

Effects of thermal processing methods on the chemical composition, microbial quality, and sensory properties of processed giant African land and water snail meats

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Abstract

This study evaluated the effects of different heat treatment methods on the chemical composition, microbial quality, and sensory properties of giant African land and water snail meats. A total of one hundred (100) fresh snails, comprising fifty (50) land snails and fifty (50) water snails, were processed by deshelling, washing, salting, and rinsing with potable water. The samples were divided into five groups, with four groups subjected to oven drying, cooking, roasting, and hot air dehydration, respectively, while the fifth group served as the untreated control. Standard analytical methods were employed to determine proximate composition, mineral and vitamin content, microbial load, and sensory characteristics. The results revealed that all heat treatments significantly reduced moisture content, thereby improving the shelf stability of the snail meats. Moisture content ranged from 6.00–17.26% for land snails and 6.17–14.39% for water snails, compared to higher values observed in the raw samples. Protein content decreased slightly following processing, whereas fat, ash, and fibre contents showed moderate variations, with a slight increase in carbohydrate content. Additionally, heat treatments led to reductions in mineral, vitamin, and anti-nutritional components. A significant reduction in microbial load was observed across all treatments, with total viable counts decreasing from 41.4×10^4 and 33.4×10^4 cfu/g in raw land and water snails to as low as 2.2×10^4 and 2.0×10^4 cfu/g, respectively, after hot air dehydration. Lead (Pb) was not detected in any sample. Sensory evaluation indicated that cooked samples were the most preferred. Generally, the findings demonstrated that heat treatments effectively enhance safety, shelf life, and consumer acceptability while retaining essential nutrients.

Keywords: Snail, nutritional composition, anti-nutritional factors, proximate, lead, microbial load

Introduction

The increasing global population and rising demand for high-quality dietary protein have intensified the search for alternative and sustainable food resources, particularly in developing countries where protein-energy malnutrition remains a significant public health concern (FAO, 2020) [14]. Animal protein plays a critical role in human nutrition by supplying essential amino acids required for growth, tissue repair, enzyme synthesis, and immune function (Ajomiew *et al.*, 2024). However, the widening gap between livestock production and protein demand, coupled with challenges such as inadequate storage facilities and inconsistent power supply in countries like Nigeria, has necessitated the exploration of non-conventional protein sources. In this regard, edible snails, especially the giant African land snail (*Archachatina marginata*) and aquatic species such as *Littorina littorea*, have gained recognition as affordable, accessible, and nutritionally valuable alternatives capable of contributing to food security and livelihoods.

Snail meat is highly valued for its rich nutritional composition, being a good source of high-quality protein, essential amino acids, minerals (including calcium, iron, and magnesium), and beneficial unsaturated fatty acids, while remaining relatively low in fat and cholesterol. These attributes make it a desirable component of healthy diets and a delicacy in many parts of West Africa. Beyond its nutritional importance, snail production and processing also provide economic benefits through income generation, employment opportunities, and reduced post-harvest losses,

particularly when preservation methods such as smoke-drying are employed (Egbe *et al.*, 2021; Olomu, 2011) [17]. Nevertheless, snail availability is often seasonal, with abundance during the rainy season and scarcity during the dry season due to aestivation, environmental factors, and declining wild populations resulting from deforestation and overexploitation. These challenges underscore the need for improved processing and preservation techniques to ensure year-round availability and quality.

Despite their benefits, snails are highly perishable and susceptible to microbial contamination due to their close interaction with soil, water, and organic matter, as well as their indiscriminate feeding habits. They may harbor a wide range of microorganisms, including potential pathogens, thereby posing health risks if consumed without proper processing. Heat treatment methods such as boiling, roasting, frying, steaming, and smoking are commonly used to enhance microbial safety, extend shelf life, and improve sensory qualities such as taste, texture, and aroma. However, these thermal processes can also induce significant changes in the chemical composition of snail meat, affecting protein structure, lipid stability, and mineral content, which may either enhance or reduce nutritional value. Given these combined effects on chemical, microbial, and sensory attributes, this study evaluated the impact of different heat treatment methods on giant African land and water snail processed meats with the aim of identifying optimal processing conditions that ensure safety, nutritional quality, and consumer acceptability.

Materials and Methods

1. Collection of Samples

One hundred (100) snails: fifty (50) African Giant Land Snail and fifty (50) of Water Snail were purchased from Akpan Andem and Itu Markets respectively, Akwa Ibom State. Each of the snails weighing 100g at fresh weight. They were carried in plastic containers to the Food Processing Laboratory in preparation for processing and analysis.

2. Sample Preparation and Processing

2.1. Preparation of Fresh Snail Meat

The method of Djikeng *et al.* (2022) [8] was adopted for this study. The purchased snails were taken to the laboratory where their meats were removed from the shell and part of the slime removed by washing with potable water. Alum was added to the meat to stop the slime and ease handling while opening the snails to remove the non-edible parts. After this step, the snail meat was thoroughly washed with clean water, thereafter were submerged in 0.2% saline in the ratio of 1:20 w/v for 60 minutes. Then rinsed thoroughly with clean water. The treated meat was kept in ziplock bags and then subjected to different processing methods.

2.2. Sample Preparation

Three different methods were examined, each having fifteen (15) snails of African Giant Land and 15 of water snails. The shells of the 15 snails from the two species were broken and snail meats were extracted. The snail meats extracted were thoroughly washed with distilled water and 0.2 % saline water solution. The washed snail meats were submerged in 2 litres of water containing 0.2% salt. After 4 hours of soaking, they were washed thoroughly under running water and then boiled for 8-10 minutes. The water was drained and the meats were transferred into cold water. The dressed snail meats were divided into four for different heat treatments namely Oven drying, cooking, roasting and Hot air dehydration).

2.3. Processing of the Snail Meat

The raw dressed snail meats were used in this study. They were divided into four groups for the following treatments: Oven drying, cooking, roasting and hot air dehydration. Raw, unprocessed snail meats were used as control for this study.

2.3.1. Processing Treatments

Oven Drying Method

The well cleaned snail meats were deshelled, washed, soaked in 0.2 % saline solution, rinsed, roasted and were placed in an electric oven (NAAFCO BS, OVH – 102, China) at 120 °C for 10 minutes for drying to constant weight.

Cooking Method

The well cleaned snail meats were deshelled, washed, soaked in 0.2 % saline solution, rinsed, cooked and were placed in a pot and cooked until it gets tender.

Roasting Method

The well cleaned snail meats were deshelled, washed, soaked in 0.2 % saline solution, rinsed, roasted on a heated gauze for 20 minutes to roast to constant weight.

Dehydration Method

The well cleaned snail meats were deshelled, washed, soaked in 0.2 % saline solution, rinsed, dehydrated in a hot air dehydrator (BN Equipment Co. 1853-Henan, CN) at 60 °C for 9 hours.

2.4. Experimental Design

A two factor (2x3) factorial experiment in a randomized complete block design with processing methods and the snail type (African Giant Snails each of Land and Water Snail) being the factors A and B respectively, was used to study the effect of the factors on the response variables. The processing method was at four levels Oven drying, cooking, roasting and dehydration of factor A. The levels of type of snails of factor B. Responses were modelled according to Obi (2002) as:

$$Y_{ijk} = \beta_0 + A_i + B_j + (AB)_{ij} + \varepsilon_{ijk} \quad \text{-----} \quad \text{Equation (1)}$$

Where Y_{ijk} = response variable, β_0 = intercept (constant), A_i = effect of i th treatment of factor A, B_j = effect of j th levels of factor B, $(AB)_{ij}$ = effect of interaction of i th and j th levels of factors AxB, ε_{ijk} = experimental error.

2.5. Determination of the proximate composition of the dried snail meats

Proximate composition (moisture content, protein, lipid, ash, fibre) of the dried snail meats was determined using standard methods (AOAC, 2012). Carbohydrate content was determined by difference.

2.6. Determination of Mineral Content of the dried snail meats

The minerals (Ca, Fe, K, Mg, Zn, P, Pb) were determined using Atomic Absorption Spectrophotometer (UNICAM model 939) described by Fraga *et al.* (2004).

2.7. Determination of Anti-nutritional factors of the dried snail meats

Tannins, Phytate, and Oxalate was determined following the standard methods of Onwuka (2005).

2.8. Determination of the vitamin composition of the dried snail meats

Vitamin A and Vitamin E was determined using the method described by AOAC (2012).

2.9. Determination of the microbiological examination of the dried snail meats

Microbiological analysis was carried out using the pour plate method as described by Onwuka (2005). Total viable bacteria and total fungal counts were estimated by multiplying the means of the total colonies by the dilution factor.

2.10. Determination of Sensory Evaluation of the dried snail meats

A 20-member consumer acceptance panel (Semi-trained) was drawn from the staff and student population of the Department of Food Science and Technology of the University of Uyo to evaluate the sensory characteristics of the snail meat from the different processing methods spiced with salt and pepper. A 9-point hedonic scale questionnaire with 9 = like extremely, 5 = neither like nor dislike and 1 =

dislike extremely was adopted according to literature (Lawless and Heymann, 1998). Each samples were assigned a 3-digit code and presented in a white ceramic plate in a white lighted and quiet laboratory environment. Samples were served in a randomized order with potable water and spit cup for rinsing of mouth in-between tasting of samples (Nwabueze *et al.*, 2008; Okafor and Ugwu, 2014). Sensory attributes were evaluated by the panelists for product appearance, aroma, texture, taste, and overall acceptability.

2.11. Statistical Analysis

All the data were subjected to statistical analysis using Analysis of Variance (ANOVA). The means were then separated with the use of Duncan New Multiple Range Test (DMRT) using the Statistical Package for the Social Sciences (SPSS) 23.0 software.

Results and Discussion

1. Proximate Composition of African Giant Land and Water Snail

The proximate composition of processed land and water snail meats is presented in Table 1. The moisture content ranged from 6.00–17.26% for land snails and 6.17–14.39% for water snails, values that are comparable to previous reports, although slightly higher than 6.58% reported by Engmann *et al.* (2013) [12] and within the range of 4.75–12.50% reported by Djikeng *et al.* (2023). The higher

moisture content observed in raw samples compared to processed ones confirms the effectiveness of heat treatments in moisture reduction. Lower moisture values recorded in oven-dried and dehydrated samples can be attributed to the removal of water by hot air, thereby enhancing shelf stability. In contrast, increased moisture in some treated samples may be linked to protein denaturation, which enhances water-binding capacity. Ash content ranged from 2.23–2.59% (land) and 2.17–2.21% (water), aligning with values reported in literature and indicating appreciable mineral content. Slight reductions in ash values may be due to mineral leaching during processing. Fat content was low (1.16–1.83%), confirming that snail meat is a lean protein source, consistent with earlier findings.

Protein content ranged from 35.86–47.50% for land snails and 34.53–42.62% for water snails, supporting the classification of snail meat as a rich protein source, although slightly lower than some reported values, possibly due to processing effects. Fibre content was relatively low (0.58–1.30%) compared to previous studies, likely due to heat treatment impacts. Carbohydrate content ranged from 31.12–41.13% (land) and 39.04–53.73% (water), showing a slight increase compared to some earlier reports. Overall, the results indicate that processing methods influence proximate composition but retain the nutritional value of snail meat.

Table 1: Proximate composition (%) of processed land and water snail meat

| Samples | Moisture | Protein | Fat | Ash | Fibre | CHO |
|--------------------|---------------------------|----------------------------|--------------------------|---------------------------|---------------------------|----------------------------|
| Land Snail | | | | | | |
| A ₀ | 15.92 ^a ± 0.02 | 47.50 ^a ± 0.01 | 1.46 ^c ± 0.04 | 2.70 ^a ± 0.02 | 1.30 ^a ± 0.02 | 31.12 ^d ± 0.11 |
| A ₁ | 6.00 ^d ± 0.01 | 38.76 ^{ab} ± 0.01 | 1.83 ^a ± 0.00 | 2.47 ^{bc} ± 0.01 | 1.11 ^b ± 0.02 | 49.83 ^a ± 0.02 |
| A ₂ | 17.26 ^b ± 0.01 | 35.86 ^c ± 0.02 | 1.28 ^d ± 0.02 | 2.35 ^c ± 0.02 | 1.12 ^{ab} ± 0.03 | 41.13 ^c ± 0.01 |
| A ₃ | 13.12 ^c ± 0.02 | 36.75 ^b ± 0.02 | 1.49 ^c ± 0.01 | 2.33 ^c ± 0.10 | 1.04 ^d ± 0.02 | 45.27 ^b ± 0.03 |
| A ₄ | 8.11 ^{cd} ± 0.02 | 38.69 ^{ab} ± 0.04 | 1.72 ^b ± 0.03 | 2.59 ^b ± 0.01 | 1.06 ^c ± 0.03 | 47.83 ^a ± 0.10 |
| Water Snail | | | | | | |
| B ₀ | 13.41 ^b ± 0.04 | 42.62 ^a ± 0.05 | 1.20 ^d ± 0.02 | 2.63 ^a ± 0.01 | 1.10 ^a ± 0.06 | 39.04 ^d ± 0.01 |
| B ₁ | 6.17 ^d ± 0.02 | 35.72 ^{ab} ± 0.10 | 1.55 ^a ± 0.02 | 2.21 ^a ± 0.01 | 0.62 ^c ± 0.03 | 53.73 ^a ± 0.02 |
| B ₂ | 14.39 ^a ± 0.01 | 34.53 ^b ± 0.04 | 1.16 ^a ± 0.10 | 2.17 ^c ± 0.02 | 0.87 ^{ab} ± 0.01 | 46.88 ^c ± 0.01 |
| B ₃ | 10.68 ^b ± 0.00 | 35.08 ^{ab} ± 0.04 | 1.33 ^c ± 0.02 | 2.20 ^{ab} ± 0.15 | 0.17 ^d ± 0.02 | 49.92 ^{bc} ± 0.02 |
| B ₄ | 7.80 ^{cd} ± 0.10 | 35.62 ^{ab} ± 0.01 | 1.54 ^a ± 0.10 | 2.18 ^c ± 0.01 | 0.58 ^c ± 0.01 | 52.28 ^b ± 0.01 |

Values are means of triplicate determination ± standard deviation. Means with different superscript in the same column are significantly (p<0.05) different.

Key: A₀ = Raw land snail meat, A₁ = Oven dried land snail, A₂ = Cooked land snail, A₃ = Roasted land snail, A₄ = Dehydrated land snail, B₀ = Raw water snail meat, B₁ = Oven dried water snail, B₂ = Cooked water snail, B₃ = Roasted water snail, B₄ = Dehydrated water snail.

2. Mineral Composition of African Giant Land and Water Snail meats

The mineral composition of processed and raw (control) land and water snail meats is presented in Table 2. Calcium content ranged from 45.57–51.10 mg/100 g for land snails and 2.20–4.15 mg/100 g for water snails, which is lower than values reported by Uboh *et al.* (2014) [23] and Djikeng *et al.* (2022) [8] but aligns with the findings of Olatidoye and Sobowale (2016) [16]. Calcium plays a vital role in bone and teeth formation, blood clotting, and nutrient metabolism (Kouadio *et al.*, 2015). Magnesium levels varied between 62.22–64.23 mg/100 g for land snails and 40.81–64.19 mg/100 g for water snails, slightly higher than Uboh *et al.* (2014) [23] but lower than Djikeng *et al.* (2022) [8]. Magnesium is crucial for cellular metabolism, enzyme activation, and nerve impulse transmission (Steinberg *et al.*, 2003). Phosphorus content ranged from 80.18–82.60

mg/100 g for land snails and 55.13 mg/100 g for water snails, lower than some reports but consistent with others (Uboh *et al.*, 2014) [23]. Phosphorus is important for bone strength, enzymatic functions, and B-vitamin activation (FNB, 1997). Iron content varied between 6.18–8.53 mg/100 g for land snails and 4.25–14.80 mg/100 g for water snails, reflecting slight losses due to heat treatment. Iron is essential for oxygen transport, heme synthesis, and redox reactions (Lukaski, 2004).

Zinc content ranged from 0.89–1.50 mg/100 g for land snails and 0.74–2.14 mg/100 g for water snails, lower than previous reports (Djikeng *et al.*, 2022; Engmann *et al.*, 2013) [8, 12], suggesting partial mineral degradation during processing. Potassium levels were 92.71–96.17 mg/100 g for land snails and 66.37–69.10 mg/100 g for water snails, also lower than previously reported, possibly due to heat

and leaching during processing. Potassium is key for intracellular cation balance, water regulation, and acid-base homeostasis (Otten *et al.*, 2006). Lead was not detected in any samples, indicating that heat treatment effectively eliminated this non-essential and potentially toxic element,

consistent with previous findings of very low lead concentrations in unprocessed snails (Omuku *et al.*, 2023) [18]. Overall, the results indicate that while processing slightly reduces some mineral levels, essential elements are retained at nutritionally significant amounts.

Table 2: Mineral Composition (mg/100g) of Processed Land and Water Snail meat

| Samples | Ca | Fe | Mg | K | P | Zn | Pb |
|--------------------|--------------------------|--------------------------|--------------------------|---------------------------|---------------------------|-------------------------|------|
| Land Snail | | | | | | | |
| A ₀ | 51.10 ^a ±0.04 | 8.53 ^a ±0.02 | 65.20 ^b ±0.01 | 96.17 ^a ±0.01 | 82.60 ^a ±0.01 | 1.50 ^a ±0.01 | 0.01 |
| A ₁ | 48.35 ^b ±0.01 | 7.48 ^a ±0.01 | 62.22 ^d ±0.01 | 94.58 ^b ±0.01 | 81.29 ^b ±0.02 | 1.31 ^a ±0.01 | ND |
| A ₂ | 45.57 ^d ±0.02 | 6.18 ^d ±0.01 | 62.78 ^c ±0.02 | 92.79 ^d ±0.01 | 80.81 ^c ±0.01 | 0.89 ^c ±0.02 | ND |
| A ₃ | 47.89 ^c ±0.01 | 7.31 ^b ±0.02 | 63.48 ^b ±0.01 | 93.26 ^c ±0.01 | 81.28 ^b ±0.02 | 1.14 ^c ±0.03 | ND |
| A ₄ | 48.65 ^b ±0.02 | 7.27 ^b ±0.01 | 64.23 ^a ±0.01 | 95.19 ^a ±0.02 | 82.17 ^a ±0.02 | 1.32 ^a ±0.01 | ND |
| Water Snail | | | | | | | |
| B ₀ | 4.15 ^a ±0.01 | 14.80 ^a ±0.01 | 44.60 ^b ±0.01 | 69.10 ^a ±0.01 | 58.11 ^b ±0.01 | 2.14 ^a ±0.01 | 0.04 |
| B ₁ | 3.61 ^b ±0.00 | 14.25 ^d ±0.11 | 43.27 ^b ±0.01 | 68.39 ^b ±0.02 | 56.89 ^b ±0.01 | 1.32 ^b ±0.02 | ND |
| B ₂ | 2.20 ^d ±0.02 | 12.84 ^c ±0.01 | 40.81 ^d ±0.02 | 66.37 ^{cd} ±0.02 | 55.13 ^{cd} ±0.01 | 0.74 ^c ±0.02 | ND |
| B ₃ | 2.79 ^c ±0.10 | 13.72 ^b ±0.01 | 42.75 ^c ±0.01 | 67.78 ^c ±0.11 | 55.67 ^c ±0.08 | 1.19 ^b ±0.01 | ND |
| B ₄ | 3.38 ^{bc} ±0.15 | 14.68 ^a ±0.02 | 64.19 ^a ±0.01 | 68.92 ^a ±0.01 | 57.28 ^a ±0.03 | 1.39 ^a ±0.02 | ND |

Values are means of triplicate determination ± standard deviation. Means with different superscript in the same column are significantly (p<0.05) different.

Key: A₀ = Raw land snail meat, A₁ = Oven dried land snail, A₂ = Cooked land snail, A₃ = Roasted land snail, A₄ = Dehydrated land snail, B₀ = Raw water snail meat, B₁ = Oven dried water snail, B₂ = Cooked water snail, B₃ = Roasted water snail, B₄ = Dehydrated water snail.

3. Vitamin Composition of African Giant Land and Water Snail Meats

The vitamin composition of processed and unprocessed land and water snail are presented Table 3. Vitamin A composition of processed and unprocessed snail in this study was in the range of 47.81 – 91.16 mg/100g while processed water snail ranged from 24.29 – 47.22 mg/100g. The range observed in this study for processed land snail was significantly higher than the report of Cagiltay *et al.* (2011) for unprocessed garden snail with (5.462mg/100g). Similar observation was observed for water snail that the vitamin A report of the present study was equally very

high when compared with the study of Cagiltay *et al.* (2011).

In terms of vitamin E, it was observed that the report from the finding of the present study with concentration of (1.85 – 6.72 mg/100g) and (1.38 – 5.11 mg/100g) for processed land and water snail meats. The value from the study for both land and water snail was in agreement with the findings of Cagiltay *et al.* (2011) for unprocessed garden snail with concentration of 0.88 mg/100g of vitamin E. the low values observed for snail from land and water could be attributed to the fact that they are rich sources of vitamin E rather vitamin A and other vitamins not evaluated.

Table 3: Vitamin Composition of Processed Land and Water Snail meat

| Samples | Vitamin A (mg/100g) | Vitamin E (mg/100g) |
|--------------------|----------------------------|---------------------------|
| Land Snail | | |
| A ₀ | 91.16 ^a ± 0.01 | 6.72 ^a ± 0.01 |
| A ₁ | 64.78 ^b ± 0.01 | 3.37 ^a ± 0.02 |
| A ₂ | 47.81 ^d ± 0.03 | 1.85 ^d ± 0.01 |
| A ₃ | 49.21 ^c ± 0.11 | 2.37 ^c ± 0.02 |
| A ₄ | 66.37 ^{ab} ± 0.10 | 3.18 ^{ab} ± 0.10 |
| Water Snail | | |
| B ₀ | 47.22 ^a ± 0.01 | 5.11 ^a ± 0.01 |
| B ₁ | 28.62 ^b ± 0.10 | 2.15 ^b ± 0.02 |
| B ₂ | 25.37 ^c ± 0.02 | 1.38 ^d ± 0.10 |
| B ₃ | 24.29 ^d ± 0.03 | 1.99 ^c ± 0.03 |
| B ₄ | 27.68 ^b ± 0.02 | 2.47 ^{ab} ± 0.03 |

Values are means of triplicate determination ± standard deviation. Means with different superscript in the same column are significantly (p<0.05) different.

Key: A₀ = Raw land snail meat, A₁ = Oven dried land snail, A₂ = Cooked land snail, A₃ = Roasted land snail, A₄ = Dehydrated land snail, B₀ = Raw water snail meat, B₁ = Oven dried water snail, B₂ = Cooked water snail, B₃ = Roasted water snail, B₄ = Dehydrated water snail.

4. Microbial Load of Processed Land and Water Snail Meats

The microbial load of processed and unprocessed land and water snails is presented in Table 4. Total bacterial counts

(TBC) of unprocessed and processed land snails ranged from 2.2 × 10⁴ to 44 × 10⁴ cfu/g, while water snails ranged from 2.0 × 10⁴ to 33 × 10⁴ cfu/g. These values for processed samples align with previous reports by Akpomie *et al.*

(2019) [4], who recorded lower bacterial counts in boiled, oven-dried, fried, and smoked snail samples, though counts for unprocessed snails were substantially higher in their study. The high bacterial load observed in unprocessed snail meat is expected, as snails are known to harbor diverse microorganisms, many of which can be pathogenic, posing potential foodborne risks if consumed raw or inadequately processed (Cardoso *et al.*, 2012) [7]. Heat treatment significantly reduced bacterial populations in all processed samples, indicating the effectiveness of thermal processing in improving microbial safety. Total fungal counts (TFC) followed a similar trend, with unprocessed land and water snails recording 5×10^4 cfu/g and 2×10^4 cfu/g, respectively, whereas processed samples exhibited markedly lower fungal loads.

The reduction in microbial load observed in processed snail meats can be attributed to the heat-labile nature of most bacteria and fungi. Land snails exhibited higher microbial counts than water snails, likely due to their interaction with soil and ability to produce spores that survive adverse conditions, whereas aquatic snails generally harbor fewer microorganisms. The results confirm that effective heat processing including boiling, roasting, oven drying, and hot air dehydration substantially minimizes microbial contamination, enhancing the safety and shelf-life of snail meat. These findings support previous observations by Paralapari *et al.* (2014), highlighting that proper processing effectively eliminates or reduces microbial populations, making snail meat safe for human consumption.

Table 4: Microbial Load (cfu/g) of processed land and Water Snail

| Samples | Total Bacterial Count | Total Fungal Count |
|--------------------|--------------------------------|--------------------------------|
| Land snail | | |
| A ₀ | $44 \times 10^{4a} \pm 0.17$ | $5 \times 10^{4a} \pm 0.03$ |
| A ₁ | $4.0 \times 10^{4c} \pm 0.11$ | $1.2 \times 10^{4c} \pm 0.08$ |
| A ₂ | $7.3 \times 10^{4b} \pm 0.15$ | $1.0 \times 10^{4d} \pm 0.02$ |
| A ₃ | $3.1 \times 10^{4cd} \pm 0.05$ | $1.1 \times 10^{4cd} \pm 0.02$ |
| A ₄ | $2.2 \times 10^{4d} \pm 0.09$ | $1.3 \times 10^{4b} \pm 0.05$ |
| Water snail | | |
| B ₀ | $33 \times 10^{4a} \pm 0.32$ | $2 \times 10^{4a} \pm 0.03$ |
| B ₁ | $3.3 \times 10^{4c} \pm 0.06$ | $1.3 \times 10^{4b} \pm 0.02$ |
| B ₂ | $2.4 \times 10^{4cd} \pm 0.01$ | $1.2 \times 10^{4c} \pm 0.03$ |
| B ₃ | $4.2 \times 10^{4b} \pm 0.02$ | $1.0 \times 10^{4d} \pm 0.02$ |
| B ₄ | $2.0 \times 10^{4d} \pm 0.06$ | $1.2 \times 10^{4cd} \pm 0.01$ |

Values are means of triplicate determination \pm standard deviation. Means with different superscript in the same column are significantly ($p < 0.05$) different.

Key: A₀ = Raw land snail meat, A₁ = Oven dried land snail, A₂ = Cooked land snail, A₃ = Roasted land snail, A₄ = Dehydrated land snail, B₀ = Raw water snail meat, B₁ = Oven dried water snail, B₂ = Cooked water snail, B₃ = Roasted water snail, B₄ = Dehydrated water snail.

5. Anti-Nutrient Composition of African Giant Land and Water Snail Meats

The anti-nutritional composition of processed land and water snails is presented in Table 5. Anti-nutritional factors are known to limit the utilization of many food species due to their potential negative effects on human and animal health. Tannins, for example, have traditionally been considered anti-nutritional, although their impact depends on chemical structure and dosage (Shantibala *et al.*, 2014). In this study, tannin levels ranged from 4.38–7.18 mg/100 g for land snails and 2.22–7.81 mg/100 g for water snails, with cooked samples exhibiting the lowest concentrations (4.38 and 2.22 mg/100 g) followed by roasted samples. The generally low tannin content across processed samples can be attributed to the application of heat, which reduces tannin levels. These findings align with previous reports of 7.48, 9.44, and 2.99 mg/100 g for unprocessed *A. achatina*, *A. fulica*, and *Limicolaria* sp., respectively (Omuku *et al.*, 2023) [18]. Oxalate levels ranged from 2.19–6.10 mg/100 g

for land snails and 1.94–5.93 mg/100 g for water snails, with observed values slightly higher than those reported by Omuku *et al.* (2023) [18].

Phytate content ranged from 1.12–3.90 mg/100 g for land snails and 1.09–3.10 mg/100 g for water snails, with all processed samples showing reduced levels, indicating that heat treatments effectively lowered phytate concentrations to permissible levels. Although slightly higher than unprocessed values reported by Omuku *et al.* (2023) [18], the levels recorded in this study remain within safe limits for human consumption. Anti-nutritional factors, when present in high concentrations, may interfere with mineral absorption, irritate the throat, or mimic arthritis-like symptoms (Shittu & Abubakar, 2014) [21]. The results demonstrate that processing methods such as cooking, roasting, and dehydration can effectively mitigate anti-nutritional factors in snail meat while preserving its nutritional value, making it safer and more suitable for human consumption.

Table 5: Anti-nutritional composition (mg/100g) of processed land and water snail

| Samples | Tannin | Oxalate | Phytate |
|-------------------|-------------------|----------------------|-------------------|
| Land snail | | | |
| A ₀ | $7.18^a \pm 0.01$ | $6.10^a \pm 0.01$ | $3.90^a \pm 0.01$ |
| A ₁ | $5.30^c \pm 0.01$ | $4.32^b \pm 0.02$ | $2.63^b \pm 0.01$ |
| A ₂ | $4.38^d \pm 0.02$ | $2.76^c \pm 0.01$ | $1.12^d \pm 0.02$ |
| A ₃ | $4.78^d \pm 0.02$ | $2.19^d \pm 0.02$ | $1.81^c \pm 0.03$ |
| A ₄ | $6.19^b \pm 0.01$ | $4.86^{ab} \pm 0.02$ | $2.84^a \pm 0.01$ |

| Water snail | | | |
|----------------|--------------------------|--------------------------|---------------------------|
| B ₀ | 7.81 ^a ± 0.01 | 5.93 ^a ± 0.01 | 3.10 ^a ± 0.01 |
| B ₁ | 3.59 ^b ± 0.02 | 3.59 ^b ± 0.02 | 2.53 ^b ± 0.10 |
| B ₂ | 2.22 ^d ± 0.10 | 1.94 ^d ± 0.01 | 1.25 ^c ± 0.02 |
| B ₃ | 2.78 ^c ± 0.02 | 2.32 ^c ± 0.02 | 1.09 ^d ± 0.00 |
| B ₄ | 4.19 ^b ± 0.01 | 3.77 ^b ± 0.01 | 2.41 ^{bc} ± 0.01 |

Values are means of triplicate determination ± standard deviation. Means with different superscript in the same column are significantly (p<0.05) different.

Key: A₀ = Raw land snail meat, A₁ = Oven dried land snail, A₂ = Cooked land snail, A₃ = Roasted land snail, A₄ = Dehydrated land snail, B₀ = Raw water snail meat, B₁ = Oven dried water snail, B₂ = Cooked water snail, B₃ = Roasted water snail, B₄ = Dehydrated water snail.

6. Sensory Attributes of Land and Water Snail Meats

The sensory evaluation of processed land and water snails is summarized in Table 6. Overall, the appearance of the samples was slightly liked, with mean scores ranging from 6.14 to 6.94. Among the samples, dehydrated water snail (B₄) received the highest appearance score (6.94), followed closely by cooked land snail (A₂) with 6.86, while oven-dried land snail (A₁) had the lowest score. In terms of taste, panelists preferred cooked land and water snails (A₂ and B₂), which scored 7.41 and 7.33, respectively. Oven-dried samples (A₁ and B₁) followed with scores of 6.82 and 6.73, while dehydrated water snail (B₄) received the lowest score of 6.26. Juiciness scores indicated that most samples were neither liked nor disliked, with cooked land and water snails (A₂ and B₂) being slightly preferred, recording scores of

5.71 and 5.48, while roasted samples (A₃ and B₃) scored lowest (5.14 and 5.12).

Regarding mouthfeel, panelists slightly liked all the samples, with scores ranging from 6.34 to 7.76. Cooked snails (A₂ and B₂) were most preferred, scoring 7.76 and 7.42, whereas dehydrated samples (A₄ and B₄) received the lowest scores of 6.43 and 6.34. For overall acceptability, cooked snails again led with mean scores of 7.84 (A₂) and 7.42 (B₂), followed by oven-dried samples (A₁ and B₁) with 7.36 and 7.20. Dehydrated samples were the least preferred (6.78–6.66). Overall, the sensory results indicate that cooking was the most favored processing method, likely due to panelists' familiarity with market-prepared cooked snails, followed by oven drying, while roasting and dehydration were less appreciated.

Table 6: Sensory evaluation of processed land and water snail

| Sample | Appearance | Taste | Juiciness | Mouthfeel | General acceptability |
|--------------------|---------------------------|---------------------------|--------------------------|---------------------------|---------------------------|
| Land snail | | | | | |
| A ₁ | 6.23 ^f ± 0.02 | 6.82 ^c ± 0.01 | 5.37 ^c ± 0.01 | 6.83 ^c ± 0.01 | 7.36 ^c ± 0.03 |
| A ₂ | 6.86 ^b ± 0.03 | 7.41 ^a ± 0.03 | 5.71 ^a ± 0.00 | 7.76 ^a ± 0.02 | 7.84 ^a ± 0.01 |
| A ₃ | 6.14 ^g ± 0.02 | 6.54 ^f ± 0.03 | 5.14 ^g ± 0.03 | 7.26 ^c ± 0.01 | 6.86 ^{fg} ± 0.02 |
| A ₄ | 6.32 ^{de} ± 0.10 | 6.65 ^e ± 0.03 | 5.16 ^f ± 0.02 | 6.43 ^{fg} ± 0.10 | 6.78 ^f ± 0.10 |
| Water snail | | | | | |
| B ₁ | 6.71 ^c ± 0.01 | 6.73 ^d ± 0.02 | 5.28 ^d ± 0.02 | 6.79 ^f ± 0.01 | 7.20 ^d ± 0.02 |
| B ₂ | 6.27 ^e ± 0.03 | 7.33 ^b ± 0.10 | 5.48 ^b ± 0.03 | 7.42 ^b ± 0.03 | 7.42 ^b ± 0.03 |
| B ₃ | 6.33 ^d ± 0.10 | 6.44 ^{fg} ± 0.10 | 5.12 ^g ± 0.02 | 6.88 ^{de} ± 0.03 | 7.14 ^e ± 0.10 |
| B ₄ | 6.94 ^a ± 0.03 | 6.26 ^g ± 0.02 | 5.48 ^e ± 0.61 | 6.34 ^g ± 0.02 | 6.66 ^g ± 0.03 |

Values are means of triplicate determination ± standard deviation. Means with different superscript in the same column are significantly (p<0.05) different.

Key: A₀ = Raw land snail meat, A₁ = Oven dried land snail, A₂ = Cooked land snail, A₃ = Roasted land snail, A₄ = Dehydrated land snail, B₀ = Raw water snail meat, B₁ = Oven dried water snail, B₂ = Cooked water snail, B₃ = Roasted water snail, B₄ = Dehydrated water snail.

Conclusion

This study evaluated the effects of different processing methods oven drying, cooking, roasting, and hot air dehydration on the chemical composition, anti-nutritional factors, microbial quality, and sensory attributes of giant African land and water snail meats. The results confirmed that snail meat is a nutritionally rich food source, containing high levels of protein, carbohydrates, and essential minerals such as calcium, magnesium, phosphorus, and potassium. Although heat treatments caused slight variations in nutrient composition, they did not result in significant nutrient losses. Notably, all processing methods effectively reduced anti-nutritional factors and microbial load to levels considered safe for human consumption, thereby improving the overall quality and safety of the products. Among the processing methods investigated, cooking emerged as the most effective in terms of nutritional retention, microbial safety, and sensory acceptability, followed by oven drying. These methods significantly reduced pathogenic microorganisms and enhanced organoleptic properties such as taste, texture, and overall consumer preference, with

cooked samples receiving the highest acceptability ratings. Based on these findings, cooking and oven drying are recommended as the most suitable processing techniques for snail meat, as they ensure improved preservation, safety, and quality while maintaining desirable nutritional characteristics. Furthermore, there is a need for future research to investigate the shelf-life stability, storage conditions, and potential industrial applications of processed snail meat, particularly in dried or powdered forms, to enhance its utilization in food formulation and commercialization.

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