



Morphometry and Nutritional Composition of Edible Mollusc Shells from Mkpatak, Nigeria: Implications for Industrial and Nutritional Applications

Etukudo, O. M.^{1*}, Ekerette, E. E.², Okonko, L. E.³ and Jonah, E. S.⁴

Abstract

The giant African land snails possess protective shells that support their soft bodies and help prevent dehydration. These functions are influenced by the chemical composition of the shells. This study investigated the shell morphometry and nutritional composition of edible molluscs (*A. marginata*, *A. achatina*, and *A. fulica*) procured from Offiong market in Mkpatak, Akwa Ibom State, Nigeria. The snails were washed with de-ionized water and dilute acid, cleaned and dried with hand towel after which it was de-shelled. The shells were then dried at 50 °C for 48 hours, ground into fine powder, and sieved to achieve uniformity in particle size and kept in clean and dry plastic bottles for further chemical analysis. Morphometric, proximate, and mineral analyses of the snail's shell were conducted. Significant interspecies differences ($P < 0.05$) were recorded in all measured parameters. *A. marginata* exhibited the highest values across morphometric indices (shell weight, length, and width), indicating its potential for structural applications. Proximate analysis revealed variations in protein, crude fibre, ash, fat, and carbohydrate contents, with *A. achatina* shell showing the highest fat and carbohydrate concentrations, while *A. marginata* had the highest crude protein. Mineral analysis indicated Mg and Fe as the most abundant elements, particularly in *A. achatina* shells, while calcium was generally high across all species, supporting its role as a major structural component. The findings indicate the biological and biotechnological potential of mollusc shells, suggesting their suitability as low-cost sources of minerals, construction materials, and feed additives in animal nutrition.

✉ Etukudo, O. M.: owoism1981@gmail.com; Phone No.: +2348132080471

¹ Department of Biological Sciences, Faculty of Computing and Applied Sciences, Topfaith University Mkpatak, Akwa Ibom State, Nigeria.

² Department of Genetics and Biotechnology, University of Calabar, Cross River State, Nigeria.

³ Department of Biological Sciences, Clifford University, Owerri, Abia State, Nigeria.

⁴ Library Unit, Topfaith University Mkpatak, Akwa Ibom State, Nigeria.

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1.0 Introduction

Molluscs have traditionally been identified and characterized using shell morphology, genital anatomy, and mantle coloration, criteria that remain essential in taxonomic classification and the description of new species (Okon, and Ibom, 2012; Etukudo *et al.*, 2017a). However, species exhibiting similar morphological traits, particularly during their juvenile stages, often pose taxonomic challenges due to extensive intraspecific variation (Etukudo *et al.*, 2024f). Morphometric and phenotypic traits such as body weight, shell length and width, mouth shell dimensions, and number of shell whorls are commonly used for species differentiation and are believed to be genetically regulated (Ibom, 2009; Okon and Ibom, 2012; Etukudo, 2017; Etukudo *et al.*, 2024h).

The shells of molluscs, primarily composed of calcium carbonate, perform critical biological functions by enclosing, supporting, and protecting the soft tissues of animals within the phylum Mollusca (Etukudo, 2024j). This phylum encompasses a range of species including snails, periwinkles, and clams (Ademolu *et al.*, 2015; Etukudo, 2024j). Despite the widespread consumption of animal-derived products such as milk, eggs, meat, and fish for their nutritional and sensory qualities, mollusc shells are often regarded as waste and are discarded (Ademolu *et al.*, 2015). Their improper disposal contributes to environmental problems such as offensive odors and visual pollution (Adewuyi and Ola, 2005; Ademolu *et al.*, 2015).

The shells of giant African land snails (*Archachatina marginata*, *Achatina achatina*, and *Achatina fulica*) are composed predominantly of calcium carbonate (CaCO_3), which imparts structural hardness and rigidity (Etukudo and Okon, 2025a). This structural composition plays a crucial role in protecting the animal from predators and adverse environmental conditions (Ponder *et al.*, 2019; Etukudo *et al.*, 2024h). In *A. marginata*, key inorganic constituents identified in the shell include K_2O , Fe_2O_3 , CaO , P_2O_5 , Al_2O_3 , ZnO , SrO , Cr_2O_3 , TiO_2 , and MnO (Ponder *et al.*, 2019). The concentration of metals has been reported in descending order as follows: $\text{Ca} > \text{K} > \text{Na} > \text{Mg} > \text{Fe} > \text{Zn}$ (Jatto *et al.*, 2010; Kolawole *et al.*, 2017; Owoyemi and Owoyemi, 2020), underscoring calcium carbonate as the principal component (Egonmwan, 2008; Ademolu *et al.*, 2015). Additionally, mineral ions such as Mg^{2+} , Ca^{2+} , Fe^{2+} , Na^+ , K^+ , and Cl^- have been reported in *A. marginata* shells (Houndonougbo *et al.*, 2012; Ademolu *et al.*, 2016; Říhová *et al.*, 2018).

Beyond their structural and ecological roles, snail shells also have traditional and domestic applications. They serve not only as a dietary calcium source for livestock but also hold value in ethnomedicine. In rural communities, shells are used for storing herbal remedies, and are commonly employed for washing utensils and brushing teeth (Ademolu *et al.*, 2015; Akinnusi *et al.*, 2018; Etukudo and Okon, 2025a).

Although mollusc shells hold promise as low-cost sources of minerals and industrial raw materials,

data on their properties remain scarce for specific Nigerian locations. In Mkpatak, a major mollusc-harvesting hub, shells are discarded despite potential uses in feed, fertilizer, and biomaterials. Local ecological conditions may influence shell size and composition, yet no study has assessed these parameters here. This research fills that gap by providing the first morphometric and nutritional profile of edible mollusc shells from Mkpatak, supporting their targeted industrial and nutritional applications.

2.0 Materials and Methods

2.1 Study area

The research was carried out in the Biochemistry Laboratory of Topfaith University, Mkpatak, Akwa Ibom State, Nigeria.

2.2 Experimental animals and processing of snails

A total of 150 adult black-skinned snails, comprising 50 individuals each of *Archachatina marginata*, *Achatina achatina*, and *Achatina fulica* were procured from Offiong Market in Essien Udim Local Government Area, Akwa Ibom State, Nigeria. Species identification and classification into *A. marginata*, *A. achatina*, and *A. fulica* were carried out using morphological profiles and templates established by Okon and Ibom (2012). Selection criteria also included the presence of four (4) to five (5) shell whorls, characteristic of the three species. Within each species, snails were randomly assigned into ten (10) replicate groups of five individuals each, and groups were labeled Replicate 1 to Replicate 10. For each replicate, the five (5) snails were washed with de-ionized water and dilute acid, cleaned and dried with hand towel after which it was sacrificed, and soft tissues and shells were separated following methods used by Ademolu *et al.* (2016). The shells were then dried at 50°C for 48 hours, ground into fine powder, and sieved to achieve uniformity in particle size and kept in

clean and dry plastic bottles for further chemical analysis.

2.3 Shell morphometry analysis

The snails selected for this study exhibited variation in the number of shell whorls (4 to 5), a criterion used to minimize age-related differences. The snail species were de-shelled and the shell weights of the three species were measured using a digital vernier caliper (± 0.01 mm) and a digital balance (± 0.01 g), and no physical injuries were observed on any of the specimens.

A range of phenotypic traits was recorded for each snail, including Shell Length (SL), Shell Width (SW), Length from Apex to First Whorl (LAFW), and Shell Weight (SLW). These measurements were obtained using standard protocols, with the snails positioned vertically (apex downward, broader part upward) and minimize stress.

Dimensional shell parameters such as SL, SW, and LAFW were measured using a Vernier caliper, while shell weight was determined using an electronic balance with 0.01 g precision. Qualitative trait including number of whorls was observed visually. Measurement procedures followed the methodologies of Memel *et al.* (2017) and Nkwendem *et al.* (2019). Methods employed for measurement of SL, SW, and LAFW are shown in Figure 1.

2.4 Proximate and mineral analysis

The proximate components (moisture, crude protein, fat, ash, and crude fiber) were determined using the standard procedures outlined in AOAC, (2005) methods. Carbohydrate content was calculated by subtracting the total of these components from 100. Mineral analysis (including calcium, potassium, sodium, magnesium, iron, phosphorus, and zinc) was carried out using an Atomic Absorption Spectrophotometer (Model 721, Medifriend, England), following the method described in AOAC, (2005) protocols.

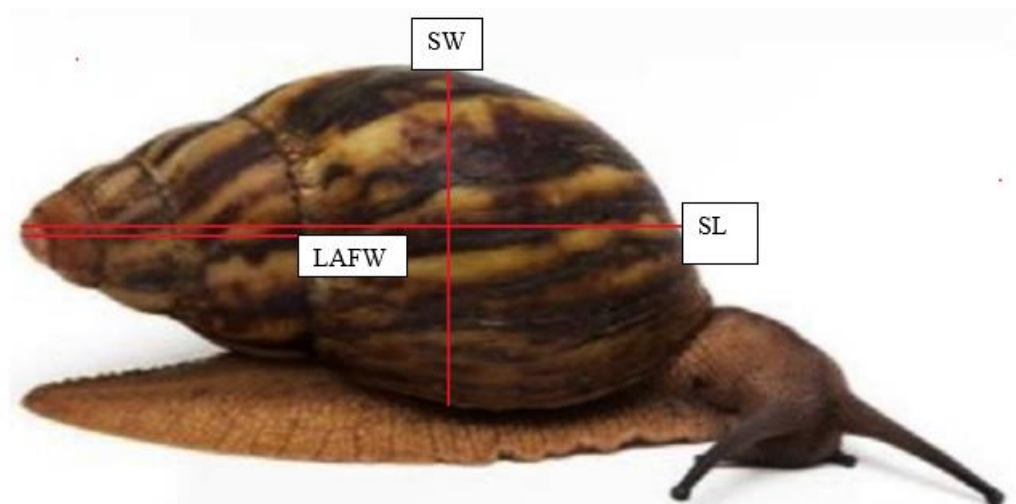


Figure 1: Method used for measuring shell dimensions of snails

2.5 Statistical analysis

The collected data were analyzed using SPSS Version 18 (SPSS, Inc., USA). ANOVA was performed to determine significant differences ($P < 0.05$), and means were compared using the Least Significant Difference (LSD) method. Mean, standard deviation, and standard errors were calculated following Dafaallah, (2017).

3.0 Results and Discussion

3.1 Morphometric properties of the mollusc shells.

The morphometric properties of mollusc shells from *Archachatina marginata*, *Achatina achatina*, and *Achatina fulica* were expressed as mean \pm standard deviation, along with the Coefficient of Variation for each parameter, significant

interspecies variability in shell properties was recorded (Table 1). Among the three species, *A. marginata* exhibited the highest mean values across all morphometric properties measured, followed by *A. achatina*, while *A. fulica* consistently recorded the lowest values.

The shell weight (SLW) showed a species-dependent variation, with *A. marginata* species having the highest mean shell weight (23 ± 15.18 g), followed by *A. achatina* (16 ± 9.13 g), and *A. fulica* (10 ± 0.60 g). *A. marginata* recorded the highest coefficient of variation (CV) of (66.0 %) for shell weight, showing a broad size range within this species, while the least coefficient of variation (CV = 6.0 %), indicating more uniformity in shell weight.

Table 1: Morphometric properties of the mollusc shells

Parameter	<i>A. marginata</i>		<i>A. achatina</i>		<i>A. fulica</i>	
	$\mu \pm s$	CV (%)	$\mu \pm s$	CV (%)	$\mu \pm s$	CV (%)
SLW (g)	23 ± 15.18^a	66.0	16 ± 9.13^b	57.06	10 ± 0.60^c	6.0
SL (mm)	141.3 ± 30.12^a	21.32	127.7 ± 56.03^b	43.87	81.7 ± 26.22^c	32.37
SW (mm)	80.7 ± 28.10^a	34.82	66.7 ± 28.24^b	42.34	44.0 ± 19.06^c	43.32
LAFW (mm)	75.6 ± 22.29^a	29.48	64.7 ± 21.11^b	32.63	45.4 ± 23.13^c	50.94

^{abc} Means on the same row with different superscripts are significantly different at $P < 0.05$.

SLW = Shell weight, SL = Shell length, SW = Shell width, LAFW = Length from Apex to First Whorl, CV (%) = Coefficient of Variation, $\mu \pm s$ = mean \pm standard deviation, *A. fulica* = *Achatina fulica*, *A. marginata* = *Archachatina marginata*, *A. achatina* = *Achatina Achatina*.

There was also a significant ($P < 0.05$) variation in shell length (SL) and shell width (SW) among the species of snails studied (Table 1). The longest and widest shells (141.3 ± 30.12 mm and 80.7 ± 28.10 mm) respectively, was recorded for *A. marginata* species, which was in line with its known status as the largest land snails in Nigeria in the Guinness Book of records (Okon *et al.*, 2012; Etukudo *et al.*, 2017 b). *A. achatina* followed with shell length (127.7 ± 56.03 mm), and shell width (66.7 ± 28.24 mm), while *A. fulica* snail recorded the shortest and narrowest shells (81.7 ± 26.22 mm SL and 44.0 ± 19.06 mm SW). the high coefficient of variations recorded especially for *A. achatina* species (43.87 % for SL; 42.34 % for SW), tailored towards substantial morphometric variability, which may be due to genetic diversity, age distribution, or environmental factors.

The Length from Apex to First Whorl (LAFW) followed the same decreasing trend: *A. marginata* species (75.6 ± 22.29 mm), *A. achatina* species (64.7 ± 21.11 mm), and *A. fulica* species (45.4 ± 23.13 mm). *A. fulica* species recorded the highest coefficient of variation (50.94 %), indicating pronounced variation in LAFW within the population.

The overall significant differences ($P < 0.05$) observed in morphometric properties of mollusc shells among the three species of snails likely reflect adaptations to growth conditions, ecological niches, and genetic constitution of the snails (Nkwendem *et al.*, 2023). The high SL and SW recorded across the three species of snails is in agreement with the reported of Adewuyi, (2014) and Ademolu *et al.* (2015) that because of their shell thickness they can be used for cutting objects and storing substances, and as good replacement for Ordinary Portland Cement in concrete production, because of their strong, hard and bristle properties. The high variation observed in *A. marginata* and *A. achatina* species may

indicate broader ecological plasticity and potential for selective breeding in conservation or domestication programs, while the low variability recorded in *A. fulica* suggests either a more uniform genetic pool or narrower environmental distribution (Ademolu *et al.*, 2015; Akinnusi *et al.*, 2018).

3.2 Proximate composition of the mollusc shells

The proximate composition of the shells derived from *A. marginata*, *A. achatina*, and *A. fulica* snails is presented in Table 2. The moisture content across all the three species was consistently 0.00 g/100 g. significant differences ($P < 0.05$) were recorded in the other proximate components.

The fat content of the shells ranged from 0.43 ± 0.06 g/100 g in *A. fulica* snail to 0.80 ± 0.05 g/100 g in *A. achatina* snail. High significant fat content ($P < 0.05$) was recorded in the shell of *A. achatina* than *A. marginata* and *A. fulica* shells. High content of Ash was observed in the shell of *A. fulica* snail (9.48 ± 0.56 g/100 g), followed by *A. marginata* shell (8.68 ± 0.44 g/100 g), while the lowest value (2.17 ± 0.42 g/100 g) was observed in *A. achatina* shell. Significant variation was observed in crude fibre content of the shells, with the highest (4.19 ± 0.61 g/100 g) recorded in *A. achatina* shell and *A. marginata* shell the lowest (2.36 ± 0.58 g/100 g). High significant ($P < 0.05$) crude protein was observed in *A. marginata* shell (0.40 ± 0.03 g/100 g) compared to *A. achatina* and *A. fulica* shells respectively. Carbohydrate content was highest (90.96 ± 15.92 g/100 g) in *A. achatina* shell, followed by *A. fulica* shell (88.07 ± 18.32 g/100 g), and the least value (85.92 ± 13.21 g/100 g) was recorded in *A. marginata* shell. No moisture was detected in all the shells of the three snail species studied. These observations were in line with the report of Ademolu *et al.* (2015), who recorded no moisture content in

Meretrix lusoria, *A. marginata*, *A. fulica*, and *A. achatina* shells.

Table 2: Proximate composition of the mollusc shells (g/100g)

Parameter	<i>A. marginata</i>		<i>A. achatina</i>		<i>A. fulica</i>	
	$\mu \pm s$	CV (%)	$\mu \pm s$	CV (%)	$\mu \pm s$	CV (%)
Moisture	0.00	0.00	0.00	0.00	0.00	0.00
Fat	0.76 \pm 0.09 ^b	11.84	0.80 \pm 0.05 ^a	6.30	0.43 \pm 0.06 ^c	13.95
Ash	8.68 \pm 0.44 ^b	5.07	2.17 \pm 0.42 ^c	19.35	9.48 \pm 0.56 ^a	5.91
Crude fibre	2.36 \pm 0.58 ^c	24.58	4.19 \pm 0.61 ^a	14.56	3.80 \pm 0.69 ^b	18.16
Crude Protein	0.40 \pm 0.03 ^a	7.50	0.18 \pm 0.04 ^c	22.22	0.29 \pm 0.07 ^b	24.14
Carbohydrate	85.92 \pm 13.21 ^c	15.37	90.96 \pm 15.92 ^a	17.50	88.07 \pm 18.32 ^b	20.80

^{abc} Means on the same row with different superscripts are significantly different at P< 0.05.

The authors further noted that the low moisture content of mollusc shells makes them suitable for use as coarse aggregates in construction. The absence of moisture observed in this study in all the mollusc shells samples suggests that the drying process was thorough, possibly due to complete dehydration prior to analysis. Variations were observed in fat content, with *A. achatina* shell recording the highest value unlike the other two species. The low-fat content observed in this study were in agreement with the reports of Yusuff and Oseni, (2004) who noted the same low-fat content in the shell of pond snail (*Lymnae stagnalis*). On the other hand, Ademolu *et al.* (2015) also reported low fat content but in different shells of

snails (*Archachatina marginata*, *Achatina achatina*, *Meretrix lusoria*, *Mercenaria mercenaria*, *Achatina fulica*, and *Littorina littorea*). The high fat content recorded in only *A. achatina* in this study, may indicate species-specific lipid deposition or retention in the shell matrix. Low fat and protein levels (Figure 2), indicate limited nutritional value in those macronutrients but donot reduce the shells' possible applications in industrial and biocomposite development processes (Ademolu *et al.*, 2015). Generally, mollusc shells are not known traditionally for fat content (Ademolu *et al.*, 2015).

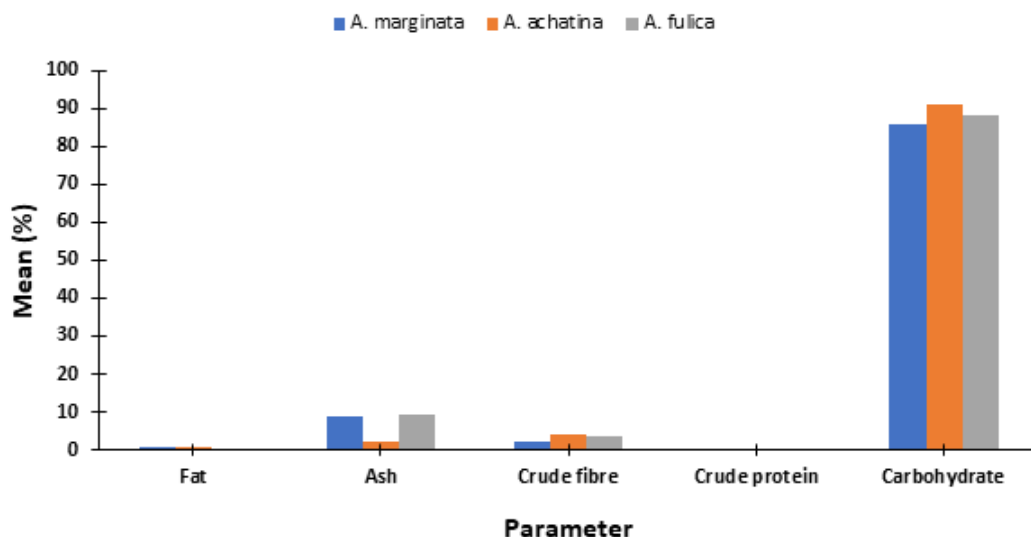


Figure 2: Proximate composition of the mollusc shells

Ash content was notably higher in *A. fulica* and *A. marginata* shells, indicating potential for use in mineral supplementation (Fig. 2). The high concentration of ash recorded in *A. marginata* and *A. fulica* shells in this study reveals a considerable amount of inorganic minerals, most likely calcium carbonate, which forms the basic matrix of mollusc shells. This is in line with their potential as sources of calcium for bioceramics or animal feed (Ademolu *et al.*, 2015). On the other hand, the lower ash concentration in *A. achatina* shell might reflect variations in shell density or mineralization patterns. The results obtained in this study for ash content were in line with the findings of Ademolu *et al.*, (2015).

The low crude fibre and protein levels observed in this study were in line with the reports of Amubode and Fafunwa, (2014) and Ademolu *et al.* (2015). Although the levels of fibre and protein were low, significantly they varied among the species studied. The high content of fibre in the shell of *A. achatina* may reflect shell adaptations structurally, while the high level of protein in *A. marginata* shell indicates a richer organic matrix, due to variations in shell formation mechanisms (Etukudo *et al.*, 2024c, d).

In this study, the shells are rich in carbohydrate, which likely reflects the predominance of polysaccharide-based structures (Fig. 2). The shell of *A. achatina* had the highest carbohydrate concentration, likely reflecting the residual organic matrix and undetected compounds; however, the large standard deviations indicate considerable within-species variability. Jatto *et al.* (2010) and Ademolu *et al.* (2015) noted that the high concentration of carbohydrate indicates the presence of polysaccharides and glycoproteins. Thus, shell of molluscs can be added to animal feeds as energy source.

Low coefficient of variation (CV) values was recorded for fat and ash in this study, showing

homogeneity, whereas crude fibre, protein, and carbohydrates recorded higher CVs which implies more biological variability. These findings align with previous reports on interspecies variability in mollusc shell biochemistry and highlight their diverse biotechnological potentials (Ozgo, 2012; Owoyemi and Owoyemi, 2020; Nkwendem *et al.*, 2023; Bashê and Al-Qassab, 2024)

3.3 Mineral analysis of the mollusc shells

All the mineral elements analyzed were detected in the shells, although their concentrations differed across the samples (Table 3). Magnesium was the most abundant mineral, ranging from 9.02 ± 0.47 to 73.50 ± 19.03 mg/g, followed by iron, which ranged from 8.01 ± 0.50 to 51.30 ± 16.03 mg/g, while Phosphorus recorded the lowest values, ranging from 0.48 ± 0.03 to 0.71 ± 0.04 mg/g respectively. *A. achatina* shells had the highest levels of Mg, Fe, and K, which were significantly ($P < 0.05$) higher than *A. marginata* and *A. fulica* shells. Conversely, *A. fulica* shells showed the highest levels of Zn, Na, and P, which were significantly ($P < 0.05$) higher than *A. marginata* and *A. achatina* shells. The lowest levels of Mg, Fe, and Ca were recorded in *A. fulica* shells.

The bar graph (Figure 3) presents the mineral composition of mollusc shells from three species: *A. marginata* (blue), *A. achatina* (orange), and *A. fulica* (gray). The minerals analyzed include Fe, Zn, Ca, Mg, Na, K, and P, with concentrations expressed in mg/g. The mineral composition of mollusc shells revealed marked interspecific differences among *A. marginata*, *A. achatina*, and *A. fulica*. Iron (Fe), calcium (Ca), and magnesium (Mg) emerged as the predominant minerals, while zinc (Zn), sodium (Na), potassium (K), and phosphorus (P) were detected only in trace amounts.

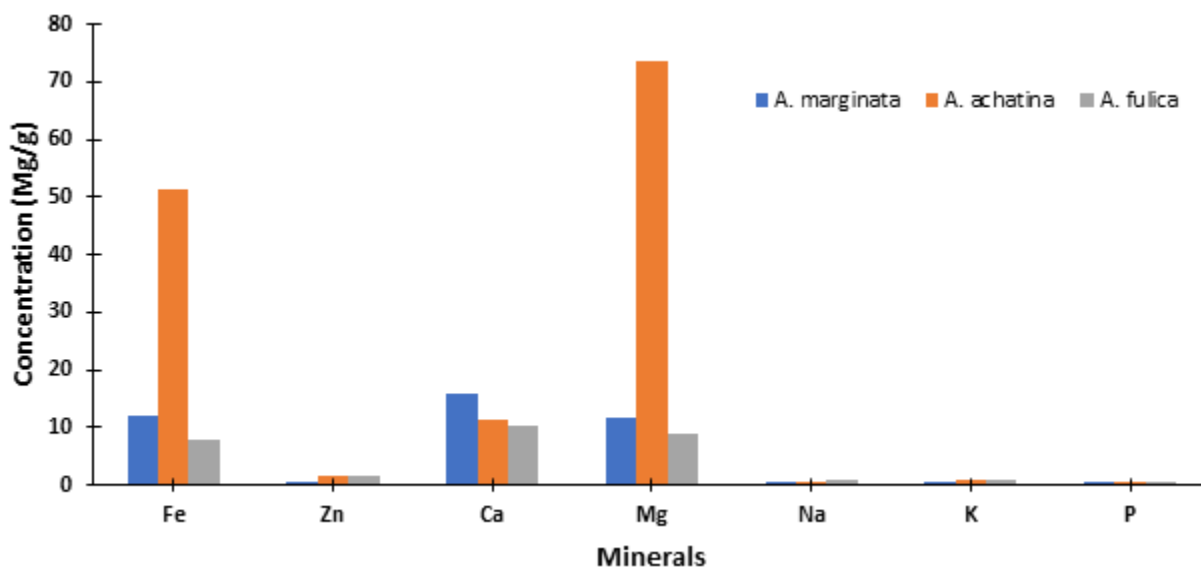
Table 3: Mineral analysis of the mollusc shells (mg/g)

Parameter	<i>A. marginata</i>		<i>A. achatina</i>		<i>A. fulica</i>	
	$\mu \pm s$	CV (%)	$\mu \pm s$	CV (%)	$\mu \pm s$	CV (%)
Fe	12.05 \pm 3.12 ^b	25.89	51.30 \pm 16.03 ^a	31.25	8.01 \pm 0.50 ^c	6.24
Zn	0.60 \pm 0.09 ^c	15.0	1.57 \pm 0.19 ^b	12.10	1.62 \pm 0.20 ^a	12.35
Ca	15.80 \pm 2.01 ^a	12.72	11.28 \pm 1.78 ^b	15.78	10.47 \pm 1.61 ^c	15.38
Mg	11.71 \pm 1.72 ^b	14.69	73.50 \pm 19.03 ^a	25.89	9.02 \pm 0.47 ^c	5.21
Na	0.70 \pm 0.04 ^b	5.71	0.63 \pm 0.11 ^c	17.46	1.01 \pm 0.12 ^a	11.88
K	0.69 \pm 0.06 ^c	8.70	0.92 \pm 0.08 ^a	8.70	0.84 \pm 0.07 ^b	8.33
P	0.67 \pm 0.09 ^b	13.43	0.48 \pm 0.03 ^c	6.30	0.71 \pm 0.04 ^a	5.63

^{abc} Means on the same row with different superscripts are significantly different at $P < 0.05$.

The mineral composition of the mollusc shells revealed significant ($P < 0.05$) variations among the different species studied. Notably, the *A. achatina* shells exhibited significantly higher levels of Fe and Mg compared to the other species. This difference may be attributed to genetic and species-specific differences, feeding behaviour and diet preferences, and habitat and environmental exposure. According to Owoyemi

and Owoyemi (2020), the chemical composition of shells can be influenced by changes in the habitat and environment. Magnesium and iron, though required in different proportions, are important for optimal health, productivity, and reproduction in livestock. Therefore, a balanced diet with adequate Mg and Fe prevents metabolism, and supports animal performance (Nkansah *et al.*, 2021; Etukudo *et al.*, 2024c, d).

**Figure 3:** Mineral composition of mollusc shells

In addition, Ca was found to be significantly more abundant than other minerals, and it was the next after Fe and Mg in mollusc shells. The high calcium concentration observed in this study confirms that calcium carbonate (CaCO_3) is the principal component of mollusc shells, and this

high calcium content may explain the traditional use of mollusc shells as abrasives, tooth-cleaning agents, and for controlling bleeding, as previously reported by Ademolu *et al.* (2015). Blood clotting involves the transformation of fibrinogen into fibrin, which creates a mesh that covers and seals

wounds, this process is highly dependent on the availability of calcium (Ademolu *et al.*, 2015). The abundance of essential minerals, particularly those needed for dental health, supports the use of snail shells in traditional tooth-cleaning formulations in rural parts of Ondo State, Nigeria, where the shells are oven-dried, ground into fine powder, and stored in clean containers (Ademolu *et al.*, 2015).

Phosphorus, potassium, sodium, and zinc concentrations in mollusc shells were found to be low in all the samples. This low concentration of these minerals, example, Zn in mollusc shells can be safely included in livestock diets because they are needed in minute quantity for enzyme function, immune system, and skin integrity (Ademolu *et al.*, 2015).

4.0 Conclusion

This study provides the first comparative morphometric, biochemical, and mineral profile of *A. marginata*, *A. achatina*, and *A. fulica* shells from Mkpatak, revealing distinct interspecies strengths that can inform targeted utilization strategies. The superior shell size and elevated protein content in *A. marginata* indicate its suitability for structural biocomposites and protein-enriched animal feed formulations. The enhanced Mg and Fe concentrations in *A. achatina*, alongside higher carbohydrate and fat levels, point to novel applications in oral hygiene products, hemostatic agents, and specialized dietary supplements for livestock. The consistently low moisture content across all species underscores shell stability, favouring long-term storage and processing for industrial, agricultural, and traditional uses. High Ca levels in all species confirm their value in cement production, bone health supplements, and ethnomedicinal preparations. By linking species-specific shell traits to specialized industrial and nutritional uses, this research establishes a

foundation for value-added processing, sustainable waste management, and local economic development in Mkpatak.

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