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DIETARY COMPOSITION IN DRIED FLESH OF AFRICAN GIANT SNAIL AND TROPICAL PERIWINKLE PURCHASED FROM ROAD SIDE HAWKERS IN NSUKKA L.G.A., ENUGU STATE

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ABSTRACT

The study evaluates the dietary composition in flesh of *Archachatina marginata var saturalis* and *Tympanotonus fuscatus* (Radula) bought from road side hawkers in Nsukka L.G.A. of Enugu State. An experimental study of the dried matter of both sampled species were carried out using proximate analysis in accordance to AOAC. The results showed that the dried matter of *A. marginatavar. saturalis* flesh has protein content of (86.96 ± 0.37%), fat (7.35 ± 0.24), fibre (5.06 ± 0.03), carbohydrates (4.56 ± 0.45) and ash (1.88 ± 0.19), moisture (1.54 ± 0.21), whereas in *T. fuscatusvar. radula* the carbohydrates content was observed as (21.52 ± 1.50), protein content (25.96 ± 0.56), ash (16.30 ± 1.09), fat (8.36 ± 0.29), moisture (7.86 ± 0.39) and fibre (1.53 ± 0.76). The two samples revealed high protein content in *A. marginatavar. saturalis* and in *T. fuscatus* carbohydrate is equally high with least low value in ash and fibre respectively. This showed that *A. marginatavar. saturalis* is very rich in protein than *T. fuscatus var. radula.* Consumption of the species meat will provide the body with these essential nutrients that is needed for majorities of the cell activities and body build up and growth for both old and young by incorporating into our diets.

Keywords: *Proximate, Dietary, Mollusca, Protein, Utilization*

INTRODUCTION

Archachatina marginata var saturalis (African Giant Snail) is an invertebrate belonging to the phylum Mollusca. The word 'mollusca' is derived from the Latin word, *mollis*, meaning soft (McFaddenand Keeton, 2001). The African giant land snails under the class gastropods known as the largest of the molluscs. Molluscs radiate successfully into a variety of habitats, the great majority of which are aquatic, some are found mostly in shallow waters and sometimes in inter-tidal zones where they burrow into the mud in the beds of the river which serve as their habitat (Jamabo and Chinda, 2010). Maikano (2015) asserted that molluscs are generally triploblastic, coelomate and mostly bilaterally symmetrical and that, the body cavity consists of haemocoelien with soft non-segmented bodies.

In Nigeria, snail habitat ranges from the dense tropical high rainfall forest region of the south to the fringing riparian forests of the derived Guinea savannah (Odaibo, 2003). *A. marginatavar saturalis* are distributed all over the swamp forest zones in Africa. This snail species according to Akinnusi (2004), Ogogo (2004), and Ibom *et al.*,(2009) is native to Nigeria but has spread to other African countries and beyond, South East Abia and the Pacific Islands through Commerce (Olaleye, 2013). *Archachatina marginatavar saturalis*, are nocturnal and feed on a wide variety of feed mainly in the night, early morning, evening or on cold-rainy day. Their activity level (including their rate of feeding) fluctuates with the ambient temperature. Their meats are non-conventional wildlife protein source in Nigeria and some parts of Africa (Fagbuaro *et al.* 2006).

Tympanotonus fuscatus, the West African Mud Creeper or tropical periwinkle is a species of snail living in brackish water, a gastropod mollusc in the family Potamididae (Appleton *et al.*, 2009). It is the only extant species in the genus T*ympanotonus* (Reid *et al.*, 2008). Their shells can reach a size of about 35–100 millimeters.

Periwinkles are marine molluscs that are represented in the mangrove swamp, lagoons and estuaries by two genera *Tympanotonus* and *Pachymelania*. *Tympanotonus fuscatus* are shellfish dominantly found in brackish waters of the riverine areas of Nigeria where they are highly prolific. *Tympanotonus fuscatus* thrives better in brackish waters that are rich in organic matter and minerals (Ogogo, 2004). The tropical periwinkle (*Tympanotonus fuscatus*) has two varieties; the spiky shell called *Tympanotonus fuscatus var radula* while the smooth granulated one called *Tympanotonus fuscatus var ovum*. Studies have shown that both can exist within the same ecosystem but one variety is usually dominant.

According to Mba (2002), the protein contents and chemical score of the molluscs are better than the values for egg. Traditionally, snail meat has been a major ingredient in the diet of people living in the forest zone (Agbogidi and Okonta, 2011).

The meat is a highly priced delicacy in many cities in Nigeria where it is popularly called "Congo meat". Snail meat is an excellent source of animal protein in many parts of West and Central Africa (Blay *et al.,* 2004), with protein content (20.7 %) higher than that of conventional food animals (Malik *et al.,* 2011). The meat is also rich in iron (Agbogidi *et al.,* 2008), potassium, phosphorous, essential amino acids and vitamins C and B complex (Baba and Adeleke, 2006; Okpeze, Omole, Ajayi and Adebowale, 2007) and low in fat (Cobbinah *et al.,* 2008).

Obande *et al.* (2013) describe the flesh of *Archachatina marginata* to have high quality food rich in protein, low in fats and a good source of iron. On the same note, Obande *et al.* (2013) reported that shellfishes are a good-source of protein, low fat and macro- minerals and trace elements such as copper, iron, zinc and manganese.

Apart from its excellent nutritional value, edible molluscs meat has also been reported to be of a good medicinal value (Abere and Lammed, 2008). The low cholesterol level of the meat has made it useful in the treatment of arteriosclerosis and other heart related diseases (Abere and Lammed, 2008). In Ghana, the bluish liquid obtained when the flesh is removed from the shell is believed to be good for infant development **(**Cobbinah *et al.,* 2008).

In the face of the growing awareness on the various disadvantages linked to the red meat from ruminants, e.g., beef, mutton as implicated by high possession of high cholesterol that may increase the risk to various forms or heart diseases especially arteriosclerosis. There is need to look inwards on the use of acceptable and low level cholesterol meat product that could help to limit the incidence of heart diseases.

Traditionally, snail meat has been a major ingredient in the diet of people living in the rainforest zone and the mangrove swamp region of Nigeria. According to Blay *et al.* (2004), asserted that snails are very nutritious foodstuff of highly priced delicacy, in many cities in Nigeria. Also, *Tympanotonus fuscatus* meat is an excellent source of animal protein in many parts of Nigeria with high protein higher than that of conventional food animals. Their meat is also rich in iron, potassium, phosphorous, essential amino acids and vitamin C and B complex and low in fat. Apart from its excellent nutritional value, snail meal has also been reported to be of good nutritional value.

The study evaluates the dietary composition of the flesh of *Archachatina marginata* (African giant snail) and *Tympanotonus fuscatus* (Tropical periwinkle).

MATERIALS AND METHODS

Sample collection

Archachatina marginata (Saturalis) and *Tympanotonus fuscatus* (Radula) were bought from hawkers at the ultra – modern market inNsukka Local Government Area of Enugu state. Nsukka is on longitude 7^{o} 15^{I} E and $7^{o}30^{I}$E and latitudes $6^{o}45^{I}$N and 7^{o}N respectively and is bounded on the north by Igbo-Eze local government area, on the south and southeast by Igbo-Etiti and Isi-Uzo local government area respectively; on the South-West by Uzo-Uwani local government area; and on the north–west by Kogi State. The mean daily temperature of the area is about 27^{o}C – 28^{o}C and the two prominent climatic seasons are the rainy season lasting from April to October. While the dry season lasting from November to march (Federal Republic of Nigeria Official Gadzette, 2007).

Population and Sample Design

A total number of thirty six (36) *Archachatina marginata* (Saturalis) and forty seven (47) *Tympanotonus fuscatus* (Radula) were purchased.

The samples were washed with warm water and potash to reduce the slimy substance on the *Archachatina marginata* (Saturalis) flesh while the *Tympanotonus fuscatus* (Radula) was washed with clean water. Both sampled species edible portion were oven dried at 75^{o}C and ground to fine powder.

The mean dry weight of edible tissues of triplicate samples of each of *Archachatina marginata* (Saturalis) and *Tympanotonus fuscatus* (Radula) were grounded and packed in low density polyethylene (LDPE) bags and refrigerated for further analysis. Both sampled specieswere then carried to the Product Development Research Programme and Soil Science Department of the Institute of Agricultural Research (I.A.R.), Ahmadu Bello University, Zaria for analysis.

Procedures for proximate analysis of *Archachatina marginata* (Saturalis) and *Tympanotonus fuscatus* (Radula) dry weight (edible portion)

A proximate analysis was determination by prescribed methods of moisture ash, crude protein, crude lipid and nitrogen free extract. The samples were analysed in triplicate by standard methods (AOAC, 2005).

Determination of moisture content

Aluminium or plastic dishes were washed and dried to a constant weight in an air oven at 100^{o}c. They were later removed and cooled in a dessicator and weighed (W_1) 2 grams of grounded (powdered) samples were placed in the weighted moisture dish (W_2). The crucible containing the samples were kept in an oven at 100^{o}c for about 3 hours, removed and cooled in the dessicator and weighed (W_3).

The moisture was calculated as

$$\%\text{moisture} = \frac{W2-W3}{W2-W1} X\ 100$$

Determination of Ash content

Crucibles were cleaned and dried in the oven. After drying, they were cooled in the dessicator and weighed (W_1). 2 grams of the grounded samples (powdered) were placed in the crucible and weighed (W_2). They were transferred into furnace for 550^{o}c, then removed, cooled in the dessicator and weighed (W_3).

The ash was calculated as:

$$\%\text{ of Ash} = \frac{W3-W1}{W2-W1} X\ 100$$

Determination of fiber content

3grams of the samples were places in a beaker containing 1.2ml of conc. Tetraoxosulphate (vi) and (H_2SO_4) per 100ml of solution and bolted for about 30minites, the solution was filtered and washed with hot water. The residue was transferred to a beaker containing 1.2 gram of NaOH per 100ml solution, and bolted for 30 minutes, the residue was again washed with hot water and dried in an oven and weighed (C_2), the weighed samples were incinerated in a furnace for about 550^{o}c. remove and allow to cool, and weigh (c_3)/

The crude fiber was calculated as:

$$\% \text{ fiber} = \frac{C2-C3}{W} X\ 100$$

Determination of lipid (Fat)

250ml clean boiling flask was dry in an oven and later transferred into a dessicator and allowed to cool 2grams of samples are weighed into a labeled filter paper. The boiling flask is then filled with about 300ml of petroleum either. The soxhlet apparatus was assembled and allowed to reflux for about 8 hours. Then after, the flask containing the sample solution was removed and transferred to an oven to dry. It was then transferred from the oven into a dessicator and allowed to cool and finally weighed.

Lipid was calculated as:

$$\% \text{ fat} = \frac{weightoffat}{Weightofsample} X\ 100$$

Determination of protein

Digestion

2grams of samples were weighed and put into a Kjeldahl flask. One tablet of catalyst (copper) and 25ml cone tetraoxosulphate (VI) acid was added to the sample in the kjeldalh flask. The solution was then transferred to the fume cupboard where it was heated until it assumes a green colour and any black particle showing at the mouth and neck of the flask was washed with distilled water. After cooling, the digest was transferred with several washing into 250ml with distilled water.

Distillation

The Marichan distillation apparatus was steamed before use under the condenser, 100ml containing 5ml of boric indicator was used. 5ml of the digest was pipetted into the body of the apparatus via the small funnel aperture and then washed with distilled water followed by 5ml of 60% NaOH solution. The solution was steam again for about 5-7 minutes to collect enough ammonium sulphate. Finally, the receiving flask was removed and the tip of the condenser was washed down in the flask.

Titration

Solution was titrated in the receiving flask using N/100(0.01N) hydrochloric acid. The nitrogen content was calculated and protein content as well.

Determination of carbohydrate

By difference: Carbohydrate content is obtained by calculation having estimated all other fractions by proximate analysis. i.e = 100 – (% moisture + % Ash + % protein + % fat).

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DATA ANALYSIS

Data from the proximate analysis was subjected to statistical analysis: mean and standard deviation and represented in a histogram, standard error of measurement (SEM) and student t-test. Analyses were carried out using Microsoft Excel 2007 (Microsoft Inc.) and SPSS Version 20.

RESULTS AND DISCUSSION

The results of the mean proximate composition of the sampled snails are presented in figure 1.

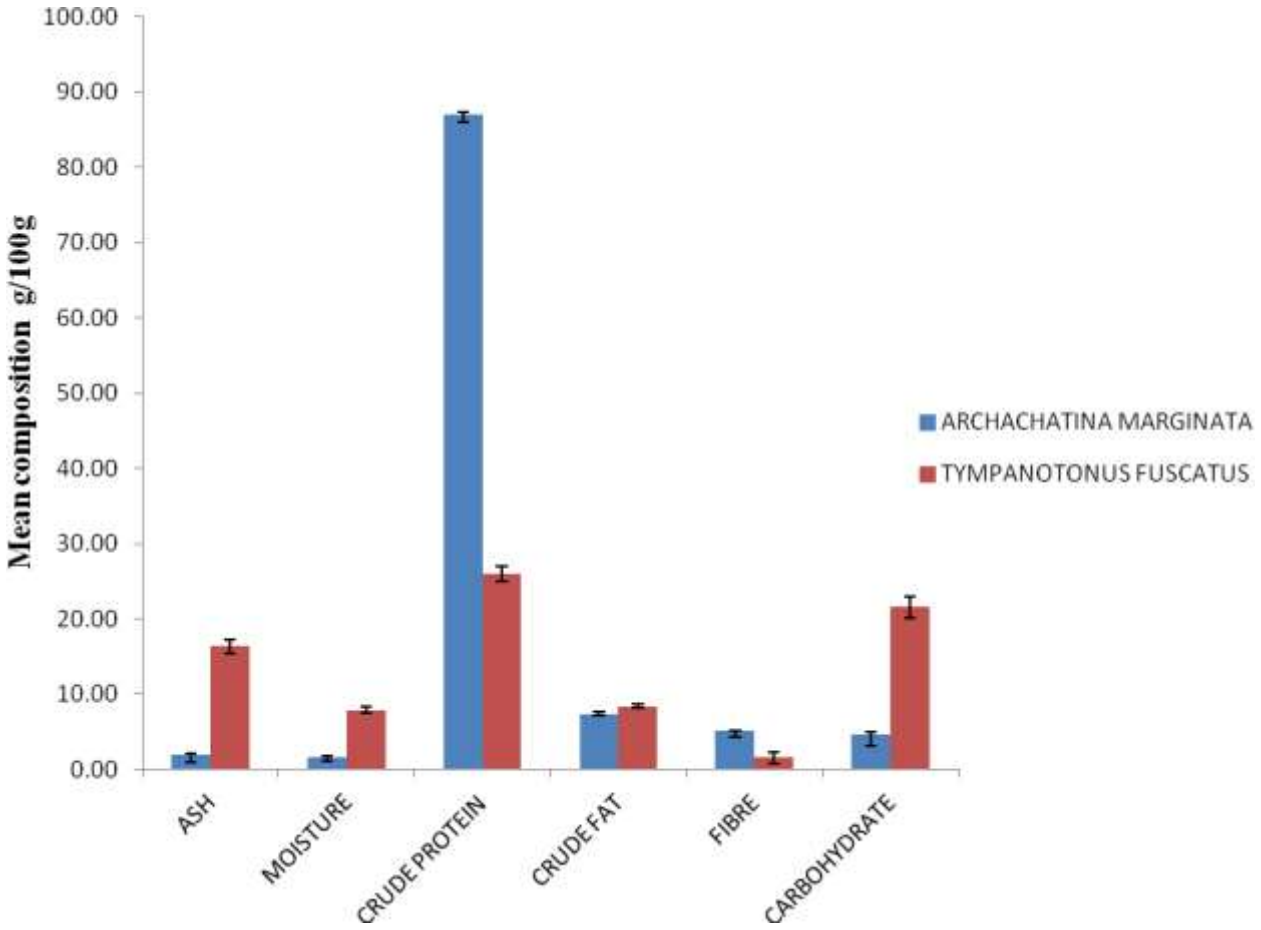

Fig. 1: Comparative proximate composition of dried flesh of Archachatina marginata var. saturalis and Tympanotonus fuscatus var. radula

Figure 1 shows high crude protein content of (86.96 ± 0.37) in *Archachatina marginata* var Saturalis (86.96 ± 0.37) than *Tympanotonus fuscatus* (25.96 ± 0.56) higher than other nutritional contents. The lowest nutritional composition was recorded in the fibre content for *Tympanotonus fuscatus* (1.53 ± 0.76) and moisture content for *Archachatina marginata* (1.54 ± 0.23).

The present study showed an ash content of 1.88 ± 0.19 for *Archachatina marginata* and *Tympanotonus fuscatus* (16.30 ± 1.09). The latter result is higher than the result 10.16 ± 0.09 obtained by (Ehigiator and Oterai, 2012) while the value for *Archachatina marginata* is similar to what was observed by (Wosu, 2003) for dried meat. The differences in values indicate that *Tympanotonus fuscatus* absorbs less water than the *Archachatina marginata*.

The moisture content of 1.54 ± 0.23 in *Archachatina marginata* and7.86 ± 0.39*Tympanotonus fuscatus* dried weight respectively differs completely from the fresh flesh recorded by Wosu (2003) for aquatic snails as 73.7% and 10.37 ±0.08 reported by (Ehigiator and Oterai, 2012).

The protein content of 86.96 ± 0.37 in *A. marginata* is higher while in *T. fuscatus* 25.96 ± 0.56 was obtained. The value obtained for *A. marginata* is higher than the result by Malik *et al.* (2011) and Wosu (2003) as 20.7% *Archachatina marginata.* In *Tympanotonus fuscatus*, Ehgiator and Oterai (2012) results reveals 68.46 ± 0.26, which is equally higher than what was obtained in the present study. However, their findings are centered on percentage wet basis. The present results also supported Wosu (2003) findings that on dry matter based *Archachatina marginata* meat had higher protein content than

the *Tympanotonus fuscatus*. Based on these variations, it simply means that *Archachatina marginata* is a good source of protein and could be used to compliment the cereal sources of protein making good their relative deficiency of lysine Ludorff and Meyer in Cagiltay *et al.* (2011) are of the view that factors like collection method and location, season and sexual condition are important factors for the nutritional compositions.

The fat content in *Archachatina marginata* of 7.35 ± 0.24 is lower than that of the *Tympanotonus fuscatus* of 8.36 ± 0.29. The results obtained were higher than those reported by Wosu (2003) which was between the range of 1.21 – 1.64% for land snails while the value for *Tympanotonus fuscatus* shows similarity with the result 7.68 ± 0.24 obtained by (Ehigiator and Oterai, 2012). The values obtained from the present study is higher than the fat contents in the dried flesh of *Archachatina marginata* 2.44% and *Tympanotonus fuscatus* of 1.32% as observed by (Ehigiator and Oterai, 2012). Comparing the present studies result with other animal food; it was noted that the fat contents of *Archachatina marginata* and *Tympanotonus fuscatus* are higher than 1.0% for egg white and yolk in small amount, whole cow milk of 3.8% and goat milk of 4.8% but lower than the meat of chicken (12.6%), turkey of 20.2%, dried fish of 21.0%, lamb of 27.7%, beef 22.0% and relatively very high in pork of 45.0%. These shows that *Archachatina marginata* and *Tympanotonus fuscatus* have a low fat content making the meat a good antidote for hypertensive patient and those that have fat related diseases like arteriosclerosis (Abere and Lameed, 2008). Variations in the fat contents between species could be due to the location and origin of species (Lee *et al.*, 2004).

The result of the t- test for the proximate analysis between *Archachatina marginatavar. saturalis* and *Tympanotonus fuscatus var. radula* dried flesh are presented in table 1

Table 1: Mean and Independent Samples Test proximate composition between *Archachatina marginata var. saturalis* and *Tympanotonus fuscatus var. radula* dried flesh.

Species	N	Mean	S. D.	Df	t-value	Level of significance
A. Marginata	6	17.89	33.90	10	0.95	0.05
T. fuscatus	6	16.92	14.69			

The *p*- value for the equal variances t-test is $p = 0.95$. Since this *p* – value is greater than 0.05, the decision would be that there is no significant difference between the proximate composition of *Archachatina marginata var. saturalis* and *Tympanotonus fuscatus var. radula* dried flesh.

The mean proximate compostion of *Archachatina marginata var. saturalis* (M = 17.89, SD = 33.90, N = 6) was not significantly different (p > 0.05) from *Tympanotonus fuscatus var. radula* (M = 16.92, 8jup/zYTF^%gr bh SD = 14.69, N = 6) dried flesh.

The results of the caloric values for crude protein, lipid and carbohydrates *Archachatina marginata var. saturalis* and *Tympanotonus fuscatus var. radula* are presented in table 2.

Table 2: Caloric values for Crude Protein, Lipid and Carbohydrates in *Archachatina marginata var. saturalis* and *Tympanotonus fuscatus var. radula*

Parameters	*A. Marginata* kcal/g	*T. fuscatus* kcal/g	*df*	*t-value*	*Level of significance*
Crude Protein	478.28	142.78			
Lipid	69.83	79.42	4	0.59	0.05
Carbohydrates	18.7	88.23			
Total Calories	**566.81**	**310.43**			

Table 1 shows the caloric values for crude protein, lipid and carbohydrates. In *A.marginata*, crude protein has the highest value (478.28) followed by lipid (69.83) and carbohydrates (18.7) whereas in *T. fuscatus* crude protein (142.78) then lipid

(79.42) and carbohydrates (88.23). Total calories obtained in *A. marginata* were 566.81 higher than the *T. fuscatus* which was 310.43. The results indicates that there is no significant difference in calories calculated between *Archachatina marginata var. saturalis* and *Tympanotonus fuscatus var. radula.*

CONCLUSION

The proximate composition of *Archachatina marginata var. saturalis* and *Tympanotonus fuscatus var. radula* driedflesh revealed crude protein (86.96 ± 0.37) has the highest percentage composition in *Archachatina marginata var. saturalis* while in *Tympanotonus fuscatus var. radula* the percentage composition of crude protein is 25.96 ± 0.56. The result showed that there is no significant different ($p > 0.05$) in the proximate composition of dried flesh of *Archachatina marginata var saturalis* and *Tympanotonus fuscatus var. radula*.

Archachatina marginata and *Tympanotonus fuscatus* are invertebrates belonging to the class gastropoda. Their edible parts (meat) serve as luxury food for human consumption and has medicinal effect, used in the treatment of heart related diseases like arteriosclerosis because of their low fat contents. The present study also reveals that the species meat is a good source of protein and can be used as a substitute for fish which has a higher protein contents. Edible snail and periwinkle meat should be incorporated into our diet as their meat provides an alternative source of protein which is higher than the conventional red meat.

REFERENCES

Abere, S. A. and Lameed, G. A. (2008). The medical utilization of snails in some selected states in Nigeria. In: J.C. Onyekwelu, V.A.J. Adekunle and D.O. Oke (Eds). *Proceeding of the 1st National Conference of the Forests and Forest Products society (FFPs)*, Akure, Ondo State, Nigeria. pp. 233-237.

Agbogidi, O. M., Okonta, B. A. and Ezeana, E. L. (2008).Effects of two edible fruits on the growth performance of African giant land Snail (*Archachatina marginata* Swaison), *Journal of Agricultural and Biological Science, 3,26-29.*

Agbogidi, O. M. and Okonta, B. C. (2011). Reducing poverty through Snail farming in Nigeria. *Agriculture and Biology Journal of Northern America, 2,169-172.*

Akinnusi, O. (2002) *Introduction of Snails and Snail farming.* Triolas Publishing Company.

A.O.A.C. (Association of Official Analytical Chemists), (2005). *Official Methods of Analysis of the AOAC* (W.howrwitz Editor) Eighteeth Edition, Washington D.C.

Appleton C., Jørgensen A., Kristensen T. K. and Stensgaard A-S. (2009). *Tympanotonus fuscatus.* In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. www.iucnredlist.org>. retrieved on 10 April 2011.

Baba, K. M. and Adeleke, M. T. (2006).Profitability of Snail Production in Osun State. *Nigeria Journal of Agriculture and Food Science34*, 147-155.

Blay, E. T., Heloo, J., Ofori, J. B. and Nartey, E. (2004). Agrodiversity within and without conserved forest for enhancing livelihood. In Gyasi, E.A. Kranjac-Berisavljevic G., Baly, E. T., Oduro, W. (Eds). *Managing agrodiversity and traditional way. Lesson from West African in suitable use of biodviersity and related Resources*. Tokyo - United Nations, University Press.

Çağıltay, F., Erkan, N., Tosun, D. and Selçuk, A. (2011). Amino acid, fatty acid, vitamin and mineral contents of the edible garden snail (*Helix aspersa*). *Journal of Fisheries Sciences.com.5 (4)*: 354-363

Cobbinah, J. R. Vink, A. and Onwuka B. (2008). *Snail farming: Production processing and marketing* (1st ed). Agromissi Foundation Agrodok 47 and CTA, Wageningen.

Ehigiator, F. A. R. and Oterai, E. A. (2012). *Chemical Composition and Amino acid profile of caridean prawn (Macrobranchium vollenhovenii)* from Benin River, Edo State, Nigeria. IJRRAS 11(1) 162 – 167.

Fagbuaro, O., Oso, J. A., Edward, J. B. and Ogunleye, R. F.(2006). Nutritional status of four Giant- Land snails in Nigeria. .*Journal of Zhejiang University, Science B, 7*(9): 686-689.

Federal Republic of Nigeria Official Gazette (2007). *Legal Notice on Publication of the Details of the Breakdown of the National and State Provisional Totals 2006 Census*. (PDF). Retrieved 4-08-2014.

Ibom, L. A. Okon, B. A. and Essien, A. O. (2008). Morphonetric analysis of eggs laid by two ectotypes of *Archachatina marginata* (Swainson) raised in captivity. *Proceedings of the 35th Annual conference of Nigerian society for Animal production* (NSAP) March 16-20, 2008 Ayeloro Ogun state, Nigeria pp 28-30.

Jamabo, N. and Chinda, A. (2010). Aspects of the Ecology of *Tympanotonus fuscatus var fuscatuis* (Linnaeus, 1758) in the Mangrove Swamps of the Upper Bonny River, Niger Delta, Nigeria. *Current ResearchJournal of Biological Sciences***2** (1): 42-47.

Lee, M. K., Moon, J.H. and Ryu, H.S. (2004). Nutritional composition and protein quality of giant snail product. *Journal of Korean society of food and Nutrition, 2*, 453-458.

Lee, S.Y. and Söderhäll, K. (2001). Characterization of a pattern recognition proein, a masquerade – like protein in the freshwater crayfish (*Pacifastacus leniusculus).Journal of Immunol,* 166, 7319-7326.

Maikano, A. (2015). *The living world of molluscs*. Zaria. A.B.U. press ltd. p. 34-63.ISBN:978-125-731-8.

Malik, A. A., Aremu, A., Bayode, G. B. and Ibrahim, B. A. (2011). A nutritional and organoleptics assessment of the meat of the giant African land snail (*Archachatina marginata* Swaison) compared to the meat of the giant African livestock. *Livestock Research for Rural Development, 23,* 3.

Mba, A. U. (2002.) Chemical Composition of some local sources of protein foods for man. *Nigeria Journal of Nutrition Science***1**:142-147.

McFadden, C.H. and Keeton, W.T. (2001). *Biology and exploration of life.* (2nd ed.). U.S.A.: W. W. Norton & Company Inc. pp.22-23 & 941.

Obande, R. A., Omeji S, and Isiguzo I. (2013). Proximate Composition and mineral content of the fresh water snail (Pila ampullaceal) from River Benue, Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology, 2*(6), 43-46.

Odaibo, A. B. (2003). Studies on growth and aestivation in *Archachatina marginata* (Pfeiffer) (Pulmonata: Achatinidae) ovum in the laboratory. *Zoologist*, 2: 30-35.

Ogogo, A. U. (2004). *Wildlife management in Nigeria. Objectives, principles and procedures. Calabar median communications.* Pp 134-154.

Okpeze, C. N., Omole, A. J., Ajayi, F. T. and Adebowale, E. A. (2007). Effects of Feeding adults snail with *Styolsanthes guianesisor, Lablab purpurius* as Substitute for pawpaw leaf. *African Journal of Biotechnology, 6*,1959-1962.

Olaleye, D. A. (2013). Consumers' Preferences for Snail Meat in the African Community of Pittsburgh, Pennsylvania. *M.Sc. Research Paper presented in Agriculture and Natural Resources Degree*. University of Tennessee at Martin.

Reid, D. G.., Dyal, P., Lozouet, P., Glaubrecht, M. and Williams, S. T. (2008). "Mudwhelks and mangroves: The evolutionary history of an ecological association (Gastropoda: Potamididae)". *Molecular Phylogenetics and Evolution 47* (2): 680–699. doi:10.1016/j.ympev.2008.01.003. PMID 18359643.

Wosu, I.O. (2003). *Commercial snail farming in West Africa*: A guide. Ap Express PublishersLtd, Nsukka.

APPENDIX I

Caloric value

The caloric values of the lipid, crude protein and carbohydrate were calculated using standard conversion factors (Winberg, 1971) as follows:

i. Lipid caloric value = amount of lipid g/100g x 9.5kcal/g.
ii. Protein caloric value = amount of protein g/100g x 5.5kcal/g.
iii. Carbohydrate caloric value = carbohydrate values x 4.1kcal/g
iv. Total calory = Lipid x protein x carbohydrate value (kcal/g)