INNOVARE JOURNAL OF MEDICAL SCIENCES

Vol 13, Issue 3, 2025

Online - 2321-4406
Print - 2614-5006

Review Article

SNAIL MUCIN: A NOVEL BIOACTIVE INGREDIENT IN PHARMACEUTICALS – A REVIEW

PRIYANKA BEHERA, ADITI SHARMA, SHUBHAM BISWAL, BIPIN BIHARI PANDA, PRASANTA KUMAR BISWAL*

Department of Pharmaceutics, Gayatri College of Pharmacy, Jamadarpali, Odisha, India. Email: drprasantabiswal74@gmail.com

Received: 22 February 2025, Revised and Accepted: 06 March 2025

ABSTRACT

Snail mucin is popular for its wide range of ingredients and potential benefits. Snail extract's widespread appearance in different pharmaceutical formulations encourages an investigation into the medical and cosmetic benefits. Its main aims to explain current literature on the variety of snail mucin applications. Typically, we present a review of the uses, global market scenario and research, and limitations to snail mucin. A literature search was conducted on different journals reviewing snail mucin and their application in medical and cosmetic fields examining their uses. Economic reports were also found out for global market scenario. The therapeutic use of snail mucin in medical fields was studied as antimicrobial agents, drug delivery vehicles, antitumor agents, wound healing agents, and biomaterial coatings among others. In addition, the use in cosmetic fields includes antiaging, hydrating, antiacne, scarring, and hyperpigmentation treatments. It is important to highlight that most studies conducted were preclinical or small clinical studies, stressing the need for additional large-scale clinical trials to support these claims. Investigations into the global market found estimates ranging from $457 million to $1.2 billion with upward projections in the upcoming decade. The limitations include ethical habitats for collection, allergy investigation, and missing clinical studies. The findings presented here emphasize the expanding uses of snail mucin and its ingredients alongside a growing market cosmetic industry should consider. We also emphasize the need for appropriate clinical trials into the stated benefits of snail mucin to ensure consumer safety and ethical extraction of mucin.

Keywords: Snail mucin, Ingredients, Research, Biomaterial, Clinical studies.

 DOI: http://dx.doi.org/10.22159/ijms.2025v13i2.53953. Journal homepage: https://innovareacademics.in/journals/index.php/ijms

INTRODUCTION

To cure a wide range of disorders, scientists have long searched for compounds with medicinal properties that may be extracted from a number of sources, such as plants and animals. Over the years, new drugs made from natural substances have consistently shown that this is the most effective approach to drug development. According to historical literature, many natural raw materials are used extensively in the production of pharmaceuticals. Aspirin, digoxin, pilocarpine, and morphine, which was derived from opium in the 19th century, are among the medications used in pharmacies today. Antibiotics were discovered in the 20th century, revolutionizing medicine and making them necessary drugs for diseases caused by bacterial infections. Certain antiviral and anticancer drugs are also regarded as natural remedies. Along with plant-based ingredients, materials from animals are also used in making medicines. For example, the alkaloid secreted by the frog *Epipedobates tricolor* is about ten times stronger than morphine [1].

A secretion from land snails called snail mucin has shown great promise as a bioactive substance with a wide range of possible uses in medicine. Due to their ability to heal wounds and regenerate skin, snail-based medicines have long been used in folk medicine. These assertions have been supported by contemporary scientific studies, which show that snail mucin contains a complex mixture of antimicrobial peptides, glycoproteins, glycolic acid, hyaluronic acid, and allantoin, all of which work together to produce its therapeutic properties [2].

Mollusca snails, the second largest category in the animal kingdom with about 80,000 species, can also produce compounds that could be used medicinally. This group includes people who live on land as well as in water. Mollusca snails, the second largest group in the animal kingdom with about 80,000 species, can produce compounds with potential medicinal uses. This group includes species that live both on land and in water. Mollusca have been used by humans since ancient times.

The potential medical use of snail discharge mucus was known to the ancient Greeks. Snail mucin has been utilized for decades worldwide since Hippocrates recommended its use in ancient Greece to soothe sore skin. Snail mucin was used to cure children's tetanus, insect bites, and hemorrhoids during the Han Dynasty in China. Chilean snail farmers also found that it helped heal skin lesions without leaving scars. When cooked, the uncooked shell of a snail has remarkable softening and healing properties, according to Celse. Pliny recommended applying snail treatments to burns, abscesses, nosebleeds, and other ailments. Galien recommended preventing fetal edema by utilizing snail mucus. In the 17th century, snail mucus was used to cure dermatological diseases, according to scientific data. It has also been used to treat the symptoms of tuberculosis and nephritis. In the 19th century, as the pharmaceutical business expanded, more and more medications containing snail mucus were created. With the advancement of scientific research and the identification of novel compounds in snail mucus, sustained interest in these molluscs has been observed over the subsequent years. Snail mucus is secreted by individual mucous pedal glands and covers the entire animal's exterior. Edema and stomach-related ailmentss have been treated with snail shells. Table 1 illustrates the different species of Mollusca and its pharmacological effects [2,3].

Snail mucus and extract have been used in numerous dermatology care areas, from speeding up the healing process for burn patients to being included in everyday skincare products for their alleged antiaging and antiacne qualities. Snail mucin's potential is still being studied, but what makes it interesting are its animal origins and the methods used to collect it. Snail mucus has a number of well-known skincare ingredients, such as hyaluronic acid, growth factors, and antioxidants, making it easy to use into skincare products. Snail mucin also contains glycosaminoglycans (GAGs), glycoproteins, allantoin, glycolic acid, lactic acid, collagen, and elastin. Snail mucin is a particularly unique natural product since it has a unique combination of components that are not typically seen in nature. Snail slime is clear and pale yellow in

Table 1: Different species of *Mollusca*

***Mollusca* species**	**Common name**	**Chemical compounds**	**Pharmacological effects**
Archachatina marginata	Banana rasp snail	Peptides and proteins, glycosaminoglycans, mucopolysaccharides, fatty acids, flavonoids	Antibiotics effects, antimicrobial Effects, immunomodulatory effect, antioxidant properties
Helix aspersa	Garden Snail	Mucopolysaccharides, glycoproteins, Omega 3 and omega 6 fatty acids, flavonoids, Vitamin E and C, collagen, mucin, proteases, amylases	Anti-inflammatory effect, antioxidant properties, antibacterial effects, antiaging, digestive aid
Tikoconus costarricanus	*Tikoconus costarricanus* (land snail)	Mucopolysaccharides, Glycoproteins, fatty acids (oleic, linoleic acid), flavonoids, Vitamin E and C, achacin collagen, mucin, proteases, amylases, hyaluronic acid	Antimicrobial effects, antioxidant, wound healing and skin regeneration,
Anion subfuscus	Dusky arion or black snail	Glycoproteins, fatty acids, flavonoids, Vitamin E and C, achacin collagen, mucin, phenolics, glycosaminoglycans, polysaccharides	Anti-inflammatory and antioxidant properties, wound healing, anticancer effect, antimicrobial properties, neuroprotective effects
Helix pomatia	Burgundy snail or roman snail	Allantoin, collagen, glycolic acid, antimicrobial peptides, achacin, glycoproteins, amino glycosaminoglycans, glutathione, cytotoxic peptides, flavonoids	Wound healing and skin regeneration, antimicrobial effects, immunomodulatory effect, antioxidant properties, potential anticancer activity
Archatina fulica	Kalutara snail or giant African snail	Glycoproteins, fatty acids, flavonoids, Vitamin E and C, achacin collagen, mucin, phenolics, glycosaminoglycans, polysaccharides, chitin, and chitosan derivatives	Antimicrobial effect, wound healing and skin regeneration, anti-inflammatory effects, antioxidant properties, gastro protective effects, neuroprotective effects

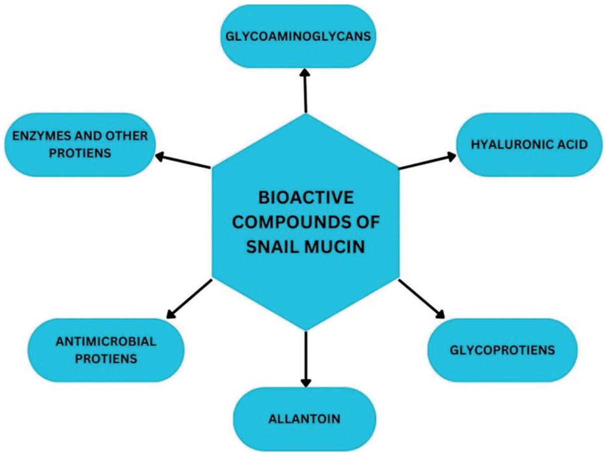

Fig. 1: Bioactive compound of snail mucin

Fig. 3: Pharmacological effect of snail mucin

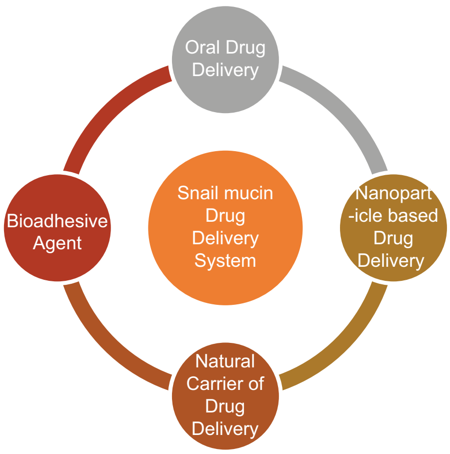

Fig. 2: Snail mucin drug delivery system

color, with a density of 102 g/mL and a pH of roughly 4.80. Numerous applications for snail mucus and extract have been proposed over the years, including antimicrobial agents, drug delivery systems, anticancer agents, wound healing agents, biomaterial coatings, and skincare products that combat acne and aging [4].

Snail mucin's distinct makeup allows it to influence cellular functions essential for tissue regeneration, including increased collagen synthesis, decreased oxidative stress, and controlled inflammatory responses [5]. Its moisturizing and antiaging qualities have made it a prominent element in cosmeceuticals, but its uses are not limited to skincare. Snail mucin has potential applications in a variety of pharmaceutical fields, such as regenerative medicine, drug delivery systems, and chronic wound care [6]. The natural origin and biocompatibility of snail mucin make it an even more appealing substitute for synthetic substances in terms of sustainability and efficacy. Its capacity to engage with biological systems when causing few adverse effects makes it a flexible component for creating novel medicinal solutions [7].

Examining snail mucin's developing function as a bioactive component in medications is the goal of this review. It will explore its biochemical features, how it works, and its uses in areas like tissue engineering, antimicrobial therapy, and chronic wound care.

SNAIL MUCIN

Terrestrial gastropods like *Cornu aspersum*, also referred to as garden snails, produce snail mucin, a viscous secretion that has gained recognition as a multipurpose bioactive substance with uses in dermatology and medicine. The abundance of bioactive compounds in this secretion supports its antibacterial, anti-inflammatory, and regenerative qualities [1].

The polysaccharides known as GAGs are essential for tissue hydration and extracellular matrix stability, which promote cell migration and proliferation [8]. Snail mucus contains hyaluronic acid, which is well-known for its moisturizing qualities and helps preserve the suppleness and hydration of the skin [5]. By increasing fibroblast activity and reducing oxidative stress, a substance similar to allantoin encourages cell proliferation and wound healing [7]. Peptides with broad-spectrum antibacterial activity are found in snail mucus, which helps prevent infections, particularly in chronic wounds [6].

For reliable treatment results, standardized protocols must be developed due to species and extraction process variations in composition. In order to satisfy the increasing demand when maintaining ecological balance, sustainable and cruelty-free harvesting methods are crucial [9]. To confirm its effectiveness and safety in various therapeutic scenarios, extensive preclinical and clinical research is required [1].

BIOACTIVE COMPOUNDS OF SNAIL MUCIN

A wide variety of bioactive substances found in snail mucin, which is secreted by terrestrial snails including *C. aspersum* and *Achatina fulica*, give it its exceptional medicinal qualities. GAGs, glycolic acid, hyaluronic acid, allantoin, and antimicrobial peptides are some of these substances. Each of these elements is essential to the biological processes that render snail mucin useful material for medicinal use, as illustrated in Figure 1.

GAGs

Long-chain polysaccharides called GAGs are essential for preserving the extracellular matrix's structural integrity. GAGs in snail mucus aid in regulating tissue hydration and suppleness, which encourages cell migration and proliferation. According to studies, GAGs improve fibroblast activity and lower oxidative stress, which aids in wound healing [7].

Hyaluronic acid

One well-known humectant with a high capacity to retain water is hyaluronic acid. It is essential for preserving the suppleness and moisture of the skin. By speeding up re-epithelialization and encouraging angiogenesis, hyaluronic acid from snail mucus has been shown in pharmaceuticals to improve the effectiveness of wound healing treatments [1].

Glycoproteins

Snail mucin's healing qualities depend on the glycoproteins it contains. Collagen and elastin, which are essential for skin repair and preserving tissue integrity, are produced in response to these chemicals. Glycoproteins have also been linked to tissue remodeling, inflammation reduction, and immune response modulation [5].

Allantoin

A naturally occurring substance with calming and restorative qualities is allantoin. It promotes cell growth and is frequently found in cosmetics and wound care products. Allantoin plays a major role in the therapeutic effects of snail mucin by enhancing fibroblast activity and reducing oxidative stress [7].

Antimicrobial peptides

A natural defense against infections is offered by the antibacterial peptides found in snail mucus. Gram-positive and Gram-negative bacteria, as well as some fungal species, are specifically targeted by the bacteriostatic and bactericidal action of these peptides. The prevention of infections in chronic wounds and other susceptible tissues depends on this antimicrobial action [6].

Enzymes and other proteins

Enzymes and proteins with anti-inflammatory and antioxidant qualities are also abundant in snail mucus. To promote a quicker recovery from tissue injury and inflammation, these substances help neutralize free radicals and control proinflammatory cytokines [10,11].

SNAIL MUCIN IN DRUG DELIVERY SYSTEM

To enhance medication delivery methods, the pharmaceutical industry is constantly looking for novel materials. The multifunctionality and biocompatibility of snail mucin have made it a promising bioactive molecule. Because of its potential to act as a carrier for active pharmaceutical ingredients, its use in drug delivery systems has accelerated from its historical use in cosmetics. In topical formulations like creams and gels, snail mucin has demonstrated promise as a carrier. Its capacity to moisturize and heal wounds improves medication stability and skin penetration. To treat burns and skin infections, for example, snail mucin-based gels greatly increased the bioavailability of antibiotics and anti-inflammatory drugs [12]. Its capacity to hasten wound healing, which is essential for topical treatments, was also emphasized [13]. Figure 2 illustrated in Snail mucin Drug delivery system.

Oral drug delivery

Snail mucin can increase the solubility and bioavailability of poorly soluble medications when administered orally. Its mucoadhesive qualities guarantee extended retention in the gastrointestinal system, improving the effectiveness and absorption of medications. Mucin's sticky properties enabled improved localization and regulated medication release in the stomach during the development of gastroretentive drug delivery systems [14].

Nanoparticle-based drug delivery systems

Snail mucin has been investigated recently in drug delivery systems based on nanoparticles. Snail mucin has been used as a stabilizer in nanoparticles, improving drug encapsulation and enabling sustained release. In cancer treatment, snail mucin-based nanoparticles help deliver drugs directly to target cells, reduce side effects, and enhance treatment effectiveness [15].

Natural carrier for drug delivery

Another use for snail mucin is as a natural drug delivery carrier. Snail mucin's glycoproteins and hyaluronic acid can act as medication transporters, improving stability and absorption. Using polyethylene glycol to bind metformin hydrochloride to the mucin of giant African land snails, for example, enhanced the drug's bioavailability [16].

Bioadhesive agent

Mucin from snails is a bioadhesive agent. Drug adherence to biological surfaces is improved by snail mucin's adhesive qualities, which also increase absorption and residence time. It is especially beneficial in applications like transdermal patches and wound healing [17].

PHARMACOLOGICAL EFFECT OF SNAIL MUCIN

Snail mucins as antitumor agents

A viable treatment for melanoma, one of the deadliest skin malignancies, has been demonstrated by snail mucin [18]. Although recent advancements in cancer treatment have increased remission rates and extended life expectancies for individuals affected, melanoma has not seen comparable results [19]. Finding innovative and efficient treatment methods for melanoma is crucial because this cancer frequently develops resistance to existing treatments. According to a study on melanoma cell lines, snail mucus reduced the vitality and prevented melanoma cells from metastasizing [18]. An apoptotic event linked to cleavage of the poly (ADP-ribose) polymerase was identified as the cause of the cells' decreased viability. Furthermore, integrin activity and expression were blocked, which prevented the cancer from growing and hence inhibited metastasis [20]. Another study found that *Helix aspersa* mucin has ant melanogenic effects by suppressing the growth of two human melanoma cell lines. It works by increasing tumor necrosis factor-α (TNF-α) and inhibiting nuclear factor-kappa B (NF-κB), which is linked to cancer progression [21]. Although it is still in its infancy, the biomedical world is becoming increasingly interested in using snail mucins as antitumor medicines.

Snail mucins as antimicrobial agents

Antibiotic-resistant microorganisms are a growing problem for which there are few effective remedies. Mollusca rely on innate immunity and physical barriers to defend themselves from pathogens because they lack adaptive immunity [22]. The majority of snails' feet come into touch with surfaces that are contaminated with parasites and pathogens the most, and mucus secreted along the feet provides protection from these microorganisms. The mucus of the giant African land snail, *A. fulica*, was among the first to be tested for antibacterial action [23]. *A. fulica* mucus [24] showed encouraging antibacterial efficacy against both Gram-negative bacteria, such as *Escherichia coli* and *Pseudomonas aeruginosa*, and Gram-positive bacteria, such as *Bacillus subtilis* and *Staphylococcus aureus*. In a mouse model, *A. fulica* mucus secretions applied via wound dressing films reduced the growth of *S. aureus* and *Staphylococcus epidermidis* bacteria [25]. The wound dressings accelerated the rate of collagen deposition and granulation tissue development, both of which are known to speed up the healing process [26]. *H. aspersa* mucus showed antibacterial efficacy against many *P. aeruginosa* strains in a related investigation [27]. In addition, 28 clinical wound samples that were obtained with known common infections were dressed with the mucus of *Archachatina marginata* and *A. fulica* [28]. The mucus demonstrated antibacterial activity against wound-isolated *Pseudomonas*, *Streptococcus*, and *Staphylococcus*. In the same study, some mucus discharges were more effective at inhibiting infections than commercial antibiotics when compared to seven popular medicines, such as amoxicillin, streptomycin, and chloramphenicol. Research on the antibacterial qualities of snail mucus is ongoing and expanding.

Snail mucus used as bioinspired materials

Researching naturally occurring compounds as a basis for creating new materials has produced several ground-breaking products, including morphine, penicillin, and Lipitor. The usage of mucins as a biomaterial covering has also been employed to lessen inorganic implant rejection. Treating infections after surgery is much more expensive than the original operation, and over 1 million implant rejections due to infection occur each year [29]. The immunological response caused by immunoglobulin G and immunoglobulin M absorption into polyethylene terephthalate, a common material used in medical implants, was significantly decreased by applying mucin-based films to the plastic [30,31]. Comparing the mucin coating to the uncoated plastic, the same study also showed that it decreased the activation of fibrinogen, a recognized inflammatory factor, upon contact. Other investigations have demonstrated that mucins decrease the reproduction of microbes on implanted devices [32,33]. Technologies based on mucins have enormous potential to revolutionize the biomaterials industry. The employment of mucins in the production of water-soluble hydrocarbons is an illustration of their use as biomaterials. While the non-complexed hydrocarbon would precipitate quickly from solution, the hydrocarbon complex remained suspended in aqueous conditions even after many months when mucin and/or mucin-mimicking compounds were ligated with a hydrophobic lipid chain [33,34]. Combaa's group used this property to enhance glucose detection by creating a stable carbon nanotube–mucin complex for a sandwich-style glucose biosensor Compared to traditional devices that do not use this sensor design matrix, the resulting bioanalytical device is 40% faster and 20% more sensitive [34].

Snail mucins as wound healing

Snail mucins as wound healing Snail mucus has emerged as a valuable resource in wound research and has the ability to promote healing [28,35]. It has been demonstrated that mucins from the *H. aspersa* (garden snail) aid in skin regeneration following acute radiodermatitis, a frequent side effect of radiation therapy [36,37]. According to reports, garden snail mucus accelerated healing rates by regulating free radicals and antioxidants [37,38]. In rat models, garden mucus improved erythema, and the same rodents also displayed a decrease in photoaging [38]. Mucins have demonstrated the capacity to be applied to internal wounds in addition to external lesions. To lessen or completely eradicate gastric mucosal damage, mucins have been used in conjunction with oral non-steroidal anti-inflammatory medications (NSAIDs) [39]. Although NSAIDs have negative side effects linked to liver and gastrointestinal damage, they also reduce inflammation. Mucin has been demonstrated to treat peptic ulcers, a side effect brought on by NSAIDs, and many businesses have resorted to natural solutions to combat these negative effects [40,41]. Peptic ulcer illness has been successfully treated with a combination of *A. fulica* mucin and the antibiotic clarithromycin (Mu *et al*., 2008; Kabakambira *et al.,* 2018). Apart from its antiulcer qualities, mucin's concentration accelerated ulcer healing compared to clarithromycin alone. Figure 3 illustratre the pharmacological effect of Snail Mucin.

CONCLUSION

The varied bioactive chemicals found in snail mucin, such as glycoproteins, hyaluronic acid, glycolic acid, and antimicrobial peptides, have made it a promising bioactive element in medications. These substances support snail mucin's pharmacological actions, which include wound healing, anti-inflammatory, antibacterial, and antioxidant qualities. Snail mucin has also demonstrated promise in improving drug stability, bioavailability, and targeted distribution in drug delivery systems, which makes it an important part of innovative therapeutic formulations. To establish the specific pharmacological actions and therapeutic potential, more thorough clinical and preclinical research are required, as these effects are frequently not fully characterized. Its full potential may be further unlocked with more study and development, opening the door to creative pharmacological applications.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

AUTHORS FUNDING

The authors received no extramural funding for the study.

REFERENCES

1. Waluga-Kozłowska EW, Jasik K, Wcisło-Dziadecka DO, Pol P, Kuźnik-Trocha KO, Komosińska-Vassev KA, *et al.* Snail mucus-a natural origin substance with potential use in medicine. Acta Pol Pharm 2021;78:793-800.
2. Um JY, Kang SY, Kim HJ, Chung BY, Park CW, Kim HO. Transient receptor potential vanilloid-3 (TRPV3) channel induces dermal fibrosis via the TRPV3/TSLP/Smad2/3 pathways in dermal fibroblasts. J Dermatol Sci. 2020 Feb;97(2):117-24. doi: 10.1016/j.jdermsci.2019.12.011
3. Dhiman V, Pant D. Human health and snails. J Immunoassay Immunochem 2021;42:211-35.
4. Parkin DM, Bray F, Ferlay J, Pisani P. Global cancer statistics, 2002. CA Cancer J Clin 2005;55:74-108.
5. Thavendiranathan P, Poulin F, Lim KD, Plana JC, Woo A, Marwick TH. Use of myocardial strain imaging by echocardiography for the early detection of cardiotoxicity in patients during and after cancer chemotherapy: A systematic review. J Am Coll Cardiol 2014;63:2751-68.

6. Park S, Kim HS, Lee JH, Son ED, Lee J, Kim MH, et al. Effects of snail secretion filtrate on fibroblast proliferation and matrix remodeling. *Biochem J.* 2017;474(13):2531-44.
7. Wu H, Gao Y, Tu J, Li J, Liu Y, Hu J. Snail mucin-derived nanoparticles for sustained drug delivery and promoting diabetic wound healing *in vitro* and *in vivo*. *Nanomed Nanotechnol Biol Med.* 2021;38:102794.
8. Yoon SY, Park SH, Oh SH, Kim JY, Lee JH, and Park JK. Decellularized extracellular matrix derived from Achatina fulica foot mucus as a novel biomaterial for tissue engineering. Appl Biol Chem 2019;62:70.
9. Velkova L, Slominski A. Structure and antibacterial activity of isolated peptides from the mucus of garden snail *Cornu aspersum*. *Bulgar Chem Commun*. 2018;50:23-129
10. González C. Sustainable heliculture and ethical harvesting of bioactive compounds: A review. *J. Environ. Biotechnol.* 2020;9(1):15-24.
11. Patel P, Garala K, Singh S, Prajapati BG, Chittasupho C. Lipid-based nanoparticles in delivering bioactive compounds for improving therapeutic efficacy. Pharmaceuticals. 2022;17:329.
12. Smith DR. Unveiling the therapeutic journey of snail mucus in diabetic wound care. *J Biol Res* (Thessalon). 2025 Jan 27;52(1):3.
13. Kim HJ, Lee KM, Park S. Exploring snail secretion filtrate for enhanced drug bioavailability: A review. *Int J Biomed Mater* 2022;14:1012-24.
14. Sharma R, Parvez N. Snail mucin: A bioactive powerhouse in regenerative medicine and drug delivery. *J Pharm Innov* 2023;18:345-60.
15. Esposito M, Cortese M. Advanced drug delivery systems using snail mucin: Applications and perspectives. *Mater Sci Med* 2021;25:987-99.
16. Liu Y, Zhang J, Zhao X. Role of snail mucin in nanoparticle drug delivery systems: A review. *Drug Deliv Lett* 2020;10:75-84.
17. McDermott M, Cerullo AR, Parziale J, Achrak E, Sultana S, Ferd J, *et al*. Advancing discovery of snail mucins function and application. *Front Bioeng Biotechnol* 2021;9:734023.
18. Arhewoh MI, Eraga SO, Builders PF, Uduh UA. Snail mucin-based formulation of ibuprofen for transdermal delivery. *J Sci Pract Pharm* 2014;1:31-6.
19. Ellijimi C, Ben Hammouda M, Othman H, Moslah W, Jebali J, Mabrouk HB, *et al*. Helix aspersa *maxima* mucus exhibits antimelanogenic and antitumoral effects against melanoma cells. *Biomed Pharmacother* 2018;101:871-80.
20. Rutkowski P, Kozak K. News from the melanoma sessions of the European Cancer Congress 2017. *BMC Med* 2017;15:57.
21. Premi S. Role of melanin chemiexcitation in melanoma progression and drug resistance. *Front Oncol* 2020;10:1305.
22. Domínguez-Martín EM, Tavares J, Ríjo P, Díaz-Lanza AM. Zoopharmacology: A way to discover new cancer treatments. *Biomolecules* 2020;10:817.
23. Gerdol M. Immune-related genes in gastropods and bivalves: A comparative overview. *Invertebr Surviv J* 2017;14:103-18.
24. Iguchi SMM, Aikawa T, Matsumoto JJ. Antibacterial activity of snail mucus mucin. *Comp Biochem Physiol A Physiol* 1982;72:571-4.
25. Mumuni MA, Kenechukwu FC, Ofokansi KC, Attama AA, Díaz DD. Insulin-loaded mucoadhesive nanoparticles based on mucin-chitosan complexes for oral delivery and diabetes treatment. *Carbohydr Polym* 2020;229:115506.
26. Santana WA, Melo CM, Cardoso JC, Pereira-Filho RN, Rabelo AS, Reis FP, *et al*. Assessment of antimicrobial activity and healing potential of mucous secretion of Achatina fulica. *Int J Morphol* 2012;30:365-73.
27. Martins MD, Caetano FA, Sírio OJ, Yiomasa MM, Mizusaki CI, Figueiredo LD. Macroscopic and microscopic evaluation of healing in experimentally induced skin lesions in rabbits treated with mucoglyco protein secretion from the snail Achatina fulica. *Braz J Vet Res Anim Sci* 2003;40:213.
28. Pitt SJ, Graham MA, Dedi CG, Taylor-Harris PM, Gunn A. Antimicrobial properties of mucus from the brown garden snail Helix aspersa. *Br J Biomed Sci* 2015;72:174-81; quiz 208.
29. Etim L, Aleruchi C, Obande G. Antibacterial properties of snail mucus on bacteria isolated from patients with wound infection. *Br Microbiol Res J* 2016;11:1-9.
30. Darouiche RO. Treatment of infections associated with surgical implants. *N Engl J Med* 2004;350:1422-9.
31. Sandberg T, Karlsson Ott M, Carlsson J, Feiler A, Caldwell KD. Potential use of mucins as biomaterial coatings. II. Mucin coatings affect the conformation and neutrophil-activating properties of adsorbed host proteins--toward a mucosal mimic. J Biomed Mater Res A 2009;91A:773-85.
32. Silva G, da costa Valente ML, Bachmann L, dos Reis AC. Use of polyethylene terephthalate as a prosthetic component in the prosthesis on an overdenture implant. Mater Sci Eng C Mater Biol Appl 2019;99:1341-9.
33. Co JY, Crouzier T, Ribbeck K. Probing the role of mucin-bound glycans in bacterial repulsion by mucin coatings. Adv Mater Interfaces 2015;2:1500179.
34. Comba FN, Romero MR, Garay FS, Baruzzi AM. Mucin and carbon nanotube-based biosensor for detection of glucose in human plasma. Anal Biochem 2018;550:34-40.
35. Adikwu MU, editor. Multifarious potentials of tropical animal-derived biopolymers in drug delivery: Lessons from the African snail mucin. In: Biopolymers in Drug Delivery: Recent Advances and Challenges. Sharjah, UAE: Bentham Science Publishers; 2012. p. 27-38.
36. Hymes SR, Strom EA, Fife C. Radiation dermatitis: Clinical presentation, pathophysiology, and treatment. J Am Acad Dermatol 2006;54:28-46.
37. Nguyen JK, Masub N, Jagdeo J. Bioactive ingredients in Korean cosmeceuticals: Trends and research evidence. J Cosmet Dermatol 2020;19:1555-69.
38. Lim VZ, Yong AA, Tan WP, Zhao X, Vitale M, Goh CL. Efficacy and safety of a new cosmeceutical regimen based on the combination of snail secretion filtrate and snail egg extract to improve signs of skin aging. J Clin Aesthet Dermatol 2020;13:31-6.
39. Abdulla A, Adams N, Bone M, Elliott AM, Gaffin J, Jones D, *et al*. Guidance on the management of pain in older people. Age Ageing 2013;42(Suppl 1):i1-57.
40. Mu A, Okolie CO, Agboke AA. The effect of snail mucin on the ulcer healing rate of clarithromycin. J Pharm Res 2008;8:6-8.
41. Kabakambira JD, Hategeka C, Page C, Ntirenganya C, Dusabejambo V, Ndoli J, *et al*. Efficacy of *Helicobacter pylori* eradication regimens in Rwanda: A randomized controlled trial. BMC Gastroenterol 2018;18:134.