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Effect of Feeding Yellow Maize, White Sorghum and Pearl Millet as Energy Sources on Mineral Intake, Retention and Utilisation by Guinea Fowl Under Intensive Management System

[1]S C Chiripasi, J C Moreki, [2]S J Nsoso and M Letso

Department of Animal Science and Production, Botswana College of Agriculture, P/Bag 0027, Gaborone, Botswana

jcmoreki@gmail.com

ABSTRACT

The effects of feeding yellow maize, white sorghum and pearl millet as energy sources on mineral intake, retention and utilisation in guinea fowl up to 16 weeks of age were investigated. Two hundred and forty day old keets were randomly assigned to four dietary treatments each having four replicates (n=6/replicate). The four treatments were yellow maize, white sorghum, pearl millet and a commercial broiler diet (control) fed at starter, grower and finisher phases. At 6, 12 and 16 weeks of age, blood and faecal samples were collected from three randomly selected birds from each replicate and analysed for minerals. At 16 weeks of age, birds were sacrificed and the left tibiae collected for bone physical dimensions and mineral composition. Meat samples were collected from the thighs and decomposed by microwave digestion method for analysis of various minerals. Data were regarded as a split plot design with four dietary treatments and analysed using the General Linear Model Procedures in Statistical Analysis System. There were no significant differences among bone length and width of birds fed sorghum, millet, maize or control diets at 6 and 16 weeks of age.Birds fed millet based diet had significantly higher bone weights (9.35±0.13g) than birds on the other three treatment diets. Bone Na, Mg and K contents decreased by 26%, 27% and 25%, respectively from 6 to 12 weeks of age and thereafter remained constant. Feeding a diet containing millet resulted in higher bone P (124195.66±1459.25 mg/L) than those fed other treatment diets. Birds fed diet containing sorghum had the lowest Zn (232.66±11.16 mg/L), Mn (18.37±1.31mg/L), Cu(4.49±0.66 mg/L) and Fe (124.61±8.44 mg/L) bone mineral contents compared to those fed other treatment diets. Calcium, Na, K and Mg contents in the meat decreased over time. Birds fed millet diets had significantly higher blood Ca (291.50±18.24 mg/L) than birds fed other treatment diets. The P and K contents of blood obtained from birds fed control diet were significantly lower than blood obtained from the other treatment diets at 16 weeks of age. Average daily mineral intakes significantly increased from 6 to 12 weeks of age. However, no significant differences were noted in the average daily mineral intakes of K, Zn and Mn from 12 to 16 weeks of age. The high mineral intakes observed at 6 weeks of age were driven by the need for growth in keets. Percentage Na and K retentions did not differ significantly between birds fed sorghum, millet and maize diets. These results suggest that pearl millet and white sorghum can replace maize in guinea fowl diets without negatively affecting mineral intake, retention and utilization. Further studies should be carried out to evaluate the effect of millet, sorghum and maize grains on meat sensory characteristics and bone strength of guinea fowl.

Keywords: Bone mineral compositions, bone physical dimensions,cereal grains, mineral intake, mineral retention

1. INTRODUCTION

Cereal grains, especially maize which form the bulk of energy in poultry feeds are in short supply as a result of industrial and human needs. This has resulted in competition between humans and animals for available feed resources, and hence high cost of animal production[1]. According to Nworgu [2], the rising cost of poultry feeds have continued to be a major problem in the developing countries as feed cost is about 65 to 70% of the total cost of production. Similarly, there has been a steady increase in the cost of conventional feed ingredients such as maize, groundnut cake, soybean meal and fish meal in the past years and this has led to an increase in the prices of animal protein sources [3].

Guinea fowl require 12.12 MJ/kg and 11.30 MJ/kg of energy during the starter and grower phases, respectively [4]. This requirement can be met by substituting white sorghum for maize [5] or pearl millet incorporated with non-starch polysaccharides hydrolysing enzymes to improve efficiency of feed utilisation since pearl millet has a lower energy value than yellow maize [6]. Niranjan and Yadav [7] stated that maize can be replaced with pearl millet in poultry diets without negatively affecting growth performance and haematobiochemical parameters in broilers. Millet contains the same Ca (0.29%), total P (0.48%), Mg (651.45 ppm) and Cu (4.42 ppm) as maize [8].

White sorghum has a nutritive value almost similar to that of maize with white sorghum containing more ash content (19 %) than maize (11 %); therefore it can completely substitute maize in poultry diets [9, 10]. White sorghum contains 12.8 MJ/kg DM apparent ME in guinea fowl [11]. According to Medugu [3], red and brown sorghums contain medium to high levels of tannins (0.2 to 2.0%) which lower dry matter (DM) and protein digestibility, and inhibit digestive enzymes. Kumar [12] stated that red or brown sorghum should be incorporated up to 33% in poultry diets. According toWaniska[13], the colour of the grain is not suggestive of tannins and only a few sorghum cultivars with pigmented testa and B1 and

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B2 genes produce tannins. In view of this, alternative sources of feed ingredients in poultry diets should be searched in order to improve production.This study was carried out to determine the mineral intake, retention and utilisation by guinea fowl fed yellow maize, sorghum and millet as energy sources and reared under the intensive system from day old to 16 weeks of age.

2. MATERIALS AND METHODS

The experiment was carried out at the Guinea Fowl Unit of the Botswana College of Agriculture (BCA), Sebele from February to May 2012. The site is located on 24º 33′ S, 24º 54′ E and is at an altitude of 994 m above sea level. The average annual rainfall is 450 mm and the mean daily temperature is 30 °C [14].

2.1Animal Management

Two hundred and forty day old keets were obtained from BCA Hatchery Unit and randomly assigned to four dietary treatments, each having four replicates (6 birds/replicate). The four treatments were maize, millet, sorghum based diets and commercial broiler diet as control. The initial weights of birds were determined by weighing 20% of the birds at placement (*i.e.*, at day old) and the coefficient of variation of the flock determined. Keets were reared in a closed room with air conditioning from day old to four weeks of age. Each treatment was placed in 1 m x 0.7 m x 1.2 m wooden pen with wood shavings as litter material. The brooder was maintained at a temperature of 36 °C and lighting provided for 24 hours a day for one week. Thereafter, lighting was reduced to 23 hours a day and temperatures reduced gradually until 25 °C. Keets were vaccinated against Newcastle disease and Gumboro at two weeks of age using ND Clone 9 and Gumboro vaccines, respectively. The vaccines were administered orally. Keets were individually tagged at four weeks of age and transferred to an open-sided house. Each replicate was housed in a 1.8 m x 1.6 m wire mesh fenced pen with wood shavings used as litter on concrete floors. Vitamin and mineral supplement (Phenix stresspac) was added to drinking water during the first five days of age and at placement. The house curtains were raised during the day for natural lighting and closed at night for protection against cold conditions.

2.2 Diets

Birds were fed starter (0 to 6 weeks), grower (7 to 12 weeks) and finisher (13 to 16 weeks) diets (Tables 1, 2 and 3).Yellow maize, white sorghum and pearl millet were obtained from Botswana Agriculture Marketing Board, ground and mixed with other ingredients to form a total mixed ration for the three treatment diets. Diets were formulated according to the Botswana standard for guinea fowl [15]. A commercial broiler diet (control) was obtained from retail shops in Gaborone. Experimental diets were analysed for energy and crude protein to ensure accurate diet formulation. The diets for each feeding phase were isocaloric and isonitrogenous. Feed and water were provided *ad libitum*.

Table 1: Nutrient composition of guinea fowl starter diets fed from 0 to 6 weeks of age reared under the intensive management system

Age of birds		**0 to 6 weeks**		
Crude Protein (%)	**24**	**24** **Yellow maize**	**24** **Sorghum**	**24** **Millet**
Treatments	**Control**	**1**	**2**	**3**
Ingredients				
Yellow maize (9% CP)	-	46.27	-	-
Sorghum (10.6% CP)	-	-	48.99	-
Millet (14% CP)		-	-	55.93
Soy bean meal (38% CP)		46.63	43.91	36.97
Fishmeal (60% CP)	-	3	3	3
Dehydrated alfalfa (16% CP)	-	2.0	2.0	2.0
Dicalcium phosphate (%)	-	0.35	0.35	0.35
Vitamin/ mineral premix (%)	-	1.5	1.5	1.5
Iodised salt (%)	-	0.25	0.25	0.25
Antibiotics and coccidiostat (%)	-	+	+	+
Commercial diet	100	-	-	-
Total	100	100	100	100
Calculated composition				
Metabolisable Energy (MJ/kg)	12.13	12.13	12.13	12.13
Crude protein (%)	24	24	24	24
Calcium (%)	0.90	0.90	0.90	0.90
Total Phosphorus (%)	0.70	0.70	0.70	0.70
Available Phosphorus (%)	0.55	0.55	0.55	0.55

Table 2: Nutrient composition of guinea fowl grower diets fed from 7 to 12 weeks of age reared under the intensive management system

Age of birds		**7 to 12 weeks**		
Crude Protein (%)	**20**	**20** **Yellow maize**	**20** **Sorghum**	**20** **Millet**
Treatments	**Control**	**1**	**2**	**3**
Ingredients				
Yellow maize (9% CP)	-	60.07	-	-
Sorghum (10. 6% CP)	-	-	64.42	-
Millet (14% CP)		-	-	72.58
Soy bean meal (38% CP)		32.83	28.48	20.32
Fishmeal (60% CP)	-	3	3	3
Dehydrated alfalfa (16% CP)	-	2.0	2.0	2.0
Dicalcium phosphate (%)	-	0.35	0.35	0.35
Vitamin/ mineral premix (%)	-	1.5	1.5	1.5
Iodised salt (%)	-	0.25	0.25	0.25
Antibiotics and coccidiostat (%)	-	+	+	+
Commercial diet (%)	100	-	-	-
Total	100	100	100	100
Calculated composition				
Metabolisable Energy (MJ/kg)	11.30	11.30	11.30	11.30
Crude protein (%)	20	20	20	20
Calcium (%)	0.90	0.90	0.90	0.90
Total Phosphorus (%)	0.70	0.70	0.70	0.70
Available Phosphorus (%)	0.55	0.55	0.55	0.55

Table 3: Nutrient composition of guinea fowl finisher diets fed from 13 to 16 weeks of age reared under the intensive management system

Age of birds		**13 to 16 weeks**		
Crude Protein (%)	**15**	**15** **Yellow maize**	**15** **Sorghum**	**15** **Millet**
Treatments	**Control**	**1**	**2**	**3**
Ingredients				
Yellow maize (9% CP)	-	77.33	-	-
Sorghum (10.6% CP)	-	-	81.84	-
Millet (14% CP)		-	-	92.36
Soy bean meal (38% CP)		15.57	11.06	0.54
Fishmeal (60% CP)	-	3	3	3
Dehydrated alfalfa (16% CP)	-	2.0	2.0	2.0
Dicalcium phosphate (%)	-	0.35	0.35	0.35
Vitamin/ mineral premix (%)	-	1.5	1.5	1.5
Iodised salt (%)	-	0.25	0.25	0.25
Antibiotics and coccidiostat (%)	-	+	+	+
Commercial diet	100	-	-	-
Total	100	100	100	100
Calculated composition				
Metabolisable Energy (MJ/kg)	12.13	12.13	3100	3100
Crude protein (%)	15	15	15	15
Calcium (%)	0.90	0.90	0.90	0.90
Total Phosphorus (%)	0.70	0.70	0.70	0.70
Available Phosphorus (%)	0.55	0.55	0.55	0.55

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3. DATA COLLECTION

Feed intake was measured by giving pre-weighed feed allocations to each replicate group throughout the week and unconsumed feed weighed back at the end of the week. Pen body weights (BW) were also recorded on weekly basis. Bird's mineral intake was calculated by multiplying percentage of minerals in the feed by feed intake [16].

Feed samples were collected and oven dried at 60 °C for 24 hours to determine DM content. After drying, the feeds were digested using the Ethos 1 Advanced Microwave digestion System. The digesta was then analysed for minerals as described by Association of Official Analytical Chemists [17].

At 6, 12 and 16 weeks of age, blood samples were collected from the radial vein of three randomly selected birds from each replicate (*i.e.*, 12 birds/treatment) using 21 gauge needles. The radial vein was raised by pressing the interior side of the wing with a thumb then inserting the needle into the vein. About 10 ml of blood was collected into plain vacutainer tubes and the serum separated immediately after clotting. The serum was stored at -20 °C until further analysis [18]. Thereafter, stored serum samples were thawed and 1 ml of the serum was digested in a microwave with 5 ml of 70% nitric acid and 2 ml of deionised water. After digestion the volume was made to 100 ml with deionised water. The mixture was then used for mineral analysis.

Faecal samples from the randomly selected birds were collected at 6, 12 and 16 weeks of age. Birds were individually caged where lighting was reduced for approximately 15 minutes until sufficient excreta were collected in metal trays (minimum of 5 g per bird). Following faecal collection, birds were returned to their original pens. Faecal matter was dried in the oven at 100 ^{o}C for 24 hours and air cooled and thereafter DM determined. The faecal matter was then pulverized using laboratory mill with a 1 mm sieve and homogenised by thoroughly mixing before taking a representative sample for determination of minerals. Approximately 1 g sample of faecal material was then ashed in a muffle furnace at 550 ^{o}C for 8 hours until a white or grey ash residue was obtained. The ash sample was cooled in a desiccator. The residue was dissolved in 5 ml of 25% nitric acid, and when necessary, the mixture was heated slowly to dissolve the residue. The solution was transferred to a 100 ml volumetric flask and made up to volume with deionised water before mineral analysis [16]. Mineral retention was calculated by subtracting faecal mineral content from the guinea fowl mineral intake. Mineral retention was expressed as a percentage of each mineral intake.

At 16 weeks of age, all the birds were slaughtered by stunning at the BCA slaughterhouse and carcasses stored at 0 °C in the cold room and the tibiae removed the next day. Bones were excised and defleshed without boiling. Thereafter, bones were weighed using an electronic balance with accuracy 0.001 grams. Bones were analysed for physical bone characteristics (weight, length and bone shaft width) using an electronic calliper with an accuracy of 0.001 cm [19]. Thereafter, bone samples were ashed in a muffle furnace at 550 °C for 8 hours. Approximately 1 g of each bone ash sample was then dissolved in 10 ml of 3M hydrochloric acid and boiled for 10 minutes. The samples were allowed to cool and filtered into a 100 ml volumetric flask. Thereafter, the volume was topped to 100 ml with deionised water and analysed for minerals [20].

Meat samples were collected from the thighs of the carcasses and decomposed by microwave digestion method for the analysis of various minerals. A known quantity, approximately 1 g of each sample was digested with 5 ml of concentrated HNO_3 and 2 ml of deionised water for 30 minutes in a microwave digestion system. The digesta was allowed to cool and filtered into a 100 ml volumetric flask. The volume was topped to 100 ml with deionised water and analysed for minerals.

A Perkin Elmer ICP-Optical Emission Spectrometer Optima 7300 DV Series was used to determine Ca, Mg, Cu, Fe, Mn, K, Na and Zn and UV flame photometer was used to estimate P [17].

4. STATISTICAL ANALYSIS

Data were analysed using General Linear Model Procedures in Statistical Analysis System [21]. In this analysis, data were regarded as a split plot design with four dietary treatments being the main plots and age as sub plots. The following model was used:

$Y_{ijkl} = \mu + A_i + A_{ij} + B_k + (AB)_{jk} + E_{ijkl}$

where Y_{ijkl}= response variables (bone width, bone weight, bone length, bone mineral composition, blood mineral composition, meat mineral composition and mineral retention);

μ = general mean; A_i = effect of treatment diet; A_{ij}= treatment error; B_k= effect of age; $(AB)_{jk}$= interaction between treatment and age; E_{ijkl}= residual error.

The reported Least Squares Means were separated using the Dunnett's mean separation test [22]. Significance was declared at $P<0.05$.

5. RESULTS AND DISCUSSIONS

5.1Daily mineral intake

Control diet seemed to promote higher daily average Ca intakes than millet and maize diets which did not differ significantly from each other (Table 4). Average daily Ca intakes of 1.02 g reported in this study agrees with 1.0 g in broiler breeder pullets fed 2% Ca reported by Moreki [16]. Excessive dietary Ca levels can increase the pH in the gut resulting in decreased absorption of P from the intestines, as well as, that of Mg, Mn and Zn [23]. No significant differences were noted in the P, Na and Mg average daily intakes in birds fed millet and maize diets. Ibitoye [24] found that feed intake in broiler chickens raised to 8 weeks of age was significantly higher in birds fed white millet diets compared to sorghum diets. Average

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Table 4: Effect of dietary treatments on daily macro mineral intake of guinea fowl reared up to 16 weeks under the intensive management system

Mineral	Treatment	6 weeks	12 weeks	16 weeks
Ca (g)	Control	0.14 ± 0.083^{ax}	1.23 ± 0.083^{ay}	1.21 ± 0.083^{ay}
	Sorghum	0.46 ± 0.083^{bx}	1.36 ± 0.083^{ay}	1.25 ± 0.083^{by}
	Millet	0.44 ± 0.083^{bx}	1.02 ± 0.083^{by}	0.85 ± 0.083^{cz}
	Maize	0.34 ± 0.083^{bx}	1.05 ± 0.083^{by}	0.99 ± 0.083^{cy}
P (g)	Control	0.2075 ± 0.1052^{bx}	1.29 ± 0.1052^{ay}	1.52 ± 0.1052^{bz}
	Sorghum	0.5450 ± 0.1052^{ax}	1.41 ± 0.1052^{ay}	1.83 ± 0.1052^{az}
	Millet	0.6350 ± 0.1052^{ax}	1.43 ± 0.1052^{ay}	1.13 ± 0.1052^{cz}
	Maize	0.6250 ± 0.1052^{ax}	1.50 ± 0.1052^{ay}	1.16 ± 0.1052^{cz}
Na (g)	Control	0.23 ± 0.1289^{bx}	2.26 ± 0.1289^{ay}	0.23 ± 0.1289^{cz}
	Sorghum	0.77 ± 0.1289^{ax}	2.57 ± 0.1289^{ay}	2.28 ± 0.1289^{ay}
	Millet	0.77 ± 0.1289^{az}	2.18 ± 0.1289^{ax}	1.42 ± 0.1289^{by}
	Maize	0.75 ± 0.1289^{az}	1.39 ± 0.1289^{by}	1.53 ± 0.1289^{bx}
Mg (g)	Control	0.76 ± 0.1511^{bx}	2.05 ± 0.1511^{ay}	2.05 ± 0.1511^{ay}
	Sorghum	0.72 ± 0.1511^{bx}	2.20 ± 0.1511^{ay}	2.35 ± 0.1511^{az}
	Millet	0.84 ± 0.1511^{ax}	2.33 ± 0.1511^{ay}	1.71 ± 0.1511^{bz}
	Maize	0.71 ± 0.1511^{bx}	1.93 ± 0.1511^{ay}	1.84 ± 0.1511^{bz}
K (g)	Control	0.0054 ± 0.0032^{cx}	0.0426 ± 0.0032^{ay}	0.0442 ± 0.0032^{ay}
	Sorghum	0.0155 ± 0.0032^{bx}	0.0421 ± 0.0032^{ay}	0.0492 ± 0.0032^{ay}
	Millet	0.0229 ± 0.0032^{ax}	0.0469 ± 0.0032^{ay}	0.0403 ± 0.0032^{ay}
	Maize	0.0192 ± 0.0032^{bx}	0.0539 ± 0.0032^{by}	0.0398 ± 0.0032^{bz}

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;
P<0.05; means ±SE.

Table 5: Effect of dietary treatments on daily micro mineral intake of guinea fowl reared up to 16 weeks under the intensive management system

Mineral	Treatment	6 weeks	12 weeks	16 weeks
Zn (g)	Control	0.1712 ± 0.1241^{ax}	0.4602 ± 0.1241^{ay}	1.6990 ± 0.1241^{az}
	Sorghum	0.4327 ± 0.1241^{bx}	1.8940 ± 0.1241^{by}	2.0040 ± 0.1241^{ay}
	Millet	0.6995 ± 0.1241^{bx}	1.7120 ± 0.1241^{by}	1.6055 ± 0.1241^{ay}
	Maize	0.4725 ± 0.1241^{bx}	2.1232 ± 0.1241^{cy}	0.3302 ± 0.1241^{bz}
Mn (g)	Control	0.0048 ± 0.0015^{ax}	0.0227 ± 0.0015^{ay}	0.0219 ± 0.0015^{ay}
	Sorghum	0.0086 ± 0.0015^{bx}	0.0191 ± 0.0015^{by}	0.0292 ± 0.0015^{az}
	Millet	0.0095 ± 0.0015^{bx}	0.0225 ± 0.0015^{ay}	0.0158 ± 0.0015^{bz}
	Maize	0.0069 ± 0.0015^{ax}	0.0212 ± 0.0015^{ay}	0.0247 ± 0.0015^{ay}
Cu (g)	Control	0.0360 ± 0.024^{ax}	0.2577 ± 0.024^{ay}	0.3397 ± 0.024^{az}
	Sorghum	0.1302 ± 0.024^{bx}	0.2777 ± 0.024^{ay}	0.3822 ± 0.024^{az}
	Millet	0.1432 ± 0.024^{bx}	0.3115 ± 0.024^{ay}	0.2905 ± 0.024^{az}
	Maize	0.1232 ± 0.024^{bx}	0.3195 ± 0.024^{ay}	0.3890 ± 0.024^{az}
Fe (g)	Control	0.0020 ± 0.0002^{ax}	0.0009 ± 0.0002^{ay}	0.0017 ± 0.0002^{az}
	Sorghum	0.0004 ± 0.0002^{bx}	0.0016 ± 0.0002^{ay}	0.0015 ± 0.0002^{az}
	Millet	0.0006 ± 0.0002^{bx}	0.0013 ± 0.0002^{ay}	0.0010 ± 0.0002^{bz}
	Maize	0.0006 ± 0.0002^{bx}	0.0015 ± 0.0002^{ay}	0.0030 ± 0.0002^{cz}

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;
P<0.05; means ± SE.

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daily mineral intakes in the present study significantly increased from 6 to 12 weeks of age (Tables 4 and 5). However, no significant differences were noted in the average daily mineral intakes of K, Zn and Mn from 12 to 16 weeks of age. The high mineral intakes observed at 6 weeks of age were driven by the need for growth in keets. Insignificant differences in mineral intakes from 12 to 16 weeks of age show that growth is rapid during the first 12 weeks of age.

5.2 Mineral retention

To eliminate differences in dietary mineral intake as a factor, retention was expressed as a percentage of intakes. Birds fed sorghum diets retained more Ca and P compared to birds fed other treatment diets (Table 6). Calcium and P retentions reported in this study are higher than those reported by Hocking [25]averaging 300 g/kg of intake in growing turkeys at 13 weeks of age. The differences in the results may be due to differences in diets and species used in the two experiments. In the present study, no significant differences were noted between percentage retention of Mg in birds fed sorghum, maize and millet diets. Birds fed maize diet retained more Fe than those fed other treatment diets (Table 7). Percentage Na and K retentions did not differ significantly between birds fed sorghum, millet and maize diets. These results show that millet, sorghum and maize compare favourably amongst each other and therefore can replace each other without affecting percentage retentions. Generally, mineral retention percentages increased with age (Tables 6 and 7). Increase in mineral retention percentages with age indicates that more minerals are utilized for growth and reproduction as the bird ages. De Verdal [26] stated that apparent metabolisable energy and quantity of excreta relative to feed consumption traits can be included in selection schemes to improve retention and limit the environmental impact of poultry production. Supplementing diets with organically complexed Zn, Cu, Mn and Fe improves broiler performance and reduces mineral excretions [20].

Table 6: Effect of dietary treatments on macro mineral percentage retention in guinea fowl reared up to 16 weeks under the intensive management system

Mineral	Treatment	6 weeks	12 weeks	16 weeks
Ca (%)	Control	34.22 ± 0.24^{ax}	86.61 ± 0.24^{ay}	36.28 ± 0.24^{bx}
	Sorghum	75.31 ± 0.24^{bx}	55.10 ± 0.24^{by}	55.07 ± 0.24^{ab}
	Millet	70.70 ± 0.24^{bx}	29.47 ± 0.24^{cz}	41.82 ± 0.24^{by}
	Maize	64.57 ± 0.24^{bx}	26.79 ± 0.24^{cz}	40.73 ± 0.24^{by}
P (%)	Control	99.15 ± 0.25^{ax}	97.92 ± 0.25^{by}	98.52 ± 0.25^{by}
	Sorghum	99.76 ± 0.25^{ax}	98.68 ± 0.25^{ay}	99.30 ± 0.25^{ax}
	Millet	97.03 ± 0.25^{bx}	98.08 ± 0.25^{ay}	97.85 ± 0.25^{cx}
	Maize	97.18 ± 0.25^{bx}	98.18 ± 0.25^{ay}	98.02 ± 0.25^{by}
Na (%)	Control	80.72 ± 2.00^{ax}	97.31 ± 2.00^{ay}	75.12 ± 2.00^{az}
	Sorghum	96.46 ± 2.00^{bx}	98.37 ± 2.00^{ay}	98.71 ± 2.00^{by}
	Millet	97.12 ± 2.00^{bx}	97.72 ± 2.00^{ax}	96.47 ± 2.00^{by}
	Maize	93.53 ± 2.00^{by}	96.41 ± 2.00^{ax}	96.82 ± 2.00^{bx}
Mg (%)	Control	68.17 ± 5.36^{ax}	59.23 ± 5.36^{ay}	70.01 ± 5.36^{ay}
	Sorghum	35.76 ± 5.36^{bx}	69.42 ± 5.36^{ay}	86.22 ± 5.36^{az}
	Millet	46.65 ± 5.36^{bx}	42.07 ± 5.36^{ay}	60.15 ± 5.36^{az}
	Maize	32.47 ± 5.36^{bx}	60.27 ± 5.36^{ay}	72.42 ± 5.36^{az}
K (%)	Control	43.45 ± 3.96^{bx}	94.68 ± 3.96^{cy}	61.70 ± 3.96^{bz}
	Sorghum	93.70 ± 3.96^{ax}	99.66 ± 3.96^{ax}	97.28 ± 3.96^{ax}
	Millet	95.59 ± 3.96^{ax}	96.00 ± 3.96^{bx}	95.32 ± 3.96^{ax}
	Maize	92.91 ± 3.96^{ax}	96.44 ± 3.96^{bx}	96.05 ± 3.96^{ax}

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;
$P<0.05$; means ± SE.

Table 7: Effect of dietary treatments on micro mineral percentage retention in guinea fowl reared up to 16 weeks under the intensive management system

Mineral	Treatment	6 weeks	12 weeks	16 weeks
Zn (%)	Control	21.30 ± 4.29^{ax}	66.36 ± 3.96^{ay}	80.16 ± 3.96^{az}
	Sorghum	42.74 ± 3.96^{bx}	81.34 ± 3.96^{by}	89.49 ± 3.96^{ay}
	Millet	61.53 ± 3.96^{cx}	68.27 ± 3.96^{ax}	73.45 ± 3.96^{by}
	Maize	71.32 ± 3.96^{dx}	69.31 ± 3.96^{ay}	33.68 ± 3.96^{cz}
Mn (%)	Control	52.99 ± 5.79^{ax}	76.13 ± 5.79^{ay}	83.18 ± 5.79^{az}
	Sorghum	48.04 ± 5.79^{bx}	73.13 ± 5.79^{ay}	95.31 ± 5.79^{az}
	Millet	60.14 ± 5.79^{cx}	68.17 ± 5.79^{ax}	62.84 ± 5.79^{bx}
	Maize	34.96 ± 5.79^{dx}	64.17 ± 5.79^{ay}	82.69 ± 5.79^{az}
Cu (%)	Control	38.10 ± 4.77^{ax}	87.84 ± 4.77^{ay}	94.42 ± 4.77^{az}
	Sorghum	89.59 ± 4.77^{bx}	89.30 ± 4.77^{bx}	83.23 ± 4.77^{bx}
	Millet	91.26 ± 4.77^{cx}	92.52 ± 4.77^{cx}	89.87 ± 4.77^{bx}
	Maize	89.20 ± 4.77^{bx}	7.23 ± 4.77^{dy}	93.41 ± 4.77^{az}
Fe (%)	Control	75.63 ± 6.55^{ax}	37.32 ± 6.55^{ay}	78.60 ± 6.55^{az}
	Sorghum	43.53 ± 6.55^{bx}	84.05 ± 6.55^{by}	90.39 ± 6.55^{bz}
	Millet	69.97 ± 6.55^{cx}	76.58 ± 6.55^{cy}	74.30 ± 6.55^{ay}
	Maize	73.88 ± 6.55^{dx}	78.27 ± 6.55^{dy}	93.52 ± 6.55^{bz}

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;
$P<0.05$; means ± SE.

5.3 Bone physical dimensions

There were no significant differences among bone length and width of birds fed sorghum, millet, maize or control diets at 6 and 16 weeks of age. However, birds fed millet and control diets had significantly higher bone lengths at 12 weeks of age than birds fed other treatment diets which did not differ significantly from each other (Table 8). Bone length increased by 48% and 10% from 6 to 12 weeks of age and 12 to 16 weeks, respectively. These values show that bone development and growth is rapid during the first 12 weeks of age. This result agrees with Moreki [27] who found that tibia length in broiler breeder pullets increased by 46% and 13% between 6 and 12 weeks and 12 and 16 weeks, respectively. No significant differences were observed in bone weights of birds fed different cereal based diets at 6 weeks of age.

At 12 weeks of age, birds fed millet based diet had significantly higher bone weights than birds fed other three treatment diets which did not differ significantly from each other (Table 8). However, only birds fed maize based diets had significantly lower bone weights at 16 weeks of age.Heavier bone weights in birds fed millet diets suggested that millet promoted more bone growth than sorghum and maize. Vasan [28] reported a higher digestibility of pearl millet compared to sorghum in cockerels. The authors also stated that digestibility of sorghum was similar to that of maize which explains higher bone growths in guinea fowl fed millet diets compared to sorghum and maize diets reported in this study. The higher crude protein content (14%) in millet which promotes growth could have contributed to heavy bones of guinea fowl.

Table 8: Effect of dietary treatments on bone dimensions of guinea fowl reared up to 16 weeks under the intensive management system

	Treatment	6 weeks	12 weeks	16 weeks
Length(mm)	Maize	74.02 ± 1.12^{ax}	108.06 ± 1.12^{aby}	118.33 ± 1.19^{az}
	Sorghum	73.62 ± 1.17^{ax}	106.79 ± 1.12^{by}	120.49 ± 1.19^{az}
	Millet	74.13 ± 1.95^{ax}	110.71 ± 1.12^{ay}	119.84 ± 1.19^{az}
	Control	72.45 ± 1.17^{ax}	110.42 ± 1.12^{aby}	121.59 ± 1.19^{az}
Width (mm)	Maize	4.78 ± 0.16^{ax}	6.46 ± 0.16^{by}	6.48 ± 0.13^{by}
	Sorghum	4.72 ± 0.16^{ax}	6.12 ± 0.16^{by}	7.43 ± 0.13^{az}
	Millet	4.61 ± 0.27^{ax}	7.11 ± 0.16^{ay}	7.25 ± 0.13^{ay}
	Control	4.77 ± 0.16^{ax}	6.60 ± 0.16^{aby}	7.64 ± 0.13^{az}
Weight (g)	Maize	2.99 ± 0.27^{ax}	8.38 ± 0.27^{by}	8.94 ± 0.27^{by}
	Sorghum	2.79 ± 0.28^{ax}	8.06 ± 0.27^{by}	9.33 ± 0.27^{abz}
	Millet	2.85 ± 0.46^{ax}	11.11 ± 0.26^{ay}	9.35 ± 0.27^{abz}
	Control	2.68 ± 0.28^{ax}	8.76 ± 0.27^{by}	9.89 ± 0.27^{az}

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;$P<0.05$; means ± SE.

5.4Bone mineral composition

Birds fed diets containing sorghum had significantly lower bone Ca content compared to birds fed other treatment diets at 6 weeks of age which did not differ significantly from each other (Table 9). Bone Ca and P contents were highest at 16 weeks of age (Table 9). Feeding a diet containing millet resulted in higher bone P than those fed other treatment diets, which did not differ significantly from each other at 16 weeks of age. No significant differences were reported in bone P contents of birds fed the four different treatment diets at 6 and 12 weeks of age. Sodium and Mg contents were higher in birds fed diets containing millet from 6 and 12 weeks of age (Table 9). At 16 weeks of age, birds fed control diet had significantly lower bone Na and K content than birds fed other treatment diets which did not differ significantly from each other. Bone Mg content did not differ significantly among treatment diets at 6 and 16 weeks of age. The K content was significantly lower in bones of birds fed maize and control diets, respectively. Bone Na, Mg and K contents decreased by 26%, 27% and 25%, respectively from 6 to 12 weeks of age and thereafter remained constant. The decrease could be ascribable to increased levels of cereals in the diets from starter to grower phases. Cereal grains contain anti-nutritional factors such as tannins and phytates which reduce bioavailability and utilisation of minerals to the guinea fowl [29].

Birds fed diet containing sorghum had the lowest Zn, Mn, Cu and Fe bone mineral contents compared to those fed other treatment diets (Tables 10). Low bone micro mineral contents reported in this study might be due to the presence of anti-nutritional factors such as tannins which bind with nutrients and reduce utilization of energy, proteins and specific amino acids resulting in reduced growth rates and increased leg abnormalities [9, 12, 30]. The amount of inorganic material present in bone is positively correlated to its degree of hardness, compression strength, tensile strength and flexibility [31]. The present results clearly indicate that pearl millet could be used as an alternative energy source in poultry diets in regions where maize production is marginal. According to Vasan [8], millet has high true Ca, Cu, Mg, Mn and P bioavailability of 72%, 64%, 38%, 93% and 49%, respectively in cockerels. The performance and carcass yield of broilers fed diets containing up to 50% pearl millet were evaluated and were found to be equivalent or better than those of broilers fed typical maize-soybean diets [32].

Table 9: Effect of dietary treatments on bone macro mineral composition of guinea fowl reared up to 16 weeks under the intensive management system

	Treatment	6 weeks	12 weeks	16 weeks
Ca (mg/L)	Control	$180416.66 \pm 6646.64^{ax}$	$153583.33 \pm 6646.64^{by}$	$235800.33 \pm 6646.64^{az}$
	Sorghum	$151546.66 \pm 6646.64^{bx}$	$170008.33 \pm 6646.64^{ay}$	$232766.66 \pm 6646.64^{az}$
	Millet	$174283.33 \pm 6646.64^{abx}$	$176183.33 \pm 6646.64^{ax}$	$237041.66 \pm 6646.64^{ay}$
	Maize	$191908.33 \pm 6646.64^{ax}$	$169466.66 \pm 6646.64^{ay}$	$232283.33 \pm 6646.64^{az}$
P (mg/L)	Control	$90075.66 \pm 1459.25^{ax}$	$89250.66 \pm 1459.25^{ax}$	$112490.33 \pm 1459.25^{by}$
	Sorghum	$82575.33 \pm 1459.25^{ax}$	$89625.33 \pm 1459.25^{ax}$	$107083.66 \pm 1459.25^{by}$
	Millet	$86175.33 \pm 1459.25^{ax}$	$87750.33 \pm 1459.25^{ax}$	$124195.66 \pm 1459.25^{ay}$
	Maize	$83650.66 \pm 1459.25^{ax}$	$88800.33 \pm 1459.25^{ax}$	$105864.66 \pm 1459.25^{by}$
Na (mg/L)	Control	189.88 ± 53.18^{ax}	139.30 ± 53.18^{by}	111.44 ± 53.18^{bz}
	Sorghum	189.14 ± 53.18^{ax}	139.33 ± 53.18^{by}	146.16 ± 53.18^{az}
	Millet	193.22 ± 53.18^{ax}	141.96 ± 53.18^{ay}	163.89 ± 53.18^{az}
	Maize	182.74 ± 53.18^{bx}	139.86 ± 53.18^{aby}	146.16 ± 53.18^{az}
Mg (mg/L)	Control	778.60 ± 7.31^{ax}	562.04 ± 7.31^{by}	567.05 ± 7.31^{ay}
	Sorghum	775.43 ± 7.31^{ax}	562.29 ± 7.31^{by}	570.82 ± 7.31^{ay}
	Millet	779.09 ± 7.31^{ax}	566.35 ± 7.31^{ay}	535.88 ± 7.31^{ay}
	Maize	766.57 ± 7.31^{ax}	562.34 ± 7.31^{by}	568.33 ± 7.31^{ay}
K (mg/L)	Control	3736.43 ± 55.48^{ax}	2633.19 ± 55.48^{ay}	2524.13 ± 55.48^{by}
	Sorghum	3569.82 ± 55.48^{ax}	2629.13 ± 55.48^{ay}	2736.60 ± 55.48^{ay}
	Millet	3580.23 ± 55.48^{ax}	2640.73 ± 55.48^{ay}	2674.04 ± 55.48^{ay}
	Maize	3226.23 ± 55.48^{bx}	2610.09 ± 55.48^{ay}	2702.54 ± 55.48^{ay}

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;
$P<0.05$; means ± SE.

Table 10: Effect of dietary treatments on bone micro mineral composition of guinea fowl reared up to 16 weeks under the intensive management system

	Treatment	6 weeks	12 weeks	16 weeks
Zn (mg/L)	Control	268.19 ± 11.16^{ax}	211.86 ± 11.16^{ay}	267.57 ± 11.16^{ax}
	Sorghum	209.76 ± 11.16^{bcxy}	183.26 ± 11.16^{bx}	232.66 ± 11.16^{ay}
	Millet	226.75 ± 11.16^{bx}	210.81 ± 11.16^{ax}	258.31 ± 11.16^{ay}
	Maize	185.06 ± 11.16^{cx}	226.29 ± 11.16^{ay}	267.57 ± 11.16^{az}
Mn (mg/L)	Control	5.75 ± 1.31^{ax}	8.85 ± 1.31^{ay}	15.67 ± 1.31^{bx}
	Sorghum	1.93 ± 1.31^{bx}	5.44 ± 1.31^{by}	18.37 ± 1.31^{abz}
	Millet	1.97 ± 1.31^{bx}	9.25 ± 1.31^{by}	22.59 ± 1.31^{az}
	Maize	2.68 ± 1.31^{bx}	4.05 ± 1.31^{ay}	23.36 ± 1.31^{az}
Cu (mg/L)	Control	4.80 ± 0.66^{abx}	4.96 ± 0.66^{ax}	10.33 ± 0.66^{ay}
	Sorghum	4.63 ± 0.66^{bx}	3.27 ± 0.66^{bcx}	4.49 ± 0.66^{bx}
	Millet	3.86 ± 0.66^{bx}	4.55 ± 0.66^{abx}	4.92 ± 0.66^{bx}
	Maize	6.30 ± 0.66^{ax}	2.21 ± 0.66^{cy}	5.96 ± 0.66^{bx}
Fe (mg/L)	Control	101.66 ± 8.44^{ax}	95.16 ± 8.44^{bx}	155.93 ± 8.44^{aby}
	Sorghum	94.04 ± 8.44^{ax}	98.32 ± 8.44^{bx}	124.61 ± 8.44^{by}
	Millet	106.14 ± 8.44^{ax}	123.44 ± 8.44^{ay}	156.24 ± 8.44^{abz}
	Maize	89.17 ± 8.44^{ax}	101.24 ± 8.44^{aby}	160.15 ± 8.44^{az}

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;
P<0.05;means ± SE.

5.5 Meat mineral composition

Birds fed diets containing maize had significantly lower meat Ca content than birds fed other three treatment diets at 6 weeks of age where the control and millet diets did not differ from each other (Table 11). Meat from birds fed on sorghum diets had significantly higher Ca content than birds on control and maize diets at 6 and 12 weeks of age. At 16 weeks of age, meat from birds fed control diet had significantly higher Ca content than those fed other treatment diets, which did not differ significantly from each other (Table 11). Phosphorus was significantly higher in the meat from birds fed maize and control diets compared to those fed other treatment diets (Table 11). A study by Agwunobi and Ekpenyong [33] showed that guinea fowl meat had significantly (*P*< 0.05) more protein and ash contents, particularly Ca and P than broiler meat. In this study, no significant differences were noted in the K content of meat from bird fed different treatment diets at all ages except for K content in birds fed control diet at 16 weeks of age which was significantly lower than the meat from other three treatment diets (Table 11).

Mareko [34] reported K levels of 0.82% and 0.90% at 16 weeks of age in guinea fowl reared on earth and concrete floors, respectively. Meat from birds fed control diet had significantly lower Na content than birds fed other three treatment diets, which did not differ significantly from each other at 6 and 16 weeks of age (Table 11). At 12 weeks of age, meat from birds fed control and sorghum diets did not differ significantly from each other and was higher than meat from birds fed millet and maize diets (Table 11). The Na content of guinea fowl meat which ranged from 530.55 to 911.76 mg/l reported in this study is in disagreement with Tlhong [35] who reported Na values ranging from 16.48 to 18.32 mg/100g(164.8 to 183.2mg/l) in guinea fowl. However, the Na contents reported in the two studies are relatively low and therefore can be a promising tool in the marketing strategies of this meat type as a healthy food compared to meat from other species. The human body requires approximately 500mg of Na per day [36].

Calcium, Na, K and Mg contents in the meat decreased from 6 to 16 weeks of age. Phosphorus decreased with age from 6 to 12 weeks of age and thereafter remained constant. A decrease in meat mineral contents with age shows that the nutrient value of meat decreases with age (Table 11). Moreki [37] reported that DM, moisture, ash, protein and fat contents of guinea fowl meat fed pearl millet, yellow maize or sorghum as energy sources increased with age up to 12 weeks of age. According to Mareko [34], rearing guinea fowl beyond 16 weeks of age does not add any nutritional value to the meat. As a result, the authors concluded that it is advisable for farmers to slaughter or sell their birds on or before 16 weeks of age.

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Table 11: Effect of dietary treatments on meat macro mineral composition of guinea fowl reared up to 16 weeks under the intensive management system

	Treatment	6 weeks	12 weeks	16 weeks
Ca (mg/L)	Control	211.78 ± 15.40^{bx}	133.00 ± 15.40^{aby}	107.94 ± 15.40^{az}
	Sorghum	259.44 ± 15.40^{ax}	154.30 ± 15.40^{aby}	51.56 ± 15.40^{bz}
	Millet	220.02 ± 15.40^{bx}	182.60 ± 15.40^{ax}	60.89 ± 15.40^{by}
	Maize	161.50 ± 15.40^{cx}	98.01 ± 15.40^{by}	57.68 ± 15.40^{bz}
P (mg/L)	Control	73.076 ± 0.11^{ax}	61.382 ± 0.11^{ay}	59.23 ± 0.11^{ay}
	Sorghum	68.402 ± 0.11^{abx}	53.508 ± 0.11^{by}	52.24 ± 0.11^{by}
	Millet	64.656 ± 0.11^{bx}	53.286 ± 0.11^{by}	56.532 ± 0.11^{aby}
	Maize	70.134 ± 0.11^{abx}	56.794 ± 0.11^{aby}	53.188 ± 0.11^{aby}
Na (mg/L)	Control	911.76 ± 21.43^{bx}	874.07 ± 21.43^{ax}	530.55 ± 21.43^{bz}
	Sorghum	959.91 ± 21.43^{abx}	860.58 ± 21.43^{ay}	587.06 ± 21.43^{abz}
	Millet	991.31 ± 21.43^{ax}	754.66 ± 21.43^{by}	648.78 ± 21.43^{az}
	Maize	942.62 ± 21.43^{abx}	794.71 ± 21.43^{by}	601.23 ± 21.43^{abz}
Mg (mg/L)	Control	264.96 ± 10.48^{bx}	282.59 ± 10.48^{ax}	205.23 ± 10.48^{ay}
	Sorghum	293.81 ± 10.48^{abx}	265.79 ± 10.48^{ax}	225.88 ± 10.48^{ay}
	Millet	287.68 ± 10.48^{abx}	243.32 ± 10.48^{by}	237.69 ± 10.48^{ay}
	Maize	302.52 ± 10.48^{ax}	286.28 ± 10.48^{ax}	131.24 ± 10.48^{by}
K (mg/L)	Control	1745.74 ± 20.71^{ax}	1761.85 ± 20.71^{ax}	1574.43 ± 20.71^{by}
	Sorghum	1781.40 ± 20.71^{ax}	1725.76 ± 20.71^{abxy}	1672.68 ± 20.71^{ay}
	Millet	1756.75 ± 20.71^{ax}	1688.78 ± 20.71^{by}	1724.10 ± 20.71^{ay}
	Maize	1766.70 ± 20.71^{ax}	1765.18 ± 20.71^{ax}	1677.86 ± 20.71^{ay}

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;
$P<0.05$; means ± SE.

No significant differences were noted in the Mn content of meat from birds fed different treatment diets at 6 weeks of age (Table 12). At 12 weeks of age, meat from birds fed sorghum based diets had the lowest Mn contents than birds fed maize and millet which did not differ significantly from each other. At 16 weeks of age, Mn content of meat from birds fed sorghum and maize did not differ significantly from each other and was higher than that ofbirds fed control and millet diets. Copper content in the meat from birds fed maize and control diet was the same and significantly higher than that of birds fed sorghum and from each other and were higher than those fed millet diets (Table 12). No significant differences were noted in the Zn content of birds on sorghum and maize diets at all ages (Table 12). Bao [20] reported concentrations of Fe, Cu, Mn and Zn to be 150mg/g, 9 mg/ml, 7 mg/ml and 50mg/ml, respectively in broilers reared up to 29 days of age. The authors concluded that if dietary deficiency of micro minerals is mild, the animal usually reduces the rate of growth and excretion to maintain normal tissue millet diets, which did not differ significantly from each other at 6 weeks of age. At 12 weeks of age, Cu content of meat from birds fed millet diets was significantly higher than meatfrom birds on other treatment diets, which did not differ significantly from each other. Meat from birds fed millet diets contained the lowest Fe (91.95 mg/l) contents. On the other hand, Fe contents of meat from birds fed sorghum diets were significantly higher than those from birds fed other three treatment diets at 6 weeks of age. At 12 weeks of age, meat from birds fed sorghum and maize based diets did not differ significantly concentrations.Unlike the bone mineral composition, meat from birds fed sorghum diets compared favourably to those fed maize and millet in terms of mineral composition. This result suggests that sorghum can replace millet or maize in guinea fowl diets and still obtain meat with good mineral composition to meet human nutritional requirements. Guinea fowl meat with its optimum mineral levels can be a good mineral supplement in human nutrition to prevent disease and stunted growth.

Table 12: Effect of dietary treatments on meat micro mineral composition of guinea fowl reared up to 16 weeks under the intensive management system

	Treatment	6weeks	12weeks	16weeks
Zn (mg/L)	Control	20.17 ± 20.71^{bx}	26.86 ± 20.71^{ay}	24.07 ± 20.71^{axy}
	Sorghum	24.80 ± 20.71^{ax}	23.32 ± 20.71^{aby}	21.21 ± 20.71^{axy}
	Millet	28.95 ± 20.71^{ax}	21.70 ± 20.71^{by}	27.15 ± 20.71^{axz}
	Maize	24.70 ± 20.71^{ax}	24.79 ± 20.71^{abx}	28.67 ± 20.71^{ay}
Mn (mg/L)	Control	3.03 ± 0.73^{ax}	9.24 ± 0.73^{ay}	22.69 ± 0.73^{bz}
	Sorghum	2.61 ± 0.73^{ax}	4.03 ± 0.73^{cy}	28.79 ± 0.73^{az}
	Millet	2.13 ± 0.73^{ax}	7.10 ± 0.73^{by}	23.87 ± 0.73^{bz}
	Maize	2.82 ± 0.73^{ax}	7.72 ± 0.73^{by}	29.52 ± 0.73^{az}
Cu (mg/L)	Control	6.15 ± 0.73^{ax}	8.53 ± 0.73^{by}	10.54 ± 0.73^{az}
	Sorghum	3.71 ± 0.73^{bx}	8.55 ± 0.73^{by}	8.24 ± 0.73^{ay}
	Millet	4.00 ± 0.73^{bx}	14.24 ± 0.73^{ay}	9.07 ± 0.73^{az}
	Maize	6.97 ± 0.73^{ax}	8.90 ± 0.73^{by}	2.28 ± 0.73^{bz}
Fe (mg/L)	Control	29.56 ± 1.41^{bx}	41.58 ± 1.41^{ay}	41.40 ± 1.41^{ay}
	Sorghum	47.32 ± 1.41^{ax}	32.14 ± 1.41^{by}	36.53 ± 1.41^{bz}
	Millet	27.46 ± 1.41^{bx}	24.58 ± 1.41^{cx}	43.81 ± 1.41^{ay}
	Maize	30.14 ± 1.41^{bx}	32.51 ± 1.41^{bx}	42.00 ± 1.41^{ay}

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;
P<0.05; means ± SE.

5.6 Blood mineral composition

Birds fed millet-based diets had significantly higher blood Ca than birds fed other treatment diets which did not differ significantly from each other at 12 weeks of age (Table 13). However, no significant differences were noted among treatments at 6 and 16 weeks of age. The blood Ca contents that ranged from 114.74±18.24 to 291.50±18.24 mg/L reported in this study are higher than that of mammals which is 80 to 120 mg/l, but lower than that of laying hens which is 300 to 400 mg/l [38]. Laying hens require more Ca for egg shell formation compared to requirements for growth in guinea fowl at 16 weeks of age. The P and K contents of blood obtained from birds fed control diet were significantly lower thanthat of other treatment diets which did not differ significantly from each other at 16 weeks of age (Table 13). The Na content in the blood of birds fed millet and sorghum diet was significantly higher than in the blood of birds fed other treatment diets, which did not differ significantly from each other at week 6 and 12, respectively (Table 13). Medugu [39] reported Na values of 147.50 mmol/l, 160 mmol/l and 155 mmol/l in the blood of broiler chickens fed maize, millet and low tannin sorghum, respectively. The differences in the results may be due to differences in cereal varieties, environments, species, stage of growth (age) and diet formulations used in the two experiments. Birds fed millet diets had significantly higher Mg content compared to other treatment diets which did not differ from each other (Table 13).

Generally, macro minerals in the blood increased significantly with age from 12 to 16 weeks of age (Table 13). No significant differences were noted in the Mg content of blood obtained from birds fed maize-based diets at all ages. Significant decreases with age in the K content of blood from all treatment diets were noted (Table 13). On the other hand, micro minerals in the blood generally decreased with age (Table 14). Micro minerals are incorporated in bone formation depending on the amount in blood circulation [40]. The decrease in micro minerals reported in this study might result in decreased mineral utilization in bone formation, thus increased leg abnormalities.

Table13: Effect of dietary treatments on blood macro mineral composition of guinea fowl reared up to 16 weeks under the intensive management system

	Treatment	6 weeks	12 weeks	16 weeks
Ca (mg/L)	Control	171.55 ± 18.24^{ax}	158.36 ± 18.24^{bx}	259.18 ± 18.24^{aby}
	Sorghum	114.74 ± 18.24^{ax}	153.12 ± 18.24^{bx}	255.40 ± 18.24^{aby}
	Millet	126.65 ± 18.24^{ax}	297.60 ± 18.24^{ay}	291.50 ± 18.24^{ay}
	Maize	162.93 ± 18.24^{ax}	141.83 ± 18.24^{bx}	228.11 ± 18.24^{by}
P (mg/L)	Control	81.16 ± 0.04^{ax}	82.95 ± 0.04^{ax}	60.90 ± 0.04^{by}
	Sorghum	84.35 ± 0.04^{ax}	79.66 ± 0.04^{abx}	69.78 ± 0.04^{ay}
	Millet	80.37 ± 0.04^{ax}	79.29 ± 0.04^{abyx}	72.36 ± 0.04^{ay}
	Maize	78.21 ± 0.04^{ax}	68.47 ± 0.04^{bx}	71.17 ± 0.04^{ay}
Na (mg/L)	Control	938.97 ± 10.69^{bx}	953.07 ± 10.69^{by}	1027.68 ± 10.69^{az}
	Sorghum	947.87 ± 10.69^{bx}	1017.39 ± 10.69^{ay}	1055.38 ± 10.69^{az}
	Millet	983.29 ± 10.69^{ax}	963.54 ± 10.69^{bx}	1056.60 ± 10.69^{ay}
	Maize	955.88 ± 10.69^{abx}	957.06 ± 10.69^{bx}	1058.33 ± 10.69^{ay}
Mg (mg/L)	Control	58.05 ± 2.45^{bx}	48.71 ± 2.45^{cy}	63.77 ± 2.45^{bz}
	Sorghum	57.53 ± 2.45^{bx}	54.91 ± 2.45^{ay}	68.05 ± 2.45^{by}
	Millet	73.69 ± 2.45^{ax}	107.65 ± 2.45^{bx}	81.38 ± 2.45^{az}
	Maize	60.40 ± 2.45^{bx}	55.12 ± 2.45^{bx}	69.12 ± 2.45^{bx}
K (mg/L)	Control	561.06 ± 17.83^{abx}	362.66 ± 17.83^{ay}	155.83 ± 17.83^{bz}
	Sorghum	566.44 ± 17.83^{abx}	380.27 ± 17.83^{ay}	212.17 ± 17.83^{az}
	Millet	614.09 ± 17.83^{ax}	369.97 ± 17.83^{ay}	221.32 ± 17.83^{az}
	Maize	497.94 ± 17.83^{bx}	398.42 ± 17.83^{ay}	190.16 ± 17.83^{abz}

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;

Table 14: Effect of dietary treatments on blood micro mineral composition of guinea fowl reared up to 16 weeks under the intensive management system

	Treatment	6 weeks	12 weeks	16 weeks
Zn (mg/L)	Control	8.32 ± 0.29^{cx}	9.17 ± 0.29^{ay}	5.01 ± 0.29^{az}
	Sorghum	9.87 ± 0.29^{bx}	8.12 ± 0.29^{by}	3.34 ± 0.29^{bz}
	Millet	12.44 ± 0.29^{ax}	8.56 ± 0.29^{aby}	3.25 ± 0.29^{bz}
	Maize	9.97 ± 0.29^{bx}	8.07 ± 0.29^{by}	3.95 ± 0.29^{bz}
Mn (mg/L)	Control	6.25 ± 0.45^{ax}	6.50 ± 0.45^{ax}	4.62 ± 0.45^{by}
	Sorghum	4.47 ± 0.45^{bx}	4.41 ± 0.45^{bx}	7.55 ± 0.45^{ay}
	Millet	5.85 ± 0.45^{abx}	6.13 ± 0.45^{ax}	5.30 ± 0.45^{bx}
	Maize	6.86 ± 0.45^{ax}	5.39 ± 0.45^{aby}	7.06 ± 0.45^{azx}
Cu (mg/L)	Control	4.73 ± 0.81^{bx}	4.30 ± 0.81^{cx}	17.22 ± 0.81^{ay}
	Sorghum	3.42 ± 0.81^{bx}	5.75 ± 0.81^{by}	12.22 ± 0.81^{bz}
	Millet	4.32 ± 0.81^{bx}	6.99 ± 0.81^{ay}	11.82 ± 0.81^{bz}
	Maize	6.64 ± 0.81^{ax}	5.22 ± 0.81^{bx}	11.36 ± 0.81^{by}
Fe (mg/L)	Control	22.61 ± 1.91^{bx}	2.58 ± 1.91^{bcy}	25.37 ± 1.91^{abx}
	Sorghum	21.81 ± 1.91^{bx}	3.35 ± 1.91^{aby}	25.54 ± 1.91^{abz}
	Millet	39.58 ± 1.91^{ax}	4.19 ± 1.91^{ay}	23.37 ± 1.91^{bz}
	Maize	15.94 ± 1.91^{bx}	2.09 ± 1.91^{cy}	26.74 ± 1.9^{az}

^{ab}Means in the same column within a parameter with different superscripts differ significantly;
^{xy}Means in the same row within a parameter with different superscripts differ significantly;
$P<0.05$; means ± SE.

6. CONCLUSION

Birds fed millet diets generally promoted higher bone physical dimensions and chemical compositions, and blood mineral composition in guinea fowl. Both sorghum and millet-based diets resulted in higher meat mineral compositions, mineral intake and mineral retention percentages compared to maize-based diets in guinea fowl reared up to 16 weeks of age. These results suggest that pearl millet and white sorghum can replace maize in guinea fowl diets without negatively affecting mineral intake, retention and utilization.Further studies should be carried out to evaluate the effect of millet, sorghum and maize grains on meat sensory characteristics and bone integrity of the guinea fowl.

REFERENCES

[1]Adejinmi, O.O., Hamazat, R.A. and Fapohunda, J.B. (2007).Performance and nutrient digestibility of rabbits.*Nigerian Journal for Animal Production*, 34(1): 63-68.

[2]Nworgu, F.C., Adebowale, E.A., Oredein, O.A. and Oni, A. (1999).Prospects and economics of broiler chicken production using two plant protein sources. *Tropical Journal of Animal Science*, 2: 159-166.

[3]Medugu, C.I., Raji, A.O., Igwebuike, J.U. and Barwa, E. (2011).Alternative cereal grains and cereal by-products as sources of energy in poultry diets- A review. *Research Opinions in Animal and Veterinary Sciences*, 1: 530-542.

[4]Nahashon, S.N., Adefope, N., Amenyenu, A., Lema, M. and Wright, D. (2006). Growth and carcass characteristics of French guinea broilers fed diets with varying concentrations of metabolizable energy. *Journal of Sustainable Agriculture*, 27: 25-43.

[5]Ambula, M.K., Oduha, G.W. and Tuitoek, J.K. (2001). Effects of sorghum tannins, a tannin binder (polyvinylpyrrolidone) and sorghum inclusion level on the performance of broiler chicks. *Asian-Australian Journal of Animal Science*, 14:1276-1281.

[6]Rama Rao, S.V., Raju, M.V., Reddy, M.R. and Panda, A.K.(2004). Replacement of yellow maize with pearl millet (*Pennisetumtyphoids*), foxtail millet (*Setariaitalica*) or finger millet (*Eleusinecoracana*) in broiler chicken diets containing supplemental enzymes. *Asian-Australasian Journal of Animal Science*,17: 836-842.

[7]Niranjan, U.P.S. and Yadav, K.R. (2009). Effect of pearl millet based diet with or without enzyme supplementation on broilers. *Indian Veterinary Journal*, 86: 210-211.

[8]Vasan, P., Mandal, A.B. and Kadam, M.M. (2009b).Biological availability of minerals from pearl millet in adult roosters.*Indian Veterinary Journal*, 86: 208-209.

[9]Jacob, J.P., Mitaru, B.N., Mbugua, P.N. and Blair, R. (1996). The effect of substituting Kenyan Serena sorghum for maize in broiler starter diets with different dietary crude protein and methionine levels. *Animal Feed Science Technology*, 69:27-39.

[10]Esonu, B.V., Anumni, P., Obinna, K. and Eneremadu, O.F. (1999). Evaluation of combination of maize/ sorghum based brewer's grains, Cocoyam corns and cassava root meals as substitute for maize in broiler finisher diets. *Indian Journal of Animal Science*, 69:129-130.

[11]Mandal, A.B., Tyagi, P.K., Alangovan, A.V., Kaur, S. and Johri, A.K. (2006). Comparative apparent metabolizable energy values of high, medium and low tannin varieties of sorghum in cockerel, guinea fowl and quail. *British Poultry Science Journal*, 47: 336-341.

[12]Kumar, V., Elangovan, A.V. and Mandel, A.B. (2005).Utilisation of reconstituted high tannin sorghum in the diet of broiler chickens.*Asian-Australasian Journal of Animal Science,* 18: 183-186.

[13]Waniska, R.D.(2000). Structure, phenolic compounds, and antifungal proteins of sorghum caryopses. Technical and institutional options for sorghum grain mold management. Proceedings of an international consultation, 18-19 May 2000, ICRISAT, Patancheru, India.Pages 72-106.

[14]Aganga, A.A. and Omphile, C.H. (2000). Forage resources of Botswana. Government Printers, Gaborone.

[15]BOS,234 (2006). Guinea fowl standards.Botswana Bureau of Standards. Gaborone, Botswana.

[16]Moreki, J.C., Van der Merwe, H.J. and Hayes, J.P. (2011b). Effect of dietary calcium intake on its retention by caged broiler breeder hens.*Research Opinions in Animal and Veterinary Sciences,* 1: 258-265.

[17]A.O.A.C. (1996).Official Methods of Analysis.Association of Analytical Chemists, Washington, D. C.

[18]Onyeanusi, B.I. (2007). Calcium and phosphorus levels in Nigerian guinea fowls.*International Journal of Poultry Science*, 6: 610-611.

[19]Moreki, J.C. (2005). The influence of calcium intake by broiler breeders on bone development and egg characteristics.Doctor of Philosophy Thesis.University of Free State. South Africa.

[20]Bao, Y.M., Choct, M., Iji, P.A. and Bruerton, K. (2007).Effect of organically complexed copper, iron, manganese, and zinc on broiler performance, mineral excretion and accumulation in tissues. *Journal of Applied Poultry Research*, 16: 448-455.

[21]SAS Institute. (2003). User's Guide: Statistics, SAS Institute Inc., Cary, North Carolina, USA.

[22]Dunnett, C.W. (1955). A multiple comparison procedure for comparing several treatments with a control.*Journal of the American Statistical Association*, 50:1096–1121.

[23]Ensminger, M.E. (1992). Poultry Science. Interstate Publishing, INC., Danville, Illinois, USA.

[24]Ibitoye, E.B., Olorede, B.R., Jimoh, A.A. and Abubakar, H. (2012). Comparative performance and organ relative weight of broiler chickens fed three sources of energy diet. *Journal of Animal Production Advances*, 2: 233-238.

[25]Hocking, P.M, Robertson, G.W., Nixey, C. (2002). Effects of dietary calcium and phosphorus on mineral retention, growth, feed efficiency and walking ability in growing turkeys.*British Poultry Science Journal*,43: 607-14.

[26]De Verdal, H., Narcy, A., Bastianelli, D., Chapuis, H., Même, N.,Urvoix, S., Le Bihan-Duval, E. and Mignon-Grasteau1, S. (2011).Improving the efficiency of feed utilization in poultry by selection. 2. Genetic parameters of excretion traits and correlations with anatomy of the gastro-

intestinal tract and digestive efficiency. *BMC Genetics*, 12:71-81.

[27]Moreki, J.C., Van der Merwe, H.J. and Hayes, J.P. (2011a). Influence of dietary calcium levels on bone development in broiler breeder pullets up to 18 weeks of age. *Online Journal of Animal and Feed Research*, 1: 28-40.

[28]Vasan, P., Mandal, A.B. and Mukund, M. (2009a). Nutritive value of pearl millet fed to adult white leghorn cockerels. *Indian Veterinary Journal*, 86: 278-280.

[29]Pinter, J., Bujan, M., Homen, B., Gazic, K., Sikiric, M., Cerny, T. (2005). Effects of supplemental phytase on the mineral content in tibia of broilers fed different cereal based diets. *Czech Journal of Animal Science*, 50: 68-73. [40]Whitehead, C.C. (2002). Influence of vitamins and minerals on bone formation and quality. In: Proceedings of the 11th WPSA European Poultry Conference, Bremen, August 6–10.

[30]Etuk, E.B., Ifeduba, A.V., Okata, U.E., Chiaka, I., Okoli, Ifeanyi, C., Okeudo, N.J., Esonu, B.O., Udedibie, A.B.I. and Moreki, J.C. (2012).Nutrient Composition and Feeding Value of Sorghum for Livestock and Poultry: a Review. *Journal of Animal Science Advances*, 2: 510-524.

[31]Bonser, R.H.C. and Casinos, A. (2003).Regional variation in cortical bone properties from broiler fowl-a first look. *British Poultry Science Journal*, 44: 350-354.

[32]Davis, J., Dale, I.M.N. and Ferreira, F.J. (2003). Pearl millet as an alternative feed ingredient in broiler diets. *Journal of Applied Poultry Research*, 12: 137-144.

[33]Agwunobi, L.N. and Ekpenyong, T.E. (1990).Nutritive and economic value of guinea fowl (*Numidameleagris*) production in developing countries.*Journal of the Science of Food and Agriculture*, 52: 301-308.

[34]Mareko, M.H.D., Nsoso, S.J. and Lebetwa, N. (2008). Nutritive value of meat of guinea fowl raised on concrete and bare soil floors from 16-26 weeks of age. *Research Journal of Animal Sciences*, 2: 5-11.

[35]Tlhong, T.M. (2008). Meat quality of raw and processed guinea fowl.Master of Science thesis.Stellenbosch University. Page 62-66.

[36]Graudal, N.A., Hubeck-Graudal, T. and Jurgens, G. (2011).Effects of low sodium diet versus high sodium diet on blood pressure, renin, aldosterone, catecholamines, cholesterol, and triglyceride. Retrieved 04/12/12 fromhttp://onlinelibrary.wiley.com/doi/10.1002/14651858.CD004022.pub3/abstract

[37]Moreki, J.C., Podi, K.T., Nthoiwa, P.G. and Machete, J.B. (2012).Chemical Analysis and Sensory Evaluation of Guinea Fowl Meat Fed Diets Containing Three Cereal Grains as Energy Sources up to 12 Weeks of Age. *International Journal of Science and Advanced Technology*, 2: 59-66.

[38]McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. and Morgan, C. A. (2002).Animal Nutrition.6th Edition. Person Education Limited, Essex, U.K. Page 108.

[39]Medugu, C.I., Kwari, I.D., Igwebuike, J., Nkama, I., Mohammed, I.D. and Hamaker, B. (2010). Carcass and blood components of broiler chickens fed sorghum or millet as replacement for maize in the semi arid zone of Nigeria. *Agriculture and Biology Journal of North America*, 1: 326-329.

[40]Whitehead, C.C. (2002). Influence of vitamins and minerals on bone formation and quality. In: Proceedings of the 11th WPSA European Poultry Conference, Bremen, August 6-10.