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Lifecycle Evaluation of the Nutritional Benefits and Biosafety of Snail (*Archachatina marginata*)

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Authors' contributions

This work was carried out in collaboration among all authors. Author KAS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author BTO managed the analyses of the study. Author KOJ managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Ninety snails *Archachatina marginata* (Swainson, 1821), which comprised 30 each of adults (325.43 ± 2.03 g), growers (119.05 ± 1.05 g) and snailets (33.05 ± 1.00 g) were used to determine the lifecycle nutritional and bio-safety benefits of consumption of snail meat. This study was aimed to further investigate, the nutrients, heavy metals and bio-safety of snail consumed by Nigerians, due to increasing industrialization, use of agro-chemical mineral exploration, fumes from vehicles and improper disposal of refuse and sewage. Each age group was regarded as a treatment, for the holistic determination of the proximate, macronutrient, heavy metals, lipid profile and carcass yield of the snail meat. The snail was carefully cleaned and dressed for meat samples collection in triplicates for subsequent laboratory determination of the nutritional and bio-safety parameters. The

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collected samples were processed, using standard procedures. Data were collected for proximate components (Crude protein, crude fibre, Ether Extract, NFE and Ash), macronutrients (Na, K, Ca, P, Mg and Fe) heavy metals (Cu, Pb, Ni, Cd, Cr and MN), total cholesterol and lipid profile (HDL, LDL and FFA) and carcass yield. Data collected were subjected to (ANOVA), in a complete randomized design, while significant means were separated using Duncan's Multiple Range Test. Proximate components such as Crude protein 15.88±1,39% and ether extract 1.24 ± 0.22%, increased ($P<0.05$) with the age of snail, while NFE reduced with age. Highest ($P<0.05$) carcass yield (44.23%) was obtained for snailets, with corresponding least ($P<0.05$) values for total cholesterol, LDL, HDL and FFA, cholesterol levels were significantly varied, in all groups and the contents of macronutrients and heavy metals in snail meat were tolerable in human nutrition and therefore not deleterious.

Keywords: Snail meat; carcass yield; nutrients heavy metals; macronutrients.

1. INTRODUCTION

Food items are produced throughout the year, due to the need to feed on a daily basis, this encompasses crops and animals. The animal being protein source is a very vital component of the human food chain [1] and has been discriminated to be grossly inadequate in the diet, in most developing countries [2].

In order to salvage the gross inadequacy of conventional animal protein sources like cattle, sheep, Goat, Poultry, and others, non-conventional protein sources, such as the micro-livestock like Quail, Snail and Guinea fowl are cheaper alternatives within the reach of the rural dwellers, who are regarded as poor [3].

Snail farming is becoming a very popular vocation, due to its embracement as an empowerment and job creation avenue by the Federal Government of Nigeria (17). It has been adjudged as a self-sustaining business, requiring small capital, land and other logistics, with resultant job creation potentials, along its value chain; for collectors, farmers, marketers, and research scientists [4,5].

An analysis of snail market revealed that snails of different species, such as *Archachatina marginata, Archatina achatina, Achachatina fulica and Limicolaria* species are restricted to the southern parts of Nigeria, with the predominance of *Archachatina marginata* (11). Snail gathering is very popular in West Africa, especially during the raining season, in the forest ecological zones (7), this is not sustainable, due to the decline in snail population and an ever-increasing human populations combined with other factors, such as climate change human activities, like deforestation, construction, use of agrochemicals and unregulated land-use system (7).

It is very important to protect snail from extinction through advocacy on its nutritional importance and its adoption in the treatment of many diseases, such as hypertension (9), reduction of blood sugar, skin diseases and general well-being (16). In the views of the marketers, traditional healer and consumers, the snail do not only to bridge the wide animal protein intake gap in human, but it is also regarded as an antidote for the treatment of ailments.

Musa et al. [2] inferred that environment and soil have a significant influence on the chemical and proximate composition of snail meat, shell and haemolymph, since they hibernate in the soil, feed on decaying plants and crops. In order to ensure that humans are fed with safe animal protein from Snails, the effort is made to evaluate the meat of *Archachatina marginata* for its nutritional properties and bio-safety to humans.

Africa Giant Land Snail or Black Snail (*Archachatina marginata*) is very common in Nigeria and most research resources are concentrated on its breeding [6], multiplication and utilization, humans must, however, feed on rich and safe food, hence the need for this study to further investigate, the nutrients, heavy metals and bio-safety of snail consumed by Nigerians, due to increasing industrialization, use of agro-chemical mineral exploration, fumes from vehicles and improper disposal of refuse and sewage.

2. MATERIALS AND METHODS

2.1 Experimental Animals

Ninety Snails (*Archachatina marginata*), which comprised of thirty each of snailets, growers and adults were sourced from collectors from the rural settlement in Oluyole Local Government

Area of Oyo State, Nigeria, to ascertain the nutritional and bio-safety properties of snail meat. The three categories had a corresponding weight of 328.43 ± 2.0 g, 119.05± 1.5 and 33.05 ± 1 g for adult, growers and snailets respectively.

2.2 Experimental Procedure

2.2.1 Snail processing for carcass analysis

The individual snail was cleaned with distilled water, after which the shell was carefully broken for the separation of the shell, visceral mass, foot, for carcass yield analysis. This was done for each adult, grower and snailet. 5 g of muscle was collected from each sample, further washed with distilled water and stored at -18ºC prior to analysis [7].

2.3 Chemical Analysis of Snail Meat for Heavy Metals

Collected samples were pre-digested in 10 ml concentrated $HN0_3$ at 135ºc until the liquid was clear. Then followed by the addition of 10 ml $HN0_3$ and 2 ml $Hcl0_3$, until the liquid becomes clear and colourless. The digest was slowly evaporated till near dryness. Then, dissolved in 1M $HN0_3$, filtered through Whitman N01 filter paper and diluted to 25 ml with 1 m $HN0_3$, the resulting solution was analyzed for with Cd, Pb, Zn, Mn, Fc, Cu, Cr and Co, with graphite furnace atomic absorption spectrophotometer (GBC scientific equipment seas AA). Control procedure was carried out for result reliability.

2.4 Proximate and Macronutrient Analysis of Snail

The proximate composition of snail meat was determined by the official method of analysis as described by the Association of Official Analytical Chemists [8]. This elicited the component crude protein, crude fibre, ether extract, Nitrogen free Extract, Ash and Moisture. All analyses were carried out in triplicate.

The level of calcium, potassium and sodium was determined by the method of A.G.Arc. (975.11), by the use of Jenway digital flame Photometer (PFP7, model). Phosphorus content of meat samples was determined by the use of a spectrophotometric method [8] and magnesium by A.O.A.C (975.23).

2.5 Determination of Cholesterol Content and Profile of Snail Meat

The cholesterol content of snail meat samples was determined to elicit total cholesterol and component High-Density Lipid (HDL), Low-Density Lipid (LDL) and Free Fatty Acid (FFA), using the procedure highlighted by Idowu et al. [9].

2.6 Statistical Analysis

Data collected were subjected to Analysis of variance (ANOVA), using complete Randomized Design, while significant means were separated ($P<0.05$), using Duncan's Multiple Range Test (1995) as explained by Sam et al. [10].

3. RESULTS

3.1 Proximate Composition of the Meat of Different Age Categories

Table 1 shows the proximate parameters in the different age groups of *Archachatina marginata*, which varied significantly ($p<0.05$) in all the treatment. All proximate constituents, such as dry matter 19.61 ± 1.14% crude protein, 15.83 ± 1.39%, ether extract, 1.24 ± 0.22% and Ash, 1.18 ± 0.16%, were highest ($P<0.05$) in adult Snails; except its carbohydrate component (Nitrogen Free Extract), which reduced ($P<0.05$) from snailets to adults.

Table 1. Proximate composition of the meat of different age categories of snail (*Achachatina marginata)*

Parameters (%)	T_1 (Adult)	T_2(Grower)	T_3(Snailet)	± SEM
Dry matter	20.75	20.07^b	19.61^b	0.50
Crude protein	17.22^a	16.30^b	15.83^b	0.50
Ether Extract	1.46^a	1.35^{ab}	1.24^b	0.15
Ash	1.34^a	1.24^b	1.18^b	0.06
Nitrogen Free Extract	59.23^b	60.04^b	62.14^a	1.10

abc: Means along the same row with different superscripts are significantly different (P<0.05)

Table 2. Mineral composition of the meat of three age categories of snails (*Archachatina marginata*)

Parameters (mg/100 g)	T_1(Adult)	T_2(Grower)	T_3(Snailet)	± SEM
Sodium	44.75[a]	39.57[b]	31.26[b]	1.20
Pottasium	92.34[a]	77.55[b]	69.24[b]	2.34
Calcuim	42.19[a]	31.64[b]	26.46[b]	2.11
Phosphorus	295.64[a]	286.65[b]	274.50[b]	1.71
Magnesium	59.23[b]	60.04[b]	238.80[a]	1.23
Iron	9.53[a]	7.37[b]	5.25[c]	1.48

abc: Means along the same row with different superscripts are significantly different (P<0.05)

Table 3. Carcass analysis of different age categories of snail *(Archachatina marginata*)

Parameters (mg/100 g)	Ti (Adult)	T2(Grower)	T3(Snailet)	± SEM
Live weight (g)	328.43	119.05	33.05	-
Shell Weight (%)	29.45[a]	21.95[b]	17.17[c]	1.53
Offal Weight (%)	36.27[c]	42.35[a]	38.59[b]	0.94
Dressing (%)	34.25[c]	35.66[b]	38.59[b]	1.02

abc: Means along the same row with different superscripts are significantly different (P<0.05)

Table 4. Cholesterol analysis of different age categories of snail (*Archachatina marginata*)

Parameters (mg/100 g)	Ti (Adult)	T2(Grower)	T3(Snailet)	± SEM
Total cholesterol	18.33[a]	13.50[b]	11.59[c]	2.07
HDL	2.06[a]	1.96[b]	1.97[b]	0.12
LDL	3.30[c]	3.08[a]	2.72[b]	0.25
Free Fatty Acid	12.97[c]	8.50[b]	7.10[b]	0.46

abc: Means along the same row with different superscripts are significantly different (P<0.05)

3.2 Mineral Composition

Table 2 shows the level of Sodium, Potassium, Calcium, Phosphorus, Magnesium and Iron in the meat of snail due to their importance in body metabolism and human nutrition and health. The values obtained were 31.20 – 44.75 (Na), 69.24 – 92.34 (K), 26.46 – 42.19(ca), 274.50 – 295.64 (P), 238.80 – 266.70 (Mg) and 5.25 – 9.53 (Fe)mg/100h, all values were highest (<0.05) for adult snails.

3.3 Carcass Analysis of 3 Days Categories of Snail (*Archachatina marginata*)

The carcass yield of *Archachatina marginata* was elicited in Table 3. This showed the dressing percentage, which was estimated from the weight of foot divided by total live weight, expressed as a percentage. All values for carcass analysis parameters were significantly (P<0.05) varied. Highest shell weight (17.17%) and least offal weight (36.27%) and dressing percentage (34.25%), were obtained for adult snails. Highest dressing percentage (44.23%) was obtained in snailets. Shell accounted for 29.45% in adult snails.

3.4 Cholesterol Analysis of Snails (*Archachatina marginata*)

Table 4 shows the cholesterol profile of snail meat, which showed the total cholesterol, low-Density Lipid (LDL) High-Density Lipid (HDL) and Free Fatty acid (FFA). The content of total cholesterol, HDL, LDL and FFA increased with the age of snail. Highest 18.33 mg/100 g cholesterol was obtained for adult snail, followed by 13.50 mg/100 g for growers and least for snailet. Adults had highest HDL(2.06 mg/100 g), LDL (3.30 mg/100 g) and FFA(12.97 mg/100 g).

3.5 Heavy Metal Content

Table 5 revealed the levels of Cu, Pb, Co, Ni, Cd, Cr and Mn in snail meat. The probe into heavy metals is due to their lethal nature when present in high quantity, it is dangerous because the human body does not have a good mechanism for eliminating them, their bio-accumulation is dangerous and must be avoided. The outcome of the analysis showed that snail meat had 8.76 ± 1.8 (Cu) 0.04±002 (Pb), 0.021 ± 0.027 (Co), 2.0 ± 1.27 (Ni), 0.02 ± 0.002 (Cd), 1.32 ± 1.41 (Cr) and 3.68 ± 2.56 (Mn) in Mg/kg. the levels vary (p<0.05) and increased age of snails.

Table 5. Heavy metal content of the meat of (*Archachatina marginata*)

Parameters (mg/kg)	T1 (Adult)	T2(Grower)	T3(Snailet)	± SEM
Cu	10.56[a]	9.58[a]	8.76[a]	1.0
Pb	0.008[a]	0.006[a]	0.004[a]	0.002
Ni	3.27[c]	3.02[a]	2.0[a]	1.1
Cd	0.004	0.003[a]	0.002[a]	0.002
Cr	2.63[a]	1.42[a]	1.32[a]	0.5
Mn	6.24	5.79[a]	3.68[a]	-

abc: Means along the same row with different superscripts are significantly different (P<0.05)

4. DISCUSSION

4.1 Proximate Composition

Highest dry matter, crude protein, ether extract and ash is not unexpected since they are required for growth development and formation of reproductive parts [11], there is however an inverse relationship between the level of crude protein and NFE, with the highest value of 62.14% in Snailets. The increased requirement for sugar for body process could be responsible for the observed variation. Adult snails are more active and have more requirements for energy substrate [4]. All age categories were good sources of protein and low in ether extract, which is consistent with the findings of [12,3], that snail meat compared with sources of animal protein like beef, mutton, chicken and goat meat and its level of fat and cholesterol.

4.2 Carcass Analysis of 3 Age Categories of Snail (*Archachatina marginata*)

Highest dressing percentage (44.23%) was obtained is snailets. Shell accounted for 29.45% in adult snails due to its size, thickness and shell calcification [4]. Offal weight (42.35%) was highest in growers, because of its active rate of formation of internal organs, such as reproductive, digestive excretory and others. The foot, which is the edible part of snail was least in the adult snail, the low values of less than 40% are characteristic of snails from the wild, without any organized feeding programme and an indication that balanced diet is required for good carcass yield in snails [13]. The lower the offal and shell weight, the higher the dressing percentage. However, for the purpose of conservation and prevention of extinction, the consumption of snailets is discouraged, through advocacy [14], because many generations of snails are aborted, by preventing, maturity, egg-laying and reproduction. The determination of carcass yield gives an indication of feed utilization, feed quality and meat yielded by the snail. An average farmer planning his foundation stock of snail is guided by the fullness of the foot in the shell, low carcass yield is an indication of starvation, aestivation and unfavourable environment condition. The result revealed that snail carcass yield is lower than that of grasscutter (60%) and 55% each for rabbit and goat [15]. Omole [13] commented that snails fed balanced diets had improved carcass yield of above 45%.

All values were highest (<0.05) for adult snails, thus confirming the finding of [12], when it was revealed that mineral availability increase with the age of snail. On a general note, snail meat of all age categories had more iron them goat meat, Tilapia fish, beef and mutton. The optimal use of cholesterol is ensured by the right combination of the component lipids. Good quality cholesterol must be richer in HDL that LDL [15] to prevent arteriosclerosis. The HDL is vital, as a demobilized of fat from the wall of blood vessels, thus preventing blockage.

Snailets had the least value for total cholesterol, HDL, LDL and FFA, this could be the reason for the increasing consumption of snailets , and sub-adult snails are some communities in Nigeria [13] On a general note, snail meat consumption is beneficial and recommended for people suffering from blood and fat-related diseases, irrespective of the age of such snail.

4.3 Mineral Composition of Snail Meat of Three Age Categories (*Archachatina marginata*)

All mineral salts, Na, K, Ca, P, Mg and Fe increased with the age of snail, thus corroborating the findings of [12], When they stated that snail meat is rich in mineral nutrients though low in sodium, [13] emphasized that snail meat is higher in iron than goat meat, Tilapia fish, beef and mutton and was regarded as the preferred meat for the elderly, hypertensives and people suffering from anemia. The consumption

of snail meat is good for the heart, due to its richness in K, Ca and Magnesium.

4.4 Heavy Metal Content

The outcome of the analysis showed that snail meat had 8.76 ± 1.8 (Cu) 0.04±002 (Pb), 0.021 ± 0.027 (Co), 2.0 ± 1.27 (Ni), 0.02 ± 0.002 (Cd), 1.32 ± 1.41 (Cr) and 3.68 ± 2.56 (Mn) in mg/kg. the levels vary ($p<0.05$) and increased age of snails, however, values were within permissible limit in human nutrition [15,17,7], hence the consumption of snails of any age may not be deleterious to human health, however the consumption of snailets and sub-adult is been discouraged through advocacy and promotion of snail farming to avoid extinction of snails.

5. CONCLUSION

The trial has revealed that snail meat is rich in mineral elements and low in crude fibre, fat, cholesterol and LDL. It is nutritionally beneficial in Na, K Ca, P, Mg and Fe and its levels of heavy metals were within levels tolerable in human nutrition.

Snail carcass yield of 35 – 45% is lower than that of Grasscutter (63%), Boilers (60%) and 55%, each for Rabbit and Goat. To further enhance the nutritional benefits of snail meat and improve performance, captive breeding, balanced diet and advocacy on snail conservation are important and should be adopted by all the stakeholders in snail production. Snail meat is safe and it consumption is not dangerous to human health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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