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Calcium and phosphorus contents of body parts of some domestic animals used as meat source in Nigeria

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ABSTRACT

Objective: To investigate the calcium and phosphorus contents of four domestic animals used as sources of meat in Nigeria. **Methods:** The calcium contents of the body parts of the animals were determined using atomic absorption spectrometer. Their phosphorus contents were determined colorimetrically using the molybdenum blue method. **Results:** The calcium and phosphorus contents were significantly higher in the bone samples than in the other animal parts investigated ($P<0.05$). The calcium contents of all the edible parts were higher in chicken than in the other animals. High calcium and phosphorus contents were detected in the faeces of chicken and goat, and that of cattle and goat, respectively. Low calcium and phosphorus contents were detected in the urine samples. Calcium : phosphorus ratios calculated for the bones of chicken, cattle and goat were satisfactory. **Conclusions:** In conclusion, calcium and phosphorus contents of the animal parts vary significantly and their relative contents may be related to the animal's diet. Chicken parts may be the preferred dietary source of these minerals. This study highlights the need for routine investigation of the mineral contents of food, which is necessary for proper nutritional guidelines.

1. Introduction

It is well established that calcium and phosphorus are required in human diet to meet the body requirement for growth and maintenance of normal physiological functions[1]. Calcium and phosphorus are important structural elements in both the skeleton and teeth and are constantly being mobilized to maintain the blood levels needed to regulate body functions[2]. *Plasma calcium* is essential for the regulation of blood, and is required for membrane permeability, neuromuscular excitability, transmission of nerve impulses and activation of certain enzyme systems[3,4]. Phosphorus has more functions than any other mineral elements in the body. It forms a complex with calcium carbonate, which lends rigidity to bones and teeth. It serves as a component of buffers in body fluids, as a component of ATP and creatinin phosphate used for energy transformation and also as an essential component of nucleic acid and nucleoprotein responsible for cell division, reproduction and transformation of hereditary traits[2,5]. Phosphorus is also concerned with brain and nerve metabolism, and is an important constituent of enzymes and co-enzymes, which are important for tissue respiration.

Abnormal levels of these minerals in the body can lead to a variety of disease states. These range from rickets in children, osteomalacia and osteoporosis in adults, for calcium, to anorexia, impaired growth, osteomalacia, skeletal demineralization, proximal muscle atrophy and weakness, cardiac arrhythmia, respiratory insufficiency, increased erythrocyte and lymphocyte dysfunction, rickets, susceptibility to infection, nervous system disorder and even death for phosphorus[3,5].

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Abnormal calcium and phosphorus levels in the blood may be linked to dietary intake, although other factors like gastrointestinal absorption and exchange of calcium and phosphorus in the blood, among others, may be involved. For optimal body physiological functions, calcium and phosphorus need to be present in the diet at required levels[6]. Adequate calcium and phosphorus nutrition is dependent upon sufficient supply of each element, a suitable ratio between them and the presence of Vitamin D. Generally, human nutritionists recommend a calcium and phosphorus ratio of 1.5∶1 at infancy, and 1∶1 from year one through the rest of life-although ratios between 2∶1 and 1∶2 are considered satisfactory[7]. Known dietary sources of calcium and phosphorus include baked foods, dairy and dairy products, fruits, grains, meat, fish, poultry and vegetables[8]. In Nigeria, and perhaps in some other developing countries, the majority of the populace, particularly the elderly, rarely consumes milk and other diary products, which are the best sources of theses minerals[9]. People in this age group frequently suffer from osteomalacia, osteoporosis and other disease states associated with abnormal calcium and phosphorus levels in the body.

Hitherto, there is paucity of data on the calcium and phosphorus contents of some domestic animals which frequently serve as source of meat in Nigeria. Calcium and phosphorus contents of some animals in some parts of the world are however documented[10,11]. The knowledge of the calcium and phosphorus contents of some of these domestic animals will provide proper nutritional guidelines for the elderly in particular who depend on meat for their daily calcium and phosphorus need. Besides, this will make for optimal growth, functional performance and continued well-being of the generality of the populace.

We report in this paper, the determination of calcium and phosphorus contents of the bone, blood, serum, faeces, urine and some fleshy parts of four domestic animals used as sources of meat in Nigeria. We have adopted simple analytical methods previously reported for the quantitative estimation of these minerals in bone and body fluids[12].

2. Materials and methods

2.1. Collection of samples

The domestic animals used were obtained from the abattoir of Ogige Market, Nsukka, Enugu State, Nigeria. The animals were slaughtered and the required body parts (bones, kidney, liver and muscles) as well as body fluids/secretions (blood, serum, faeces and urine) were collected in clear polythene bags and analyzed subsequently.

2.2. Chemicals and reagents

Analytical grades of hydrochloric acid, sulfuric acid, trichloroacetic acid (TCA), calcium chloride dehydrate, strontium chloride, aminonaphtol sulphuric acid, sodium sulphate, sodium bisulphate, ammonium molybdate were used.

2.3. Study design

The domestic animals, goats, pigs, cattle and chicken included in this study are the commonest sources of meat within Nsukka and its environs. The abattoir is located within the major market in Nsukka metropolis. The parts analyzed are also the most commonly consumed. The analysis was extended to body fluids and secretions like blood, serum, faeces and urine to investigate the dietary contributions to mineral contents.

2.4. Preparation of samples for analysis

The meat samples (bones, liver, kidney and muscles) and faeces were dried to constant weight at 105 ℃ for 2 days and stored in a desiccator until used. 2 g each of the dried samples were ashed in a muffle furnace at 550 ℃. The ash was dissolved in 10 mL of 1.0 M HCl, filtered and the filtrate made up to 100 mL with distilled water[13]. 5 mL each of urine, serum and blood was digested in 95 mL of 5% TCA and allowed to stand for 5 min. The mixture was centrifuged at 1 500 rpm for 5 min and the clear supernatant collected for analysis.

2.5. Spectrophotometric determination of calcium

The calcium contents of the samples were determined using AAS (Alpha 4 ASS fisons). Stock solution of calcium (500 ppm) was prepared by dissolving 1.834 g of $CaCl_2 \cdot 2H_2O$ in distilled water and making up to 1 L. Concentrations of 1-5 ppm were obtained from the stock by dilution. 1 mL each of the test samples prepared as described above were diluted in 20 mL of 1% $SrCl_2$ and used for the analysis. The standard calcium solutions and the diluted samples were in turn aspirated and the absorbance determined at 423.6 nm. Absorbance values of the standard were plotted against the respective concentrations. The calcium contents of the samples were determined from the regression equation.

2.6. Spectrophotometric determination of phosphorus

Stock solutions of phosphorus (100 ppm) were prepared both in 1M HCl and in 5% TCA. To 5 mL of each of the serial diluted solutions (2, 4, 6, 8, 10 ppm) in 5% TCA was added 1.0 mL molybdate reagent and 0.4 mL of amino naphtol sulphuric acid reagent. The solutions were allowed to stand for 15 min and the absorbance read at 690 nm in a spectrophotometer (UNICO® UV-2102 PC Spectrophotometer) against a reagent blank similarly prepared but omitting the phosphorus solutions. Absorbance values obtained were plotted against the respective concentrations to get the standard curve for phosphorus in 5% TCA. Standard curve for phosphorus in 1 M HCl was similarly determined.

5 mL of the serum, blood or urine samples in 5% TCA and 5 mL of bone, liver, kidney, muscles or faeces samples

in 1 M HCl, prepared as described above were analyzed as for the standard phosphorus solution. The concentrations of phosphorus in the samples were calculated from the respective regression equations.

2.7. Statistical analysis

Data obtained were analyzed by SPSS version 11 using one way ANOVA and subjected to Fischer LSD post hoc tests and expressed as mean±SEM. Differences between means were considered significant at $P<0.05$.

3. Results

The results of calcium and phosphorus contents of the animal parts are shown in Tables 1 and 2 respectively. The calcium and phosphorus contents were higher in bone than in the other parts of all the domestic animals studied. The calcium contents of the bone were found to vary among the animals with the highest in chicken [(742.37±15.94) ppm) and the lowest in pig [(623.93±2.53) ppm]. There was no significant difference in the phosphorus contents of the bones of chicken, cattle and goat. These were, however, significantly higher than the phosphorus content of pig.

The calcium contents of the blood, kidney, and muscle were higher in chicken than in the other animals. For all the animals, higher calcium contents were detected in the kidney and muscle compared to the liver. The calcium contents of the faeces were higher in chicken and goat than in the other animals. In every case studied, the lowest calcium contents were detected in the urine samples.

The phosphorus contents of the kidney, liver and muscle did not vary significantly in all the animals. Higher values were however detected for cattle and goat. Very high phosphorus contents were found in the faeces of cattle [(286.95±0.00) ppm] and goat [(201.68±0.04) ppm]. These values were significantly higher than those found in chicken and pig. Phosphorus contents of the blood did not vary significantly, though a higher value was detected in pig [(26.25±0.06) ppm].

The calculated calcium: phosphorus ratio is shown in Table 3. Ratios of 2.5∶1, 2.6∶1, 2.2∶1 and 6.4∶1, were found in the bone of chicken, cattle, goat and pig respectively. Very low calcium: phosphorus ratios were calculated for the other parts of all the animals studied.

Table 1
Calcium contents of the various animal parts (n= 5)(Mean±SEM, ppm).

Body parts	Calcium content			
	Chicken	Cattle	Goat	Pig
Blood	1.93±0.01	1.43±0.01	1.49±0.01	1.53±0.04
Bone	742.37±15.94	730.33±13.62	655.60±12.84	623.93±2.53
Faeces	222.40±45.65*	3.84±0.40	220.00±4.04*	6.96±0.81
Kidney	14.30±2.08*	4.47±0.01	2.13±0.10	1.52±0.06
Liver	1.45±0.34	1.72±0.10	0.93±0.01	0.98±0.01
Muscle	13.83±0.29*	3.04±0.01	5.52±0.64	3.15±0.12
Serum	1.58±0.07	1.10±0.01	1.55±0.06	1.73±0.10
Urine	NA	0.16±0.03	0.28±0.15	0.43±0.04

NA: Not applicable; *$P<0.05$, significantly higher than in others.

Table 2
Phosphorus contents of the various animal parts(n= 5)(Mean±SEM, ppm)

Body parts	Phosphorus contents			
	Chicken	Cattle	Goat	Pig
Blood	19.02±0.10	17.10±0.32	22.20±0.03	26.25±0.06
Bone	292.13±0.39*	278.87±0.43*	293.05±0.12*	98.18±0.19
Faeces	56.78±1.14	286.95±0.00*	201.68±0.04*	99.15±0.98
Kidney	116.50±0.00	173.88±0.01*	176.35±0.00*	55.13±0.79
Liver	116.45±0.00	174.76±0.32*	176.45±0.00*	50.58±0.04
Muscles	108.58±0.04	174.63±0.10*	153.07±0.09	62.25±0.14
Serum	20.13±0.22	16.38±0.13	10.90±0.32	13.00±0.14
Urine	NA	15.18±0.19	5.87±0.10	21.58±1.83

NA: Not applicable; *$P<0.05$, significantly higher than in others.

Table 3
Calcium–Phosphorus ratios of the animal parts.

Body parts	Ratios			
	Chicken	Cattle	Goat	Pig
Blood	0.102	0.084	0.067	0.072
Bone	2.541	2.618	2.237	6.355
Faeces	3.917	0.013	0.013	0.070
Kidney	0.123	0.026	0.012	0.028
Liver	0.013	0.010	0.005	0.019
Muscles	0.127	0.017	0.036	0.051
Serum	0.079	0.067	0.142	0.115
Urine	NA	0.011	0.048	0.020

NA: Not applicable.

4. Discussion

Significant variations were observed in the calcium and phosphorus contents of the parts of all the animals studied. The relatively high calcium and phosphorus contents of bone in all the animals as reported in this work are consistent with reports from similar studies[11]. Calcium is the most abundant cation in the body with approximately 99% found in the bone and teeth, and the remainder distributed in soft tissues and body fluids[6]. Phosphorus is also a major constituent of bone and teeth, and an essential component of organic compounds involved in almost every aspect of metabolism[14-16]. The high calcium contents of chicken bone may be a direct consequence of chicken feed, which are known to be rich in calcium[17]. This could also be true for the observed high calcium content of goat bone. The faeces samples of both chicken and goat in this study were found to contain high quantities of calcium. This observation suggests high calcium diets for both animals. The observed high calcium contents of cattle bone may be attributed to the presence of vitamin D, which makes possible the assimilation and utilization of calcium and phosphorus in this animal[7].

Generally, higher calcium contents were found in kidney and muscles than in the liver. The higher calcium contents of the kidney in all the animals relative to that in liver can be attributed to the fact that the kidney is critically important in calcium homeostasis[15]. Calcium is filtered and reabsorbed in the kidney[18], and as a result, minimal calcium is excreted in the urine. In this study, it was also found that very low concentration of calcium was detected in the urine of all the animals.

There were no significant differences in the phosphorus contents of the other parts in all the animals studied. The higher contents of phosphorus detected in each of the parts for cattle and goat when compared with those of chicken and pig are, however, of interest. A plausible explanation may be that the feed of cattle and goat are rich in these minerals. This is supported by the fact that higher contents of these minerals were found in the faeces of cattle and goat when compared with those of chicken and pig.

The results of this study reveal that the calcium contents of the edible parts viz. bone, liver, kidney and muscle are correspondingly higher in chicken than in the other animals studied. The phosphorus contents were also found to be equally high in chicken, cattle and goat. The pig's contents of theses minerals were quite low in all the edible parts. Chicken bone could, therefore, be regarded as the best source of these minerals. The calcium: phosphorus ratio of 2.5 : 1 is very close to the range of values recommended by human nutritionists as satisfactory[7]. More so, chicken bone is soft and can be masticated with ease even by the elderly. Although cattle and goat have similar calcium: phosphorus ratios, the bones of these animals are normally hard and not always very acceptable as food, particularly to the elderly. The calcium: phosphorus ratio of pig bone was found to be very high (6.36 : 1) and thus, far from satisfactory.

In conclusion, variations were found in the calcium and phosphorus contents of the different parts of the domestic animals included in this study. The relative contents of these minerals may be a direct consequence of the individual animal's diet. Chicken, cattle and goat bones have high contents of these mineral as well as a suitable ratio between them to justify their use as dietary sources. However, chicken bone may be a preferred source, particularly to the elderly. This study highlights among other things the need for routine determination of the mineral contents of foods frequently consumed by the generality of the populace, which is necessary for proper nutritional guidelines.

Conflict of interest statement

We declare that we have no conflict of interest.

References

[1]McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA. *Animal Nutrition*. 6th ed. Harlow, USA: Pearson Educational Limited; 2002.
[2] Friedman PA. Agents affecting mineral ion homeostasis and bone turnover. In: Brunton LL, Lazo JS, Parker KL. *Goodman and Gilman the pharmacological basis of therapeutics*. 11th ed. USA: Pergamon Press; 2006. 1647-78.
[3]Guyton AC, Hall JE. *Textbook of medical physiology*. 11th edition. Philadelphia: W. B. Saunders Company; 2006.
[4]Hays VW, Swenson MJ. Minerals. In: Dukes HH, Reece WO. *Dukes' physiology of domestic animals*.12th ed. New York: Cornell University Press; 2004. 575-99.
[5]Knochel JP. Phosphorus. In: Shils ME, Shike M. *Modern nutrition in health and disease*. 10th ed. Lippincott: Willians and Wilkins; 2006. 211-22.
[6]National Research Council. *Nutritional requirements of beef cattle*. Washington DC: Academies Press; 1996.
[7]Ensminger AH, Ensminger ME, Konlande JE, Robson JRK. *Food for health: A nutrition encyclopedia*. California: Penguin Press; 1986.
[8]Hands ES. *Food finder: food sources of vitamins and minerals*. 2nd ed. Salem: ESHA Research; 1990.
[9]Bales CW, Anderson JJB. Influence of nutritional factors on bone health of the elderly. In: Anderson JJB, Garner EC. *Calcium and phosphorus in health and disease*. Florida: CRC Press; 1996, p. 319-37.
[10]Paul AA, Southgate DAT. *The composition of food*. 4th ed. London: HMSO; 1978.
[11]Sabir SM, Khan WS, Hayat I. Effect of environmental pollution on the quality of meat in District Bagh, Azad Kashmir. *Pakistan J Nutr* 2003; **2**: 98-101.
[12]Pungor EE. *A practical guide to instrumental analysis*. Florida: CRC Press; 1995.
[13]Olamuyiwa AO. *Handling of meat and meat products for analysis (Raw and processed). Two-day mandatory workshop on sample preparation for the analysis of food*. Lagos: IPAN; 2003, p. 44-52.
[14]Baron DN. *A short textbook of chemical pathology*. Britain: Hodder and Stoughton Educational; 1980.
[15]Wardlaw GM. *Contemporary nutrition: Issues and insights*. 3rd ed. London: Brown and Benchmark; 1997.
[16]Sith R. Bone minerals. In: Garrow JS, James WPT. *Human nutrition and dietetics*. 10th ed. London: Harcourt Brace and Co; 2000.
[17]Obioha FC. *A guide to poultry production in the tropics*. Enugu: ACENA Publishers; 1992.
[18]Groff JL, Gropper SS, Hint SM. *Advanced nutrition and human metabolism*. 2nd ed. USA: West Publishing Cons; 1995.