International Journal of Food Science and Nutrition
www.foodsciencejournal.com
ISSN: 2455-4898
Received: 23-08-2024, Accepted: 22-09-2024, Published: 07-10-2024
Volume 9, Issue 4, 2024, Page No. 8-14

Nutritional potentials of garden snail (*Limicolaria aurora*) and giant African land snail (*Achatina fulica*) in Akwa Ibom State, Nigeria

Owoidihe Monday Etukudo[1*], Ekerette Emmamuel Ekerette[2], Lawrence Enyioha Okonko[3], Nko Samuel Bassey[1]
[1] Department of Biological Sciences, Topfaith University, Mkpatak, Akwa Ibom State, Nigeria
[2] Department of Genetics and Biotechnology, University of Calabar, Calabar, Nigeria
[3] Department of Biological Sciences, Clifford University, Owerrinta, Aba, Abia State, Nigeria

Abstract
Due to the rapid increase in the population globally coupled with the daily increase in the demand for protein, it is needful to source for cost-effective and readily available protein sources. The study investigated the proximate, mineral and amino acid compositions of meat powders from two species of snails (*Limicolaria aurora* and *Achatina fulica*) that were handpicked around Topfaith University, Mkpatak Campus in Akwa Ibom State, Nigeria. Sixty (60) land snails consisting of thirty (30) each of Garden snails (*L. aurora*) and giant African land snail (*A. fulica*) were handpicked around Topfaith University, Mkpatak Campus in Akwa Ibom State, Nigeria.The samples were removed from their shells, and washed with deionized water and dilute acid. The meats were then dried at 65–70°C for 24 hours, ground into fine powder, and sieved to achieve uniformity in particle size. Proximate, mineral and amino acid analyses were conducted. Significant differences ($P < 0.05$) were observed in proximate, mineral and amino acid compositions among the meat powders of the studied snail species. Most essential amino acids such as Leucine, histidine, lysine, arginine, threonine, valine, methionine, isoleucine and phenylalanine were present. Proximate analysis revealed high energy, protein and carbohydrate but low fat and ash contents in the two species of snails. Mineral analysis indicated high levels of Ca, Na, K, Mg, P, while Fe were significantly low across the two species. The high protein and low-fat contents suggest that snail meat powder could be used as additives for food fortification to meet the demand for protein globally.

Keywords: Proximate, mineral, amino acid, composition, snail, meat

Introduction

Limicolaria aurora and *Achatina fulica* are species of land snail belonging to the phylum–Mollusca, class–Gastropoda, order–Stylommatophora and family–Achatinidae [1, 2]. They provide high-quality proteins with essential amino acids necessary for growth, repair, and maintenance of human health [3, 4]. The fatty acid content of shell-bearing animals contributes significantly to a healthy diet [4, 5]. Differences in the nutritional composition of land snails depend on factors such as species, sex, feeding habits, age, and seasonal conditions [4, 6, 7]. Land snails are the largest invertebrates after arthropods, which possesses diverse phenotypic traits and habitat preferences [4].

These land snails hold economic importance in Nigeria, especially in Akwa Ibom State, where they are harvested by hand-picking and marketed for their protein, minerals, vitamins, and essential amino acids [4, 6]. Their affordability makes them a staple protein source for both low-income earners and wealthier individuals. Due to their cholesterol-free meat, they have been used for the treatment of cardiac related illnesses [4].

The method of harvesting and gathering of these land snails involve indiscriminate hunting of the snails by hand-picking them from the bush, field, fences and rocks all year round but their population tends to increase rapidly during the month of April and August in Nigeria. Their shells are smooth with variety of beautiful colors and patterns. The dried and powdered form of the shells can be used to improve mineral content of animal feeds [7, 8].

These species of snail are found in Nigeria and other countries in West Africa with high nutritive and reproductive potentials, which can compete favorably with other livestock species.[9] Consumption of animal-based protein is reduced in Nigeria due to the current economic situation. It is therefore inevitable to improve the current situation in Nigeria by increasing animal productivity, especially the micro-livestock such as garden and giant African land snails because of its efficacy in the production of cheap and available animal-base nutrients and proteins to her populace. There are a lot of animal-based proteins and nutrients in animals such as clam, periwinkle and land snails but the rate of consumption of these animals is low due to the fact that there is paucity information about their nutritional potentials [4, 10, 11]. Due to scanty literature on the nutritional composition of these snails, this research is therefore tailor towards evaluating the nutritional potentials of *Limicolaria aurora* and *Achatina fulica* snails in Akwa Ibom State, Nigeria.

Materials and methods

Experimental animals

Sixty (60) land snails consisting of thirty (30) each of Garden snails (*L. aurora*) and giant African land snail (*A. fulica*) were handpicked around Topfaith University, Mkpatak Campus in Akwa Ibom State, Nigeria.

Preparation of the experimental animals into dried powder

The snails obtained for this study were processed according to the method outlined by [4, 12]. The snail meats were carefully removed with the aid of stainless iron from the shells, washed with deionized water and dilute acid that was prepared from 1M solution in order to remove blood, slime and any other adhering contamination, and allowed to dry, and weighed. The snail's meat was dried at 65 – 70^{0}C for 24 hours in an Oven (Model–TT-9023A Techmel and Techmel, USA). Dried samples were milled separately into fine powder using a manual grinder and sieved with a 0.5µm mesh size to achieve uniformity in particle size.

Amino acid analysis

The amino acid composition of the samples was determined using the method described by [13]. The samples for amino acid analysis were dried to constant weight, defatted, hydrolysed, evaporated in a rotary evaporator (Model 800D, SearchTech Instruments, British Standard) and loaded into an Amino acid analyser (Perkin and Elmer Model 403, USA). Essential amino acid scores were computed according to the FAO/WHO reference amino acid pattern [49].

Proximate and mineral analysis

The proximate analyses (moisture, crude protein, fat, ash) were analyzed by adopting the methods described in [14]. The carbohydrate content was calculated by subtracting 100 from the total of all the other proximate measurements (Crude protein, fat, fibre and ash). The minerals (Ca, K, Na, Mg, Fe, P, and Zn) were analyzed using an Atomic Absorption Spectrophotometer (Model 721, Medifriend, England) as described in [14].

Statistical analysis

The data collected were subjected to statistical analysis using a statistical package for Social Sciences Version 18 statistical package (SPSS, Inc. USA). Analysis of Variance (ANOVA) was done to determine significant differences at (P < 0.05). The means were separated using the Least Significant Difference (LSD). The mean, standard deviation and standard errors were calculated according to [15].

Results and discussion

Table 1: Proximate composition of *Limicolaria aurora* and *Achatina fulica* snail's meat powder (dry matter basis).

Parameters	*Limicolaria aurora* snail	*Achatina fulica* snail
Moisture (%)	70.34 ± 1.62^a	5.00 ± 0.03^b
Crude protein (%)	50.48 ± 0.50^b	63.10 ± 1.42^a
Crude fat (%)	10.00 ± 0.39^a	3.47 ± 0.76^b
Carbohydrate (%)	26.50 ± 1.92^b	28.10 ± 1.40^a
Ash (%)	12.00 ± 0.61^a	3.10 ± 0.06^b
Energy (Kcal/100g)	475.42 ± 1.76^b	1615 ± 1.61^a

^{ab} Means on the same row with different superscripts are significantly different at (P < 0.05)

Table 2: Mineral content of *Limicolaria aurora* and *Achatina fulica* snail's meat powder (Mg/100g)

Parameters	*Limicolaria aurora* snail	*Achatina fulica* snail
Ca	403.00 ± 1.23^b	415.00 ± 4.10^a
Na	180.00 ± 0.47^a	81.43 ± 0.81^b
K	523.01 ± 1.23^a	115.04 ± 5.04^b
Mg	765.10 ± 2.10^a	305.02 ± 1.34^b
P	632.02 ± 3.03^a	69.10 ± 0.06^b
Zn	281.01 ± 0.51^a	6.00 ± 2.10^b
Fe	4.78 ± 3.14^b	24.21 ± 0.23^a

^{ab}Means on the same row with different superscripts are significantly different at (P < 0.05)

Table 3: Amino acid composition of *Limicolaria aurora* and *Achatina fulica* snail's meat powder (Mg/100g protein)

Amino acid	*Limicolaria aurora* snail	*Achatina fulica* snail
Leucine (Leu)^a	65.05 ± 0.24^a	57.00 ± 1.32^b
Histidine (His)^a	36.00 ± 0.02^b	41.34 ± 3.71^a
Lysine (Lys)^a	48.34 ± 2.10^b	54.12 ± 1.51^a
Arginine (Arg)^a	59.23 ± 0.20^b	67.07 ± 0.04^a
Threonine (Thr)^a	17.01 ± 4.02^b	25.01 ± 3.21^a
Valine (Val)^a	43.42 ± 1.21^a	22.09 ± 2.01^b
Methionine (Met)^a	19.13 ± 2.26^a	14.00 ± 1.67^b
Isoleucine (Ile)^a	50.51 ± 1.23^a	40.05 ± 4.05^b
Phenylalanine (Phe)^a	45.00 ± 4.12^a	36.10 ± 1.45^b
Tyrosine (Tyr)	26.18 ± 1.03^a	23.04 ± 0.05^b
Cystine (Cys)	6.12 ± 2.13^b	9.87 ± 1.42^a
Alanine (Ala)	37.04 ± 1.20^a	29.00 ± 2.10^b
Glycine (Gly)	49.00 ± 0.07^b	54.07 ± 1.41^a
Proline (Pro)	42.23 ± 1.67^a	31.34 ± 2.13^b
Glutamic acid (Glu)	13.60 ± 2.10^b	96.04 ± 1.30^a
Serine (Ser)	38.10 ± 1.67^a	32.00 ± 2.03^b
Aspartic Acid (Asp)	78.24 ± 1.34^a	71.00 ± 1.09^b
Total Amino Acid (TAA)	674.20 ±0.48^b	703.14 ± 2.64^a
Total Essential Amino Acid (TEAA)		
With Histidine	383.69 ± 0.48^a	356.78 ± 2.64^b
No Histidine	347.69 ± 0.46^a	315.44 ± 1.07^b

^{ab}Means on the same row with different superscripts are significantly different at (P< 0.05). Abbreviations: TAA = Total Amino Acid; TEAA = Total Essential Amino Acid. The superscripts "a" on the amino acids indicate Essential Amino Acids

Proximate composition of *Limicolaria aurora* and *Achatina fulica* snails

The proximate composition of the meat powder derived from the edible portions of the two snail's species is detailed in Table 1. Significant variations (P < 0.05) were observed in the proximate composition among the studied snail's species.

The predominant organic constituent of the meat powders derived from the two snail's species was protein. *Achatina fulica* exhibited the highest protein content at 63.10%, significantly differing (P < 0.05) from *Limicolaria aurora* species.

This significant variation recorded in this study is likely attributed to differences in species, locations, physical and other environmental factors such as temperature, given that gastropods are ectothermic animals [4, 6, 16]. This finding is in tandem with previous reports by [4]. Which highlighted the influence of climate, location, and dietary variables on the physiology of gastropods. Similar variations in proximate composition within and between species of mollusks were also reported by [4, 17] and among different species of gastropods [4, 18].

Protein content was generally higher (63.10%) in *Achatina fulica* snail compared to the value 50.48% obtained for *Limicolaria aurora* snail. The protein levels observed for *Achatina fulica* in this study fell within the range of 62.56% as reported by [19] for the same species of snail, also the protein concentration in the *Limicolaria aurora* was lower than the value of 66.76% reported by [21] but was in line with the value of 51.40% as reported by [20].

The crude protein value compares favourably with values reported by [21] for rock snail (*Thais coronata*) (58.48%), land snails (*Achatina achatina*, 72.10% and *Archachatina marginata*, 84.80%) by [4], Periwinkle species (*T. fuscatus*, 47.01% and *P. aurita*, 52.12%) by[4], crayfish (*Puramonetes variuns*, 69.5 g/l00 g)by[22], clam (*Egreria radiata*, 61.00 g/l00 g) and whole hen's egg (50.00 g/ 100 g) by [23]. Proteins serve as major components and sources of amino acids in our diets, enhancing growth, development, and maintenance of living systems [4]. The observed high protein concentration in these two snail species suggests their nutritional potential and that their meat powders could be incorporated for fortifying carbohydrate-based diets, so as address the issue of protein-energy malnutrition among the populace. Hence, these two snail species which is easy to come by, can provide as much dietary protein as the more costly chicken egg.

The fat content recorded in this study differed significantly (P < 0.05) between the two snail species, with *Limicolaria aurora* species recording the highest fat level of 10%, while *A. fulica* recorded the least value of 3.47% fat respectively. The fat levels recorded in this study for *L. aurora* snail was higher that the values of 9.70g/100g for *L. aurora* by [20], 3.19% for *Thais coronata* by [22], 6.20% for *A. achatina*, 4.40% for *A. marginata*, 4.00% for *T. fuscatus*, 3.02% for *P. aurita* respectively by [4]. Conversely, the fat content of meat powder obtained for *A. fulica* in this study was lower than 6.31% (*T. fuscatus*) and 6.73% (*P. aurita*) reported by [24], and 7.68% (*T. fuscatus*) by [24].The low-fat content observed in this study for the two snail species suggests that they can be used for the treatment of hypertension and arteriosclerosis by incorporating meat powder into diets for consumption [4, 25].

The carbohydrate concentration of the meat powder from *A. fulica* gastropod species were significantly (P < 0.05) differed from that of *L. aurora*. *A. fulica* species exhibited the highest carbohydrate concentration at 28.10%, while *L. aurora* species had 26.50%. This high carbohydrate concentration obtained in this study for *A. fulica* species is in line with the value of 27.29% report of [19] for the same species of snail, but lower than those reported by [4] for *T. fuscatus* (35.12%) and *P. Aurita* (34.02%). This high level of carbohydrate concentration in *A. fulica* species in this study suggests that the *A. fulica* has ample hydrogen, oxygen, and carbon for carbohydrate synthesis, which fuels their muscular movement and regulates body temperature.

The ash concentration in this study was significantly (P < 0.05) higher *L. aurora* species 12.00% compared to *A. fulica* species with ash concentration of 3.10%. This high content of ash observed in this study for *L. aurora* species was not in agreement with the results of 4.10% obtained by [21] for the same species of snail. On the other hand, the results of ash content obtained in this study for *A. fulica* were in agreement with those reported by [19] where they reported the value of 3.00% ash concentration for *A. fulica* species of snail. This differences in ash concentration obtained for this two snail species may be due to differences in breed. The ash content serves as a vital indicator of the nutritional value and processing of food items. Higher ash content is typically associated with processed foods compared to natural foods with lower ash content. More so, ash content provides insight into the inorganic concentration of a sample and the origin of mineral elements. The elevated ash content observed in the meat powders of *L. aurora* species in this study suggests a high concentration of mineral elements, indicative of processed foods.

Moisture in a sample is an indication of how long that sample can be stored. The percentage of moisture attained was high in *L. aurora* species (70.34%) than in *A. fulica* (5.00%). This means that dried snail meat, when well packaged, can be kept for a significant period. The energy values obtained were high for the two snail species (1615 Kcal/100g for *A. fulica* and 475.42Kcal/100g for *L. aurora* species) and differ from each other significantly. The higher energy value suggests that the two-snail meat can offer substantial calories in human nutrition. Energy value of 1611.44KJ/100g was reported by [19] for *A. fulica* meat and 478.35Kcal/100g for *L. aurora* meat by [21] respectively.

Mineral content in *Limicolaria aurora* and *Achatina fulica* meat powder

The mineral content analysis of *L. aurora* and *A. fulica* species revealed varying quantities of all analyzed minerals in the meat powders, with significant differences (P < 0.05) observed among the two snail species (Table 2). Among the minerals analyzed, include; calcium, sodium, potassium, magnesium, phosphorus, zinc and iron respectively. Magnesium exhibited the highest concentration among all the mineral analyzed, with *L. aurora* species recording the highest amount at 765.10mg/100g, while iron showed the lowest concentration at 4.78mg/100g for the same species. On the other hand, calcium was recorded the highest 415.00mg/100g concentration among all the mineral analyzed for *A. fulica* species, while the least zinc-value of 6.00mg/100g was recorded for the same species of snail. Contrary to the typical low calcium content of meats, as reported by [25], ranging from 9 to 11mg/100g, this study found a notable presence of calcium in the two snail species analyzed. The value of calcium 415.00mg/100g obtained in this study for *A. fulica* species of snail was higher than the value of 402.29mg/100g reported by [19] for the same snail species. However, the value 403.00mg/100g calcium recorded in this study for *L. aurora* was higher than 1.13g/100 reported by [26] for the same species. High calcium content of 780mg/100g in *A. fulica* was also reported by [27], while [28] recorded 750mg/100g of calcium in *H. pomatia* from the Cukurova region of Turkey. This differences in the calcium composition may be due to the type of feed fed by the snails in the wild. Compared to other animal products like milk (120mg/100g), eggs (54mg/100g), liver (6mg/100g), and beef (7mg/100g), which have lower calcium concentrations, gastropods exhibit high concentration of calcium content [29]. Given the importance of calcium in bone and teeth development during infancy and childhood, it is suggested that inclusion of these powdered snail meat into diets for infants, will contribute significantly to their calcium intake [4, 30].

The sodium concentration obtained for *L. aurora* and *A. fulica* species of snail were significantly (P< 0.05) differ from one another, with the highest value 180.00mg/100g recorded for *L. aurora* species, while 81.43mg/100g was for *A. fulica* species. This result obtained in this study for the both species were higher than the reports of [19, 26] for *L. aurora* 2.32mg/100g and *A. fulica* 73.38mg/100g respectively. This difference may be due the differences in breed of the snail and the type of diet consumed by the snails in the wild. Sodium is needed in our bodies to balance the amount and distribution of water, also played a key role in the control of our blood pressure. More so, sodium is also important to help our muscles and heart contract and to allow our nerve cells to carry messages (nerve impulses) between the brain and the body [31]. These two snail species are good source of sodium; hence consumption of the meat will increase the amount of sodium in our bodies.

There was a significant (P < 0.05) difference in potassium content between the two species of snail studied (Table 2). *L. aurora* species recorded the highest 523.01mg/100g against 115.04mg/100g recorded for *A. fulica* species in this study. The result obtained in this study were higher than the reports of [19, 26] for *L. aurora* 2.23mg/100g and *A. fulica* 111.02mg/100g respectively. This high concentration of potassium in the two snail species suggests that they could be used to treat high blood pressure, also increases vasodilation and urinary sodium excretion, which in turn reduces plasma volume; this effect may be more pronounced in salt-sensitives individuals [32, 33, 34].

Magnesium was the mineral with the highest concentration among the minerals found in the meat powder of *L. aurora* snail species but second after calcium among the mineral found in *A. fulica* snail meat powder studied. There was a significant (P < 0.05) difference in magnesium content between the two species of snail studied (Table 2). The values obtained in this study were higher than those reported by [19], where they recorded 301.20mg/100g for *A. fulica* and 304.62mg/100g for *A. achatina*. However, the results were higher than those reported by [26], where they recorded 0.28mg/100g for *L. aurora* species of snail. This difference may be due the differences in breed of the snail and the type of diet consumed by the snails in the wild. Magnesium is an essential mineral for human nutrition, it is needed for more than 300 biochemical reactions in the body. It helps to maintain normal nerve and muscle function, supports a healthy immune system, keeps the heartbeat steady, and helps bones remain strong. It also helps adjust blood glucose levels. It aids in the production of energy and protein [35]. Hence, consumption of these snails will help to boost the amount of magnesium in our bodies due to its importance.

The phosphorus concentration ranged from 632.02mg/100g to 69.10mg/100g in this study, with *L. aurora* exhibiting the highest phosphorus content than *A. fulica* (Table 2). There was a significant (P < 0.05) difference in the level of phosphorus in the meat powder among the two snail species studied. These results were higher than the values of 0.15mg/100g and 61.29mg/100g that were reported by [19, 26] for *L. aurora* and *A. fulica* snails respectively. Phosphorus is also a component of teeth and bones, similar to calcium, with approximately 85% of phosphorus found in bones [36]. The phosphorus concentration in milk, beef, liver, and eggs was reported by [29] to be 95mg/100g, 156mg/100g, 313mg/100g, and 218mg/100g, respectively. Comparing the results obtained in this study for phosphorus shows that *L. aurora* snail species is a good source of phosphorus unlike *A. fulica* snail.

Zinc was found in significant concentrations in the two meat samples studied, with *L. aurora* exhibiting the highest level (281.01mg/100g), while the lowest value (6.00mg/100g) of Zn was recorded for *A. fulica* species. There was a significant (P < 0.05) difference in zinc concentration between the two snail species studied. These findings were consistent with the reports of [19], where they obtained Zn values of 5.81mg/100g and 6.28mg/100g for *A. fulica* and *A. achatina*, respectively. However, the Zn contents in this study were higher than the values (3.08mg/100g and 2.64mg/100g) for *T. fuscatus* and *P. aurita* species, respectively, recorded by [22]. This difference may be due the differences in breed of the snail, genetic constitution and the type of diet consumed by the snails in the wild. Zinc plays a crucial role in dark adaptation and night vision in the human system [37, 38]. It is also essential for the production of nucleic acids (DNA and RNA), proteins, insulin hormones, and the normal functioning of the immune system and enzyme activation [39].

The iron (Fe) content was higher in *A. fulica* (24.21mg/100g) than in *L. aurora* species (4.78mg/100g) in this study [19]. Reported Fe concentrations of 26.64mg/100g for *A. fulica*, which were slightly higher than the results obtained in this study. This difference may be due the differences in breed of the snail, genetic constitution and the type of diet consumed by the snails in the wild. Iron is an important mineral for the formation of the *heme* molecule in hemoglobin, which carries oxygen in the bloodstream to different parts of the body. Sufficient iron intake in the diet is essential for reducing the incidence of iron deficiency anemia, especially in young children [40]. Based on the findings of this study, it is suggested that these two snail's species should be included in the diets of children due to their high iron content.

Amino acid composition of *Limicolaria aurora* and *Achatina fulica* snail's meat powder

The results of the total amino acid composition of *L. aurora* and *A. fulica* meat powders was 674.20mg/100g protein and 703.14mg/100g protein, respectively, as summarized in Table 3. There was a significant (P < 0.05) difference in the amino acids content between the two species of snail studied (Table 3). Aspartic acid and Glutamic acid were the highest contributors to the total amino acid content for *L. aurora* snail and *A. fulica* snail respectively. For *L. aurora* and *A. fulica* meat powders, the total essential amino acids with Histidine were 383.69mg/100g protein and 356.78mg/100g protein, respectively. Without Histidine, the total essential amino acids for the same species of snails were 347.69mg/100g protein and 315.44mg/100g protein, respectively, with leucine making the major contribution for *L. aurora* snail while arginine contributed majorly for *A. fulica* snail sample. Threonine was the least contributor to the essential amino acids for *L. aurora* snail while Methionine was the least contributor to the essential amino acids *A. fulica* snail sample.

Amino acids function as the building blocks of proteins, important for growth and development [5, 48]. In the meat powder (edible portions) of *L. aurora* and *A. fulica* snails, seventeen amino acids were identified, showing variations in individual, total, and essential amino acids among the two snail species studied [4, 22, 42, 43].

The higher concentrations of amino acids like Lys, Asp, Arg, Ser, and IIe in *Limicolaria* that was observed by [42] were also recorded in this study compared to *A. fulica* snail, despite the smaller size of the species. Variations in amino acid quantity within and between different species of snails have been observed by different researchers to be influenced by factors such as size, species, geographical location, and seasonal conditions [4].

Amino acids play essential functions in normal growth and development, with essential amino acids obtained from foods is needed to promote normal growth and maintenance of nitrogen balance. Their absence in foods may impair tissue growth and repair [4, 22, 45]. The essential amino acid composition in this study differs from the report of [26], with leucine being the highest contributor to total essential amino acids for *L. aurora* snail [42]. Reported lysine as the major contributor from *Limicoralia* species to essential amino acids. On the other hand, the high contribution of arginine to essential amino acid from *A. fulica* snail recorded in this study is in line with the report of [44] but differ from the report of [46] where they recorded threonine as the major contributor to essential amino acid.

A comparison of the essential amino acid content in this study with the [49] reference values indicated that most of the amino acids met the recommended range for infants and adults, and were significantly higher than the recommended amounts for pre-school and school children. [4, 42] attributed the availability of these amino acids to the lack of fibre and anti-nutritional properties in the samples. The high concentration of lysine recorded in this study for the two snail species aligns with previous works by [42], suggesting its efficacy for fortifying maize food products used for weaning children in some countries.

Furthermore, this research revealed that the two snail species were rich in histidine and arginine amino acids, which are important for children, as reported by [4, 47, 48, 49]. These findings indicate that the protein in *L. aurora* and *A. fulica* meat powders is of very high quality, with balanced essential amino acids suitable for food supplementation and fortification purposes.

Conclusion

The study showed significant variations in proximate composition, mineral content and amino acid concentration between the meat powders derived from *L. aurora* and *A. fulica*. These snail species exhibited high protein content and low-fat content. The essential amino acids identified in the study met the recommended ranges by FAO/WHO for both children aged 2 to 5 years and adults. Due to this low fat and high protein concentrations in the meat powders of these snail species, they can serve as valuable dietary supplements. However, the low-fat concentration suggests their potential use as additives in diets for individuals with hypertension and other fat related disorders. Strategically incorporating these meat powders into diet supplementation, fortifications, formulations, and development efforts can effectively leverage these affordable, nutritious, and natural sources of meat protein.

Significance statement

Significant differences were observed in proximate, mineral and amino acid compositions among the meat powders of the studied snail species. Most essential amino acids such as leucine, histidine, lysine, arginine, threonine, valine, methionine, isoleucine and phenylalanine were present. Proximate analysis revealed high energy, protein and carbohydrate but low fat and ash contents in the two species of snails. Mineral analysis indicated high levels of Ca, Na, K, Mg, P, while Fe were significantly low across the two species. The high protein and low-fat contents suggest that snail meat powder could be used as additives for food fortification to meet the demand for protein globally.

Competing interests.

The authors declare no conflicts of interest.

Author contributions

Owoidihe M. E. conceived the idea, provided support, and critically revised the manuscript. Ekerette E. E. structured the contents. Owoidihe M. E. and Lawrence E. O. wrote the manuscript. Nko S. B. contributed to the finding of materials. Owoidihe M. E. and Ekerette E. E. contributed to proofreading. All authors read and approved the final manuscript.

Acknowledgments

The authors wish to acknowledge all the laboratory attendance of both Biochemical and Biological Sciences at Topfaith University, Mkpatak, Akwa Ibom State, Nigeria.

References

1. Raut SK, Barker GM. *Achatina fulica* Bowdich and Other Achatinidae as Pests in Tropical Agriculture. In: Barker GM, editor. Molluscs as Crop Pests. Hamilton: CABI Publishing, 2002, 55-114.
2. Cowie RH, Dillon RT, Robinson DG, Smith JW. Alien non-marine snails and slugs of priority quarantine importance in the United States: A preliminary risk assessment. Am Malacol Bull,2009:27(1-2):113-132. doi:10.4003/006.027.0210.
3. Food and Agriculture Organization of the United Nations/World Health Organization. Report on the Joint FAO/WHO Expert Consultations on the Risks and Benefits of Fish Consumption. FAO Fisheries and Aquaculture Report No, 2010, 978.
4. Owoidihe ME, Etukudo E, Ekerette EE, John AU, Luka TT, Samuel BN, *et al*. Amino Acid Profile and Mineral Content Variations in Gastropod Species (*Archachatina marginata*, *Achatina achatina*, *Tympanotanus fuscatus*, *and Pachymelania aurita*): Implications for Dietary Enrichment. Eur J Nutr Food Saf,2024:16(8):130-141. DOI: https://doi.org/10.9734/ejnfs/2024/v16i81501.
5. Ersoy B, Sereflisan H. The proximate composition and fatty acid profile of edible parts of two freshwater mussels. Turk J Fish Aquat Sci,2010:10:71-74.
6. Periyasamy N, Srinivasan M, Devanathan K, Balakrishnam S. Nutritional value of gastropod, Babylonia spirata (Linnaeus, 1858) from Thazhanguda, Southeast Coast of India. Asian Pac J Trop Biomed,2011:249-252.
7. Etukudo OM, Asuquo BO, Ekaluo UB, Okon B, Ekerette EE, Umoyen AJ, *et al*. Evaluation of Genetic Diversity in giant African land snails using ISSR markers. Asian J Adv Agric Res,2018:7(2):1-13.
8. Ngenwi AA, Mafeni JM, Etchu KA, Oben FT. Characteristics of snail farmers and constraints to increased production in West and Central Africa. Afr J Environ Sci Technol,2010:4(5):274-278.
9. Sogbesan OA, Ugwumba AA, Madu CT. Nutritive potentials and utilization of garden snail (*Limicolaria aurora*) meat meal in the diet of *Clarias gariepinus* fingerlings. Afr J Biotechnol,2006:5(20):1999-2003.
10. Umoh IB, Bassir O. Nutrient changes in some traditional Nigerian foods during cooking-part 1: Vitamin changes. Food Chem,1977:2:155-160.
11. Mba AU. Chemical composition of some local sources of protein foods for man. Nigerian J Nutr Sci,1980:1(2):142-227.
12. Felici A, Bilandzic N, Magi GE, Iaffaldano N, Fiordelmondo E, Doti G, *et al*. Evaluation of long sea snail *hinia reticulata* (gastropod) from the middle Adriatic Sea as a possible alternative for human consumption. Food,2020:9(7):905.

13. Spackman DH, Stein EH, Moore S. Automatic recording apparatus for use in chromatography of amino acids. Anal Chem,1958:30:1191-1197.
14. AOAC. Official Methods of Analysis,18th ed. Washington D.C.: Association of Official Analytical Chemists: 2005.
15. Steel RG, Torrie JH. Principles and Procedures of Statistics: A Biometrical Approach,2nd ed. New York: McGraw-Hill: 1980. p,20-90.
16. Celik MY, Culha ST, Culha M, Yildiz H, Acarli S, Celik I, *et al*. Comparative study of biochemical composition of some marine edible molluscs at Canakkale Coast, Turkey. Indian J Geo-Marine Sci,2014:43(4):601-606.
17. Nurnadia AA, Azina A, Amin I. Proximate composition and energetic value of selected marine fish and shellfish from West Coast of Peninsular Malaysia. Int Food Res J,2011:18:137-148.
18. Adebayo-Tayo BC, Onilude AA, Etuk FI. Studies on microbiological, proximate, mineral and heavy metal composition of fresh water snails from Niger Delta Creek in Nigeria. Assumption Univ J Technol,2011:4(4):290-298.
19. Nkansah MA, Eric AA, Francis O. Mineral and proximate composition of the meat and shell of three snail species. J Home Page: www.cell.com/heliyon,2021:7.
20. Udoh AP, Akpanyung EO, Igiren IE. Nutrients and antinutrients in small snails (*Limicolaria aurora*). J Food Chem,1995:53:239-241.
21. Sogbesan OA, Ugwumba AA, Madu CT. Nutritive potentials and utilization of garden snail (*Limicolaria aurora*) meat meal in the diet of *Clarias gariepinus* fingerlings. Afr J Biotechnol,2001:5(20):1999-2003.
22. Inyang UE, Idorenyin GE, Barthlomew NE. Comparative study on the chemical composition and amino acid profile of periwinkle and rock snail meat powders. Int J Food Biotechnol,2018:3(2):54-59.
23. Ifon ET, Umoh IB. Biochemical and nutritional evaluation of Egreria radiata (clam), a delicacy of some riverine peasant populations in Nigeria. Food Chem,1987:24:21-27.
24. Ehigiator FAR, Oterai EA. Chemical composition and amino acid profile of a Caridean prawn (*Macrobrachium vollenhovenii*) from Ovia River and tropical periwinkle (*Tympanotonus fuscatus*) from Benin River, Edo State, Nigeria. Int J Recent Res Appl Sci,2012:11(1):162-167.
25. Alasalvar C, Taylor KDA, Zubcov E, Shahidi F, Alexis M. Differentiation of cultured and wild sea bass (Dicentrarchus labrax): total lipid content, fatty acid and trace element composition. Food Chem,2002:79(3):145-150.
26. Sogbesan OA, Ugwumba AA. Culture and nutrient values of *Limicolaria aurora* (Jay, 1989) (Mollusca: Achatinidae) raised in two different conditions. Rev Cient UDO Agrícola,2012:12(2):479-485.
27. Ademolu KO, Idowu AB, Mafiana CF, Osinowo OA. Performance, proximate and mineral analyses of African giant land snail (*Archachatina marginata*) fed different nitrogen sources. Afr J Biotechnol,2004:3:412-417.
28. Dambo WB. Tolerance of periwinkle Pachymelania aurita and *Tympanotonus fuscatus* to refined oil. Environ Pollut,1993:99:293-296.
29. Grosvernor MB, Smolin LA. Nutrition: From Science to Life. New York: Harcourt College Publishers, 2002, 404-469.
30. Engmann FN, Afoakwah NA, Darko PO, Sefah W. Proximate and mineral composition of snail (Achatina achatina) meat: any nutritional justification acclaimed health benefits? J Basic Appl Sci Res,2013:3(4):8-15.
31. European Food Safety Authority. Scientific Opinion on the dietary reference values for sodium. EFSA J,2019:17(9):5778.
32. Preuss HG, Clouatre DL. Sodium, chloride, and potassium. In: Erdman JW, Macdonald IA, Zeisel SH, editors. Present Knowledge in Nutrition,10th ed. Washington, DC: Wiley-Blackwell, 2012, 475-492.
33. Bailey JL, Sands JM, Franch HA. Water, electrolytes, and acid-base metabolism. In: Ross AC, Caballero B, Cousins RJ, Tucker KL, Ziegler TR, editors. Modern Nutrition in Health and Disease,11th ed. Baltimore, MD: Lippincott Williams & Wilkins: 2014. p,102-132.
34. Stone MS, Martyn L, Weaver CM. Potassium intake, bioavailability, hypertension, and glucose control. Nutrients,2016:8.
35. Yu ASL. Disorders of magnesium and phosphorus. In: Goldman L, Schafer AI, editors. Goldman-Cecil Medicine,26th ed. Philadelphia, PA: Elsevier: 2020. p,111.
36. Ihekoronye AI, Ngoddy PO. Integrated Food Science and Technology for the Tropics. London: MacMillan Edu. Publishers: 1985. p,283-285.
37. Burton BT, Foster WR. Human Nutrition. 4th ed. New York: McGraw-Hill Book Company, 1988, 49.
38. Christian P, West KP Jr. Interaction between zinc and vitamin A: an update. Am J Clin Nutr,1998:68(2):435S-441S.
39. Lilly TT, Immaculate JK, Jamila P. Macro and micronutrients of selected marine fishes in Tuticorin, South East Coast of India. Int Food Res J,2017:24(1):191-201.
40. Aksu T, Unal S. Iron deficiency anemia in infancy, childhood, and adolescence. Turk Arch Pediatr,2023:58(4):358-362.
41. Sarma D, Das PD, Das P, Bisht HCS, Akhtar MS, Ciji A. Fatty acid, amino acid and mineral composition of rainbow trout (*Oncorhynchus mykiss*) of Indian Himalaya. Indian J Anim Res,2015:49(3):399-404.
42. Adeyeye EI, Afolabi EO. Amino acid composition of three different types of land snails consumed in Nigeria. Food Chem,2004:85:535-539.
43. Babu A, Venkatesan V, Rajagopal S. Fatty acid and amino acid composition of the gastropods, *Tonna dolium* (Linnaeus, 1758) and *Phalium glaucum* (Linnaeus, 1758) from the Gulf of Mannar, South East Coast of India. Ann Food Sci Technol,2011:12(1):159-163.
44. Mead AR, Kemmerer AR. Amino acid content of dehydrated giant African snails (*Achatina fulica Bowdich*). Science,1953:117(3032):138-139.
45. Jayaprabha D. Amino acid and fatty acid profile of the marine gastropod *Turbo brunneus* (L., 1758) along the Gulf of Mannar Region of Thoothukudi. Int J Recent Innov Trends Comput Commun,2016:4(5):284-287.

46. Manukovsky NS, Kovalev V, Tikhomirov AA, Tikhomirov AA, Kalacheva GS. The giant African land snail *Achatina fulica* (Bowdich, 1720) as a candidate species for bioregenerative life support systems. J Siberian Fed Univ Biol,2015:8(1):18-31.
47. Muller HG, Tobin G. Nutrition and Food Processing. London, UK: Groom Helm: 1980.
48. FAO/WHO/UNU. Energy and protein requirements. Report of a Joint FAO/WHO/UNU Expert Consultation. World Health Organization Technical Report Series 724. Geneva: WHO: 1985.