SERICULTURE

Devarshi .R. Jadia *
School of Biotechnology and Bioinformatics,
D.Y. Patil Deemed to be University
Navi Mumbai, India
jadiadevarshi@gmail.com

Dr. Sheetal Sonawdekar,
School of Biotechnology and Bioinformatics,
D.Y. Patil Deemed to be University,
Navi Mumbai, India

ABSTRACT

Sericulture, the cultivation of silkworms to produce silk, is one of the various significant industries in today's world due to its economical, ecological, and cultural implications. Sericulture contributes greatly to sustainable development and also the well-being of communities involved in its practice. Believed to have been first produced in China in the Neolithic period, sericulture has evolved through the years in its process, cultivation, and manufacturing techniques. Silk being one of the most elegant and high-quality textiles in the world, has boosted the practice of sericulture in various parts of the world and has become the source of income for millions of people. New technological innovations are being implemented across the globe to improve silk production, reduce environmental impact, make use of automation, and increase the yield and quality of silk.

Keywords– Sericulture, Silk, Silkworms, Silk farming, Silk rearing

I. INTRODUCTION

Sericulture is the practice of cultivating and rearing silkworms to extract silk from them. Originated in China, sericulture has been in practice for thousands of years and today, China and India are the two main producers of silk around the globe.
Due to its natural sheen, unparalleled grandeur, high quality and durability, and soft touch, silk is one of the most popular textiles in the world. It is also known as the 'Queen of Textiles'. India in particular has a rich and complex history of silk and its silk trade, dating back to the 15th century.
Sericulture provides employment to approximately 8.7 million people in the country, out of which a sizable number of people belong to the economically-weaker sections.
Also, India is the only country that produces all five commercial silks, namely, mulberry, tropical tasar, oak tasar, eri, and muga.

A. History of Sericulture

- Sericulture can be dated back to ancient China in around 2700-2500 BCE. Silkworms and their capabilities of producing silk were rumoured to be discovered by a Chinese Empress and since then silk became highly-prized. Soon after, the Silk Trade routes were developed, connecting the East to the West.
- In the 4th century CE, sericulture slowly started establishing itself in certain parts of Asia like Korea, India, and Japan.
- By the 6th century CE, sericulture practice began in the Byzantine Empire and in Europe.
- Sericulture was also spread to the Islamic world in the 7th and 8th centuries CE.
- In the 18th and 19th centuries, sericulture was modernized due to the development of machinery. Silk cultivation thrived in France, Italy, India, and China.
- Presently, sericulture is one of the most profound and important industries in the world, contributing to the financial, cultural, and economical sectors of several countries.

- Advances in genetics, breeding, and modern technology have further improved silk cultivation and its quality.

B. Significance of Sericulture

- Economic Importance: Sericulture provides income and employment opportunities to millions of people including farmers, artists, labourers, etc.
- International Trade: Silk is known as a luxury fabric and its trade between countries helps to improve the economy and generate revenue.
- Sustainable Livelihood: Sericulture offers a sustainable livelihood to farmers and people belonging to the rural areas of the country.
- Environmental Benefits: Silk is a biodegradable and renewable source, making it environmentally friendly as compared to synthetic fibers.
- Research and Innovation: Sericulture encourages research and innovation in various fields such as genetics, agriculture, and textile industry.
- Tourism and Craftsmanship: Regions that are famous for sericulture often attract tourists who are curious about the silk farming industry and the craftsmanship behind it.
- Preservation of Biodiversity: Sericulture encourages the plantation of mulberry trees, which serves as food for silkworms.
- Health Benefits: Not only produced for its luxurious fabric feel, silk is also known for its hypoallergenic and moisture-wicking properties. It is recommended for people with sensitive skin or allergies. (Mehta, 2020)

II. PROCESS OF SILK PRODUCTION

The process of producing silk is divided into three parts-

1) Morticulture - cultivation of mulberry leaves
2) Silkworm rearing - promoting growth of silkworms
3) Silkworm reeling - extraction of silk filaments

The extracted silk filaments are woven together to form a thread.

- Morticulture

Morticulture is the process of planting mulberry trees which act as food for silkworms. The leaves of mulberry plants are known to be silkworm feed. The mulberry plants are grown via three different methods:

(a) Cultivation from seeds
(b) Root grafting
(c) Stem grafting

The mulberry leaves are harvested from the plants through any of the following three methods:

(a) Leaf picking - hand picking of individual leaves
(b) Branch cutting - cutting of an entire branch
(c) Top shoot harvesting - removal of the shoot tops

- Silkworm rearing

The female silk moth lays eggs on a specially prepared cardboard or paper. Usually, 300-500 eggs are obtained from one female silk moth. These eggs hatch into tiny silkworm larvae called silkworm eggs. The hatched larvae are placed on mulberry leaves. Feeding on these leaves, the larvae grow and their size increases. During the process of feeding on the leaves, the silkworms also shed their skin to accommodate their growing bodies. After they have reached their full size, the silkworms start spinning their cocoons. They secrete a sticky substance called sericin which hardens when in contact with air, to form silk threads. Silkworms wrap themselves in these silk threads to form a protective cocoon.

- Silkworm reeling

These cocoons are boiled or heated to soften the sericin and kill the pupa. After boiling, the sericin is loosened and the outer layers of the cocoon begin to unwind. This is called reeling. The silk threads are reeled onto spindles or bobbins. The raw silk threads are then processed in order to remove any remaining sericin, dirt, or impurities. The threads are then twisted together to form silk yarns which can be dyed or woven into a fabric.

III. TYPES OF SILK

- Mulberry silk
  It is the most common and widely-used type of silk. It is produced from a species of silkworms known as Bombyx mori that exclusively feed on mulberry leaves. Mulberry silk is known for its luxurious quality, natural sheen, fine texture, high quality, and smoothness.

- Tussar silk
  Also known as “wild silk” or “forest silk”, Tussar silk is derived by silkworms of the Antheraea genus. These silkworms feed not only on mulberry leaves but also wild trees and shrubs. Due to this, Tussar silk has a coarser texture and a more textured appearance compared to mulberry leaves. This silk is used in making scarves, sarees, and rusty fabrics.

- Eri silk
  Eri silk is produced by caterpillars of the Eri silkworms that feed on castor leaves. Having a wool-like feel, eri silk is more textured and less lustrous. It is used for textiles, winter clothing, and shawls.

- Muga silk
  Produced by the Muga silkworm, Muga silk is a golden-hued silk that is exclusively found in the state of Assam in India. This silk is known for its natural shimmer and durability. It is used for traditional Assamese attire and decorative textiles.

- Vegan silk
  This type of silk is produced in such a way that the silkworms are not harmed. In this method of silk production, the silkworms are allowed to complete their lifecycle and emerge out of their cocoons before the silk is harvested. This vegan silk is less finer in texture than the traditional silk but it appeals to those who priortize animal welfare. It is also known as Ahimsa silk or Peace silk

IV. LATEST TECHNOLOGICAL CHANGES IN SERICULTURE

Over the years, sericulture has modernized in several ways due to the latest innovations in biotechnology. Technologies such as gene therapy, gene editing, nano-biotechnology, and transgenic technology are being used to overcome several problems that are facing while practising the traditional silk production process. These technological innovations aim at making sericulture more efficient, sustainable, and economically viable.
(Chauhan, Tayal, 2017)

(a) Genetics
Due to recent genetic research, improved versions of silkworm strains have been developed that have a higher silk yield, better growth rate, and are disease resistant. Genetic manipulation has also played a pivotal role in quality and quantity of silk production.

(b) Detection and Management of Disease
DNA-based diagnostics and molecular markers help to identify diseases and pathogens in silkworms at an early stage and in an accurate way. This helps early detection and prevention of diseases, thus reducing the risk of outbreaks.

(c) Automatic Cocoon Harvesting
Automated cocoon harvesting machines have now been developed that harvest silk cocoons in a more efficient way. These machines automatically unwind the silk threads from the cocoons without harming them and thus reducing manual labour and also improving the overall silk quality.

(d) Sericulture Sensors and IoT
Sensors are now being integrated into silk rearing processes that help to monitor environmental conditions, temperature, humidity, etc. This data helps breeders and farmers make informed decisions about the silk rearing conditions.

(e) Biotechnology
Advancements in biotechnology such as genetic modifications are now being considered in order to enhance silkworm characteristics such as silk quality, resistance to diseases, feeding habits, etc.

(f) Sustainable Mulberry Farming
Modern agricultural methods are being implemented in the plantation of mulberry trees as well. This includes practices such as efficient irrigation, organic farming techniques, and integrated pest control. These practices help to maintain a sustainable and high-quality supply of mulberry leaves for silkworm feed.

(g) Mechanized Silk Reeling
Mechanical machines and devices have been developed for the process of silk reeling, reducing the manual labour and improving the silk yield and quality by optimizing the unwinding process.

(h) Artificial Diet Development
Traditionally, silkworms rely on mulberry leaves as their primary source of food. However, to reduce the dependency on mulberry plants, scientists have developed an artificial diet that provides balanced nutrition to silkworms and also enhances silkworm health and silk production.

(i) Silk Degumming and Finishing
Technological innovations in silk degumming, that involves the removal of sericin from silk fibers, have led to the development of eco-friendly degumming practices that use enzymes and reduce water consumption. These machines increase the efficiency of silk extraction and ensure higher yields.

(j) Waste Utilization
Innovations in waste utilization methods have shown that the waste materials produced in the production of silk, such as pupal shells and discarded cocoon waste can be processed to extract valuable components and can also be used like organic fertilizers or animal feed.

These technological innovations have not only improved the efficiency and productivity of the sericulture industry but have also opened up new avenues for research, development, and the utilization of silk in various applications.

Fig 1: Silkworm rearing on mulberry leaves
(Image courtesy - Soi, 2019)

V. NEW INNOVATIVE METHODS IN SERICULTURE

(a) Vertical Farming for Mulberry Cultivation
Vertical farming refers to growing of crops in stacked layers, typically in a controlled environment. Vertical farming in mulberry cultivation can result in the optimal space usage, reduced water consumption, and controlled environmental conditions, resulting in higher quality mulberry leaves.

(b) Insect Cell-Based Silk Production
Ongoing research depicts the usage of insect cell cultures to create silk proteins without actually using silkworms. By using genetic engineering, silk proteins can be syntheized and harvested from insect cultures in bioreactors. This method can result in sustainable and scalable silk production.

(c) Integrated Pest Management (IPM)
IPM refers to a holistic approach for pest management that minimizes the use of chemical pesticides. This method includes biological control, crop rotation, habitat manipulation, and other sustainable techniques to manage pests in sericulture.

(d) 3-D Printed Silk Structures
Silk proteins can be extracted and then 3-D printed into various structures such as textiles, scaffolds for tissue engineering, and certain fashion items.

(e) Nanostructured Silk Materials
Having enhanced properties, nanostructured silk materials also have various applications such as wound healing, drug delivery, and high-performance textiles.

(f) Silk Waste Recycling:
Efforts are being made to recycle the waste materials that are generated during the silk reeling process. These waste materials can be processed into new silk products, thus reducing waste and promoting sustainability.

(g) Ethical and Sustainable Sericulture
Technological innovations are not only focusing on high silk yield but also on ethical and sustainable sericulture practices such as allowing the silkworm to complete its lifecycle before the silk is harvested, minimizing the use of chemicals, and also promoting the well-being of farmers and workers.

(h) Genome Editing and Genetic Engineering

Latest genetic engineering techniques, including CRISPR-Cas9, are being used to precisely modify the genes of the silkworms. This can result in the development of silkworm strains with the desired characteristics.

(i) Hybrid Silkworm Varieties
Ongoing research focuses on creating hybrid varieties by crossing different strains with desirable traits. These hybrids may depict improved silk production, disease resistance, and adaptation to the surroundings.

(j) Precision Farming
This includes making use of technologies like drones, sensors, and satellite imagery to monitor the mulberry cultivation. This provides data such as soil conditions, moisture levels, pest infestations, etc.

These new methods and approaches are driven by technological advancements in biotechnology, genetics, nanotechnology, automation, and sustainability initiatives. These methods thus help to enhance the silk production, reduce environmental impact, and improve the overall efficiency of the process. (Savithri, Sujathamma, Neeraja, 2023)

VI. CLUSTER PROMOTION PROGRAM

In an effort to develop and promote the sericulture industry in a geographic area, the cluster promotion program was introduced by the government recently. The program was initiated with an aim to uplift India in international markets related to the quality and production of high-quality raw silk.
In this approach, a cluster of villages and families located in a particular area are selected and adopted to have area/mass and maximum effect and uses of the improved technologies that are introduced under this program. These cluster activities are managed by scientists, project leaders, and other workers in association with the local stakeholders.
Under this programme, villages within the radius of around 20 km in order were selected to save time and money on transport and to facilitate closer interactions of scientists and other resources.

Working of the cluster promotion program:

(a) Identification and Formation:
Suitable regions for cultivation of mulberry plants with appropriate climatic conditions, availability of resources, and other conditions were identified and then clusters consisting of farmers, silk producers, researchers, government officials, were formed.

(b) Infrastructure and Resource Development:
Necessary infrastructure such as mulberry plantations, rearing houses, processing facilities and other resources required such as high-quality mulberry leaves, improved silkworm breeds, and processing equipment is crucial.

(c) Knowledge Sharing and Training:
Training programs, workshops, and seminars are organized to educate and train the farmers and workers about modern sericulture practises, disease management, pest control, etc.

(d) Trade Linkages:
Cluster programs establish linkages between producers and markets. This connects silk producers with buyers, designers, and manufacturers. This expands market and trade opportunities and also increases the income of sericulture stakeholders.

(e) Quality Assurance:
The cluster encourages quality control measures to ensure that the silk produced meets the international standards. Implementing quality assurance methods from cocoon rearing to silk processing helps to enhance the marketability of products.

(f) Sustainable Practices:
Clusters promote sustainable sericulture practices that prioritize environmental, social, and economical aspects. Sustainable practices involve methods like waste management, organic mulberry cultivation, and ethical treatment of silkworms.

(g) Monitoring and Evaluation:
Regular monitoring and evaluation of the cluster promotion program helps to assess the further areas of improvement, identifying successes, and necessary adjustments required.

Under the cluster promotion program, the Central Silk Board (CSB) and State Sericulture Departments of India have jointly organized 50 sericulture clusters covering mulberry, vanya, and post cocoon sectors spread over 17 states. Each cluster was directly looked after by one scientist and one technical staff from the CSB.

Seri-polyclinics:
Sericulture clinics were established in cluster areas and were maintained by progressive farmers, technical staff, officials from CSB, etc. These clinics served as a guidance centre for the problems that were faced by the farmers involved in mulberry cultivation, silkworm rearing, etc and also facilitated the sale of disinfectants, chemicals, and other appliances that were needed for sericultural activities.

Well maintained cluster programs in sericulture can lead to increased production, enhanced product quality, greater market access, and overall socio-economic development in the region,

VII. APPLICATIONS OF SILK

Silk, with its unique properties, has various applications in several different fields.

(a) Sutures and Surgical Mesh: Silk's strength and biocompatibility make it suitable for sutures and surgical mesh.
(b) Drug Delivery System: Silk nanoparticles and films can be used to encapsulate and deliver drugs to specific sites in the body, improving drug effectiveness and reducing side effects.
(c) Tissue Engineering: Silk scaffolds provide a biocompatible framework for growing tissues and organs. They can be used for wound healing and regenerative medicine.
(d) Biodegradable Electronics: Silk-based electronics can be designed to dissolve over time, making them ideal for temporary medical implants and environmental monitoring devices.
(e) Photonic Crystals: Silk fibers can be used to create photonic crystals that manipulate light in certain ways, used in applications such as optical communication and sensing.
(f) Silk Sensors: Silk-based sensors can be integrated into fabrics or structures that can monitor environmental conditions such as temperature, humidity, etc.
(g) Supercapacitors: Silk-based materials can be used as electrodes in supercapacitors, which store and release energy, enabling applications in electronics and energy systems.
(h) Silk Membranes: Silk-based membranes can be used in water filtration systems, removing impurities and contaminants from water.
(i) Sericin in Cosmetics: Sericin from silk can be used in cosmetic products for its moisturising and anti-aging properties.
(j) Self-cleaning Fabrics: Silk fabrics can be coated with hydrophobic or photocatalytic coating to create self-cleaning textiles that repel dirt and pollutants.
(k) Lab-on-a-chip Devices: Silk-based microfluidic devices can be used for precise manipulation of small volumes of fluids in applications like medical diagnostics and chemical analysis.

VIII. CONCLUSION

Silk with its wide-ranging potential has applications not only in the textile and cloth industry but in various other technological fields. The unique characteristics of silk such as strength, elasticity, biodegradability, and biocompatibility regarding different biomedical uses make it remarkable application for a wide variety of technical and medical applications.

In India, sericulture is an age-old practice and tradition that has mingled with the culture and life of Indians. Silk production in India has a rich, intricate, and prosperous history. The practice of sericulture provides employment opportunities even in rural areas where job prospects are limited and thus offers a sustainable livelihood to farmers, manufacturers, and others involved in the practice of silk production.

REFERENCES

1. Sericulture as a sustainable agroindustry (Altman, Farrel, 2022)
2. Mulberry Sericulture (Chauhan, Tayal, 2017)
3. The genetics and genomics of the silkworm (Goldsmith, Shimada, Abe, 2005)
4. Technology adaptation in sericulture management in India (Gowda, Murthy, Muniraju, 2012)
5. Recent trends in the development and diversification of sericulture natural products for innovative and sustainable applications (Jaiswal, Banerjee, V.P., 2021)
6. Developments in the use of silk by-products and silk waste (Javali, Padaki, Das, Malali, 2015)
7. Importance of Sericulture: Brief Overview (Mehta, 2020)
8. Silkworm genomics- progress and prospects (Nagaraju, Goldsmith, 2002)
9. Cluster Promotion Program– 2008-12- A New Dimension in the Promotion of Bivoltine Sericulture (Qadri, 2012)
10. Indian Sericulture Industry for Sustainable Rural Economy (Savithri, Sujathamma, Neeraja, 2023)
11. Technological innovations in Sericulture (Sharma, Gupta, P. Sharma, Qadri, Bandral, Bali, 2022)
12. Innovations in Silkworm Rearing and Importance: Recent Advances (Singh, Nigam, Kapila, 2021)
13. Molecular markers and their application in mulberry breeding (Vijayan, 2007)
14. Sericulture and Pest Management (Sathe, Jadhav, 2022)
15. https://tigs.res.in/improving-sericulture-with-new-genetic-technologies/
16. https://ich.unesco.org/en/RL/sericulture-and-traditional-production-of-silk-for-weaving-01890
17. https://www.britannica.com/topic/sericulture
18. https://www.commonobjective.co/article/silk-and-sustainable-silk
19. (Fig 1) - Soi, 2019