women's empowerment, environmental safety, agricultural integration, and infrastructure development. Sericulture uses have recently been broadened to include human and cattle nutrition, cosmetic manufacturing, medicines, biomedical and bioengineering, cars, home construction, and art craft. The genetic elucidation of silkworm B. mori has sparked considerable interest in its use in labs worldwide. Advanced genetic technology have permitted functional investigation of B. mori genes and advanced genetic manipulation of silkworms, hence increasing their commercial worth. This has also aided the development of comparable technology in non-model insects. Enhanced genetic modification skills will result in newer enhanced phenotypes, increasing sericulture economic success. Traditional breeding procedures have not resulted in higher silk quality and quantity from individual silkworms. BmNPV grasserie disease is a serious setback in sericulture, resulting in financial losses for producers. Prevention and therapy are ineffectual, and the relationship between genetic and host variables is unknown. Early diagnosis of BmNPV infection in silkworm rearing is critical to preventing its spread. Advanced disease diagnostic methods, such as antibody-based biosensors and lateral flow assays, have great sensitivity and specificity, making them suitable for unprocessed and crude materials.

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