Agri Articles

(e-Magazine for Agricultural Articles)

Volume: 05, Issue: 06 (NOV-DEC, 2025)

Available online at http://www.agriarticles.com

Sericin: The Hidden Treasure Inside Silk

*Tejaswini A S, Shravanilakshmi V and Harish Gowda

Department of Sericulture, University of Agricultural Sciences, GKVK, Bangalore, Karnataka-560065, India

*Corresponding Author's email: tejuas345@gmail.com

Sericin is a natural globular protein obtained from the cocoon of the silkworm *Bombyx mori*. It acts as a protective gum that binds the two fibroin filaments together to form a compact and durable silk cocoon. Chemically, sericin is rich in polar amino acids such as serine, glycine, aspartic acid and threonine, which contribute to its strong hydrophilicity and excellent moisture-retention capacity. In a typical silkworm cocoon, sericin constitutes approximately 20–30% of the total cocoon weight, while the remaining portion is mainly fibroin. Traditionally, sericin has been removed and discarded during the degumming process in silk reeling, leading to significant environmental pollution due to its high biological oxygen demand (BOD) and chemical oxygen demand (COD). However, growing scientific research has revealed that sericin possesses valuable biological properties, including antioxidant, antibacterial, anti-inflammatory and UV-protective activities. These multifunctional characteristics have transformed sericin from an industrial waste into an important bioactive material with promising applications in cosmetics, pharmaceuticals, biomedical engineering and food packaging (Aad R *et al*., 2024). In recent years, increased emphasis on sustainable resource utilization and eco-friendly biomaterials has driven interest in efficient recovery and utilization of sericin. Its biocompatibility, biodegradability and film-forming ability make it suitable for wound dressings, drug delivery systems, tissue engineering scaffolds and skin-care formulations. Thus, sericin represents a unique example of how a conventional by-product of the silk industry can be converted into a high-value biomaterial through scientific intervention, contributing simultaneously to environmental protection and economic development in sericulture-based communities.

Silk and sericin basics

Silk fibers consist mainly of two components: a structural core protein called fibroin and an amorphous coating protein called sericin that acts as a natural glue around the fibroin filaments. In cocoon production, sericin protects the pupa and contributes to the mechanical integrity and cohesion of the silk thread, but conventional textile processing removes it almost completely. Sericin typically accounts for roughly one-fifth to one-third of the cocoon weight, depending on silkworm strain and processing conditions. During degumming, hot water, alkali or soap solutions solubilize sericin and release it into wastewater, making its recovery a key step in sustainable silk processing.

Chemical composition and structure

Sericin is rich in polar amino acids such as serine, aspartic acid, glycine, threonine and others, leading to high hydrophilicity and multiple reactive side groups. The abundance of hydroxyl, carboxyl and amino groups supports hydrogen bonding, metal ion binding and formation of blends or crosslinked networks with synthetic and natural polymers. The protein shows a wide molecular-weight distribution, often from about 20 kDa to over 400 kDa, which depends strongly on extraction method, pH and temperature. Sericin can adopt random coil, β-sheet and other conformations; controlling these structures influences film formation, mechanical strength, solubility and degradation rates for material design.

Physicochemical properties

Because of its hydrophilic amino acid composition, sericin readily absorbs and retains water, giving it excellent moisturizing and humectant properties. The protein also displays good film-forming ability, enabling the creation of thin, flexible coatings, membranes and microcapsules. Sericin's multiple functional groups make it compatible with various modification strategies, such as crosslinking, grafting and blending with polymers including chitosan, gelatin and poly(vinyl alcohol). These modifications help tune properties like mechanical strength, swelling, degradation behaviour and bioactivity for targeted applications in tissue engineering, drug delivery and packaging.

Biological activities

Sericin exhibits several bioactive properties, including antioxidant, antimicrobial, anti-inflammatory and anti-tyrosinase effects. The antioxidant behavior is largely attributed to its amino acid composition and ability to scavenge reactive oxygen species, contributing to cytoprotection and improved cell viability. In vitro and in vivo studies have shown that sericin can promote cell adhesion and proliferation, stimulate collagen production and support re-epithelialization, all of which are beneficial for wound healing and tissue regeneration. Sericin has also been reported to have anti-tumor or chemopreventive effects in certain models and to modulate immune responses, although these roles require further clinical validation.

Extraction and purification

Sericin is usually obtained from degumming solutions generated in silk processing or through dedicated extraction from cocoons using water, mild alkali, organic acids or enzymatic methods. The choice of method strongly affects the molecular weight distribution, integrity of peptide chains and functional properties of the recovered protein (Seo, S. J *et al*., 2023).

Eco-friendly approaches, such as water-only boiling or low-chemical extraction, seek to preserve sericin's bioactivity while minimizing environmental impact. Subsequent purification steps, including filtration, dialysis, precipitation and drying (e.g., lyophilization or spray-drying) convert sericin solutions into stable powders or concentrates suitable for formulation in cosmetic, pharmaceutical and food products.

Environmental and economic importance

Historically, degumming wastewater containing sericin contributed to high chemical oxygen demand and contamination in regions with intensive silk processing. Recovering sericin from these streams reduces pollutant loads and aligns with circular-economy principles by turning a problematic effluent into a valuable raw material. This valorization adds an additional revenue stream for the silk industry through sericin-based cosmetics, biomedical products and specialty ingredients. The shift from "waste" to "resource" also supports sustainable branding and can drive innovation in rural sericulture communities by enabling new small-scale enterprises around sericin processing and formulation.

Sericin in wound healing and dermatology

One of the most studied applications of sericin is as a wound dressing component and skin-care ingredient. Sericin-based hydrogels, films and composite dressings can maintain a moist environment, facilitate gas exchange and support cell migration while providing some intrinsic antimicrobial and antioxidant protection. In dermatology and cosmetic science, sericin is valued for its moisturizing capability, film formation and perceived skin-smoothening effect. It has been incorporated into creams, lotions, shampoos and serums, where it can help retain skin hydration, protect against environmental stress and potentially mitigate UV-induced damage when combined with other actives.

Sericin in tissue engineering and regenerative medicine

Sericin's biocompatibility and ability to support cell adhesion make it suitable for tissue engineering scaffolds when used alone or with polymers like fibroin, collagen or chitosan. Researchers have fabricated sericin-containing sponges, nanofibers and hydrogels for skin, bone, cartilage and nerve regeneration, often reporting enhanced cell proliferation and differentiation (Sabu Mathew, S *et al*., 2024). Recent work has highlighted unmodified sericin as a dual-functional biomaterial in bone tissue engineering, where it promotes osteoblast proliferation and exhibits antibacterial and anti-biofilm activity against Staphylococcus aureus. Such dual behavior is particularly attractive for orthopedic implants and bone fillers that need both regenerative and infection-control functions.

Sericin in drug delivery systems

Sericin's functional groups allow conjugation with drugs and the formation of nanoparticles, microparticles and hydrogels that can encapsulate and release active compounds in a controlled manner. Its hydrophilicity and biodegradability support use as a carrier for small molecules, proteins and nucleic acids in topical and systemic therapies. Sericin-based carriers have been explored for anticancer agents, antibiotics, and anti-inflammatory drugs, among others, with the goal of improving stability, targeting or safety profiles. In some systems, the inherent antioxidant or protective properties of sericin can synergize with the loaded drug to enhance therapeutic outcomes.

Sericin in cosmetics and personal care

The cosmetic industry has embraced sericin as a multifunctional ingredient for skin and hair formulations. Its film-forming ability allows it to deposit on skin or hair surfaces, improving smoothness, shine and moisture retention in products such as conditioners, shampoos, lotions and facial masks. Sericin is also investigated for its anti-tyrosinase activity and potential to help with skin tone uniformity and photoprotection when used with other actives. The natural and biodegradable origin of sericin appeals to consumers seeking "green" or sustainable cosmetic ingredients, adding marketing value to formulations.

Sericin in food and nutraceutical applications

In the food sector, sericin is being explored as a functional ingredient and as a component of edible films and coatings. Its strong hydrophilicity, absence of fat and capacity to form thin films make it suitable as a fat-free coating to reduce moisture loss and oxidative deterioration in fruits and vegetables. Studies have shown that sericin-based coatings can reduce weight loss, browning, and polyphenol oxidase activity in produce such as apples, mangoes, and mushrooms, thereby extending shelf life and preserving quality. There is also interest in sericin as a source of bioactive peptides or as a nutraceutical component contributing antioxidant and potential metabolic health benefits, although human clinical evidence remains limited (Wang, Y *et al*., 2025).

Sericin in biotechnology and cell culture

Sericin has been used as a supplement in cell culture media for various mammalian cell lines, including epithelial, kidney, liver and hybridoma cells, where it supports growth and viability. It can sometimes replace or reduce serum components, offering a more defined, animal derived component reduced option for bioprocessing. In cryopreservation, sericin has been investigated as a protective additive that improves post thaw survival by mitigating oxidative and osmotic stress. These applications highlight sericin not only as a structural biomaterial but also as a functional component in bioprocess and cell therapy workflows.

By products of sericin

Safety, toxicity and regulatory aspects

Sericin is generally regarded as biocompatible and shows low toxicity in most in vitro and animal studies at relevant concentrations. However, its composition can vary with extraction conditions and poorly controlled preparations may contain residual chemicals or degradation products that affect safety. For cosmetic and food uses, regulatory authorities typically require evidence of purity, absence of harmful contaminants and appropriate toxicological assessment. Clinical testing is still relatively limited, so careful standardization, quality control and long-term safety studies are essential before broad therapeutic deployment.

Challenges and research gaps

Despite rapid progress, sericin research faces several challenges, including batch-to-batch variability, instability in some formulations and incomplete understanding of long-term degradation and immunological responses in humans. The wide molecular-weight distribution and sensitivity to processing conditions also complicate efforts to define sericin as a consistent single ingredient. Further work is needed to establish robust extraction, fractionation and characterization protocols that link specific sericin fractions to particular functions. Expanded clinical studies, especially in wound care, dermatology, bone regeneration and metabolic health, will be crucial for translating promising preclinical data into approved products.

Future perspectives

Emerging research points toward advanced sericin-based nanomaterials, hybrid scaffolds and smart delivery systems that respond to environmental triggers such as pH, temperature, or enzymes. Combining sericin with other natural and synthetic polymers may yield next-generation biomaterials with tailored mechanical properties, degradation rates and multi-functional bioactivity. From a sustainability standpoint, integrating sericin recovery into silk production could become a standard practice, supported by policies encouraging waste reduction and bio-based materials. Cross-sector collaborations among sericulture, textile, biomedical, cosmetic and food industries may accelerate innovation and commercial adoption of sericin technologies.

Conclusion

Sericin has evolved from an overlooked by-product of silk production into a highly versatile, bioactive protein with applications in medicine, cosmetics, food technology and biotechnology. Its unique combination of hydrophilicity, functional groups, film-forming capacity and biological activities underpins its value as both a structural biomaterial and a functional ingredient across diverse sectors. By enabling circular use of silk industry waste, sericin contributes to environmental sustainability and new economic opportunities, particularly in regions where sericulture is important. Continued research into standardized extraction, safety profiling and clinically validated applications will determine how fully sericin's promise as a next-generation biomaterial is realized.

References

1. Aad, R., Dragojlov, I., & Vesentini, S. (2024). Sericin protein: structure, properties and applications. *J. Fun. Biomaterials*, *15*(11), 322.
2. Sabu Mathew, S., Maria, H. J., Allardyce, B. J., Rajkhowa, R., & Thomas, S. (2024). Waste to wealth: exploring the versatile prospects of discarded silk sericin. *ACS Sustain. Chem. Eng*, *12*(3), 1165-1184.
3. Seo, S. J., Das, G., Shin, H. S., & Patra, J. K. (2023). Silk sericin protein materials: characteristics and applications in food-sector industries. *Int. j. mol. sci*, *24*(5), 4951.
4. Wang, Y., Gao, J., Yang, Y., Zhu, L., Yang, W., Li, P., ... & Yang, W. (2025). A Review on the Extraction Methods, Bioactivities and Application in Foods of Silk Sericin. *J. Food Biochem*, *2025*(1), 2155701.