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Nanita Bora
M.Sc. (Agri), Department of Sericulture, Assam Agricultural University, Jorhat, Assam, India

Shilpa Saikia
M.Sc. (Agri), Department of Sericulture, Assam Agricultural University, Jorhat, Assam, India

Corresponding Author:
Shilpa Saikia
M.Sc. (Agri), Department of Sericulture, Assam Agricultural University, Jorhat, Assam, India

A review on recent trends and concept of silk beyond textile

Nanita Bora and Shilpa Saikia

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Abstract
Sericulture is the process of rearing silkworms for the production of silk fibers. Traditionally, it is mainly practiced in textile industries to produce high end textile apparel. A large amount of sericulture value added products (from silkworm cultivation to post-cocoon technology), can also add extra revenue to the seri-economy. Silk has wide range of multidimensional applications in the fields of regenerative drugs, tissue engineering, medical textiles, drug delivery systems, cosmeceuticals, food additives, and manufacturing of valuable biomaterials.

Keywords: Medical textiles, regenerative drugs, seri-economy, tissue engineering

Introduction
Sericulture is an age old agro based industry that weaves together the tapestry of history, culture and wonder of nature. '*Silk*' is the main output of this industry holding the crown of '*Queen of Textile'* among the different textile fibers. Due of its versatility and wide range of application silk is not limited to the textile industry. It continues to bridging the gap between ancient tradition and modern innovation. Silk has many industrial and commercial uses.

Recent trends and concepts in sericultural innovations
Silkworms are the lepidopteran insect. The mulberry silkworm *Bombyx mori* L. being a useful model for the biological research, in the field of genetic engineering techniques like bioengineering, nanotechnology it is used as highly potent tool for developing some novel concepts. For the production of foreign protein study on silk gland become a modern trend after the making of transgenic silkworm by the *piggyBack* transposon mediated technology. More than 10 numbers of foreign proteins were expressed successfully in transgenic silkworm in last decade (Sharma *et al*., 2022) [16].

Silk micrococoons, a novel approach
Researchers have manufactured microscopic version of the cocoons spun by silkworms, which could be used to store sensitive proteins and other molecules for a wide range of uses. These micrococoons are more than a thousand times smaller than the natural one crafted by the silkworms. These are comprises of a solid and tough shell of silk nano-fibrils that surround and protect a centre of liquid cargo. Micrococoons are prepared from the native silk feedstocks extracted from the silk gland of 5th instar *B. mori* larvae that had just started to construct the cocoon (Laity *et al*., 2015) [10]. These nanostructures are utilized to fabricate structurally and functionally efficient materials such as hydrogel, fibers, films, coating and 3D materials (Wang *et al*., 2018) [22]. Some of the potential application of these micrococoons are-
It is an extremely versatile drug delivery nanomaterial from the silk. The major silk protein fibroin's molecules possess amine, hydroxyl, carboxyl and thiol as a functional group of amino acid which can anchor many biomolecules as marker for active targeting and can be modified to manage to entrap drug properties (Phama and Tiyaboonchaia, 2020) [15]. Because of its high entrapping efficiency, increases drug solubility and stability, drug loaded fibroin nanoparticles are found promising to fix the obstacles of the pharmaceutical products that are available as small molecules in the market (Sharma *et al*., 2022) [16]. To revitalize cell growth and differentiation during tissue regeneration some growth factors and enzymes are highly

used in therapeutic proteins. But there are so many limitations like limited tissue penetration, low stability level and potential toxicity in the clinical application of enzymes. Fibroin nanoparticles have the potential to deliver big molecules to achieve therapeutic protein delivery (Sharma *et al*., 2022) [16]. Fibroin nanoparticles have been used in delivering bovine serum albumin, vascular endothelial growth factor etc. (Chen *et al*., 2018; Kundu *et al*., 2010) [2, 9]. Micrococoons can be effectively used in gene delivery and vaccine delivery due to its verified higher transfection efficiency and higher degree of specificity of fibroin (Sharma *et al*., 2022) [16]. Dong *et al*. (2015) [6] reported the better cell adhesion in human corneal epithelial cells when silk fibroin coated liposomes loaded with ibuprofen used for ocular delivery. Filon *et al*. (2015) [7] reported that fibroin nanoparticles serve as a promising vehicle for drug delivery through transdermal surfaces. Micrococoon can increase the stability and lifetime of an antibody and have potential to treat the major protein misfold disorders such as Alzimer and Parkinson's disease (Shimanovich *et al*., 2017) [17].

Innovation of different biomaterials from the silk:

- **Seri surgical scaffolds:** It is a bioresorbable, silk-derived scaffold for soft tissue support. Ultra-pure strands of fibroin in Seri Surgical Scaffold prompt a muted immune response also having highly moldable and drapable nature extracted from the silk from the *Bombyx mori* (Jewell *et al*., 2015) [8]. These are used in plastic surgery like breast reconstruction, body contouring, brachioplasty etc.
- **Silk solutions:** Solubilized aqueous form of *B. mori* silk has been investigated for a range of therapeutic applications, including treatment of diabetes, chronic wounds and inflammation. Studies have been made to utilize the silk solution for the treatment of ocular conditions like dry eye and corneal injury (Sharma *et al*., 2022) [16].
- **Skin grafts/ artificial skin from silk:** Skin is the largest organ and the protective barrier to the other organs of our body. Due to some illness it can get damaged in such a way that it needs some replacement in form of graft. A good graft should have the property to cover or to protect the intended place without any negative immune response. The biomaterial derived from the silk has the ability to mimic the human skin (Altman *et al*., 2003) [1]. Electrospun fibroin from the muga silkworm (*A. assamensis*) and eri silkworm (*S. ricini*) have been successfully used in wound healing (chouhan *et al*., 2017) [3].
- **Bone grafts:** Among the different biomaterials to develop scaffold based bone tissue, fibroin has almost all the properties suitable for developing osteoinductive functional bone graft that resemble collagen (Wittmer *et al*., 2011) [23]. Silk fibroin extracted from the tropical tasar silkworm i.e *A. mylitta* can be used to make porous scaffolds that mimic borne tissue (Mandal and Kundu, 2009) [12].
- **Surgical sutures:** Silk has been used as surgical sutures in cardiovascular, ocular and neural surgery because of its super knot strength, wound safty and biocompatibility (Chu, 2013) [4].
- **Hydrogels:** Silk fibroin hydrogels are emerging as useful tool for therapeutic delivery of stem cells (Sharma *et al*., 2022) [16].
- **Electrospun silk:** Silk fibroin fabricated by electrospinning has been explored for a wide range of application starting from wound dressing to the vascular grafting.

Commercial uses of silk proteins:

The 'core' protein fibroin and the sericin represents a unique family of structural proteins which are biocompatible, biodegradable, anti-inflammatory and also offering a wide range of properties. Because of these properties they have been used in different commercial sectors:

- **In cosmetic industry:** The silk protein sericin can be used in cosmetic industry to prepare cosmetic formulations such as gels, creams, shampoos etc. due to its gelling property, moisture retention capacity, easy skin adhesion, elasticity, anti-aging, anti-wrinkle, anti-inflammatory effects (Padamwar and Pawar, 2004, Singh *et al*., 2014) [14, 18].
- **In food industry:** Proper food packaging not only maintain the cost-benefit ratio to the food companies it also prevents the food from contamination. But some low grade packaging and food coating materials has become the contributing factors of migration of chemical substances from that material to the food. Currently scientists are searching for alternative sources of coating materials to use in food industries and they found the low cost edible coating materials prepared from sericin which serves as a alternative coating materials (Tarangini *et al*., 2022) [20]. Sericin coating on fruits like apple, mango, banana, strawberries, mushrooms and vegetables prevents browning, weight loss and polyphenol oxidase activity to a great extent (Thongsook and Tiyaboonchai, 2011; Cuervo *et al*., 2021) [21, 5]. Apart from the coating and packaging materials, food products prepared with sericin helps in controlling the diabetics. Sericin can be use as an ingredient in salad dressing and making jelly desert (Matran *et al*., 2023) [13].

Conclusion

Global developments are switching towards sustainable and friendly materials along with production process. Accordingly, natural fiber applications are gaining acceptance universally. Silk, the natural protein fiber has recently experienced more attention due to the innovative technologies that has extended the use of silk fiber beyond the traditional textile industry. The unique and versatile properties of silk make it suitable to produce diversified products and extensive use has been recorded in biochemical field as sutures. Therefore, it is crucial to enhance the production of silk in regard to annual global demand for future needs.

References

1. Altman G, Diaz F, Jakuba G, Calabro T, Horan R, Chen J. Silk-based biomaterials. Biomaterials. 2003;24(3):401-16.
2. Chen BQ, Kankala RK, He GY, Yang DY, Li GP, Wang P. Supercritical fluid-assisted fabrication of indocyanine green-encapsulated silk fibroin nanoparticles for dual-triggered cancer therapy. ACS

Biomaterials Science & Engineering. 2018;4(10):3487-97.
3. Chouhan D, Chakraborthy B, Nandi S, Mandal B. Role of non-mulberry silk fibroin in deposition & regulation of extracellular matrix towards accelerated wound healing. Acta Biomaterialia. 2017;48:157-74.
4. Chu C. Types & properties of surgical sutures. In: Biotextiles as medical implants. Elsevier; c2013. p. 231-73.
5. Cuervo Osorio GA, Murillo Arias YA, Urrea Vélez L. Study of the effect of sericin coatings extracted from Bombyx mori silkworm cocoons on fruit degradation. Revista ION. 2021;34(1):15-25.
6. Dong Y, Dong P, Huang D, Mei L, Xia Y, Wang Z. Fabrication and characterization of silk fibroin-coated liposomes for ocular drug delivery. Eur J Pharm Biopharm. 2015;91:82-90.
7. Filon FL, Mauro M, Adami G, Bovenzi M, Crosera M. Nanoparticles skin absorption: new aspects for a safety profile evaluation. Regul Toxicol Pharmacol. 2015;72(2):310-22.
8. Jewell M, Daunch W, Bengtson BP, Mortarino E. The development of SERI® surgical scaffold, an engineered biological scaffold. Ann NY Acad Sci. 2015;1358(1):44-5.
9. Kundu J, Chung YI, Kim YH, Tae G, Kundu SC. Silk fibroin nanoparticles for cellular uptake and controlled release. Int J Pharm. 2010;388(1-2):242-50.
10. Laity RR, Gilks SE, Holland C. Rheological behaviour of native silk feedstocks. Polymer. 2015;67(1):28-39.
11. Madhu Sree G, Felshia SS, Madhavan S, Allwin SIJ. Silk sericin & its food application: a review. Res J Pharm Technol. 2023;16(4):2068-74.
12. Mandal B, Kundu S. Osteogenic & adipogenic differentiation of rat bone marrow cells on non-mulberry & mulberry silk gland fibroin 3D scaffolds. Biomaterials. 2009;30(28):5019-30.
13. Matran IM, Matran C, Tarcea M. Sustainable prebiotic dessert with sericin produced by Bombyx mori worms. Sustainability. 2023;15(1):110.
14. Padamwar MN, Pawar AP. Silk sericin & its application: a review. J Sci Ind Res. 2004;63:323-9.
15. Phama DT, Tiyaboonchai T. Fibroin nanoparticles: a promising drug delivery system. Drug Deliv. 2020;27(1):431-48.
16. Sharma A, Gupta RK, Sharma P, Qadir J, Bandral RS, Bali K. Technological innovations in sericulture. Sericologia. 2022;7(1):7-15.
17. Shimanovich U, Ruggeri FS, Genst ED, Adamcik J, Barros TP, Porter D. Silk micrococoons for protein stabilization and molecular encapsulation. Nat Commun. 2017;8:15902.
18. Singh MK. Cosmeto-textiles: a new aspect of technical textiles. In: Handbook of Cosmetic Science and Technology. CRC Press; c2014. p. 4.
19. Takechi T, Maekawa ZI, Sugimura Y. Use of sericin as an ingredient of salad dressing. Food Sci Technol Res. 2011;17(6):493-7.
20. Tarangini K, Kavi P, Jagajjanani Rao K. Application of sericin-based edible coating material for postharvest shelf-life extension and preservation of tomatoes. eFood. c2022;3(5)
21. Thongsook T, Tiyaboonchai W. Inhibitory effect of sericin on polyphenol oxidase and its application as edible coating. Int J Food Sci Technol. 2011;46(10):2052-61.
22. Wang Y, Guo J, Zhou L, Ye C, Omenetto FG, Kaplan DL. Design, fabrication and function of silk-based nanomaterials. Adv Funct Mater. 2018;28(1805305):1-24.
23. Wittmer C, Claudepierre T, Reber M, Wiedemann P, Garlick J, Kaplan DL. Multifunctionalized electrospun silk fibers promote axon regeneration in the central nervous system. Adv Funct Mater. 2011;21(22):4232-42.