Nutrient composition of different species of land snails (White-skinned and Black-skinned Archachatina Marginata and Limicolaria) in Calabar, Nigeria

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ABSTRACT

Background: *Snail farming is relatively new in West Africa, especially in Calabar, where snails are commonly consumed but under-researched, with limited information available on their nutritional composition and potential health benefits.*

Objective: *The study investigated the nutritional composition of different species of land snails, focusing on white-skinned (AMW) and black-skinned (AMB) Archachatina marginata, and Limicolaria (L) snails. Their proximate, mineral, and vitamin compositions were evaluated for nutritional value and dietary benefits.*

Methods: *Snail samples were bought from a local market in Calabar. Proximate composition (moisture, crude fibre, fat, ash, protein, carbohydrates), mineral content (iron, zinc, calcium, magnesium, potassium), and vitamin levels (A, E, K, D) were analysed using standard procedures. Statistical significance was determined at ($p \leq 0.05$).*

Results: *Moisture content was highest in L (89.50 ± 0.10%) and lowest in AMB (86.10 ± 0.01%). L had undetectable crude fibre. AMW and AMB had higher crude fat (2.82 ± 0.25%, 2.60 ± 0.02%) than L (1.23 ± 0.25%). AMB exhibited the highest protein content (8.37 ± 0.02%). AMW had the highest iron (2.44 ± 0.01 mg/100g), zinc (5.66 ± 0.02 mg/100g), and calcium (6.77 ± 0.02 mg/100g), while AMB had the highest magnesium (26.44 ± 0.04 mg/100g) and vitamin A (8.37 ± 0.01 mg/100g). AMW showed the highest vitamin E (0.66 ± 0.01 mg/100g). Significant differences were observed among species for most nutrients.*

Conclusion: *The snail species varied significantly in proximate, mineral, and vitamin compositions, highlighting their nutritional diversity and potential dietary importance. This study contributes valuable insights to nutritional.*

Keywords: Archachatina marginata, Limicolaria, proximate composition, micronutrients, snails.

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INTRODUCTION

The nutrients essential for human life, growth, and tissue repair include carbohydrates, proteins, fats, minerals, vitamins, water, and fibre (1). Protein, especially animal-based protein, is often in short supply in many people's diets in developing countries. Animal proteins have a more balanced and bioavailable amino acid profile than plant-based proteins (1). The acute shortage of animal protein in many people's diets, particularly in West Africa, necessitates efforts to promote the rearing of highly prolific and desirable animal protein sources (2).

While snails have been consumed as food since prehistoric times, the domestication and farming of snails, known as heliculture, is a relatively new venture in most of West Africa (3). The potential of the snail industry and the promotion of snail farming is a promising means of bridging the protein deficiency gap in many countries, as snails are highly prolific and nutritious (4). However, to fully harness this potential, it is crucial to understand the detailed nutritional profile of different snail species. This knowledge is essential to optimising their utilisation as a sustainable source of animal protein.
Snail meat is highly nutritious and an affordable alternative to beef that could help address protein malnutrition in developing countries like Nigeria. Research has shown that snail meat is richer in protein, iron, and essential amino acids than beef. In Nigeria, just 25g of snail meat can provide 45% of a child's daily protein needs (5, 6). Snails are widely available and cultivated in many parts of Africa, making them a cost-effective source of animal protein. Studies have found that the giant West African land snail (*Archachatina marginata*) is particularly high in protein (18-21% on a wet weight basis) and minerals like zinc, iron, magnesium, calcium, and phosphorus (7–9).
The high nutritional value of snail meat, combined with its affordability and accessibility, make it a promising solution to combat protein malnutrition, especially among vulnerable populations like children and pregnant women in developing countries. Incorporating snail meat into the diet through dishes like snail pie could be an effective way to improve nutrition and food security (10). However, more research is needed to characterise the nutrient profile of different snail species fully and species to optimize their use in nutrition interventions. Therefore, this research was aimed at investigating the proximate, mineral, and vitamin composition of different species of land snail; White-skinned, Black-skinned *Archachatina marginata*, (Giant African Land snails known in Calabar as 'Ekwong' in Efik)and *Limicolaria* (tropical air-breathing land snail also known as Ekwong' in Efik) found in the Calabar metropolis of Nigeria.

MATERIALS AND METHODS

Materials

The materials that were used in this research include the following: White-skinned and Black-skinned *Archachatina marginata* and *Limicolaria*. These were bought from markets within the Calabar Metropolis

Samples

Eighty (80) medium-sized live land snails, each of three different species of *Archachatina marginata* consisting of white-skinned, black-skinned and *Limicolaria* snails, were weighed in the wet state and collected from two locations (Ediba and Target). They were adult snails whose exact ages could not be ascertained. The samples are shown in Figures 2 and 3.

Chemicals

The study used petroleum ether, sulphuric acid, sodium hydroxide solution, hydrochloric acid, distilled water, Kjeltec catalyst, bromocresol green, methyl red, ammonia solution, boric acid, methanol, acetylene and nitrous oxide, alumina, and silica. All chemicals were purchased from Avogadro Chemical Stores, Lagos, Nigeria.

Sample preparation

The flesh of the land snail was carefully deshelled using a local deshelling instrument. The gut content was removed with a clean stainless-steel kitchen knife. The fresh meat was then washed with 0.1 % HCl solution to remove the slime and rewashed with clean water to remove the solution. The snails were chopped into smaller sizes to facilitate the drying. The fresh matter of the samples were dehydrated in a laboratory oven at 60°C for 24 hours (7). The dried samples were reduced to powder using a Binatone (BLG 620) blender at 3000rpm. The samples were stored at room temperature in an air-tight container for proximate composition, mineral analysis and vitamin profile.

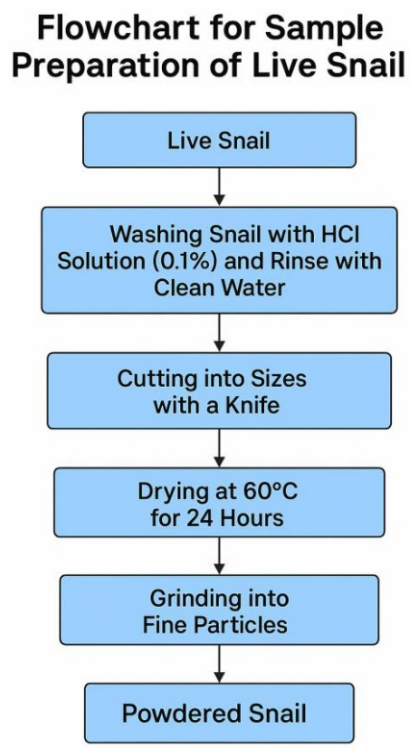

Fig. 1: Flowchart for sample preparation of live snail

The three blended dried snails were analysed for moisture content, crude fat, crude protein, total ash content, crude fibre, mineral content, and vitamin profile according to the Association of Official Analytical Chemists (AOAC)(11) analysis method. The carbohydrate content of the sample was determined by difference.

Moisture content determination

The Petri dishes were washed thoroughly, dried in the oven, and placed inside a desiccator to cool and weigh. Five grams each of the samples were then placed on the weighed dishes, and the weight of the dishes plus the weight of the samples were taken (in triplicate). The samples were allowed to dry in the oven for three hours at 105°C and 30 minutes for the next two hours until constant weight was obtained. The sample was put in the desiccators and allowed to cool, and the dry weight of the sample plus the dish was taken. The calculation for the moisture was done as follows:

$$\%Moisture = \frac{loss\ in\ wt.of\ sample}{orginal\ wt.of\ the\ sample} \times 100$$

Determination of ash content

A 2g dry sample of finely ground snail was weighed into a crucible, and the sample was then transferred into a pre-heated muffle furnace at 550°C and left at that temperature for 8 hours until a white or light grey ash was obtained. Finally, it was cooled in a desiccator and reweighed. The percentage ash sample was calculated as follows:

$$\%\ Ash = \frac{weight\ of\ ash}{original\ weight} \times 100$$

Determination of fat content

The Soxhlet extraction method was employed to determine crude fat content. An assembled Soxhlet extractor with a reflux condenser and a previously weighed distillation flask was used. Each 2 g sample was placed into a fat-free extraction thimble, plugged with cotton wool, and positioned in the extraction chamber. The distillation flask was filled with 300 cm^3 of petroleum ether and heated on a heating mantle. Refluxing continued for 4 hours until the extractor siphoned over. Following extraction, the remaining solvent in the distillation flask was evaporated. The samples were then dried at 105°C for 1 hour in an oven, transferred to a desiccator to cool, and weighed.

Determination of protein

The crude protein content of the samples was determined using the Kjeldahl method. Each 5 g sample was weighed into a digestion flask, and a Kjeldahl catalyst tablet and 15 ml of concentrated sulfuric acid were added. The flasks were heated at 420°C for 30 minutes until a clear mixture was obtained, then cooled and diluted with 50 ml of distilled water. The diluted contents were placed in a Kjeldahl analyser with 50 ml of 40% sodium hydroxide and heated to release ammonia, which was distilled into a flask containing 25 ml of 2% boric acid. During distillation, an indicator of bromocresol green and methyl red was added. The ammonia reacted with boric acid to form ammonium borate, which was titrated against 0.1 M hydrochloric acid to a purplish-grey endpoint. The percentage of nitrogen was calculated using the formula:

$$\%\ Nitrogen = \frac{1.401\ \times M \times (titre - blank)}{weight\ of\ the\ sample}$$

Where M = molarity of acid
ml blank = 0.2
ml titrant = volume of acid used.
The % crude protein was obtained by multiplying % nitrogen by a factor of 6.25.

Determination of carbohydrate

The carbohydrate content of the snails was determined by difference:
% Carbohydrates= 100 – (% moisture + % ash content + % crude protein + % crude fibre + % crude fat).

Mineral content determination

The Flame Atomic Absorption Spectrophotometry Analysis was used to determine the mineral content (iron, zinc, calcium, magnesium, and potassium) as described by (12). Briefly, 5 g of each sample was diluted in 100 ml of distilled water in a conical flask and introduced into the spray chamber through a capillary tube. The liquid sample was aerosolised and mixed with combustible gases (acetylene and air or acetylene and nitrous oxide) in the spray chamber and then burned in a flame. As the solution evaporated, the sample's atoms were produced. Ultraviolet light from a hollow cathode lamp was used to excite these atoms. When the atoms returned to their ground state, they emitted radiation at specific wavelengths. The intensity of this light, measured at characteristic wavelengths (e.g., sodium (Na) appears yellow), indicated the presence and concentration of minerals in the sample.

Vitamin determination

The snail meals were assessed for vitamins (vitamins A, D, E, and K) using chromatography as described by (13). This technique involved a long, thin tube filled with C 18 bonded silica packing material, through which fluids flowed to separate and quantify the fat-soluble vitamins. Upon injecting a sample at one end, different chemical structures in the sample travelled through the tube at unique rates based on their interactions with the packing material, leading to their separation. The separated substances were measured as they emerged from the far end of the tube, producing distinct peaks that were analysed with a mass spectrometer to measure their masses. Vitamin A and E in the snail meals were simultaneously measured on one HPLC column by injecting standard solutions and eluting with a methanol/water mixture, using a flow rate gradient to ensure different retention times and eliminate interfering matrix peaks. Vitamin K was determined using HPLC with fluorescence detection. In contrast, vitamin D was quantitatively analysed through liquid chromatography following sample saponification and extraction, with purification achieved via sequential alumina and silica columns.

Data analysis

The data generated from three replicates were expressed as mean ± standard deviation. Statistical analysis was performed using analysis of variance (ANOVA) with a significance level at $p \leq 0.05$, conducted in SPSS (version 17), to assess differences in quality attributes among samples from different species of land snails. Mean differences were further analysed using Duncan's multiple-range comparison test within the same statistical package.

RESULTS

Proximate composition of different species of land snail

The proximate composition of white (AMW) and black-skinned (AMB) *Archachatina maginata*, as well as *Limicolaria* (L) snails, is presented in Table 1. Moisture content varied significantly among the samples, with L showing the highest moisture content (89.50 ± 0.10%), followed by AMW (86.60 ± 0.05%) and AMB (86.10 ± 0.01%). Crude fibre was detectable in AMW (0.25 ± 0.25%) and AMB (0.50 ± 0.02%) but was not detected (ND) in L. In terms of crude fat, AMW (2.82 ± 0.25%) and AMB (2.60 ± 0.02%) had higher values compared to L (1.23 ± 0.25%). Ash content was relatively consistent among AMW (2.50 ± 2.25%) and AMB (2.25 ± 1.50%), but slightly lower in L (1.50 ± 0.50%). Protein content exhibited significant variability, with AMB (8.37 ± 0.02%) showing the highest value, followed by L (7.56 ± 0.02%) and AMW (7.41 ± 0.01%). Carbohydrate levels were generally low across all samples, with AMW (0.42 ± 2.26%) and L (0.21 ± 0.67%) showing higher values compared to AMB (0.18 ± 2.50%).

Mineral composition of the land snail species

Table 2 presents the mineral composition of white-skinned (AMW), black-skinned (AMB), and *Limicolaria* (L) snails, expressed in milligrams per 100 grams with mean values and standard deviations. Iron content was highest in AMW (2.44 ± 0.01 mg/100g), followed by AMB (2.14 ± 0.01 mg/100g) and L (1.97 ± 0.01 mg/100g). Zinc content varied with AMW showing the highest (5.66 ± 0.02 mg/100g), followed by L (5.22 ± 0.02 mg/100g) and AMB (4.66 ± 0.01 mg/100g). Calcium levels were highest in AMW (6.77 ± 0.02 mg/100g), followed by AMB (5.45 ± 0.00 mg/100g) and L (4.44 ± 0.01 mg/100g). Magnesium content was highest in AMB (26.44 ± 0.04 mg/100g), followed by AMW (24.56 ± 0.02 mg/100g) and L (22.77 ± 0.01 mg/100g). Potassium content was highest in AMW (97.88 ± 0.02 mg/100g), followed by AMB (88.65 ± 0.01 mg/100g) and L (79.50 ± 0.05 mg/100g).

Vitamin composition

Table 3 presents the vitamin composition (% mean ± SD) of white-skinned (AMW), black-skinned (AMB), and *Limicolaria* (L) snails. Vitamin A content was highest in AMB (8.37 ± 0.006mg/100g), followed by L (7.45 ± 0.006mg/100g) and AMW (6.25 ± 0.006mg/100g). Vitamin E content varied, with AMW showing the highest (0.66 ± 0.006mg/100g), followed by AMB (0.55 ± 0.006mg/100g) and L (0.49 ± 0.006mg/100g). Vitamin K levels were

Table 1: Proximate composition of white, black-skinned *Archachatina naginata* and *Limicolaria* snail.

Composition	AMW	AMB	L
Moisture	86.60 ± 0.05^{a}	86.10 ± 0.01^{b}	89.50 ± 0.10^{c}
Crude fibre	0.25 ± 0.25^{ab}	0.50 ± 0.02^{a}	ND
Crude fat	2.82 ± 0.25^{a}	2.60 ± 0.02^{a}	1.23 ± 0.25^{b}
Ash	2.50 ± 2.25^{a}	2.25 ± 1.50^{a}	1.50 ± 0.50^{a}
Protein	7.41 ± 0.01^{c}	8.37 ± 0.02^{a}	7.56 ± 0.02^{b}
Carbohydrate	0.42 ± 2.26^{b}	0.18 ± 2.50^{b}	0.21 ± 0.67^{a}

Values are means of triplicate determinations (±SD). Means with the same letter within the same row are statistically similar ($p > 0.05$). ND = not detected.

Table 2: Mineral composition of snail foot tissue (mg/100g, mean ±SD)

Elements	AMW	AMB	L
Iron	2.44±0.01[a]	2.14±0.01[b]	1.97±0.01[c]
Zinc	5.66±0.02[a]	4.66±0.01[c]	5.22±0.02[b]
Calcium	6.77±0.02[a]	5.45±0.00[b]	4.44±0.01[c]
Magnesium	24.56±0.02[b]	26.44±0.04[a]	22.77±0.01[c]
Potassium	97.88±0.02[a]	88.65±0.01[b]	79.50±0.05[c]

Values are means of triplicate determinations (±SD). Means with the same letter within the same row are statistically similar ($p > 0.05$). Key: AMW white is skinned snail; AMB is black-skinned snail; L is *Limicolaria*

Table 3: Vitamin composition of the land snail species

Vitamin	AMW	AMB	L
Vitamin A (mg/100g)	6.25±0.006[c]	8.37±0.006[a]	7.45±0.006[b]
Vitamin E (mg/100g)	0.66±0.006[a]	0.55±0.006[b]	0.49±0.006[c]
Vitamin K (µg/100g)	0.025±0.001[c]	0.035±0.001[b]	0.038±0.001[a]
Vitamin D (µg/100g)	0.048±0.001[a]	0.035±0.001[c]	0.037±0.001[b]

Values are means of triplicate determinations (±SD). Means with the same letter within the same row are statistically similar ($p > 0.05$). Key: AMW white is skinned snail; AMB is black-skinned snail; L is *Limicolaria*

highest in L (0.038 ± 0.001µg/100g), followed by AMB (0.035 ± 0.001µg/100g) and AMW (0.025 ± 0.001µg/100g). Vitamin D content was highest in AMW (0.048 ± 0.001µg/100g), followed by L (0.037 ± 0.001µg/100g) and AMB (0.035 ± 0.001µg/100g).

DISCUSSION

Snail meat has long been recognised for its rich nutritional value and is widely consumed in various cultures, particularly in Africa and Asia (14, 15). The proximate composition of snail meat typically includes high moisture content, contributing to its tenderness and palatability. Protein content in snail meat is substantial, providing essential amino acids crucial for human health, such as lysine, phenylalanine, and tyrosine (3, 10). These proteins support growth, tissue repair, and various metabolic functions (1). Fat content in snail meat is generally low to moderate, making it a healthy protein source with essential fatty acids that support cardiovascular health. Crude fibre content is minimal, usually below 1%, aligning with its tender texture. The ash content in snail meat, representing its mineral composition, includes important minerals such as iron, zinc, and copper (16). These minerals are vital for numerous bodily functions, including immune response, enzymatic processes, and oxygen transport (17). Carbohydrate levels in snail meat are typically low, making it suitable for low-carbohydrate diets and individuals managing conditions such as diabetes. The nutritional profile of snail meat positions it as a beneficial dietary component, providing essential nutrients while maintaining low levels of fat and carbohydrates (18, 19).

The proximate composition of white-skinned *Archachatina marginata* (AMW), black-skinned *Archachatina marginata* (AMB), and *Limicolaria* (L) snails reveals significant variations across different nutritional parameters. Moisture content was highest in *Limicolaria* snails (89.50 ± 0.10%), followed by AMW (86.60 ± 0.05%) and AMB (86.10 ± 0.01%). This high moisture content is consistent with previous studies that highlight the juiciness and tenderness of snail meat (3, 19). Crude fibre was detected in AMW (0.25 ± 0.25%) and AMB (0.50 ± 0.02%), but not in L snails, which aligns with existing literature reporting low fibre content in snail meat, typically below 1% (19, 20) Crude fat content was higher in AMW (2.82 ± 0.25%) and AMB (2.60 ± 0.02%) compared to L snails (1.23 ± 0.25%). This range is consistent with the documented fat content for *Archachatina marginata*, providing essential fatty acids for cardiovascular health (7, 19). The ash content was consistent across AMW (2.50 ± 2.25%), AMB (2.25 ± 1.50%), and L snails (1.50 ± 0.50%), falling within the typical 1.5% to 3% range. These minerals, including iron, zinc, and copper, are crucial for various physiological functions, such as preventing iron deficiency anaemia and supporting enzymatic functions and haemoglobin synthesis.

Protein content varied significantly, with AMB having the highest value (8.37 ± 0.02%), followed by L snails (7.56 ± 0.02%) and AMW (7.41 ± 0.01%). This protein level aligns with previous reports of 7% to 9% for land snails, providing essential amino acids for growth and tissue repair. Carbohydrate levels were low across all samples, with AMW (0.42 ± 2.26%) and L snails (0.21 ± 0.67%) showing higher values compared to AMB (0.18 ± 2.50%). This aligns with the known low carbohydrate content of snail meat, making it suitable for low-carb diets and managing diabetes (3). These findings align with previous research and highlight snail meat as a healthy addition to the diet, promoting growth, maintaining well-being, and aiding in managing certain health conditions (14).

The mineral composition of the land snails in this study aligns with findings from various similar studies (7, 8, 21). The studies revealed significant levels of minerals, including calcium, iron, magnesium, and potassium. *Archachatina marginata* had the highest concentrations, with calcium at 126.40 mg/100g, iron at 2.29 mg/100g, magnesium at 25.01 mg/100g, and potassium at 97.88 mg/100g. These values are comparable to those observed in our white-skinned snails (AMW) for the same minerals except for significantly lower calcium. They also found *Archachatina marginata* to have the best overall nutritional profile among the three species they studied. Other studies on the mineral composition of other edible land snail species, such as *Cyclophorus Saturnus* and *Mediterranean escargot*, have highlighted this variability, reinforcing the need to evaluate each species' specific nutritional characteristics (14, 20).

The nutritional benefits of these minerals are well-documented. Calcium is crucial for bone health, iron is essential for oxygen transport in the blood, magnesium supports muscle and nerve function, and potassium helps regulate fluid balance and muscle contractions (1). The high mineral content in snails makes them a valuable dietary component, especially in regions where these nutrients might be deficient in the typical diet (1). Moreover, the variation in mineral content among different snail species can influence their dietary significance. For example, the higher magnesium content in black-skinned snails (AMB) compared to *Limicolaria* (L) suggests that AMB might benefit individuals needing higher magnesium intake. Similarly, the higher zinc content in AMW can support immune function and wound healing. Overall, the distinct mineral profiles of these snail species highlight their potential as a nutritious food source, contributing to a balanced diet and addressing specific nutritional needs. Based on the mineral composition data, the three snail species exhibit distinct nutritional profiles that could influence their dietary significance.

The white-skinned snail (AMW) stands out as a potentially superior source of several key minerals, including iron, zinc, calcium, and potassium, with significantly higher concentrations compared to the black-skinned snail (AMB) and the *Limicolaria* (L) snail. In contrast, the black-skinned snail (AMB) had the highest magnesium content. These differences in mineral content suggest that the snail species may have varying nutritional benefits and could be selectively utilised in dietary applications to target specific mineral requirements. This negates a widespread myth that white-skinned snails are 'unhealthy', with some cultures even forbidding their consumption.

The research indicates that the black-skinned snail (AMB) had the highest vitamin A content (8.37 ± 0.006mg/100g), followed by the *Limicolaria* (L) snail (7.45 ± 0.006mg/100g) and the white-skinned snail (AMW) (6.25 ± 0.006mg/100g). Vitamin A is an essential nutrient crucial in various physiological processes, including vision, immune function, and skin health (22). The observed differences in vitamin A content among the snail species could be attributed to factors such as diet, habitat, and genetic variations, which can influence the accumulation of this nutrient in the snail tissues (23). The white-skinned snail (AMW) exhibited the highest vitamin E content (0.66 ± 0.006mg/100g), followed by the black-skinned snail (AMB) (0.55 ± 0.006mg/100g) and the *Limicolaria* (L) snail (0.49 ± 0.006mg/100g). Vitamin E is a potent antioxidant that protects cells from oxidative damage and plays a role in maintaining a healthy immune system (24). The variations in vitamin E content among the snail species could be influenced by factors such as the snails' feeding habits, environmental conditions, and metabolic processes.

The *Limicolaria* (L) snail had the highest vitamin K levels (0.038 ± 0.001μg/100g), followed by the black-skinned snail (AMB) (0.035 ± 0.001μg/100g) and the white-skinned snail (AMW) (0.025 ± 0.001μg/100g). Vitamin K is essential for blood clotting and bone health. The differences in vitamin K content among the snail species could be related to their dietary preferences and ability to synthesise or accumulate this nutrient in their tissues. The white-skinned snail (AMW) had the highest vitamin D content (0.048 ± 0.001μg/100g), followed by the *Limicolaria* (L) snail (0.037 ± 0.001μg/100g) and the black-skinned snail (AMB) (0.035 ± 0.001μg/100g). Vitamin D is crucial for maintaining calcium and phosphorus homeostasis, supporting bone health, and regulating immune function (23). Factors such as sunlight exposure, metabolic processes, and dietary sources of vitamin D could influence the variations in vitamin D content among the snail species (25).

These macro and micro elements play important roles in the body. Thus, the consumption of these various snail species will contribute significantly to meeting the RDAs of these essential nutrients especially for vulnerable groups such as children and pregnant mothers. With the current rise in the prevalence of non-communicable disease (NCDs), consumption of lesser-known species of both animal and plant foods that are equally rich in essential nutrients, should be promoted (26). In addition, the findings of this research also indicate a very low-fat content in the three snail species, hence they may be a healthier alternative to red meat – especially for people managing any of the NCDs

These findings underscore the nutritional variability across different snail species, which could affect their dietary value and potential applications in nutrition and food science. Further research is needed to explore the underlying factors contributing to the observed differences in vitamin composition, such as the snails' feeding habits, environmental conditions, and genetic factors. Additionally, studies investigating these vitamins' bioavailability and potential health benefits in the context of snail consumption would provide valuable insights for developing snail-based food products and dietary supplements.

CONCLUSION

The results of this study reconfirm the macro and micronutrient content of snails, which could be used as food for humans. Snail production and consumption would go a long way in enhancing a nutritionally balanced diet. Apart from the relatively high protein content, all three species of land snails are good sources of zinc, calcium, magnesium, potassium, and iron. The nutritional analysis of white-skinned *Archachatina marginata* (AMW), black-skinned *Archachatina* marginata (AMB), and *Limicolaria* (L) snails revealed significant differences in their proximate, mineral, and vitamin compositions. AMB exhibited the highest protein content and vitamin A levels, while AMW had superior concentrations of essential minerals (iron, zinc, calcium, potassium) and vitamins E and D. *Limicolaria*, though lower in overall nutrients, showed the highest moisture content and vitamin K levels.

RECOMMENDATIONS

Land snails, especially AMW and AMB, should be

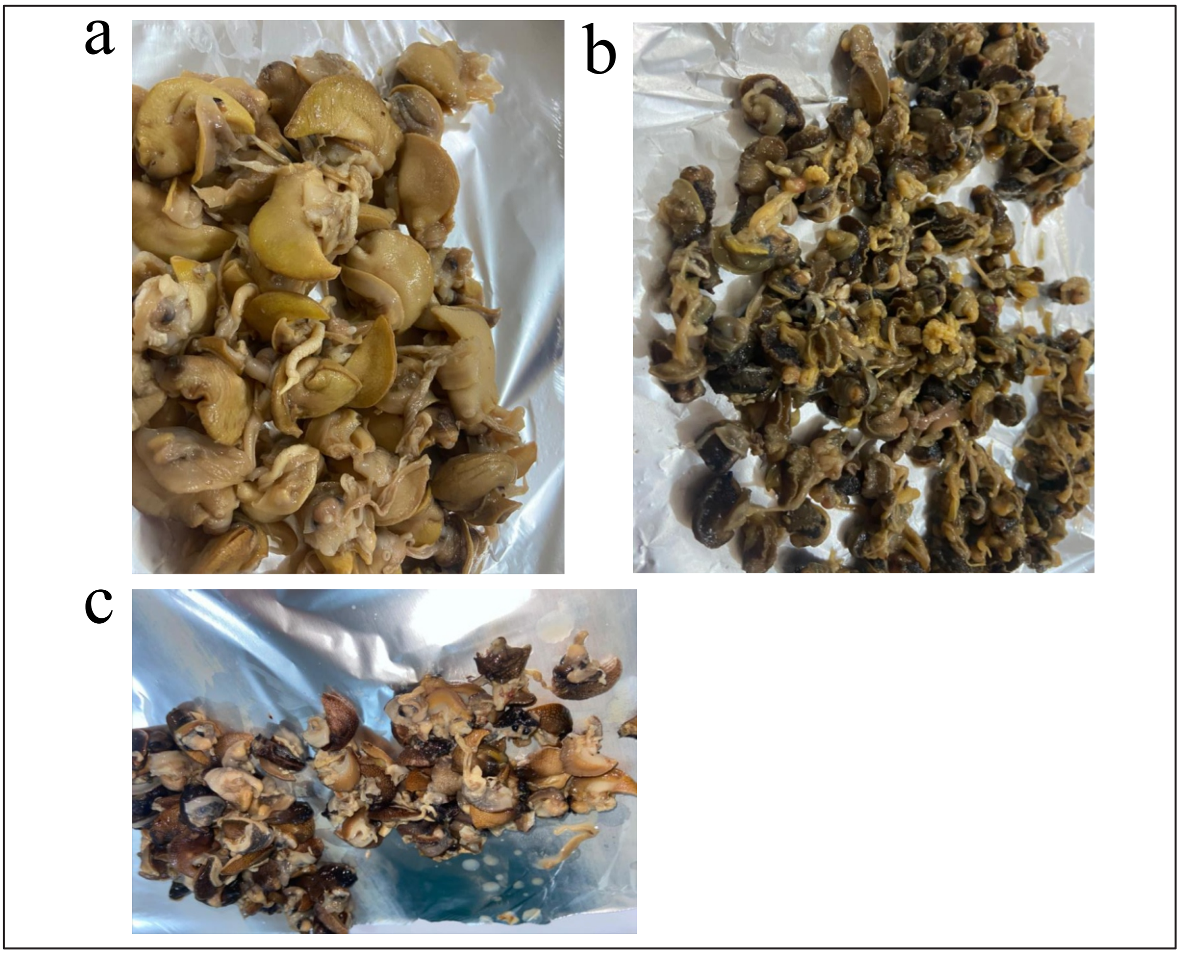

Figure 2: Carefully deshelled snails: plate a represents AMW, b represents AMB and c represents L

Figure 3: Dried powdered sample of land snails

promoted for their nutritional benefits, with AMB being prioritized for its protein content and AMW for its mineral and vitamin E content. Public education on their health benefits, investment in snail farming, and development of processing methods for high-moisture snails like *Limicolaria* can enhance their dietary inclusion and economic viability.

CONFLICT OF INTEREST

The authors hereby declare no conflict of interest exists.

AVAILABILITY OF DATA AND MATERIALS STATEMENT

All data is available in the manuscript. Additional information can be made available upon request.

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