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Arachnids, myriapods, amphibians, and molluscs – edible species, nutritional value, and safety concerns

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Abstract

Like insects, arachnids and myriapods have a long history of traditional consumption in many regions of the world. This review presents a comprehensive list of edible arachnids, myriapods, amphibians, and mollusks, along with available information on their nutritional value and food safety. Besides their medicinal properties, arachnids and myriapods are also nutritionally valuable and may contribute to addressing malnutrition. However, a major drawback is that many species produce potent toxins and venoms, highlighting the importance of identifying edible species and ensuring their proper preparation. In addition, limited data is available regarding the chemical risks associated with wild-caught animals, posing a potential threat to consumer safety. Amphibians and molluscs, such as frogs and snails, are very popular culinary delicacies. With few exceptions, frogs and snails are non-toxic, nutritious, easy to collect, and easy to farm, which makes them perfect addition for the food industry. They require minimal food and water, making them cost-effective to farm and a viable nutrition source for low-income populations. Snails are highly nutritious, particularly rich in minerals. However, similar to arachnids and myriapods, proper preparation, such as boiling, is essential before consumption, as some snails and frogs may harbor pathogenic microorganisms. Although arachnids, myriapods, amphibians, and mollusks are nutritious, providing essential proteins, amino acids, and minerals, they are not widely accepted by some consumers, primarily due to concerns about illness or poisoning. To increase acceptability and integrate them into everyday diets, more research is needed to determine the most important safety risks, develop effective prevention strategies, and optimize preparation methods. Ensuring consumer safety through such research would increase confidence and encourage the consumption of these unconventional food sources.

Keywords*: arachnids; myriapods; amphibians; molluscs; nutritional value; safety risks; edible species.*

INTRODUCTION

Although the term arachnophagy is present in the literature, edible arachnid and myriapod species are still frequently categorized under entomophagy in research [1]. According to certain ethnozoological classification systems, arachnids (e.g., spiders, ticks, and scorpions) and myriapods (e.g., centipedes and millipedes) are usually classified as „types of insects" [1]. Edible insects are increasingly recognized as an alternative source of animal protein [2] and are widely incorporated as additives in various food products [3]. However, the consumption of arachnids and myriapods remains relatively uncommon [1]. Ethnobiological studies have documented their use in traditional medicine across different cultures [4], leading to their classification as functional foods in certain contexts [1]. The acceptability of arachnids and myriapods as food appears to be lower than that of edible insects, mainly due to concerns about their venom and cultural perceptions [1]. Even though the consumption of these species is often regarded as an unconventional dietary practice, spiders and scorpions are becoming more accessible to those interested in consuming them [5]. On the other hand, amphibians (frogs) and molluscs (snails) are widely incorporated into human diets across the world [6,7]. Frog meat is highly nutritious, providing a rich source of protein, minerals, and essential amino acids [7]. Due to global warming, habitat destruction, and overexploitation for food, frogs are one of the most threatened groups of vertebrates, with over

6.000 known species being threatened with extinction [6]. Therefore, farming them would help preserve wild species of frogs and make them safer as food source [7]. Marine and terrestrial snails are present as food in many different parts of the world, especially in France, where they represent culinary delicacy [8]. Snail meat is highly nutritious, offering a good source of protein and minerals. However, careful preparation is essential to ensure consumer safety [8].

Edible arachnids and myriapods

Taxonomic information on edible arachnids and myriapods remains preliminary, with the possibility of additional species being identified in the future [1]. Due to their high diversity and adaptability, arachnids and myriapods represent a more reliable food source compared to vertebrate animals [1]. A list of edible arachnids and myriapods is presented in **Table 1** [1].

Table 1. List of some edible arachnids and myriapods.

Family	Genus and Species	Fauna	Distribution	Reference
Araneidae	*Araneus* spp.	African	Benin	[9]
	Argiope pulchella	Oriental	India	[10]
	Neoscona mukerijei	Oriental	India	[10]
	Neoscona theisi	Oriental	India	[10]
	Nephila sp.	Oriental	Indonesia	[11]
	Nephila inaurata	African	Madagascar	[12]
	Nephilia madagascarensis	African	Madagascar	[1]
	Nephilia antipodiana	Oriental	Thailand	[1]
	Nephilia clavata	Oriental	India	[13]
	Nehilia pilipes	Oriental	Thailand	[1]
	Nephilia edulis	Australian	New Caledonia	[1]
	Nephilia clavipes	Neotropical	Mexico	[14]
Lycosidae	*Pardosa bimanica*	Oriental	India	[10]
Salticidae	*Salticus sp.*	African	Benin	[9]
Sparassidae	*Heteropoda venatoria*	Neotropical	Venezuela	[15]
Theraphosidae	*Brachypelma vagans*	Neotropical	Mexico	[1]
	Holothele waikoshiemi	neotropical	Venezuela	[15]
	Theraphosa apophysis	Neotropical	Venezuela	[1]
	Theraphosa blondi	Neotropical	Venezuela	[16]
	Avicularia avicularia	Neotropical	Venezuela	[1]
	Haploplema minax	Oriental	Myanmar	[17]
	Haploplema albostriatus	Oriental	Cambodia	[17]
	Haplonema longipes	Oriental	Cambodia	[17]
	Haplonema lividus	Oriental	Cambodia	[17]

Buthidae	*Leirus quinquestriatus hebraeus*	Palearctic	Ottoman Levant	[1]
	Mesobuthus martensii	Palearctic	China	[18]
	Centruoides suffusus	Neotropical	Mexico	[1]
	Centruiodes nigrimanus	Neotropical	Mexico	[1]
Scorpionidae	*Heterometrus swammerdami*	Oriental	India	[4]
	Heterometrus longimanus	Oriental	Laos	[1]
	Heterometrus spinifer	Oriental	Malaysia, Thailand	[1]
	Pandinus imperator	African	Benin	[9]
	Heterometruss p.	Oriental	Cambodia, Thailand	[1]
Vaejovidae	*Vaejovis oaxaca*	Neotropical	Mexico	[1]
Ixodidae	*Ixodidae gen.*	African	Benin, Madagascar	[19]
Acaridae	*Acarus siro*	Palearctic	Germany	[20]
	Tyrophagus casei	palearctic	France	[20]
Trombididae	*Trombidius grandisimum*	Oriental	India	[21]
Gomphodesmidae	*Tymbodesmus falcatus*	African	Burkina Faso	[22]
	Sphenodesmus sheribongensis	African	Burkina Faso	[22]
Arthrosphaeridae	*Arthrosphaera fumosa*	Oriental	India	[23]
	Arthrosphaera magna	Oriental	India	[23]
Scolopendridae	*Scolopendra gigantea*	Neotropical	Venezuela	[1]
	Scolopendra damnosa	Palearctic	North Korea	[24]
	Scolopendra subspinipes	Palearctic	China	[25]

Order *Aranea*

Several spider species are consumed worldwide. In Madagascar, *Nephila inaurata* and *Nephila madagascarensis* are fried in oil or fat [1]. In Thailand, *Nephila edulis* and other Nephila species are consumed raw or cooked, while in New Guinea and New Caledonia, *Nephila* spp. are traditionally roasted [26]. Beyond their use as food, spiders of the *Nephila* genus are notable for their silk, which has applications in traditional fishing and neurosurgery [29]. Among Indigenous groups in South America, the Piaroa and Yanomamo consume large tarantulas such as *Theraphosa apophysis* and *Theraphosa blondi* [1]. These spiders are typically defanged, roasted, and eaten with salt or pepper sauce [1]. In India, spiders are used in zootherapy, where they are dried, ground, and administered orally to treat ailments such as dry cough, bronchitis, asthma, and digestive conditions in children [10].

Order *Scorpionidae*

Scorpions are widely consumed, often as part of traditional folk medicine, due to their perceived medicinal properties [27]. Some are processed into powder and prescribed for oral consumption [1]. Ancient medical texts describe *Mesobuthus martensii* as possessing antispasmodic, analgesic, and detoxifying properties, as well as being used in the treatment of ulcers [30]. In North Mexico, particularly in the state of Durango, scorpions are incorporated into local cuisine [1]. They are typically brought live to restaurants, placed in jars of alcohol, and then cleaned thoroughly before being fried in hot oil until crispy [1]. They are then served in tacos with tomato and lettuce [1].

Order *Acari*

The order Acari, comprising mites and ticks, includes some species consumed by various ethnic groups. In Mahbo, Madagascar, tick consumption has been recorded at the household level [1]. Among the Wama people of Benin, blood-filled ticks are eaten as part of traditional practices [19]. In the Satpura Plateau of Madhya Pradesh, India, mites are consumed as medicinal food [21]. Additionally, certain mites play a role in cheese production, contributing to the ripening process [1]. However, in most cases, ticks and mites are rejected as food due to safety concerns, as they are hematophagous organisms that feed on the blood of various animals and humans [31].

Class *Diplopoda*

The consumption of millipedes has been documented in Burkina Faso, where the Bobo people consume *Tymbodesmus falcatus* and *Sphenodesmus sheribongensis* [1]. Their calcified exoskeleton is considered a potential source of calcium, while their digestive tract primarily contains soil and decomposed plant material [22]. In certain traditional practices, toxic millipedes are consumed as part of malaria control rituals, while in India, some Indigenous tribes use millipedes in traditional medicine for tuberculosis treatment [1]. In Burkina Faso, millipedes are processed by boiling or cooking in water previously filtered through firewood ashes to mitigate potential toxicity [22].

Class *Chilopoda*

Centipedes, such as *Scolopendra subspinipes mutilans*, are used both as food and traditional medicine

Table 2. Approximate composition (dry matter-based) of arachnids and myriapods compared to insects [1].

Nutrients	*Araneae*	*Scorpionidae*	*Diplopoda*	*Chilopoda*	House cricket (*Acheta domesticus*)	Yellow Mealworm (*Tenebrio molitor*)	Black soldier fly (*Hermetia illucens*)	House fly (*Musca domestica*)
Protein (%)	32.0-77.0	52.0-73.0	7.0-25.0	55.0	67.0	49.0	45.0	78.0
Fat (%)	2.0-60.0	10.0-16.0	4.0-5.0	27.0-31.0	22.0	35.0	36.0	8.0
Ashes (%)	3.0-10.0	6.0-7.0	1.0-42.0	-	4.0	2.0	9.0	7.0
Na (mg/kg)	3.17	433.0	2.18	-	4.4	1.4	2.3	887.0
K (mg/kg)	7.79	690.0-700.0	1.0-17.80	-	11.3	9.0	11.7	4.53
Ca (mg/kg)	1.26	590.0-600.0	43.0-174.0	-	1.3	400.0	24.1	9.34
Mg (mg/kg)	1.34	490.0-500.0	3.0-8.76	-	1.1	2.1	4.5	1.74
P (mg/kg)	84.44	-	6.25	-	7.9	7.5	9.2	3.56
Se (mg/kg)	1.0	-	0.0-1.0	-	-	-	-	<1.0
Fe (mg/kg)	24.0-170.0	135.0-138.0	0.0-10.60	-	62.7	54.1	-	67.0
Zn (mg/kg)	40.0-237.0	51.0-53.0	2.0-160.0	-	218.0	137.0	145.0	56.0
Mn (mg/kg)	5.0-46.0	-	0.0-4.99	-	37.0	14.0	160.0	62.0
Cu (mg/kg)	9.0-66.0	-	2.0-789.0	-	20.0	16.0	10.0	4.0

in Southeast Asia [24]. They are typically dried, ground into powder, and incorporated into conventional foods as a dietary supplement [1].

Chemical composition and nutritional characteristics of edible arachnids and myriapods

The composition and nutritional value of edible insects have been extensively researched and documented [2,3]. However, data on the nutritional composition of edible arachnids and myriapods remain limited. These organisms have the potential to help in addressing malnutrition, particularly in children, by serving as food additives [1]. Current research employs various analytical methods, making direct data comparisons challenging [1]. The nutritional composition of spiders and scorpions is poorly documented [1], and no available literature provides data on the composition of ixodid ticks and mites. Some information exists for millipedes, though the edibility of the analyzed species remains unidentified [1]. For centipedes, a single study by Kim *et al.* (2017) [32] analyzed *Scolopendra subspinipes mutilans* specimens from various regions in Korea, reporting a crude protein content of 54.9% and crude fat content ranging from 26.8% to 30.6%. Although specific data are lacking, it is reasonable to assume that, similar to insects, the nutritional value of arachnids and myriapods varies depending on diet [1].

For instance, detritivorous millipedes likely have lower protein content than predatory millipede species [28]. Additionally, protein content variations are species-dependent for both arachnids and millipedes, as observed in edible insects [2]. Even greater variations have been recorded in mineral content among these taxa [1]. An approximate comparison of nutrient content between arachnids, myriapods, and insects is presented in **Table 2** [1], while **Figure 1** illustrates the variations in protein content across these groups according to order/class [1,2].

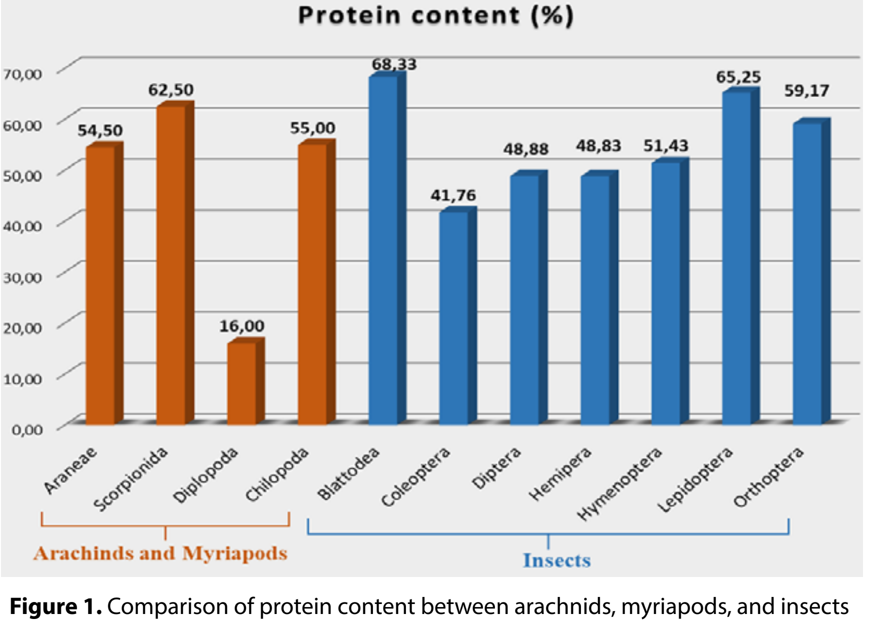

Figure 1. Comparison of protein content between arachnids, myriapods, and insects depending on the order/class [1,2].

Food safety of arachnids and myriapods

Regarding food safety, the European Food Safety Authority (EFSA) has conducted risk analyses; however, arachnids and myriapods continue to be grouped with insects, and specific food safety data for these taxa remain scarce [1]. Most food safety risks associated with arachnids and myriapods are similar to those of edible insects, including bacterial contamination (*Staphylococcus aureus*, *Clostridium* spp., *Vibrio* spp., *Streptococcus* spp., *Clostridium* spp.), viruses (though specific viruses have yet to be identified), allergic reactions, and the presence of toxic elements such as lead, mercury, arsenic, and cadmium [1,2]. A major safety concern unique to arachnids and myriapods is the presence of venom, which poses potential risks if not properly neutralized before consumption [1]. The primary food safety guideline for these organisms is that they should never be consumed raw, as they may act as vectors for various microorganisms and parasites [1]. Key safety concerns related to the consumption of arachnids and myriapods are summarized in **Figure 2** [1,2].

Edible amphibians and molluscs

Frogs, amphibians belonging to the family *Ranidae*, include over 50 edible species consumed worldwide [7]. Nowadays, frog meat has become an increasingly popular delicacy in European restaurants [33], with France, the United States, and Belgium being the largest importers of frog legs [34]. The American bullfrog (*Rana catesbeiana*) and the Indian bullfrog (*Rana tigrin*a) are the most widely consumed frog species globally [7]. **Figure 3** shows the global distribution and edible species of frogs [7]. Frog farming is highly profitable due to the minimal space, food, and water requirements, allowing for high-yield production [35]. The main producers of farmed frogs include Indonesia, Taiwan (province of China), and Turkey [7].

Frog meat is commercially available in various forms, including whole carcasses, fresh legs, and frozen legs, with labeling standards differing by country [7]. Frog meat is highly nutritious, offering a rich source of protein, minerals, and essential amino acids [7]. Due to its well-balanced amino acid profile, 100 g of cultured frog meat can supply more than the daily recommended amino acid

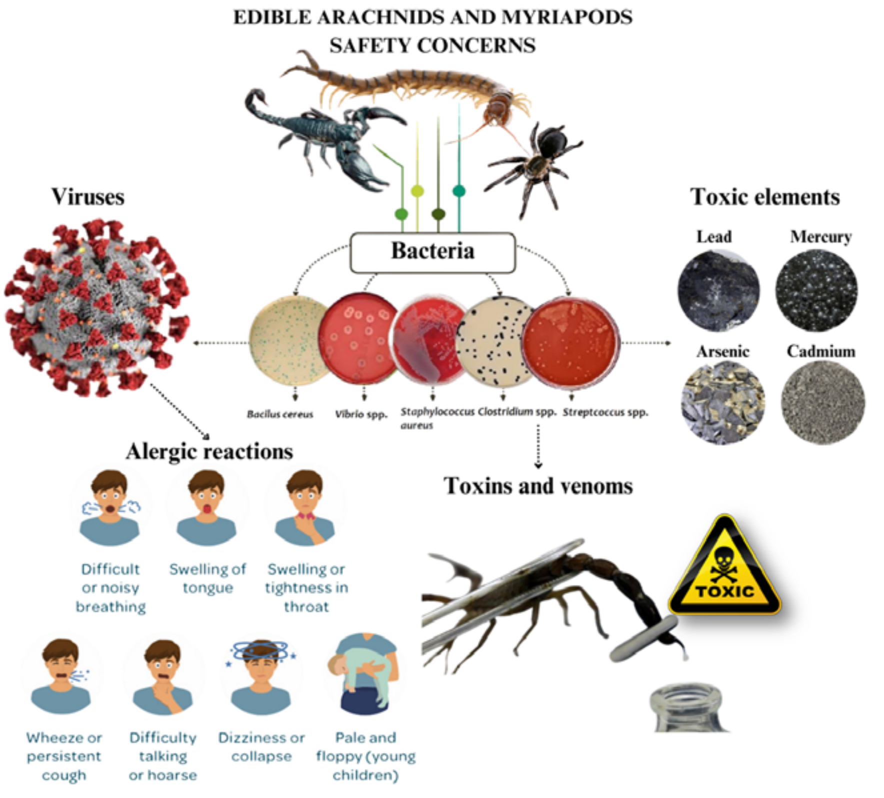

Figure 2. Safety concerns related to the consumption of arachnids and myriapods [1,2].

intake for adults [33]. Additionally, its mineral composition provides essential nutrients required for human health [7]. The proximate composition and key nutritional characteristics of frog meat are summarized in **Table 3** [7].

Snails, belonging to the phylum *Mollusca*, represent an important and intriguing food source in the human diet [8]. They are categorized into two main groups: marine and terrestrial (land) snails [8]. Both types are consumed in various regions worldwide, including Jamaica, Mexico, Taiwan, the Philippines, Thailand, New Caledonia, and Mediterranean countries such as France, where snails are considered a renowned culinary delicacy [8]. Among the most consumed terrestrial snail species are *Helix aspersa* (vineyard snail), *Archachatina marginata* (giant West African snail), and *Achatina fulica* (giant African snail) [36]. Regarding their nutritional profile, snails are characterized by a high water content (ranging from 75% to 85%) and a low fat content (rarely higher than 2%) [8]. The edible pedal mass (foot) contains approximately 10% to 20% protein [8]. Snail meat is also a valuable source of essential minerals, particularly Ca, P, Mg, K, and Na, with smaller amounts of Fe, Zn, Mn, and Cu [8]. Despite its nutritional benefits, snail meat requires careful preparation to ensure food safety [37]. Farmed snails are typically not

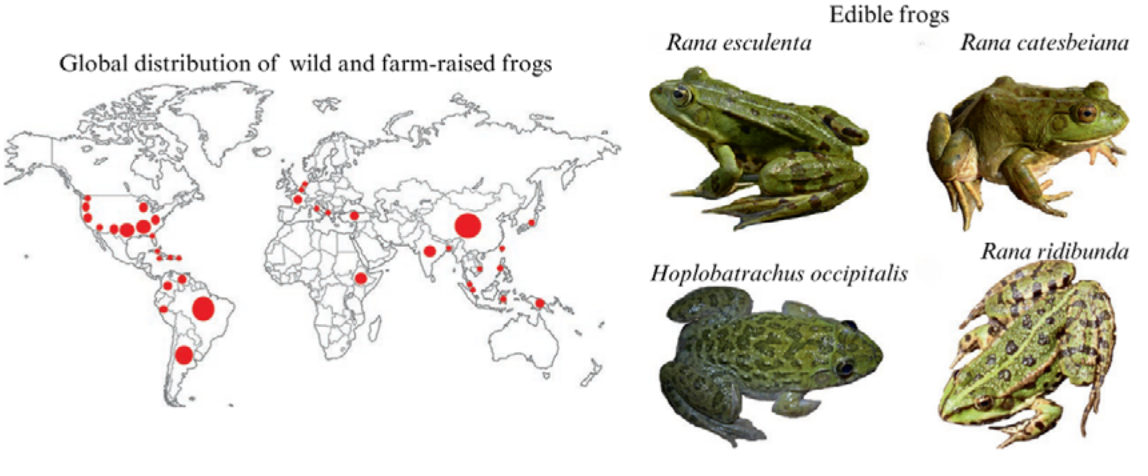

Figure 3. Distribution and edible species of frogs in the world [7].

fed before processing to empty their digestive tracts, whereas wild-caught snails may pose a greater risk if their gut contents are not properly removed [8]. Additionally, several microorganisms have been identified in snail meat, including *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus*, *Bacillus subtilis*, *Aspergillus terreus,* and *Aspergillus fumigatus* [37]. Another concern is the potential accumulation of pollutants and toxic metals, particularly in snails harvested from industrialized areas [8]. A comparison of the protein and fat content in snails versus conventional foods is shown in **Figure 4** [38], while the nutritional composition of different snail species is summarized in **Table 4** [38].

CONCLUSION

Despite their presence in various traditional diets, arachnids and myriapods remain a localized and underutilized food source. Beyond their nutritional benefits, they possess significant medicinal properties. However, the overexploitation of edible species from the wild poses a serious threat to their survival. Farming of

Table 3. Proximate composition and nutritional characteristics of frog meat [7].

	Rana esculenta	***Rana galamensis***	***Rana catesbeiana***	***Rana ridibunda***
Proximate composition	**g/100 g**	**g/100g dry matter**	**g/100 g**	**g/100 g**
Moisture	78.8-79.7	-	72.8-79.2	74.8-79.4
Protein	18.8-19.2	53.7	13.6-19.4	18.5-22.9
Fat	0.62-1.2	9.52	0.33-7.4	0.74-0.93
Ash	0.56-0.85	6.1	0.20-3.1	1-1.4
Fatty acids	**%**	**%**	**n/a**	**mg/100 g frog**
SFA	26.8-31.7	31.2-32.5	-	167-199
MUFA	18.5-42.5	22.7-23.8	-	35.9-90.3
PUFA	20.3-30.3	37.6-40.1	-	245-276
Amino acids	**g/100 g protein**	**g/100 g protein**	**n/a**	**mg/100 g frog**
Lysine	5.4-6.9	6.9	-	1341-1720
Methionine	3.0-4.6	3.0	-	532-562
Leucine	6.1-7.1	7.1	-	867-1454
Isoleucine	3.4-4.0	4.0	-	824-971
Phenylalanine	3.8-5.0	5.0	-	795-797
Valin	4.0-4.8	4.8	-	854-936
Serine	4.9-5.2	5.2	-	695-905
Arginine	5.8-6.6	6.6	-	747-1177
Cysteine	1.1	1.1	-	147-196
Alanine	5.6-6.1	6.1	-	1011-1302
Minerals	**mg/100 g**	**n/a**	**n/a**	**mg/100 g**
Ca	7.7-15.6	-	-	22.5-24.0
Mg	6.6-8.9	-	-	17-23
P	28.69-46.4	-	-	140-160
Na	0.91-1.22	-	-	28.9-48.1
K	32.7-62.1	-	-	350-366
Fe	0.18-0.20	-	-	0.55-1.21

***Note**: SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids.*

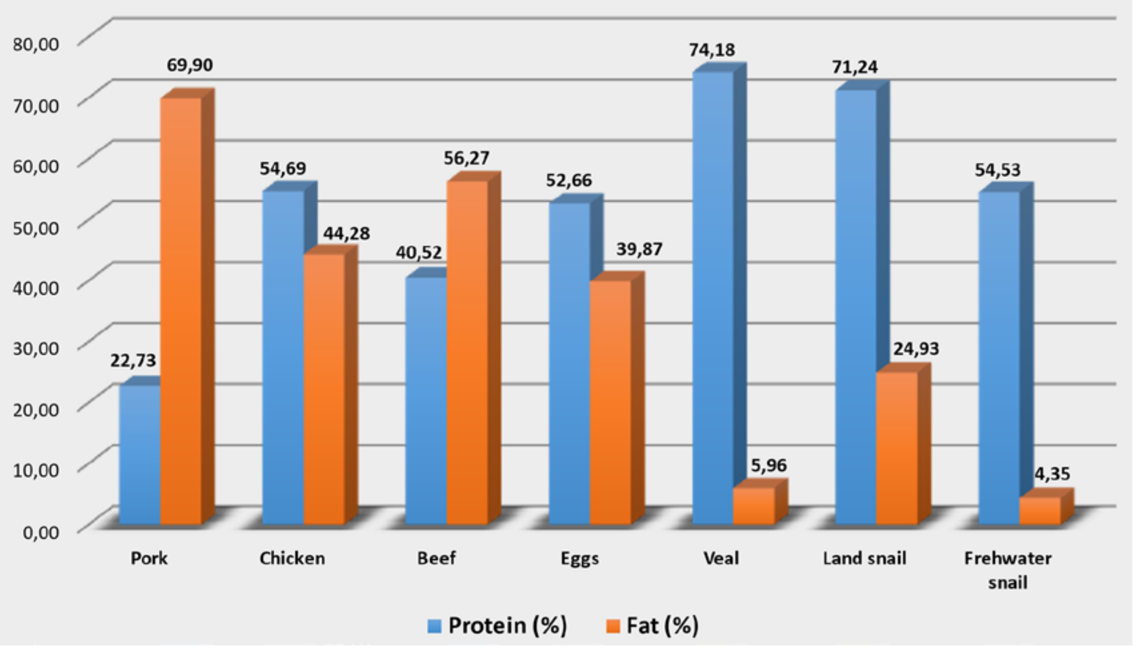

Figure 4. Comparison of protein and fat content of conventional food and snails [38].

Table 4. Content composition of land, freshwater, and brackish water edible snails [38].

Species name	Habitat	Moisture	Crude protein	Crude fat	Crude fiber	Nitrogen-free extract	**Ash**
Achtina achtina	Land	75.28	69.58	8.94	0	12.06	9.43
Achtina fuilca	Land	79.28	48.65	7.77	0	34.99	8.59
Archachatina marginata	Land	73.67	74.17	9.27	0	6.84	9.72
Archachatina marginata ovum	Land	80.78	84.43	4.5	0.5	6.57	4.0
Lanistes varicus	Fresh water	75.80	70.0	1.75	1.25	19.0	8.0
Nucella lapillus	Sea water	73.69	82.25	8.5	1.5	0.75	8.0
Pila ampullaceal	Fresh water	76.32	40.06	0.25	0.13	31.25	23.40
Lymnaea stagnalis	Pond	38.62	41.71	4.48	6.63	41.63	5.57
Bellamya bengalensis	Fresh water	82.10	50.09	5.50	0.20	24.07	20.34
Melania tuberculata	Fresh water	74.60	48.65	7.06	0.18	29.79	14.5
Anisus convexiusculus	Fresh water	75.7	53.20	4.0	0.15	23.84	18.96
Helix aspera	Land snail	82.50	73.54	3.31	0	28.51	6.11
Helix aspersa aspersa	Land snail	83.70	65.20	10.0	-	0	-
Helix aspersa maxima	Land snail	85.80	58.0	10.85	-	13.8	-
Helix lucorum	Land snail	82.83	65.33	6.53	-	-	-
Helix pomatia	Land snail	84.65	63.73	5.15	-	-	-

edible arachnids and myriapods is the only sustainable solution, yet biological constraints make their cultivation challenging. Integration of arachnid and myriapod rearing into existing insect farms could be an economically feasible approach. Frog meat provides an essential protein source for low-income populations, yet the uncontrolled harvesting of edible frog species from the wild risks their extinction. Farming frogs on a larger scale would not only ensure food security but also help conserve wild populations. Similarly, snails represent a highly nutritious yet underutilized additional protein source. Although deficiencies in certain amino acids limit their dietary potential, their low resource requirements make them an efficient alternative to conventional livestock. Addressing consumer perception, particularly the appeal of whole, unprocessed snails, could significantly increase their acceptance as food. To fully unlock the potential of these unconventional protein food sources, further research is required to improve taxonomic classification, nutritional profiling, and food safety assessments, particularly for arachnids and myriapods. Establishing standardized methodologies for data collection and comparison is essential. Equally important is consumer education, raising awareness, and disseminating scientific findings, which will play a crucial role in improving acceptability and fostering a sustainable market for these alternative sources of proteins in human nutrition.

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Arahnide, stonoge, žabe i puževi – jestive vrste, nutritivna vrednost i bezbednost

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Kratak sadržaj

Kao i insekti, arahnide i stonoge se tradicionalno konzumiraju u mnogim regionima sveta. U ovom preglednom radu dat je spisak jestivih arahnida i stonoga, kao i sve dostupne informacije o njihovoj nutritivnoj vrednosti i potencijalnim rizicima po bezbednost hrane. Arahnide i stonoge imaju lekovita svojstva, zbog kojih im se pridaje sve veća pažnja. Njihov dobar nutritivni sastav može biti od velike pomoći u prevazilaženju pothranjenosti. Glavni nedostatak je što mnoge vrste poseduju jake toksine i otrove, pa je izuzetno važno znati koje vrste su jestive i kako ih pravilno pripremiti. Takođe, podaci o hemijskim opasnostima su veoma oskudni kada su u pitanju ulovljene životinje iz divljine, što potencijalno može predstavljati pretnju po bezbednost potrošača. Vodozemci i mekušci, kao što su žabe i puževi, su veoma popularne kulinarske poslastice. Uz nekoliko izuzetaka, žabe i puževi su netoksični, hranljivi, lako se sakupljaju i uzgajaju, što ih čini savršenim dodatkom za prehrambenu industriju. Oni ne zahtevaju mnogo hrane i vode, ekonomski su isplativi za uzgoj, što ih čini odličnim za populaciju sa niskim prihodima. Puževi su nutritivno bogata hrana, posebno mineralima. Kao i za arahnide i stonoge, važna je pravilna priprema pre konzumiranja (kuvanje), s obzirom da neke žabe i puževi mogu sadržati patogene mikroorganizme. Iako arahnide, stonoge, vodozemci i mekušci imaju visoku hranljivu vrednost (bogati proteinima, aminokiselinama i mineralima), pojedini potrošači pokazuju odbojnost, uglavnom zbog straha od bolesti ili trovanja. Kako bi se ovakva nekonvencionalna hrana približila potrošačima i postala deo svakodnevne ishrane, potrebno je više istraživanja kako bi se utvrdili bezbednosni rizici, preventivne mere i način pripreme za konzumaciju. Obezbeđivanjem bezbednosti nekonvencionalne hrane, poput arahnida, stonoga, vodozemaca i puževa, povećalo bi se poverenje kod potrošača čime bi se podstakla njihova konzumacija.

Ključne reči: *arahnide; stonoge; vodozemci; mekušci; nutritivna vrednost; bezbednost; jestive vrste.*