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Biochemical and Nutritional Composition of Giant African Land Snail (*Archachatina marginata*) from Southwest Nigeria

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ABSTRACT

The survival of snails has been associated with the microclimate variables of their environment. Therefore, a comparative analysis of the biochemical composition of the haemolymph, mineral and proximate analysis of the flesh of the giant African land snail (*Archachatina marginata*) obtained from five southwestern states of Nigeria was conducted. Mature snails purchased from notable markets in Ogun, Oyo, Lagos, Osun and Ondo states were dissected. An analysis of the biochemical composition of the haemolymph and proximate composition of the flesh was done using standard methods, while a mineral composition analysis of the flesh and haemolymph was done using a Atomic Absorption Spectrophotometer and Flame Photometer. Snails from Oyo state had significantly higher ($p<0.05$) concentrations of glucose (35.00±0.20), protein (54.15±0.02) and lipid (22.90±0.05) in their haemolymph than those from the other locations. Concentrations of Na^+, Ca^{2+}, Cl- and PO_4^{2-} were observed to be significantly higher ($p<0.05$) in the haemolymph of the snails than in the flesh. Protein was observed to be higher than other metabolites in both the haemolymph and the flesh of *A. marginata* collected from the five states. The flesh of snails obtained from Ogun state recorded significantly higher ($p<0.05$) values of ash (1.73±0.02), crude fibre (1.01±0.01), crude protein (20.22±0.02) and carbohydrate (1.09±0.01) content than those from the other states examined. No significant difference ($p>0.05$) was observed in the values of Mg^{2+}, PO_4^{2-} and Cl^- across the five states. Although climatic conditions could have influenced some biochemical composition of the snails, the snails collected from the five southwestern states of Nigeria examined were equally nutritious.

Keywords: Haemolymph, proximate, mineral, environment, climate, snail biochemistry

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INTRODUCTION

Snails are invertebrates with a soft body that is covered by a hard calcerous shell. They belong to the phylum Mollusca and the class Gastropoda. They are bilaterally symmetrical with over 100,000 species known worldwide (Segun, 1995). They spend most of the daytime under stones, soil litter or decaying organic matter (Ajayi et al., 1978). According to Yoloye (1994), snails are the largest group among the molluscs after arthropods. Land snails' habitat ranges from the dense tropical high forest in southern Nigeria to the fringing riparian forests of the Guinea savannah (Ajayi et al., 1980; Odaibo, 1997).

In West Africa, snail meat has traditionally been a major source of protein in the diet of people living in the forest belt (Cobbinah, 1993). According to Fagbuaro et al. (2006), snail meat is now becoming a highly relished delicacy in Nigeria that is also an important source of animal protein for coastal communities. The edible portion of the snail is reported to be rich in protein (Imevbore & Ademosun, 1988), calcium, magnesium, zinc and iron and it has very low fat content (Babalola & Akinsoyinu, 2009; Uboh et al., 2010; Adeola et al., 2010). Its protein is also reported to contain all the essential amino acids such as lysine, leucine, isoleucine and phenylalanine that are needed by the body for metabolic activities (Aboua, 1995; Ademolu et al., 2004). Reports also have shown that snail meat has medicinal value and can be used to treat ailments such as whooping cough, anaemia, asthma and high blood pressure due to its relatively low cholesterol level but high mineral content (Ebenebe, 2000; Akinnusi, 1998).

Haemolymph is regarded as a blood analogue found in all arthropods and most molluscs (Abdussamad et al., 2010). It is composed of water, inorganic salts (mostly Na, Cl, K, Mg and Ca) and organic compounds (mostly carbohydrates, proteins and lipids) (Ademolu et al., 2011; Ademolu et al., 2006; Ademolu et al., 2009; Akinloye & Olorode, 2000). Since the haemolymph directly bathe snail organs in an open circulation (Miller & Harley, 1996), it has been associated with snail growth performance and susceptibility to infection and aggression (Ademolu et al., 2011). Ejidike et al. (2004) also reported that microclimatic variables like relative humidity, rainfall, photoperiod and temperature are important determinants that allow the snail species to thrive and that its survival depends greatly on these variables.

Alternative protein derived from the consumption of snails, especially in the southwestern region of Nigeria (Fagbuaro et al., 2006) has been drawing attention lately. Although there has been advocacy for snail rearing over the years, a substantial amount consumed is still sourced from the wild (Ademolu et al., 2004). Similarly, there has been speculation among the local people that the snails collected from some of the southwestern states of Nigeria are of better quality than those from other states. This however, has not received any scientific attention. In order to justify this claim and identify the land areas that support the success of these snails in the wild, there is a need to assess the biochemical and nutritional composition of the commonly eaten giant land snail from the different states of southwestern Nigeria.

This study was therefore aimed at assessing the variation in the biochemical composition of the giant African land snail, *Archachatina marginata*, obtained from five southwestern states of Nigeria through biochemical evaluation of minerals found in the snail as well as through nutritional analysis of its haemolymph and flesh.

MATERIALS AND METHOD

Snail Sample Collection

Five southwestern states of Nigeria, Ogun, Oyo, Lagos, Osun and Ondo, were chosen for this study. The environmental description of each state is presented in Table 1. Twenty-five mature snails were purchased from notable snail markets from each state: Itoku market, Abeokuta (Ogun), Oje market (Oyo), Oyingbo market (Lagos), Oja Oba market, Osogbo (Osun) and Oja Oba market, Akure (Ondo). Snails were randomly

Table 1
Environmental description of the five southwestern states of Nigeria chosen for this study

	Coordinates	Climate type	Average daily temperature	Topography	Vegetation	Average rainfall
Oyo	8°00'N 4°00'E	Equatorial climate	25°C to 35°C	Gentle rolling low land	Rain forest and Guinea savannah	800 mm to 1800 mm
Lagos	6°27'11''N 3°23'45''E	Tropical climate	25°C to 29°C	Island, sandbars and lagoon	Tropical swamp forest consisting of fresh water and mangrove swamp forests	1270 mm to 2540 mm
Osun	7°30'N 4°30'E	Tropical climate	21.1°C to 31.1°C	Undulating land formation with isolated hills	Derived savannah, secondary forest regrowth	800 mm to 1500 mm
Ondo	7°10'N 5o05'E	Tropical climate	21°C to 29°C	Lowland with rugged hills	Mangrove swamps, rainforest, derived savannah	2,000 mm to 1150 mm
Ogun	7°00'N 3°35'E	Tropical climate	24°C to 30°C	Undulating lowlands of coastal secondary rocks with scattered hills and river valleys	Tropical rain forest and Guinea savannah	1000 mm to 2000 mm

Sources: OYSG (2015); LSG (2015); OSG (2015); TFN (2015); Online Nigeria (2015a, b, c); OSSG (2004) purchased from various local snail traders who assured that the snails were sourced from the wild in the respective states. The snails were transferred to the laboratory of the Biological Sciences Department, Federal University of Agriculture, Abeokuta for biochemical analyses.

Biochemical Analysis of the Haemolymph

The apex of the snails' shell was broken and the haemolymph was collected using the method described by Ademolu et al. (2004). The protein concentration of each sample was determined immediately using the biuret method described by Henry et al. (1974). The glucose content was determined by the colorimetric method of Baumniger (1974). The lipids assay was done following the method of Grant et al. (1987). The haemolymph sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), phosphate (PO^{4-}) and chloride (Cl^-) were determined by the method described in the Association of Official Analytical Chemists (AOAC) publication (1990).

Proximate and Mineral Analyses of the Flesh

Dissected samples of snail flesh were dried at 60°C for 48 h in an oven. The dried samples were powdered in a Moulinex blender and sieved through a 450 μm sieve. The final powdered sample was stored in a desiccator and used for proximate and mineral content determination.

The powdered samples were digested with a mixture of per chloric acid and nitric acid (1:2 v/v) and cooled to room temperature. Na^+ and K^+ were determined by flame photometer while Ca^{2+}, and Mg^{2+} were determined using an atomic absorption spectrophotometer (Model AA.403). Methods in Henry et al. (1974) were used to assess the PO_4^{2-} and Cl^- content of the tissue.

Chemical analysis to determine the proximate composition of the flesh (crude protein, crude fibre, ash, moisture and fat content) was carried out by the method described by the AOAC (1990).

Data Analysis

Data were analysed using the Statistical Package for Social Sciences (SPSS) version 20.0 (IBM Corp, 2011). The Analysis of Variance test (ANOVA) was used to test for significant differences in the measured variables of the snail flesh obtained from the different states in southwest Nigeria. A post-hoc test was conducted utilising the Duncan Multiple Range test, with the p value set at 0.05.

RESULTS

Biochemical Composition of Haemolymph

The concentrations of glucose, protein and lipid were significantly different ($p<0.05$) in the haemolymph of the snails obtained from the five states (Table 2). Snails obtained from Oyo state had significantly higher ($p<0.05$) concentrations of glucose

(35.00±0.20 mg/dl), protein (54.15±0.02) and lipid (22.90±0.05) in their haemolymph than those from other locations. Similarly, snails obtained from Oyo state recorded significantly higher ($p<0.05$) haemolymph concentrations of Ca^{2+} and Cl- (10.15±0.02 mg/dl and 99.50±0.20 mm/l, respectively). The lowest concentration of Ca^{2+} and Cl^- was recorded in the haemolymph of snails obtained from Lagos state (Table 2).

Table 2
Biochemical composition of the haemolymph of archachatina marginata obtained from five southwestern states of Nigeria

	Glucose (mg/dl)	Protein (g/l)	Lipid (mg/dl)	Na^+ (mm/l)	Ca^{2+} (mg/dl)	Cl^- (mm/l)	PO_4^{2-} (mg/l)
OGUN	15.70±0.20^d	27.35±0.02^d	15.50±0.20^d	134.00±0.20^{bc}	9.95±0.02^a	94.50±0.20^c	1.70±0.10^c
ONDO	20.00±0.20^b	32.20±0.20^b	15.20±0.10^d	134.00±0.20^{bc}	9.95±0.03^a	97.50±0.20^b	2.30±0.20^b
LAGOS	16.35±.02^c	28.25±0.02^c	16.75±0.02^c	136.50±0.20^a	9.50±0.20^b	94.00±0.20^c	2.85±0.02^a
OYO	35.00±0.20^a	54.15±0.02^a	22.90±0.05^a	133.50±0.20^c	10.15±0.02^a	99.50±0.20^a	2.65±0.02^{ab}
OSUN	15.75±0.02^d	21.15±0.01^e	18.20±0.10^b	134.50±0.10^b	9.85±0.01^a	98.00±0.20^b	2.85±0.02^a

^{abcd}Mean values (± Standard Error) in the same column having the same superscript are not significantly different ($p>0.05$)

Proximate Composition of Snail Flesh

Protein content of the snail flesh from all the states ranged from 12.54±0.02 to 20.22±0.02 g/100g. Snail flesh obtained from Ogun state recorded significantly higher ($p<0.05$) values of ash (1.73±0.02), crude fibre (1.01±0.01), crude protein (20.22±0.02), carbohydrate (1.09±0.01) and fat (2.09±0.11) content than the values recorded for snail flesh from the other southwestern states of Nigeria (Table 3).

Table 3
Proximate composition (g/100g) of the flesh of archachatina marginata obtained from five southwestern states of Nigeria

	Moisture Content	Fat Content	Ash Content	Crude Fibre	Crude Protein	Carbohydrate
OGUN	73.95±0.02^e	2.09±0.11^a	1.73±0.02^a	1.01±0.01^a	20.22±0.02^a	1.09±0.01^a
ONDO	77.00±0.20^d	1.77±0.02^b	1.53±0.01^b	0.89±0.02^b	17.88±0.01^b	0.94±0.01^b
LAGOS	78.85±0.02^b	1.60±0.10^{bc}	1.40±0.05^c	0.82±0.01^c	16.42±0.02^c	0.92±0.02^{bc}
OYO	79.67±0.02^a	1.46±0.02^c	1.35±0.01^c	0.79±0.01^c	15.77±0.01^d	0.86±0.02^c
OSUN	77.41±0.01^c	1.73±0.02^b	1.51±0.01^b	0.88±0.01^b	12.54±0.02^e	0.95±0.02^b

^{abcd}Mean values (± Standard Error) in the same column having the same superscript are not significantly different ($p>0.05$)

Mineral Composition of Snail Flesh

Calcium (Ca^{2+}) was significantly lower ($p<0.05$) in the flesh of snails from Oyo and Osun states than in the flesh of snails from Ogun Ondo and Lagos (Table 4). There was no significant difference ($p>0.05$) in the values of Mg^{2+}, PO_4^{2-} and Cl^- in snail flesh from the different states. However, K^+ was higher in the flesh of the snails compared to other minerals, followed by Na^+, PO_4^{2-}, Ca^{2+}, Mg^{2+} and Cl^-.

Table 4
Mineral composition of the flesh of archachatina marginata obtained from five southwestern states of Nigeria

	Na^+ (mm/l)	K^+ (mm/l)	Ca^{2+} (mg/dl)	Mg^{2+} (mg/dl)	PO_4^{2-} (mg/l)	C^{l-} (mm/l)
OGUN	$1.05{\pm}0.02^b$	$2.97{\pm}0.01^c$	$0.42{\pm}0.02^{ab}$	$0.27{\pm}0.02^a$	$0.53{\pm}0.01^a$	$0.02{\pm}0.00^a$
ONDO	$1.27{\pm}0.02^a$	$3.43{\pm}0.02^a$	$0.43{\pm}0.02^a$	$0.27{\pm}0.02^a$	$0.54{\pm}0.02^a$	$0.02{\pm}0.00^b$
LAGOS	$1.29{\pm}0.01^a$	$2.90{\pm}0.05^c$	$0.41{\pm}0.01^{ab}$	$0.29{\pm}0.01^a$	$0.56{\pm}0.02^a$	$0.02{\pm}0.00^{ab}$
OYO	$1.09{\pm}0.02^b$	$3.19{\pm}0.01^b$	$0.32{\pm}0.01^c$	$0.28{\pm}0.01^a$	$0.52{\pm}0.02^a$	$0.02{\pm}0.00^{ab}$
OSUN	$1.23{\pm}0.02^a$	$3.11{\pm}0.01^b$	$0.36{\pm}0.02^{bc}$	$0.27{\pm}0.02^a$	$0.55{\pm}0.02^a$	$0.02{\pm}0.00^{ab}$

^{abc}Mean values (± Standard Error) in the same column having the same superscript are not significantly different ($p>0.05$)

DISCUSSION

The results of this study showed that location was a factor affecting the chemical constituency of the haemolymph of the giant African land snail found in five southwestern states of Nigeria. Ejidike et al. (2004) reported that dietary variables have influence on the physiology of giant African land snails. It was therefore not unexpected that environmental and dietary variables could have contributed to the variations observed in the composition of snail flesh in snails obtained from the different locations.

The concentration of glucose, protein and lipid was significantly higher in the haemolymph of snails obtained from Oyo state than those obtained from the other states of Southwest Nigeria. Of the five states examined, Oyo state has the highest average daily temperature (25°C-35°C). Since haemolymph is the fluid that bathes the flesh of snails, any physiological process that takes place in the body of the snails must be reflected in the haemolymph (Akinloye & Olorode, 2000). Ademolu et al. (2006) recorded a strong relationship between the haemolymph concentration of glucose, lipid and protein and the modified environment. Snails are ectothermic animals; their physiological processes are affected by environmental factors like temperature (Odiete, 1999). It is therefore not unexpected that higher concentrations of glucose, protein and lipid in the haemolymph of the snails from Oyo state could have been aimed at overcoming the challenges that arose from the higher average daily temperature of the state.

However, concentrations of glucose, protein and lipid recorded in snails from the five states compared well with those of normal and albino *A. marginata* (Ademolu et al., 2006; Ademolu et al., 2011).

The concentration of sodium, calcium, chloride and phosphate was observed to be higher in the haemolymph of the snails than in their flesh. The function of the haemolymph in the open circulatory system of snails is to serve as transport of nutrients to the various body parts (Miller & Harley, 1996). Hence, it is expected that the haemolymph should contain higher concentrations of minerals for absorption into body tissue (as recorded by the current study). Haemolymph biochemical properties of *A. marginata* have been reported to influence physiological processes (Akinloye & Olorode, 2000) and growth performance (South, 1990; Ademolu et al., 2006) of the land snail.

South (1990) and Ademolu et al. (2009) also reported that Na^+ and Cl^- were the most abundant ions in the haemolymph of the slug *Arion ater* and the land snail, *A. marginata*, respectively. The role of Na^+ in nervous communication is significant. Therefore, higher concentrations of Na^+ recorded in the haemolymph of snails in this study could have been responsible for the control of the contraction of their muscular foot (Miller & Harley, 1996).

The concentration of protein was higher than that of other metabolites in both the haemolymph and the flesh of *A. marginata* from the five states. This is in agreement with South (1992), who reported that protein was the most abundant solute in snail haemolymph. Similarly, protein was also reported to be higher than other metabolites in *A. marginata* reared under various environments (Ademolu et al., 2006; Ademolu et al., 201). Snails are thus a good source of protein (Akinnusi, 2002; Amusan & Omidiji, 1988; Imeuevbove & Ademosun, 1988) regardless of the location from which they were collected.

A. marginata collected from the five southwestern states of Nigeria was high in nutritional composition such as crude protein, carbohydrate, fat, ash and fibre. Values of crude protein, carbohydrate, fat, ash and fibre obtained compared well with those of *A. marginata, A. achatina* and *Limicolaria* spp. (Fagbuaro et al., 2006) and *Achatina achatina* (Babalola & Akinsoyinu, 2009). However, the values were higher than those of *Limicolaria* spp. and *Achatina fulica* (Babalola & Akinsoyinu, 2009) and the fresh water snail, *Pila ampullacea* (Obande et al., 2013).

This study showed that higher concentrations of lipid, protein and glucose recorded in snails from Oyo state could be a means for the snails of surviving high average daily temperature. Also, concentrations of minerals were higher in the haemolymph than in the flesh of the snails. *Archachatina marginata* collected from the five southwestern states of Nigeria examined was equally nutritious.

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