Chapter 4

Smart Sericulture: The Next Era of Silk Farming

Wisdom Leaf Press
Pages number, 19–24

https://journals.icapsr.com/index.php/wlp
DOI: 10.55938/wlp.v1i4.162

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Abstract

Sericulture provides a profitable revenue stream, self-employment, and higher returns on investment. This study explores employing electrical technologies for enhancing existing silkworm rearing processes. It automates facilities by monitoring temperature and humidity, enabling for improved control of cocoon growth phases with the use of micro controllers. This method guarantees the best outcomes at each step of cocoon growth. The SeriFarm Automation System (SFAS) is an Internet of Things (IoT)-based framework which incorporates advanced sensors to improve silkworm health and productivity. In contrast with Manual Sericulture Management (MSM), SFAS enhances silk production by 0.40% and optimizes labor efficiency by 0.25%. This innovative method offers a sustainable, scalable, and more productive alternative to silk farming, bringing in an era of innovation for the organization. The article emphasizes research on the mulberry garden water fertilizer integrated machine, which controls irrigation and fertilization with artificial intelligence (AI). This unique technique ensures that mulberry plants receive the nutrients they require at all phases of growth. It also examines the machine's future development tendencies, with an emphasis on mulberry garden growth and water fertilizer integration technologies. A cloud-based monitoring system for environmental factors has been developed at a sericulture farm. The system detects temperature and humidity on a regular basis and transmits the results to a platform-as-a-service cloud. This permits monitoring from anywhere in the world. The system may be expanded to monitor several silkworm rearing properties by installing wireless data gathering devices at each one and transmitting the data to a centralized PC for cloud service updates. This review explores at the qualities, structure, and applications of silkworms in a variety of sectors such as science, research, and engineering. It goes over how they are utilized in surgical meshes, textiles, wound healing, tissue engineering, medicinal applications, industrial materials, electricity, and optical devices. The research additionally looks at silk materials including sericin and fibroin, which are employed in pharmacological, cosmetic, and healthcare industries.

Keywords

Sericulture, Sericulture Innovations, Eri Silkworm Rearing, Mulberry Plants, Digitized Silkworm Breeding

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1. **Introduction**Sericulture, the art and science of silkworm farming, provides employment and revenue for India's rural people through both on-farm and off-farm activities. Sericulture innovations, especially revolutionary mulberry growing techniques, can assist farmers in planting large areas and ensuring mass-scale silkworm production. Resource staff-led programs, trainings, and seminars can encourage farmers to embrace new approaches, promoting technology transfer and innovation acceptance [1]. Sericulture, a labor-intensive sector in the Indian economy, supports a large section of the population by providing farmers and their families with profitable self-employment opportunities. Technological developments have resulted in contemporary sericulture operations at the farm and industry levels, increasing silk yield. Innovations are simple to learn, maintain, and cost effective, making them critical for creating high-quality cocoons and boosting silk output. This technological advancement makes a substantial contribution to sericulture's development [2]. Sericulture, a significant agricultural business, involves the production and extraction of silkworms, which helps to create jobs in rural areas, alleviate poverty, and generate foreign revenue. Silkworms require proper care, especially during their temperature and humidity-sensitive larval cycle. Advanced image processing identifies infections and developmental phases, resulting in a dynamic dataset for business advancement [3]. Silkworms produce silk, a fibrous animal protein, which is mass-produced through sericulture. This labor-intensive industry employs the majority of the population and promotes the socio-economic level of rural communities. Technological innovations are critical for the sector's development since they have resulted in contemporary sericulture operations at the farm and industry levels, increasing silk output. Innovations are simple to learn, maintain, and cost-effective, and investments in technology, training, and marketing help to improve the sericulture industry's overall competency [4]. Silkworms are essential for basic silk production and domestication, and they offer several applications in biology and science. Bombyx mori silk, a silkworm, has acquired popularity due to its natural production, biocompatibility, and distinct mechanical characteristics. Silkworm production is commercially significant, and they may be managed for a variety of applications. The correct utilization of silkworms requires an assessment of their characteristics [5]. Agriculture, like numerous other aspects of life, is being transformed by innovation. However, sericulture is still trailing behind in terms of integrating these innovations. Detecting diseases in silkworms is a time-consuming operation, but early diagnosis might assist farmers avoid disease spread. A system developed to diagnose healthy and sick silkworms employing deep neural networks, resulting in a promising accuracy rate. This breakthrough might assist farmers in taking the required security measures to avoid disease spread [6]. Choosing silk fiber based on technical qualities and identifying the relationship between fiber and reproductive and cocoon productivity is critical for efficient production. This includes developing breeds and industrial hybrids with high fiber indicators that match global market and industry standards, as well as enhancing the genetics and selection methods of mulberry silkworms [7]. Domestication of silkworms enables for the extraction of enormous amounts of fibroin from silk cocoons, although this approach has sustainability and quality challenges. Recombinant DNA technology is an achievable solution for addressing these challenges, but further optimization is required due to the enormous size and repetitive structure of fibroin's DNA and amino acid sequencing [8].

2. **Smart Sericulture: The Next Era of Silk Farming**

Sericulture is the most common technique for producing silkworms for silk products, with healthy growth dependent on temperature and moisture levels. Disinfection is essential for effective rearing. An Arduino-enabled Internet of Things (IoT) platform been designed to monitor and activate the system, which employs image processing technology for identifying silkworm life cycle stages and allows for real-time data gathering [9]. The implementation of the IoT within Sericulture offers the promise to substantially strengthen efficiency and productivity. Traditional approaches, especially Manual Sericulture Management (MSM), have limited output due to labor-intensiveness and the lack of ability to manage the rearing environment. IoT-driven sericulture approach employs cutting-edge sensors and management systems to provide silkworms more accurate environmental parameters, automated feeding mechanisms, and real-time health monitoring [10]. An Arduino microcontroller and IoT devices are employed to manage the silkworm by considering temperature, humidity, and light. Sensor data from field devices is transmitted over a cloud server, allowing farmers to monitor from anywhere. The objective is to produce high-quality silk with minimum human interaction, offering an efficient solution for the sericulture industry at a low cost [11]. Market demand contributes to an increase in the utilization of silkworm cocoons as raw silk resources. However, the existing identification procedure is inadequate, with manual selection determining which cocoons are superior and which are substandard. Automated optical equipment, notably the YOLO algorithm, are needed for assisting employees in cocoon selection, as Deep Learning has increased in popularity for image categorization [12]. The eri silkworm rearing process can be monitored through wireless sensor network-based devices, with an emphasis on temperature, relative humidity, and light intensity. The sensor is connected to a microprocessor, and additional sensor nodes must exist for comprehensive monitoring. A master node connects each node in the wireless sensor network, creating a star-shaped design. Before being placed for data collecting throughout the rearing process, the system is evaluated in a laboratory and compared to conventional equipment [13]. The water fertilizer integrated machine is a novel agricultural device that employs artificial intelligence (AI) to regulate irrigation and fertilization in agricultural crops. It makes sure that mulberry plants in fields receive adequate nutrients during all growth phases, increasing the efficiency of agricultural activities [14]. The digital power of technology, that includes machine learning, deep learning, and blockchain technology, has transformed several industries, including communication media, finances, real estate, and copyrights. These technologies have boosted efficiency and minimized dangers, allowing for the effective application of blockchain in supply chain networks, notably in the sericulture business [15]. Precision farming is a sericulture management approach which employs site-specific information to control production inputs and outputs. GPS, GIS, decision support systems, remote sensing collection, variable rate technology (VRT), and sensor-controlled atomization all contribute to cost reduction, yield optimization, and revenue maximization. These components collaborate to build a geo-referenced field map, offer location-specific parameter values, and manage pesticide delivery through VRT technology [16]. Cloud computing has proven beneficial for a variety of industries, notably sericulture monitoring. The preservation of measurement data is critical for a variety of applications, including silkworm development and cocoon quality control. Temperature and humidity are important elements impacting insect physiology, and farmers must ensure that these factors are accurately measured in their silkworm raising environment. Cloud providers provide a variety of services to help individuals meet their requirements [17]. The autonomous guided vehicle transfers a silkworm dropping shifting structure, which is subsequently processed by an assembly that removes waste and feeds silkworms. Currently, large silkworm breeding is difficult due to the short 4-to-5 stage breeding time and the high labour specialization necessary for mulberry leaf delivery. Additionally, the procedure of adding silkworm beds and mulberry to the tray raises manufacturing costs due to the high labor required. To overcome this challenge, technology that allows digitized silkworm breeding has been developed [18]. A novel approach, factory-like silkworm rearing using artificial feed for all stages, promises to boost efficiency and minimize expenses. Accurate feeding is critical in this procedure. A machine vision system is utilized to capture digital images of silkworms during their primary stages. An enhanced Mask R-CNN model is offered for detecting silkworms and fake diet residue. The initial model is enhanced employing noise data annotations, pixel reweighting, and bounding box fine-tuning techniques. A more robust model has been created to increase detection and segmentation capacities [19].

3. Recommendations

Based on our thorough literature review, we propose the following recommendations for a robust and thriving sericulture.

- Future research should focus on the ecological effects of fibroin production throughout its life cycle, identifying critical hotspots and optimizing for green chemistry principles. Ideally, highly concentrated and pure soluble fibroin should be manufactured in a cruelty-free and ecologically responsible conduct, yielding a higher-quality product.
- Research into the metabolic specialization of silkworm cells to produce reiterated fibroin has the potential to maximize the expression platform. This might lead to increased yields and scalability in recombinant fibroin manufacturing, potentially replacing existing silk extraction procedures in the biomedical sector.
- IoT technologies can boost cocoon output and profitability by allowing farmers to modernize old methods, enhancing the sericulture industry's overall competency through technological and training expenditures.
- The study of silkworm genetics at the grassroots level could enhance its attributes through biotechnological techniques, balancing innovation and tradition by employing sophisticated IoT technology for accuracy and efficiency, thus strengthening the entire silkworm research process.
- Modernizing silk manufacturing operations and rearing techniques can enhance silk output while reducing labor and costs, potentially leading to increased silk production and quality.
- In the near future, the Indian government will probably attempt to control the commercial release of transgenic silkworms, with an emphasis on their particular benefits. This will boost overall silk output and provides greater profits to seri-farmers.
- Manylabs platform-as-a-service (PaaS) provides a user-friendly platform for downloading and deleting data from any location, as well as statistical analysis tools for sericulture farmers that need technical programming experience. The cloud service is user-friendly, and data access is effortless, making it an invaluable tool for farmers.

Conclusion

Silk fibroin is a biopolymer with unique mechanical characteristics that potentially outperform synthetic polymers. Its intricate hierarchical structure self-assembles, beginning with silk glands and ends with the formation of cocoons. Fibroin is biocompatible and biodegradable, making it an excellent choice for biomedical applications. However, production and processing present issues in terms of repeatability, sustainability, and ethics. Future research should focus on the environmental performance of current fibroin manufacturing throughout its life cycle. Technological advancements are critical to attaining the objective of employing silks for novel biomaterials and applications in medicine, cosmetics, and other industries. Farmers-linked sericulture and advancements in sericulture technology can aid in the creation of novel silk-based biomaterials. Silk nano powder has previously been employed in medical and cosmetic purposes. Researchers are looking at protein-based biomaterials, and India is a suitable area for commercial release of genetically modified silkworms due to the absence of close relatives in the wild and the mulberry silkworm's need on humans for life. India's closeness to Bombyx mori and reliance on people make it a suitable place for commercial silkworm cultivation. Sericulture, a labor-intensive industry, has to be strengthened and expanded via technological innovation. By concentrating on farmers and advancing sericulture technology, new ideas may be produced. Managing obstacles and implementing novel technology can result in high-quality cocoon manufacturing. Farmers should learn about emerging technology and gladly accept them. Sericulture, India's labor-intensive sector, provides a huge number of people with profitable self-employment opportunities. However, worker wages exceed total cocoon output, lowering labor reliance and manufacturing costs. Sericulture development relies heavily on innovation, which involves the exploration of new ideas, equipment, and procedures. Investment in technology, technological promotion, and training programs may all help to increase competency. Accepting problems and adopting innovations can lead to advances in sericulture, as both acceptance of obstacles and adoption of innovations promote overall growth.

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References

1. Qadir J., Islam T., Sudan N., Aryan S. Grass Root innovations for Better Performance of Sericulture Industry.
2. Rafiq I., Salim D., Bhat A., Bhat S. A., Buhroo Z. I., Nagoo S. A. Emerging Technologies for Sericulture Development.
3. Kumari D. A., Moneekha G., Sree P. N., Ranjani P. J. S., Neenasri S. (2024, January). Digital Farming for Silkworms: A Technological Breakthrough. In *2024 5th International Conference on Mobile Computing and Sustainable Informatics (ICMCSI)*. (pp. 352–356). IEEE
4. Singh T., Nigam A., Kapila R. (2021). Innovations in silkworm rearing and importance: recent advances. *TEXTILE Association*, *82*(2), 87–90.
5. Chand S., Chand S., Raula B. (2023). Usage of silkworm materials in various ground of science and research. *Journal of Natural Fibers*, *20*(1), 2139328.
6. Nagashetti S. M., Biradar S., Dambal S. D., Raghavendra C. G., Parameshachari B. D. (2021, October). Detection of disease in Bombyx mori silkworm by using image analysis approach. In *2021 IEEE Mysore Sub Section International Conference (MysuruCon)*. (pp. 440–444). IEEE
7. Daniyarov U., Rakhmanberdiev V. (2023, January). Creation of New Thin Silk Fiber Systems from "Chinese 108" and "YA-120" Breeds of Mulberry Silk Worm. In *International Scientific Conference Fundamental and Applied Scientific Research in the Development of Agriculture in the Far East* (pp. 555–563). Cham: Switzerland Springer Nature.
8. Bitar L., Isella B., Bertella F., Vasconcelos C. B., Harings J., Kopp A., … Bortesi L. (2024). Sustainable Bombyx mori's silk fibroin for biomedical applications as a molecular biotechnology challenge: A review. *International Journal of Biological Macromolecules*, 130374.
9. Veena S., Lakshmi A. S., Fathima S. T., Thanushree S. (2024, April). Automated Worms Monitoring System. In *2024 International Conference on Knowledge Engineering and Communication Systems (ICKECS)* (Vol. *1*,. pp. 1-4). IEEE
10. Sangeetha K. N., Punya H. R., Srujan S. P., Sunil P., Harshitha G., Mallikarjunaswamy S., … Shilpa M. (2024, August). Pilot Implementation of Efficient Automation in Sericulture Farms Using Internet of Things (IoT). In *2024 Second International Conference on Networks, Multimedia and Information Technology (NMITCON)* (pp. 1–5). IEEE.
11. Ghantasala K. C., Madala K., Nalamala B., Yarasu V. M. S. S., Thammisetty S. (2023, December). Smart Sericulture Monitoring System using IoT. In *2023 Innovations in Power and Advanced Computing Technologies (i-PACT)*. (pp. 1–5). IEEE
12. Kumar K., Pavan N., Yashas R., Rajesh R., Rakshith B. G. (2022, November). Advancement in Sericulture Using Image Processing. In *International Conference on Computational Intelligence in Machine Learning* (pp. 675–683). Singapore: Springer Nature Singapore.

13. Doloi A., Barkataki N., Saikia M., Saikia D. (2019). Development of a wireless sensor network based smart multiple ambient conditions sensing system for the rearing process of eri silkworm. *International Journal of Advanced Technology and Engineering Exploration*, *6*(52), 50–60.
14. Cen D., Lei L., Liu Z., Chen Z., Qin Y., Xu Y. (2023, November). Research Status and Application of Water and Fertilizer Integrated Machine for Smart Mulberry Garden. In *International Conference on Computer Engineering and Networks* (pp. 1–17). Singapore: Springer Nature Singapore.
15. Vijaya G. S., Sevukamoorthy L., Rajamani D. (2024). Adoption and Impact of Blockchain Technology on the Silk Industry's Supply Chain. *Digital Agricultural Ecosystem: Revolutionary Advancements in Agriculture*, 91–121.
16. Badhai S., Gupta A. K., Koiri B. PRECISION FARMING COMPONENTS AND IMPORTANCE OF PRECISION FARMING: A REVIEW. *Advances in Microbiology*, *5*.
17. Thirumeni E., Vairamani K. (2017). Application of cloud computing in sericulture monitoring. *Int J Comput Sci (IJCS J)*, *5*(1), 1839–1848.
18. Jeong S. K., Jang S. W., kook Son J., Kim S. W. (2023). Development of an Automatic Silkworm Breeding System. *International Journal of Industrial Entomology*, *47*(2).
19. Ruimin H. E., Kefeng Z. H. E. N. G., Qinyang W. E. I., Xiaobin Z. H. A. N. G., Jun Z. H. A. N. G., Yihang Z. H. U., … Qing G. U. (2022). Identification and counting of silkworms in factory farm using improved mask R-CNN model. *Smart Agriculture*, *4*(2), 163.