Growth Performance and Carcass Characteristics of Guinea Fowl (Numida meleagris) Fed Diets Containing Three Local Grown Cereals as Energy Sources Raised Under Intensive System

Master of Science (MSc) in Animal Science

By

Samuel Uaperendua Tjetjoo

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A Dissertation presented to the Department of Animal Science and Production in partial fulfilment of the requirements for the Degree of Master of Science (MSc) in Animal Science (Nutrition)
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Samuel Uaperendua Tjetjoo

Faculty of Agriculture
Department of Animal Science and Production
Botswana College of Agriculture
University of Botswana

Supervisor: **Dr. J.C. Moreki**
Co-Supervisors: **Prof. S.J. Nsoso**
Prof. O.R. Madibela

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DECLARATION

I declare that the dissertation hereby submitted by me for the Master of Science degree at Botswana College of Agriculture, University of Botswana, is my own independent work and has not previously been submitted by me at another university/faculty for the award of any other degree or diploma.

Samuel Uaperendua Tjetjoo

July 2014

APPROVAL

Supervisor's name	Date	Signature
J.C. Moreki	15-07-14	
Co-supervisor's name	**Date**	**Signature**
S.J. Nsoso	06-08-2014	
O.R. Madibela	15/7/14	
Head of Department's name	**Date**	**Signature**
S.J. Nsoso	06-08-2014	
Dean of Faculty's name	**Date**	**Signature**
J.M. Kamau	08-08-14	

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ABSTRACT

This study investigated growth performance and carcass characteristics of guinea fowl fed diets containing three local grown cereals as energy sources in comparison to commercial broiler diets (control). Birds were raised under intensive system from 3 to 16 weeks of age. In the first experiment a completely randomized design was used where 160 guinea fowl keets were randomly assigned to four dietary treatments. Each dietary treatment had 40 birds with four replicates of 10 birds each. Feed and water were provided *ad libitum*. The growth performance and parameters studied were feed intake (FI), feed conversion ratio (FCR), body weight (BW), body weight gain (BWG), body length, body circumference, wing stretch, shank length and neck length. Data were analyzed using General Linear Model Procedure in Statistical Analysis Software (version 9.0). The results showed that dietary treatment did not ($p>0.05$) influence morphological parameters of growth and performance of guinea fowl at the same age. From 3 to 16 weeks of age FI was significantly ($p<0.001$) lower for birds on control diet (13714.79±209.65 g) than maize (16085±209.65 g), millet (1609.63±209.65 g) and sorghum (15872±209.65 g) diets while maize, millet and sorghum diets did not differ significantly. Similarly, FCR was significantly ($p<0.001$) lower for birds on control diet (11.33±0.37) than maize (13.91±0.37), millet (14.90±0.37) and sorghum (13.72±0.37) diets while the later diets did not differ significantly from each other. Average weekly BWG was significantly ($p<0.05$) lower for birds on millet diet (82.98±2.18 g) than birds on control (93.14±2.18 g), maize (89.25±2.18 g) and sorghum (89.03±2.18 g) diets while the later treatments did not differ significantly from each other.

In the second experiment carcass parameters of birds were evaluated. Parameters for carcass characteristics studied were dressed carcass weight, carcass yield, gizzard weight, heart weight, liver weight, drumstick weight, thigh weight, back weight, breast weight and wing weight. On average, 3 birds from each replicate (12 birds from each dietary treatment) were randomly selected and sacrificed in the abattoir at 6, 12 and 16 weeks of age for carcass evaluation. From 6 to 16 weeks of age guinea fowl on control diets had significantly ($p<0.001$) higher carcass dressed weight (707.08±10.94 g) than maize (686.50±10.94 g); millet (633.63±10.94 g) and sorghum (690.30±10.94 g). Maize and sorghum diets did not differ significantly from each other. Dietary treatment had no significant ($p>0.05$) influence on guinea fowl carcass yield. Empty gizzard, heart, liver, drumstick, thigh, back and breast were significantly ($p<0.001$) influenced by dietary treatments.

Generally, morphological parameters of growth and carcass characteristics significantly ($p<0.001$) increased with guinea fowl age. These results suggest that maize, sorghum or millet diets can be used in guinea fowl diets without affecting growth performance and carcass characteristics of guinea fowl. Further studies on the acceptance of meat by consumers and cost-benefit analysis of the dietary treatments should be conducted to complete comparison of locally available cereal grains and commercial feeds.

Key words: Carcass characteristics, cereal grains, growth parameters, guinea fowl, intensive system

DEDICATION

I dedicate this work to my late parents Mr Katjiuari Timoteus Tjetjoo and Mrs Uamuatjiuru Christophine Tjetjoo for being the best mentors for me. I am particularly grateful to my father who provided the necessary foundation for my education but could not live long to cherish my academic success.

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LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

BCA	Botswana College of Agriculture
BOS	Botswana Standard
BW	Body Weight
BWG	Body Weight Gain
CP	Crude Protein
cm	centimetre
CV	Coefficient of Variation
DCP	Dicalcium phosphate
FAO	Food and Agricultural Organisation
FI	Feed Intake
FCR	Feed Conversion Ratio
g	gram
GLM	General Linear Model
ISPAAD	Integrated Support Programme for Arable Agriculture Development
IU	International Unit
LSD	Least Significant Difference
m	metres
ME	Metabolizable Energy
mg	milligram
MJ	Mega Joules
NFE	Nitrogen-Free Extract
NRC	National Research Council
REML	Restricted Maximum Likelihood
SAS	Statistical Analysis Software

CHAPTER 1

GENERAL INTRODUCTION

Guinea fowl strains descended from the helmeted guinea fowl (*Numida meleagris)* (Moreki, 2009) which originated in Africa (Belshaw, 1985; Somes, 1996; Embury, 2001). Guinea fowl were first domesticated by ancient Egyptians (Bonds, 1997). Guinea fowl has wide distribution in Africa and has distinct popularity with smallholder farmers (Microlivestock, 1991; Nwagu and Alawa, 1995; Bonds, 1997). This bird occurs in Asia and Latin America as a semi-domesticated species, while in Europe, North America and Australia, large-scale production of guinea fowl dominates (Nwagu and Alawa, 1995; Bonds, 1997; Embury, 2001). Its attractive plumage and value as a table bird with gamey flavour, high yield of 80% after processing (Saina, 2005) and high meat to bone ratio has led to its worldwide acceptance (Embury, 2001). Despite the interest in guinea fowl production, there exists a dearth of information on guinea fowl production, in contrast to chickens where extensive research is available (Kusina and Kusina, 1999; Maphosa *et al.* 2004; Muchadeyi *et al.* 2004).

As in most African countries, commercial guinea fowl production in Botswana is in its infancy with production mainly at subsistence level. However, there is evidence of their acceptance in the country as shown by numerous visits by farmers to the Department of Animal Production and Department of Wildlife and National Parks offices across the country seeking technical information on guinea fowl production (Poultry Annual Report, 2006). The introduction of the Livestock Management and Infrastructure Development (LIMID) support scheme in 2007 opened an opportunities for guinea fowl production in the country. In LIMID Phase I, resource-poor farmers were supplied with 25 guinea fowl each as a means of eliminating destitution (Ministry of Agriculture, 2006). Moreki *et al.* (2010) reported that 233 guinea fowl projects were established countrywide through LIMID assistance. The sum of P2187447.00 (USD330634.83) was used to purchase 4235 guinea fowl for the 233 projects. The Department of Wildlife and National Parks, in April 2010, showed that there were 1808 guinea fowl projects in the country. Nsoso *et al.* (2006) reported that information on guinea fowl production in Botswana was very scanty. According to Mareko *et al.* (2008), the scarcity of the information is even worse with regard to carcass/meat characteristics.

1.1 Justification

In Botswana, domesticated guinea fowl are fed commercial broiler and layer diets with cereal grains and green vegetables such as spinach and cabbage leafs used as supplementary feeds. Although, commercial poultry diets are balanced rations, supplementary feeding is done because it is expensive to feed commercial poultry diets during production of guinea fowl since majority of farmers are resource poor. This is compounded by the fact that guinea fowl take long period to reach slaughter weight and continuous feeding of commercial diets is costly. At present, there are no formulated diets for guinea fowl in the country. This implies that the nutritional requirements of guinea fowl may not be met, thus compromising their performance or oversupplied resulting in feed wastage. Therefore, feeding guinea fowl diets that meet their nutritional requirements can improve their performance; hence promoting food security and contributing to poverty eradication in accordance with the country's Vision 2016 and Millennium Development Goals.

The introduction of the Integrated Support Programme for Arable Agriculture Development (ISPAAD) by the government in 2008 has contributed to increased cereal grain production. Morewagae (2009) reported that since its inception ISPAAD has increased cereal production in Botswana from 15 to 27.5%. The main cereals produced in Botswana are maize, sorghum and pearl millet and these are grown mainly for human consumption. Traditionally, cereal grains are mostly used in poultry diet formulation as energy sources. However, Lassiter *et al.* (1982) argued that these grains differ in their relative nutritional characteristics and hence may affect production differently. In guinea fowl production, feeding costs constitute about 65 to 70% of the total cost of production (Chiripasi *et al.* 2013). This indicates that the development of the guinea fowl industry depends to a large extent on the availability of feedstuffs that are used in feed manufacturing. Increased cereal production in the country is a welcome development for human consumption and production of animal feeds using locally available feedstuffs.

The study comprises two experiments.

1.2 Objective

The overall objective of the study was to evaluate growth performance and carcass characteristics of guinea fowl fed diets containing three cereal grains i.e. yellow maize, white sorghum and pearl millet as energy sources in comparison to commercial broiler diets under intensive management system.

Experiment 1: Growth performance of guinea fowl (*Numida meleagris*) fed diets containing three local grown cereals as energy sources raised under intensive system.

The specific objectives were to:

- Determine the weekly feed intake of guinea fowl fed diets containing three cereal grains as energy sources and commercial broiler diets.
- Determine the weekly weight gains of guinea fowl fed diets containing three cereal grains as energy sources and commercial broiler diets.
- Calculate the feed conversion ratio (FCR) of guinea fowl fed diets containing three grains as energy sources and commercial broiler diets.

The hypothesis tested was:

H_0: There is no difference in growth performance between guinea fowl fed diets containing three cereal grains as energy sources and those fed commercial broiler diets.

H_1: There is a significant difference in growth performance between guinea fowl fed diets containing three cereal grains as energy sources and those fed commercial broiler diets.

Experiment 2: Carcass characteristics of guinea fowl (*Numida meleagris*) fed diets containing three local grown cereals as energy sources raised under intensive system.

The specific objective was to compare the carcass characteristics i.e. dressed weight, dressed percentage and drumstick weight, thigh weight, wing weight, breast weight and back weight of guinea fowl fed diets containing three cereal grains as energy sources and commercial broiler diets.
The hypothesis tested was:

H_0: There is no difference in carcass characteristics between guinea fowl fed diets containing three cereal grains as energy sources and those fed commercial broiler diets.

H_1: There is a significant difference in carcass characteristics between guinea fowl fed diets containing three cereal grains as energy sources and those fed commercial broiler diets.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Guinea fowl belongs to the pheasant family which is indigenous to Africa (Ikani and Dafwang, 2004). Moreki (2009) points out that guinea fowl are indigenous to the grasslands of most Africa south of Sahara, where they occupy all habitats except dense forests and treeless deserts. Being indigenous to temperate Southern Africa, they appear to adapt to both warm and cold environments. Guinea fowl production has long contributed substantially to the supply of animal protein in the world (Nwagu and Alawa, 1995).

There are several strains of guinea fowl but the most common is the red–wattled fowl (*N. meleagris*), a domestic strain which is distributed throughout the world. There is also the blue wattled guinea fowl (*N. ptilorhyncha*), which carries a collarette of feathers around the upper part of the neck (Say, 1987). According to Saina (2005), *N. meleagris* descends from West Africa but has acclimatised throughout the world. It is a chicken-sized bird which measures from 40-71 cm in length and weighs approximately 0.7-1.6 kg. This bird is kept for meat and egg production. The female and male guinea fowl look alike although the male has larger helmet and thicker wattles compared to the female (Say, 1987). *N. meleagris* has also been exported to Europe for genetic improvement under intensive environment (Saina, 2005). The three principal varieties of guinea fowl recognised across the world are Pearl, Lavender and White with the Pearl being the most common.

Guinea fowl are kept for various purposes depending on the society. Like chicken, guinea fowl are an important source of animal protein (Mallia, 1999). Saina *et al.* (2005) stated that there are hardly any cultural barriers against consumption of guinea fowl products. Guinea fowl meat is served extensively in hotels and restaurants because of its wild gamey flavour (Feltwell, 1992). Some farmers keep guinea fowl out of curiosity and as "watch animals" around homesteads. Guinea fowl have an excellent eye-sight, a harsh cry and shriek at the slightest provocation (Microlivestock, 1991; Mallia, 1999; Smith, 2000) which can alert people of danger before it occurs. In addition, guinea fowl are kept for income generation (Ligomela, 2000) and for control of snakes, mice, ticks, other pests and weeds (Cactus Ranch, 2001; Frit's Farm, 2001). According to Saina (2005), the factors that influence productivity of guinea fowl are management system, nutrition, diseases, housing, provision of extension services and the availability of a market for the products.

2.2 Rearing systems

There are three systems of rearing guinea fowl: intensive, semi-intensive and extensive (also called free range or scavenging system). In commercial production, guinea fowl are raised in confinement with management practices similar to those of chickens (Nahashon *et al.*, 2009). The intensive system of guinea fowl production is based on specialized strains of guinea fowl (broilers, breeders and layers). In this system, birds do not have access to an outdoor environment as they are permanently enclosed and fed complete diets. Feed and water are made available all the time. Ikani and Dafwang (2004) stated that the intensive system involves confining the birds in doors either in battery cages or on deep litter within a large controlled environment. Currently, it is practised in developed countries where specialised breeds of guinea fowl have been developed and the production is commercialised (Galor, 1983; Robinson, 2000; Embury, 2001).

The semi-intensive management system refers to the provision of permanent housing with access provided to a yard or the surrounding environment (Fanatico, 1998). This is the common system of rearing guinea fowl in Botswana. Under this system, birds are given supplementary feed and water within houses (Embury, 2001). Open-sided houses in which ventilation is naturally aided are the most common type of housing as they are cheap to construct and maintain. The houses are equipped with laying nests, perches and runs. Earth floors are commonly used and where concrete floors are used wood shavings and sand are used, with sand being the most common (Moreki, 2009). Nsoso *et al.* (2006) found no significant difference in growth and morphological parameters of guinea fowl raised on concrete and earth floors in Botswana. In addition, diseases are controlled to enhance guinea fowl productivity.

Guinea fowl can also be reared under extensive production systems as they have a greater ability to survive under the poor free range conditions of management than exotic chickens (Dahouda *et al.*, 2007). In most developing countries, guinea fowl farming is based mainly on the free range system, which is characterised by low productivity (Mallia, 1999). In this system, birds are not confined and thus are free to fend for their roost, as well as, ridding the field of insect pests and weed seeds (Ikani and Dafwang 2004). The management of birds in this system is almost at no cost to the farmer because birds find their own feed and shelter. Scavenging is the main feeding system under free-range systems. Saina (2005) in Zimbabwe stated that under this system, no standard poultry management practices are followed and most of the poultry feeds available are of poor quality and in short supply during the dry season. The shortage of feed resources is also worsened by competition with humans and expanding intensive livestock production (Mwale *et al.*, 2008), as well as, production of bio-fuels.

Schwanz (1987) indicated that when raising guinea fowl, one has to ensure that traditional techniques are maintained in order to respect their free ranging instinct, an attribute that helps to maintain the meat's gamey flavour which leads to its demand in large markets and its extensive sales in higher priced restaurants.

2.3 Feeds and feeding

Guinea fowl are omnivores; they have a unique ability to utilize a wide range of flora and fauna as feed resources (Saina, 2005). In the wild, they eat a wide variety of feedstuffs but most important are weeds grasses, insects and waste grain (Adeyemo and Oyejola, 2004; Moreki, 2009). Also, Tewe (1983) reported that insects form a component feature in guinea fowl diets suggesting that protein and energy rich components predominate in the diets for maintenance of the daily activities of this bird. However, this is only true during the wet season when insects and grasses are abundant but as according to Saina (2005) birds are challenged during the dry season.

Guinea fowl also consume non-conventional feeds not used in chicken feeding (Bonds, 1997). For instance, Agbede and Aletor (2003) reported that leucaena leaf concentrate can easily replace fish meal up to 25% without any adverse effect on performance, carcass characteristics, muscle development or haemoglobin and serum metabolites. Nwagu and Alawa (1995) stated that guinea fowl digest nitrogen-free-extract and lignin components of feed better than chicken but have a disadvantage of poor utilisation of crude protein. Therefore, according to Nwagu and Alawa (1995) it is necessary for the requirements of guinea fowl for energy and nitrogen fractions of feed to be comprehensively evaluated for optimal physical and economic performance under different management systems.

Diets formulated to meet the nutrient requirements of guinea fowl are available elsewhere but not in Botswana. Complete diets (starter, grower and finisher) for guinea fowl are available from commercial feed millers in countries such as Australia, France and Italy (Galor, 1983; Embury, 2001) but not in Botswana as the industry is in its infancy. However, a guinea fowl feed standard (BOS 234:2006) was developed to enhance promotion of guinea fowl farming in Botswana in 2006.

2.4 Nutritive value of cereal grains

Compared to leguminous crops such as soybean and cowpea, cereal grains have low content of certain essential amino acids (Table 2.1). As a consequence, diets for non-ruminant animals from cereals must be supplemented with additional sources of protein (Lewis *et al,* 1982) or synthetic amino acids. According to Smith (1990), the protein requirement of birds is defined as a requirement for the supply of each essential amino acid together with a sufficient supply of suitable nitrogenous compounds from which non-essential amino acids can be synthesized. Miles and Jacob (1997) argued that a protein that does not contain the proper amount of required (essential) amino acids will be an imbalanced protein and will have a lower nutritional value to the bird. Protein of cereal grains and most other plant protein concentrates fail to supply the complete amino acid needs of poultry due to shortage of methionine and lysine. Additionally, Sales (2006) reported that birds are unable to synthesize nine of the 20 amino acids in proteins because of lack of specific enzymes. Therefore, the protein in the diet must supply sufficient levels of essential amino acids to meet the bird's requirements.

Maize and sorghum have many similar nutritional characteristics. Yellow maize is preferred in livestock feeding because it contains xanthophylls which give poultry meat, animal fat and egg yolk the colour appreciated by consumers in many countries. In contrast, sorghum lacks the xanthophylls found in maize but typically contains slightly more protein (FAO, 1997). Sorghum grain is one of the important crops grown in many arid and semi-arid regions of Asia and Africa (Mulimani and Supriya, 2005). However, a factor that must be considered when using sorghum grains in animal nutrition is the presence of phenolic substances (tannins), which limit large-scale use (Faquinello *et al.* 2004). The tannin content of sorghum is closely related to seed colour; the dark pigmentation of the seeds is due to their (tannins) presence (Boren and Waniska1992). The tannin ratios depend on the type and hybrids of sorghum, which can change according to the region it is raised and its glume portion (Pond *et al.,* 1995; NRC, 1996). Imik (2009) reported that animals have different sensitivities towards feed substances containing tannins, which depends on their ability to denature tannins with digestive enzymes. Tannins bind to certain digestive enzymes attached to the membrane of the small intestine thereby depressing digestive function (Walker, 1999). According to Butler *et al.* (1984), tannins in sorghum can bind dietary proteins and reduce their digestibility resulting in reduced performance for instance poor growth rates.

Table 2.1: Nutrient composition of maize, sorghum and pearl millet

Nutrients	Maize	Millet	Sorghum	Soybean meal
ME* (MJ/kg)	14.03	11.20	13.77	9.42
Protein (%)	8.5	14.0	8.8	42.5
Arginine (%)	0.6	0.3	0.4	3.0
Cystine (%)	0.1	0.1	0.2	0.7
Glycine (%)	0.5	0.4	0.3	1.5
Histidine (%)	0.3	0.2	0.2	1.0
Isoleucine (%)	0.3	0.5	0.4	1.6
Leucine (%)	0.9	1.2	1.5	2.6
Lysine (%)	0.4	0.3	0.3	2.1
Methionine (%)	0.1	0.3	0.1	0.3
Phenylalanine (%)	0.4	0.6	0.6	1.7
Serine (%)	0.4	-	0.5	1.9
Threonine (%)	0.4	0.4	0.4	1.4
Tryptophan (%)	-	0.1	0.1	0.7
Tyrosine (%)	0.3	-	0.4	1.2
Valine (%)	0.5	0.6	0.5	1.6
Ether Extracts (%)	3.8	4.3	2.9	18.6
Linoleic Acid (%)	2.20	0.84	1.13	-
Crude fibre (%)	2.2	3.0	2.3	5.7
Calcium (%)	0.02	0.05	0.04	0.37
Total Phosphorus (%)	0.28	0.32	-	-
NonPhytate Phosphorus(%)	0.08	0.12	0.30	0.68
Potassium (%)	0.30	0.43	0.35	2.41
Chlorine (%)	0.04	0.14	0.09	0.01
Sodium (%)	0.02	0.04	0.01	0.02
Sulphur (%)	0.08	0.13	0.08	0.24
Magnesium (mg)	0.12	0.16	0.15	0.40
Manganese (mg)	7.0	31.0	15.0	44.18
Zinc (mg)	18.0	13.0	15.0	49.08
Iron (mg)	45.0	25.0	45.0	-
Copper (mg)	3.0	22.0	10.0	22.33
Selenium (mg)	0.03	-	0.20	0.24
Riboflavin (mg)	1.0	1.6	1.3	3.2
Pantothenic acid (mg)	4.0	7.8	12.4	17.4
Niacin (mg)	24.0	53.0	41.0	24.5
Choline (mg)	620	793	668	3184.3
Biotin (mg)	0.06	-	0.26	0.416
Folacin (mg)	0.4	-	0.2	-
Thiamine (mg)	3.5	6.7	3.0	12.24
Vitamin E (mg)	22.0	-	7.0	-
Pyridoxine (mg)	-	-	5.2	-

Source: National Research Council (1994); Jurgens (2002)
ME* - Metabolizable Energy

Sorghum tannins are of the condensed type (proanthocyanidins) as hydrolysable tannins apparently do not occur in sorghum (Butler, 1989). Condensed tannins are flavonoid polymers which are non-toxic and not absorbed, whereas hydrolysable tannins are polymers of gallic or ellagic acid esterified to a core molecule commonly glucose or a polyphenol and potentially toxic (Reed, 1995). Elkin *et al.* (1990) reported a negative correlation between tannin content and amino acid availability. According to Gilani *et al.* (2005), the presence of high levels of tannins in cereals such as sorghum can result in significantly reduced protein and amino acid digestibilities up to 23% in rats, poultry and pigs. This finding is in agreement with Ebadi *et al.* (2005) who found that true amino acid availability decreased when tannins increased. The authors (Ebadi *et al.*, 2005) reported that all amino acids had a lower availability in high tannin sorghum (0.37%) than in low tannin sorghum (0.09%) and medium tannin sorghum (0.19%). The same study by Ebadi *et al.* (2005) reported that the availability of proline was most influenced by tannin. The availability of proline was 91.55% for low tannin sorghum, 84.82% for medium tannin sorghum and 22.82% for high tannin sorghum. Molnár *et al.* (2001) stated that low tannin sorghums are similar to maize in nutritional value. According to Imik (2009), brown sorghums have various proportions of tannins and white sorghums have none. Brown and white sorghums are grown throughout the world including Botswana. The common sorghum varieties in Botswana are *phofu*, *segaolane* and *sephala* which are all classified as sweet or white sorghum. According to Walker (1999) white sorghums can be formulated with confidence at high levels in poultry and swine feeds.

As shown in Table 2.1, millet has a higher level of crude protein and a better amino acid profile than sorghum (Rai *et al.*, 1999). The feed value of millet is comparable to that of maize (Andrews and Kumar, 1992). Despite its protein quality, millet contains significant amounts of phytic acid which is a recognized anti-nutritional factor affecting the bioavailability of major minerals such as calcium and phosphorus and trace minerals such as zinc, iron, copper and manganese (Eltayeb *et al.*, 2007). Other anti-nutrients of importance in millet are tannins and polyphenols which are known to limit its utilization by animals. Eltayeb *et al.* (2007) stated that phytic acid is reduced by soaking, dehulling and fermentation.

The potential protein sources that can be used in guinea fowl diets are fishmeal and soyabean meal. Fishmeal is an excellent source of protein for poultry with a crude protein (CP) of 57 - 77% and contains an excellent quantity and profile of amino acids which can offset the deficiencies of certain limiting amino acids in cereal grains. The protein in fishmeal is an excellent source of lysine, methionine and tryptophan which are essential amino acids required by poultry (Miles and Jacob 1997).

Soybean meal is the most popular source of supplemental protein in livestock feeds due to its high nutrient composition. The popularity of soybean meal in swine and poultry feeds is largely due to its high concentration of protein (38 – 48%) and its excellent profile of highly digestible amino acids

(Cromwell, 1999). Carlini and Udedibie, (1997) reported that in spite of its many virtues, like most high protein plant materials and most of the oilseeds, soybean meal posseses a certain amount of anti-nutritional factors such as trypsin inhibitors, lectins (phytohaemagglutinins), goitrogens and phytic acid. Trypsin inhibitors are polypeptides that form well characterised stable complexes with trypsin on a one-to-one molar ratio, obstructing the enzymatic action. Also, trypsin inhibitors have the ability to inhibit the activity of proteolytic enzymes within the gastrointestinal tract of animals (Liener and Kakade, 1980). Carlini and Udedibie (1997) stated that these inhibitors are destroyed by moist heat, so they are routinely destroyed during the normal processing steps in soybean meal. The challenge for Botswana poultry industry is that the country does not produce fishmeal and soybean meal as there are imported at great cost.

2.5 Feed intake and body weight gain

According to Botswana Standard for guinea fowl (BOS 234:2006), guinea fowl diets should contain 24-25% CP, 20% CP and 15% CP during starting, and the growing periods (grower 1 and grower 2) (Table 2.2). Grower 2 diet is used to finish guinea fowl. Say (1987) noted that the nutritional characteristics of guinea fowl feed are closer to those of chickens with the former having a slightly higher percentages of lysine and methionine for growth and laying. Ensminger *et al.* (1990) and Leeson and Summers (1997) reported that guinea fowl have higher protein requirements than chickens (Tables 2.2 and 2.3). A balanced ration which meets the bird's nutritional requirements is considered a prerequisite for efficient egg production and meat production (Saina, 2005). Ikani and Dafwang (2004) reported feed intake of guinea fowl to be 25–30 g; 50–60 g and 70–80 g *per* day between the ages of 0 to 6 weeks, 7–12 weeks and 13–16 weeks, respectively.

Compared to chickens, guinea fowl have slow growth rates (Bokoungou, 2005) and utilize feed less efficiently (Olomu, 1983). This finding is in agreement with that of Ayorinde and Ayeni (1983) who reported that guinea fowl tend to be slow in growing, weighing less than 1 kg at 8 weeks of age compared to broilers which reach 1.5 to 2 kg in 6-8 weeks. Oguntona (1982) in Nigeria reported varied body weights of 245.20 – 726.0 g at 12 weeks and 590.24 – 1387.4 g at point of lay (28 weeks). Although guinea fowl have slow growth rate than broiler chickens, the carcass yield (dressing percentage) of male and female guinea broilers at 12 weeks of age is about 76.8% and 76.9%, respectively (Hughes and Jones, 1980). Nahashon *et al.* (2005) reported carcass yields of about 70% at 8 weeks of age.

Table 2.2: Nutrient composition of guinea fowl diets

Nutrient	Starter	Grower		Breeder
		1	2	
Crude protein (%)	24 – 25	20	15	18
Metabolizable energy (MJ/kg)	12.13	12.13	11.30	12.13
Calcium (%)	1.2	1.00	0.80	3.0
Available phosphorus (%)	0.50	0.50	0.40	0.40
Sodium (%)	0.18	0.48	0.18	0.18
Arginine (%)	1.5	1.20	0.80	0.91
Lysine (%)	1.30	1.20	0.82	0.83
Methionine (%)	0.52	0.45	0.34	0.55
Methionine + cystine (%)	0.91	0.80	0.61	0.74
Tryptophan (%)	0.22	0.22	0.15	0.17
Histidine (%)	0.54	0.45	0.35	0.41
Leucine (%)	1.50	1.40	1.10	0.80
Isoleucine (%)	1.00	1.70	1.30	0.73
Phenyalanine (%)	1.00	0.93	0.74	0.74
Phenyalanine (%) + tyrosine (%)	1.50	1.4	1.1	1.00
Threonine (%)	0.93	0.81	0.62	0.71
Valine (%)	1.10	1.00	0.75	0.72
Vitamins (per kg of diet)				
Vitamin A (IU)	5000	4000	4000	5000
Vitamin D3 (IU)	2500	2000	2000	2500
Choline equivalents (mg)	1000	750	750	1000
Riboflavin (mg)	4.0	3.0	3.0	4.0
Pantothenic acid (mg)	12	9.0	9.0	12
Vitamin B12 (mg)	0.012	0.01	0.01	0.012
Folic acid (mg)	1.0	0.08	0.08	1.0
Biotin (mg)	0.25	0.20	0.20	0.25
Niacin (mg)	60	40	40	60
Vitamin K (mg)	2.0	1.5	1.5	2.0
Vitamin E (IU)	25	15	15	25
Thiamin (mg)	2.5	2.0	2.0	2.5
Pyridoxine (mg)	5.0	4.0	4.0	5.0
Trace minerals (per kg of diet)				
Manganese (mg)	70	55	55	70
Iron (mg)	80	70	70	80
Copper (mg)	10	8.0	8.0	10
Zinc (mg)	80	60	60	80
Selenium (mg)	0.30	0.2	0.2	0.3
Iodine (mg)	0.40	0.4	0.4	0.4

Source: Ensminger *et al.* (1990); Leeson and Summers (1997) cited in BOS 234:2006

Table 2.3: Nutrient composition of commercial broiler chicken diet

Category	Growing 0-6 weeks	Growing 6-14 weeks	Growing 14-20 weeks
ME (MJ/kg) diet	12.14	12.14	12.14
Protein (%)	18.0	15.0	12.0
Arginine (%)	1.00	0.83	0.67
Glycine and serine (%)	0.70	0.58	0.47
Histidine (%)	0.26	0.22	0.17
Isoleucine (%)	0.60	0.50	0.40
Leucine (%)	1.00	0.83	0.67
Lysine (%)	0.85	0.60	0.45
Methionine + cystine (%)	0.60	0.50	0.40
Methionine (%)	0.30	0.25	0.20
Phenylalanine + tyrosine (%)	1.00	0.83	0.67
Phenylalanine (%)	0.54	0.45	0.36
Threonine (%)	0.68	0.57	0.37
Tryptophan (%)	0.17	0.14	0.11
Valine (%)	0.62	0.52	0.41
Linoleic acid (%)	1.00	1.00	1.00
Calcium (%)	0.80	0.70	0.60
Phosphorus, available (%)	0.40	0.35	0.30
Potassium (%)	0.40	0.30	0.25
Sodium (%)	0.15	0.15	0.15
Chlorine (%)	0.15	0.12	0.12
Magnesium (mg)	600	500	400
Manganese (mg)	60	30	30
Zinc (mg)	40	35	35
Iron (mg)	80	60	60
Copper (mg)	8.0	6.0	6.0
Iodine (mg)	0.35	0.35	0.35
Selenium (mg)	0.15	0.10	0.10
Vitamin A (IU)	1,500	1,500	1,500
Vitamin D (ICU)	200	200	200
Vitamin E (IU)	10	5.0	5.0
Vitamin K (mg)	0.50	0.50	0.50
Riboflavin (mg)	3.60	1.80	1.80
Pantothenic acid (mg)	10.0	10.0	10.0
Niacin (mg)	27.0	11.0	11.0
Vitamin B12 (mg)	0.009	0.003	0.003
Choline (mg)	1,300	900	500
Biotin (mg)	0.15	0.10	0.10
Folacin (mg)	0.55	0.25	0.25
Thiamin (mg)	1.8	1.3	1.3
Pyridoxine (mg)	3.0	3.0	3.0

(National Research Council, 1994)

2.6 Carcass Characteristics

The optimum age of slaughtering guinea fowl is at 16 weeks of age because of the subsequent decline in feed conversion ratio (Ayorinde *et al.* 1989; Knox, 2000; Robinson, 2000; Embury, 2001). At this age, live weight of unimproved indigenous guinea fowl is approximately 1.0 kg (Ayorinde *et* *al.* 1989; Mundra *et al.* 1993) and that of improved strains is approximately 2.0 kg (Knox, 2000; Embury, 2001). According to Say (1987), guinea fowl meat contains 23% protein and 4% fat. In Botswana, Mareko *et al.* (2008) estimated that guinea fowl meat protein content averages well above the typical mammalian muscle at 19%. Guinea fowl meat has low fat content (4%) compared to chicken (11%) and other major meat types such as beef (21%), lamb (25%) and pork (21%) (Say, 1987). These attributes make guinea fowl meat to appeal to the health conscious market. According to Ayorinde *et al.* (1989), the percentage yield of the carcass depends on variety and age of guinea fowl. This long time to reach slaughter weight is a challenge to guinea fowl production that is begging for research initiatives.

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CHAPTER 3

GROWTH PERFORMANCE OF GUINEA FOWL (*Numida meleagris*) FED DIETS CONTAINING THREE LOCAL GROWN CEREALS AS ENERGY SOURCES RAISED UNDER INTENSIVE SYSTEM

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Abstract: This study investigated growth performance and carcass characteristics of guinea fowl fed diets containing yellow maize, white sorghum and pearl millet as energy sources in comparison to commercial broiler diets (control). Birds were raised under intensive system from 3 to 16 weeks of age. A completely randomized design was used where 160 guinea fowl keets were randomly assigned to four dietary treatments. Each dietary treatment had 40 birds with four replicates of 10 birds each. Feed and water were provided *ad libitum*. The growth performance and parameters studied were feed intake (FI), feed conversion ratio (FCR), body weight (BW), body weight gain (BWG), body length, body circumference, wing stretch, shank length and neck length. Data were analyzed using General Linear Model Procedure in Statistical Analysis Software (version 9.0). The results showed that dietary treatment did not ($p>0.05$) influence morphological parameters of growth and performance of guinea fowl at the same age. From 3 to 16 weeks of age FI was significantly ($p<0.001$) lower for birds on control diet (13714.79±209.65 g) than maize (16085±209.65 g), millet (1609.63±209.65 g) and sorghum (15872±209.65 g) diets while maize, pearl millet and sorghum diets did not differ significantly. Similarly, FCR was significantly ($p<0.001$) lower for birds on control diet (11.33±0.37) than maize (13.91±0.37), pearl millet (14.90±0.37) and sorghum (13.72±0.37) diets while the later diets did not differ significantly from each other. Average weekly BWG was significantly ($p<0.05$) lower for birds on millet diet (82.98±2.18 g) than birds on control (93.14±2.18 g), maize (89.25±2.18 g) and sorghum (89.03±2.18 g) diets while the later treatments did not differ significantly from each other.

Generally, morphological parameters of growth significantly ($p<0.001$) increased with guinea fowl age. These results suggest that maize, sorghum or pearl millet diets can be used in guinea fowl diets without affecting growth performance of guinea fowl. Further studies on the acceptance of meat by consumers and cost-benefit analysis of the dietary treatments should be conducted to complete comparison of locally available cereal grains and commercial feeds.

Key words: cereal grains, growth parameters, guinea fowl, intensive system

3.1 Introduction

The production of guinea fowl as an alternative poultry enterprise is gaining ground throughout the world, especially in developing countries that have shown increasing demand for this particular meat (Mareko *et al.*, 2006; Nahashon *et al.*, 2006; Dahouda *et al.*, 2009; Yildirim, 2012). The gamey flavour of guinea fowl meat may be the factor influencing its preference and demand. Guinea fowl adapt to different environmental conditions and as such, they are ubiquitous (Kokosyński *et al.*, 2011). As a result of this increasing interest in guinea fowl farming and gradual domestication of the bird, feeding management and breeding strategies are required that will bring about improvement in its performance (Ogah, 2011). Moreover, turning guinea fowl production into a profitable enterprise requires understanding of their growth characteristics and patterns as these would allow design of optimum management practices and hence improved profitability (Nahashon *et al.*, 2006; Elhashmi *et al.*, 2012).

The success of the conventional poultry meat production has been strongly related to improvements in growth rates and carcass yield (Musa *et al.*, 2006). Indigenous guinea fowl varieties have lower body weights (Ayorinde *et al.*, 1989; Mundra *et al.*, 1993; Nwagu and Alawa, 1995) than improved strains. Furthermore, Ayorinde and Ayeni (1983) reported that a guinea fowl tends to grow slowly weighing less than 1 kg at 8 weeks of age compared to a broiler chicken which reaches 1.5 to 2 kg in 6-8 weeks. Nahashon *et al.* (2005) reported carcass yield in guinea fowl of 70% at 8 weeks of age. In addition, Hughes and Jones (1980) reported carcass yield (dressing percentage) of male and female guinea broilers at 12 weeks of age to be 76.8% and 76.9%, respectively. Slightly higher carcass yields of 75.5% and 75.8% were reported by Olawumi and Fagbuaro (2011) in males and females broiler chickens respectively, at 8 weeks of age. On the other hand, Raji *et al.*(2010) obtained carcass yields of 74.5% and 74.3% in males and females broiler chickens respectively, at 12 weeks of age.

Guinea fowl farming is in its infancy in Botswana (Moreki and Ditshupo 2012; Tebesi *et al.*, 2012); hence information on their nutrition is limited. According to Saina (2005) and Nahashon *et al.* (2006), the profitability of guinea fowl is hampered by poor nutrition due in part to lack of management and feeding guidelines. Therefore, the aim of this study was to evaluate growth performance of guinea fowl under intensive management system fed diets containing three cereal grains i.e., millet, sorghum and yellow maize as energy sources in comparison to commercial broiler diets (control). The specific objectives of this study were to determine on weekly basis:

1. Feed intake (FI) of guinea fowl fed diets containing three cereal grains as energy sources in comparison to commercial broiler diets;

2. Shank length, neck length, body length, body circumference and wing stretch length of guinea fowl fed diets containing three cereal grains as energy sources in comparison to commercial broiler diets; and
3. Body weight (BW), body weight gain (BWG) and feed conversion ratio (FCR) of guinea fowl fed three cereal grains as energy sources in comparison to commercial broiler diets.

3.2 Materials and Methods

3.2.1 Experimental site

The study was carried out at Botswana College of Agriculture (BCA) Guinea Fowl Rearing Unit, Sebele Content farm from February to June 2012. The BCA is 24° 33' S, 24° 54' E and is located at an altitude of 994 m above sea level with an average annual rainfall of 538 mm (Emongor, 2007). The average daily minimum and maximum temperatures in summer are about 18 ^{0}C and 32 ^{0}C , respectively whereas in winter about -5 ^{0}C and 21 ^{0}C, respectively.

3.2.2 Experimental design and management of keets

A completely randomized design was used where 160 keets were randomly allocated to four dietary treatments: control (commercial broiler diet), maize, millet and sorghum. Each dietary treatment had 40 birds with four replicates of 10 birds each.

A total of 160 keets were hatched at BCA hatchery unit and raised in a closed house which provided both warmth and adequate ventilation. At four weeks of age, the keets were transferred to 16 growing pens where they were randomly assigned to four dietary treatment groups. The four treatments comprised control diet and experimental diets consisting of yellow maize, white sorghum and millet as energy sources. Birds were housed in earth floor pens with perches. One drinker and a feeder were placed in each pen. Feed and water were provided *ad libitum* to all treatments.

3.2.3 Experimental diets

The nutrient compositions of the experimental diets are shown in Tables 3.1 to 3.3 while the nutrient composition for control diet is shown in Table 3.4. Diets for each feeding phase were isocaloric and isonitrogenous. Cereal grains were bought from Botswana Agricultural Marketing Board and commercial broiler diets and feed premixes from feed distributors and feed manufacturers. Experimental diets were mixed at the Department of Agricultural Research in Sebele and were formulated according to Botswana Standard for Guinea fowl (BOS 234:2006). As shown in Tables 3.1 to 3.3, starter diet containing 24% CP and 12.13 MJ/Kg ME and was fed from 0 to 6 weeks of age; a grower diet (20% CP and 12.13 MJ/Kg ME) from 7 to 12 weeks of age while a finisher diet (15% CP and 11.30 MJ/Kg ME) was fed from 13 to 16 weeks of age. In this study, 16 weeks was regarded as market age of guinea fowl because at this stage there is subsequent decline in feed conversion ratio (Ayorinde et al. 1989; Knox, 2000; Robinson, 2000; Embury, 2001).

Table 3.1: Composition of experimental diets containing yellow maize as the main energy source fed to guinea fowl from 0 to 16 weeks of age under intensive management system

Category	0-6 weeks	7-12 weeks	13-16 weeks
ME, MJ/Kg	12.13	12.13	11.30
Crude protein, %	24	20	15
Ingredient, %			
Yellow maize (10.6% CP)	46.27	61.00	77.33
Soybean meal (38% CP)	46.63	32.83	15.57
Fishmeal (60% CP)	3.0	3.0	3.0
Lucerne (16% CP)	2.0	2.0	2.0
Vitamin premix	1.5	1.5	1.5
DCP	0.35	0.35	0.35
Salt	0.25	0.25	0.25
Proximate analysis			
Dry matter, %	86.19	87.22	88.42
Moisture, %	13.81	12.78	11.58
Crude protein, %	24.76	20.48	15.17
Crude fibre, %	2.20	3.38	3.47
Crude fat, %	5.27	5.83	5.85
Ash, %	5.90	6.00	5.73
NFE, %	48.06	51.53	58.20
ME, MJ/Kg	11.98	11.91	11.07

CP = Crude protein; DCP = Dicalcium phosphate; ME = Metabolizable energy; NFE= Nitrogen Free Extract

Table 3.2: Composition of experimental diets containing white sorghum as the main energy source fed to guinea fowl from 0 to 16 weeks of age under intensive management system

Category	0-6 weeks	7-12 weeks	13-16 weeks
ME, MJ/Kg	12.13	12.13	11.30
Crude protein, %	24	20	15
Ingredient, %			
Sorghum (10.6% CP)	48.99	64.42	81.84
Soybean meal (38% CP)	43.91	28.48	11.06
Fishmeal (60% CP)	3.0	3.0	3.0
Lucerne (16% CP)	2.0	2.0	2.0
Vitamin premix	1.5	1.5	1.5
DCP	0.35	0.35	0.35
Salt	0.25	0.25	0.25
Proximate analysis			
Dry matter, %	88.30	88.43	88.14
Moisture, %	11.70	11.57	11.86
Crude protein, %	22.98	19.73	13.80
Crude fibre, %	2.18	3.45	3.83
Crude fat, %	7.39	7.83	7.90
Ash, %	5.44	5.30	5.42
NFE, %	50.31	52.12	57.19
ME, MJ/Kg	11.95	11.87	10.99

CP = Crude protein; DCP = Dicalcium phosphate; ME = Metabolizable energy; NFE = Nitrogen-Free Extract

Table 3.3: Composition of experimental diets containing pearl millet as the main energy source fed to guinea fowl from 0 to 16 weeks of age under intensive management system

Category	0-6 weeks	7-12 weeks	13-16 weeks
ME, MJ/Kg	12.13	12.13	11.30
Crude protein, %	24	20	15
Ingredient, %			
Millet (14.0% CP)	55.93	72.58	92.36
Soybean meal (38% CP)	36.97	20.32	0.54
Fishmeal (60% CP)	3.0	3.0	3.0
Lucerne (16% CP)	2.0	2.0	2.0
Vitamin premix	1.5	1.5	1.5
DCP	0.35	0.35	0.35
Salt	0.25	0.25	0.25
Proximate analysis			
Dry matter, %	88.51	88.33	88.03
Moisture, %	11.49	11.67	11.97
Crude protein, %	23.75	19.17	14.08
Crude fibre, %	2.47	2.96	3.83
Crude fat, %	7.63	7.65	7.21
Ash, %	6.34	7.06	6.41
NFE, %	48.32	51.49	56.50
ME, MJ/Kg	11.88	11.84	10.96

CP = Crude protein; DCP = Dicalcium phosphate; ME = Metabolizable energy; NFE = Nitrogen-Free Extract

Table 3.4: Nutrient composition of commercial broiler diets fed to guinea fowl from 0 to 16 weeks of age under intensive management system

Ingredients	Starter's mash	Grower's mash	Finisher's mash
Protein (%)	20	18	16
Moisture (%)	12	12	12
Fibre (%)	5.0	6.0	7.0
Calcium (%)	0.8	0.7	0.6
Fat (%)	2.5	2.5	2.5
Phosphorus (%)	0.6	0.6	0.5
Lysine (%)	1.2	1.0	0.9
ME, MJ/Kg	12.0	12.2	12.6

ME = Metabolizable energy

3.2.4 Data collection

Data collection started at three weeks of age. Feed intake was determined as the difference between the amount of feed offered and refusals (Tufarelli *et al.*, 2011) in each replicate. Pen body weights were recorded on weekly basis. Body weight and FI were measured in the morning before watering and feeding. Body weight gain was determined as the difference between BW of the present week from that of the previous week over seven days (Oke *et al.*, 2012). Morphological parameters of growth such as body length, body circumference, shank length, neck length and wing stretch length were measured weekly (Nsoso *et al.*, 2006, 2008) using a measuring tape. On average, 14 birds *per* treatment were randomly selected, measured and weighed from 3 to 16 weeks of age. The FCR was calculated by dividing the average weekly FI with the average weekly BWG for each replicate (Santiago and Rodriguez, 2005; Tufarelli *et al.*, 2011).

3.2.5 Statistical analyses

Data on FI, average weekly BWG and FCR were analyzed using the Procedure General Linear Model (GLM) of SAS (version 9.0, 2002 - 2008) (SAS Institute, 2002) to determine the effect of dietary treatments on growth parameters of guinea fowl. To evaluate treatment and time interactions time-series data were subjected to restricted maximum likelihood (REML) to estimate repeated measures by the use of statement within Proc Mixed procedure of SAS (2002-2008) to estimate variances and covariance (Holland, 2006). The results reported are least square means separated using Least Significant Difference (LSD). The following statistical model was used:

$$Y_{ijk} = \mu + T_i + \beta_{ji} + E_{ijk}$$

where Y_{ijk} = Observed variables (FI, FCR, BWG, BW, body length, body circumference, wing stretch, shank length, neck length).

μ = Overall mean

$_i$ = Treatment effects (Diets: control, maize, millet, sorghum)

β_{ji} = Replicate effects

E_{ijk} = Error which is randomly distributed

3.3 Results and Discussion

3.3.1 Feed intake and feed conversion ratio

Guinea fowl on control diet had significantly ($p<0.05$) lower FI than other dietary treatments while maize, millet and sorghum were all similar to each other (Table 3.5). This result of control diet is inconsistent with Nahashon *et al.* (2005) and Seabo *et al.* (2011) who fed commercial diets and reported increased FI in guinea fowl fed. In this study, the control CP levels for starter, grower and finisher diets were 20%, 18% and 16%, respectively. On the other hand, the CP levels for experimental diets (maize, millet and sorghum) were 24%, 20% and 15% for starter, grower and finisher diets, respectively. The discrepancies between the control and the experimental diets may be due to the amount of CP supplied and also to the quality of protein and amino acids profile.

Feed conversion ratio was significantly lower for guinea fowl on control diet compared to other dietary treatments which did not differ from each other, (Table 3.5) indicating superiority of control. The values recorded in this study were lower than those obtained by Nahashon *et al.* (2011) which were 20.63 and 18.13 at 16 weeks of age in guinea fowl reared at 15.6 birds/m^2 and 18 birds/m^2, respectively. In the current study, the stocking density of 10 birds/m^2 was used. This present results should be read with caution since birds were observed scooping diets outside feeders. According to Ikani and Dafwang (2004), guinea fowl have high FCR because of their tendency to waste feed by scooping and picking of the feed, which was also observed in this study. This call for an alternative method for measuring efficiency of feed utilization in guinea fowl.

Table 3.5: Cumulative Feed intake, Feed conversion and Body weight gain per guinea fowl fed commercial broiler diets and experimental diets in 13 weeks under intensive management system

Weeks	Treatments				CV	Significance Level
		Experimental Diets				
	Control	Maize	Millet	Sorghum		
FI (g)	13714.09±209.65^{a}	16085±209.65^{b}	16019.63±209.65^{b}	15872.52±209.65^{b}	2.72	***
FCR	11.33±0.37^{a}	13.91±0.37^{b}	14.90±0.37^{b}	13.72±0.37^{b}	5.50	***
BWG (g)	93.14±2.18^{b}	89.25±2.18^{ab}	82.98±2.18^{a}	89.03±2.18^{ab}	4.93	*

^{a,b} Row means with different superscripts are significantly different
FI = Feed Intake; FCR = Feed Conversion Ratio; BWG = Body Weight Gain; * = (p<0.05), *** = (p<0.001)

3.3.2 Body weight and body weight gain

Generally, dietary treatment had no influence on BW at the same stage of growth (Table 3.6) except on weeks 13, 15 and 16 (p<0.01) when millet fed birds weighed lower. No explanation could be advanced for differences observed during these periods. This observation is consistent with previous findings by Nsoso *et al.* (2003, 2006) who fed guinea fowl keets commercial broiler diets and reported no significant difference in live weights at the same stage of growth and development.

At 12 weeks of age, BW of guinea fowl in the current study was 1049.49±14.22 g, 999.95±14.22 g, 1057.69±14.22 g and 1013.24±14.22 g for control, maize, millet and sorghum diets, respectively. Slightly higher BW values of 1210 g, 1370 g and 1470 g were reported by Seabo *et al.* (2011) during the same period. The difference in BW between the two studies could be due to variation in sources of protein used in the dietary treatments. For instance, the present study, used soybean meal as a protein source while sunflower cake was used in the study by Seabo *et al.* (2011). Araújo *et al.* (2011) indicated that despite its high fibre content (14%) and deficient lysine (0.5%) compared to soybean meal, sunflower cake is relatively rich in sulphur amino acids (methionine and cystine). Sulphur amino acids play an important role in poultry nutrition because they are essential for optimum muscle accretion (Vieira *et al.*, 2004). The present study recorded BW of 1408.98±28.62 g at 16 weeks of age for birds on control diet, the period during which Nsoso *et al.* (2003) in Botswana recorded 1400 g BW of the progeny of wild and domesticated indigenous guinea fowl. However, a lower BW of 1208±6.86 g was reported by Ogah (2011) in Nigeria in indigenous guinea fowl during the same period. Differences in the above studies may be due to differences in quality of diets and suggests a need for more research in guinea fowl nutrition.

Guinea fowl fed millet diet had significantly lower BWG compared to other dietary treatments, which did not differ significantly from each other (Table 3.5). The lower BWG in guinea fowl fed millet diet can be attributed to the presence of tannins in millet that hinders the utilization of feeds by monogastric animals, especially poultry. Tannins depress growth rate and feed utilization by forming complexes with proteins and carbohydrates or inhibiting digestive enzymes (Medugu *et al.*, 2012). Sorghum is also known for having tannins, however, in the present study the sorghum used was likely to have no tannins since it was of white colour (Imik, 2009).

Table 3.6: Means and standard errors of guinea fowl body weights (g) fed commercial broiler diets and experimental diets from 3 to 16 weeks of age under intensive management system

Weeks	Treatments				CV	Effects Trt x Time
		Experimental Diets				
	Control	Maize	Millet	Sorghum		
3	198.13±2.03	198.13±2.03	198.75±2.03	196.25±2.03	2.58	NS
4	211.27±6.37	207.51±6.37	217.43±6.37	224.43±6.37	13.53	NS
5	310.81±7.70	308.17±7.70	322.51±7.70	317.03±7.70	13.14	NS
6	434.28±9.21	396.97±9.21	425.89±9.21	441.40±9.21	10.72	NS
7	530.57±15.42	490.02±15.42	491.81±15.42	496.06±15.42	11.30	NS
8	665.21±15.52	629.73±15.52	624.93±15.52	634.90±15.52	10.83	NS
9	785.81±17.78	737.87±17.78	757.19±17.78	763.05±17.78	9.32	NS
10	894.70±16.99	856.21±16.99	844.16±16.99	899.11±16.99	8.57	NS
11	1028.41±14.2	979.68±14.27	1019.36±14.2	1004.84±14.2	6.93	NS
12	1049.49±14.2	999.95±14.22	1057.69±14.2	1013.24±14.2	7.45	NS
13	1217.35±22.8^{b}	1137.93±22.8^{ab}	1074.91±22.8^{a}	1140.30±22.8^{ab}	8.36	**
14	1274.49±30.9	1219.93±30.9	1180.91±30.9	1227.30±30.9	7.37	NS
15	1353.26±30.04^{b}	1299.00±30.04^{ab}	1241.82±30.04^{a}	1288.16±30.04^{ab}	6.95	**
16	1408.98±28.62^{b}	1358.43±28.62^{ab}	1277.43±28.62^{a}	1353.65±28.62^{ab}	7.44	**

^{a,b,c} Row means with different superscripts are significantly different; NS = Non Significant;
** = (p<0.01), NS = p>0.05, Trt = Treatment

3.3.3 Body length

Generally, there was no significant difference in body length of guinea fowl at the same age (Table 3.7) except during week 10 (p<0.01) when birds on millet diet were shorter and week 12 (p<0.001) when birds on maize and sorghum were shorter. During week 13 (p<0.01) birds on millet were shorter and on week 16 (p<0.001) sorghum fed birds were shorter. These differences are likely to be just after fact since no justifiable explanation can be advanced. From 5 to 12 weeks of age body length increased by 17.98 cm, 14.58 cm, 17.26 cm and 14.31 cm for control, maize, millet and sorghum diets, respectively. Nsoso *et al.* (2006) reported body length increase of 22.79 cm for guinea fowl raised on concrete floor during the same period. The present study also raised birds on concrete floor finish therefore this could not be a factor that resulted in differences in the two studies. The differences in results between the two studies could therefore be attributable to differences in dietary treatments. The present study fed control (commercial broiler diets) and formulated guinea fowl diets containing maize, millet and sorghum as energy sources, whereas commercial broiler starter and grower diets were fed by Nsoso *et al.* (2006).

In this study, body length was 28.03 cm, 26.75 cm, 26.24 cm and 26.12 cm for control, maize, millet and sorghum diets, respectively from 3 to 16 weeks of age. These values are higher than 22.17±0.13 cm body length value obtained by Ogah (2011) during the same period. Guinea fowl breeds and environmental factors might have contributed to variations in the results in these studies. The present study used the pearl and lavender strains while Ogah *et al.* (2011) used indigenous guinea fowl.

Table 3.7: Means and standard errors of growth of guinea fowl body lengths (cm) fed commercial broiler diets and experimental diets from 3 to 16 weeks of age under intensive management system

Weeks	Treatments				CV	Effects
		Experimental Diets				Trt x Time
	Control	Maize	Millet	Sorghum		
3	15.40±0.39	15.10±0.39	14.89±0.39	15.66±0.39	9.06	NS
4	19.38±0.30	19.07±0.30	19.27±0.30	19.81±0.30	9.08	NS
5	23.61±0.55	22.89±0.55	23.81±0.55	24.01±0.55	6.36	NS
6	27.96±0.43	26.44±0.43	27.43±0.43	27.83±0.43	5.64	NS
7	30.68±0.59	29.13±0.59	29.28±0.59	29.21±0.59	5.51	NS
8	33.59±0.70	31.93±0.70	31.88±0.70	32.71±0.70	6.63	NS
9	36.16±0.45	35.01±0.45	34.64±0.45	34.66±0.45	5.12	NS
10	35.89±0.56[ab]	36.67±0.56[b]	34.39±0.56[a]	35.51±0.56[ab]	4.68	**
11	39.90±0.78	38.83±0.78	38.86±0.78	38.57±0.78	4.68	NS
12	41.59±0.63[b]	37.47±0.63[a]	41.07±0.63[b]	38.32±0.63[a]	5.86	***
13	39.97±0.66[b]	39.36±0.66[ab]	37.28±0.66[a]	38.91±0.66[ab]	5.89	**
14	42.23±0.47	41.71±0.47	40.88±0.47	41.52±0.47	4.48	NS
15	43.14±0.70	41.85±0.70	40.78±0.70	41.30±0.70	5.47	NS
16	43.43±1.66[b]	41.71±1.66[ab]	41.13±1.66[ab]	39.78±1.66[a]	9.76	***

[a,b] Row means with different superscripts are significantly different, NS = Non Significant
** = ($p<0.01$), *** = ($p<0.001$), NS = $p>0.05$, Trt = Treatment

3.3.4 Body circumference

Dietary treatment had no significant influence on body circumference of guinea fowl at the same stage of growth. Generally, body circumference significantly ($p<0.001$) increased with age of guinea fowl in all dietary treatments (Table 3.8). Kasperska *et al.* (2011) contended that the increase in body circumference may be indicative of the normal growth and good development of internal organs. In the present study, body circumference was 37.36±0.52 cm, 36.80±0.52, 36.35±0.52 and 37.28±0.52 cm for control, maize, millet and sorghum diets, respectively at 13 weeks of age. This finding is inconsistent with Kasperska *et al.* (2011) who reported lower body circumference of 27.2 cm and 26.2 cm for male and female guinea fowl, respectively at 13 weeks of age. The variation in results for the two studies might be due to differences in breeds, environmental conditions and dietary treatments. The present study used the pearl and lavender strains while Kasperska *et al.* (2011) used grey pearl. In addition, the study was conducted in Sebele, Botswana which according to Emongor, (2007) has an average annual rainfall of 538 mm and mean daily temperature of 30 °C. Bydgoszcz in Poland has an average annual rainfall of 500 – 550 mm and average annual temperature of 7.5 to 8.0 °C (Slowinska *et al.*, 2010).

Table 3.8: Means and standard errors of guinea fowl body circumferences (cm) fed commercial broiler diets and experimental diets from 3 to 16 weeks of age under intensive management system

Weeks	Treatments				CV	Effects
		Experimental Diets				Trt x time
	Control	Maize	Millet	Sorghum		
3	15.93±0.38	15.61±0.38	16.57±0.38	16.57±0.38	6.99	NS
4	20.11±0.33	19.79±0.33	19.69±0.33	20.27±0.33	5.38	NS
5	23.22±0.39	22.71±0.39	23.14±0.39	23.04±0.39	5.38	NS
6	26.49±0.41	25.20±0.41	25.98±0.41	26.33±0.41	4.68	NS
7	28.06±0.43	27.45±0.43	27.09±0.43	27.16±0.43	4.38	NS
8	31.19±0.47	30.46±0.47	30.28±0.47	29.91±0.47	4.47	NS
9	32.49±0.66	31.03±0.66	30.76±0.66	32.51±0.66	7.55	NS
10	33.86±0.37	33.64±0.37	33.55±0.37	33.48±0.37	4.60	NS
11	35.32±0.54	33.68±0.54	34.08±0.54	33.35±0.54	6.81	NS
12	36.12±0.34	35.78±0.34	35.18±0.34	35.40±0.34	4.52	NS
13	37.36±0.52	36.80±0.52	36.35±0.52	37.28±0.52	4.21	NS
14	38.36±0.53	38.07±0.53	37.52±0.53	38.72±0.53	5.01	NS
15	38.71±0.75	38.43±0.75	38.78±0.75	38.09±0.75	4.92	NS
16	37.13±0.87	37.08±0.87	36.38±0.87	35.83±0.87	6.57	NS

NS = Non Significant, NS = p>0.05, Trt = Treatment

3.3.5 Wing stretch

Generally, wing stretch of guinea fowl was not significantly affected by dietary treatment at the same age of growth (Table 3.9) except during week 4 ($p<0.001$) when birds fed control and maize diets had shorter wing stretch and during weeks 7 and 15 ($p<0.01$) when millet fed birds had shorter wing stretch._Similarly, during week 16 ($p<0.001$) sorghum fed birds had shorter wing stretch. There is no scientific explanation for this difference in wing stretch. In this study, wing stretch values obtained from 5 to 12 weeks were 19.73±0.36 to 27.95±0.74 cm; 20.76±0.36 to 28.09±0.74 cm; 20.44±0.36 to 28.32±0.74 cm; 19.88±0.36 to 29.49±0.74 cm for control, maize, millet and sorghum diets, respectively. These values are lower than 26.39±0.20 to 49.00±0.41 cm and 27.47±0.35 to 47.85±0.41 cm reported by Nsoso *et al.* (2006) during the same period. In the present study, wing stretch values of 26.68±0.53 cm, 27.05±0.53 cm, 24.93±0.53 cm and 25.97±0.53 cm for control, maize, millet and sorghum diets, respectively were recorded at 16 weeks of age. In Nigeria, Fajemilehin (2010) reported wing stretch values of 19.26±0.23 cm, 19.50±0.21 cm and 19.53±0.24 cm, respectively on the Pearl, Ash and Black guinea fowl types at 16 weeks of age. Similarly to Fajemilehin (2010), Ogah (2011) reported the wing stretch value of 19.38±0.08 cm during the same period. According to Nsoso *et al.* (2006), wings are late maturing traits and are a physiological advantage to guinea fowl as they are flighty and revert easily to feral conditions.

Table 3.9: Means and standard errors of guinea fowl wing stretches (cm) fed commercial broiler diets and experimental diets from 3 to 16 weeks of age under intensive management system

Weeks		Treatments			CV	Effects
		Experimental Diets				Trt x time
	Control	Maize	Millet	Sorghum		
3	14.36±0.40	14.87±0.40	15.67±0.40	15.22±0.40	7.91	NS
4	17.06±0.26^{a}	17.86±0.26^{ab}	19.29±0.26^{c}	18.16±0.26^{b}	6.28	***
5	19.73±0.36	20.76±0.36	20.44±0.36	19.88±0.36	3.91	NS
6	21.83±0.39	21.35±0.39	21.92±0.39	22.08±0.39	5.49	NS
7	22.98±0.32^{ab}	23.56±0.32^{b}	21.91±0.32^{a}	22.28±0.32^{a}	5.06	**
8	25.80±0.51	26.48±0.51	25.73±0.51	25.90±0.51	6.19	NS
9	23.89±0.35	24.83±0.35	24.27±0.35	24.04±0.35	4.51	NS
10	28.70±0.61	29.18±0.61	27.91±0.61	27.86±0.61	7.35	NS
11	24.83±0.69	25.23±0.69	25.01±0.69	24.61±0.69	5.90	NS
12	27.95±0.74	28.09±0.74	28.32±0.74	29.49±0.74	6.14	NS
13	28.66±0.44	29.60±0.44	28.64±0.44	29.28±0.44	3.90	NS
14	28.43±0.49	29.47±0.49	28.54±0.49	28.38±0.49	4.51	NS
15	29.77±0.74^{ab}	30.13±0.74^{b}	28.28±0.74^{a}	29.88±0.74^{ab}	6.63	**
16	26.68±0.53^{b}	27.05±0.53^{b}	24.93±0.53^{a}	25.97±0.53^{ab}	5.78	***

^{a,b,c} Row means with different superscripts are significantly different; NS = Non Significant

** = (p<0.01), *** = (p<0.001), NS = p>0.05, Trt = Treatment

3.3.6 Shank length

Generally, shank length of guinea fowl was not affected by dietary treatment (Table 3.10) at the same age of growth except during week 12 (p<0.001) when sorghum fed birds had longer shanks. According to Nsoso *et al.* (2006) and Fajemilehin (2010), shank length constitutes the length of the leg and is an early maturing trait that is needed to support the whole body frame. From 5 to 12 weeks of age, shank length increased (p<0.001) significantly by 5.35 cm, 5.27 cm, 5.34 cm and 7.31 cm for control, maize, millet and sorghum, respectively. Nsoso *et al.* (2006) reported guinea fowl shank length increases of 8.91 cm and 8.38 cm during the same period. The difference in results could be due to variation in stocking densities for the two studies. In the present study guinea fowl were reared at 10 birds/m^2, whereas in the study by Nsoso *et al* (2006) they were reared at 4 birds/m^2. According to Estevez (2007), high stocking density in poultry results in reduced BW, FI and FCR and this affects growth due to crowding and stress. High stocking density also leads to poor air quality at bird level due to inadequate air exchange and increased ammonia (Feddes *et al.*, 2002). Furthermore, high stocking density results in reduced access to feed and water, thus contributing to poor growth rate.

In the present study, at 13 weeks of age guinea shank length was 13.76±0.14 cm, 13.26±0.14 cm, 13.28±0.14 cm and 13.13±0.14 cm for control, maize, millet and sorghum, respectively almost double the figure observed by Kasperska *et al* (2011). Lower shank length of 6.4 cm was obtained by Kasperska *et al.* (2011) in guinea fowl fed commercial turkey diet at 13 weeks of age. The shank length at 16 weeks of age in the present study was 14.60±0.19 cm, 14.35±0.19 cm, 13.51±0.19 cm and 14.44±0.19 cm for control, maize, millet and sorghum diets, respectively. Fajemilehin (2010) in Nigeria found lower shank length values in three varieties of helmeted guinea fowl (Pearl: 7.14±0.07 cm; Ash: 7.04±0.05 cm and Black: 7.01±0.10 cm) at 16 weeks of age. The differences in shank length might be due to environmental and breed factors in the above studies. The current study commenced during the wet season in February while that of Fajemilehin (2010) started during the dry season in September. Obidi *et al.* (2008) stated that seasonal factors exert significant influence on domestic birds. The authors (Obidi *et al.*, 2008) pointed out that direct climatic factors acting on the birds include high ambient temperature and relative humidity resulting in severe heat stress. These factors will affect bird's performance by reducing BW, FI and FCR. Furthermore, mineral metabolism and deposition in bones are affected by heat stress in poultry (Abioja *et al.*, 2012).

Table 3.10: Means and standard errors of guinea fowl shank lengths (cm) fed commercial broiler diets and experimental diets from 3 to 16 weeks of age under intensive management system

Weeks	Treatments				CV	Effects Trt x time
		Experimental Diets				
	Control	Maize	Millet	Sorghum		
3	5.88±0.11	6.06±0.11	5.64±0.11	6.10±0.11	7.07	NS
4	6.89±0.11	7.04±0.11	7.13±0.11	6.99±0.11	8.24	NS
5	8.13±0.18	8.26±0.18	8.44±0.18	8.28±0.18	7.16	NS
6	9.68±0.13	9.38±0.13	9.43±0.13	9.41±0.13	4.64	NS
7	10.59±0.20	10.01±0.20	10.08±0.20	10.06±0.20	5.28	NS
8	11.36±0.15	11.04±0.15	11.41±0.15	11.19±0.15	6.37	NS
9	12.26±0.13	12.18±0.13	12.18±0.13	12.18±0.13	3.80	NS
10	12.48±0.12	12.22±0.12	12.14±0.12	12.48±0.12	4.35	NS
11	13.31±0.14	13.01±0.14	13.16±0.14	13.16±0.14	3.75	NS
12	13.48±0.99^{a}	13.53±0.99^{a}	13.78±0.99^{a}	15.59±0.99^{b}	26.38	***
13	13.76±0.14	13.26±0.14	13.28±0.14	13.13±0.14	3.79	NS
14	13.83±0.13	13.39±0.13	13.30±0.13	13.80±0.13	4.24	NS
15	13.94±0.17	13.86±0.17	13.65±0.17	13.87±0.17	4.54	NS
16	14.60±0.19	14.35±0.19	13.51±0.19	14.44±0.19	5.44	NS

^{a,b}Row means with different superscripts are significantly different; NS = Non Significant.

*** = (p<0.001), NS = p>0.05, Trt = Treatment

3.3.7 Neck length

Neck length of guinea fowl was not significantly affected by dietary treatment (Table 3.11) at the same stage of growth except in weeks 4 and 5 when birds on maize and control respectively had shorter neck lengths. From 5 to 12 weeks of age neck length increased by 4.12 cm, 3.76 cm, 3.82 cm and 3.52 cm for control, maize, millet and sorghum diets, respectively. These values are lower than 6.45 cm reported by Nsoso *et al.* (2006) during the same period. The authors (Nsoso *et al.*, 2006) stated that neck length is an early maturing trait that enables birds to have good view of their surroundings in order to detect danger or see predators in advance. Probably the growth of the neck in the present study which was generally inferior to that of Nsoso *et al.* (2006) is consistent with the overall growth of birds.

Table 3.11: Means and standard errors of guinea fowl neck lengths (cm) fed commercial broiler diets and experimental diet from 3 to 16 weeks of age under intensive management system

Weeks	Treatments				CV	Effects
		Experimental Diets				Trt x time
	Control	Maize	Millet	Sorghum		
3	4.15±0.25	4.40±0.25	4.38±0.25	4.11±0.25	12.63	NS
4	5.13±0.13^{ab}	4.83±0.13^{a}	5.09±0.13^{ab}	5.35±0.13^{b}	5.10	**
5	5.83±0.23^{a}	6.12±0.23^{ab}	6.19±0.23^{ab}	6.45±0.23^{b}	8.78	**
6	6.45±0.15	6.43±0.15	6.55±0.15	6.49±0.15	5.38	NS
7	7.13±0.15	6.90±0.15	6.88±0.15	6.91±0.15	6.29	NS
8	7.88±0.07	7.73±0.07	7.90±0.07	8.13±0.07	4.80	NS
9	8.51±0.05	8.56±0.0	8.44±0.05	8.51±0.05	2.43	NS
10	8.51±0.18	8.86±0.18	9.21±0.18	9.06±0.18	4.46	NS
11	9.67±0.07	9.46±0.07	9.67±0.07	9.51±0.07	2.97	NS
12	9.95±0.07	9.88±0.07	10.01±0.07	9.97±0.07	2.10	NS
13	11.53±0.28	11.16±0.28	11.43±0.28	11.22±0.28	5.12	NS
14	11.65±0.25	11.42±0.25	11.66±0.25	11.63±0.25	4.20	NS
15	12.73±0.15	12.53±0.15	12.69±0.15	12.70±0.15	4.29	NS
16	12.39±0.10	12.52±0.10	12.31±0.10	12.26±0.10	2.44	NS

^{a,b} Row means with different superscripts are significantly different; NS = Non Significant
** = (p<0.01), , NS = p>0.05, Trt = Treatment

3.4 Conclusion

Generally, dietary treatment did not have significant effect on morphological parameters of growth in guinea fowl during the same stage of growth and development. These results suggest that maize, sorghum or millet diets can be used in guinea fowl diets without affecting growth performance.

Further research on meat characteristics and acceptance by consumers should be carried out. Due to similarity between dietary treatments a cost-benefit analysis should be conducted to complete comparison of locally available cereal grains and commercial feeds.

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CHAPTER 4

CARCASS CHARACTERISTICS OF GUINEA FOWL *(Numida meleagris)* FED DIETS CONTAINING THREE LOCAL GROWN CEREALS AS ENERGY SOURCES RAISED UNDER INTENSIVE SYSTEM

Abstract: This study investigated carcass characteristics of guinea fowl fed diets containing_yellow maize, white sorghum and pearl millet as energy sources in comparison to commercial broiler diets (control). Parameters for carcass characteristics studied were dressed carcass weight, carcass yield, gizzard weight, heart weight, liver weight, drumstick weight, thigh weight, back weight, breast weight and wing weight. On average, 3 birds from each replicate (12 birds from each dietary treatment) were randomly selected and sacrificed in the abattoir at 6, 12 and 16 weeks of age for carcass evaluation. From 6 to 16 weeks of age guinea fowl on control diets had significantly ($p<0.001$) higher carcass dressed weight (707.08±10.94 g) than maize (686.50±10.94 g); millet (633.63±10.94 g) and sorghum (690.30±10.94 g). Maize and sorghum diets did not differ significantly from each other. Dietary treatment had no significant ($p>0.05$) influence on guinea fowl carcass yield. Empty gizzard, heart, liver, drumstick, thigh, back and breast were significantly ($p<0.001$) influenced by dietary treatments.

Generally, carcass characteristics significantly ($p<0.05$) increased with guinea fowl age. These results suggest that yellow maize, white sorghum or pearl millet diets can be used in guinea fowl diets without affecting carcass characteristics of guinea fowl. Further studies on the acceptance of meat by consumers and cost-benefit analysis of the dietary treatments should be conducted to complete comparison of locally available cereal grains and commercial feeds.

Key words: Carcass characteristics, cereal grains, guinea fowl

4.1 Introduction

Guinea fowl can be kept for both meat and egg production (Mohamed *et al.*, 2012). Unlike chicken eggs, consumption of guinea fowl eggs is not popular, thus guinea fowl are raised mainly for meat which is served in restaurants around the world, especially as substitutes for game birds (Nobo *et al.*, 2012). Guinea fowl have low input requirements, greater capacity to scavenge for feed and high quality meat (Mwale *et al.* 2008). Musa *et al.* (2006) noted that the success of conventional poultry meat production is strongly related to improvements in growth and carcass yield, mainly by increasing breast proportion and reducing abdominal fat. The authors (Musa *et al.*, 2006) further mentioned that the proportions of major carcass tissues (i.e. breast, liver, heart, leg and abdominal fat) and their distribution throughout the carcass is important to carcass value. Manipulation of these traits depends on the combination of genes and nutrition (Musa *et al.*, 2006). Therefore, guinea fowl production requires knowledge and understanding of their growth characteristics and patterns to allow for the design of optimum management practices (Elhashmi *et al.*, 2012).

The optimum age of slaughtering guinea fowl is 16 weeks because of the subsequent decline in FCR (Ayorinde *et al.* 1989; Embury, 2001). At this age, live weight of unimproved indigenous guinea fowl is approximately 1.0 kg (Ayorinde *et al.* 1989; Mundra *et al.* 1993) while that of improved strains is approximately 2.0 kg (Embury, 2001). Guinea fowl meat contains higher protein content of 23% than 22.3% for beef (Say 1987; de Moreno *et al.*, 2000). In Botswana, Moreki *et al.* (2012) obtained protein content in guinea fowl meat of 22.9% and 31.6% at 6 and 12 weeks of age, respectively. There is a lack of information on effects of nutrition on carcass characteristics of guinea fowl in Botswana. Therefore, the aim of this study was to evaluate the carcass characteristics of guinea fowl fed diets containing three cereal grains i.e., millet, white sorghum and yellow maize as energy sources in comparison to commercial broiler diets under intensive management system. The specific objective of the study was to compare the carcass characteristics for instance dressed weight, dressed percentage and drumstick weight, thigh weight, wing weight, breast weight and back weight of guinea fowl fed diets containing three cereal grains (yellow maize, pearl millet and sorghum) as energy sources in comparison to commercial broiler diets.

4.2 Materials and Methods

4.2.1 Experimental site

The study was carried out at BCA Guinea Fowl Rearing Unit, Sebele Content farm from March to June 2012. The trial took 10 weeks to complete. The BCA is 24° 33′ S, 24° 54′ E and is located at an altitude of 994 m above sea level with an average annual rainfall of 538 mm (Emongor, 2007). The average daily minimum and maximum temperatures in summer are about 18 ^{0}C and 32 ^{0}C, respectively whereas in winter about -5.^{0}C and 21 ^{0}C, respectively.

4.2.2 Experimental design

A completely randomized design was used where 40 keets were randomly allocated to four dietary treatments: control (commercial broiler diet), yellow maize, pearl millet and white sorghum. Each treatment had 40 keets with four replicates of 10 birds each. The birds and diets composition are similar to those used in chapter 3.

4.2.3 Processing procedures

At 6, 12 and 16 weeks of age, 3 birds from each replicate (12 birds from each dietary treatment) were randomly selected and sacrificed in the abattoir (BCA poultry abattoir) for carcass evaluation. Feed and water were withdrawn 12 hours prior to slaughter to prevent digesta and faeces from contaminating carcasses. Three birds *per* replicate were manually caught and weighed individually (final weight), put in crates and transported to slaughter facility where they were sacrificed. Birds were sacrificed by cervical dislocation (Moreki *et al.*, 2011), bled by section of the jugular veins (Ikani and Dafwang 2004) and scalded in hot water at 65 - 70 °C for 3 minutes (Adetola *et al.*, 2012). Thereafter, carcasses were placed in a plugging machine for de-feathering. After removal of the head, shanks and feet, the carcasses were manually eviscerated and re-weighed to obtain carcass weight. The final weight and carcass weight were used to determine the dressing percentage of the birds, expressed as carcass weight/final weight*100 (Mareko *et al.*, 2006). Carcass characteristics were determined through the physical dissection method described by Van Marle-Köster and Webb (2000). Physical dissection involved precise cutting of a carcass into commercially cut parts and weighing the parts to determine meat and bone yield. The parameters that were measured through dissection included carcass weight, drumstick weights, thigh weights, wing weights, breast weight and back weight. The heart, liver and empty gizzard were also weighed. Gizzards were emptied prior to weighing.

4.2.4 Statistical analyses

Data were analyzed using the Procedure General Linear Model (GLM) of SAS (version 9.0, 2002 - 2008) (SAS Institute, 2002) to determine the effect of dietary treatments on carcass characteristics. The results reported are least square means separated using Least Significant Difference (LSD). The following statistical model was used:

$$Y_{ijk} = \mu + T_i + \beta_{ji} + E_{ijk}$$

Where Y_{ijk} = Observed variables (carcass weight, gizzard weight, heart weight, liver weight, drumstick weight, thigh weight, back weight, breast weight and wing weight).

μ = Overall mean

T_i = Treatment effects (Diets: control, maize, millet, sorghum)

β_{ji} = Replicate effects

E_{ijk} = Error which is randomly distributed

4.3 Results and Discussion

4.3.1 Dressed weight and carcass yield

Carcass dressed weight of guinea fowl was not significantly affected by dietary treatment at the same age. However, carcass dressed weight increased significantly ($p<0.001$) overtime (Table 4.1). In agreement with the present study, Kokoszyński *et al.* (2011) obtained a steady increase of carcass dressed weight (866 to 947 and 890 to 973 g) from 13 to 16 weeks of age for male and female guinea fowl, respectively. At 12 weeks of age, carcass dressed weight values from the present study were higher than those reported by Laudadio *et al.* (2012). The authors (Laudadio *et al.*, 2012) reported carcass dressed weight values of 694 g and 696 g in guinea fowl fed wheat middling-soy diet and wheat middling-micronized-dehulled pea diet, respectively during the same period. On the contrary, Mareko *et al.* (2006) obtained a higher carcass dressed weight value of 1056±0.087 g at 12 weeks of age. The differences in carcass dressed weight values between the present study and that of Mareko *et al* (2006) study could be due to the types of diet fed per guinea fowl stage of growth. The present study fed commercial broiler diet (control) and formulated guinea fowl diets consisting of maize, sorghum and millet as starter diet from 3 to 6 weeks of age, grower diet from 7 to 12 weeks and finisher diet from 13 to 16 weeks while in the study by Mareko *et al.* (2006) guinea fowl were fed grower diet from 5 weeks to 14 weeks of age. Nobo *et al.* (2012) reported slightly lower carcass dressed weight values of 654 g and 655 g for female and male guinea fowl, respectively at 13 weeks of age. Guinea fowl in the study by Nobo *et al.* (2012) were fed varying levels of *Phane* meal (*Imbrasia belina*). According to Madibela *et al.* (2007), *Phane* meal is high in chitin making it highly unpalatable and poorly digestible leading to reduced feed intake.

Table 4.1: Means and standard errors of guinea fowl carcass dressed weight (g) fed commercial broiler diets and experimental diets at 6, 12 and 16 weeks of age under intensive management system

Weeks	Treatments				CV	Significance level
		Experimental Diets				
	Control	Maize	Millet	Sorghum		
6	304.09 ± 12.14^{ax}	283.56 ± 12.14^{ax}	304.80 ± 12.14^{ax}	287.88 ± 12.14^{ax}	6.61	NS
12	761.58 ± 13.44^{ay}	733.04 ± 13.44^{ay}	762.20 ± 13.44^{ay}	743.18 ± 13.44^{ay}	7.86	NS
16	1011.17 ± 23.34^{az}	970.06 ± 23.34^{az}	938.43 ± 23.34^{az}	978.18 ± 23.34^{az}	8.54	NS

^{a} Row means with same superscripts are not significantly different

^{x,y,z} Column means with different superscripts are significantly different

NS = Non Significant, NS = ($p>0.05$)

In the current study, dressed carcass weight at 16 weeks of age was consistent with Kokoszyński *et al.* (2011) who found dressed carcass weight of 947 and 973 g in male and female guinea fowl, respectively during the same period. The similarity between the two studies can be attributed to the same strain of guinea fowl (pearl) used in both studies. Also, the two studies used dietary treatments with chemical composition which are almost similar. In this study, starter diet contained 24% CP and 12.13 MJ/Kg ME; grower diet; 20% CP and 12.13 MJ/Kg ME and finisher diet; 15% CP and 11.30 MJ/Kg ME. In the study by Kokoszyński *et al.* (2011) starter diet contained 24.5% CP and 12.15 MJ/Kg ME; grower diet; 22.6% CP and 12.35 MJ/Kg ME and finisher diet; 20.7% CP and 12.55 MJ/Kg ME.

Dietary treatment had no influence on guinea fowl carcass yield at 6, 12 and 16 weeks of age (Table 4.2). Musa *et al.* (2006) stated that birds of similar body composition possess similar body carcasses and slaughter by-products composition. However, carcass yield significantly increased over time. Murawska *et al.*, (2011) reported an increase in the carcass yield of broilers as a result of an increase in the content of edible portions (lean meant and giblets) and a decrease in non-edible components (offal and bones) due to nutrition. Commercial mixed diets with high nutrient concentrations fed to poultry affect the function and weight of gastrointestinal tract segments (Obun, 2008). Havenstein *et al.* (1994) observed that the decrease in gastrointestinal tract is a natural consequence of adjusting to feeding conditions.

In the present study, guinea fowl carcass yield (dressing percentage) at 12 weeks of age was comparable to Fuentes *et al.* (1998) values of 75.13% and 75.74% for male and female guinea fowl, respectively. On the other hand, Seabo *et al.* (2011) obtained higher carcass yield values of 87.5%, 87.6% and 87.5% in guinea fowl on 14% CP, 16% CP and 18% CP diets, respectively at 12 weeks of age. The difference in carcass yield between the three studies could be due to variations in sources of protein for dietary treatments. In the present study and that of Fuentes *et al.* (1998), soybean meal was used as a protein source in dietary treatments, whereas Seabo *et al.* (2011) used sunflower cake as a protein source. Araújo *et al.* (2011) contended that despite its high fibre content (14%) and deficient lysine (0.5%) compared to soybean meal, sunflower cake is relatively rich in sulphur amino acids (methionine and cysteine). Sulphur amino acids are essential for optimum muscle accretion (Vieira *et al.*, 2004).

Marcko *et al.* (2006) reported a higher carcass yield of 94.17% at 12 weeks of age in guinea fowl raised on concrete floor. The variation in carcass yield values between the present study and that of

Mareko *et al.* (2006) could be due to difference in dietary treatments for guinea fowl stage of growth. The present study fed commercial broiler diet (control) and formulated guinea fowl diets consisting of maize, sorghum and millet as starter, grower and finisher diets while in the study by Mareko *et al.* (2006) guinea fowl were fed only broiler grower diet. No explanation could be advanced for the difference between the commercial diets in the present study and the broiler grower diet in Mareko *et al.* 2006 study. In agreement with the present study, Saina (2005) obtained carcass yield value of 71.6% in guinea fowl at 16 weeks of age. However, Kokoszyński *et al.* (2011) reported lower carcass yield values of 70.1% and 70.7% in male and female guinea fowl, respectively at 16 weeks of age. According to Mareko *et al.* (2006), carcass dressing percentage is influenced by the stage of maturity, degree of finish, breed and intestinal contents (offals).

Table 4.2: Means and standard errors of guinea fowl carcass yield (%) fed commercial broiler diets and experimental diets at 6, 12 and 16 weeks of age under intensive management system

Weeks	Treatments				CV	Significance level
		Experimental Diets				
	Control	Maize	Millet	Sorghum		
6	71.31±4.29	72.51±4.29	73.47±4.29	67.18±4.29	11.17	NS
12	73.09±2.14	73.81±2.14	72.15±2.14	73.54±2.14	10.11	NS
16	72.13±1.62	71.83±1.62	74.33±1.62	72.37±1.62	13.21	NS

NS = Non Significant, NS = (p>0.05)

4.3.2 Empty gizzard weight

Empty gizzard weight was not significantly affected by dietary treatment at the same age. However, empty gizzard weight increased significantly (p<0.001) with age for all the dietary treatments (Table 4.3). Obun *et al.* (2008) noted that the size of the gizzard is determined by the amount of work required by the muscular walls of the organ to grind feed particles. In the opinion of Hetland *et al.* (2005), the gizzard activity is more strongly stimulated by fibre structures. In this study, empty gizzard weight at 12 weeks of age was higher than the values reported by Seabo *et al.* (2011) of 26.53 g, 27.50 g and 26.48 g in guinea fowl fed diets containing three varying protein levels. The difference in empty gizzard weight in the present study and that of Seabo *et al.* (2011) could thus be due to variation in both composition and fibre contents of dietary treatments. Murawska *et al.* (2011) noted that in modern poultry the gizzard works less intensively due to considerable modifications in the composition and structure of the feed which gradually diminishes the size of the organ. The present study recorded lower gizzard weights at 16 weeks of age compared to 30 g reported by Nsoso *et al.* (2003). The difference in gizzard weight could be due to variations in dietary treatments used for the two studies. The present study fed commercial broiler diet (control) and formulated guinea fowl diets consisting of maize, sorghum and millet. The guinea fowl in the study by Nsoso *et al.* (2003) were fed a mixed diet of sorghum, maize and sunflower during the same period.

Table 4.3: Means and standard errors of guinea fowl empty gizzard weight (g) fed commercial broiler diets and experimental diets at 6, 12 and 16 weeks of age under intensive management system

Weeks	Treatments				CV	Significance level
		Experimental Diets				
	Control	Maize	Millet	Sorghum		
6	12.11±0.78^{ax}	13.21±0.78^{ax}	12.42±0.78^{ax}	12.94±0.78^{ax}	12.85	NS
12	20.20±1.43^{ay}	20.61±1.43^{ay}	21.23±1.43^{ay}	22.47±1.43^{ay}	14.16	NS
16	20.98±1.56^{ay}	25.22±1.56^{ay}	26.48±1.56^{ay}	26.23±1.56^{ay}	12.07	NS

^{a} Row means with same superscripts are not significantly different
^{x,y} Column means with different superscripts are significantly different
NS = Non Significant, NS = (p>0.05)

4.3.3 Heart weight

Dietary treatment had no significant influence on heart weight of guinea fowl at the same age. However, heart weight significantly increased with age (Table 4.4). Tarhyel *et al.* (2012) noted that the increase in heart weight could be attributed to the fact that as the birds advance in age, the body organs also develop to conform to the general body growth pattern. The present study recorded higher heart weight values at 12 weeks of age than those from a study by Seabo *et al.* (2011) who observed values of 3.89, 3.86 and 3.85 g obtained from guinea fowl fed varying protein levels. However, the present study recorded lower heart weight values at 16 weeks of age than Nsoso *et al.* (2003) who reported a heart weight value of 10 g. The difference in heart weight values between the two studies could be due to variation in dietary treatments resulting from the sources of protein used. The present study used soybean meal as protein source, whereas Nsoso *et al.* (2003) used sunflower cake. Sunflower is relatively rich in sulphur amino acids (Araújo *et al.*, 2011) which are essential for optimum muscle accretion (Vieira *et al.*, 2004).

Table 4.4: Means and standard errors of guinea fowl heart weight (g) fed commercial broiler diets and experimental diets at 6, 12 and 16 weeks of age under intensive management system

Weeks	Treatments				CV	Significance level
		Experimental Diets				
	Control	Maize	Millet	Sorghum		
6	2.78 ± 0.19^{ax}	2.85 ± 0.19^{ax}	2.74 ± 0.19^{ax}	3.12 ± 0.19^{ax}	13.98	NS
12	5.66 ± 0.26^{ay}	5.52 ± 0.26^{ay}	5.80 ± 0.26^{ay}	5.83 ± 0.26^{ay}	15.96	NS
16	7.20 ± 0.24^{az}	7.10 ± 0.24^{az}	7.49 ± 0.24^{az}	7.03 ± 0.34^{az}	14.85	NS

^{a} Row means with same superscripts are not significantly different
$^{x, y, z}$ Column means with different superscripts are significantly different
NS = Non Significant, NS = ($p>0.05$)

4.3.4 Liver weight

Generally, dietary treatment had no significant effect on the liver weight at the same age. However, liver weight significantly ($p<0.001$) increased over time (Table 4.5). Mutayoba *et al.* (2003) stated that increases in liver weight indicate that the feed stimulates the organ. The authors (Mutayoba *et al.*, 2003) argued that the increase may be related to the need of the liver to increase its efficiency for metabolism and detoxify anti-nutritional factors in the diet. Sorghum contains tannins which limit its usage (Faquinello *et al.*, 2004). Tannins bind to certain digestive enzymes attached to the membrane of the small intestine thereby depressing digestive function (Walker, 1999). Similarly, millet contains significant amounts of phytic acid which are recognized anti-nutritional factors affecting the bioavailability of major minerals such as calcium and phosphorus and trace minerals such as zinc, iron, copper and manganese (Eltayeb *et al.*, 2007).

This study recorded higher liver weight values at 12 weeks of age than those reported by Seabo *et al.* (2011) during the same period. The difference in liver weights between the two studies could be due to variation in energy and CP levels or anti-nutritional factors in the dietary treatments. In the present study the energy and CP levels were 12.14 MJ/Kg ME and 20%, 18% and 16% for control diet's starter, grower and finisher respectively, and 12.13 MJ/Kg ME and 24%, 20% and 15% for experimental guinea fowl diets. On the contrary, Seabo *et al.* (2011) used 11.72 MJ/Kg ME and 18%, 16% and 14% CP levels. Consistent with the current study, Hosseini-Vashan *et al* (2010) reported an increase in liver weight of broiler chickens with increased energy and CP levels.

In this study, liver weight values (12.97 – 14.87 g) recorded at 16 weeks of age were inconsistent with 20.0 g obtained by Nsoso *et al.* (2003) during the same period. The difference in liver weights could be attributed to variation in sources of protein and energy levels of the dietary treatments. This study used soybean meal which Kalbande *et al.* (2009) noted is deficient in methionine whereas

Nsoso *et al.* (2003) used sunflower. According to Sayda *et al.* (2011), sunflower is relatively rich in sulphur containing amino acids; methionine and cysteine. Carew *et al.* (2003) noted that reduction in liver weight is often an index of nutrient deficiencies especially protein.

Table 4.5: Means and standard errors of guinea fowl liver weight (g) fed commercial broiler diets and experimental diets at 6, 12 and 16 weeks of age under intensive management system

Weeks	Treatments				CV	Significance level
		Experimental Diets				
	Control	Maize	Millet	Sorghum		
6	6.89 ± 0.17^{ax}	7.57 ± 0.17^{bx}	6.72 ± 0.17^{ax}	7.67 ± 0.17^{bx}	14.79	**
12	12.13 ± 0.41^{ay}	12.19 ± 0.41^{ay}	12.08 ± 0.41^{ay}	12.56 ± 0.41^{ay}	14.07	NS
16	14.14 ± 0.52^{az}	14.78 ± 0.52^{az}	12.97 ± 0.52^{az}	14.40 ± 0.52^{az}	8.81	NS

^{a,b} Row means with different superscripts are significantly different
^{x,y,z} Column means with different superscripts are significantly different, NS = Non significant
** = ($p<0.01$), NS = ($p>0.05$)

4.3.5 Drumstick weight

Dietary treatment had no significant effect on guinea fowl drumstick weight at the same age. However, drumstick weight significantly ($p<0.001$) increased with age of guinea fowl for all dietary treatments (Table 4.6). In agreement with the current study, Saina (2005) obtained a drumstick weight of 105.6±11.1 g at 16 weeks of age. Nsoso *et al.* (2003) obtained drumstick weight of 100 g during the same period which was similar to those of millet fed birds but lower than control, maize and sorghum. The difference in drumstick weights in the current study and that of Nsoso *et al.* (2003) can be attributed to variation in treatments and guinea fowl strains used. The present study fed control (commercial broiler diets) and formulated guinea fowl diets containing maize, millet and sorghum as energy sources. On the other hand, guinea fowl in the study by Nsoso *et al.* (2003) were fed a mixed diet of sorghum, maize and sunflower. Furthermore, the present study used pearl and lavender strains while Nsoso *et al.* (2003) used the progenies of wild and domesticated indigenous guinea fowl (the pearl) strains. According to Saina (2005), indigenous guinea fowl strains have lower performance than improved strains.

Table 4.6: Means and standard errors of guinea fowl drumstick weight (g) fed commercial broiler diets and experimental diets at 6, 12 and 16 weeks of age under intensive management system

Weeks	Treatments				CV	Significance level
		Experimental diets				
	Control	Maize	Millet	Sorghum		
6	34.98 ± 0.84^{ax}	33.34 ± 0.84^{ax}	35.07 ± 0.84^{ax}	35.97 ± 0.84^{ax}	11.32	NS
12	90.29 ± 2.02^{ay}	88.35 ± 2.02^{ay}	91.24 ± 2.02^{ay}	85.11 ± 2.02^{ay}	10.99	NS
16	124.33 ± 2.91^{az}	112.25 ± 2.91^{az}	108.95 ± 2.91^{az}	119.75 ± 2.91^{az}	9.91	NS

[a] Row means with same superscripts are not significantly different
[x, y, z] Column means with different superscripts are significantly different
NS = Non-Significant, NS = ($p>0.05$)

4.3.6 Thigh weight

Dietary treatment did not significantly affect guinea fowl thigh weight at the same age. On the other hand, thigh weight significantly ($p<0.001$) increased with age of guinea fowl for all dietary treatments (Table 4.7). In agreement with present study, Nsoso *et al.* (2003) obtained a thigh weight value of 140 g at 16 weeks of age. On the contrary, Saina (2005) and Ogah (2011) reported much lower thigh weight values of 131.7±15.5 g and 72.39±0.64 g, respectively during the same period. The difference in thigh weights between the three studies could be due to variation in CP levels in dietary treatments as well as strains of guinea fowl used. The present study fed starter diets containing 24% CP; grower diets of 20% CP and finisher diets of 15% CP. Saina (2005) fed a broiler finisher diet which contained 18% CP while Ogah (2011) fed a diet containing 18% CP. The current study used pearl and lavender guinea fowl strains while Saina (2005) used indigenous guinea fowl.

Table 4.7: Means and standard errors of guinea fowl thigh weight (g) fed commercial broiler diets and experimental diets at 6, 12 and 16 weeks of age under intensive management system

Weeks	Treatments				CV	Significance level
		Experimental Diets				
	Control	Maize	Millet	Sorghum		
6	44.08 ± 2.02^{ax}	38.86 ± 2.02^{ax}	44.56 ± 2.02^{ax}	42.96 ± 2.02^{ax}	10.76	NS
12	107.68 ± 4.79^{ay}	107.12 ± 4.79^{ay}	113.84 ± 4.79^{ay}	106.23 ± 4.79^{ay}	10.74	NS
16	147.18 ± 4.40^{az}	156.05 ± 4.40^{az}	139.85 ± 4.40^{az}	152.28 ± 4.40^{az}	10.19	NS

[a] Row means with same superscripts are not significantly different
[x, y, z] Column means with different superscripts are significantly different
NS = Non Significant, NS = ($p>0.05$)

4.3.7 Back weight

Generally, back weight was not significantly influenced by dietary treatment at the same age except at week 16 when control was superior. In all dietary treatments back weight significantly ($p<0.001$) increased with age of guinea fowl (Table 4.8). Back weight value at 16 weeks of age in the present study for birds on control diets was consistent with Nsoso *et al.* (2003) who obtained 120 g during the same period. On the other hand, Saina (2005) reported a higher back weight value of 130.0 g during the same period. The variation in back weights between these studies might be due to the difference in energy levels of the dietary treatments. The current study used diets with energy levels of 12.14 MJ/Kg ME for control diet's starter, grower and finisher respectively, and 12.13 MJ/Kg ME for experimental guinea fowl diets. On the contrary, Saina (2005) used a broiler diet of 13 MJ/Kg ME. Teteh *et al.* (2010) obtained better growth rates in broilers fed high energy diets. The authors attributed the good results to the use of energy for efficient retention of protein for growth.

Table 4.8: Means and standard errors of guinea fowl back weights (g) fed commercial broiler diets and experimental diets at 6, 12 and 16 weeks of age under intensive management system

Weeks	Treatments				CV	Significance level
		Experimental Diets				
	Control	Maize	Millet	Sorghum		
6	33.33 ± 1.44^{ax}	35.50 ± 1.44^{ax}	33.59 ± 1.44^{ax}	35.29 ± 1.44^{ax}	13.52	NS
12	85.44 ± 2.91^{ay}	86.78 ± 2.91^{ay}	80.63 ± 2.91^{ay}	81.86 ± 2.91^{ay}	13.01	NS
16	119.55 ± 3.48^{bz}	98.91 ± 3.48^{az}	98.33 ± 3.48^{az}	106.20 ± 3.48^{abz}	15.35	**

^{a,b} Row means with different superscripts are significantly different
^{x,y,z} Column means with different superscripts are significantly different, NS = Non Significant
** = ($p<0.001$), NS = ($p>0.05$)

4.3.8 Breast weight

Breast weight of guinea fowl was not significantly affected by dietary treatment. However, breast weight significantly increased with age (Table 4.9). Likewise, Kokoszyński *et al.* (2011) reported higher breast muscles in carcasses from guinea fowl at 16 weeks of age. The values for breast weight obtained in the current study at 16 weeks of age are consistent with the value of 280 g reported by Nsoso *et al.* (2003) during the same period. Lower breast weight value of 267.23±1.69 g was reported by Ogah (2011) during the same period. The variation in breast weights between these studies might be due to the difference in protein and energy levels of the dietary treatments and guinea fowl strains used. In this study, starter diet contained 24% CP and 12.13 MJ/Kg ME; grower diet; 20% CP and 12.13 MJ/Kg ME and finisher diet; 15% CP and 11.30 MJ/Kg ME. Ogah (2011) fed a concentrate diet containing 18% CP and 11.30 MJ/Kg ME. According to Tesseraud *et al.* (2003), dietary protein restrictions reduce breast muscle weight. Similarly, Dairo *et al.* (2010) reported low breast weight in broiler chickens fed low energy diets (11.62 MJ/Kg ME and 11.49 MJ/Kg ME for starter and finisher diets, respectively) as opposed to normal energy diets (12.43 MJ/Kg ME and 12.54 MJ/Kg ME for starter and finisher diets respectively). The authors (Dario *et al.*, 2010) opined that protein and energy are the determinants in the evaluation of the performance and production coefficients of farm animals. In addition, the current study used pearl and lavender guinea fowl strains while Ogah (2011) used indigenous guinea fowl. According to Bernacki *et al.* (2012), carcass percentage of the breast muscle is significantly influenced by genotype and content of depot fat. The authors (Bernacki et al., 2012) also stated that the high content of breast muscle in carcasses makes guinea fowl suitable for use as broilers.

Table 4.9: Means and standard errors of guinea fowl breast weight (g) fed commercial broiler diets and experimental diets at 6, 12 and 16 weeks of age under intensive management system

Weeks	Treatments				CV	Significance level
		Experimental Diets				
	Control	Maize	Millet	Sorghum		
6	71.87±2.83^{ax}	69.05±2.83^{ax}	71.30±2.83^{ax}	74.83±2.83^{ax}	14.36	NS
12	214.00±5.06^{ay}	220.14±5.06^{ay}	219.23±5.06^{ay}	215.60±5.06^{ay}	9.57	NS
16	316.36±9.00^{az}	292.93±9.00^{az}	284.08±9.00^{az}	294.68±9.00^{az}	10.07	NS

^{a} Row means with same superscripts are not significantly different
^{x,y,z} Column means with different superscripts are significantly different, NS = Non-Significant
NS = (p>0.05)

4.3.9 Wing weight

Generally, wing weight of guinea fowl was not influenced by dietary treatment at the same age except at week 16 ($p<0.01$) when millet fed birds had lower wing weight. However, wing weight significantly ($p<0.001$) increased with age (Table 4.10). In the current study, wing weights of control and maize fed birds were consistent with 130 g obtained by Nsoso *et al.* (2003). A lower wing weight value of 121.3±10.7 g similar to that of birds on sorghum diets was recorded by Saina (2005) during the same period. The variation in wing weight between these studies is attributable to dietary treatments and guinea fowl strains. The current study used the pearl and lavender guinea fowl strains while Saina (2005) used indigenous guinea fowl. Indigenous guinea fowl strains have lower body weights than improved strains (Saina 2005).

Table 4.10: Means and standard errors of guinea fowl wing weight (g) fed commercial broiler diets and experimental diets at 6, 12 and 16 weeks of age under intensive management system

Weeks	Treatments				CV	Significance level
		Experimental Diets				
	Control	Maize	Millet	Sorghum		
6	48.03 ± 1.43^{ax}	48.31 ± 1.43^{ax}	47.90 ± 1.43^{ax}	52.10 ± 1.43^{ax}	9.76	NS
12	112.92 ± 2.50^{ay}	112.02 ± 2.50^{ay}	114.38 ± 2.50^{ay}	112.36 ± 2.50^{ay}	7.74	NS
16	130.76 ± 1.82^{bz}	127.74 ± 1.82^{bz}	112.36 ± 1.82^{ay}	124.24 ± 1.82^{bz}	6.36	**

^{a,b} Row means with different superscripts are significantly different
^{x,y,z} Column means with different superscripts are significantly different, NS = Non Significant
** = ($p<0.001$), NS = ($p>0.05$)

4.4 Conclusion

Generally, dietary treatment had no influence on guinea fowl carcass characteristics at 6, 12 and 16 weeks of age. However, variation did occur for liver weight, back weight and wing weight. These results suggest that yellow maize, white sorghum or pearl millet diets can replace commercial broiler diets in guinea fowl diets without affecting these traits. Further research on meat characteristics and acceptance by consumers and cost-benefit analysis of the dietary treatments should be carried out to evaluate the effect of formulating guinea fowl diets using locally available cereal grains.

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Growth Performance of Guinea Fowl Fed Diets Containing Yellow Maize, Millet and White Sorghum as Energy Sources and Raised under Intensive System

Samuel Uaperendua Tjetjoo, John Cassius Moreki,
Shalaulani James Nsoso and Othusitse Ricky Madibela
Department of Animal Science and Production, Botswana College of Agriculture,
Private Bag, 0027, Gaborone, Botswana

Abstract: This study investigated growth performance of guinea fowl fed diets containing 3 cereal grains as energy sources in comparison to commercial broiler diets. Birds were raised under intensive system from 3 to 16 weeks of age. A completely randomized design was used where 160 keets were randomly assigned to 4 dietary treatments. Each treatment had 40 birds with 4 replicates of 10 birds each. Data were analyzed using General Linear Model Procedure of Statistical Analysis Software (version 9.0). The results showed that dietary treatment did not (P>0.05) influence body length, body circumference, wing stretch, shank length and neck length of guinea fowl. From 3 to 16 weeks of age feed intake was significantly (P<0.0001) lower for control diet (13714.79±209.65 g) than maize (16085±209.65 g), millet (1609.63±209.65 g) and sorghum (15872±209.65 g) diets. Furthermore, FCR was significantly (P<0.0001) lower on control diet (11.33±0.37) than maize (13.91±0.37), millet (14.90±0.37) and sorghum (13.72±0.37) diets. Average weekly body weight gain was significantly (P<0.05) lower for birds on millet diet (82.98±2.18 g) than birds on control (93.14±2.18 g), maize (89.25±2.18 g) and sorghum (89.03±2.18 g) diets. These results suggest that cereal grains can be used in guinea fowl diets without affecting performance.

Key words: Dietary treatment, growth parameters, guinea fowl, intensive system, keets

INTRODUCTION

The production of guinea fowl as an alternative poultry enterprise is gaining ground throughout the world, especially in developing countries which have shown increasing demand for this particular meat (Nahashon *et al.*, 2006; Yildirim, 2012). The gamey flavour of guinea fowl meat may be the factor influencing its preference and demand. Guinea fowl adapt to different environmental conditions and as such, they are ubiquitous (Kokosyzyski, 2011). As a result of the increasing interest in guinea fowl farming and gradual domestication of the bird, feeding management and breeding strategies are required that will bring about improvement in its performance (Ogah, 2011). However, according to Nahashon *et al.* (2006) and Elhashmi *et al.* (2011), turning guinea fowl production into a profitable enterprise requires understanding of their growth characteristics and patterns as these allow the design of optimum management practices and hence improved profitability.

The success of poultry meat production has been strongly related to improvements in growth rates and carcass yield (Musa *et al.*, 2006). Indigenous guinea fowl varieties have lower body weights (Mundra *et al.*, 1993) than improved strains. Furthermore, Ayorinde and Ayeni (1983) reported that a guinea fowl tends to grow slowly weighing less than 1 kg at 8 weeks of age compared to a broiler chicken which reaches 1.5 to 2 kg in 6-8 weeks. Nahashon *et al.* (2005) reported carcass yields of about 70% at 8 weeks of age. Similarly, Teye *et al.* (2006) obtained a carcass yield of 66.9 and 69.7% for male and female Cobb broilers at 8 weeks of age, respectively. Hughes and Jones (1980) reported carcass yield (dressing percentage) of male and female guinea fowl broilers at 12 weeks of age to be 76.8 and 76.9%, respectively.

Guinea fowl farming is in its infancy in Botswana (Tebesi *et al.*, 2012); hence information on their nutrition is limited. According to Nahashon *et al.* (2006), the profitability of guinea fowl is hampered by poor nutrition due in part to lack of management and feeding guidelines. Currently, formulated guinea fowl diets are not available in Botswana resulting in guinea fowl fed commercial diets for chickens. Therefore, a study was conducted to evaluate growth performance of guinea fowl under intensive management system fed diets containing millet, white sorghum and yellow maize as energy sources in comparison to commercial broiler diets (control).

MATERIALS AND METHODS

Experimental site: The study was carried out at Botswana College of Agriculture (BCA) Guinea Fowl Rearing Unit, Sebele Content farm from February to

Corresponding Author: John Cassius Moreki, Department of Animal Science and Production, Botswana College of Agriculture, Private Bag, 0027, Gaborone, Botswana

June 2012. The BCA is 24°33' S, 24°54' E and is located at an altitude of 994 m above sea level with an average annual rainfall of 538 mm and mean daily temperature of 30°C (Emongor, 2007).

Experimental design: A completely randomized design was used where 160 keets were randomly allocated to 4 dietary treatments: control (commercial broiler diet), maize, millet and sorghum. Each dietary treatment had 40 birds with four replicates of 10 birds each.

Management of keets: A total of 160 keets were hatched at BCA hatchery unit and raised in a closed house which provided both warmth and adequate ventilation. At 4 weeks of age, the keets were transferred to 16 growing pens where they were randomly assigned to 4 dietary treatment groups. The 4 treatments comprised control diet and experimental diets consisting of yellow maize, white sorghum and millet as energy sources. Birds were raised on earth floor pens with perches. A drinker and a feeder were placed in each pen. Feed and water were provided *ad libitum* to all treatments.

Experimental diets: Dietary treatments comprised control diet and experimental diets consisting of yellow maize, white sorghum and millet as energy sources. Diets for each feeding phase were isocaloric and isonitrogenous. Cereal grains were bought from Botswana Agricultural Marketing Board and commercial broiler diets and feed premixes from feed distributors and feed manufacturers. Experimental diets were mixed at the Department of Agricultural Research and were formulated according to Botswana Standard for Guinea fowl (BOS 234:2006). Experimental diets contained 24% CP and 12.13 MJ/Kg ME starter diet which was fed from 0 to 6 weeks of age; a grower diet (20% CP and 12.13 MJ/Kg ME) from 7 to 12 weeks of age and a finisher diet (15% CP and 11.30 MJ/Kg ME) fed from 13 to 16 weeks of age. The commercial broiler diet contained 20% CP and 12.0 MJ/Kg ME starter diet and was fed from 0 to 6 weeks of age; a grower diet (18% CP and 12.2 MJ/Kg ME) from 7 to 12 weeks of age and a finisher diet (16% CP and 12.6 MJ/Kg ME) was fed from 13 to 16 weeks of age. In this study, 16 weeks was regarded as market age of guinea fowl.

Data collection: Data collection started at 3 weeks of age. Feed Intake (FI) was determined as the difference between the amount of feed offered and refusals (Tufarelli *et al*., 2011) in each replicate. Pen body weights were recorded on weekly basis. Body Weight (BW) and FI were measured in the morning before watering and feeding. Body Weight Gain (BWG) was determined as the difference between BW of the present week from that of the previous week over 7 days (Oke *et al*., 2012). Morphological parameters of growth such as body length, body circumference, shank length, neck length and wing stretch length were measured weekly (Nsoso *et al*., 2006) using a measuring tape. On average, 14 birds per treatment were randomly selected, measured and weighed from 3 to 16 weeks of age. Feed conversion ratio (FCR) was calculated by dividing the average weekly FI with the average weekly BWG for each replicate (Tufarelli *et al*., 2011). Mortality was recorded throughout the experimental period.

Statistical analyses: Data on FI, average weekly BWG and FCR were analyzed using General Linear Model (GLM) procedure of SAS (version 9.0, 2002-2008) (SAS Institute, 2002) to determine the effect of dietary treatments on growth parameters of guinea fowl. The results reported are least square means separated using Least Significant Difference (LSD). The following statistical model was used:

$$Y_{ijk} = \mu + T_i + \beta_j + E_{ijk}$$

where, Y_{ijk} = Observed variables (FI, FCR, BWG, BW, body length, body circumference, wing stretch, shank length, neck length):

μ = Overall mean
T_i = Treatment effects (Diets: control, maize, millet, sorghum)
β_j = Replicate effects
E_{ijk} = Error which is randomly distributed

RESULTS

Table 1 presents a cumulative FI, FCR and BWG of guinea fowl in 13 weeks of production. Dietary treatment had a significant effect on FI, FCR and BWG. Guinea fowl fed control diet showed a significantly ($P<0.001$) lower overall (0-91 days) FI and FCR compared with maize, millet and sorghum diets. A significant ($P<0.05$) effect of the dietary treatment on BWG was observed on guinea fowl fed millet diet.

Body weight: The effects of dietary treatment on guinea fowl BW is shown in Table 2. Generally, treatments had no significant ($P>0.05$) influence on BW.

Body length: Table 3 shows the effect of dietary treatment on guinea fowl body length. Generally, there was no significant ($P>0.05$) effect of treatments on body length.

Body circumference: Table 4 shows the effect of dietary treatment on guinea fowl body circumference. Dietary treatment did not cause a significant ($P>0.05$) difference on guinea fowl body circumference.

Wing stretch: Generally, wing stretch of guinea fowl was not significantly ($P>0.05$) affected by dietary treatment (Table 5).

Table 1: Cumulative feed intake, feed conversion and body weight gain per guinea fowl fed commercial broiler diets and experimental diets from 3 to 16 weeks under intensive management system

		Treatments (experimental diets)				
Parameters	Control	Maize	Millet	Sorghum	CV	SL
FI (g)	13714.79±209.65^{a}	16085±209.65^{b}	16019.63±209.65^{b}	15872.52±209.65^{b}	2.72	***
FCR	11.33±0.37^{a}	13.91±0.37^{b}	14.90±0.37^{b}	13.72±0.37^{b}	5.50	***
BWG (g)	93.14±2.18^{b}	89.25±2.18^{ab}	82.98±2.18^{a}	89.03±2.18^{ab}	4.93	*

^{a,b}Row means with different superscripts are significantly different. FI: Feed Intake; FCR: Feed conversion ratio; BWG: Body weight gain; SL: Significance level. Significant *(P<0.05), Significant ***(P<0.001)

Table 2: Means and standard errors of guinea fowl body weights (g) fed commercial broiler diets and experimental diets from 3 to 16 weeks of age under intensive management system

		Treatments (experimental diets)				
Weeks	Control	Maize	Millet	Sorghum	CV	SL
3	198.13±2.03	198.13±2.03	198.75±2.03	198.25±2.03	2.58	NS
4	211.27±6.37	207.51±6.37	217.43±6.37	224.43±6.37	13.53	NS
5	310.81±7.70	308.17±7.70	322.51±7.70	317.03±7.70	13.14	NS
6	434.28±9.21^{ab}	398.97±9.21^{a}	425.89±9.21^{ab}	441.40±9.21^{b}	10.72	*
7	530.57±15.42	490.02±15.42	491.81±15.42	496.06±15.42	11.30	NS
8	665.21±15.52	629.73±15.52	624.93±15.52	634.90±15.52	10.83	NS
9	785.81±17.78	737.87±17.78	757.19±17.78	763.05±17.78	9.32	NS
10	894.70±16.99	856.21±16.99	844.16±16.99	899.11±16.99	8.57	NS
11	1028.41±14.2^{c}	979.68±14.27^{a}	1019.36±14.2^{c}	1004.84±14.2^{b}	6.93	*
12	1049.49±14.2	999.95±14.22	1057.69±14.2	1013.24±14.2	7.45	NS
13	1217.49±22.8^{b}	1137.93±22.8^{ab}	1074.91±22.8^{a}	1140.30±22.8^{ab}	8.36	**
14	1274.49±30.9	1219.93±30.9	1180.91±30.9	1227.30±30.9	7.37	NS
15	1353.26±30.04	1299.00±30.04	1241.82±30.04	1288.16±30.04	6.95	NS
16	1408.98±28.62^{b}	1358.43±28.62^{ab}	1277.43±28.62^{a}	1353.65±28.62^{ab}	7.44	*

^{a,b,c}Row means with different superscripts are significantly different. SL: Significance level. Significant* (P<0.05), Significant** (P<0.01), Non-significant (NS-P>0.05)

Table 3: Means and standard errors of growth of guinea fowl body lengths (cm) fed commercial broiler diets and experimental diets from 3 to 16 weeks of age under intensive management system

		Treatments (experimental diets)				
Weeks	Control	Maize	Millet	Sorghum	CV	SL
3	15.40±0.39	15.10±0.39	14.89±0.39	15.66±0.39	9.06	NS
4	19.38±0.30	19.07±0.30	19.27±0.30	19.81±0.30	9.08	NS
5	23.61±0.55	22.89±0.55	23.81±0.55	24.01±0.55	6.36	NS
6	27.96±0.43	26.44±0.43	27.43±0.43	27.83±0.43	5.64	NS
7	30.68±0.59	29.13±0.59	29.28±0.59	29.21±0.59	5.51	NS
8	33.59±0.70	31.93±0.70	31.88±0.70	32.71±0.70	6.63	NS
9	36.16±0.45	35.01±0.45	34.64±0.45	34.66±0.45	5.12	NS
10	35.89±0.56	36.67±0.56	34.39±0.56	35.51±0.56	4.68	NS
11	39.90±0.78	38.83±0.78	38.86±0.78	38.57±0.78	4.68	NS
12	41.59±0.63^{b}	37.47±0.63^{a}	41.07±0.63^{b}	38.32±0.63^{a}	5.86	***
13	39.97±0.66^{b}	39.36±0.66^{ab}	37.28±0.66^{a}	38.91±0.66^{ab}	5.89	**
14	42.23±0.47	41.71±0.47	40.88±0.47	41.52±0.47	4.48	NS
15	43.14±0.70	41.85±0.70	40.78±0.70	41.30±0.70	5.47	NS
16	3.43±1.66	41.71±1.66	41.13±1.66	39.78±1.66	9.76	NS

^{a,b}Row means with different superscripts are significantly different. SL: Significance level. Significant level **(P<0.01), Significant ***(P<0.001), Non-significant (NS-P>0.05)

Shank length: Table 6 shows the effect of dietary treatments on guinea fowl shank length. Generally, shank length of was not significantly (P>0.05) influenced by dietary treatment.

Neck length: Neck length of guinea fowl was not significantly (P>0.05) affected by dietary treatment (Table 7).

DISCUSSION

This study was conducted to investigate growth performance of guinea fowl fed diets containing millet, white sorghum and yellow maize as energy sources in comparison to commercial broiler diets. Guinea fowl fed control diet had significantly (P<0.001) lower overall (0-91 days) FI and FCR than other dietary treatments which themselves did not differ significantly. This result is in

Table 4: Means and standard errors of guinea fowl body circumferences (cm) fed commercial broiler diets and experimental diets from 3 to 16 weeks of age under intensive management system

		Treatments (experimental diets)				
Weeks	Control	Maize	Millet	Sorghum	CV	SL
3	15.93±0.38	15.61±0.38	16.57±0.38	16.57±0.38	6.99	NS
4	20.11±0.33	19.79±0.33	19.69±0.33	20.27±0.33	5.38	NS
5	23.22±0.39	22.71±0.39	23.14±0.39	23.04±0.39	5.38	NS
6	26.49±0.41	25.20±0.41	25.98±0.41	26.33±0.41	4.68	NS
7	28.06±0.43	27.45±0.43	27.09±0.43	27.16±0.43	4.38	NS
8	31.19±0.47	30.46±0.47	30.28±0.47	29.91±0.47	4.47	NS
9	32.49±0.66	31.03±0.66	30.76±0.66	32.51±0.66	7.55	NS
10	33.86±0.37	33.64±0.37	33.55±0.37	33.48±0.37	4.60	NS
11	35.32±0.54	33.68±0.54	34.08±0.54	33.35±0.54	6.61	NS
12	36.12±0.34	35.78±0.34	35.18±0.34	35.40±0.34	4.52	NS
13	37.36±0.52	36.60±0.52	36.35±0.52	37.28±0.52	4.21	NS
14	38.36±0.53	38.07±0.53	37.52±0.53	38.72±0.53	5.01	NS
15	38.71±0.75	38.43±0.75	38.78±0.75	38.09±0.75	4.92	NS
16	3.13±0.87	37.08±0.87	36.38±0.87	35.83±0.87	6.57	NS

SL: Significant level, Non-significant (NS-P>0.05)

Table 5: Means and standard errors of guinea fowl wing stretches (cm) fed commercial broiler diets and experimental diets from 3 to 16 weeks of age under intensive management system

		Treatments (experimental diets)				
Weeks	Control	Maize	Millet	Sorghum	CV	SL
3	14.36±0.40	14.87±0.40	15.67±0.40	15.22±0.40	7.91	NS
4	17.06±0.26^{c}	17.86±0.26^{bc}	19.29±0.26^{a}	18.16±0.26^{b}	6.28	***
5	19.73±0.36	20.76±0.36	20.44±0.36	19.88±0.36	3.91	NS
6	21.83±0.39	21.35±0.39	21.92±0.39	22.08±0.39	5.49	NS
7	22.98±0.32^{ab}	23.56±0.32^{a}	21.91±0.32^{c}	22.28±0.32^{b}	5.06	*
8	25.80±0.51	26.48±0.51	25.73±0.51	25.90±0.51	6.19	NS
9	23.89±0.35	24.83±0.35	24.27±0.35	24.04±0.35	4.51	NS
10	28.70±0.61	29.18±0.61	27.91±0.61	27.86±0.61	7.35	NS
11	24.83±0.69	25.23±0.69	25.01±0.69	24.61±0.69	5.90	NS
12	27.95±0.74	28.09±0.74	28.32±0.74	29.49±0.74	6.14	NS
13	28.66±0.44	29.60±0.44	28.64±0.44	29.28±0.44	3.90	NS
14	28.43±0.49	29.47±0.49	28.54±0.49	28.38±0.49	4.51	NS
15	29.77±0.74	30.13±0.74	28.28±0.74	29.88±0.74	6.63	NS
16	26.68±0.53^{b}	27.05±0.53^{a}	24.93±0.53^{c}	25.97±0.53^{bc}	5.78	*

^{a,b,c}Row means with different superscripts are significantly different,
SL: Significant level *(P<0.05), ***(P<0.001), Non-significant (NS-P>0.05)

Table 6: Means and standard errors of guinea fowl shank lengths (cm) fed commercial broiler diets and experimental diets from 3 to 16 weeks of age under intensive management system

		Treatments (experimental diets)				
Weeks	Control	Maize	Millet	Sorghum	CV	SL
3	5.88±0.11	6.06±0.11	5.64±0.11	6.10±0.11	7.07	NS
4	6.89±0.11	7.04±0.11	7.13±0.11	6.99±0.11	8.24	NS
5	8.13±0.18	8.26±0.18	8.44±0.18	8.28±0.18	7.16	NS
6	9.68±0.13	9.38±0.13	9.43±0.13	9.41±0.13	4.64	NS
7	10.59±0.20	10.01±0.20	10.08±0.20	10.06±0.20	5.28	NS
8	11.36±0.15	11.04±0.15	11.41±0.15	11.19±0.15	6.37	NS
9	12.26±0.13	12.18±0.13	12.18±0.13	12.18±0.13	3.80	NS
10	12.46±0.12	12.22±0.12	12.14±0.12	12.48±0.12	4.35	NS
11	13.31±0.14	13.01±0.14	13.16±0.14	13.16±0.14	3.75	NS
12	13.48±0.99	13.63±0.99	13.78±0.99	15.59±0.99	26.38	NS
13	13.76±0.14^{a}	13.26±0.14^{ab}	13.28±0.14^{ab}	13.13±0.14^{b}	3.79	*
14	13.83±0.13^{a}	13.39±0.13^{ab}	13.30±0.13^{b}	13.80±0.13^{ab}	4.24	*
15	13.94±0.17	13.86±0.17	13.65±0.17	13.87±0.17	4.54	NS
16	14.60±0.19	14.35±0.19	13.51±0.19	14.44±0.19	5.44	NS

^{a,b}Row means with different superscripts are significantly different. SL: Significant level *(P<0.05), Non-significant (NS-P>0.05)

Table 7: Means and standard errors of guinea fowl neck lengths (cm) fed commercial broiler diets and experimental diet from 3 to 16 weeks of age under intensive management system

		Treatments (experimental diets)				
Weeks	Control	Maize	Millet	Sorghum	CV	SL
3	4.15±0.25	4.40±0.25	4.38±0.25	4.11±0.25	12.63	NS
4	5.13±0.13	4.83±0.13	5.09±0.13	5.35±0.13	5.10	NS
5	5.83±0.23	6.12±0.23	6.19±0.23	6.45±0.23	8.78	NS
6	6.45±0.15	6.43±0.15	6.55±0.15	6.49±0.15	5.38	NS
7	7.13±0.15	6.90±0.15	6.88±0.15	6.91±0.15	6.29	NS
8	7.88±0.07	7.73±0.07	7.90±0.07	8.13±0.07	4.80	NS
9	8.51±0.05	8.56±0.07	8.44±0.05	8.51±0.05	2.43	NS
10	8.51±0.18	8.86±0.18	9.21±0.18	9.06±0.18	4.46	NS
11	9.67±0.07	9.46±0.07	9.67±0.07	9.51±0.07	2.97	NS
12	9.95±0.07	9.88±0.07	10.01±0.07	9.97±0.07	2.10	NS
13	11.53±0.28	11.16±0.28	11.43±0.28	11.22±0.28	5.12	NS
14	11.65±0.25	11.42±0.25	11.66±0.25	11.63±0.25	4.20	NS
15	12.73±0.15	12.53±0.15	12.69±0.15	12.70±0.15	4.29	NS
16	12.39±0.10	12.52±0.10	12.31±0.10	12.26±0.10	2.44	NS

SL: Significant level, Non-significant (NS-P>0.05)

agreement with Nahashon *et al.* (2005) and Seabo *et al.* (2011) who reported increased FI in guinea fowl fed increased dietary CP levels. Nahashon *et al.* (2011) reported higher FCR values (20.63 and 18.13 in guinea fowl reared at 15.6 birds/m^2 and 18 birds/m^2, respectively) at 16 weeks of age. The stocking density of 10 birds/m^2 was used in the current study. According to Ikani and Dafwang (2005), guinea fowl have high FCR because of their tendency to waste feed by scooping and picking of the feed which was also observed in this study.

In general, dietary treatment had no influence on BW at the same stage of growth. This observation is consistent with previous findings by Nsoso *et al.* (2003, 2006) who fed guinea fowl keets commercial broiler diets and reported no significant difference in live weights at the same stage of growth and development. At 12 weeks of age, BW of guinea fowl was lower than that reported by Seabo *et al.* (2011) during the same period. The difference in BW between the two studies could be due to variation in sources of protein used in the dietary treatments. For instance, the present study, used soybean meal as a protein source while sunflower was used in the study by Seabo *et al.* (2011). Araujo *et al.* (2011) contended that despite its high fibre content (14%) and deficient lysine (0.5%) compared to soybean meal, sunflower cake is relatively rich in sulphur amino acids (methionine and cystine). Sulphur amino acids play an important role in poultry nutrition because they are essential for optimum muscle accretion (Vieira *et al.*, 2004). At 16 weeks of age BW in the present study was consistent with Nsoso *et al.* (2003) in Botswana in the wild and domesticated indigenous guinea fowl. However, Ogah (2011) in Nigeria reported a lower BW during the same period in indigenous guinea fowl.

Guinea fowl fed millet diet had significantly lower BWG ($P<0.05$) compared to other dietary treatments which did not differ significantly from each other. The lower BWG in guinea fowl fed millet diet can be attributed to the presence of tannins in millet that hinders the utilization of feeds by monogastric animals, especially poultry. Tannins depress growth rate and feed utilization by forming complexes with proteins and carbohydrates or inhibiting digestive enzymes (Medugu *et al.*, 2012).

Generally, there was no significant difference in body length of guinea fowl at the same age. From 5 to 12 weeks of age body length increases for all the dietary treatments was lower than 22.79 cm reported by Nsoso *et al.* (2006) in guinea fowl raised on concrete floor during the same period. The present study also raised birds on concrete floor finish. The differences in results between the two studies could be attributable to differences in dietary treatments. The present study fed control (commercial broiler diets) and formulated guinea fowl diets containing maize, millet and sorghum as energy sources, whereas commercial broiler starter and grower diets were fed by Nsoso *et al.* (2006). In this study, body length was higher than 22.17±0.13 cm obtained in Nigeria by Ogah (2011) in indigenous guinea fowl from 3 to 16 weeks of age. Guinea fowl breeds and environmental factors might have contributed to variations in the results in these studies.

Body circumference generally increased with age of guinea fowl in all dietary treatments. Kasperska *et al.* (2011) contended that the increase in body circumference may be indicative of the normal growth and good development of internal organs. In the present study, body circumference at 13 weeks of age for all the dietary treatments was inconsistent with Kasperska *et al.* (2011) who reported lower body circumference of 27.2 and 26.2 cm for male and female guinea fowl, respectively. The variation in results for the two studies might be due to differences in breeds, environmental conditions and dietary treatments. The present study used pearl and lavender strains while Kasperska *et al.* (2011) used the grey pearl. In addition, the study was conducted in Sebele, Botswana which has an average annual rainfall of 538 mm and mean daily temperature of 30° (Emongor, 2007). Bydgoscz in Poland has an average annual rainfall of 500-550 mm and average annual temperature of 7.5 to 8.0°C (Slowinska *et al.*, 2010).

Generally, wing stretch of guinea fowl was not significantly affected by dietary treatment at the same age of growth. In this study, wing stretch values obtained from 5 to 12 weeks were lower than those reported by Nsoso *et al.* (2006) during the same period. However, the present study, recorded higher wing stretch values at 16 weeks of age than Fajemilehin (2010) in Nigeria for the Pearl, Ash and Black guinea fowl types. Similarly, a lower value of 19.38±0.08 cm was reported by Ogah (2011) during the same period. According to Nsoso *et al.* (2006), wings are late maturing traits and are a physiological advantage to guinea fowl as they are flighty and revert easily to feral conditions.

In general, shank length of guinea fowl was not affected by dietary treatment. According to Nsoso *et al.* (2006) and Fajemilehin (2010), shank length constitutes the length of the leg and is an early maturing trait that is needed to support the whole body frame. From 5 to 12 weeks of age, shank length in this study was lower than 8.91 and 8.38 cm obtained by Nsoso *et al.* (2006) during the same period. The difference in results could be due to variation in stocking densities for the two studies. In the first study guinea fowl were reared at 10 birds/m^2, whereas in the second study they were reared at 4 birds/m^2. According to Estevez (2007), high stocking density in poultry results in reduced BW, FI and FCR and this affects growth. Again, high stocking density leads to poor air quality at bird level due to inadequate air exchange and increased ammonia (Feddes *et al.*, 2002). Furthermore, high stocking density results in reduced access to feed and water, thus contributing to poor growth rate. In this study, at 13 weeks of age guinea fowl shank length for control, maize, millet and sorghum diets was higher than 6.4 cm obtained by Kasperska *et al.* (2011) in guinea fowl fed commercial turkey diet. The shank length at 16 weeks of age in the present study was also higher than Fajemilehin (2010) in Nigeria in three varieties of helmeted guinea fowl (Pearl: 7.14±0.07 cm; Ash: 7.04±0.05 cm and Black: 7.01±0.10 cm) at 16 weeks of age. The differences in shank length values might be due to environmental and breeds factors for the two studies. The current study commenced during the wet season in February while that of Fajemilehin (2010) in Nigeria started during the dry season in September. Obidi *et al.* (2008) stated that seasonal factors exert significant influence on domestic birds. The authors pointed out that direct climatic factors acting on the birds include high ambient temperature and relative humidity resulting in severe heat stress. These factors will affect bird's performance by reducing BW, FI and FCR. Furthermore, mineral metabolism and deposition in bones are affected by heat stress in poultry (Abioja *et al.*, 2012).

Neck length of guinea fowl was not significantly affected by dietary treatment. From 5 to 12 weeks of age neck length increase for the dietary treatments was lower than 6.45 cm reported by Nsoso *et al.* (2006) during the same period. Neck length is an early maturing trait that enables birds to have good view of their surroundings in order to detect danger or see predators in advance (Nsoso *et al.*, 2006).

Conclusion: In conclusion, generally, dietary treatment did not have significant effect on morphological parameters of growth in guinea fowl during the same stage of growth and development. These results suggest that maize, sorghum or millet diets can be used in guinea fowl diets without affecting growth performance.

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