



Exploring The Therapeutic And Cosmetic Potential Of Snail Mucin: Future Prospectives

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ABSTRACT:

Mucins are a broad family of proteins with multiple functions and characteristics. Snails use mucin proteins in their mucous for several activities including microbial protection, adhesion, and lubrication. Snail Mucin is a complex mixture of Glycoprotein, Hyaluronic acid and Glycollic acid that has emerged as a promising ingredient in Pharmaceutical and Cosmetic industries. Recent studies have highlighted its advanced functions, including wound healing, Anti-aging, Skin hydration, Antimicrobial, Anti-inflammatory, etc. Snail mucin's unique composition and advanced functions states that it is a promising ingredient for future applications in skincare, wound healing, and regenerative medicine. Future research and development are needed to fully explore its potential and unlock new therapeutic opportunities.

KEYWORDS: H.aspersa, Snail mucin, Cosmetic Dermatology, Mollusks, Snail slime, Snail extract.

INTRODUCTION:

Snails represent a vast and varied group of organisms classified under the class Gastropoda within the phylum Mollusca. The key component responsible for the characteristics of mucus is mucins, a family of heavily glycosylated proteins synthesized in the epithelial cells of most animals. Snail mucus, an intriguing secretion produced by different snail species, serves several biological functions, including protection against microbes, facilitation of movement, adhesion, and moisture retention. Additionally, it inhibits bacterial growth and combats harmful microbes. The species *Helix aspersa* Müller and *H. aspersa* var. *maxima*, commonly sourced from farm breeding, are primarily utilized for extracting mucus as a cosmetic ingredient.¹

Table 1: snail mucin and their industry application

Snail slime is a transparent, slightly amber fluid with a pH of 4.80 and a density of 1.02 g/ml. It is rich in

Mollusca Species	Common Name	Applicable Sectors	Uses
<i>Archachatina marginata</i> 	Banana Rasp Snail	Antimicrobial Pharmacology Wound Care	Antibiotic Drug Delivery & Medication Wound Dressing
<i>Achatina fulica</i> 	Kalutara snail	Antimicrobial Pharmacology Wound Care	Antibiotic Drug Delivery Medication Wound Dressing
<i>Arion subfuscus</i> 	Dusky Arion	Medical Equipment	Surgical Glue
<i>Helix aspersa</i> 	Garden Snail	Cosmetics	Skin Care Cancer Treatment Topical Antibiotic
<i>Tikoconus Costarricanus</i> 	T. Costarricanus	Biotech	Adhesion and Lubrication
<i>Helix pomatia</i> 	Burgundy snail	Personal care	Shampoo

various active components, such as allantoin, elastin, collagen, proteins, antioxidants, enzymes, metal ions, proteoglycans, glycosaminoglycans, vitamins, minerals, as well as mucin, mitomycin AF, and achacin. Different species of snails produce several unique types of functional mucuses. The presence of numerous reputable skincare ingredients, including growth factors, antioxidants, and hyaluronic acid, facilitates the incorporation of snail mucin into skincare products.² Additionally, snail mucin contains glycosaminoglycans, glycoproteins, allantoin, glycolic acid, lactic acid, collagen, and elastin. This distinctive composition makes snail mucin an exceptional natural substance, providing a rare blend of ingredients that are not commonly found in nature.

THE COMPOSITION OF THE SNAIL MUCUS:

The composition of snail mucus differs based on the species, its function, and the level of adhesion. Typically, it comprises between 90% and approximately 99.7% water.³ Additionally, snail mucus contains mucin, mitamycin AF, and achacin.^{3,4} Mucin serves as the primary macromolecular component of mucus, contributing to its regenerative capabilities. It includes active antimicrobial proteins effective against both gram-positive and gram-negative bacteria.^{3,4} The antibacterial, antifungal, and antiviral characteristics of mucus have been validated through in vitro studies. Furthermore, snail mucin exhibits antioxidant properties and contains components such as allantoin, hyaluronic acid, polypeptides, and proteins that demonstrate regenerative and stimulating effects.⁵ The properties and composition of the mucus filtrate from *Helix aspersa Müller* are detailed in the following Table (2).

Table 2: Properties and composition of the *helix aspersa müller* mucus filtrate

Specification	Values	Specification	Values
Aspects	Clear liquid	Glycolic acid	0.99 g/100 g
Color	Slightly amber	Hyaluronic acid	<0.1 g/100 g
pH	4.80	Elastin	0.092 g/100 g
Refractive Index	1.3405	Collagen	0.32 g/100 g
Density	102 g/ ml	Trans-retinol	<0.10 g/100 g
Dry weight	3 g/100 g	13-cis-retinol	<10 g/100 g
Protein content	1.54 g/100 g	Chromium (Cr)	0.007 mg/ kg
Vitamin E	<0.10 mg/ kg	Copper (Cu)	5.04 mg/ kg
Vitamin C	0.13 mg/ kg	Mercury (Hg)	0.22 mg/ kg
Vitamin B12	<10 g/100 g	Cadmium (Cd)	0.012 mg/ kg
Vitamin B3	<10 g /100 g	Cobalt (Co)	<0.001 mg/ kg
Allantoin	0.081 g/100 g	Nickel (Ni)	0.820 mg/ kg

FUNCTION OF SNAIL MUCIN IN MEDICINE:

Mucin which is isolated from snail mucus has a wide range of applications in chemistry, biology, biotechnology and biomedicine.^{6,7} It affects the healing of wounds, facilitates the formation of new tissues and enhances the natural regenerative response. Snail mucus affects the viability of cells, stimulates the proliferation of fibroblasts, and may also participate in the transformation of the extracellular matrix. Antibiotic activity included the inhibition of both *S. aureus* and *S. epidermidis* when snail mucus from *Achatina fulica* was integrated into the wound dressings of mice. Another snail species, *Achatina reticulata*, had antimicrobial activity against *E. coli*, *S. aureus*, *K. pneumoniae*, and *P. aeruginosa* that was comparable to conventional antibiotics.

Snail mucin when digested can also affect the bacteria of the gut microbiome as it was found to ameliorate symptoms of loperamide-induced constipation in rats. Snail mucus consists of active substances, which include heparan sulfate, isolates, and calcium. Isolates have an analgesic and antibacterial effect, while calcium is responsible for the proper maintenance of constant parameters in the body. *Helix aspersa* mucus inhibits the production of melanin and the action of tyrosinase. Based on the above, it heals melanogenesis and has anti-cancer properties against human melanoma cell.⁸ Snails are used in Italy for the treatment of dermatological diseases, their mucus is rubbed into the skin to heal inflammation and acne, accelerate wound healing, and treat warts. Snail mucin also has been successfully incorporated in drug delivering vehicles, particularly via patches due to its bioadhesive properties and assistance with diffusion across membranes.

The mucin from *Archachatina marginata* was integrated into a transdermal ibuprofen patch with efficacious drug diffusion in rats. Snail mucin has also been successfully incorporated as wound healing agents in full-thickness skin wounds. A biological adhesive derived from snail mucus gel consisting of positively charged protein and polyanionic glycosaminoglycan exhibited acceleration of wounds in normal and diabetic male rats. Additionally, there was a decrease of inflammation in chronic wounds and an improvement in epithelial regeneration and angiogenesis when this adhesive was used.

PHARMACOLOGICAL ACTIVITY:

1. Anti-tumor agent:

Snail mucin has demonstrated potential as a therapeutic agent against melanoma, one of the most aggressive forms of skin cancer.¹⁰ Although advancements in cancer treatment have led to improved remission rates and extended survival for many patients, similar progress has not been observed in melanoma cases.¹¹ Given the frequent development of treatment resistance in this type of cancer, there is an urgent necessity to explore effective new strategies for its management. To meet this demand, research was conducted on the impact of *H. aspersa* mucus on melanoma cell lines. The findings indicated a reduction in melanin overproduction and a decrease in tyrosinase activity, both of which are linked to oxidative stress at the cellular level and the growth of melanoma cells. Additionally, another study found that *H. aspersa* mucin directly inhibited the proliferation of two human melanoma cell lines, providing clear evidence of its anti-melanogenic effects. Although still in the preliminary stages of research, the potential use of snail mucins as anti-tumour agents is increasingly capturing the attention of the biomedical field.

2. Wound healing:

Snail mucus has been recognized for its healing properties and has emerged as a significant asset in wound research. Mucins derived from the *Helix aspersa*/*Cornu aspersum* (Garden Snail) have demonstrated efficacy in promoting skin regeneration following acute radiodermatitis, a frequent consequence of radiotherapy.¹² Reports indicate that garden snail mucus enhances healing rates by regulating antioxidants and free radicals. Additionally, this mucus has shown a notable improvement in erythema in rat models, and daily application over a three-month period resulted in a decrease in signs of photoaging in these animals. Beyond superficial injuries, mucins have also proven effective for internal wounds. They have been utilized in conjunction with oral non-steroidal anti-inflammatory drugs (NSAIDs),¹³ which are among the most commonly prescribed medications, to mitigate or prevent gastric mucosal damage. While NSAIDs are effective in reducing inflammation, they can lead to adverse effects such as gastrointestinal injury and liver damage, prompting pharmaceutical companies to seek solutions to alleviate these side effects. Many have turned to natural products for this purpose. Mucins have been found to be beneficial in treating peptic ulcers, a common side effect of NSAIDs. The traditional approach to managing peptic ulcers involves a combination of antibiotics and anti-ulcer medications, which are categorized into two types: those that reduce pepsin secretion and those that support mucosal integrity. A combination of the antibiotic clarithromycin and *A. fulica* mucin has yielded promising results in treating peptic ulcer disease. Furthermore, the healing rate of ulcers was found to increase with higher concentrations of mucin, surpassing the effectiveness of clarithromycin alone.

3. As drug delivery vehicles:

The versatility of snail mucin biopolymers positions them as highly promising candidates for innovative drug delivery systems. During the mating process, male snails launch a dart that delivers mucus enriched with accessory proteins into the female, thereby enhancing her fertility.¹⁴ This intricate mechanism operates through a multifunctional system, where each element fulfills a specific role. The dart functions like a needle, penetrating tissue and injecting the mucus that contains the accessory proteins into the female snail. Similarly, mucus can be modified to serve as a delivery vehicle for bioactive compounds. Snail mucus is particularly compatible with medications absorbed through mucosal membranes due to its ability to facilitate diffusion across these barriers.¹⁵ For instance, metformin hydrochloride, a medication for diabetes, was linked to Giant African Land Snail mucin using polyethylene glycol (PEG) to enhance the drug's bioavailability. The metformin-loaded PEGylated mucin demonstrated improved pharmacokinetics and pharmacodynamics for this typically poorly absorbed drug, achieving a release rate of 92% compared to the 81% currently available in the market.

In another study, whole *Costus afer* (ginger lily) flowers combined with snail mucus resulted in a dose-dependent reduction of blood glucose levels in diabetic *Mus musculus* (Swiss albino mice), indicating the potential anti-diabetic properties of snail mucin. Drug-binding polymer matrices and mucin-containing

vaterite crystals have been utilized as carriers for drug delivery, enabling effective loading and controlled release of small anti-cancer agents and protein-based therapeutics. Vaterite microcrystals, when crystallized at mucin concentrations of 1-6 mg/ml, exhibit enhanced retention of cationic bioactivities and stability under physiological conditions. Furthermore, mucins have been combined with photosensitizers to improve targeting and optimize the delivery control into cancerous cells. Self-assembled mucin multilayer capsules and mucin-based microparticles are particularly noteworthy for future research on controlled release drug delivery systems, especially in addressing issues related to biocompatibility, biodegradability, and mucoadhesion.

SNAIL MUCIN IN COSMETOLOGY:

1. Anti-aging agent:

The anti-aging properties of snail mucin have been highlighted through various studies. Specific glycoproteins and peptides have been shown to enhance fibroblast production of collagen and elastin, substances that the body naturally produces in lesser amounts as it ages.¹⁶ Research on skin aging indicates that this process is partly due to an increase in matrix metalloproteinase expression and a reduction in glycosaminoglycans and proteoglycans that make up the skin. This results in a more youthful and firm appearance, along with improved skin elasticity. Furthermore, snail mucin derived from *Helix aspersa muller mucus*, a widely used species in cosmetic formulations, has been developed into a Helix Complex preparation. When this Helix Complex was applied to fibroblast cultures, it provided protection against apoptosis and promoted fibroblast proliferation both directly and indirectly through cytokine release and cytoskeletal reorganization.¹⁶ A similar effect on fibroblast induction was observed with mucin from another common snail species, *Cryptomphalus aspersa*, known as SCA.

In a study involving 25 participants, daily application of mucin from this species resulted in noticeable improvements in coarse periorcular and fine facial wrinkles after 8 and 12 weeks of use. Additionally, enhancements in skin texture were recorded through silicone skin impressions taken before and after the treatment. Another investigation involving 10 subjects applied a cream containing 80% snail mucin to the lateral epicanthal area and left cheek twice daily for four weeks, revealing statistically significant improvements in dermal density, skin elasticity, and wrinkle reduction as assessed by surveys.¹⁷ The secretion from *Cryptomphalus aspersa* (SCA) was also combined with antioxidant ingredients such as ectoine, coffeeberry oil, and olive oil in various formulations, including a lipid-free serum and a cream, which demonstrated a reduction in signs of skin aging among 125 women aged 40 to 65, a demographic typically targeted for anti-aging treatments. Following 45 days of application, cytometry indicated enhanced firmness and elasticity within the dermal layer. Patients who received photoaging treatment using a nonablative laser and subsequently underwent treatment with SCA 40% reported a faster recovery, diminished erythema, reduced tightness and burning sensations, along with an 11% increase in elasticity.¹⁸

2. Hydration:

The inclusion of hyaluronic acid, a potent humectant, in snail mucin underscores its capacity to retain moisture in the skin. Hyaluronic acid, a type of glycosaminoglycan, possesses a distinctive helical structure that enables it to retain water up to 1000 times its own weight, thereby stabilizing the extracellular matrix and maintaining hydration.¹⁹ Research on mucin derived from *H. aspersa* was conducted with healthy Caucasian female participants to evaluate its hydrating effects. This was assessed by measuring trans epidermal water loss (TEWL) using a Tewameter and corneometer probe, which revealed a reduction in TEWL immediately after application, as well as at 1 hour and 24 hours post-application.

3. Anti-acne:

The anti-acne properties of snail mucin can be partially attributed to its antibacterial and anti-inflammatory characteristics previously mentioned. A study was conducted using a combination serum made from snail secretion filtrate, *Calendula officinalis*, and *Glycyrrhiza glabra* root extract on patients experiencing mild-to-moderate "maskne," a term referring to acne caused by wearing masks. After a 12-week period, the treatment group exhibited a significant reduction in inflammatory acne lesions, although there were no observed changes in erythema scores, non-inflammatory lesions, or sebum levels. Additionally, the exfoliative acids present in snail mucin, such as glycolic acid and lactic acid, may aid in unclogging pores and decreasing sebum production, which plays a role in the development of acne.²⁰

4. Scarring and Hyperpigmentation:

Similar to wound healing, the cosmetic use of snail mucin focuses on addressing scars that often result from previous acne lesions or skin injuries. Research has shown that snail mucin derived from *Cryptomphalus Aspersa* enhances the proliferation and migration of human keratinocytes and fibroblasts in a manner that is both time- and dose-dependent. Additionally, an increase in the expression of adhesion proteins such as E-cadherin, β -catenin, vinculin, and β 1-integrin has been noted, indicating a probable mechanism involved in scar healing.²¹ Another commonly utilized ingredient for scar treatment is exfoliative alpha-hydroxy acids, including lactic acid, which functions by loosening the connections between desmosomes in the epidermis, thereby facilitating deeper penetration of other products. While not the primary components, lactic acid and glycolic acid are also present in smaller amounts within snail mucin, suggesting a potential method for scar treatment. Glycolic acid specifically targets atrophic acne scars and post-inflammatory hyperpigmentation due to its keratolytic effects and its ability to stimulate the development of new skin cells.^{22,23}

SNAIL MUCUS EXTRACTION:

The anatomy of snails features a variety of permanent and temporary grooves and wrinkles. The permanent indentations facilitate the expulsion of body fluids or mucus. There are two distinct types of mucus: the universally produced limosin, which aids in locomotion, and the species-specific cryptosin, which is secreted in response to significant irritation. The characteristics of mucus, including its color, structure, and density, serve as taxonomic indications.

Limosin is a clear mucus primarily composed of water, whereas cryptosin is thick and foamy. In the cosmetic and pharmaceutical sectors, only cryptosin is utilized, and it is harvested in a manner that does not harm the snails.¹ Given that stress can lead to the release of toxic substances into the mucus, it is essential to filter it to ensure the raw material is microbiologically pure.

One method for extracting mucus for cosmetic purposes involves low-voltage electrical stimulation. This contemporary technique is considered safe for the snails. The mollusks are placed in a specialized device with distilled water and subjected to low-voltage electrical stimulation before being returned to their breeding environment. The collected mucus undergoes homogenization, centrifugation, and filtration, allowing for multiple extractions of the raw material. Another extraction method employs a 3% sodium chloride (NaCl) solution, which irritates and stimulates mucus production. NaCl also influences the protein content of the raw material.² This approach can yield approximately 600 ml of extract from 500 snails, with subsequent stages involving sterilization and filtration of the mucus.

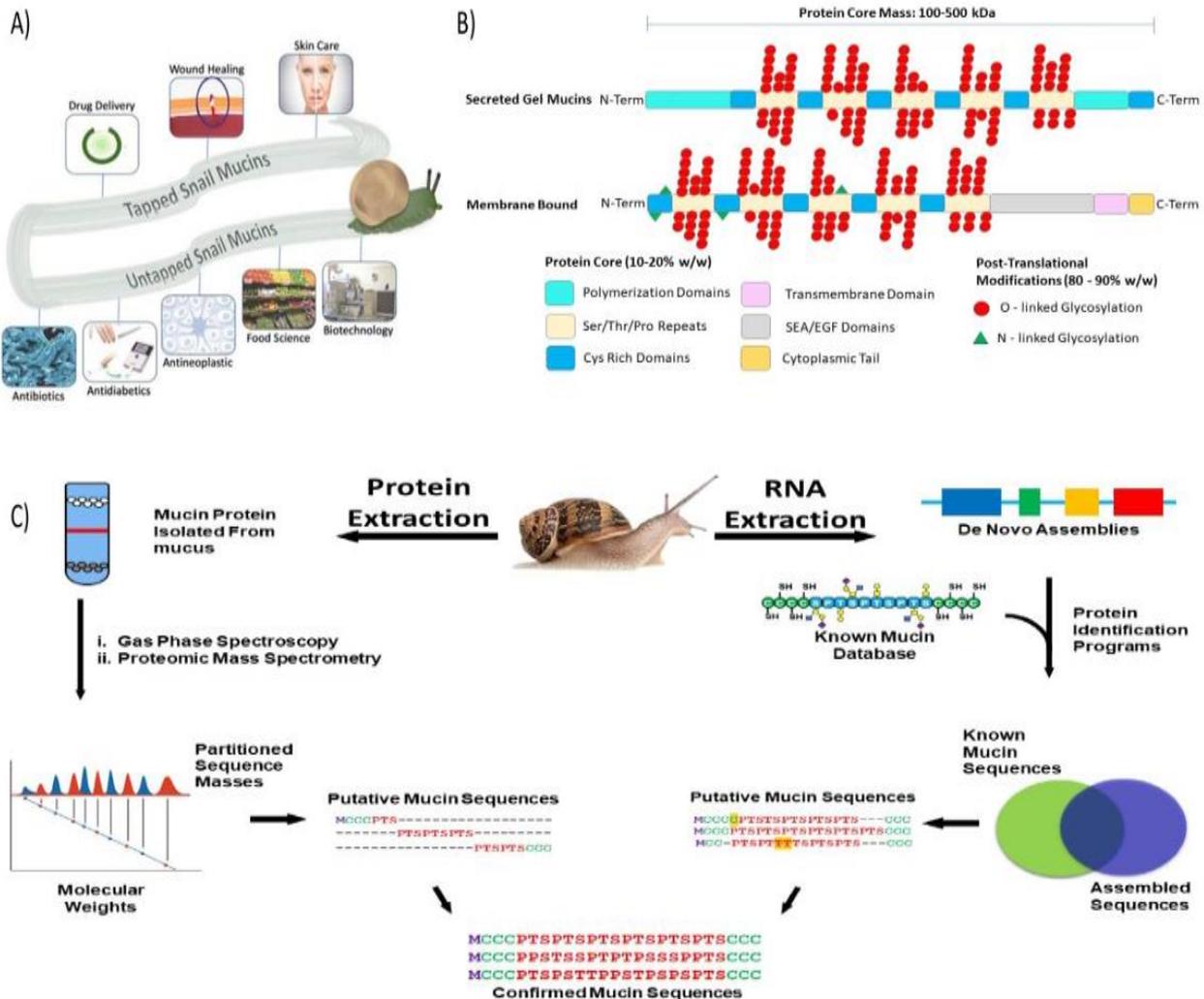


figure 1:

(a) applications of snail mucin. snail mucin has been used for skincare, woundhealing and rejuvenation, and drug delivery. mucins from snails are being studied for potential applications in food science, implant coatings, and biotechnology.

(b) a two-dimensional depiction of the mucin structures. mucins have two structural components: a protein core and glycan branching. the protein core is a protein sequence of variable length depending on the mucin gene, which has been further modified with glycosylation branches. the protein structure comprises numerous domains that change according to the function and cellular location of the mucin. glycan branches, which contain 3-18 sugars, account for the majority of mucin mass. the many varieties of mucins and their stereotypical properties are represented in two dimensions.

(c) using an integrated omics approach to determine snail mucin sequence, structure, and function. path 1 (left) extracts crude mucin proteins and separates them from cellular detritus to get sequence masses using spectroscopic and mass spectrometric analysis. path 2 (right) involves extracting rna from mucus glands or the entire animal, assembling it into a database, blasting it against a known mucin database, and obtaining potential mucin sequences. by combining the proteomic and rna processes, we confirmed the alternative type mucin sequence for further study.

MARKETED FORMULATIONS:

Type	Brand Name	Company Name	Price
1. Mucin Power Essence	Advanced Snail 96 Mucin Power Essence (100ml) 	COSRX	₹ 1,015
2. Face Wash	Snail 99 Mucin Face Wash (100 ml) 	BELLAVITA	₹ 229
3. Moisturizing Cream	Advanced Snail 92 All In One Cream (100 g) 	COSRX	₹ 1,072
4. Face Wash	Snail Foam Face Wash (80 ml) 	MIRABELLEm	₹ 249
5. Face Serum	Snail Magic Barrier Repair Essence (50ml) 	CONSCIOUS CHEMIST	₹ 519

Table 3: Marketed Formulations of Snail Mucin**Remark and Future Perspective:**

Snails inhabit almost every biome, and the variations in environmental conditions seem to influence the diversity of mucin genes and the multifunctionality of mucus. Snail mucins exhibit significant potential in biomedical and biotechnological applications, serving as a promising bioinspired resource.²⁴

The characterization of these mucins is not limited by their intrinsic value but rather by challenges related to access and the complexity involved in identifying, purifying, and studying the molecules. Numerous

questions remain regarding the properties of mucins and mucus in relation to their practical applications. This perspective highlights the substantial potential yield of snail mucins, and by employing a flexible comparative omics approach, we can enhance our understanding of these distinctive proteins and their beneficial biological and chemical characteristics.

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