

The Nutrient Composition of the African Rat

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Abstract: The aim of this study is to evaluate and provide nutritional information of the various parts of the rat in raw state. The rodent species are promising because their meat is desirable and nutritional. A complex combination of financial limitation, preference and cultural values underscore the nutritional value of giant rat as food security. There is little contribution of various parts of adult male African giant rat (*Cricetomys gambianus*) to nutrient intake. The proximate chemical composition, minerals, and cholesterol contents of the skin, liver, limb muscle and brain of African giant rat were investigated using standard methods. The brain had the highest levels of phospholipids, moisture and phosphorus. Limb muscle and liver had highest content of protein while skin had the lowest value. Liver and limb muscle had comparable fat values with brain having the lowest. All samples had excess of iron than Recommended Daily Allowance (RDA). The limb muscle had higher values of potassium, zinc and magnesium. The limb muscle appeared to be more desirable in terms of nutritive value.

Key words: Cholesterol, giant rat, minerals, phospholipids, proximate composition

INTRODUCTION

Composition of meat cannot be described only in terms of different components and their percentages since meat includes the entire carcass along with the muscles, fatty tissues bones, tendons, edible organs and glands; all these give a wide range of components and thus of composition and nutritive values (Southgate, 1983). The composition of meat depends on the ration of fat to lean which determines the energy value and concentration of virtually all nutrients because the nutrients are present in different concentration in the fat and lean. More than 71 genera and 89 species of rodents mostly (*Hystricomorphs*) have been consumed by man in tropical world rodents are accepted as a popular source of protein. Giant rat is one of the popular rodents consumed in Nigeria others are squirrels and porcupines but Nigerians have deficiency of animal protein in their diet. In Southern Nigeria 71% especially among the low-socio economic status, accept giant rat as food. Bush meat, like giant rat is a major food item accounting for about 20-90%. The female average weight is 1.2 kg and the male 1.3 kg (Kruger, 2009). According to Hoffman (2008), rodents are most promising as large commercial commodities and their meat is desirable and nutritional contributing from 20% to 90% of the total animal protein consumed by most rural West Africans (University of Nebraska, 1990). Martin (2009) reported that in Nigeria protein from wild animals (bush meat) in the 1970s over 50% of the population ate bush

meat regularly and that bush meat was popular with all income groups. The nutritional value of Africa giant in terms of low fat (chiefly triglycerides, phospholipids and glycolipid in the brain and lipoproteins in the tissues) levels, physiological and ecological adaptation to African environment, disease tolerance and productivity is comparable to meat of many domestic species (FAO, 2009). The amino acid composition is close to the reference (Paul *et al.*, 1980). The fat is Meat is composed of water which is closely related to fat content and to less extent to the ash and carbohydrate content. The fat content in wild ruminants is less saturated because the fat contents are lower. Minerals like sodium and calcium are low in meat while potassium, phosphorus and magnesium are high however iron is high in meats that have not been bled. The consumption of bush meat is changing due to increasing demand from urban dwellers and dwindling supplies of wild animals in rapidly degrading rural environment. Asibey and Eyeson (1975) did not provide nutrition information on African giant rat though they reported extensive chemical analysis on wild life in Ghana and East Africa. Tewe and Ajayi (1978) reported some data on the nutritive value of Africa giant rat that compared favorably with that of poultry, pork and mutton but did not report mineral data on the edible parts and organs. Zyl and Merwe (1999) reported that the cholesterol content of vondo meat for fresh mass or dry mass, respectively. It compares favorably with rabbit meat of 44.2+3.1 mg/100g fresh mass.

Little attention has been given to the beneficial effects of rodents to human food security (Assogbadjo *et al.*, 2005); and little information had been published on the composition and nutritive value of Africa giant rat carcass.

This study will provide information on the nutrient composition of edible portions of Africa giant rats. The information will be valuable in the estimation of Africa giant rat to the nutrient intake of the consumers and in filling the missing gap in food composition table and in diet therapy of nutrition related diseases.

MATERIALS AND METHODS

The study was conducted in the Department of Human Nutrition, University of Ibadan, Nigeria in 2009.

Preparation of samples:

Male adult rats were used.

Proximate composition and minerals: Proximate chemical composition was carried out according to AOAC (2005).

Dry matter of gruel: Into already weighed plastic dish, a spoonful (10 mL spoon was scooped, weighed and the weight recorded. This was later transferred into oven at 105°C for 24 h, after which it was weighed for dry matter determination.

Minerals:

Procedure: One gram of sample (on dry matter basis) was weighed into each crucible and transferred into Muffle Furnace pre-set at 530°C for 120 min. The crucibles were cooled and weighed; this was done in triplicates. The percentage ash was calculated. Three milliliters of 50% nitric acid was added to crucibles with ash samples and heated slowly on a heating plate until the ash was still black, the crucible was replaced in the furnace for another 60 min. After the slow heating, 2 mL of 50% HCl was added to each crucible and left for 15 min. Where there was suspension, the mixture was filtered with filter paper (Filtres Durieux No 111-70 m/m Filtration Rapide). The filtrate was poured into 25 mL volumetric flasks. Each crucible was rinsed with Millipore water 3 times into the volumetric flasks and made up to volume with Millipore water.

Some aliquots from each volumetric flask was stored in propylene tubes for colorimetric estimation of phosphorus while the remaining was used for the determination of macro elements Ca, Fe, K, Na and oligo-elements Mg, Cu, Zn and Mn by atomic absorption. Phosphorus was determined using spectrophotometer at 430 nm.

Estimation of individual lipids: Lipid profiling of Brain, liver, muscle and skin were subjected to lipid profile analysis (Lipomics Technologies, west sacramento, CA); which involved extraction of organ content and tissue lipids with authentic internal standards added by using the Method of Folch *et al.* (1957) using chloroform-methanol (2:1, vol/vol). One gram of sample was homogenized with 20 cm³ chloroform and washed in methanol: water v/v for 4 times. The volume of tissue was estimated to be specific gravity of water 1 cm³. The homogenate was allowed to stand at room temperature for 1 h, filtered through fat-free filter paper. The low phase of the filtrate was purified according to the method of (Folch *et al.*, 1957) the lower phase consisted of pure lipids and neutral lipids.

The upper phase consisted of non-lipid materials and phospholipids.

Wt of sample = 1g

Wt of beaker = wg

Wt of lipid extracted = (w1-w)g

total lipid extracted (%) = $\frac{\text{wt of lipid extracted} \times 100}{\text{Wt of sample}}$

Separation of individual lipids (qualitative): Preparative TLC was used to separate individual lipids classes into cholesterol, cholesterol, cholesterol esters, monoglycerols, diglycerols, triglycerols, free fatty acids, phosphatidyl choline phosphatidyl serine and phosphatidyl glycerol within each extract. A measured quantity of phospholipid was applied using a capillary tube. Phospholipids were separated using chloroform and water 65: 55:4 v/v/v. Development time was approximately 1 h. The plates were removed and air dried for a few minutes and spotted with iodine vapor. Neutral lipids were separated with petroleum ether 4.0-6.0.

Diethyl ether: acetic acid 80:20:1 v/v/v was used to extract phospholipids remaining in the original sample. Development time was approximately 40 min. Plates were removed, air dried and spotted with iodine vapor.

R.F values of the various spots were calculated and compared with those of the known standard lipid.

R.F. = $\frac{\text{Distance moved by spot}}{\text{Distance moved by solvent front}}$

The TLC plates were dried to remove all traces of iodine vapor and solvent. In this work the developed TLC plates were placed in TLC tank containing 2.3 crystals of iodine stain. The plates were then dried under nitrogen for 3 h.

Quantitative estimation of individual lipids: The determination of total lipids was done by the

Table 1: Proximate chemical analysis of the African giant rat

Nutrient g/100g	Skin	Muscle	Liver	Brain
Moisture	56.8±0.11	65.4±0.03	62.1±0.02	72.8±0.02
Crude Protein	8.7±0.02	20.1±0.03	18.39±0.03	12.3±0.01
Fat	9.8±0.02	11.4±0.02	10.2±0.03	5.6±0.02
Ash	7.9±0.05	2.0±0.02	5.7±0.06	6.2±0.03
Carbohydrate	16.7±0.03	1.0±0.02	3.7±0.03	3.2±0.02

Folch *et al.* method (1957) by replacing chloroform by dichloromethane. The sample was ground with an Ultraturrax IKAT 25 in a mixture dichloromethane/methanol (2/1), containing 0.01% BHT (antioxidant agent) was then filtered vacuum 3 times (filter Wattman GF/A55 mm deposited on membrane filter made of stainless steel, coated with silica).

The TLC plates were dried to remove all traces of iodine vapor and solvent. In this study the developed TLC plates were placed in TLC tank containing 2.3 crystals of iodine stain. The plates were then dried under nitrogen for 3 h. Individual lipid fractions were scraped from the plate and eluted with chloroform: methanol (2:1 v/v) mixture into a parked tube previously washed with the same solvent and evaporated off. The amount of each unknown neutral lipid was read from a standard calibration curve using various concentration of phosphatidyl choline in chloroform: methanol mixture (2:1 v/v). About 0.5 cm³ of dichromate was used as a blank. The tubes were placed in water bath at 100°C/45 min; shaken and cooled under water. 10 cm³ of water was added. The content of each tube were thoroughly mixed and the Optical Density (O.D) read at 350 nm (Riemenschneider, 1964).

$$\frac{\text{O.D blank} - \text{O.D unknown}}{\text{O.D blank} - \text{O.D of standard}} = \frac{\mu\text{g of lipid unknown}}{\mu\text{g of lipid standard}}$$

The amount of each unknown phospholipids was read from standard curve of various concentration of phosphatidyl choline. The TLC plates were dried to remove all traces of iodine vapor and solvent. In this work the developed TLC plates were placed in TLC tank containing 2-3 crystals of iodine stain. The plates were then dried under nitrogen for 3 h.

Statistics: Significance of difference between organs total lipids and metabolite concentrations was assessed by unpaired Students t-test, with p<0.05 considered significant. This statistical approach has been used previously to evaluate this type of lipid profile analysis (Bruder *et al.*, 2005).

RESULTS AND DISCUSSION

Moisture: Table 1 showed that the moisture content was higher in brain followed by muscle, liver and skin, respectively. The fat is composed of water which is

closely related to fat content and to less extent to the ash and carbohydrate content. All these values were however lower than that of raw ostrich beef and chicken Sales *et al.* (1996)

Protein: Apart from water, protein form major part of lean body tissue. 17% of body weight is protein. Protein is required for regulation and maintenance of body functions like blood clotting, cell repair, enzymes, hormone transportation of many substances. Low protein in diet slows down anabolism leading to decrease in size of heart and liver. Only brain resist protein breakdown. Food and Nutrition Board (2005) allow 35% of total calorie intake to be supplied by protein. In this study, as shown in Table 1, the limb muscle had the highest protein value which compared favorable with the report of (Ajayi and Tewe, 1979; Asibey and Eyeson, 1975). The skin had the lowest crude protein value. Generally the value of crude protein of Africa giant rat compare favorably with that of other wild and domestic animals (Paul and Southgate, 1978) RDA for protein is 0.8 g/Kg of healthy body weight. In this study, the values protein were comparable (<http://www.buzzler.com/articles/liver-nutritionfacts.html>).

Carbohydrate: Carbohydrate is the main fuel sources of cells. The muscle depends on it for physical activity. Liver and muscles are major storage organs of glycogen. Table 1 in this study, however showed highest value of carbohydrate in skin, followed by liver and muscle, respectively. The high value of skin might be due to the fact that glucose is stored as glycogen under the skin (Kramilich *et al.*, 1973). However, the value of carbohydrate the value of carbohydrate was higher than that of calf liver (<http://www.buzzler.com/articles/liver-nutritionfacts.html>).

Fat: There is no RDA for fat though the 2005 dietary Guidelines for Americans recommend total fat intake should not exceed 20-35% of total calories which equals 44-78 g/day for a person that consumes 2000 kcal/day. The brain is 60% fat due to large amount of myelin which is 70% fat this insulates the axons and neurons (Dorfman, 2005). Lipid in this study as indicated in Table 1, is higher in the brain than other parts this is in agreement with Wardlaw and Smith (2007) reported that many types of phospholipids exist in the brain which showed a proportional increase in both PhosphoLipid

and non-

Table 2: Mineral composition of African giant rat

Mineral mg/100g	Skin	Muscle	Liver	Brain
Calcium	93.3±0.14	50.0±0.03	30.3±0.02	57.0±0.02
Potassium	993.8±0.02	1387.5±0.02	1162.5±0.02	1312.5±0.03
Phosphorus	750±0.22	750.0±0.04	1500.0±0.03	1650.0±0.04
Iron	70±0.12	73.0±0.50	167.8±0.03	95.8±0.06
Zinc	8.5±0.15	175.0±0.12	15.5±0.05	11.8±0.09
Magnesium	200.0±0.60	260.0±0.44	105.0±0.02	22.5±0.05

Table 3: Mineral safety index of parts of African giant rat

sample	Fe			P			Mg			Zn			Ca		
	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D
Limb muscle	10	10.7	0.7	15	9.8	5.2	33	577.3	-544.3	10	0.60	9.4	6.7	27.2	-20.5
Liver	10	21.4	-11.4	15	3.9	11.1	33	49.5	-16.5	10	0.40	9.6	6.7	62.5	-55.8
Brain	10	23.6	13.6	15	0.84	14.2	33	38.9	-5.9	10	0.70	9.2	6.7	35.7	-29.0
Skin	10	10.7	0.7	15	7.5	7.5	33	28.1	4.9	10	1.9	8.1	6.7	26.1	-19.4

TV= Tabulated value

CV= Calculated value

D= Difference between calculated value and tabulated value.

Tabulated Mineral Safety Index x Value of mineral in sample = Mineral Safety index
Recommended Adult intake of mineral

Table 4: Individual lipid, cholesterol and free fatty acid composition of African Giant Rat

Lipid mg/100g	Skin	Muscle	Liver	Brain
Monoglycerol	5.0±0.05	-	150.0±0.12	20.0±0.13
Diacylglycerol	50.0±0.03	50.0±0.03	30.0±0.02	Not detected
Cholesterol	150.0±0.03	70.2±0.02	140.7±0.03	60.0±0.02
Free fatty acid	150.0±0.02	20.0±0.14	150.6±0.04	50.0±0.02
Phospholipid	173.20±0.49	182.4±0.05	185.4±0.016	198.4±0.03

Phospholipid such that the ratios of these lipids to total lipids remain unchanged this is physiologically significant since stabilizing the activity of the central nervous system is of paramount importance to survival. Neura activity is heavily dependent on lipid particularly Phospholipid (Bruder *et al.*, 2005).

The brain therefore must have mechanism to maintain Phospholipid concentrations. The brain maintain lipid more than the liver, Also changes in dietary lipid are reflected at the organ/tissue (Bruder *et al.*, 2005). Increase in hepatic monoglycerol may be due to increased synthesis and/or a reduction in degradation or secretion. Increased in fatty acids in liver may be due to reflected increased concentrations in dietary intake. The difference in lipid and fatty acids distribution within each organ might be due to the rats' dietary influence on lipid and fatty acids status in liver and brain. The value of fat in this study (Table 1) was higher than that of calf liver (<http://www/buzzler.com/articles/liver-nutritionfacts.html>).

Mineral safety index: Mineral Safety Index (minimum toxic dose of minerals) is a numerical statement of the safety of high doses of minerals in relation to the United States RDA (Table 3, Whitney *et al.*, 1990). In this study, the limb muscle had comparable MSI in phosphorus, lower value in magnesium, calcium and higher than MSI values in zinc and iron. The liver had higher value than

recommended MSI values in phosphorus, zinc and iron but lower in magnesium and calcium. The brain had higher MSI values in Phosphorus, zinc and iron, comparable value in magnesium and calcium. The Skin had comparable value in phosphorus,, lower values in magnesium, zinc and calcium but higher MSI level in iron.

Phospholipids like lecithin are emulsifiers allowing water and fat to mix, they participate in fat digestion in the intestine (Table 4). However the value of lipid in the liver is higher than that of the skin this might be due to the fact that liver is the storage organ. The phospholipids contents of liver, brain muscle and skin in this work were significantly ($p<0.05$) higher than that reported by Bruder *et al.* (2005) in brain and liver of normaxia 7 day old rat; while the diacylglycerol levels in brain and liver of African Giant rat in this work were significantly ($p>0.05$) lower. The difference might be due to difference in the age of the rats used in this study compared to that Bruder *et al.* (2005).

Cholesterol level in this study, as shown in Table 4, was significantly higher ($p<0.05$) in skin than liver, brain and limb muscle. However the level of cholesterol in liver was significantly higher ($p<0.05$), than reported for calf liver (<http://www/buzzler.com/articles/liver-nutritionfacts.html>). The United States Dietary Association (USDA) reported 3.81 mg of cholesterol in cow liver. Cholesterol

is found in abundance in cell membranes. They help in integrity of membrane and ability of cells to communicate with each other. Cholesterol helps to secure important proteins in the membrane by stabilizing certain proteins together in lipid rafts.

However the cholesterol contents in the brain and liver of this study, (Table 4), were significantly lower than that of pork brain (310 mg/100 gm) and liver (368 mg/100 g) and than that of cow brain (2670 mg/100 g) and liver (323 mg/100 gm) (Cholesterol content in common foods on line assessed July 25 2010). The cholesterol level was also lower than that of Grasscutter liver and the value of 650 mg/100 g reported for Bovine liver cholesterol content (Ejike and Emmanuel, 2009).

Monoacylglycerol in this study as indicted in Table 4 was absent in muscle and very low in skin but significantly higher ($p < 0.05$) in liver. Monoglycerols is less effective as substrate for LPL - mediated hydrolysis, effect than diacylglycerols once inside the erythrocytes, the monoglycerol molecules and fatty acids are re-esterified to triacylglycerols. Glycerols are present in form of its esters (glycerides) in all animals, vegetables, fats and oils (www.nutriology.com/TGmetab.html). In this study the liver had the highest value of monoglycerols; followed by the brain and the lowest value in the skin while the muscle had none.

The diacylglycerol was absent in the brain, low in liver and average but comparable in skin and muscle as shown in Table 4. The higher level of diacylglycerol in liver and skin may be due dietary intake (Bruder *et al.*, 2005).

The RDA level of cholesterol is 45-75 mg/day. From this study all parts of Africa Giant rat will satisfy cholesterol requirement as indicated in Table 4. Bruder *et al.* (2005) reported diacylglycerol in neonatal rat Brain to be 5.0 and 6.0 $\mu\text{mol/g}$ in the liver.

Free fatty acids give food its unique taste and smell. According to (Wardlaw and Smith, 2007), there is a new study underway for Conjugated Linoleic Acid (CLA) for possible health benefits including cancer prevention decreasing of body fat and improving insulin level in diabetes Wardlaw and Smith (2007). According to Masterjohn (2005), arachnoic acid and DHA are the only essential fatty acids. Arachnoic acid is necessary for growth, proper hydration, healthy hair while DHA is necessary for learning, intelligence and visual activity Masterjohn (2005) Liver from land animals does not appear to contain significant quantities of DHA but it probably does when the animals are fed grass which is higher in Omega-3-fatty acids than grain.

Alterations in brain 22:6n-3 and other long chain fatty acids have been associated with changes in physiological function for example enzyme activity. The RDA recommends 35% of fatty acid of calories consumed for adult. According to Table 4 in this study, fatty acid

values were comparable in skin and liver samples and significantly higher ($p < 0.05$) than that of muscle and brain samples.

The result of various minerals in different parts of the African Giant Rat is shown in Table 2. Although Abulude (2009) reported that Ca, Mg, Fe had values that were comparable to other sources of conventional minerals; most of the minerals in this study (Table 2), did not meet the recommended daily allowance.

Calcium All cells need calcium. 99% of calcium in the body is used for bone and teeth development Wardlaw and Smith (2007). It is also essential for blood clotting and muscle contraction, adequate calcium decreases risk of colon cancer, high blood pressure, cholesterol obesity and osteoporosis. In this study the skin had almost triple calcium value compared to the liver and limb muscle. RDA for calcium is 800-1200 mg/day (Table 2). However none of the calcium levels in all the samples met the RDA values.

Phosphorus: Phosphorus is a component of enzymes, DNA, cell membrane and bone. The RDA level of phosphorus is 700 mg/day for adult. The values in skin and limb muscle as presented in Table 2, met the RDA values. However the values in liver and brain doubles the RDA level excess phosphorus might impair liver function and where calcium intake is low can affect phosphorus-to-calcium ratio leading to bone loss.

Magnesium: Magnesium is important for nerve and hear function and in many enzymes reactions. Deficiency of magnesium can result in irregular heart-beat, weakness, muscle pain, disorientation and seizures. Although magnesium values in the skin and limb muscle (Table 2), were significantly higher ($p < 0.05$) than in liver and brain, the value did not meet the RDA values for adult male of 400 mg and adult female of 310 mg/day.

Zinc: Zinc bioavailability can be decreased by lack of animal protein. About 40% of dietary zinc is absorbed especially when animal protein sources are used. About 200 enzymes require zinc as a co-factor. Zinc is needed for DNA, cell membrane, insulin release and storage and protein metabolism. The RDA value for female adult is 8 mg/day and for male adult 11 mg/day. In this study zinc value in the skin (Table 2), met the RDA value for adult male while values in limb muscle and liver were significantly higher than RDA levels.

Iron: About 40% of total iron in animal is in form of hemoglobin (red blood cells and myoglobin (pigment found ion muscle cells). This is called heme iron. Non-heme iron is found in animal flesh, small portion is stored in liver. Iron is needed in blood building, enzymes and compounds that cell use in energy production Wardlaw

and Smith (2007). Iron is also needed for brain and immune function, and also contributes to drug detoxification in the liver. Deficiency of iron leads to anemia and loss of appetite. RDA value for adult female is 18 mg/day and adult male 8 mg/day. The high value in females might be required to substitute for loss during monthly menstrual period. However in this study, the values of iron in all the samples as shown in Table 2, were 10-20 times higher than RDA levels with the liver having the highest value this might be because iron is stored in the liver; liver is usually recommended for pregnant women and anemic patients. Excess iron might lead to stomach irritation and can lead to toxic symptoms and over facilitation of the oxidation of carbohydrates, proteins and fats (Adeyeye and Faleye, 2004).

CONCLUSION

The Giant rat had the highest value of phospholipids in the brain. All samples had excess of iron than recommended values. Giant rat limb muscle had high values of potassium, zinc and magnesium while the brain had higher phosphorus value. Organs examined were low in calcium.

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