European Journal of Nutrition & Food Safety

12(6): 99-108, 2020; Article no.EJNFS.58401
ISSN: 2347-5641

Assessment of Nutritional Properties and Heavy Metal Composition of African Giant Land Snails (*Archachatina marginata*) and Clams (*Mercenaria mercenaria*) from Ekowe Community

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Authors' contributions

This work was carried out in collaboration among all authors. Author OIO conceptualized the research study, preparation of final manuscript, manage the literature searches. Author EEC reviewed and edited the draft manuscript. Author AMO supervised the research work. Author RA developed study design and carried out formal analysis. All authors read and approved the final manuscript.

Article Information

DOI:10.9734/EJNFS/2020/v12i630242
Editor(s):
(1) Dr. Raffaella Preti, Sapienza University of Rome, Italy.
Reviewers:
(1) Ausama Ayob Jaccob, Basrah University, Iraq.
(2) Anchal Choudhary, Patanjali Research Institute, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/58401

Original Research Article

Received 17 April 2020
Accepted 23 June 2020
Published 04 July 2020

ABSTRACT

Aims: This research was aimed at assessing the nutritional properties and heavy metal compositions of African giant land snails (*Archachatina marginata*) and clams (*Mercenaria mercenaria*) from Ekowe community.
Methodology: Mineral and vitamin contents were analyzed using the standard method of Association of Analytical Chemist. While standard wet digestion procedure was adopted in the sample preparation, heavy metals were analyzed using the Atomic Absorption Spectrophotometer technique.

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Results: Moisture contents were 76±0.63% & 78.4±0.06%, ash content, 1.37±0.01% & 3.45±0.01%, crude protein, 18.62±0.74% & 12.74±0.01% and lipid, 1.34±0.01% & 0.07±0.01% for *Archachatina marginata* and *Mercenaria mercenaria* respectively. Mineral contents were in this order: Ca > K > PO_4> Mg > Na > Fe >Mn for *Archachatina marginata* while *Mercenaria mercenaria* was Ca> K > PO_4 > Mg > Fe >Mn> Na. Vitamins profiles in *Archachatina marginata* were 5.20±0.198%, 0.144±0.004%, 0.05±0.003% and 0.78±0.035% for vitamin A, B_1, B_2 & E respectively. While *Mercenaria mercenaria* was 3.93±0.070%, 0.13±0.0025%, 0.075±0.001% & 0.84±0.01% for vitamins A, B_1, B_2 & E respectively. Heavy metal results in *Archachatina marginata* was in order of Zn > Cu > Cd > Ni > Cr while for *Mercenaria mercenaria* was Zn > Cu > Cd > Cr > Ni.

Conclusion: These metal values were low and within the WHO permissible limits. The result shows that snail could complement the required micro and macro nutrients and vitamins needed for proper growth and development in human and hence recommended for regular consumption.

Keywords: Mercenaria mercenaria; Archachatina marginata; nutritional properties; heavy metals; Ekowe.

1. INTRODUCTION

Archachatina marginata (AM) commonly called African giant land snail also known as Osie in Izon, Dodonkodi in Hausa, Igbin in Yoruba and Ejule in Igbo belongs to the group Phylum *Mollusca* and Family *Achatinidae* belonging to the class Gastropoda [1]. *A. marginata* are bilaterally symmetrical invertebrates with soft segmented exoskeleton, inhabiting mostly terrestrial environments, tolerating varied environmental conditions and thrive best in temperate and tropical areas, where soil pH ranges from 4.5-8.0 [2].

Nutritionally, snails are of paramount important as source of high profile protein, low in fat and rich in iron food ideal for human nutrition especially for diabetic patients [3]. Snails serve as valuable sources of nutrition to human and animals with high levels of protein, iron, calcium, phosphorus and amino acid such as lysine, leucine, and arginine, relatively low amount of sodium, fat and cholesterol compared to poultry and other livestock [4]. Snail meat compares favourably with whole egg in all essential amino acids especially with regard to lysine, leucine, isoleucine and phenylalanine [5].

Land snails are particularly well adapted to changes in moisture and dry conditions and are able to remain sealed within their thick shells for two or more years. Most snails have thousands of microscopic tooth like structures located on a ribbon-like tongue called a radula used to cut food into small pieces. Many snails are herbivorous, eating plants or rasping algae from surfaces with their radula. Many snails ingest small amount of soil particles and rasp larger rocks or snail shells in order to obtain Calcium which is essential to reproduction, shell development (snail shells are composed mostly of calcium carbonate $CaCO_3$), and other physiological needs [6]. African giant land snails are often found in many locations and have a very diverse type of habitat especially dump and dead decay plant or sites which ultimately maximize their productivity [7]. This may lead to the bioaccumulation of heavy metals in the snails, which is a major food chain route for the human body.

Clams are normally found along the seashores and across the coastal banks of the Atlantic and Pacific Ocean. The binomial name for Clams is maxima and it fits to the Bivalvia class in the family Veneridae. The word clam is frequently used to discuss to fresh water mussels and other freshwater bivalves as well as marine bivalves [8].

The hard clam (*Mercenaria mercenaria*) is the one used in this study which is locally known as water snail, and in Izon it is called Gbou, is a round clam or hard-shelled clam which is a marine bivalve mollusk. The shell of a clam can be connected by axis joint and can be divided into equal valves. It is beneficial and good for human health since it is a rich source of many important nutrients like phosphorous, calcium, potassium, protein, iron and other vitamins needed by the body. As regards to the nutritive health benefits value of consuming clams, it results for a sensible healthy decision as they contain negligible fat and are omega-3 fatty acids rich [8].

Clams can be classified as scavengers since they make use of their taps siphons to wrench in

and then sieve tiny units of organic matter and some inorganic materials from the nearby water source which shared to almost all clams in attaining their food; they are filter feeders. It is therefore necessary to assess the heavy metal composition of these edible clams for the safety of the consuming public. Since clams are collected from coastal banks the possibility to be infected with wastes on organic and metal pollutants present in the seawater is likely to happen, hence this research which was aimed at determining the nutritional properties and heavy metal compositions of African giant land snails and clams from Ekowe community.

2. MATERIALS AND METHODS

2.1 Collection and Preparation of Snail Samples

Fresh land snails and clams were obtained from Ekowe community and were taken to the Chemistry Laboratory of the Niger Delta University, Wilberforce Island, Bayelsa State. The snail samples were sacrificed by striking with a wooden material on the shell carefully. The flesh/foot of the snail was carefully removed from the shell and washed with adequate distilled de-ionized water, then dried with a stainless plate in an oven at 85°C to constant weight in 6 hours. After drying, samples were crushed to fine powder using porcelain mortar and pestle, and then sieved using a 0.4 mm mesh. The powdered samples were stored in 100 ml air tight bottles prior to laboratory investigation.

2.2 Analysis of Land Snail and Fresh Water Snail [9]

2.2.1 Determination of moisture

Powdered snail samples (5 g) were placed in an evaporating dish with lid and placed in a hot-air oven set at 105°C for 5 h. The dish with led were removed from the oven and placed in a desiccators to cool to room temperature. The dish and sample were weighed and placed back in the oven and dried further for another 2 h. This was repeated until a constant weight in obtained.
Calculation:

$$\%\, Moisture = \frac{M1}{M2} \times 100$$

Where M1= loss in grams in sample
M2=Sample size used

2.2.2 Determination of ash content

Materials from the moisture determined sample (2 g) were placed in silica Crucible and ignited on the burner till all organic matter is shared. The crucible was then transferred to a muffle furnace maintained at 550°C and kept for 6 hours till grey ash is obtained. Cooled in a desiccators weighed to determine the % ash content.

Calculation:

$$\%\, Ash = \frac{M1}{M2} \times 100$$

Where M1= weight of ash
M2= weight of sample used

2.2.3 Determination of crude protein

2.2.3.1 Procedure

A 1.5 g powdered sample was transferred to a Kjeldahl flash 15 g of K_2SO_4, 0.5 g $CuSO_4$ and 30 ml Conc. H_2SO_4 were added to the flask. The digestion flask was then placed on the heating block and heated gently in an inclined position until frothing ceases, then boiled briskly for 2 hours. Allow to cool to room temperature. 200 ml of H_2O was mixed with 25 ml of sodium thiosulphate solution of 80 g/l. A piece of anti-bump granules are carefully added to flask 1.25 ml of A (1+1) NaOH solution was also added to make the solution strongly alkaline. Connect the flask to a distillation apparatus with an efficient splash head and condenser. A delivery tube in attached to the tip of the condenser which hips just below the surface of receiving flask containing 50 ml of boric acid and 1 ml of methyl red. The digest was distilled in the conical flask until when 150 ml of the distillate has been collected, the distillation was discontinued. The amount of N_2 was determined by titrating the distillate with 0.0 ml H_2SO_4. At the end-point the colour changes from green to pink. A blank titration was also done [9].

Calculation:

$$\%\, N_2 = ml H_2SO_4 \times M \times \frac{14}{100} \times \frac{50}{100} \times \frac{100}{10}$$

$$\%\, Protein = N_2 \times 6.25$$

Where M= molarity of H_2SO_4
14= Atomic weight of Nitrogen
50= constant
10= constant
100= percentage

2.2.4 Determination of crude lipid

A moisture free sample (2 g) were weighed into a thimble and placed in a soxhlet apparatus. The mouth of the thimble was plugged with glass wool. The flask containing the solvent was Pre-weighed before adding the 120 L of petroluemeter with anti-bumps. Assemble the boiling flask the soxhlet apparatus and the condenser into an Electrothermal heater. The extraction tool 2 hours, there weighed flask with extracted fat was placed in a hot-air oven at 100°C for 30 min, cool in a desiccators and weighed the flask.

Calculation:

$$\%\ CrudeLipid = \frac{gfatofsample \times 100}{weightofsample}$$

2.2.5 Determination of crude fibre

A 2 g of defatted dry sample was weighed in a 450 ml beaker and 200 ml of 1.25% H_2SO_4 was added and boiled for 30 min, with constant stirring. At the end of the time, the beaker was taken down, cooled and filtered by paper and the fibre properly rinse. The residue was transferred into the beaker and 200L of 1.25% NaOH was added and boiled for another 30 min at the end of the time, the sample was flittered and washed with boiling water, Hcl and again with boiling water, finishing with 3 washings with petroleum spirit. The filter paper and the residue were transferred into an oven set at 100°C for 12 h. This was then cooled, and placed in a muffle furnace for 550°C for 3 h cooled and weigh.

Calculation:

$$\%\ Fibre = \frac{weightoffibre \times 100}{weightofsample}$$

2.2.6 Dry matter (DM)

Dry mater refers to material remaining after removal of water, and the moisture content reflects the amount of water present in the feed ingredient.

Calculation:

$$100 - \%\ Moisture = \%\ DM$$

2.2.7 Nitrogen free extract (NFE)

Nitrogen free extract in the analysis of foods and animal feeds which are the fraction that contains the sugars and starches plus small amounts of other materials.

Calculation:

$$[100 - (\%ash \times \%\ protein + \%\ Lipid + \%\ fibre)]\%$$

2.3 Determination of Minerals Content in Land Snail and Fresh Water Clams

About 2 g of samples were weighed into 100 mL Kjeldahl flask for digestion followed by the addition of 15 ml of digestion acid (1 ml Perchloric acid, 4 ml H_2SO_4, 3 ml HNO_3 and 1 ml HCl.1:4:3:1) this mixture constitute the digestion acid [9] the mixture was swirled to disperse the sample. The flask was placed on the digestion block and heated gently, until the frothing ceased, the strong briskly until a clear solution was obtained. After cooling 20 ml of distilled water was added to the digest and stirred well, this was then filtered in 100 ml volumetric flask and made up to the mark with distilled water, sodium (Na) and potassium (K) were analysed on the flame photometer, calcium (Ca) Magnesium (Mg) Iron (Fe) Manganese (Mn) Copper (Cu) Zinc (Zn) were analysed on the atomic absorption spectrophotometer (AAS) (Buck 210). Phosphates (PO_4) was analysed on UV/VIS Spectrophotometer using the Ammonium Molybolate method at 690 nm (Jenway. 6300) [9].

2.4 Determination of Vitamins

2.4.1 Vitamin (A) [10]

2.4.1.1 Preparation of standard solution

About 30 mg of the oily retinylacelate was weighed into a 100 ml volumetric flask containing some absolute ethanol. The solution was made up to the mark with ethanol. This solution contains 34.4 mg vitamin. A/g appropriate working standard were then prepared for the stand curve.

Finely ground samples (0.5 g) were placed in test tubes. 200 ml of alcoholic KOH was added to the tubes followed by another 200 ml of distilled water. These were mixed using vortex mixer for 20 sec. all the tubes were stoppered and placed in water bath at 600°C for 20 mins. A 1:1 mixture of xylene-kerosene was prepared while the Samples were being saponified in the water bath. The tubes were cooled to room temperature and 200 ml of xylene and kerosene mixture added. The tube were vigorously shaken to extract

retinol for 10 min. The tubes were further centrifuged at 100 pm for 5 min. The xylene kerosene was supernatant was withdrawn with a pasture pipette into Spectrophotometer cuvettes. The Spectrometer was set at 380 nm. The Absorbance values were recorded. The extracts were transferred from the cuvettes to glass tubes and were placed in UV light chamber and were irradiated along with the blank for 35 min. Their radiated samples were transferred into the cuvettes and the Absorbance recorded at 328 nm.

Calculations:

Retinol calculations were based on its extinction coefficient Ɛ637

$$Retinol(V1 + A) = A°(328) - A' \times 637$$

Where;

A^0 = Initial Absorbance

A^1 = Absorbance after irradiation

2.4.2 Determination of vitamin B1 (Thiamin)

2.4.2.1 Procedure: fluorimeter method [9]

Ground samples (0.2 g) were weighed into a 250 ml conical flask and 75 ml of 0.1m HCl was added and brought to boiling on a water bath for 30 minutes. The flask was cooled to room temperature and 5 ml of phosphates enzyme was transferred into a 100 ml volumetric flask and incubated at 370 cover weight. The mixture was filtered and purified by passing the filtrate through a silicate packed column. A mixture of 5 ml acidic KCl was placed in a conical flask, 3 ml of alkaline ferrieyanide and 15 ml of isobutanol and shaken for 2 min. The mixture was allowed to stand to allow the alcoholic layer to separate. 3 g of amh-Na_2SO_4 was added to the alcoholic extract. 5Ml of thiamin STD solution in a 50 ml flask and made up with ferrieyanide. This is to oxidize the thiamin and convert it to thiochrom. The blank was prepared adding 5 ml of the thiochrome formed and 3 ml of 15 % NaOH in refficyonide. The flourimeter was set to 360 nm as excitation wave length and the emission wave length at 435 nm. All measurements were done in triplicates. The instrument was zeroed with 0.1m H_2SO_4 and 100% against the standard blank.

Calculation:

$$ThiaminConstant = \frac{X}{Y} \times \frac{1}{5} \times \frac{25}{V} \times \frac{100}{W}$$

Where;

X= sample reading-blank

Y= standard reading-standard blank

V = volume of sample passed through the silicate column

W= weight of sample

2.4.3 Determination of b2 (riboflavin) [9]

2.4.3.1 Procedure

Finely ground samples (0.2 g) were weighed into a conical flask. 50 ml of 0.2ml HCl was added and placed on a water-bath and boiled for 1 h. It was cooled to room temperature and the pH was further adjusted to 4.5 with 0.1 ml HCl. The solution was then filtered into 100 ml volumetric flask and the volume made up to the mark with distilled water. In order to remove interference 2 test tubes were taken and marked 1 and 2. Tube 1 contains 10 ml of filtrate and 10 ml of H_2O. Tube 2 contains 10 ml of filtrate + 1 ml of riboflavin standard 1 ml of conc. acetic acid was added to both test tubes and mixed followed by 0.5 ml of 3% $KMnO_4$ solution. The tubes were kept in the dark for 5 min and 5 ml of H_2O was added and mixed again. The flourimeter was adjusted to excitation wave length at 470 nm and emission wave length at 525 nm. It was zeroed with 0.l ml H_2SO_4 and 100% against tube 2. The Fluorescence of tube 1 was then measured; 0.02 g of $NaHSO_4$ was added to both tubes and mixed. The fluorescence was measured within 10 min and recorded as blank reading. All measurements were done in triplicates.

Calculation:

$$Riboflavin\frac{mg}{g}ofsample = \frac{X}{Y - X} \times \frac{1}{W}$$

Where;

W= weight of sample

X= reading of sample tube 1-blank read

Y= reading of sample tube 1 + standard and 2 tube

2.4.4 Determination of vitamin E [10]

2.4.4.1 Sample preparation

About 2 g of finely ground samples were placed in a 50 ml conical flask and 15 ml of Diethylether-absolute ethanol solution (600 ml diethylether + 400 ml abs. ethanol) the mixture was agitated for 10 min and left on the bench to clear. The ether layer was withdrawn with 10 ml pipette and

placed in boiling tube and capped, 1 ml of 50% KOH was then added to saponify, 2 ml of ethanol was added and incubated in a water bath at 45°C for 2 h with the bubbling of N_2 gas through the tube after incubation, 1 ml of water in the mixture was extracted 5 times with 5 ml aliquots of ether. The Organic layer was then evaporated to dryness in the water-bath at 37°C. The residue was re-dissolved in 5 ml of methanol and diluted to 10 ml with methanol.

2.4.4.2 Preparation of vitamin standard solution (from Tocopheryl acetate)

About 1.10 g of Tocopheryl acetate weighed and dissolved in 4.5 ml of absolute ethanol and 0.33 g of ascorbic acid was also added into around bottomed flask fitted with a reflux condenser. This was placed in a water-bath. 1.10ml of 50% KOH was added and the mixture was refluxed for 20 min. The flask was cooled under a running tap; 25 ml of distilled water was added and agitated for 20 sec. The mixture was then extracted thrice with 30 ml aliquots of ethanol placed in a flask. The organic phase further washed with water and Dried with anhydrous Na_2SO_4 and filtered. The filtrate was further concentrated to a final Volume of 5 ml. This was then made up to 10 ml, five (5) standards were prepared 0.2, 0.4, 0.5, 0.8 and 10 ml were transferred into 10 ml volume. 4 ml of 6.4 diethyl ether-abs, ethanol mixture was added, 1 ml of bathophenanthroline and the mixture was agitated, and 0.5 ml of $Fecl_3$, solutions was added in drops and mixed with 0.5 ml of 0.172 ml H_3PO. The blank was prepared with all the above reagents except the vitamin E.

About 0.3 ml of the snail extract in diethylether was placed in boiling tube, 4 ml of 6:4 ether ethanol mixtures was added, followed by 1 ml of bathophenanthrolines and agitated, followed by the addition 0.5 ml $Fecl_3$ in drops and mixed, 0.5 ml of 0.172 ml H_2PO_4 was finally added, mixed and agitated and left on the bench for 5 min. The Jenway 6300 Spectrophotometer was set at 534 nm and absorbance values, the Tocopheral concentration were obtained by Beer Lambert's Law. All measurements were done in triplicates.

2.5 Determination of Heavy Metals

2.5.1 Wet digestion method for snail samples

Wet digestion method was used in the preparation of the snail samples for heavy metal analysis. 1 g of the powered samples of analytical unit was weighed into 100 ml Kjedahl digestion flask and 15 ml of mixed concentrated perchloric, nitric, Sulphur and Hydrochloric acids at ratios of 1:2:1:1 was added. This was latter digested using FOSS TECATOR Digestor Model 210 at 250°C for 1 hour at the first instance and continued until a clear solution was obtained in a fume cupboard. The clear solution was filtered into a 100 ml volumetric flask and completed to the mark with de-ionised water.

2.5.2 Metal analysis

Heavy metals (Pb, Cd, Cr, Ni, Cu, Zn, Hg and As) were determined using Atomic Absorption Spectrophotometer (Buck 210). Standards for each element under investigation was prepared in part per million (ppm) and the limit standard concentration for each element was adhered to according to the BUCK Scientific instruction and the results obtained were compared with World Health Organization standards for the metals limits for human consumption [9].

Mathematical calculation used to obtain elements final concentration:

$$Element(ppm) = \frac{(\mu g/mLinsamplesolution) \times (d.f.) \times (volumemakeup)}{Sampleweightingrams}$$

Where;

d.f. is dilution factor = $\frac{finalvolumeofdilutedsolution}{volumeofaliquottakenfordilution}$

3. RESULTS AND DISCUSSION

3.1 Proximate Composition

Moisture content of *A. marginata* and *M. mercenaria* were observed to be 76±0.63% and 78.4±0.06% respectively (Table 1). The moisture content values are in agreements with works of [11]. Ash contents were 1.37±0.001% and 3.45±0.01% for *A. marginata* and *M. mercenaria* respectively as shown in Table 1. The relatively high values of ash contents imply that they may have a reasonable quantity of mineral elements for building healthy body and proper functioning of body tissues. Ash content is a measure of the total amount of mineral present within a given sample of food [12]. This result is in accordance with the findings of [13].

The mean crude protein contents of the snail samples analyzed were 18.62±0.74% and 12.74±0.01% for *A. marginata* and *M. mercenaria* respectively. When compared

with the findings of reference [14] the crude protein values of this study was lower. Mean lipid contents in the snail samples were 1.34±0.001% and 0.07±0.01% for *A. marginata* and *M. mercenaria* respectively as shown in Table 1. This result of lipid content in *A. marginata* was observed to be lower than the findings of [15].

No crude fibre was detected in *A. marginata* while for *M. mercenaria* sample; crude fibre was observed to be 0.017±0.006%. The low crude fibre content observed in this study can be attributed to a decrease in microbiological metabolism of lipopolysaccharide or due to non-utilization of the sugar during metabolic activities leaving a lower or no fibre content. These results are in agreement With that of [11].

3.2 Mineral Contents

Mineral compositions of the two snail samples were presented in Table 2. *A. marginata* had the higher calcium value of 200.06±2.07 mg/g while *M. mercenaria* recorded lower value (119.32±1.10 mg/g). This might be due to the fact that *A. marginata* lives in the soil with low exchangeable calcium and *M. mercenaria* in marine habitat. Calcium plays important roles in human and animal nutrition as it contributes to the normal Development and maintenance of bones and teeth, clothing of blood, nerve irritability, Normal heart action, muscle activity, activates enzymes. The calcium values in this study were observed to be higher than works reported by [13].

Magnesium plays various important roles in human and animal nutrition as a constituent of bones, necessary for healthy muscles, nerves and metabolism. *A. marginata* had magnesium content of 43.49±0.87 mg/100 g which was observed to be higher than those of *M. mercenaria* with 28.27±0.98 mg/100 g. This result is in concordance with the works of [12]. Mean sodium contents of *A. marginata* was 39.55±0.83 mg/g and *M. mercenaria* (0.06±0.01 mg/g). The sodium values of *A. marginata* recorded in this study were higher compared to works reported by [15]. The low levels of sodium in *M. mercenaria* meats is an attribute which makes them healthy for human consumption especially those having heart related ailments such as high blood pressure.

Potassium acts against muscular weakness which is associated with malaria and also slow down sclerosis of vascular system. It contributes to the fight against bacteria and cleanses the digestive system [16]. Mean potassium content of *A. marginata* was 188.45±0.0.95 mg/g while *M. mercenaria* (68.15±0.98 mg/g). Potassium levels observed in this study were higher than the works of [17]. Iron contents of *A. marginata* (7.49±0.01 mg/g) and *M. mercenaria* (8.25±0.01 mg/g). *A. marginata* content varies from one locality to another depending on the mineral content of the soils in which these snails are raised [4]. Due to the soluble nature of some iron compounds in water coupled with the fact that elements in solution are readily absorbed than those in solid form *A. marginata* had the highest concentration of iron. They could be recommended for pregnant women and children for bone and teeth formation as well as for hemoglobin of the red blood cells. Mean phosphate level of *A. marginata* was 125.35±1.049 mg/g and *M. mercenaria* levels were 48.76±0.89 mg/g. These findings are in accord with the works of [18].

Table 1. Proximate composition of the snail samples

Sample code	Proximate contents(%)						
	Moisture	Ash	Protein	Lipid	Fibre	DM	NFE
A. M.	76±0.63	1.37±0.01	18.62±0.74	1.34±0.01	0.00±0.00	24±0.63	78.67±0.76
M. M.	78.4±0.06	3.45±0.01	12.74±0.01	0.07±0.01	0.017±0.006	21.6±0.6	83.71±0.023

Data were expressed as Mean±SD, A.M. – Archachatina marginata M.M. – Mercenaria mercenaria

Table 2. Mineral content of the snail samples

Sample code	Mineral contents (mg/g)						
	Ca	Mg	Na	K	Fe	Mn	PO_4
A. M.	200.06±2.07	43.49±0.87	39.55±0.83	188.45±0.95	7.49±0.01	0.36±0.01	125.35±1.04
M. M.	119.32±1.10	28.27±0.98	0.06±0.01	68.15±0.98	8.25±0.01	4.44±0.01	48.76±0.89
RDA/AI (mg/day)	1000-1200	320 – 420	1300-1500	3500-4700	8-18	1.8-2.3	700

Data were expressed as Mean±SD, A.M. – Archachatina marginata, M.M. – Mercenaria mercenaria, RDA-Recommended Dietary Allowance, AI- Adequate Intake

Table 3. Vitamin content of the snail samples

Sample code	Vitamin contents (%)			
	A	B_1	B_2	E
A. M.	5.20±0.198	0.144±0.004	0.057±0.003	0.78±0.035
M. M.	3.93±0.070	0.137±0.0025	0.075±0.001	0.84±0.01
RDA/AI(mg/day)	14-16	1.5	1.1-1.3	15

Data were expressed as Mean±SD, A.M. – Archachatina marginata M.M. – Mercenaria mercenaria, RDA- Recommended Dietary Allowance, AI- Adequate Intake

Table 4. Heavy metal compositions of snail samples

Sample code	Heavy metal content (ppm)							
	Pb	Cd	Cr	Ni	Cu	Zn	Hg	As
A.M.	ND	0.14±0.001	0.018±0.002	0.032±0.002	0.96±0.007	1.45±0.01	ND	ND
M.M.	ND	0.168±0.001	0.112±0.0015	0.072±0.001	0.7±0.02	1.27±0.01	ND	ND
WHO	0.1	2.0	0.005	0.5	1.0	3.0	0.1	0.5

Data were expressed as Mean±SD, A.M. – Archachatina marginata, M.M. – Mercenaria mercenaria, WHO- World Health Organization

3.3 Vitamin Profiles

The mean values of vitamins A, B_1, B_2, and E as shown in Table 3 were 5.20±0.19, 0.144± 0.004, 0.057±0.003 and 0.78±0.035%, and 3.93±0.070, 0.137± 0.0025, 0.075 ± 0.001 and 0.84 ± 0.01% for *A. marginata* and *M. mercenaria* respectively. In human body these vitamins play important role in metabolism, immune system and digestive system. It is reported that the human body needs 1.5 mg of vitamin A, 1.4 mg of vitamin B_1, 1.6 mg vitamin B_2, and 1.7 mg of vitamin E [19]. The results shows that *A. marginata* and *M. mercenaria* are rich in vitamin A which is essential for many processes in the body, including maintaining healthy vision, ensuring the normal function of the immune system and organs and aiding the proper growth and development of fetus in the womb, therefore, the snail meats are highly recommended.These findings are in agreement with the works of [20].

3.4 Heavy Metals Levels

The mean Cadmium concentrations were 0.141±0.001ppm and 0.168±0.001ppm for *A. marginata* and *M. mercenaria* respectively. The values recorded in this work are below the WHO permissible limit for cadmium (2.0 ppm). Cadmium is a dangerous element because it can be absorbed via the alimentary tract; penetrate through placenta during pregnancy and damage the membrane and DNA. The values obtained in this study were observed to be lower than the findings of [19] who reported 0.71ppm for cadmium. These results can be attributed to the habitat and activities found in and around the environment. Mean nickel concentrations recorded in this study for both *A. marginata* and *M. mercenaria* was lower than the permissible limit by WHO of 0.5ppm [21]. The mean concentration of Chromium of *A. marginata* and *M. mercenaria* samples were lower than WHO permissible limits of 0.005ppm. The findings are in concordance with the works of [22].

The mean copper content of *A. marginata* was 0.96±0.007ppm and *M. mercenaria* was 0.70± 0.02ppm. The values are in accordance with the WHO permissible limits of 1.0ppm. Copper is an essential trace metal that forms part of several enzyme systems including cytochrome oxidase and tyrosinase. Copper is also associated with iron and catalyses' oxidation-reduction mechanisms concerned with issue respiration. The mean values for zinc was 1.50±0.01 for *A. marginata* and 1.27±0.01ppm for *M. mercenaria.* From the results in Table 4, it was observed that lead, mercury and arsenic was not detected in *A. marginata* and *M. Mercenaria*. This can be explained because of non-industrial activities in the sampling sites, most of the sources of mercury and arsenic is through industrialization.

4. CONCLUSION

Archachatina marginata and *Mercenaria mercenaria* were analyzed for mineral, vitamins and heavy metals Contents, to ascertain their safety for consumption. The values obtained were within the tolerable limit of daily consumption by WHO. While based on the high percentage of proximate, mineral and vitamin contents recorded in *Archachatina marginata,* the snail sample is more preferable to *Mercenaria mercenaria.* Due to the high protein contents of the snail samples analyzed they can

serve as a good alternative source of protein to the human body. Hence, adequate consumption of snail meat would help to alleviate protein deficiencies. The result shows that snail could complement the required micro and macro nutrients and vitamins needed for proper growth and development in human and hence recommended for regular consumption.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/58401