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Health and sustainability: The nutritional value of snail meat

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ABSTRACT

The increasing popularity of snail meat prompts research of the nutritional benefits of consuming *Helix aspersa maxima* cultivated in Bulgaria. With a high protein content and remarkably low fat content, snail meat is well-suited for the inclusion in healthy culinary recipes. Daily consumption of snails meat, which is notably rich in iron, manganese, phosphorus, calcium, and magnesium, proves to be a valuable source of essential minerals. The fatty acid profile of *Helix aspersa maxima* is characterized by the diverse range of polyunsaturated fatty acids, with linoleic acid and arachidonic acid being the most abundant. The amino acid profile of the snail meat is characterized by significant levels of essential amino acids, with leucine, lysine and threonine contributing to protein synthesis, immune function, and tissue repair, respectively. The presence of large quantities of flavour-enhancing amino acids, such as glutamic acid and aspartic acid along with glycine, arginine, and proline, suggests a rich umami taste and supports collagen formation, and structural integrity.

KEYWORDS

snail meat; proximate composition; mineral content; fatty acids; amino acids

KEY CONTRIBUTION

High protein content – 14.6%, combined with very low-fat percentage – 1.40%.
Abundant essential minerals, with very levels of Ca and P.
High concentrations of glutamic and aspartic acids contribute to its umami taste.
Snail meat exhibits a fatty acid profile comparable to the one of salmon.

Introduction

Snail consumption has been controversial throughout human history. Over the centuries, lands snails have played an important role in numerous societies. Some regarded them as an attractive food source, while others considered snails inedible. An abundance of land snail shells has been found in hundreds of archaeological sites in the Mediterranean, spanning from Algeria and Tunisia through the Pyrenees, Italy, Southern France, Southeastern Europe, Cyprus, Crete, to Ukraine (Fernandez-Lopez de Pablo et al., 2014). Anthropologist David Lubbel hypothesized that changes in natural conditions in the Mediterranean region created favourable conditions for the development of land snail population. He related his findings to Fernández-Armesto's theory that snails were the first animal species to be systematically cultivated as a food source (Lubbel, 2004).

Over time, certain snail species became preferred for consumption and were specially cultivated in Mediterranean cultures. Hunting, farming, and preparation methods evolved based on each community's cultural, social, and economic needs (Duhart, 2009). Ancient Greeks and Romans collected snails for food and medicinal purposes, with early records from Aristotle and Pliny the Elder describing snail anatomy, behaviour, and culinary uses (4th century BCE, 1st century BCE). In Ancient Rome, snails were raised in enclosed areas called cochlearia and recipes with sauces like *garum* were documented.

In medieval Europe, snails were a protein source, especially for lower classes, with notable records from Albertus Magnus in the 12th century (Lušnic Polak et al., 2023). During the Renaissance, snails became gourmet items in Italy and France, with advanced recipes like *Escargot de Bourgogne* gaining popularity. Snail markets, especially in France, supported a thriving industry, and snails were widely consumed across Europe, with local recipe variations like Spain's *caracoles* and Germany's snail dishes with bacon and cream (Davidson, 2014). In the 19th century, snail consumption declined as other protein sources spread, but snails remained important in some regions, especially during religious fasting periods due to their classification as fish, making them acceptable for consumption (Rust, 1917).

Land snails are a specialized food item that has been highly valued in many countries, particularly Mediterranean nations, Thailand, China, Taiwan and Central Africa (Nontasan et al., 2023). These mainly herbivorous species have high economic value and are considered a luxury food (Çağıltay et al., 2011). Although their nutritional composition is not widely documented, snail meat is rich in essential amino acids, proteins, vitamins, and minerals, making it a healthy choice (Adegoke et al., 2010). Recently, there has been an increasing interest in the culinary potential and nutritional benefits of snails. This is driven by the demand for novel, sustainable food sources and the appeal of exotic, high-quality ingredients. Snails are also noted for their low environmental impact compared to conventional livestock, positioning them as a viable option for sustainable food production (Baghele et al., 2022).

In Bulgaria, the cultivation and consumption of snails have evolved into a tourist attraction in the resort villages along the Black Sea (Europages, 2024). This study set out to assess *Helix aspersa maxima*'s nutritional qualities and show that the consumption of snail meat not only contributes to a well-balanced diet, but also offers a sustainable and eco-friendly alternative protein source. Traditional and innovative methods of cooking with snail meat open new possibilities for creating diverse dishes. These practices address not only dietary needs but also contribute to environmental considerations in modern cuisine.

Materials and methods

Samples

Snail meat from *Helix aspersa maxima*, belonging to the *Gastropoda* class, was purchased for analysis. The specimen, totalling 300 from the same batch, with individual weights of 6.09 ± 0.50 g (regardless of gender), were procured from the snail farm Eco-Telus in Balgarevo village, Kavarna municipality, Bulgaria. These snails were raised through semi-intensive farming and fed certified fodder. The free-range pen was utilized for the growth and fattening of adult snails. After the collection, live adults were euthanized in an autoclave (AES-75, RAYPA, Barcelona, Spain) at 90 °C for 10 minutes. The snail meat (the foot) was separated from the shell and the rest of the body, frozen in blast chiller (Fagor Advance AB-05, Fagor Industrial, Oñati, Spain) at -24 °C, and then stored and transported at -18 °C.

Moisture and protein content

The moisture and protein contents of both fresh and freeze-dried snail samples were determined following standard AOAC procedures (AOAC, 2012). Moisture content was determined by drying at 105 °C, and the weight loss during drying was used to calculate the moisture content in snail samples, presented as a percentage of fresh matter. Protein content was determined using the Kjeldahl method with a nitrogen-to-protein conversion factor of 6.25.

Amino acid profile analysis

The amino acid composition of snail meat samples was analysed using an automatic amino acid analyser. Snail samples were hydrolysed at 110 °C for 24 hours with 6 M HCl containing 0.5% 2-mercaptoethanol. The residual amount was then redissolved with 0.02 M HCl, passed through a 0.45 µm syringe filter, and analysed for amino acid composition. The composition was determined by comparing retention times and peak areas with standards and expressed as mg/g of fresh meat and mg/g of protein. The amino acid score was calculated as a percentage of adequacy based on the reference amino acid pattern.

Fatty acid composition analysis

Prior to analysis, the fatty acids in the sample were converted to their methyl esters. The methylated fatty acid sample was injected into a 7890A gas chromatograph (Agilent Technologies Inc., Santa Clara, San Francisco, CA, USA) interfaced with a 5975C mass selective detector (MSD). The separation of compounds was carried out on an HP-5 ms silica fused capillary column (30 m length × 0.32 mm i.d. × 0.25 µm film thickness). The oven temperature program began at 60 °C, held for 3 minutes, then increased at a rate of 5 °C/min to 280 °C, where it was held for 5 minutes. Helium was used as the carrier gas at a constant flow rate of 1.0 mL/min. The MSD was operated in the full-scan mode. Fatty acid composition was calculated as normalized area percentages of total fatty acids.

Mineral content

Each milled snail sample was mixed with 10 mL of 65% nitric acid (HNO_3) and left in a fume chamber overnight. The flasks were then heated until nitrogen dioxide (NO_2) fumes dissipated. After cooling, 4 mL of 70% perchloric acid ($HClO_4$) was added, and the solution was heated to dryness. Each digested sample was diluted to 50 mL, and absorbance was measured on an atomic absorption spectrophotometer (Spektra AA 220 by Varian, Australia).

Phosphorus was determined using a spectrophotometric method. Two grams of sample were dry-ashed, and 5 mL of 5 M H_2SO_4 and 5 mL of 4% sodium molybdate solution were added in a 100 mL flask, followed by 4 mL of 2% ascorbic acid. The mixture was heated until a deep blue colour developed, then diluted to 100 mL with deionized water. Absorbance was measured at 655 nm using an atomic absorption spectrophotometer (Spektra AA 220 by Varian, Australia).

Results and discussion

Proximate composition

Moisture content is one of the main factors that define the sensory evaluation of any food product. The amount of water indicates texture, tenderness, and juiciness (Brewer and Novakofski, 2008). According to the results of our study, *Helix aspersa maxima* consists of 80.2% water, 14.6% protein and 1.40% fat. These results correspond to a few analyses of the proximate composition of different species in the *Helix genus*. As it can be seen in Table 1, in a study, Milinsk et al. (2003) investigated the effect of different feeds on the proximate composition of *Helix aspersa maxima*. Their analysis showed stable moisture levels of 77.47% - 79.85%, but protein (9.50% - 12.56%) and fat (0.45% - 2.66%) were more influenced by the type of fodder.

Özoğul et al. (2005) reported similar values for wild *Helix pomatia* gathered in South Turkey. The research conducted in Morocco by Aouji et al. in 2023, registered the highest fat content in the *Helix genus* – 2.55%. On the other end of this scale are the results achieved by Paisantanakij et al. (2018). Their proximate analysis of the land snail species *Cyclophorus haughtoni* found a fat percentage of 0.38% and higher levels of protein – 14.07%. A similar analysis of another species from the *Cyclophorus genus* - *Cyclophorus Saturnus*, showed values very close to those of the *Helix genus* (Nontasan et al., 2023).

The proximate composition of African snails slightly differs from that of *Helix aspersa maxima*. The analysis of one of the most consumed species, *Archachatina marginata*, shows a moisture content of 79.48%, fat 0.70%, but high protein - 16.82% (Okonkwo and Anyaene, 2009). The values for *Archachatina achatina* show even higher protein (20.03%) and fat content (3.85%) (Nnamonu et al., 2021).

Table 1. Proximate composition of *Helix aspersa maxima* compared to other edible land snails

Species	Origin	Moisture content, %	Protein fresh sample, %	Fat, %	Reference
H. Aspersa Maxima	Bulgaria	80.2 ± 0.10	14.6 ± 0.20	1.40 ± 0.20	Present study
*H. Aspersa Maxima**	Brazil	78.41 - 79.85	9.50 - 12.56	0.63 - 2.66	Milinsk et al., 2006
Helix Pomatia	Turkiye	80.8 ± 0.87	16.35 ± 0.67	0.41 ± 0.02	Özogul et al., 2005
Helix Aspersa	Turkiye	82.50 ± 0.23	12.87 ± 0.13	0.58 ± 0.03	Çağıltay et al., 2011
Helix Aspersa Müller	Morocco	84.24 ± 1.21	10.33 ± 0.21	2.55	Aouji et al., 2023
Cyclophorus saturnus	Thailand	80.04	11.88	0.93	Nontasan et al., 2023
Cyclophorus haughtoni	Thailand	81.85	14.07	0.38	Paisantanakij et al., 2018
Archachatina Marginata	Nigeria	79.48 ± 2.50	16.82 ± 0.81	0.70 ± 0.11	Okonkwo and Anyaene 2009
Archachatina Achatina	Nigeria	73.72 ± 3.28	20.03 ± 3.50	3.85 ± 1.09	Nnamonu et al., 2021

*Values vary depending on the different feed content

The water content, substantial protein level, and diminished fat content observed in the snails from this study render them suitable for incorporation into nutritious culinary preparations.

Mineral content

Helix aspersa is known to be an excellent heavy metal bioaccumulator, even utilized as an ecological monitor. The snail's accumulation levels are dependent on the soil's mineral content and the specifics of the plants they consume. This process can be regulated through careful selection of the farming site, soil testing, and filtering the plants used for feed (Toader-Williams and Golubkina, 2009).

The mineral analysis of *Helix aspersa* maxima meat reveals a rich nutritional composition, with notably high concentrations of phosphorus (5812.6 mg/kg) and calcium (8277.2 mg/kg), essential for bone health (Serna and Bergwitz, 2020). Significant levels of potassium (3028.9 mg/kg) and sodium (4223.1 mg/kg) contribute to electrolyte balance, while iron and concentrations support blood function

and metabolic processes (Lieu et al., 2001; Metheny, 2012). The presence of zinc (26.8 mg/kg), magnesium (1645.8 mg/kg), manganese, boron, and selenium (1.92 mg/kg) add to the diverse mineral profile, indicating potential contributions to immune function, muscle and nerve health, bone formation, and antioxidant activity (Nielsen, 2020; Wangkahart et al., 2022; Guzmán et al., 2023).
The results align with similar research on other land snail species. Calcium, followed by potassium, was determined as the most abundant minerals in *Helix aspersa*, *Helix pomatia*, and *Cyclophorus Saturnus* (Çağıltay et al., 2011; Nontasan et al., 2023; Özogul et al., 2005).

Table 2. Mineral content of *Helix aspersa maxima* compared to the adequate intake, determined by European Food Safety Authority (EFSA, 2020)

	EFSA approved mg/ day		*Helix aspersa maxima*
	min	max	mg/100 g
Cu	1.60		4.35 ± 0.01
Fe	6.00	11.00	4.42 ± 0.04
Mn	3.00		1.06 ± 0.01
P	550.00		581.26 ± 1.08
Ca	750.00	950.00	827.72 ± 5.00
Mg	350.00		164.58 ± 2.02
K	3500.00		302.89 ± 3.44
Se	0.07		0.192 ± 0.001
Na	2000.00		422.31 ± 0.15

The values demonstrate that optimal daily consumption of snail meat offers a valuable source of essential minerals, compared to the adequate intake determined by the European Food Safety Authority. To fulfil daily needs for iron, manganese, phosphorus, calcium, and magnesium, an intake in the range of 90 g to 280 g of snail meat will suffice (EFSA, 2020).

Amino acids profile

The amino acid profile of *Helix aspersa maxima* reveals a diverse composition which is important for various biological functions. Among the essential amino acids, leucine holds a significant presence at 7.35% of the total protein, contributing to protein synthesis and muscle health (Casperson et al., 2012). Additionally, lysine at 6.63% and threonine at 6.12% play crucial roles in tissue repair and immune function.
Alanine, a non-essential amino acid, is notably abundant at 8%, promoting glucose production and energy metabolism (Wu, 2009).
Interestingly, the results show a relatively high concentration of flavour-enhancing amino acids, particularly glutamic and aspartic 12.82% and 16.25%, respectively, which contribute to their umami taste (Ninomiya, 2015).
The relatively high levels of glycine (7.57%), arginine (7.57%), and proline (2.8%) contribute to collagen formation, wound healing, and overall structural integrity (Arribas-López et al., 2021). Serine (3.35%) and tyrosine (4.32%) also play roles in protein synthesis and neurotransmitter production (Wu, 2009).
Helix aspersa maxima, demonstrates a distinctive amino acid profile in comparison to beef, pork, and soybean.

Table 3. Amino acid profile of snails in comparison to beef, pork, and soybean

Amino Acid	% of total amino acids			
	Helix aspersa maxima	Beef	Slow-growing chicken thigh	Soybean
Histidine	2.08 ± 0.02	3.06	3.22	3.18
Isoleucine	4.53 ± 0.01	5.38	5.11	3.04
Leucine	7.35 ± 0.02	8.86	8.38	7.40
Lysine	6.63 ± 0.07	8.86	9.71	5.88
Phenylalanine	4.54 ± 0.20	4.22	4.29	4.97
Threonine	6.12 ± 0.04	4.22	4.55	4.05
Valine	5.05 ± 0.02	6.01	5.01	3.14
Tryptophan	-	1.16	-	-
Methionine	-	2.43	1.99	1.23
Alanine	8.00 ± 0.04	6.75	5.88	4.74
Aspartic	12.82 ± 0.10	9.28	9.46	13.08
Glutamic	17.29 ± 0.18	15.19	15.75	19.97
Glycine	7.57 ± 0.02	3.06	4.86	4.55
Arginine	7.57 ± 0.17	6.96	7.92	8.11
Cysteine	-	1.48	1.07	1.27
Proline	2.80 ± 0.14	5.70	4.29	5.88
Serine	3.35 ± 0.14	4.01	4.86	5.67
Tyrosine	4.32 ± 0.02	3.38	3.63	3.84
		Mazhangara et al., 2019	Dalle Zotte et al., 2020	Serreti et al., 1994

Fatty acids profile

The fatty acid profile of *Helix aspersa maxima* includes three main types: saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA). More than half of the registered fatty acids are PUFA – 51.05%.

The polyunsaturated fatty acids in *Helix aspersa maxima* are notably diverse, with linoleic acid (C18:2) being the most abundant at 18.82%, followed by arachidonic acid (C20:4) at 14.67%, which both belong to the omega-6 family.

Among the saturated fatty acids, palmitic acid (C16:0) constitutes the highest percentage at 14.75%, followed by stearic acid (C18:0) at 12.31%, and arachidic acid (C20:0) at 2.34%. The total saturated fatty acids account for 29.40% of the overall composition. In terms of monounsaturated fatty acids, oleic acid (C18:1) is predominant, comprising 15.35% of the total fatty acids.

These findings agree with the fatty acids profile of *Cyclophorus saturnus*. Nontasan et al. (2023) determined ratio of PUFA/SFA/MUFA of 50.49%/32.31%/17.20%. Similar results were achieved by Szkucik et al. (2018) when they analysed the composition of *Helix pomatia* and *Helix aspersa aspersa*. In the study of the diet of the land snail, Milinsk et al. (2003) proved that the levels of SFA can be even more reduced in favour of MUFA, if the *Helix aspersa maxima* is submitted to enriched feedings.

Table 4. Fatty acid composition and concentration obtained from the edible part of *Helix aspersa maxima*

Fatty acids	% of total fatty acids
Palmitic acid (C16:0)	14.75 ± 0.38
Stearic acid (C18:0)	12.31 ± 0.03
Arachidic acid (C20:0)	2.34 ± 0.15
Total saturated fatty acids	**29.40**
Oleic acid (C18:1)	15.35 ± 0.26
Total monounsaturated fatty acids	**15.35**
Linoleic acid (C18:2)	18.82 ± 0.09
Linolenic acid (C18:3)	5.48 ± 0.38
Eicosadienoic acid (C20:2)	6.03 ± 0.05
Eicosatrienoic acid (C20:3)	3.52 ± 0.28
Arachidonic acid (C20:4)	14.67 ± 0.24
Eicosapentaenoic acid (C20:5)	2.52 ± 0.09
Total polyunsaturated fatty acids	**51.05**

Table 5. Comparative analysis of the fatty acid profiles in the meat of snails, pork, beef, chicken, and salmon

	Helix aspersa maxima	Pork *Longissimus thoracis*	Beef *Biceps femoris*	Dark chicken thigh	Salmon
PUFA	51.05	10.81	4.19	31.30	41.00
MUFA	15.35	51.10	21.26	42.35	33.40
SFA	29.40	38.08	74.55	36.35	25.60
	This study	Kasprzyk et al., 2015	Almeida et al., 2006		Blanchet et al. 2005

SFA have been associated with the increased risk of cardiovascular diseases as they can raise levels of LDL cholesterol. Consuming high amounts of SFA may contribute to atherosclerosis and heart disease. On the other hand, MUFA and PUFA offer cardiovascular benefits. MUFA can help improve cholesterol levels, while PUFA, such as omega-3 and omega-6 fatty acids are known for their anti-inflammatory properties and positive impact on heart health (Calder, 2015). The values show that the meat of *Helix aspersa maxima*, and land snails in total, stands out for its exceptionally high PUFA content (51.05%), indicating it to be a valuable source of essential fatty acids. While the MUFA content in snail meat (15.35%) is relatively moderate compared to pork and dark chicken thigh, it still contributes to the overall heart-healthy fat composition. The snail meat has a lower SFA content (29.40%) compared to beef and even pork and chicken, closer to salmon. These values suggest that snail meat may be a favourable choice for individuals looking to reduce their saturated fat intake

Conclusions

This research indicates that the meat of *Helix aspersa maxima* shares comparable levels of proteins, amino acids, minerals, and fatty acids with other popular protein sources, making it a valuable food source for fulfilling daily nutritional requirements. Its high protein content and low-fat percentage result in fewer calories. The snail meat is rich in essential minerals and has a favourable fatty acid profile with high levels of unsaturated fats and low levels of saturated fats. Bulgaria stands to gain economic benefits from snail cultivation, especially considering dwindling natural stocks worldwide. Further research is required to determine the optimal thermal processing of snail meat to enhance flavour and extend shelf life safely.

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