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GASTROPODA MOLLUSCA: THE OVERVIEW OF MEAT AND NON-MEAT PRODUCTS, PRODUCTION AND PROCESSING TECHNOLOGIES AND THEIR PRACTICAL APPLICATIONS

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INTRODUCTION

Gastropoda is a class of mollusks that includes snails and slugs[1]. Slugs are a type of *Gastropoda* that lack a shell and have a slimy, mucus-covered body. They are found in a wide range of habitats, from forests and fields to gardens and urban areas[2]. *Gastropoda* slugs are known for their important role in ecosystems, as both herbivores and decomposers. They feed on plants and are an important food source for a variety of animals, including birds, rodents, and other invertebrates[3].

However, *Gastropoda* slugs are also known for their potential to cause damage to crops and gardens. They can cause significant economic losses, particularly in agricultural settings, where they can damage crops and reduce yields[4].

To investigate the behavior and impact of *Gastropoda* slugs, researchers have conducted numerous studies over the years. Some studies have focused on the ecology and behavior of slugs in natural settings[5], while others have explored the effectiveness of various methods for controlling slugs in agricultural settings[6].

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[1] Mollusca: Gastropoda / Dennis M. M. et al. *Invertebrate Histology*. 2021. P. 87–132.

[2] Breuste J. The Urban Nature Concept – of What Urban Green Consists of. *Making Green Cities: Concepts, Challenges and Practice*. 2023. P. 19–50.

[3] Feeding habits and multifunctional classification of soil-associated consumers from protists to vertebrates / Potapov A. M. et al. *Biological Reviews*. 2022. 97 (3). P. 1057–1117.

[4] Barua A., Williams C. D., Ross J. L. A literature review of biological and bio-rational control strategies for slugs: Current research and future prospects. *Insects*. 2021. 12 (6). P. 541.

[5] O'Hanlon A., Williams C. D., Gormally M. J. Terrestrial slugs (Mollusca: *Gastropoda*) share common anti-predator defence mechanisms but their expression differs among species. *Journal of Zoology*. 2019. 307 (3). P. 203–214.

[6] Contact Efficacy of Different Wood Ashes against Spanish Slug, Arion vulgaris (Gastropoda: Arionidae) / Laznik Ž. et al. Applied Sciences. 2020. 10 (23). P. 8564.

In natural settings, researchers have investigated the factors that influence the distribution and abundance of slugs, including temperature, moisture, and food availability[7]. They have also studied the interactions between slugs and other organisms, including predators, parasites, and competitors.

In agricultural settings, researchers have investigated the effectiveness of various methods for controlling slugs, including cultural practices, such as crop rotation and tillage, as well as chemical and biological control methods[8, 9]. They have also studied the impact of different crop management practices on slug populations and the resulting crop damage[10].

Overall, the research on *Gastropoda* slugs has provided valuable insights into the ecology, behavior, and impact of these organisms, as well as the effectiveness of various methods for controlling their populations.

1. Analysis of achievements of foreign scientists in heliceculture

There is limited research on the role of *Gastropoda* slugs in human nutrition, and their consumption is not common in most Western cultures. However, there are some studies that have explored the nutritional value and potential health benefits of *Gastropoda* slugs as a food source.

Snails and slugs have been used to treat many human health problems since ancient times and are widely distributed in the world, and in China, snails are still used as one of the ingredients of traditional Chinese medicine[11]. In recent years, many scientists have repeatedly reported that some nutrients contained in the body of snails have a curative-prophylactic or health-improving effect on the consumer's body. For example, crude polysaccharide extracts from snails of the species *Limacus flavus* (*L. flavus*) have potential antitumor and antioxidant effects[12], and antimicrobial peptides from the mucus of the same snail are considered as a potential source for the development of new drugs, especially against bacteria

[7] Zaidi N., Douafer L., Hamdani A. Diversity and abundance of terrestrial gastropods in Skikda region (North-East Algeria): correlation with soil physi-cochemical factors. *The Journal of Basic and Applied Zoology*. 2021. 82 (1). P. 1–10.

[8] Watz J., Nyqvist D. Interspecific competition among terrestrial slugs. *Journal of Molluscan Studies*. 2022. 88 (2). P. eyac007.

[9] Early-season plant cover supports more effective pest control than insecticide applications / Rowen E. K., et al. *Ecological Applications*. 2022. 32 (5). P. e2598.

[10] Nematodes Associated with Terrestrial Slugs in Mid-Atlantic (Delaware, USA) Soybean / Kunkel B., et al. *Agronomy*. 2023. 13 (3). P. 645.

[11] Phenotypic plasticity of the invasive apple snail, *Pomacea canaliculata*, in China: a morphological differentiation analysis / Luo M et al. *Molluscan Research*. 2022. 42 (2). P. 146–157.

[12] Structure and heparanase inhibitory activity of a new glycosaminoglycan from the slug *Limacus flavus* / He Z., et al. *Carbohydrate polymers*. 2019. 220. P. 176–184.

resistant to antibiotic drugs[13]. The given facts justify the relevance of research aimed at expanding the amount of information about the specified object of research in order to determine the possibility of its use in the food industry as a raw material for the production of dietary products.

It should be noted from the outset that *L. flavus* is currently an alternative model animal for the analysis of mucosal irritation with chemical solutions that are most often recommended in the fight against the virus SARS-CoV-2. Research results have shown that this species is a promising model for mucosal irritation studies[14].

Science also knows the results of research on the stages of the life cycle of snails of the specified species (egg-laying, hatching, generation period, life span, growth parameters). The results showed that mating is not necessary for this species to lay eggs, while self-fertilization is the normal reproductive system. An individual lays 41,1±20,4 eggs. The generation period (from egg to egg) is 152,8±18,8 days. On the other hand, the maximum lifespan averaged 235,2±27,5 days. Growth parameters, depending on the increase and decrease in body weight of the snail, increased from hatching to the seventh month and reached a maximum weight of 3,51±0,86 g on average[15].

D. H. Davidson in his work studied the relative efficiency of assimilation of adults and young individuals of *L. flavus.* A high average assimilation efficiency was established for individuals fed on carrots and potatoes (76,94 and 76,87 %, respectively). Juveniles of *L. flavus* were found to have higher assimilation efficiency and ingestion rate than adults per gram of live weight[16].

In another well-known study, E. İhsan and Ş. Ridvan studied the fatty acid composition of phospholipids, neutral and total lipid content of edible land snails *H. lucorum, E. vermiculata* and *L. flavus*[17]. The analysis

[13] 13. Hayashida P. Y., da Silva Júnior P. I. *Limacus flavus* yellow slug: bioactive molecules in the mucus. *bioRxiv*. 2021-05.

[14] 14. Potential mucosal irritation discrimination of surface disinfectants employed against SARS-CoV-2 by Limacus flavus slug mucosal irritation assay / Cutuli M.A et al. *Biomedicines*. 2021. 9. P. 424.

[15] 15. Mohamed M. I., Reham F. A. Laboratoryobservations on biology of the tawnygarden slug *Limax flavus (Linnaeus)* (*Limacidae*:Mollusca). *Animal Biology Journal*. Vol. 4, Is. 1. P. 51–62.

[16] 16. Davidson D. H. Assimilation Effieiencies of Slugs on Different Food Materials. *Oecologia* (Berl.). 1976. 26. P. 267–273.

[17] İhsan Ekin, Ridvan Şeşen. Investigation of the fatty acid contents of edible snails H. lucorum, E. vermiculata and non-edible slug L. flavus. Rec. Nat. Prod. 2017. 11:6. P. 562–567.

revealed that snails and slugs are rich in C16:0, C18:0, C18:1ω9 and C18:2ω6 acids.

Phospholipid fractions contained a very high amount of C20:4ω6 (8,59 %).

Today, resistance to antimicrobial drugs has become one of the main global topics. Current reports confirm that the mucus secretions of the snail *L. fla*vus have antimicrobial, antiviral, and antifungal properties. Thus, three fractions were isolated from the mucus of *L. flavus* and showed antifungal and antibacterial activity. Mucus showed greater inhibition of some species of filamentous fungi, yeasts, gram-positive and gram-negative bacteria[18].

A novel glycosaminoglycan (LF-GAG) was isolated from the body of the snail *L. fla*vus, which potently inhibits human heparinize. Structure-activity relationship analysis revealed that LF-GAG chain length and sulfate substitution are important for its heparinize inhibitory activity[19].

Another study published in the Journal of Applied Biosciences in 2021 examined the chemical composition and nutritional value of the African giant snail (*Achatina achatina*), a large *Gastropoda* species commonly consumed in many African countries. The authors found that the snails were a good source of protein, essential amino acids, and important minerals such as iron, calcium, and phosphorus. They also noted the potential for using snails as a sustainable and affordable source of protein in regions with food insecurity[20].

In general, however, *Gastropoda* slugs are not a commonly studied or consumed food source in most Western cultures, and there is limited research on their nutritional value and potential health benefits. While *Gastropoda* slugs are not commonly consumed in most Western cultures, they are a traditional food source in some parts of the world[21]. For example, some species of land snails are considered a delicacy in certain European

[18] Slug species-and population-specific effects on the end points of the Slug Mucosal Irritation test / Dhondt M. M., et al. *Toxicology in vitro*. 2006. 20 (4). P. 448–457.

[19] Oligosaccharides from fucosylated glycosaminoglycan prevent breast cancer metastasis in mice by inhibiting heparanase activity and angiogenesis / Zhou, L., et al. *Pharmacological Research*. 2021. 166. P. 105527.

[20] Chemical composition of the flesh and mucus of land snail species (*Archachatina marginata* (Swainson), *Archachatina marginata* (Suturalis), *Achatina fulica, Achatina iostoma, Limicolaria spp*) in Gabon: Case of the Haut-Ogooué Province / Tovignon G. C. Z., et al. *Journal of Applied Biosciences*. 2021. 167 (1). P. 17391–17405.

[21] Diversity and distribution of air-breathing sea slug genus *Peronia Fleming*, 1822 (*Gastropoda*: *Onchidiidae*) in southern Japanese waters / Mizukami I., et al. *PeerJ*. 2022. 10. P. e13720.

and African countries, and are often prepared in a variety of ways, such as sautéed with garlic and herbs[22], or served in a rich sauce[23].

Scientific studies show that gastropod meat contains a large amount of proteins, vitamins and minerals, which makes it useful for the human body. For example, studies conducted in Italy have shown that the meat of Helix molluscs contains significant amounts of Fe and Mg, and is a source of vitamin B_{12} and a number of essential amino acids[24].

There are enterprises engaged in the cultivation of gastropod molluscs for their use in food. For example, in France, for many years, "bronze clams" have been grown, which are very popular in local cuisine. In addition, gastropod molluscs of the genus *Helix*[25] and *Otala*[26] are grown in Italy and Spain, which are also used in national cuisine. However, it is worth considering some ecological aspects related to the cultivation of gastropod molluscs, in particular, ensuring appropriate conditions for their maintenance and preventing escape into natural ecosystems. In addition, it is necessary to conduct additional research on the impact of gastropod meat consumption on human health.

More and more people around the world are looking for alternative sources of protein that are environmentally friendly and provide enough nutrients for a healthy diet. The use of gastropod molluscs of the class *Gastropoda*, in particular *L. flavus*, can be one of the options for solving this problem.

Using gastropods in food can be a more environmentally sustainable option than using meat from other animals. For example, it is necessary to use about 15,000 liters of water to produce one kilogram of beef, while only 5 liters are needed to grow the same kilogram of shellfish. In addition, molluscs are low-trophic animals: for their cultivation, it is not necessary to use significant amounts of grain crops and other plant resources. Also, molluscs are relatively efficient in terms of digestion and assimilation of food, so they have a high conversion of feed into meat. Compared to

[22] Ovissipour M., Rasco B., Bledsoe G. Aquatic food products. *Food Processing: Principles and Applications*. 2014. P. 501–534.

[23] Dourson D. C. The feeding behavior and diet of an endemic West Virginia land snail, *Triodopsis platysayoides*. *American Malacological Bulletin.* 2008. 26 (1/2). P. 153–159.

[24] Toxic and potentially toxic mineral elements of edible gastropods land snails (*Mediterranean Escargot*) / Tardugno R., et al. *Toxics*. 2023. 11. P. 317.

[25] Cobbinah J. R., Vink A., Onwuka B. Snail farming: production, processing and marketing. Agromisa/CTA. 2008.

[26] Nutritional and toxicity profiles of two species of land snail, Theba pisana and Otala lactea, from Morocco / Caetano D., et al. *Journal of Food Composition and Analysis.* 2021. Vol. 100. P. 103893.

traditional meats such as pork, beef and poultry, shellfish have a significantly lower impact on environmental sustainability[27].

In addition, molluscs are capable of efficient collection and preservation of food resources such as algae and plant residues. The main food source for gastropods is plant debris and leaves, which they collect with their radulae (toothed tongues). This way of feeding helps to maintain the balance in the ecosystem[28].

Studies confirm that gastropods have a low cost of energy and material costs for cultivation, which is minimized due to their low requirements for living conditions. This approach to growing shellfish can significantly reduce the costs of their production compared to other types of meat[29].

The chemical composition of different species of *Gastropoda* can vary depending on factors such as the species, location, and diet of the gastropod. Those slugs are generally a good source of protein, with some species containing up to 15–20 % protein by weight and they also contain varying amounts of fats, ranging from 1–8 %, and carbohydrates, which are usually low, ranging from 1–3 %[30]. They also tend to be low in fat and high in important minerals such as Fe, Ca, and P[31]. Some species of slugs and snails have also been found to contain bioactive compounds with potential health benefits, such as antioxidants and anti-inflammatory compounds[32].

However, there are also potential risks associated with consuming *Gastropoda* slugs. Some species may contain toxins that can cause illness

[27] Toxic Elements and Mineral Content of Different Tissues of Endemic Edible Snails (*Helix vladika* and *H. secernenda*) of Montenegro / Vukašinović-Pešić V. et al. *Foods*. 2020. 9. P. 731.

[28] A Survey Study on Parasite Presence of Edible Wild Terrestrial Snails (*Helix pomatia L.*) in Northern Cyprus / Yildirim F. K., et al. *Heat Treatment.* 5. P. 12.

[29] Processing and utilization of snail meat in alleviating protein malnutrition in Africa: a review / Adeyeye S. A.O., et al. *Nutrition & Food Science*. 2020. Vol. 50, No. 6. P. 1085–1097.

[30] Dallinger R., Berger B., Bauer-Hilty A. Purification of cadmium-binding proteins from related species of terrestrial helicidae (*Gastropoda*, Mollusca): a comparative study. *Molecular and Cellular Biochemistry*. 1989. 85. P. 135–145.

[31] Investigation of nutritional properties of three species of marine turban snails for human consumption / Ab Lah R., et al. *Food Science & Nutrition*. 2017. 5 (1). P. 14–30.

[32] Odeleye T., White W. L., Lu J. Extraction techniques and potential health benefits of bioactive compounds from marine molluscs: A review. *Food & function*. 2019. 10 (5). P. 2278–2289.

or even death if ingested[33]. Additionally, slugs and snails can harbor harmful bacteria such as *Salmonella*, which can cause foodborne illness[34].

Overall, while there is some research on the nutritional value and potential health benefits of *Gastropoda* slugs as a food source, more research is needed to better understand their safety and potential as a sustainable and affordable source of protein.

It is worth noting that the chemical composition of gastropods can be influenced by a variety of factors such as the environment they live in and the food they eat. Additionally, some gastropods can accumulate toxic substances such as heavy metals and pesticides, which can have negative health effects if consumed by humans. Therefore, it is important to ensure that any Gastropods consumed are from a safe and reputable source.

Gastropods have various edible parts, depending on the species. Some species are eaten completely, while others are eaten only after certain parts have been removed. In general, the edible parts of gastropods include the foot muscle, the digestive gland, and the gonads. The foot muscle is the large muscular organ that the snail uses to move, and it is the part that is most commonly consumed. The digestive gland, also known as the hepatopancreas, is the organ that produces digestive enzymes, and it is sometimes consumed in certain species. The gonads, also known as the "coral", are the reproductive organs of the snail, and they are sometimes considered a delicacy in certain cultures[35].

The foot muscle of gastropods is usually the most consumed part, and it is often cooked in various ways, such as grilling, boiling, or frying. The texture of the foot muscle can vary between species, and it is often described as chewy or rubbery.

The digestive gland or hepatopancreas is another part of gastropods that is sometimes consumed. This organ produces digestive enzymes and can have a slightly bitter taste. In some species, such as the giant African snail, the hepatopancreas is removed and discarded due to its toxicity.

The gonads or "coral" of gastropods are sometimes consumed and are considered a delicacy in certain cultures. The texture and flavor of the

[33] An outbreak of tetrodotoxin poisoning following gastropod mollusc consumption / Yang C. C., et al. *Human & experimental toxicology*. 1995. 14 (5). P. 446–450.

[34] Periyasamy N., Arularasan S., Gayathri S. Antibacterial activity of the tissue extracts of Conus betulinus and Conus inscriptus Linnaeus, 1758 (Mollusca: *Gastropoda*) from Nagapattinam, Southeast coast of India. *Asian Pacific Journal of Tropical Disease*. 2012. 2. P. S914-S919.

[35] Tetrodotoxin in marine bivalves and edible gastropods: A mini-review. Biessy L., et al. *Chemosphere*. 2019. 236. P. 124404.

gonads can vary between species, but they are often described as rich and creamy[36].

It is worth noting that not all species of *Gastropoda* are edible, and some can be toxic to humans due to their diet or other factors. Additionally, some species may accumulate heavy metals or other contaminants, making them unsafe for consumption[37].

Overall, the edible parts of gastropods are a good source of protein and other nutrients, and they are consumed in many cultures around the world. However, it is important to ensure that the species being consumed are safe and free from contaminants[38].

Scientists from all over the world have established the direct influence of temperature, humidity and light period on the growth rate of land snails. So, Barker and McGhie note in their work the maximum size of *Limax maximus* 95 mm in a state of rest (150 mm in a stretched state)[39].

Hommay et al. point out that the weight gain of *Limax valentianus* occurred in three distinct phases: an initial phase of rapid growth, followed by a phase of less weight gain, and finally a phase of minimal growth during which reproduction occurred. This phase ended with weight loss due to aging. The growth rate increased at 15ºC and reached a maximum value at 18 ºC[40].

Faberi et al. reported that the growth rate of *Deroceras laeve* was lower at 12ºC than at 20 ºC. The inflection point (the mean body weight at which growth rate began to decline) was reached when *Deroceras laeve* slugs were 2.5 months old and the mean body weight was 204,7 mg at 20 ºC. At the same age at 12 ºC, the body weight was 132,9 mg. In addition, slugs reached a greater mean body weight at 12 ºC (936,2 ± 18,9 mg) than at 20 ºC (409,4 ± 16,02 mg), which is approximately half the weight of slugs maintained at 12 ºC. The growth curve of *Deroceras laeve* has two phases:

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[36] Fang Z. Q., Cheung R. Y. H., Wong M. H. Heavy metal concentrations in edible bivalves and gastropods available in major markets of the Pearl River Delta. *Journal of Environmental Sciences*. 2001. 13 (2). P. 210–217.

[37] Bryan G. W., Potts G. W., Forster G. R. Heavy metals in the gastropod mollusc *Haliotis tuberculata* (L.). *Journal of the Marine Biological Association of the United Kingdom*. 1977. 57 (2). P. 379–390.

[38] Diversity of edible mollusc (Gastropoda and Bivalvia) at selected divison of Sarawak, Malaysia / Hamli H., et al. *International Journal on Advanced Science, Engineering and Information Technology*. 2012. 2 (4). P. 5–7.

[39] Barker G. M., McGhie R. A. The biology of introduced slugs (*Pulmonata*) in New Zealand 1. Introduction and notes on *Limax maximus*. *New Zealand Entomologist.* 1984. 8. P. 106–111.

[40] Growth and reproduction of the slug *Limax valentianus* Férussac in experimental conditions / Hommay G., et al. *J. Moll. Stud.* 2001. 67. P. 191–207.

a juvenile phase before oviposition and a mature oviposition phase during which the snails lay their eggs[41].

Mohamed and Ali in their work stated that growth parameters depending on the increase and decrease in body weight of the snail *L. flavus* increased from hatching to the seventh month and reached a maximum weight of 3,51 ± 0,86 g on average. The maximum rate of change in body weight was reached in the first month and was 78,8 ± 17,2 %. Subsequently, the rate of weight change decreased due to the climatic conditions of Egypt[42].

Several products and semi-finished products can be obtained from *Gastropoda*, depending on the intended use[43, 44, 45, 46, 47, 48, 49, 50, 51, 52]. The examples are shown at fig. 1. It is worth noting that not all species of *Gastropoda* are suitable for food or cosmetic use, and some may have toxic properties that make them unsuitable for processing.

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[41] Growth and reproduction of the slug *Deroceras laeve* (Müller) (Pulmonata: Stylommatophora) under controlled conditions / Faberi A. J., et al. *Spanish Journal of Agricultural Research*. 2006. 4 (4). P. 345–350.

[42] Mohamed M. I., Ali R. F. Laboratory Observations on Biology of the Tawny Garden Slug *Limax flavus* (Linnaeus) (Limacidae: Mollusca). *Animal Biology Journal*. 2013. 4 (1). P. 51.

[43] Effect of different processing methods on the proximate composition, mineral content and functional properties of snail (*Archachatina marginata*) meat / Djikeng F. T., et al. *Journal of Agriculture and Food Research*. 2022. 8. P. 100298.

[44] Is the consumption of snail meat actually healthy? / Radzki R. P., et al. *Journal of animal physiology and animal nutrition*. 2018. 102 (2). P. e885-e891.

[45] Structural characteristics and physicochemical properties of freeze-dried snail meat / Pissia M. A., et al. *LWT*. 2022. 155. P. 112980.

[46] Efficacy of compositing with snail meat powder on protein nutritional quality of sorghum–wheat buns using a rat bioassay / Agengo F. B., et al. *Journal of the Science of Food and Agriculture*. 2020. 100 (7). P. 2963–2970.

[47] Touring Club of Italy. *The Italian food guide: The ultimate guide to the regional foods of Italy*. Touring Editore. 2002.

[48] Biocrystal assembly patterns, biopolymer distribution and material property relationships in mytilus galloprovincialis, Bivalvia, and haliotis glabra, *Gastropoda*, shells / Peter N. J., et al. *Materialia*. 2023. 28. P. 101749.

[49] Bondarev I. P. Ecomorphological analyses of marine mollusks' shell thickness of Rapana venosa (Valenciennes, 1846) (*Gastropoda*: Muricidae). *International Journal of Marine Science*. 2013. 3 (45).

[50] Bioactive snail mucus-slime extract loaded chitosan scaffolds for hard tissue regeneration / Perpelek M., et al. *Biomedical Materials*. 2021. 16 (6). P. 065008.

[51] Fabrication of Helix aspersa Extract Loaded Gradient Scaffold with an Integrated Architecture for Osteochondral / Tamburaci S., et al. *ACS Applied Bio Materials*. 2023.

[52] Maćkowiak-Dryka M., Szkucik, K., Pyz-Łukasik R. Snail eggs as a raw material for the production of a caviar substitute. *Journal of veterinary research*. 2020. 64 (4). P. 543–547.

Meat

- Gastropods are often consumed as a delicacy in many countries, and their meat is a good source of protein, vitamins, and minerals. The meat can be prepared in a variety of ways, such as sautéed, grilled, fried. It can also be used as a filling for dishes like stuffed pasta, ravioli, or empanadas[43, 44].

Powder

- Some gastropods are processed into a powder, which can be used as a food ingredient or a supplement. The powder is typically made by drying the *Gastropoda* meat and then grinding it into a fine powder[45, 46].

Sauce

- In some cultures, gastropods are used to make sauces, such as the Italian sauce "sugo all'amatriciana", which is made with pancetta, tomato, and small pieces of snail[47].

Shells

- The shells of *Gastropoda* can be used in various ways, such as for decoration, as material for crafts, or for making lime or calcium carbonate[48, 49].

Cosmetic products

- Some gastropods, such as the Helix aspersa, are used in cosmetic products due to their high concentration of allantoin, which is known to be a skin-soothing agent[50, 51].

Caviar

- Some species of freshwater snails are used to produce caviar, which is a high-end luxury food product. The caviar is produced by milking the eggs from the snails, which are then salted and packaged for sale[52].

Escargot butter

- Escargot butter is a popular French condiment made by mixing butter with cooked and minced snails, garlic, and herbs. It is typically served with bread or used as a sauce for pasta dishes[53].

Snail slime

- Snail slime is a thick, sticky substance that is secreted by gastropods for a variety of purposes, including to protect their skin from damage and to aid in movement. The slime is used in cosmetic products like face creams, moisturizers, and serums due to its moisturizing and anti-aging properties[54].

Pearls

- Some species of gastropods, like abalone and conch, are used to produce pearls. The pearls are produced by inserting a small bead or piece of tissue into the animal's shell, which triggers the production of nacre, the same substance that makes up a pearl's iridescent coating[55].

Fish bait

- Gastropods like whelks and periwinkles are commonly used as fish bait, due to their strong scent and high protein content[56].

Fig. 1. The products and semi-finished products obtained from gastropods

Additionally, regulations may vary between countries regarding the processing and sale of gastropods and their products[53, 54, 55, 56].

The process of producing meat from gastropods involves several steps:

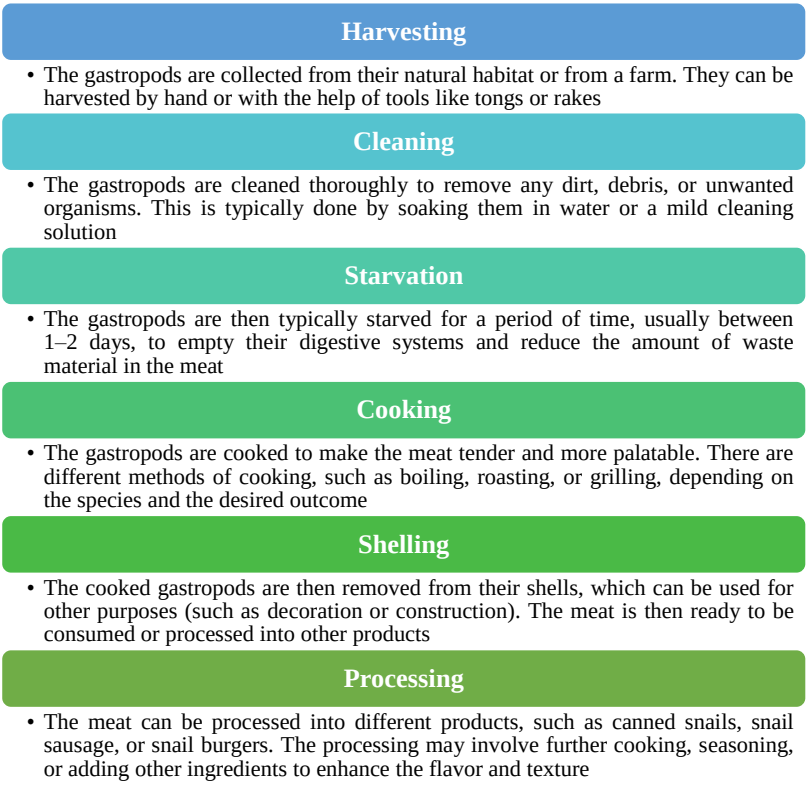

Fig. 2. Common technology of producing meat from gastropods

[53] Occurrence of biologically inactive corrinoid compounds in canned edible apple snails / Teng F., et al. *Food and Nutrition Sciences*. 2015. 6 (12). P. 1071.

[54] Snail slime-based gold nanoparticles: An interesting potential ingredient in cosmetics as an antioxidant, sunscreen, and tyrosinase inhibitor / Rizzi V., et al. *Journal of Photochemistry and Photobiology B: Biology*. 2021. 224. P. 112309.

[55] Ekin İ., Şeşen R. Molluscs: their usage as nutrition, medicine, aphrodisiac, cosmetic, jewelry, cowry, pearl, accessory and so on from the history. *Middle East Journal of Science*. 2018. 4 (1). P. 45–51.

[56] Fishhooks, lures, and sinkers: intensive manufacture of marine technology from the terminal Pleistocene at Makpan Cave, Alor Island, Indonesia / Langley M. C., et al. *The Journal of Island and Coastal Archaeology*. 2023. 18 (1). P. 33–52.

There are also different techniques and variations of this process depending on the species of *Gastropoda* and the intended use of the meat[57]. The methods used for producing meat from wild gastropods may differ from those used for farmed gastropods (fig. 3).

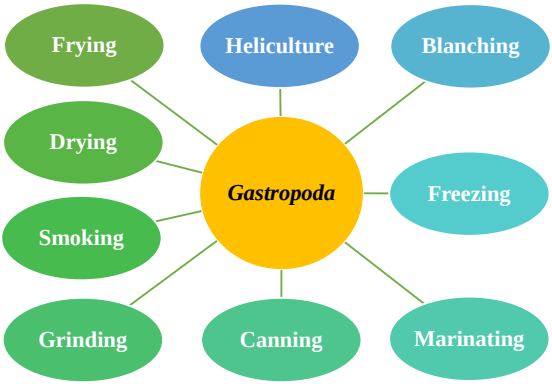

Fig. 3. Examples of techniques and variations used for producing *Gastropoda* meat[58, 59]

Gastropoda powder is a product obtained by drying and grinding different species of gastropods. It is used as a source of high-quality protein, amino acids, and minerals in the food industry. The technology of producing *Gastropoda* powder is shown below:

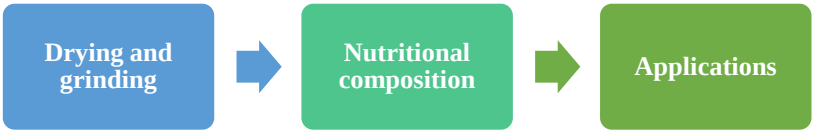

Fig. 4. Technology of producing *Gastropoda* powder

[57] Udoh J. P., Abiaobo N. O. Condition index, meat yield and population structure of the marine gastropod, Thais coronata, off Cross River Estuary, Nigeria. *Adv. Life Sci. Technol*. 2014. 23. P. 24–32.

[58] Snail farming as an alternative profitable livestock system for sustainable development / Meyo E, S. M., et al. *Sustainable development in Africa. Fostering sustainability in one of the world's most promising continents. Cham: Springer*. 2021. P. 477–490.

[59] Joshi N., Pandey S. Meat demand-snailed it: A comprehensive review on snail rearing, to meet the meat demand in future India. *J. Entomol. Zool. Stud*. 2019. 7. P. 396–400.

Gastropoda powder can be used in a variety of applications. The powder is often used as an ingredient in traditional dishes, as well as in the production of supplements and functional foods. It has been found to be a good source of protein, as well as containing other beneficial nutrients such as Ca and Fe[60].

Some studies have also explored the potential health benefits of *Gastropoda* powder, including its potential use in promoting bone health and reducing inflammation[61].

Gastropoda caviar, also known as sea snail roe or sea snail caviar, is a delicacy in some parts of the world. The caviar is made by collecting and processing the eggs of certain species of sea snails, such as abalone, whelk, and sea urchin. The process for making *Gastropoda* caviar is generally similar to that used for making traditional fish roe caviar.

There is limited information available on the technology for producing land slug caviar, as it is not a widely commercialized product. While the technology for producing land slug caviar is still being developed, it is clear that there is potential for this product to be used in the food industry as a high-protein, nutrient-dense alternative to traditional fish caviar. Further research is needed to refine the production process and evaluate the safety and potential market for this product[62].

One of the challenges of producing land slug caviar is the fact that land slugs do not lay eggs in large quantities like fish. As a result, the harvesting and processing of the eggs can be time-consuming and labor-intensive[63].

Escargot butter is a popular French delicacy made from cooked and pureed escargot (land snails) mixed with butter and various herbs and spices.

First, the escargot are removed from their shells, cleaned, and cooked in a flavorful broth. The cooked escargot are then pureed to a fine paste using a food processor or blender. In a separate bowl, softened butter is combined with finely chopped herbs such as parsley, garlic, and shallots, and mixed until well combined. The escargot paste is then added to the butter mixture and mixed until well blended.

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[60] Biochemical composition and antioxidant activity of Pleuroploca trapezium meat / Prem Anand T., et al. *J Chem Pharmaceut Res*. 2010. 2. P. 526–535.

[61] Recieps for the Mesogastropod-Strombus canarium / Arularasan S., et al. *Advance Journal of Food Science and Technology.* 2010. 2 (1). P. 31–35.

[62] Massari S., Pastore S. Heliciculture and snail caviar: new trends in the food sector. *Monograph: Future trends and challenges in the food sector. Polish Society of Commodity Science,* Cracow. 2014. P. 79–90.

[63] Microbiological assessment of land snail's caviar produced in sicily, southern italy: a first report Microbial Diversity 2019 / Sciortino S., et al. In *Microbial Diversity as a source of novelty: function, adaptation and exploitation*. 2019. Vol. 5. P. 344–345.

The resulting mixture is then wrapped in plastic wrap and chilled until firm, after which it can be sliced and served as a spread or used in a variety of dishes[64].

Italian cuisine is famous for its diverse pasta dishes and sauces. One lesser-known Italian pasta sauce is made with snails, also known as lumache. The sauce is usually prepared with tomato sauce, garlic, parsley, and white wine, and is often served over spaghetti or other types of pasta. The technology of Italian pasta sauce made with snails includes cooking the lumache in salted boiling water, their heating a large saucepan, adding other recipe ingredients, stewing the sauce and serving it over cooked pasta.

Snail slime, also known as snail mucus, is a popular ingredient in many beauty and skincare products due to its purported beneficial properties for the skin. Snail slime is obtained from the mucus secreted by land snails of the species *Helix aspersa*, which are commonly used in gastronomy as escargot[65]. The process of obtaining snail slime typically involves manually stimulating the snails to produce mucus, which is then collected and processed into a usable form. The slime is typically processed into a liquid or gel form and can be used as an ingredient in a wide range of skincare products, including moisturizers, serums, and face masks. Some studies have suggested that snail slime may have potential benefits for the skin, including moisturizing, anti-aging, and wound-healing properties. However, more research is needed to fully understand the effects of snail slime on the skin. Overall, the use of snail slime in skincare products is a growing trend, and its potential benefits are being explored by both the cosmetics industry and the scientific community.

Gastropods have been used as fish bait for many years due to their high protein content and attractive scent. The use of gastropods as fish bait has been practiced in many parts of the world, especially in Asia, where it is a popular and lucrative business. Once the gastropods are cooked, they can be preserved by drying or salting. Drying is typically done by placing the cooked gastropods in the sun for a few days until they are completely dry. Salted gastropods are typically stored in brine until they are ready to be used.

Gastropods can also be processed into powder or paste, which can be added to other ingredients to make fish bait. Some formulations of fish bait

[64] Pissia M. A., Matsakidou A., Kiosseoglou V. Raw materials from snails for food preparation. *Future Foods.* 2021. 3. P. 100034.

[65] Raynova Y., Doumanova L., Idakieva K. N. Phenoloxidase activity of *Helix aspersa maxima* (garden snail, *Gastropod*) hemocyanin. *The Protein Journal*. 2013. 32. P. 609–618.

include *Gastropoda* powder, fish meal, and soybean meal, which are mixed with water to form a dough-like consistency[66].

2. Review of Ukrainian achievements in heliculture

Herbivorous species of gastropods limit the number of aquatic vegetation, preventing the overgrowth of water bodies. Terrestrial soil molluscs enrich the soil with organic and mineral substances. However, terrestrial gastropods (for example, slugs) can damage grain and vegetable crops, fruiting bodies of edible mushrooms. Humanity, in the case of the latter, has been using numerous molluscicides for several decades. Although, a more humane, and most importantly, a safer approach to solving this problem is also possible.

An example of such an approach can be the following concept: isolation of adult pests, reproduction of safe (sterile) offspring and organization of farms for the breeding of this fauna. Thus, domestic scientists[67] claim that it is profitable not to destroy molluscs, but to collect and manufacture valuable protein and mineral feed additives for animals or to use them as food products. Moreover, the taste of grape snail meat resembles beef with mushrooms and has a high nutritional value. This idea was picked up by researchers who studied the possibility and prospects of introducing heliceculture in the natural conditions of the Odesa region[68].

The economic feasibility of creating a snail farm as an additional source of income for the hotel enterprise and craft products for the restaurant business is currently also calculated[69, 70]. However, there are almost no studies devoted to the cultivation of the slug (gastropod without a shell), whose meat and roe can also be of some value for food science, which determines the relevance of further research.

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[66] Shifting feeding behaviour of deep-sea buccinid gastropods at natural and simulated food falls / Aguzzi J., et al. *Marine Ecology Progress Series*. 2012. 458. P. 247–253.

[67] Бурлака В. А., Шевчук В. Ф., Беляєв С. М. Вирощування слимака роду Helix pomatia в умовах Полісся України. Еколого-функціональні та фауністичні аспекти досліджень молюсків, їх роль у біоіндикапії стану навколишнього середовища. *Збірник наукових праць «Волинь»*. 2004. С. 15–17.

[68] Ратушний А. Е., Вігер І. О. Можливості та перспективи впровадження геліцекультури в природних умовах південно-західної частини Одеської області. *Проблеми та перспективи розвитку освіти*, Львів. 2017. 149–152.

[69] Економічна доцільність створення равликової ферми як додаткового джерела доходу готельного підприємства / Шидловська О. Б. та ін. *Агросвіт.* 2020. № 23. С. 47–53.

[70] Паска М. З., Радзімовська О. В., Бурак М. І. Розробка нових видів делікатесних продуктів спеціального призначення. *Наукові праці Національного університету харчових технологій*. 2020. 26 (5). С. 149–155.

Ampullaria glauca, an edible water snail native to the tropical forest, which in its species, biochemical composition, nutritional and taste qualities is similar to grape one, occupies a prominent place among aquaculture objects. B. I. Gudyma thoroughly researched the meat and roe of *A. glauca* for the first time, in which he found large amounts of protein, fat, essential amino acids, complex of biologically active substances: saponins, carotenoids, glycosides, phospholipids, etc. In addition, the author proved the expediency of using both meat and roe of *A. glauca* as a dietary supplement with radioprotective properties[71].

The radioprotective properties of ampullaria meat were continued to be investigated by S. A. Krazhan and others. The authors suggested using it as a dietary supplement to replenish the body with proteins and vitamins and protect it in conditions of ionizing radiation in order to normalize metabolism[72]. A Ukrainian utility model patent protects the research results[73].

A group of scientists led by prof. Bal-Prylypko dealt with the issues of the use of delicacy meat of *A. glauca* in health nutrition and safety assessment of its caviar[74]. *A. glauca* meat and caviar has a positive effect on the state of the endocrine glands, the liver, creates favorable conditions in the body for the activation of restorative processes after ionizing radiation[75].

In our opinion, research related to the cultivation of gastropods without a shell (slugs), whose meat and roe can also be of some interest and value for food science and industry, may also be promising, which determines the relevance of further research in this context.

Gastropod molluscs, in particular *L. flavus*, are promising objects for use in human nutrition[76]. Among the reasons for such prospects, we can

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[71] Гудима Б. І. Ампулярія як новий нетрадиційний об'єкт тепловодного рибництва в Україні: автореф. дис. … канд. с.-г. наук : 06.02.03. Київ, 1999. 19 с.

[72] Радіозахисні властивості м'яса слимака *Ampullaria glauca* / С. А. Кражан, С. А. Коба, Т. В. Григоренко, Л. П. Дерев'яненко. *Наукові записки ТНПУ ім В. Гнатюка. Серія: Біологія.* 2012. № 2 (51). С. 151–154.

[73] Спосіб захисту організму від іонізуючого проміння : пат. 66516 Україна: опубл. 10.01.2012, Бюл. № 1. 3 с.

[74] Баль-Прилипко Л. Використання делікатесного м'яса ампулярій в оздоровчому харчуванні / Л. Баль-Прилипко, Л. Дерев'янко, О. Андрощук. *Продовольча індустрія АПК.* 2017. № 3. С. 13–18.

[75] Баль-Прилипко, Л. Оцінка безпечності ікри *Ampullaria glauca* для використання в оздоровчому харчуванні / Л. Баль-Прилипко, Л. Дерев'янко, О. Андрощук. *Продовольча індустрія АПК*. 2017. № 5. С. 41–44.

[76] *Limacus flavus* – перпективне джерело макронутрієнтів у дієтичному харчуванні / В. Применко, М. Головко, Т. Головко, Ю. Грищенко-Мороз. *Науково-інноваційний розвиток агровиробництва як запорука продовольчої безпеки України: вчора, сьогодні, завтра* : матеріали Всеукр. наук.-практ. конф.,

single out the high content of proteins and other useful substances, the ability to grow and reproduce quickly, as well as the technology of their cultivation and processing.

According to research, the mass cultivation of shellfish is more efficient in terms of water and energy consumption, compared to the cultivation of traditional types of meat. This reduces the amount of CO_2 emissions and other harmful substances associated with raising animals and transporting meat[77]. Gastropods do not need large food reserves. Many molluscs can live actively on small land areas or water bodies, which reduces the load on agricultural land and forest areas[78]. In addition, an important issue is the ethical aspect of growing shellfish for consumption. Compared to traditional types of slaughter animals, there is no information about the stress experienced by molluscs during their cultivation and slaughter.

From this point of view, the use of meat of gastropod molluscs in human nutrition can be a promising solution, since they do not harm the ecology and ecosystem. The main reasons for this are their very low requirements for living space and food resources, which allows them to reproduce and grow in natural conditions without significant impact on the ecosystem[79].

We conducted research on growth parameters of *L. flavus* in temperate climate latitudes of Ukraine. We associate the relevance of such a study with the change in the three main influencing factors described in work: temperature, humidity, and light period.

Fifty adults of the brown garden snail *L. flavus* were collected during October 2021 under different types of plants in the Dnipropetrovsk region. Individuals were kept in laboratory conditions at a temperature of 18,5 ± 1,7 °C and a relative humidity of 60,3 ± 5,6 % in plastic

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Київ, 20–21 жовт. 2022 р. / НААН, ННСГБ. Вінниця : ФОП Просяннікова О. М., 2022. С. 42–44.

[77] Дослідження параметрів росту *Limax Flavus* / М. П. Головко, Т. М. Головко, В. Г. Применко, Ю. М. Грищенко-Мороз. *Інноваційні технології та перспективи розвитку м'ясопереробної галузі* : тези матеріалів ІІІ Міжнар. наук.-практ. конф., 18 жовт. 2022 р., Київ. Київ : НУХТ, 2022. С. 105–106.

[78] Молюски класу *Gastropoda* як нетрадиційна м'ясна сировина / Ю. М. Грищенко-Мороз, В. Г. Применко, М. П. Головко, Т. М. Головко. *Інноваційні технології розвитку харчових і переробних виробництв та ресторанного господарства: наукові пошуки молоді* : тези доп. Всеукр. наук.-практ. конф. здобувачів вищої освіти і молодих вчених, 26 жовт. 2022 р. Харків : ДБТУ, 2022. С. 62.

[79] Молюски класу *Gastropoda*: огляд вітчизняних розробок і досліджень / В. Г. Применко, М. П. Головко, Т. М. Головко, Ю. М. Грищенко-Мороз. *Наукові проблеми харчових технологій та промислової біотехнології в контексті євроінтеграції* : тези матеріалів XI Міжнар. наук.-техн. конф., 8 лист. 2022 р., Київ. Київ : НУХТ, 2022. С. 180–181.

boxes (27×27×25) cm. Fresh lettuce (*Lactuca sativa L.*) was offered as a monosource of food, after eating which the remains were removed.

The boxes were covered with a muslin cloth secured with a rubber band to prevent the slugs from escaping. The soil in each box was re-moistened as needed twice a day and clutches were searched. The newly laid batches were left in the same box and the time of egg laying was recorded, while the adult slugs were transferred to a newly prepared box.

Juveniles (offspring) were placed separately from adults in plastic cups (10×6) cm, filled with moist clay soil with a five-centimeter layer of lettuce. Each beaker was covered with a muslin cloth with a rubber band to prevent the subjects from escaping. Fresh lettuce and moisture were added daily.

Juvenile *L. flavus* were weighed monthly from zero emergence (hatching time) to maturity using digital scales to determine their growth rate, which was calculated using the formula:

Growth rate = $(W_i – W_f) / W_f \times 100$,

where W_i and W_f are the initial and final weight of slugs at certain time intervals.

The average weight of snails and age growth rates are presented in the table.

Table 1

Weight and age growth rates of *L. flavus* ($p \leq 0.05$)

Age	Weight, g	Growth rate, %
	Average value	
Withdrawal time, month	0,053 ± 0,03	–
1st	0,36 ± 0,22	85,28 ± 12,79
2nd	1,58 ± 0,34	77,22 ± 11,58
3rd	3,69 ± 0,57	57,18 ± 14,30
4th	5,54 ± 0,72	33,39 ± 11,69
5th	6,03 ± 1,07	12,06 ± 12,46
6th	6,69 ± 0,86	5,83 ± 17,37
7th	7,32 ± 0,95	8,61 ± 19,7

The weight of the land snail *L. flavus* increased from hatching to the 7th month and reached a maximum weight of 7,32 ± 0,95 g on average with a range of 6,37 – 8,27 g. The maximum rate of weight change was recorded in the 1st month (85,28 ± 12,79 %) and was 72,49 – 98,07 %. The average monthly weight gain was within 1,05 ± 0,57 g.

A deep study of the properties of gastropod molluscs of the class *Gastropoda* will be useful in the development of new food products and dietary supplements.

Therefore, the selection of the optimal technology for the isolation of such proteins is an important research. A review of existing technologies for protein isolation of gastropod molluscs demonstrates the availability of the following methods: enzymatic hydrolysis, mechanical extraction and ultrafiltration, acid-alkaline extraction method.

Enzymatic (enzymatic) hydrolysis is based on the use of enzymes to break protein bonds to obtain protein peptides. The optimal parameters of this method consist in maintaining pH=6…8, t°=30…50 °C and the ratio of substrate to enzyme 20:1. After completion of hydrolysis, the mixture of proteins and peptides is purified using filtration and chromatography methods.

Ultrafiltration is used to obtain protein isolates from gastropods using membranes with different molecular weights compared to the molecular weight of the proteins. Usually, during ultrafiltration, the temperature is maintained from 20 to 50 °C, depending on how effectively it is necessary to isolate proteins from other components of the raw material.

The method of pH-shifting treatment consists in the use of various solutions of acids and alkalis to dissolve proteins. The optimal parameters of this method are the use of NaOH or HCl solutions with a concentration of 0.1–0.5 M at t°=20…70 °C. pH-shifting treatment is a common technology used for protein isolation from gastropods and is characterized by parameters that should be considered when optimizing the protocol for the respective mollusk or protein species (fig. 5).

The number of extractions can vary depending on the type of protein, but usually it is 1–3 repetitions.

CONCLUSIONS

Therefore, the gastropods have various uses of particularly in the food industry. Gastropods have been consumed for centuries in many cultures and are known for their unique flavor and nutritional value. The various processing techniques of *Gastropoda* usage were reviewed, including meat processing, powder and caviar productions and the use of snail slime in cosmetics. The health benefits associated with consuming gastropods were considered, including high protein and low fat content, as well as the potential medical applications of snail slime. In addition, snails are valuable sources of polyunsaturated fatty acids with broad-spectrum antimicrobial activity and inhibitory effects on human heparanase.

The conducted analysis established the possibility of reproduction, generation and weight gain of the snail *L. flavus* in laboratory conditions on a monodiet. Research on the longevity of this mollusc and alternative economically and ecologically justified sources of food for it will be promising.

Sample preparation

- The mollusk is washed, cleaned of existing substrate residues and homogenized to destroy the cellular structure and release the protein

Treatment with acid or alkali

- The sample is treated with an acid or alkali solution, depending on the nature of the protein and the desired yield.
  - concentration of buffer solutions of alkalis and acids – 0.1-0.5 M;
  - the optimal hydromodule – from 1:5 to 1:20;
  - pH value – a low pH level is created for acidic proteins (2...4), for alkaline proteins – high level (10...12);
  - temperature – 18...20°C for acidic, 60...70°C – for alkaline;
  - duration of the process – from several hours to days for acidic proteins, several hours for alkaline proteins

Centrifugation

- The pH-shifted sample is centrifuged to separate the protein extract from other components

Sedimentation

- The protein extract is precipitated with ammonium sulfate or acetone to remove impurities and concentrate the protein

Dialysis

- The protein is dialyzed to remove excess salts and buffer components from the extraction process

Fig. 5. Schematic diagram of obtaining protein isolates from the *Gastropoda* molluscs meat by the pH-shifting treatment method

In the context of the selection of methods for the concentration of *Gastropoda* proteins, the method of pH-shifting treatment allows obtaining purer protein isolates. Therefore, the use of the latter method in the isolation of protein from gastropod molluscs, in our opinion, creates prerequisites for obtaining high-quality protein isolates for the needs of the food industry and dietetics.

Overall, the study of *Gastropoda* has revealed a wealth of knowledge about the benefits of these creatures and their potential applications in various industries. Further research and exploration of *Gastropoda* are sure to yield even more benefits and innovations in the years to come.

SUMMARY

Gastropoda molluscs are promising objects for use in human nutrition. Among the reasons for such prospects, we can single out the high content of proteins and other useful substances, the ability to grow and reproduce quickly, as well as the technology of their cultivation and processing. But as a result of this study, it was established that the knowledge about gastropods of the underwater world and those with a shell is representatively covered. That is, we lack scientific information about the qualitative and quantitative characteristics of slugs. The conducted analysis established the possibility of reproduction, generation and weight gain of the snail *L. flavus* in laboratory conditions on a monodiet. The method of concentration of *Gastropoda's* proteins was selected based on pH-shifting treatment, which will allow obtaining purer protein isolates. Research on nutritional and biological values, qualitative and quantitative characteristics, longevity of this mollusc, variations of its feeding rations, etc., with the aim of creating new dietary food products will be promising.

Bibliography

1. Mollusca: Gastropoda / Dennis M. M. et al. *Invertebrate Histology*. 2021. P. 87–132. https://doi.org/10.3390/d15020219.

2. Breuste J. The Urban Nature Concept – of What Urban Green Consists of. *Making Green Cities: Concepts, Challenges and Practice*. 2023. P. 19–50. 10.1007/978-3-030-73089-5_2

3. Feeding habits and multifunctional classification of soil-associated consumers from protists to vertebrates / Potapov A. M. et al. *Biological Reviews*. 2022. 97(3). P. 1057–1117. https://doi.org/10.1111/brv.12832

4. Barua A., Williams C. D., Ross J. L. A literature review of biological and bio-rational control strategies for slugs: Current research and future prospects. *Insects*. 2021. 12(6). P. 541. https://doi.org/10.3390/insects12060541

5. O'Hanlon A., Williams C. D., Gormally M. J. Terrestrial slugs (Mollusca: *Gastropoda*) share common anti-predator defence mechanisms but their expression differs among species. *Journal of Zoology*. 2019. 307(3). P. 203–214. https://doi.org/10.1111/jzo.12635

6. Contact Efficacy of Different Wood Ashes against Spanish Slug, Arion vulgaris (*Gastropoda*: *Arionidae*) / Laznik Ž. et al. *Applied Sciences*. 2020. 10(23). P. 8564. https://doi.org/10.3390/app10238564

7. Zaidi N., Douafer L., Hamdani A. Diversity and abundance of terrestrial gastropods in Skikda region (North-East Algeria): correlation with soil physicochemical factors. *The Journal of Basic and Applied Zoology*. 2021. 82(1). P. 1–10. https://doi.org/10.1186/s41936-021-00239-6

8. Watz J., Nyqvist D. Interspecific competition among terrestrial slugs. *Journal of Molluscan Studies*. 2022. 88(2). P. eyac007. https://doi.org/10.1093/mollus/eyac007

9. Early-season plant cover supports more effective pest control than insecticide applications / Rowen E. K., et al. *Ecological Applications*. 2022. 32(5). P. e2598. https://doi.org/10.1002/eap.2598

10. Nematodes Associated with Terrestrial Slugs in Mid-Atlantic (Delaware, USA) Soybean / Kunkel B., et al. *Agronomy*. 2023. 13(3). P. 645. https://doi.org/10.3390/agronomy13030645

11. Phenotypic plasticity of the invasive apple snail, *Pomacea canaliculata*, in China: a morphological differentiation analysis / Luo M et al. *Molluscan Research*. 2022. 42(2). P. 146–157. https://doi.org/10.1080/13235818.2022.2064043

12. Structure and heparanase inhibitory activity of a new glycosaminoglycan from the slug *Limacus flavus* / He Z., et al. *Carbohydrate polymers*. 2019. 220. P. 176–184. https://doi.org/10.1016/j.carbpol.2019.05.066

13. Hayashida P. Y., da Silva Júnior P. I. *Limacus flavus* yellow slug: bioactive molecules in the mucus. *bioRxiv*. 2021-05. https://doi.org/10.1101/2021.05.06.442857

14. Potential mucosal irritation discrimination of surface disinfectants employed against SARS-CoV-2 by Limacus flavus slug mucosal irritation assay / Cutuli M.A et al. *Biomedicines*. 2021. 9. P. 424. https://doi.org/10.3390/biomedicines9040424.

15. Mohamed M. I., Reham F. A. Laboratoryobservations on biology of the tawnygarden slug *Limax flavus (Linnaeus)* (*Limacidae*:Mollusca). *Animal Biology Journal*. Vol. 4, Iss. 1. P. 51–62.

16. Davidson D. H. Assimilation Effieiencies of Slugs on Different Food Materials. *Oecologia* (Berl.). 1976. 26. P. 267–273.

17. İhsan Ekin, Ridvan Şeşen. Investigation of the fatty acid contents of edible snails *H. lucorum, E. vermiculata* and non-edible slug *L. flavus*. *Rec. Nat. Prod*. 2017. 11:6. P. 562–567.

18. Slug species-and population-specific effects on the end points of the Slug Mucosal Irritation test / Dhondt M. M., et al. *Toxicology in vitro*. 2006. 20(4). P. 448–457. https://doi.org/10.1016/j.tiv.2005.09.002

19. Oligosaccharides from fucosylated glycosaminoglycan prevent breast cancer metastasis in mice by inhibiting heparanase activity and angiogenesis / Zhou, L., et al. *Pharmacological Research*. 2021. 166. P. 105527. https://doi.org/10.1016/j.phrs.2021.105527

20. Chemical composition of the flesh and mucus of land snail species (*Archachatina marginata* (Swainson), *Archachatina marginata* (Suturalis),

Achatina fulica, Achatina iostoma, Limicolaria spp) in Gabon: Case of the Haut-Ogooué Province / Tovignon G. C. Z., et al. *Journal of Applied Biosciences*. 2021. 167(1). P. 17391–17405. https://doi.org/10.35759/JABs.167.9

21. Diversity and distribution of air-breathing sea slug genus *Peronia Fleming*, 1822 (*Gastropoda*: *Onchidiidae*) in southern Japanese waters / Mizukami I., et al. *PeerJ*. 2022. 10. P. e13720. https://doi.org/10.7717/peerj.13720

22. Ovissipour M., Rasco B., Bledsoe G. Aquatic food products. *Food Processing: Principles and Applications*. 2014. P. 501–534. https://doi.org/10.1002/9781118846315.ch22

23. Dourson D. C. The feeding behavior and diet of an endemic West Virginia land snail, *Triodopsis platysayoides*. *American Malacological Bulletin.* 2008. 26(1/2). P. 153–159. https://doi.org/10.4003/006.026.0215

24. Toxic and potentially toxic mineral elements of edible gastropods land snails (*Mediterranean Escargot*) / Tardugno R., et al. *Toxics.* 2023. 11. P. 317. https://doi.org/10.3390/toxics11040317

25. Cobbinah J. R., Vink A., Onwuka B. Snail farming: production, processing and marketing. Agromisa/CTA. 2008.

26. Nutritional and toxicity profiles of two species of land snail, Theba pisana and Otala lactea, from Morocco / Caetano D., et al. *Journal of Food Composition and Analysis.* 2021. Vol. 100. P. 103893. https://doi.org/10.1016/j.jfca.2021.103893.

27. Toxic Elements and Mineral Content of Different Tissues of Endemic Edible Snails (*Helix vladika* and *H. secernenda*) of Montenegro / Vukašinović-Pešić V. et al. *Foods*. 2020. 9. P. 731. https://doi.org/10.3390/foods9060731

28. A Survey Study on Parasite Presence of Edible Wild Terrestrial Snails (*Helix pomatia L.*) in Northern Cyprus / Yildirim F. K., et al. *Heat Treatment.* 5. P. 12.

29. Processing and utilization of snail meat in alleviating protein malnutrition in Africa: a review / Adeyeye S. A.O., et al. *Nutrition & Food Science*. 2020. Vol. 50, No. 6. P. 1085–1097. https://doi.org/10.1108/NFS-08-2019–0261.

30. Dallinger R., Berger B., Bauer-Hilty A. Purification of cadmium-binding proteins from related species of terrestrial helicidae (*Gastropoda*, Mollusca): a comparative study. *Molecular and Cellular Biochemistry*. 1989. 85. P. 135–145. https://doi.org/10.1007/BF00577109

31. Investigation of nutritional properties of three species of marine turban snails for human consumption / Ab Lah R., et al. *Food Science & Nutrition*. 2017. 5(1). P. 14–30. https://doi.org/10.1002/fsn3.360

32. Odeleye T., White W. L., Lu J. Extraction techniques and potential health benefits of bioactive compounds from marine molluscs: A review. *Food & function*. 2019. 10(5). P. 2278–2289. https://doi.org/10.1039/C9FO00172G

33. An outbreak of tetrodotoxin poisoning following gastropod mollusc consumption / Yang C. C., et al. *Human & experimental toxicology*. 1995. 14(5). P. 446–450.

34. Periyasamy N., Arularasan S., Gayathri S. Antibacterial activity of the tissue extracts of Conus betulinus and Conus inscriptus Linnaeus, 1758 (Mollusca: *Gastropoda*) from Nagapattinam, Southeast coast of India. *Asian Pacific Journal of Tropical Disease*. 2012. 2. P. S914-S919. https://doi.org/10.1016/S2222-1808(12)60291-6

35. Tetrodotoxin in marine bivalves and edible gastropods: A mini-review. Biessy L., et al. *Chemosphere*. 2019. 236. P. 124404. https://doi.org/10.1016/j.chemosphere.2019.124404

36. Fang Z. Q., Cheung R. Y. H., Wong M. H. Heavy metal concentrations in edible bivalves and gastropods available in major markets of the Pearl River Delta. *Journal of Environmental Sciences*. 2001. 13(2). P. 210–217.

37. Bryan G. W., Potts G. W., Forster G. R. Heavy metals in the gastropod mollusc *Haliotis tuberculata* (L.). *Journal of the Marine Biological Association of the United Kingdom*. 1977. 57(2). P. 379–390. https://doi.org/10.1017/S0025315400021822

38. Diversity of edible mollusc (Gastropoda and Bivalvia) at selected divison of Sarawak, Malaysia / Hamli H., et al. *International Journal on Advanced Science, Engineering and Information Technology*. 2012. 2(4). P. 5–7.

39. Barker G. M., McGhie R. A. The biology of introduced slugs (*Pulmonata*) in New Zealand 1. Introduction and notes on *Limax maximus*. *New Zealand Entomologist.* 1984. 8. P. 106–111. https://doi.org/10.1080/00779962.1984.9722482

40. Growth and reproduction of the slug *Limax valentianus* Férussac in experimental conditions / Hommay G., et al. *J. Moll. Stud.* 2001. 67. P. 191–207. https://doi.org/10.1093/mollus/67.2.191

41. Growth and reproduction of the slug *Deroceras laeve* (Müller) (Pulmonata: Stylommatophora) under controlled conditions / Faberi A. J., et al. *Spanish Journal of Agricultural Research*. 2006. 4(4). P. 345–350.

42. Mohamed M. I., Ali R. F. Laboratory Observations on Biology of the Tawny Garden Slug *Limax flavus* (Linnaeus) (Limacidae: Mollusca). *Animal Biology Journal*. 2013. 4(1). P. 51.

43. Effect of different processing methods on the proximate composition, mineral content and functional properties of snail (*Archachatina marginata*) meat / Djikeng F. T., et al. *Journal of Agriculture and Food Research*. 2022. 8. P. 100298. https://doi.org/10.1016/j.jafr.2022.100298

44. Is the consumption of snail meat actually healthy? An analysis of the osteotropic influence of snail meat as a sole source of protein in growing rats / Radzki R. P., et al. *Journal of animal physiology and animal nutrition*. 2018. 102(2). P. e885-e891. https://doi.org/10.1111/jpn.12851

45. Structural characteristics and physicochemical properties of freeze-dried snail meat / Pissia M. A., et al. *LWT*. 2022. 155. P. 112980. https://doi.org/10.1016/j.lwt.2021.112980

46. Efficacy of compositing with snail meat powder on protein nutritional quality of sorghum–wheat buns using a rat bioassay / Agengo F. B., et al. *Journal of the Science of Food and Agriculture*. 2020. 100(7). P. 2963–2970. https://doi.org/10.1002/jsfa.10324

47. Touring Club of Italy. *The Italian food guide: The ultimate guide to the regional foods of Italy*. Touring Editore. 2002.

48. Biocrystal assembly patterns, biopolymer distribution and material property relationships in mytilus galloprovincialis, Bivalvia, and haliotis glabra, *Gastropoda*, shells / Peter N. J., et al. *Materialia*. 2023. 28. P. 101749. https://doi.org/10.1016/j.mtla.2023.101749

49. Bondarev I. P. Ecomorphological analyses of marine mollusks' shell thickness of Rapana venosa (Valenciennes, 1846) (*Gastropoda*: Muricidae). *International Journal of Marine Science*. 2013. 3(45). 10.5376/ijms.2013.03.0045

50. Bioactive snail mucus-slime extract loaded chitosan scaffolds for hard tissue regeneration: the effect of mucoadhesive and antibacterial extracts on physical characteristics and bioactivity of chitosan matrix / Perpelek M., et al. *Biomedical Materials*. 2021. 16(6). P. 065008. 10.1088/1748-605X/ac2352

51. Fabrication of Helix aspersa Extract Loaded Gradient Scaffold with an Integrated Architecture for Osteochondral Tissue Regeneration: Morphology, Structure, and In Vitro Bioactivity / Tamburaci S., et al. *ACS Applied Bio Materials*. 2023. https://doi.org/10.1021/acsabm.2c01050

52. Maćkowiak-Dryka M., Szkucik, K., Pyz-Łukasik R. Snail eggs as a raw material for the production of a caviar substitute. *Journal of veterinary research*. 2020. 64(4). P. 543–547. https://doi.org/10.2478/jvetres-2020-0062

53. Occurrence of biologically inactive corrinoid compounds in canned edible apple snails / Teng F., et al. *Food and Nutrition Sciences*. 2015. 6(12). P. 1071. 10.4236/fns.2015.612111

54. Snail slime-based gold nanoparticles: An interesting potential ingredient in cosmetics as an antioxidant, sunscreen, and tyrosinase inhibitor / Rizzi V., et al. *Journal of Photochemistry and Photobiology B: Biology*. 2021. 224. P. 112309. https://doi.org/10.1016/j.jphotobiol.2021.112309

55. Ekin İ., Şeşen R. Molluscs: their usage as nutrition, medicine, aphrodisiac, cosmetic, jewelry, cowry, pearl, accessory and so on from the history. *Middle East Journal of Science*. 2018. 4(1). P. 45–51. https://doi.org/10.23884/mejs.2018.4.1.06

56. Fishhooks, lures, and sinkers: intensive manufacture of marine technology from the terminal Pleistocene at Makpan Cave, Alor Island, Indonesia / Langley M. C., et al. *The Journal of Island and Coastal Archaeology*. 2023. 18(1). P. 33–52. https://doi.org/10.1080/15564894.2020.1868631

57. Udoh J. P., Abiaobo N. O. Condition index, meat yield and population structure of the marine gastropod, Thais coronata, off Cross River Estuary, Nigeria. *Adv. Life Sci. Technol*. 2014. 23. P. 24–32.

58. Snail farming as an alternative profitable livestock system for sustainable development / Meyo E. S. M., et al. *Sustainable development in Africa. Fostering sustainability in one of the world's most promising continents. Cham: Springer*. 2021. P. 477–490.

59. Joshi N., Pandey S. Meat demand-snailed it: A comprehensive review on snail rearing, to meet the meat demand in future India. *J. Entomol. Zool. Stud*. 2019. 7. P. 396–400.

60. Biochemical composition and antioxidant activity of Pleuroploca trapezium meat / Prem Anand T., et al. *J Chem Pharmaceut Res*. 2010. 2. P.526–535.

61. Recieps for the Mesogastropod-Strombus canarium / Arularasan S., et al. *Advance Journal of Food Science and Technology*. 2010. 2(1). P. 31–35.

62. Massari S., Pastore S. Heliciculture and snail caviar: new trends in the food sector. *Monograph: Future trends and challenges in the food sector. Polish Society of Commodity Science*, Cracow. 2014. P. 79–90.

63. Microbiological assessment of land snail's caviar produced in sicily, southern italy: a first report Microbial Diversity 2019 / Sciortino S., et al. In *Microbial Diversity as a source of novelty: function, adaptation and exploitation*. 2019. Vol. 5. P. 344–345. https://hdl.handle.net/11380/1182097

64. Pissia M. A., Matsakidou A., Kiosseoglou V. Raw materials from snails for food preparation. *Future Foods.* 2021. 3. P. 100034. https://doi.org/10.1016/j.fufo.2021.100034

65. Raynova Y., Doumanova L., Idakieva K. N. Phenoloxidase activity of *Helix aspersa maxima* (garden snail, *Gastropod*) hemocyanin. *The Protein Journal*. 2013. 32. P. 609–618. https://doi.org/10.1007/s10930-013-9523-0

66. Shifting feeding behaviour of deep-sea buccinid gastropods at natural and simulated food falls / Aguzzi J., et al. *Marine Ecology Progress Series*. 2012. 458. P. 247–253. https://doi.org/10.3354/meps09758

67. Бурлака В. А., Шевчук В. Ф., Беляєв С. М. Вирощування слимака роду Helix pomatia в умовах Полісся України. Еколого-функціональні та фауністичні аспекти досліджень молюсків, їх роль у біоіндикапії стану навколишнього середовища. *Збірник наукових праць «Волинь»*. 2004. С. 15–17.

68. Ратушний А. Е., Вігер І. О. Можливості та перспективи впровадження геліцекультури в природних умовах південно-західної частини Одеської області. / А. Е. Ратушний, І. О. Вігер. *Проблеми та перспективи розвитку освіти*, м. Львів, 30–31 березня 2017 р. Львів, 2017. С. 149–152.

69. Економічна доцільність створення равликової ферми як додаткового джерела доходу готельного підприємства / Шидловська О. Б. та ін. *Агросвіт.* 2020. № 23. С. 47–53. https://doi.org/10.32702/2306-6792. 2020.23.47

70. Паска М. З., Радзімовська О. В., Бурак М. І. Розробка нових видів делікатесних продуктів спеціального призначення. *Наукові праці Національного університету харчових технологій*. 2020. 26(5). С. 149–155. 10.24263/2225-2924-2020-26-5-19

71. Гудима Б. І. Ампулярія як новий нетрадиційний об’єкт тепловодного рибництва в Україні : автореф. дис. … канд. с.-г. наук : 06.02.03. Київ, 1999. 19 с.

72. Радіозахисні властивості м’яса слимака *Ampullaria glauca* / С. А. Кражан, С. А. Коба, Т. В. Григоренко, Л. П. Дерев’яненко. *Наукові записки ТНПУ ім В. Гнатюка. Серія: Біологія*. 2012. № 2(51). С. 151–154.

73. Спосіб захисту організму від іонізуючого проміння: пат. 66516 Україна: МПК(2011.01) A01K 61/00. № u201106940 ; заявл. 02.06.2011 ; опубл. 10.01.2012, Бюл. № 1. 3 с.

74. Баль-Прилипко Л. Використання делікатесного м’яса ампулярій в оздоровчому харчуванні / Л. Баль-Прилипко, Л. Дерев’янко, О. Андрощук. *Продовольча індустрія АПК*. 2017. № 3. С. 13–18.

75. Баль-Прилипко, Л. Оцінка безпечності ікри *Ampullaria glauca* для використання в оздоровчому харчуванні / Л. Баль-Прилипко,

Л. Дерев'янко, О. Андрощук. Продовольча індустрія АПК. 2017. № 5. С. 41–44.

76. *Limacus flavus* – перпективне джерело макронутрієнтів у дієтичному харчуванні / В. Применко, М. Головко, Т. Головко, Ю. Грищенко-Мороз. Науково-інноваційний розвиток агровиробництва як запорука продовольчої безпеки України: вчора, сьогодні, завтра : матеріали Всеукр. наук.-практ. конф., Київ, 20–21 жовт. 2022 р. / НААН, ННСГБ. Вінниця, ФОП Просяннікова О. М., 2022. С. 42–44.

77. Дослідження параметрів росту *Limax Flavus* / М. П. Головко, Т. М. Головко, В. Г. Применко, Ю. М. Грищенко-Мороз. Інноваційні технології та перспективи розвитку м'ясопереробної галузі : тези матеріалів III Міжнар. наук.-практ. конф., 18 жовт. 2022 р., Київ. Київ : НУХТ, 2022. С. 105–106.

78. Молюски класу *Gastropoda* як нетрадиційна м'ясна сировина / Ю. М. Грищенко-Мороз, В. Г. Применко, М. П. Головко, Т. М. Головко. *Інноваційні технології розвитку харчових і переробних виробництв та ресторанного господарства : наукові пошуки молоді* : тези доп. Всеукр. наук.-практ. конф. здобувачів вищої освіти і молодих вчених, 26 жовт. 2022 р. Харків : ДБТУ, 2022. С. 62.

79. Молюски класу *Gastropoda*: огляд вітчизняних розробок і досліджень / В. Г. Применко, М. П. Головко, Т. М. Головко, Ю. М. Грищенко-Мороз. *Наукові проблеми харчових технологій та промислової біотехнології в контексті євроінтеграції* : тези матеріалів XI Міжнар. наук.-техн. конф., 8 лист. 2022 р., Київ. Київ : НУХТ, 2022. С. 180–181.

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