

CONCENTRATION OF NUTRIENTS PRESENT IN FRESH AND ROASTED BUSH MEAT (GRASS CUTTER) (THRYONOMYS SWIDERIANUS)

Victor-Osanyinlusi Remi¹

¹Department of Pharmaceutical Technology, Rufu Giwa Polytechnic Owo Ondo State Nigeria.

ABSTRACT

Bush meat (Grass cutter) is one of the best natural meats with lots of nutritional advantages. The increase in consumption of bush meat serves as alternative which bridges the gap of the inadequacy of animal protein and other nutrition. The grass cutter (Thryonomys swinderianus) meat samples used in this research were collected from Emure Owo market, in Owo local government of Ondo state, Nigeria. The hairy skin of the fresh lifeless grass cutter was removed using hot water. The grass cutter was dissected and the intestines were removed, washed after which the part to be used for analysis (laps) were separated and that of roasted, pounded with the aid of mortar and pestle prior to further analysis. The study examined the protein, ash, fat, vitamins, simple carbohydrates and heavy metal composition of roasted and fresh grass cutter meat samples.

Keywords: Grass cutter, Bush meat, mineral elements, Vitamin, protein, proximate composition

1. INTRODUCTION

Bush meat which is globally referred to as game animals have served as a good source of protein to rural Africa (Fonweban and Njwe, 1990).

The causes of shortage of animal protein in developing countries has been traced to low production and increasing cost of animals proteins such as beef, chicken, and pork. This has affected the consumption of animal proteins by average Nigeria (Oke. et al., 2004). Therefore the increasing consumption of bush meat serves as alternative bridging the gap of the inadequacy of animal protein. (Abulude, 2004b).

A class of animal called bush meats typically exist in the forest. The following are the common species of bush meat found in Nigeria Canivora, pHmata, rodents, pholidota, hyracoidea, artiodactyl, etc. The method adopted for killing or catching games varies from using traps or guns depending on the hunters preferred technique.

The population of bush meat in Nigeria has been greatly affected by both environmental and human activities, such as agricultural practices and community development (Abulude, 2004a).

(Hoffman, 2008) proves that bush meat provides virtually the same quantity of nutrition with domestic meat such as high protein and low fat. About 80% of Africans solely depend protein gotten from wild animal such birds, reptiles, and mammals as a supplement to their diet (Anstey, 1991).

Captain W. Allen 1843 reported that the term “bush meat” originated from western Africa when he visited and noticed natives Africa, setting bush on fire for the purpose of hunting wild animals, which they regarded as ‘bushmeat.’ Ever Since then, all wild animals hunted for food, especially in Africa have been termed as bushmeat. Wild animals serve as a source of income, and also play a unique role in the practice of traditional medicine (OrdazNemeth et al., 2017).

The grasscutter, (Thryonomys swinderianus), which has been domesticated in time immemorial, is one of the largest rodents in Africa. The occurrence of dense, thick grasses growing in Africa contributed to the distribution of the grasscutter. The natural economic ability of the grasscutter is the reason many development agencies and non-governmental organizations are interested in reducing poverty are promoting its production, particularly in countries in the West African sub-region where the meat of the animal is a delicacy. Information on the ensuing heavy metals concentration and other nutritional quantity in consumed bush meat is quite important. This interest is to ensure safe consumption of bush meat and minimizing the potential hazard effects of these metals on human health. This study will provide baseline information on the abundance of some nutritional contents on bush meat in our rural communities. Hence it aims at comparing the nutritional composition of fresh and roasted bush meat (Glasscutter) Thryonomys swinderianus. Therefore, this work is to further provide information on the nutritional quality of grass cutter bush meat prepared and sold in Emure Owo Ondo State Nigeria. The data generated and result will serve as database for future works.

2. MATERIALS AND METHOD

MATERIALS/EQUIPMENT

- ❖ Fresh and roasted bush meat
- ❖ Weighing balance

- ❖ Filter paper
- ❖ Heating mantle
- ❖ Crucible
- ❖ Beaker (Pyrex England)
- ❖ Conical flask
- ❖ Mortar and pestle
- ❖ Water bath
- ❖ Atomic Absorption Spectrophotometer etc.

CHEMICALS

All the chemicals used are of analytical grades and were obtained from reputable sources.

SAMPLE COLLECTION

- ❖ The fresh and roasted bush meat samples were purchased from Emure market in Owo local government area of Ondo state, Nigeria.

AUTHENTICATION

- ❖ It was taken to environmental biology laboratory in SLT department Rufus Giwa Polytechnic for identification.

SAMPLE PREPARATION

- The hairy skin of the lifeless grass cutter was removed using hot water. The grass cutter was dissected and the intestines were removed, washed after which the part to be used for analysis (laps) were separated, pounded with the aid of mortar and pestle, properly labeled inside a container and was sent to the laboratory for immediate analysis.
- The same part that was removed from the fresh grass cutter was equally separated from the roasted grass cutter, pounded with the aid of mortar and pestle, properly labeled inside a container and was also sent to the laboratory for immediate analysis.

PROXIMATE

FATS CONTENT DETERMINATION

A clean filter paper that is fat free was weighed (W_1) and 5g of the sample was added to the filter paper and was weighed again (W_2). This was then tied with thread and dropped inside the thimble of the soxhlet apparatus. About 250ml of petroleum ether was poured into the round bottom flask of the apparatus. The soxhlet apparatus was set up on a heating mantle and the extraction process was done for four hours in order to extract the fat with the help of the solvent. Petroleum ether siphoned over the barrel, the condenser was detached and the thimble was removed. The solvent-extract (lipids) mixture was carefully poured into a clean dried petridish and transferred into a fume cupboard for 2 hours and the solvent evaporated and it was remaining the fats that were extracted. The filter paper containing the residue was dropped in a beaker and then in an oven at 50°C and was dried to a constant weight. The filter paper was later cooled inside desiccators and reweighed again (W_3). The percentage fat was calculated.

$$\% \text{ fat content} = \frac{W_2 - W_3}{W_2} \times 100$$

$$W_2 - W_1 \quad 1$$

ASH CONTENT DETERMINATION

A crucible that is ash free was weighed and the weight was recorded (W_1). 2g of sample was weighed into the crucible (W_2) and was transferred into the muffle furnace and the muffle furnace was ignited at 600 C for four hours until a grayish white substance was obtained. The crucible was transferred from the muffle furnace into a desiccator and was cooled and was reweighed again (W_3).

The percentage ash content was calculated;

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2} \times 100$$

$$W_2 - W_1 \quad 1$$

3. DETERMINATION OF PROTEIN CONTENTS

2g of sample was weighed into 50ml kjedahl flask, and 12.5ml of concentrated H_2SO_4 was added with one kjedahl catalyst tablet. The flask was heated on a heater with a low heat for about 15minutes, and increase to medium heat for about 30minutes and finally at high heat until digested. The flask was rotated at intervals until the digest is clear, and the heating continues for few after that to ascertain completed digestion. The flask was allowed to cool and the sample residue was washed and filtered, to make the digest up to 50ml (V_1).

After the digestion was completed, 5ml of 2% boric acid (H_3BO_3) was placed into 100ml conical flask (as receiving flask) and 3 drops of mixed indicator was added. The receiving flask, was placed so that the tip of the condenser tube is below the surface of the boric acid, out of the 50ml of the digest 5ml (V_2) was pipetted into the distillation tube and 10ml of 40% NaOH was added. The heater was turn on and the distillation continues until approximately 50ml of distillate has been collected into the receiving flask, and then the heater was turn off. The distillate was titrated with 0.01M HCl and blank was titrated with the acid as well.

$$\frac{\%N = M \times T \times 0.014 \times V_1 \times 100}{W \quad V_2 \quad 1}$$

$$\% \text{ protein} = \% \text{ N} \times 6.25$$

4. VITAMIN

DETERMINATION OF VITAMIN A

The working standards were prepared from the standard stock solution which was diluted to five concentrations ranging from (5 – 500) IU/mL for the standard curve with an equation, $y = 105 \times +0.0123$, $r^2 = 0.991$. After saponification by heating the solution (30 min) with diethyl ether, the reagent (Antimony tri chloride 10 mL) was added to make solution up to 100 mL with trichloromethane (CHCl₃). A blank containing only solutions and the reagent was similarly prepared. The absorbance of each sample was read at 620 nm.

Two (2) g of well pulverized sample was weighed into a 250ml volumetric flask and dissolved in 50ml of petroleum ether:Acetone (2:1v/v) mixture was added to the extract the β -Carotene. The flask containing the mixture was placed on a shaker to shake at 200 rpm for 20min to ensure uniform mixing at room temperature. The mixture was later centrifuged at 4000 rpm for 10min and the supernatant collected and made up to 50ml with the solvent mixture. The supernatant was transferred to a 250ml separatory funnel to separate the organic layer (upper layer). The aqueous layer was discarded and the organic layer was transferred into the 50ml volumetric flask and made up with solvent mixture for reading of β -carotene. Working standard of β -carotene of range 0-50ppm or /ml were prepared from stock Beta carotene solution of 100 ppm concentration. The absorbance of samples as well as working standard solutions was read on a Cecil CE2041 UV Spectrophotometer at a wavelength of 450nm against blank.

$$\text{B - carotene } (\mu\text{g}/100\text{g}) = \text{Absorbance of sample} \times \text{Average Gradient} \times \text{Dilution Factor} 10000$$

DETERMINATION OF VITAMIN B6 (PYRIDOXINE)

(2 – 3) g of sample of sample was weighed into a 100ml beaker, 0.5g of ammonium chloride, 45ml of chloroform and 5ml of absolute alcohol were added to extract all the pyridoxine (Vit.B6). The mixture was thoroughly mixed in a separatory funnel by shaking properly for 30mins. 5ml of distilled water was added to the mixture in the separatory funnel to distinguish the aqueous layer from the chloroform layer. The chloroform layer containing the pyridoxine was filtered into a 100ml volumetric flask and made up to mark with chloroform. 0-10ppm of vitamin B6 or Pyridoxine standard were prepared from 100pm stock standard solution of pyridoxine and treated in a similar way as sample to obtain the gradient factor. The absorbance of a yellowish color solution developed was measured on Cecil 505E Spectrophotometer at a wavelength of 415mn.

Vit B6 in mg/100g was calculated using the formula:

$$\text{Absorbance of sample} \times \text{Gradient Factor} \times \text{Dilution Factor}$$

$$\text{Wt. of sample} \times 100$$

DETERMINATION OF VITAMIN B12

Vitamin B12 was determined in the sample by atomic absorption spectrophotometry (AAS). Samples were extracted with an assay solution, 5g EDTA was added to the filtrate, the PH was adjusted to 7 with NH₄OH, and 5g charcoal was added. The charcoal was removed by filtering through ashless paper which was then placed in a beaker and ashed at 600 degrees C. After dissolving the cobalt oxide from the ash in 5N HNO₃, cobalt content was determined by using AAS. To determine B12 in the sample, cobalt in the sample is multiplied by 10.43

DETERMINATION OF VITAMIN D (By Spectrophotometry)

A stock solution of standard vitamin D (0.5 $\mu\text{g}/\text{ml}$) was prepared in methanol and diluted to different concentrations ranging from 12 $\mu\text{g}/\text{mL}$ to 315 $\mu\text{g}/\text{ml}$ and UV absorbance was taken at 275 nm. Samples were first pulverized/grounded with blender and 2 - 4 gram of grounded powder was dissolved into 5 ml methanol in a 15 mL falcon tube for 2 hours in the dark with occasional vortex and the solid material was separated from the liquid methanol with whatman filter paper. Vitamin D was extracted from the methanol by mixing slowly three volume of hexane (3 x 2 ml) with the interval of 60 seconds.

SIMPLE SUGAR (CARBOHYDRATES)

About (5 – 10) g of the sample was dissolved in 50 ml of distilled water. The solution was made up to 100 ml with distilled water and filtered. About 25 ml of the mixed Fehling solution was pipetted into a conical flask followed by the addition of 15 ml of the solution from the burette. The solution was heated and on boiling, three drops of methylene blue were added. Few more drops of the solution were added from the burette 1 ml at a time to the boiling liquid until complete decolorization of the indicator was observed. The titre values obtained corresponded to the sugar content reported in mg/100 ml. The non-reducing sugars content was obtained by subtracting the reducing sugars from that of the total sugars. Multiplying the nonreducing sugar content by a factor of 0.95 gives the glucose, sucrose, galactose and lactose content in mg/100 ml.

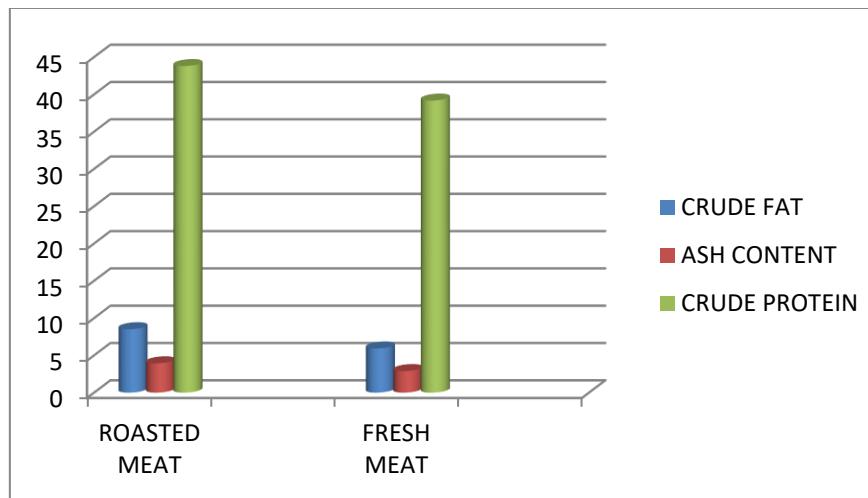
DETERMINATION OF HEAVY METALS

5g of well pulverized sample was weighed into a 250ml conical flask, 20ml of hot acid (HNO₃) was added and was placed on a heater inside Fume Cupboard, with a low heat for about 25 – 30minutes, increased to medium heat for about 15 minutes and finally at high heating until complete digestion was acquired. The flask was rotated at intervals until the digest was clear (white fumes). The heating continued for few minutes to ascertain complete digestion i.e a clear solution is an evidence of a complete digestion. It was allowed to cool, the sample residue was washed and filter, and the digest was made up the digest up to 100 ml volumetric flask. The sample bottle was filled with the digested sample and the heavy metal concentration was determined by gently introducing the extracted samples to 210 VGP Atomic Absorption Spectrophotometer (AAS).

5. RESULTS AND DISCUSSION

RESULTS OF FAT, ASH AND PROTEIN ANALYSIS OF ROASTED AND FRESH MEAT

PARAMETERS	ROASTED MEAT	FRESH MEAT
Crude fat	8.504±0.01	5.923±0.00
Ash content	3.933±0.00	2.891±0.00
Crude protein	43.795±0.00	39.167±0.00



The nutritional composition of any food influences the food quality and its public acceptance. Few of the major components of meat nutrients are the protein, mineral and lipid contents. The protein content which is the percentage nitrogen was determined by kjeldahl methods, the dry ash procedures was adopted in order to determine the ash content and then the fat content was measured by drying the samples in oven and extracting the crude fat with petroleum ether in a soxhlet extractor for 4hrs. One of the nutritive components of any meat is the lipid content. In this study, the fat content of the roasted 8.504±0.01 grass cutter meat was higher than that of fresh 5.923±0.00 grass cutter meat. The two results are in conformity with the results presented by (Adu et al., 2017) which fall within (6.50-10.1) of its lipids percentage of grass cutter, (11.0) for chicken, (13.4) for pig and very low compared to the percentage of fat presented for cow (28.0). The fat contents of both fresh and roasted meat samples in this research were higher in value than the result of fat content of domesticated grass cutter meat sample (4.2) as reported by (NRC. 1983).

The results obtained from this research are lower than the 79g of fat recommended for adult per day. It is of advantage to have low concentration of fat in meat, because it is a small portion of a meal, and then other component of a meal such as soup, rice, yam, wheat are expected to contain self-generated fat or added fat that can make up the 79g of fat

recommended per day. It was observed that the two meat samples can complement the quantity of fat needed by the body.

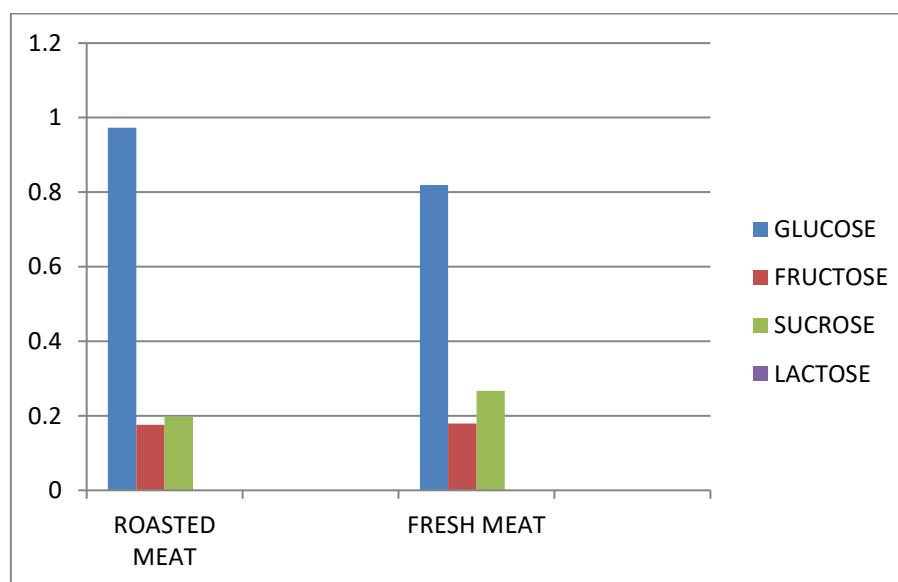
It was also confirmed that the two grass cutter meat samples are good source of protein (Roasted 43.795 ± 0.00 and fresh 39.167 ± 0.00) as it produces higher protein more than many domestic meat samples such as chicken (21.8), sheep (21.02), pig (19.4), cow (16.3) goat (20.38) and even rabbit (14-25) as reported by (Adu et al., 2017). The result obtained in this study are higher than the result (22.7) of domesticated grass cutter meat sample reported by (NRC. 1983), which obviously could have caused the differences in the results. It should be noted that protein is one of the important nutrients needed by the body in order to grow and repair tissues. Although protein can be gotten from other sources, but animal protein is essential as it is one of the easiest and cheapest way to access a healthy quantity of protein. Although the grass cutter cannot meet the daily supply of protein as requested for by RDA 56g/day and 46g/day for male adults and female adults respectively, but it can significantly contribute to the daily protein needed by the body.

The present study also identified that the roasted meat sample contains high concentration of mineral 3.933 ± 0.00 than the fresh meat sample 2.891 ± 0.00 . These results can be compared to the results of (Adu et al., 2017) who reported (0.9) ash percentage of grasscutter, (0.9-1.2) for chicken, (0.8) for pig and (1.0) for cow. The results of ash content in this study (3.933 and 2.891) are significantly different from the results reported by (Adu et al., 2017). The noticeable differences might be due to the duration and temperature of ashing, as ashing for 6 hours at temperature below 550°C (as in the case with this study) tends to give higher ash content than ashing for more hours.

The feeding and age of the grass cutter animal before harvesting could also be a contributory factor to the noticeable differences in the results presented above.

RESULTS OF SUGAR COMPOSITION OF ROASTED AND FRESH MEAT (MG/G)

PARAMETERS	ROASTED MEAT	FRESH MEAT
Glucose	0.973 ± 0.00	0.819 ± 0.00
Fructose	0.176 ± 0.00	0.179 ± 0.00
Sucrose	0.198 ± 0.00	0.267 ± 0.01
Lactose	0.00 ± 0.00	0.00 ± 0.00

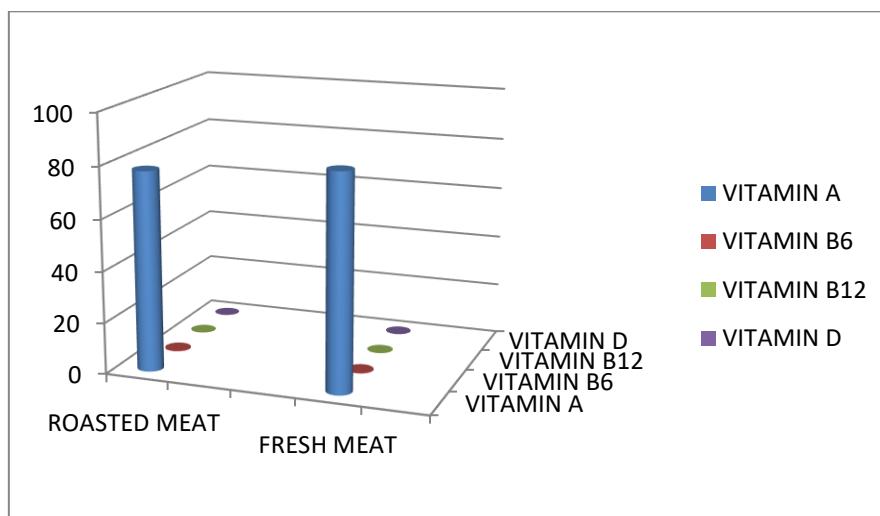


Generally, carbohydrates are one of the most important components in various food items. Simple sugar is one of the two components of carbohydrates and is very important in the body daily activities. It is sugar is further divided into monosaccharide and polysaccharide. In this present study, the two grass cutter bush meat samples contains primarily and approximately 1% of glucose (roasted 0.973 ± 0.00 , fresh 0.819 ± 0.00) which is a monosaccharide. The concentration of glucose in roasted bush meat sample was higher than fresh meat sample. It should be noted that the two bush meat samples contained the same quantity of fructose (roasted 0.176 ± 0.00 , fresh 0.179 ± 0.00). The fact that fructose is usually and slightly sweeter than glucose substantiate the lower concentration of fructose in a meat sample which is not expected to have a honey sweet taste. This research also determined the concentration of other types of simple sugar such as sucrose hat is made up of glucose and fructose, and lactose made up of glucose and galactose which are parts of disaccharides. In this study, the concentration of sucrose is higher in fresh bush meat sample

0.267 \pm 0.01 than the roasted bush meat sample 0.198 \pm 0.00. The low concentration of sucrose in the both samples is never a disappointment as sucrose is majorly found in table sugar and some selected root vegetables. This research demonstrated zero concentration of lactose in the both meat samples. Therefore, grass cutter meat may be considered part of meals to be recommended for people willing or under obligation to cut down simple sugar carbohydrates in order to manage their health.

RESULTS OF VITAMIN COMPOSITION OF ROASTED AND FRESH MEAT (MG/100G)

PARAMETERS	ROASTED MEAT	FRESH MEAT
Vitamin A	77.573 \pm 0.01	83.243 \pm 0.01
Vitamin B6	0.298 \pm 0.00	0.271 \pm 0.00
Vitamin B12	0.059 \pm 0.00	0.057 \pm 0.00
Vitamin D	0.037 \pm 0.00	0.067 \pm 0.00



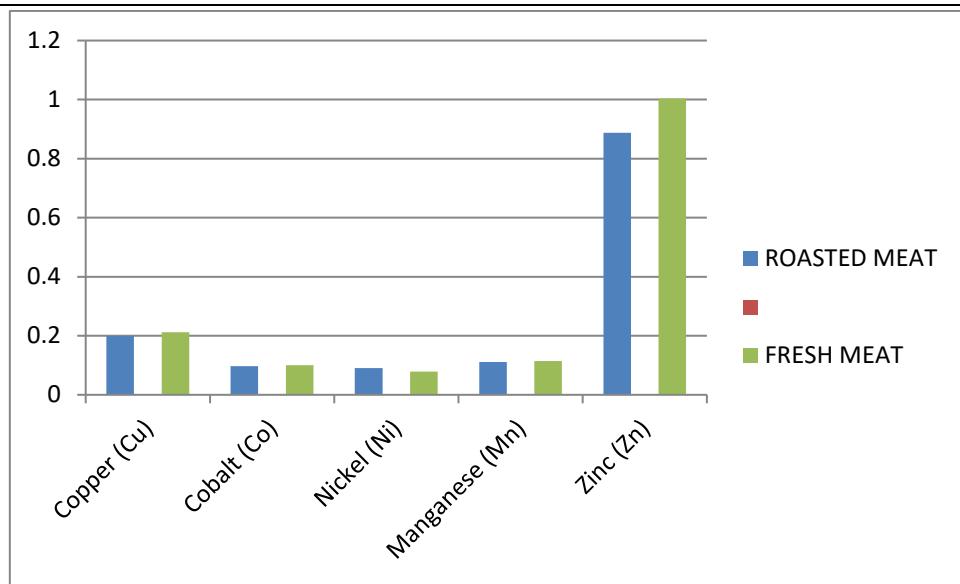
The results of vitamin analysis for both roasted and fresh bush meat are as follow: vitamin A 77.573 \pm 0.01, 83.243 \pm 0.01), vitamin B6 (0.298 \pm 0.00, 0.271 \pm 0.00), vitamin B12 (0.059 \pm 0.00, 0.057 \pm 0.00) and vitamin D (0.037 \pm 0.00, 0.067 \pm 0.00). It was observed that the concentration of vitamin A was higher in fresh bush meat (83.243 \pm 0.01) as against the roasted bush meat sample (77.573 \pm 0.01). vitamin B6 plays an important role in the brain development. Both vitamin B6 and B12 are needed in the body for the production of red blood cell and maintenance of good brain health. The two values are in conformity with the Recommended Dietary Allowance (RDA) values at 900 microgram for adult male and 800 microgram for adult female per day.

The result of vitamin D gotten from the samples (0.037 \pm 0.00, 0.067 \pm 0.00) were way below the Recommended Dietary Allowance (RDA) values 20mg for both male and female adults. it should therefore be noted that vitamin D are sufficient in egg yolk, fortified cereal, fortified milk, liver, and high fat fish than any form of meat, hence the reason for the low value of vitamin D in the grass cutter bush meat samples. This indicated that meat cannot supply concentration of vitamin D needed by the body daily, unless combined with other food such as egg yolk, fortified cereal, liver etc.

The results of the vitamin B6 and B12 in this research are equally low (0.298 \pm 0.00, 0.271 \pm 0.00) and (0.059 \pm 0.00, 0.057 \pm 0.00) respectively. The quantity of vitamin B6 found in roasted bush meat sample 0.298 \pm 0.00 is slightly higher than that of fresh bush meat sample 0.271 \pm 0.00. The both values are lower than 1.7mg recommended per day for both male and female adult. While the concentration of vitamin B12 in the two samples are almost the same (0.059 \pm 0.00, 0.057 \pm 0.00) and are equally lower compared to the recommended value 2.4mcg per day. Therefor it is recommended that meat should be combined with other food sources in order to achieve the daily recommended vitamin.

RESULTS OF HEAVY METAL COMPOSITION OF ROASTED AND FRESH MEAT (MG/KG)

PARAMETERS	ROASTED MEAT	FRESH MEAT
Copper (Cu)	0.199 \pm 0.00	0.212 \pm 0.00
Cobalt (Co)	0.097 \pm 0.00	0.100 \pm 0.00
Nikel (Ni)	0.091 \pm 0.00	0.079 \pm 0.00
Manganese (Mn)	0.111 \pm 0.00	0.114 \pm 0.00
Zinc (Zn)	0.888 \pm 0.00	1.004 \pm 0.00



Heavy metals are metals of high densities and atomic number. It can be present naturally in the environment or caused by human activities. They may be transferred into the soil and then to plants and water that will later serve as food and water for animals and grasscutters is not excluded. Concentration of heavy metal is a concern due to their possible toxicity effect on human health. The present study was undertaken to determine the presence and concentration of Copper (Cu), Cobalt (Co), Nickel (Ni), Manganese (Mn), Zinc (Zn) in the fresh and roasted grass cutter sold in Emure Owo, Ondo state. The study revealed that Copper (Cu), Cobalt (Co), Nickel (Ni), Manganese (Mn), Zinc (Zn) were all present (although in minute quantity) in both roasted and fresh samples examined. Minute quantity of Nickel was detected in the two samples roasted and fresh meat 0.091 ± 0.0 , 0.079 ± 0.00 respectively. This result are lower than the result of (Adelakun et al., 2020) who reported 0.91 for Nickel

Zinc concentration was the highest in both the roasted 0.888 ± 0.00 and fresh 1.004 ± 0.00 grass cutter lap. Zinc is an essential trace element for the livelihood of animals and humans. Zinc concentration was high in fresh sample but reduced in roasted sample. Too little zinc can cause problem and too much zinc is harmful to human health. The concentration of zinc in the present study were in conformity with the daily recommended value (11mg) indicated that the samples were not exposed to zinc contaminating agent. Copper, manganese and cobalt are essential minerals for both animals and human.

Too little of them may cause problem and too much of them may cause food poison. The fresh 0.212 ± 0.00 bush meat samples contain higher concentration of copper compared to the roasted 0.199 ± 0.00 . This could be attributed to the fact that animals were exposed to copper containing feed and drinking water contaminated by copper. According to the world health organization (WHO 1996) the recommended dietary allowance for adult is 0.9mg per day and the concentration of copper in the samples were blow the recommended value. The highest concentration of manganese was found in the fresh bush meat sample 0.114 ± 0.00 , although slightly above the concentration of the roasted 0.111 ± 0.00 bush meat sample.

The highest concentration of cobalt was found in the fresh 0.100 ± 0.00 bush meat sample compared to the roasted which was just slightly lower 0.097 ± 0.00 . This study presented low level of Manganese and cobalt, compared to the study reported by Gbogbo et al (2020) who recorded low level of cobalt and manganese in grass cutter meat and concluded that its consumption at a rate of 0.104 kg per day is safe and higher level of Mn in grass cutter found in Southwestern part of Nigeria was also reported by Soewu et al 2014. The result of cobalt presented in this work is lower the result 0.69 reported by (Adelakun et al., 2020) *Tragelaphus scriptus* (Bushbuck)

The results of Zinc (Zn) 0.888 ± 0.00 for roasted and 1.004 ± 0.00 fresh grass cutter meat samples and copper 0.199 ± 0.0 for roasted and 0.212 ± 0.00 fresh meat samples obtained in this study were comparable to the results reported by Ginevra (2005) Values for both zinc 0.98 for raw pork Saddle, 1.79 for cooked pork Saddle and copper concentration 0.12 for raw turkey lower leg, 0.16 for cooked turkey lower leg.

6. CONCLUSION

Bush meat is one of the best natural meats with lots of nutritional advantages, in rural area, bush meat are the cheapest sources of protein. They must be handled properly and thoroughly cooked to prevent transmitting of diseases to humans

7. REFERENCES

- [1] Abulude, F.O.- 2004a. Studies on termites (Macroterris sp.): Proximate composition, mineral contents and functional properties. *Adv. Food Sci.*, 26: 150-154.
- [2] Abulude, F.O.- 2004b. Proximate composition, mineral contents and functional properties of cricket (Acheta sp.). *Pak. J. Sci. Ind. Res.*, 47: 212-213.
- [3] Adelakun, Km; Kehinde, As; Joshua, Da; Ibrahim, Ao; Akinade, TG Heavy metals in Bushmeat from New-Bussa and its environs, Nigeria. *J. Appl. Sci. Environ. Manage.* Vol. 24 (4) 667- 671 April 2020. ISSN 1119-8362.
- [4] Anstey, S. (1991). Wildlife utilization in Liberia: The findings of a National Survey 1989-1990.
- [5] Anstey, S. (1991). Wildlife utilization in Liberia: The findings of a National Survey 1989-1990.
- [6] E K Adu, A Asafu-Adjaye, B A Hagan and J K Nyameasem The grasscutter: an untapped resource of Africa's grasslands *Livestock Research for Rural Development* 29 (3) 2017.
- [7] E K Adu, A Asafu-Adjaye, B A Hagan and J K Nyameasem. (2017).The grasscutter: an untapped resource of Africa's grasslands. CSIR-Animal Research Institute, P O Box AH 20, Achimota, Ghana
- [8] Fonweban, J.N and Njwe, R.M. (1990). Feed Utilization and life weight gain by African giant rat (Cricetomys gambiae, Water House) at Dschana in Cameroon, *Tropiculture*, 8: 118-120.
- [9] Gbogbo F, Rainhill JE, Koranteng SS, Owusu EH, Dorleku WP. Health risk assessment for human exposure to trace metals via bushmeat in Ghana. *Biol Trace Elem Res.* 2020;196:419-429.
- [10] Ginevra Lombardi-Boccia*, Sabina Lanzi, Altero Aguzzi Aspects of meat quality: trace elements and B vitamins in raw and cooked meats *Journal of Food Composition and Analysis* 18 (2005) 39–46.
- [11] Hoffman, L.C. (2008). The yield and nutritional value of meat from African ungulates, camelidae, rodents, ratites and reptiles. *Meat Science* 80: 94-100.
- [12] Hoffman, L.C. (2008). The yield and nutritional value of meat from African ungulates, camelidae, rodents, ratites and reptiles. *Meat Science* 80: 94-100.
- [13] Oke- D.B.- NI.O. Oke- O.E. Fasina and O.T. Olugbesan, 2004. The evaluation of kolanut test meal as a replacement for maize in broiler diets. L: Performance characteristics. *Proc. 9th Annual Conf. Animal Sci. Ass. Nigeria (ASAN)*. Sept 13th-16th 2004. Ebonyi State University, Abakaliki, Nigeria, pp: 28-30.
- [14] Ordaz-Nemeth I., Arandjelovic, M., Boesch, L., Gatiso, T., Grimes, T., Kuehl, H.S., Lormie, M., Stephens, C., Tweh, C. and Junker, K. (2017).
- [15] Soewu D, Agbolade O, Oladunjoye R, Ayodele I. Bioaccumulation of heavy metals in cane rat (*Thryonomys swinderianus*) in Ogun State, Nigeria. *J Toxicol Environ Health.* 2014;6:154-160.
- [16] World Health Organization (2007). Vitamin and mineral requirements in human nutritions, 2nd edition Geneva'
- [17] World Health Organization. Trace element in human nutrition and health. Geneva: world health organization 1996.