PERFORMANCE OF BROILER CHICKENS FED TWO VARIETIES EACH OF GUINEA CORN AND MILLET AS REPLACEMENTS FOR DIETARY MAIZE

BY

EMMANUEL AGWOR IBE

DEPARTMENT OF ANIMAL SCIENCE
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA.

MAY, 2014
PERFORMANCE OF BROILER CHICKENS FED TWO VARIETIES EACH OF GUINEA CORN AND MILLET AS REPLACEMENTS FOR DIETARY MAIZE

BY

Emmanuel Agwor IBE
B. AGRIC. (EBSU, 2008)
(MSc/Agric/05324/2010-2011)

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER DEGREE IN ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, AHMADU BELLO UNIVERSITY, ZARIA NIGERIA.

MAY, 2014
DECLARATION

I declare that the work in this thesis entitled “Performance of broiler chickens fed two varieties each of guinea corn and millet as replacements for dietary maize” has been carried by me in the Department of Animal Science, Ahmadu Bello University, under the supervision of Professor S.O. Ogundipe and Dr. S. Duru. The information derived from the literature has been duly acknowledged in the text and the list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other Institution.

EMMANUEL AGWOR IBE

Signature

Date
CERTIFICATION

This thesis entitled “PERFORMANCE OF BROILER CHICKENS FED TWO VARIETIES EACH OF GUINEA CORN AND MILLET AS REPLACEMENTS FOR DIETARY MAIZE” by EMMANUEL AGWOR IBE meets the regulations governing the award of the degree of Master of Science in Animal Science of Ahmadu Bello University, and is approved for its contribution to scientific knowledge and literary presentation.

Professor S. O. Ogundipe
Chairman, Supervisory Committee
Department of Animal Science,
A.B.U., Zaria.

Dr. S. Duru
Member, Supervisory Committee
Department of Animal Science,
A.B.U., Zaria.

Dr. S. Duru
Head, Department of Animal Science
Ahmadu Bello University, Zaria

Professor A. A. Joshua
Dean, School of Postgraduate Studies
Ahmadu Bello University, Zaria
DEDICATION

This work is dedicated to the God Almighty for His goodness and mercy upon my life and also to my beloved and caring parents Chief and Lolo Innocent Ibe Idam for their financial and moral support throughout the period of this study.
ACKNOWLEDGEMENTS

God Almighty, the Creator of mankind is acknowledged for his tender caring and life worth living, may all glory, honour, power and majesty be unto His holy Name and Lord Jesus Christ. There is no achievement without debt of gratitude to various persons and groups whose positive impact guided as a prime motivator for the achievement of success. I am deeply indebted to my supervisors Prof. S.O. Ogundipe and Dr. S. Duru and their amiable families for their encouragements, commitments and untiring efforts in providing the necessary information and resources that enabled the production of this work.

My appreciation also goes to my loving and virtuous grand-mother Oke Mama Ngozi Ugwueme Ogudu, whom I lived with throughout my childhood and even now if not of this study and also to my loving brothers and sisters; Princewill, Ogbonnia, Isu, Ogu and Ngozi who cannot stay a day without hearing from me while undergoing this course. May God Almighty grant everybody long life and prosperity in Jesus name (Amen).

My sincere appreciation also goes to Prof. G. N. Akpa, Prof. G. S. Bawa, Dr. T. S. Olugbemi, Dr. S. B. Abdu, Mrs. H. O. Nwachukwu, Mrs. E. Asumugha, Mr. I. A. Kwano, Mr. N. A. Oseni and the entire staff of Animal Science Department, for their assistance in various ways during the period of this study.

My thanks go to all the staff of Rebson feed mill Samaru, Zaria for their genuine and tremendous effort during the period of this study.

A friend in need is a friend indeed, I am not forgetting to thank my good friends namely John Makinde Olayinka, Ezekiel Bulus Doka, Friday Isu Olua, Bisong Kingsley Obi, Samuel Egwu, Badmus Kazeem Ajasa, Ishiola Abdullahi, Saidu
Omenza, Isaac Samuel and Dr. Eugenes Uche Ewelike, just to mention but a few for their enormous assistance.

I will not forget to thank the entire congregation of my church, The Lord’s Chosen Charismatic Revival Ministries for their fervent and ceaseless prayers for me and my entire family and well wishers.

And lastly, I appreciate all those that have assisted me in one way or the other, time and space will not permit me to mention their names. May God bless everybody abundantly.
ABSTRACT

Two studies were carried out to evaluate the effects of complete replacement of maize with two varieties of guinea corn and two varieties of millet on the growth performance, carcass characteristics and nutrient digestibility of broiler chickens. Five isonitrogenous and isocaloric diets (23.5% CP; 2900 Kcal/ME) and (21% CP; 3000 Kcal/ME) for the broiler starter and finisher phases respectively were formulated. Diet 1 (maize based diet) served as the control while diets 2, 3, 4 and 5 were white guinea corn, yellow guinea corn (Short kaura), pearl millet and finger millet based diets respectively. A total of 225 day-old Marshal broiler chicks were randomly allotted to the five treatments. Each treatment consisted of 45 birds with three replicates of fifteen birds each in a completely randomized design (CRD). Feeds and water were provided ad libitum. The results of the first trial showed that final body weights and weight gained were significantly (p<0.05) higher in birds fed pearl and finger millet diets (T4 and T5) respectively than other treatments. T4 (Pearl millet based diet) recorded significantly (p<0.05) the best feed conversion ratio and the lowest feed cost per kg weight gain. Those fed the control (maize based diet T1) gave similar (p>0.05) values as those fed T3 (Short kaura based diet) in all the parameters measured. Birds fed diet T2 (white guinea corn) gave significantly (p<0.05) lowest values in all parameters measured and poor feed conversion ratio at the finisher phase.

The second trial was conducted to evaluate the effects of replacing 0, 25, 50, 75 and 100% levels of maize in the diet with white guinea corn on the growth performance, nutrient digestibility and carcass characteristics of broilers. Substituting maize with white guinea corn did not adversely (p>0.05) affect feed intake across the dietary treatments. At the starter phase, birds fed 25% and 50% guinea corn diet as
replacements for maize gave comparable results as those fed diet T1 (control diet). At the finisher phase, there was no significant (p > 0.05) difference for final weight, daily weight gain, feed conversion ratio and cost of feed per kilogramme weight gain between the birds fed the control diet and those fed between 25% and 75% maize replacement by white guineacorn. Birds fed 100% white guineacorn based diet gave significantly (p < 0.05) lowest values in all parameters measured and poor feed conversion ratio. The results of digestibility trial showed no significant (p > 0.05) differences in the percent ether extract and ash digestibilities across dietary treatments. Based on the results of the studies, it was concluded that millets or Short kaura guineacorn can completely replace maize component in broilers diets with no adverse effects on feed intake, growth rate, feed conversion ratio, nutrient digestibility and carcass characteristics. Also, observations from the second experiment showed that white guineacorn could conveniently replace up to 75% of the maize in broiler starter and finisher diets respectively without any adverse effect on growth performance and carcass characteristics of broiler chickens.
TABLE OF CONTENTS

Title page...........................................................................................................ii
Declaration.........................................................................................................iii
Certification.....................................................................................................iv
Dedication.......................................................................................................v
Acknowledgements .......................................................................................vi
Abstract .........................................................................................................viii
Table of Contents ............................................................................................x
List of Tables ....................................................................................................xv

CHAPTER ONE

1.0 INTRODUCTION .......................................................................................1
  1.1 Justification .............................................................................................3
  1.2 Objectives of the Study...........................................................................3
  1.3 Research Hypotheses .............................................................................4

CHAPTER TWO

2.0 LITERATURE REVIEW ...........................................................................5
  2.1 The Role of Nutrition on Animal Production in Nigeria .........................5
  2.2 Alternative Energy Sources for Poultry..................................................6
  2.3 Nutrient Composition of Guineacorn .......................................................6
    2.3.1 Vitamin and Mineral Compositions of Guineacorn............................9
  2.4 Anti-nutrients in Guineacorn Grain.........................................................9
    2.4.1 Tannins (condensed polyphenols) in Guineacorn .............................10
2.4.2 Phytic Acid in Guineacorn .................................................................11
2.4.3 Glycosides in Guineacorn .................................................................11
2.4.4 Oxalate in Guineacorn .................................................................11
2.5 Methods of Detoxifying the Anti-nutritional Factors ..................12
2.6 Guineacorn as an Alternative Energy Source in Poultry Diets .................12
2.7 History, Taxonomy and Distribution of Millets .................................16
2.8 Chemical Composition of Millets .........................................................17
2.8.1 Carbohydrates in Millets .................................................................17
2.8.2 Proteins in Millets .................................................................17
2.8.3 Lipids in Millets .................................................................18
2.8.4 Vitamins and Minerals in Millets ...................................................19
2.8.5 Anti-nutrients in Millets .................................................................20
2.9 Nutritional and Economic Importance of Guineacorn and Millets .................................................................21
2.9.1 Commercial Products ..................................................................21
2.10 Trends in Millet Production in Africa ...........................................24
2.11 Processing of Guineacorn and Millets ...........................................24
2.12 Millets as an Alternative Energy Source in Poultry Diets ..................25
2.13 Millets Utilization in Layers Diet ..................................................30
2.14 Nutrient Requirements of Broiler Chickens ...................................32
2.14.1 Energy Requirement of Broiler Chickens ....................................32
2.14.2 Protein Requirement of Broiler Chickens ....................................34
2.14.3 Amino acid (AA) Requirements of Broiler Chickens ..................35
2.14.4 Factors Influencing Broiler Response to Ideal Amino- acids ..............37
2.14.5 Fat Requirement of Broilers ..................................................40
2.14.6 Dietary Metabolizable Energy Requirements of Broilers ..................40
2.15 Response Trends of Chickens to Differing Feed Energy and Protein Levels ............................................................. 41
2.15.1 Feed Intake .................................................................................................................... 41
2.15.2 Environmental Temperatures ......................................................................................... 43
2.15.3 Amino-acid Antagonisms .............................................................................................. 44
2.15.4 Minerals and Vitamins Requirement of Broiler Chickens .............................................. 45
2.15.5 Water Requirements of Chickens .................................................................................... 46

CHAPTER THREE

3.0 MATERIALS AND METHODS ................................................................. 48
3.1 Location of the Study ........................................................................................................ 48
3.2 Sources of the Experimental Materials ........................................................................... 48
3.3 Determination of the Proximate Composition of Feed Ingredients Used ............................. 48
3.4 Experiment 1: Performance of Broiler Chickens Fed two Varieties each of Guineacorn and Millet as Replacements for Dietary Maize
3.4.1 Preparation of Experiment 1 diets .................................................................................. 49
3.4.2 Experimental Design and Management of Birds ............................................................ 53
3.4.3 Data Collection ............................................................................................................... 53
3.4.4 Evaluation of Carcass ..................................................................................................... 53
3.4.5 Nutrient Digestibility Trial ............................................................................................. 54
3.5 Experiment 2: Performance of Broiler Chickens Fed Graded Levels of White Guineacorn as Replacements for Maize
3.5.1 Experimental Diets for Feeding Trial 2 ......................................................................... 55
3.5.2 Experimental Design and Management of Birds ............................................................ 59
3.5.3 Data Collection ............................................................................................................... 59
3.5.4 Evaluation of Carcass ..................................................................................................... 58
3.5.5 Nutrient Digestibility Trial ............................................................................................. 60
3.6 Statistical Analysis ............................................................................................................. 60
CHAPTER FOUR

4.0 RESULTS .............................................................................................................. 61
4.1 Proximate Composition .................................................................................. 61
4.2 Anti-nutritional Factors in Feed Ingredients ............................................... 62
4.3 Experiment 1: Performance of Broiler Chickens fed two varieties each of Guineacorn and Millet as replacements for dietary Maize

4.3.1 Performance of Broilers Fed Two Varieties Each of Guineacorn and Millet (0-4 weeks) ........................................................................ 65
4.3.2 Performance of Broilers Finisher Fed Two Varieties Each of Guineacorn and Millet (5-9 weeks) ................................................................. 68
4.3.3 Carcass Evaluation and Organ Weights of Broilers Fed Maize, Guineacorn and Millet diets ..................................................................... 70
4.3.4 Nutrient digestibility of Broilers Fed Guineacorn and Millet Based Diets...72

4.4 Experiment 2: Performance of Broiler Chickens Fed Graded Levels of White Guineacorn as Replacement for Dietary Maize

4.4.1 Performance of Broiler Chicks Fed Graded Levels of White Guineacorn Replacement for Dietary Maize (0-4 weeks) .............................. 74
4.4.2 Performance of Broilers Fed Graded Levels of White Guineacorn as Replacement for Dietary Maize (5-9 weeks) ......................................... 76
4.4.3 Carcass Evaluation and Organ Weights of Broilers Fed Graded Levels of White Guineacorn as Replacement for Dietary Maize ..................... 78
4.4.4 Nutrient Digestibility of Broilers Fed Graded Levels of White Guineacorn as Replacement for Maize in Broiler Finisher Diets.................... 80

CHAPTER FIVE

5.0 DISCUSSIONS .................................................................................................... 82
5.1 Proximate Composition of the Test Ingredients ............................................. 82
5.2 Anti-nutritional Factors .................................................................................. 82
5.3 Experiment 1: Performance of Broilers Chickens Fed Two Varieties Each of Guineacorn and Millet as Replacements for Dietary Maize
5.3.1 Performance of Broiler Chicks Fed Maize, Guineacorn and Millet Based Diets (0-4 weeks) ..........................................................83

5.3.2 Performance of Broilers Finisher Chicken Fed Maize, Guineacorn and Millet Based Diets (5-9 weeks) ........................................ 85

5.3.3 Carcass Characteristics and Organ Weights of Broilers Fed maize, Guineacorn and Millet Based Diets ........................................ 86

5.3.4 Nutrient Digestibility of Broilers Fed Maize, Guineacorn and Millet Diets ..........................................................87

5.4 Experiment 2: Performance of Broiler Chickens Fed Graded Levels of White Guineacorn as Replacement for Dietary Maize.........88

5.4.1 Performance of Broilers Fed Graded Levels of White Guineacorn as Replacement for Dietary Maize (0-4 weeks) ...............................88

5.4.2 Performance of Broilers Fed Graded Levels of White Guineacorn as Replacement for Maize during the Finisher Phase (5-9 weeks) .................89

5.4.3 Carcass Characteristics and Organ Weights of Broilers Fed Graded Levels of White Guineacorn as Replacement for Maize..............................89

5.4.4 Nutrient Digestibility of Broilers Fed Graded Levels of White Guineacorn as Replacement for Maize......................................................................90

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS ..........91

6.1 Summary ........................................................................................................ 91

6.2 Conclusion........................................................................................................ 92

6.3 Recommendations .......................................................................................... 93

REFERENCES .......................................................................................................94
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Nutrient Composition of Maize and Guinea corn</td>
</tr>
<tr>
<td>2.2</td>
<td>Performance of Broiler Chickens Fed Maize, Millet, Low and High Tannin Sorghum</td>
</tr>
<tr>
<td>2.3</td>
<td>Performance of Laying Hens Fed Diets Formulated on a Total of Digestible Amino- acid Basis with Increasing Levels of Pearl Millet (25-45 weeks)</td>
</tr>
<tr>
<td>2.4</td>
<td>Ideal Amino acid Ratios: Percent Essential Amino acids for Broilers as Proposed by Various Investigators</td>
</tr>
<tr>
<td>3.1</td>
<td>Percentage Composition of the Experimental Broiler Starter Diets for Experiment 1 (0-4 weeks)</td>
</tr>
<tr>
<td>3.2</td>
<td>Percentage Composition of the Experimental Broiler Finisher Diets for Experiment 1 (5-9 weeks)</td>
</tr>
<tr>
<td>3.3</td>
<td>Proximate Analysis of Broiler Starter Diets for Experiment 1</td>
</tr>
<tr>
<td>3.4</td>
<td>Percentage Composition of the Experimental Broiler Starter Diets For Feeding Trial 2 (0-4 weeks)</td>
</tr>
<tr>
<td>3.5</td>
<td>Percentage Composition of the Experimental Broiler Finisher Diets for Feeding Trial 2 (5-9 weeks)</td>
</tr>
<tr>
<td>3.6</td>
<td>Proximate Composition of the Experimental Broiler Finisher Diets for Experiment 2</td>
</tr>
<tr>
<td>4.1</td>
<td>Proximate Composition of the Feed Ingredients</td>
</tr>
<tr>
<td>4.2</td>
<td>Anti-nutritional Factors in Feed Ingredients</td>
</tr>
<tr>
<td>4.3</td>
<td>Performance of Broilers Starter Chickens Fed Maize, Guinea corn and Millet Diets (0-4 weeks)</td>
</tr>
<tr>
<td>4.4</td>
<td>Performance Characteristics of Broiler Finisher Chickens Fed Maize, Guinea corn and Millet Diets (5-9 weeks)</td>
</tr>
<tr>
<td>4.5</td>
<td>Carcass Characteristics and Organ Weights of Broilers Fed Maize, Guinea corn and Millet Based Diets</td>
</tr>
<tr>
<td>4.6</td>
<td>Nutrient Digestibility of Broilers Finisher Chicken Fed Maize, Guinea corn and Millet Based Diets</td>
</tr>
<tr>
<td>4.7</td>
<td>Performance of Broiler Starter Chicks Fed Graded Levels of White Guinea corn as Replacement for Maize (0-4 weeks)</td>
</tr>
</tbody>
</table>
4.8 Performance of Broiler Finisher Fed Graded Levels of White Guineacorn as Replacement for Maize (5-9 weeks) .............................................77

4.9 Carcass Characteristics and Organ Weights of Broilers Fed Graded Levels of White Guineacorn as Replacement for Maize ........................................79

4.10 Nutrient Digestibility of Broilers Fed Graded Levels of White Guineacorn as Replacement for Maize ............................................................. 81
CHAPTER ONE

1.0 INTRODUCTION

In a developing country like Nigeria, there is an inadequate supply of animal protein sources. An average Nigerian consumes only about 8.6g of animal protein per day as against 53.3g by the inhabitants of developed countries (Ogundipe, 1996; Ojo, 2003). Sanni and Ogundipe (2005) reported that poultry industry occupies a major position in the livestock sector of agricultural production because birds have faster gestation than other other farm animals to produce meats and eggs for human consumption.

According to Ogundipe and Sanni (2002) and FAO (2006) reports, poultry is considered to be a means of livelihood towards achieving certain level of economic independence. Adegbola (2004) reported that 41.23% of animal protein yield per annum in Nigeria is sourced from poultry meat and eggs, 9.79% from cattle and 12.43% from pigs. FAO (1995) reported that the best logical solution to Nigeria’s meat scarcity is to increase broiler chicken production.

Nutrition is perhaps the most important consideration in livestock management. Inadequate supply of feeds, nutritionally unbalanced rations, adulterated ingredients or stale feeds are some of the factors responsible for low productivity of livestock in tropics (Ogundipe, 1987; Ogundipe et al., 2003). Apart from nutrition, Poultry industry contributes significantly to family income (Ogundipe and Sanni, 2002). Therefore the major interest of the farmer is to reduce feed cost, which usually accounts for 60 to 70% of the total cost of production (Nworgu, et al; 1999; Igwebuike et al., 2001; Ogundipe, et al; 2003).

Research efforts are now geared towards evaluating alternative feed ingredients for poultry. According to Atteh and Ologbenla (1993), such alternatives should have
comparative nutritive value but cheaper than the conventional protein and energy sources and should also be available in large quantities.

Maize is used for other purposes such as biofuel, brewing, starch industries and for human consumption. However, inadequate production of this grain and the intense competition for maize between man, industries and livestock especially in the drier areas of the tropics has made poultry rations to be expensive (Asha Rajini et al., 1986; FAO, 2006).

This situation therefore forced the investigation for other alternative energy sources such as guinea corn (*Sorghum bicolor*, Linn.), finger millet (*Eleusine coracana*) and pearl millet (*Pennisetum typhoides*). Worldwide, guinea corn and millet grain crops are very important ingredients in poultry diets. They both have over 90% of the feeding value of maize (Rooney, 1990). Guinea corn and millets are the most widely grown cereal crops that have been successfully cultivated in the semi-arid regions of Asia and Africa since prehistoric times and their cost are relatively less in the areas of cultivation with little industrial uses in Nigeria. (Ravindran and Blair, 1991; Nyannor et al., 2007).

The protein in millets is well balanced in limiting amino acids for practical poultry diets. Lysine, Methionine and Cystine contents in finger millet is about 2.86%, 1.75% and 1.51% of the crude protein (Rachie and Peters, 1997). Therefore their incorporation in place of maize can reduce the dependency on maize and also the cost of poultry production. This study is aimed at evaluating the performance of broiler chickens fed two varieties each of guinea corn and millet as replacements for dietary maize.
1.1 Justification

In Nigeria, poultry enterprise is faced with myriad of problems which have resulted to a gross shortage of meat to meet up the population challenge in the country. These are attributed to the escalating cost of conventional feedstuffs, which are the major sources of energy and protein in poultry diets.

There is also stiff competition between human, industries and livestock, fluctuations in prices and unavailability of the feed ingredients for the formulation of animal feeds (Duru and Dafwang, 2010). This has resulted in high cost of broiler feed, causing economic losses in broiler production in Nigeria. Profit maximization cannot be attained unless the chickens are fed well-formulated diets at reasonable costs.

1.2 Specific Objectives of the study are to:

1. Determine the nutrient composition and anti-nutritional factors (ANFs) in guinea corn and millets.

2. Determine the performance of broilers fed guinea corn and millets based diets as replacements for dietary maize.

3. Determine carcass characteristics of broiler chickens fed guinea corn and millet based diets.

4. Determine nutrient retentions of broiler chickens fed maize, guinea corn and millet diets.
1.3 Research Hypotheses:

Null hypothesis (H₀): There are no significant differences in the performance, carcass characteristics and nutrient retentions of broilers chickens fed two varieties of guinea corn or two varieties of millet in their diets as replacements for dietary maize.

Alternate hypothesis (Hₐ): There are significant differences in the performance, carcass characteristics and nutrient retentions of broilers chickens fed two varieties of guinea corn or two varieties of millet in their diets as replacements for dietary maize.
CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Role of Nutrition in Animal Production in Nigeria

The increase in the world population has led to the need to intensify livestock production, but this is constrained by high overhead cost especially in Nigeria. With a population of about 140 million people (NPC, 2006), Nigeria is one of the countries in the world living the highest rate of population growth. Due to economic situation of the nation, protein intake of most Nigerians is inadequate and often lack protein of high biological value derivable from animal products.

The rising cost of poultry feeds have continued to be a major problem in Nigeria as feed cost is about 60 to 70% (Nworgu et al., 1999; Ogundipe, 2003; Conolly, 2012) compared to about 50 to 60% in developed countries (Tackie and Flenscher, 1995). There has been a steady increase in the cost of conventional feed ingredients such as energy and protein sources which form most of its expensive components conventionally sourced from maize, groundnut cake (GNC), soya bean meal (SBM), and fish meal. Scarcity and sometimes non-availability have led to increase in the prices of such feed ingredients (Onu and Madubuike, 2006; Adejinmi et al., 2007; Defang et al., 2008).

Cereal grains especially maize which forms the bulk of energy in poultry feeds are in short supply as a result of industrial, livestock and human needs (Slavin, 2010). This has resulted in competition between human and animal for the available feed resources, and hence high cost of animal production (Oluyemi and Roberts, 2000; Agbede et al., 2002; Aderolu et al., 2007).

However, green plants, forages and cereals have long been recognized as the most abundant potential source of proteins and carbohydrates (energy) because of their
ability to provide amino acids from a wide range of virtually unlimited and readily available primary materials (D’Mello and Devendra, 1995).

2.2 Alternative Energy Sources for Poultry

Guinea corn and millets are among the most important cereals, in terms of nutrition, production and area planted. Roughly 90% of the world’s guinea corn area and 95% of the world’s millet area lie in the developing countries, mainly in Africa and Asia (FAO, 1996). These crops are primarily grown in poor areas subject to low rainfall and drought where other grains are unsuitable for production unless irrigation is available (Nyannor et al., 2007). Guinea corn is widely grown both for food and as a feed grain, while millet is produced almost entirely for food. Guinea corn and millets constitute a major source of calories and protein for millions of people in Africa and Asia (FAO, 2012).

2.3 Nutrient Composition of Guinea corn

Whole grains of guinea corn contain approximately 89 - 90% dry matter (DM), 8.9 – 15% crude protein (CP), 2.8% ether extract (EE), 1.5 – 1.7% ash, 2.1 – 2.3% crude fibre (CF), and 71.7 – 72.3% nitrogen free extract (NFE) on as fed basis (Ensminger and Olentine, 1978; Subramanian and Metta, 2000; FAO, 2012).

The CP content of guinea corn is higher than that of maize but about equal to wheat. Protein content and composition varies due to genotype, water availability, temperature, soil fertility and environmental conditions during grain development. The protein content of guinea corn is usually 11-13% but sometimes higher values are reported (David, 1995). Prolamins (kafirins) constitute the major protein fractions in guinea corn, followed by glutelins. Grain protein is notoriously deficient in the essential amino acid lysine (Bohoua and Yelakan, 2007).
Table 2.1 shows the nutrient composition of maize and guinea corn as reported by some workers. In terms of energy value, guinea corn is rated as high as 90 – 100% of maize depending on the livestock specie. However, guinea corn is lower than maize but higher than wheat in fat content (Magness et al., 1971; Atteh, 2002). Crude fat content of guinea corn averages about 3%, which is higher than that of wheat and rice. The Fatty acid composition of guinea corn fat with high concentrations of linoleic (49%), oleic (31%), palmitic acids (14%), linolenic (2.7%) and stearic (2.1%) was similar to that of maize fat but of more unsaturated (Rooney, 1978).

Abubakar et al. (2006) reported a slightly lower calculated value of 12.15 MJ/kg and 12.92 MJ/kg metabolizable (ME) energy for unmalted and malted guinea corn, respectively. Malting increases the protein soluble sugars and lysine values of guinea corn while the tannin content reduced. (Barrett, and Larkin, 1974; Wu and Well, 1980; Kubiezek et al., 1984; Hotz and Gibson, 2007).

Guinea corn contains low levels of lysine but high tryptophan content relative to maize (Purseglove, 1972; Olomu, 1995). McDonald et al. (2000) reported that arginine, lysine, methionine, cystine and tryptophan as the main limiting indispensable amino acids in maize and guinea corn. Xanthophylls and linoleic acids are much lower in guinea corn than in maize. The yellow endosperm with carotene and xanthophylls increased the nutritive value of guinea corn (FAO, 1995; Olomu, 1995).
### Table 2.1 Nutrient Composition of Maize and Guinea corn (%)

<table>
<thead>
<tr>
<th>Components</th>
<th>maize&lt;sup&gt;a&lt;/sup&gt;</th>
<th>G’ corn&lt;sup&gt;c&lt;/sup&gt; (white dawa)</th>
<th>G’ corn&lt;sup&gt;d&lt;/sup&gt; (yellow)</th>
<th>G’ corn&lt;sup&gt;b&lt;/sup&gt; (Indian)</th>
<th>G’ corn&lt;sup&gt;b&lt;/sup&gt; (ICSVII2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>91.80</td>
<td>93.31</td>
<td>88.94</td>
<td>92.50</td>
<td>-</td>
</tr>
<tr>
<td>Organic matter</td>
<td>90.53</td>
<td>93.06</td>
<td>93.06</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Crude protein</td>
<td>8.8</td>
<td>10.48</td>
<td>14.84</td>
<td>9.50</td>
<td>8.9</td>
</tr>
<tr>
<td>Ether Extract</td>
<td>4.10</td>
<td>2.97</td>
<td>3.30</td>
<td>2.50</td>
<td>3.7</td>
</tr>
<tr>
<td>Crude Fibre</td>
<td>2.10</td>
<td>2.01</td>
<td>3.01</td>
<td>2.70</td>
<td>1.2</td>
</tr>
<tr>
<td>Ash</td>
<td>1.00</td>
<td>6.94</td>
<td>2.59</td>
<td>1.20</td>
<td>1.7</td>
</tr>
<tr>
<td>NFE</td>
<td>75.80</td>
<td>61.24</td>
<td>65.16</td>
<td>76.60</td>
<td>73.50</td>
</tr>
</tbody>
</table>

Sources:  
<sup>a</sup> Olomu (1995)  
<sup>b</sup> Subramanian and Metta (2000)  
<sup>c</sup> Abubakar et al. (2006)  
<sup>d</sup> Etuk and Ukaejiofo (2007).  
NFE = Nitrogen Free Extract
2.3.1. **Vitamin and Mineral Compositions of Guinea corn**

Guinea corn is an important source of B vitamins except B\textsubscript{12} and good source of tocopherols (FAO, 1995, 2012). Other B-complex vitamins present in guinea corn in significant amounts are vitamin B\textsubscript{6} (0.5 mg per 100g/mg), folacin (0.02 mg/100g), pantothenic acid (1.25 mg/100g) and biotin (0.042 mg/mg) (NRC, 1982). The B vitamins and minerals are concentrated in the aleurone layer and germ. Guinea corn grain contains about 1.5 ppm of total carotenoids.

Apart from maize and durum wheat, sorghum is the only cereal which contains a significant amount of β-carotene, the provitamin of vitamin A, which is important in human physiology. Sorghum is considered a good source of potassium and is practically devoid of sodium (Selle et al., 2003b). Whole grains are good sources of magnesium, iron, zinc, and copper (Hulse et al., 1980; FAO, 2012).

The bioavailability of iron in sorghum is negatively affected by the presence of polyphenols and phytates, but Derman et al. (1980) reported that iron absorption was more than 12 times greater from sorghum beer than from gruel.

Germination, decortication and/or malting and fermentation enhance the nutritional value of sorghum by causing significant changes in chemical composition and elimination of anti-nutritional factors (Taur et al., 1984; Kim et al., 2000; Wadikar et al., 2006; Amadou et al., 2011).

2.4 **Anti-nutrients in Guinea corn grain**

Anti nutritional compounds (e.g. protease inhibitors, galacto-oligosaccharides, lectins, ureases, phytates, tannins, phenolics and saponins etc.) are plant constituents which play important role in biological functions of plants. Examples are the effect of these compounds on man and animal organisms are partly negative because they can reduce the digestibility of nutrients and the absorption of minerals (Derman et al., 1980).
They may also inhibit growth as a result of their negative influence on the function of pancreases and the thyroid gland, and can cause pathological alterations in the liver.

2.4.1 Tannins (condensed polyphenols) in Guinea corn

Tannins are secondary compounds present in plants and comprise polyphenols of great diversity (Hoste et al., 2006). The physical and chemical properties of tannins vary between plants, in different plant parts and between seasons. At high levels (above 50 g/kg DM), tannins in plant material can become an antinutritional factor and can result in reduced feed intake and digestibility in animals (Barry and McNabb, 1999). All sorghum contains phenolic compounds, including phenolic acids and flavonoids. Yellow guinea corn variety was reported to have low levels of tannin (Gualitieri and Rappaccini, 1990).

These compounds can affect colour, flavour and the nutritional quality of the grain and products prepared from it. Tannins confers a bitter taste and protect the grain against insects and birds that can cause reduction in grains (Taylor, 2003; Kyarisima et al., 2004). The tannin content of seeds inhibits the activity of some enzymes hence adversely influences protein digestibility and cellulose breakdown (Elkin et al., 1996; Vinod et al., 2005).

Animal tests have proved that tannin inhibits protein absorption, decreases utilization of minerals and results in some decrease of growth. Feeding pigs with fodder containing 4.21% tannin decreased protein digestibility by 5.6% (Nyannor et al., 2007). Before ripening, the tannin content of grain is always higher than after ripening. The tannin content of dark grains is always higher than that of pale grains. (Vinod et al., 2005). Some white sorghum has pigmentation in the pericarp and testa, due to phenolic compounds.
2.4.2 Phytic Acid in Guinea corn

Phytic acid and/or phytates compete with essential dietary minerals such as calcium, zinc, iron and magnesium to make them biologically unavailable for absorption. Sorghum bran contained the highest levels of phytates. Forty to fifty percent of the phytate and of total phosphorus can be removed by abrasive dehulling (Reichert and Youngs, 1977).

2.4.3 Cyanogenic Glycosides in Guinea corn

Cyanogenic glycosides occur in most sorghum varieties. The main cyanogenic glycoside, dhurrin, which is found mainly in the leaves and germinating of cereal seeds of Sorghum, can amount to 3-4% of the total dry seedling weight (Amadou et al., 2011).

In the course of processing germinating seeds, cyanide which is a very toxic material may be released. In the traditional food processing techniques such as drying and malting, the cyanide level seemed to be lowered to zero or to well below the value that is considered toxic (Nzelibe et al., 2000; Makokha et al., 2002).

2.4.4 Oxalate in Guinea corn

Oxalate is a concern because of its negative effect on mineral availability. High oxalate diet can increase the risk of renal calcium absorption and has been implicated as a source of kidney stones (Chai and Lieberman, 2004). Also, Oke (1969) and Oboh (1986) observed that oxalate affects calcium and magnesium metabolism and react with protein to form complexes which have an inhibitory effect on peptic digestion.
2.5 Methods of Detoxifying the Anti-nutritional Factors

There are some methods employed to remove or reduce antinutritional factors in feedstuffs which can enhance the absorption and utilization of nutrients in the digestive tract. Those methods are summarized below:

a) Supplementation of high-tannin diets with phosphoric acid or dicalcium phosphate (Ibrahim et al., 1998) or Sodium bicarbonate (Banda-Nyirenda and Vohra, 1990) had a positive effect in terms of detoxification of tannins. Addition of chemicals with high affinity for tannins such as Polyethylene glycol and gelatin (Salunkhe et al., 1990) has been shown to reduce the adverse effect of tannins. They explained that the chemicals would bind dietary tannin thereby preventing the tannins from binding to nutrients.

b) Treatment of grain with 20% solution of sodium hydroxide at 70°C for 8 minutes followed by washing with hot water (60°C).

c) Soaking grain in 0.05M sodium hydroxide and potassium hydroxide or sodium carbonate at 100°C for 20 minutes.

d) Spraying ammonia solution (350 g kg⁻¹) at room temperatures for 7 days.

e) Treatment of sorghum to reduce dry matter to 70% followed by anaerobic incubation at 25°C for 48 hours (Gualtieri and Rapaccini, 1990).

2.6 Guinea corn as an Alternative Energy Source in Poultry Diets

Considering the nutritive value, cost and availability, guinea corn grain can replace maize in poultry feed as energy source without altering the performance of broiler chicken (Maunder, 2002; Rama Rao et al., 2002; Raju et al., 2003).

A study by Subramanian and Metta (2000) indicated that sorghum grain is as ideal as maize for poultry. Pro and Cuca (1968) compared two varieties of wheat with guinea corn and maize. They showed that guinea corn was effective in poultry as well as
turkey diets. Results indicated that maize, wheat and guinea corn may be used effectively in poultry diets when fed on the basis of their nutrient composition in properly balanced poultry feeds (Waldroup et al., 1967; Selle et al., 2003a; Adamu et al., 2006).

Adamu et al. (2006) also observed no depressive effect on growth and feed efficiency when guinea corn replaced maize even at 100% in meat chickens. Smithhard (2002) reported poor performance of poultry fed high tannin sorghum-based diet even when supplemented with soybean. Cullison (1987) nevertheless, reported that guinea corn can replace 50% of maize with no adverse effect on animal performance.

Rama Rao et al., (2001) and Travis et al., (2006) observed that, replacement of maize with sorghum did not reduce the live body weight (LBW), live body weight gain (LBWG), feed intake and feed conversion ratio (FCR) significantly. Additionally, nitrogen and gross energy concentrations of guinea corn was higher than that of maize. Histidine and methionine values were higher in maize than guinea corn.

Concentration of the indispensable amino acids in the grains followed the same trend as that of nitrogen (Adeola, 2006). So, the growing chicks which consumed diet based on 75% guinea corn, gave the best LBW and LBWG values, followed by those fed diets based on 25% or 50% guinea corn, respectively, while those fed diet based on 100% sorghum had the lowest value.

Reddy et al. (2008) concluded that, 50% replacement of maize with sorghum did not impair body weight and FCR of broiler, when compared with the maize based diet. Throughout the growth period (0-12 week of age), the effects of substituting maize with sorghum grains in the diets of chicks on feed intake (FI) and feed conversion (FCR) were insignificant among the dietary sorghum treatments when comparing with the control group.
The above-mentioned findings on productive performance agreed with previous workers that worked with broiler chicken and quails (Makled and Afifi, 2001; Ragab, 2001; Abd El-Hakim et al., 2003). These authors reported that, yellow maize could completely be substituted with sorghum without any adverse effects on performance. In this respect, Hala (1998) and El-Full et al. (1998) found that sorghum can completely substitute yellow maize in broiler diet with no obvious deterioration of economical efficiency.

Oria et al. (1995) stated that, the discovery of cultivars of sorghum with high in vitro protein digestibility, which may be comparable or superior to that of other cereal grains, can provide a viable alternative or complement to maize as the source of energy in poultry diets.

Sorghum grain varieties were well studied as a substitute for maize, it however contains potent polyphenolic tannin with antioxidant properties (Yokozawa et al., 1998; Awika et al., 2000). Also, El-Khalifa and El-Tinay (1994) reported that, tannin and related phenolic compounds have strong antioxidant properties. Furthermore, the antioxidant and immunomodulating properties of polyphenols in sorghum grains affect immune response by protecting against oxidative stress and lipid peroxidation, improving humoral and cellular immune response indicated by increase in bursa-derived cells and thymus cells (B and T) cell proliferation (Bendich, 2004).

From the previous findings, yellow maize could be completely substituted by sorghum without any detrimental effects on productive performance of broiler chickens. In another experiment (Nyachoti et al., 1997), high tannin guinea corn fed chickens had higher feed intake and gained more weight during 1-9 days than their maize-fed counterparts, although final live weight and feed conversion ratio was similar. Results
of the study of Jacob et al. (1996) and Ambula et al. (2001) high tannin guinea corn could be used to substitute for white maize up to 100% in broiler starter diets with no significant adverse effects on growth performance and feed conversion ratio.

Farmers have the notion that sorghum has tannin and has low energy compared to maize grain (Subramanian and Metta, 2000). Studies by Kumar et al. (2007) revealed that feeding reconstituted red sorghum-based diet with a tannin content of 16 g/kg to broiler chicken at 100% replacement of maize did not exert any appreciable influence on nutrient utilization, blood biochemicals, enzymes and gross pathological changes. However, raw red sorghum-based diet with 23 g/kg tannin fed to broiler chickens caused higher immuno-responsion when compared to their reconstituted counterpart.

It is possible that the development of low tannin sorghum could raise its value to comparable level with maize in poultry diets.

Luis (1980) observed that sorghum was similar to millet in true metabolisable energy (TME) but lower than maize. Dry matter digestion and gross energy of sorghum was, however, higher than millet. When sorghum was compared to millet and maize on an equal weight or a protein equivalent basis in broiler diets with adequate protein (22.5% CP), there was no significant differences in body weight gain or feed efficiency.

Improta and Kellems (2001) compared raw, polished and washed quinoa with wheat, sorghum and maize on low protein diet (13.28% CP) and observed that at 21 and 28 days of age broiler chicks fed sorghum had the highest survival rate (100% and 96.72% vs. 96.37 and 96.3%), respectively, for sorghum and maize. Weight gains at 7, 14 and 21 days of age were also highest for sorghum diets (88 g, 139.9 g and 221.0 g vs. 63.1 g, 76.05, and 91.0 g) respectively, for sorghum and maize based diet
respectively). Feed intake followed the same trend (33.48 kg vs. 26.36 kg) for sorghum and maize, respectively.

Results obtained with white and yellow local variety of sorghum in India by Subramanian and Metta (2000) showed no adverse effect on egg production with one-third (15%), as well as, whole replacement of maize (Table 2.3). Broilers fed both local (white and yellow) and improved (ICRISAT developed ICSV 112) varieties at 45% replacement level for maize recorded comparable performance in all parameters measured (Subramanian and Metta, 2000). This report agrees with earlier observation on the use of sorghum for layers and broilers (Thakur et al., 1984; Asha Rajani et al., 1986). However, Rama Rao et al. (1995) and Thakur et al. (1984) suggested that sorghum can replace maize from 50% to 74% only.

Blaha et al. (1984) working with 441 male broilers reported that sorghum (Var. technicum) could be used successfully as the only cereal components of diet for broilers. They observed that chickens given diet with sorghum had higher weight gains than those given diet with maize. However, FCR was better with maize based diet whereas health of chicks and sensory characteristics of meat were not affected in chickens fed sorghum except for the pale skin, legs and beak due to lack of Xanthophylls.

2.7 History, Taxonomy and Distribution of Millets

Millets belong to the Poales order and to the family of Gramineae. They are known as coarse cereals beside maize (Zea mays), sorghum (Sorghum bicolor), oats (Avena sativa), and barley (Hordeum vulgare) (Bouis, 2000; Kaur et al., 2012). Millets are in the family of cereals grown globally with differential importance across continents and within regions of the world (ICRISAT/FAO, 1996). Obilana and Manyasa (2002) reported that the most important millets are pearl millet (Pennisetum glaucum), finger
millet (*Eleusine coracana*), proso millet (*Panicum miliaceum*), and foxtail millet (*Setaria italica*).

### 2.8 Chemical Composition of Millets

#### 2.8.1 Carbohydrates in Millets

FAO (1995) and Rachie and Peters (1997) reported that millet grain contain 9.2 percent protein, 1.29 percent fat, 76.32 per cent carbohydrates, 2.24 per cent minerals, 3.90 percent ash and 0.33 percent calcium. Vitamins A, B and Phosphorus are also present in smaller quantities.

The germ of pearl millet constitutes a much larger percentage of the total kernel than that of sorghum (17.4% in millet and 9.8% in sorghum) (Ali et al., 2003; Singh et al., 2012). This difference explains in part the lower starch, the higher protein and oil contents of millet as compared to sorghum. Starch represents about 56 to 65% of the kernel and is about 20 to 22% amylase. Free sugars range from 2.6 to 2.8% of the grain. The main sugar in pearl, foxtail, finger, and proso millets is sucrose. Most of the dietary fiber of millets is insoluble.

Interestingly α-amylase activity is 8 to 10 times greater in pearl millet than in wheat (Sheorain and Wagle, 1973; Ragaee *et al.*, 2006; Singh and Raghuvashi, 2012). The lysine content of pearl millet was 21% greater than maize and 36% greater than Sorghum.

#### 2.8.2 Proteins in Millets

The protein content of pearl millet ranges from 8 to 19%, and there is better amino acid balance than in sorghum. Pearl millet contains high crude protein and well balanced amino acids that sorghum (Jambunathan and Subramanian, 1988). Finger, teff, and kodo millets have similar amounts of lysine as in pearl millet. Fractions of
protein in millets are as follows; albumins globulins from 22 to 28%, prolamin prolamin-like 22 to 35%, glutelin and glutelin-like 28 to 32% of total nitrogen. The prolamin fraction in pearl millet is smaller than sorghum (Hulse, et al., 1980). Finger millet has been reported to have a carbohydrate content of 81.5%, protein 9.8%, crude fiber 4.3%, and mineral 2.7% that is comparable to other cereals and millets (Ahmed et al., 2013). Its crude fiber and mineral contents are markedly higher than those of wheat (1.2% fiber, 1.5% minerals) and rice (0.2% fiber, 0.6% minerals); its protein is relatively better balanced; it contains more lysine, threonine, and valine than other millets (Ravindran, 1991; Sripriya et al., 1997).

NRC (1996) reported that millets are important preventive against malnutrition, especially kwashiorkor since it has a better nutritional profile than maize. For example, Calcium > 5000%, Iron and Manganese > 350% and also with higher levels of copper and essential amino acids which are recommended as the ideal food for the diabetics, elderly, the sick and especially those affected by HIV/AIDS (Bravo, 1998; Truswell, 2002; Shobana et al., 2009; Kim et al., 2011; Gupta et al., 2012). As a result, children from finger millet eating parts of the country suffer less from nutritional diseases compared to those from banana eating areas.

2.8.3 Lipids in Millets

The lipid content is generally high (3 to 6%) for pearl millet, higher than for sorghum and most other common cereals. For this reason the energy of millet is greater than that for sorghum and nearly equal to that of brown rice. About 75% of the fatty acids in pearl millet are unsaturated, and linoleic acid is particularly high (46.3%) as reported by Jambunathan and Subramanian (1988).
After hulling or milling, the high lipid content, higher amounts of unsaturated fatty acids and high enzymatic-hydrolytic activity in millet products leads to rapid development of odours and flavours.

### 2.8.4 Vitamins and Minerals in Millets

Gomez (1993) reported that finger millet is a rich source of calcium 0.33%, which is 5-30 times more than in most cereals with high phosphorus and iron contents. Its exceptionally high calcium content makes it an important food for pregnant women, nursing mothers and children. Because it is often grown in favourable production environments (unlike other millets), yields can be competitive with those of rice and other ‘green revolution’ cereals especially if research effort are increased (NRC, 1996; CGIAR, 2001).

The vitamin content of pearl millet is not much different from sorghum. Dried, matured kernels do not contain vitamin C and the B vitamins are concentrated in the aleurone layer and germ. Removing the hull by decortications reduces the levels of thiamine, riboflavin and niacin by about 50% in the flour. Niacin in cereals is found in free and bound forms and can be synthesized from tryptophan. The niacin content of the hulled millet seed is still significant. This is why pellagra the vitamin deficiency disease, is not found in areas where millet is consumed in great quantities. Malting and fermentation increases the amount of B vitamins and their availability (Hotz and Gibson, 2007). The various mineral components of sorghum and millets grain vary widely, to a large extent reflecting the mineral composition of the soils and conditions where the plants are grown. In spite of this, the total mineral (ash) content of all the millets is often higher than that of sorghum and other cereals (Olomu, 1995; Ojewola and Oyim, 2006; Hotz and Gibson, 2007; Ahmed et al., 2013).
20

Oryokot (2001) reported that the main protein fraction (eleusinin) in finger millet has high biological value with good amounts of tryptophan, cystine, methionine (approximately 5%) and total aromatic amino acids (phenylalanine and tyrosine) which are crucial to human health and growth and are deficient in the diets of the poor who live on starchy foods like cassava, plantain, polished rice and maize meal.

2.8.5 Anti-Nutrients in Millets

Millets have the following anti-nutrient components; polyphenols and tannin, phytic acid and phytate, goitrogens, and oxalic acid. Millet changes colour reversibly from grey to yellow-green at alkaline pH, and partially reversibly from grey to creamy white under acidic conditions due to the presence of phenolic compounds namely glucosylvitexin, glucosylorientin, vitexin (Reichert, 1979). Polyphenols and tannin compounds are concentrated in the bran. Decortication significantly decreases the amount of tannins with a corresponding increase in protein digestibility (Hotz and Gibson, 2007).

Chemical analysis have revealed 208 to 246 mg of phytic acid/100 g in finger millet, and the phytate content for proso millet was 0.17 to 0.47%. These values are higher than in rice (Ahmed et al., 2013).

Dehulling of pearl millet grains reduced total phytic acid, polyphenols, and tannin and significantly increased the protein digestibility but decreased the quality attributes of millet (ElShazali et al., 2011; Chandrasekara and Shadhid, 2012; Krishnan et al., 2012). Dehulling of proso millets caused a 27 to 53% reduction in phytate content (ElShazali et al., 2011; Krishnan et al., 2012). Pearl millet, along with other grains, contains oxalic acid, which forms an insoluble complex with calcium, thereby reducing biological availability of this mineral. Calcium concentration in pearl millet
is quite low, and the presence of oxalate can exacerbate the deficiency (Grewal and Jood, 2006).

2.9 Nutritional and Economic Importance of Guinea corn and Millets

NRC (1996); FAOSTAT (2005); and FAO (2012) reported that sorghum and millets play an important role in both the dietary needs and incomes of many rural households. Like other cereal grains, they are energy feeds valuable for their high caloric contents. The grains are used for poultry feeds. It is also considered a helpful famine crop as it is easily stored for lean years; the grain is readily digestible, highly nutritious and versatile, it can be cooked like rice, ground to make porridge or flour or used to make cakes (de Wet, 2006; FAO, 2012).

Sorghum and millets are eaten in a different of forms that vary from region to region. In general, it is consumed as whole grain or processed into flour, from which traditional meals are prepared (Taylor et al., 2006; Subramanian and Viswanathan 2007; Liu et al., 2012). The principal use of millet grain is for food (85%), with about 9% used for feed (FAO, 2012).

2.9.1 Commercial Products

Of major importance is that across Africa, sorghum is becoming the grain of choice for lager and stout beer brewing by major international companies (Taylor et al., 2006). This is because of its competitive price and availability compared to barley and its intrinsic good brewing properties in terms of starch content and malting quality.

In Africa, sorghum and millets are also used to produce a very wide range of traditional foods and beverage products (Taylor and Emmambux, 2008a, b). Some of these have been exploited commercially, most notably opaque beer which is brewed industrially on a large scale in several southern African countries (Daiber and Taylor, 1995). With the rapidly increasing urbanization in Africa and growth of the middle
class, who demand convenient and healthy foods, there is much scope for commercialization of other traditional African sorghum and millet products.

Other main sorghum/millet-based foods as reported by Viswanathan (2007), Taylor and Emmambax (2008a, b) include:

- Flat bread, mostly unleavened and prepared from fermented or unfermented dough in Asia and parts of Africa. Thick porridges, thin porridges, steam-cooked products, fermented breads, unfermented breads, boiled rice-like products, alcoholic beverages, non-alcoholic beverages and snacks.

- Thin or thick fermented or unfermented porridge, mainly consumed in Africa.

- Boiled products similar to those prepared from maize grits or rice.

- Preparations deep-fried in oil. Per capita consumption of sorghum is highest in Africa. For example, per capita consumption is 90-100 kg/yr in Burkina Faso and Sudan. Sorghum provides over one third of the total calorie intake in these two countries (Taylor et al., 2006). The most common and simplest food prepared from sorghum and millets is porridge.

However, in many African and Asian areas, millets serve as a major food component and various traditional foods and beverages, such as bread (fermented or unfermented), porridges, and snack foods are made of millet, specifically among the nonaffluent segments in their respective societies (Chandrasekara and Shahidi, 2011; Chandrasekara and Shahidi, 2012).

In all cultures traditionally depending on cereals, a range of treatments of the whole seed before milling and sifting has been applied. The treatments procedures are steeping, fermentation, malting, alkali or acid treatment, popping, roasting (dry or wet), parboiling, and drying.
Millet is traditionally pounded in a mortar, but mechanical dehulling and milling are increasingly used since they eliminate a considerable amount of hard labor and generally improve the quality of the flour (FAO, 2012). One of the aims of seed treatment is to remove the polyphenolic compounds from the seed. Others are to improve storage quality or to make many kinds of snacks and other popular foods.

The traditional art of food preparation is not standardized and routine procedures have been passed on to the women through generations. The stiff porridge prepared from maize or cereal mixture (maize, sorghum, pearl millet, finger millet, etc.) in Kenya, Uganda and Tanzania is commonly called ugali. The most important fermented thin porridge that is consumed in Nigeria and parts of Ghana is ogi.

In much of Northern Africa a steamed, granulated product called couscous, made from cereal flours (mostly wheat) is highly popular (FAO, 2012). In West Africa, sorghum, pearl millet, maize, and fonio are used to prepare couscous, although pearl millet is preferred. Sorghum noodles are an important food product in China. Sorghum is used for tortilla preparation either alone or in combination with maize in Honduras, Nicaragua, Guatemala, El Salvador and Mexico (FAO, 2012).

Roti is an unfermented dry pancake made in India from wheat, sorghum, pearl millet and maize flour. Sorghum grain is used in the production of two types of beer namely clear beer and opaque beer (FAO, 2012). The latter is a traditional, low-alcohol African beer that contains fine suspended particles. Sorghum is traditionally a major ingredient in home-brewed beer. Small quantities are used in the beer industries in Mexico and USA. Sorghum is a good source of starch, cellulose, and glucose syrup. Although domestication was primarily for food (and also for beer and sweet stems in Africa, and for brooms in China), crop residues have been valued as animal fodder, building materials, and fuel. By applying hydrothermic technologies (flaking, puffing,
extrusion, micronizing) new sorghum and millet products of good quality and good
taste can be produced.

2.10 Trends in Millet Production in Africa

The global area under millets has shown a slight decline from 38.1 million ha in 1981
to 37.6 million ha in the mid 1990s (FAO, 2004). Despite this global decline, Africa’s
acreage has shown a slight increase and the continent has now become the world’s
leading producer of millet. Between 1970 and 2000, millet production in Africa
increased by 22%, whereas other regions registered substantial declines. However, the
Consultative Group on International Agricultural Research (CGIAR) assumes that of
the total global millet area of 34.6 million ha (FAO, 2004), 10% is finger millet.
Within the East and Central African region, finger millet is the most important in
Uganda considering its share in the total cereal production while acreage under pearl
millet production is highest in Sudan. Other important millet producing countries
include Ethiopia, Eritrea, Tanzania and Kenya. FAO/WEP (2000) reported that
discriminative agricultural policies against millets relative to those for other cereals
and poor marketing infrastructure have exacerbated the slow productivity growth and
low producer prices resulting in low competitiveness of these crops.

2.11 Processing of Guinea corn and Millets

These are characterized by predominance of traditional practices that entail planting of
farmers home –saved seeds. The mature panicles are harvested using thumb knives
and sundried on bare ground, rocks, or mats (NRC, 1996; Ahmed et al., 2013). They
are later threshed by beating the dried panicles with sticks, winnowed in flat trays and
dehulled in mortar and pestle followed by narrow utilization based on value -added
products in the form of thin or thick porridge and alcoholic beverages (NRC, 1996;
Ahmed et al., 2013).
They are processed at household level, by the millers who at times double as traders, stockists and processors. The grains are hard - hulled and should be ground finely before being fed to animals (Calder, 1960; Raju et al., 2003; 2004). A very fine screen should be used as some of the grains are extremely small and may escape grinding if a larger gauged sieve is used (Calder, 1960). At household level, processing involves post harvest handling such as drying, threshing, winnowing, sorting and storing.

Development of products like flour to produce porridge, Atap (millet or sorghum and Cassava) and yeast with the exception of milling, which can also be done manually (Rooney, 1992). Oniang’o (1996) reported that fermentation makes nutrients present in the grains more readily available to the body by reducing the tannin binding ability.

Fortification is the process of supplementing minerals and protein contents. Rural consumers generally consume finger millet in traditional ways, with less processing. This implies that rural areas might provide a potential market for industrially processed finger millet, which could be tapped.

2.12 Millets as an Alternative Energy Source in Poultry Diets

Millets contains fewer antinutritional factors than many other grains (Andrews and Kumar, 1992; Choct, 2006) and possesses unique nutritive values that are attractive for poultry nutrition. Arabinose and xylans are the major water-soluble NSP in pearl and finger millet grains (Hadimani et al., 2001). In comparison with maize, millets possesses better ME levels and higher amino acid concentrations (Andrews and Kumar, 1992; Adeola and Orban, 1995; Yin et al., 2002; Davis et al., 2003).

Furthermore, the digestibility of essential amino acids, namely, lysine, arginine, threonine, valine and isoleucine, were higher in millet-based diets than in maize -based diets fed to pigs (Adeola and Orban, 1995). In broilers fed isonitrogenous and isocaloric pearl millet (PM) and maize -based diets, performance and carcass yields
were equivalent or better in the pearl millet groups of birds (Davis et al., 2003; Hidalgo et al., 2004; Manwar and Mandal, 2009).

It is also worth mentioning that the concentrations of ME, CP, amino acids, and antinutritional factors vary greatly between different pearl millet varieties (Buerkert et al., 2001; Mustafa et al., 2008). Millets can replace maize in the diets of broiler chickens without adverse effects on growth rate and feed conversion ratio (Adamu et al., 2001, Medugu et al., 2010 and FAO 2012).

Millets has high nutritional value, with no tannin and higher protein and mineral contents than maize and sorghum (Appa – Rao et al., 1989; NRC, 1996; Kaur et al., 2012; Ahmed et al., 2013). Millet also has higher oil content than other common cereal grains (Sullivian et al., 1990; Hill and Hanna, 1990; Adeola and Rogler, 1994) and a better source of linolenic acid (Rooney, 1978). It has also been indicated that millet is superior to maize and sorghum in protein content and quality, as well as protein efficiency ratio (PER) values.

According to Olomu (1995) millet has a lower Metabolizable Energy (2555 kcal/kg), but higher percent crude fibre (4.30), ash (3.00) and crude protein (12.0). Olomu (1995) reported 8.80, 12.00 and 9.50% CP levels for maize, millet and sorghum. Some researchers (Ojewola and Oyim, 2006) reported that millet had higher crude protein (11.90%), crude fibre (7.92%) and ash (3.83%) than maize and sorghum. Medugu et al. (2010) reported that the final body weight, average daily weight gain and feed conversion ratio (FCR) were similar when maize, millet, and sorghum with low and high tannin content were used as energy sources in broiler chicken diets. Similar results were reported by Adamu et al. (2001) when millet, maize and sorghum were fed to broiler chickens. They concluded that high- and-low tannin sorghum can be incorporated into broiler chickens diets without adverse effects on the performance
such as final body weight, daily weight gain and feed conversion ratio. However, another study found that a 75% substitution did not affect body weight gain, feed efficiency, feed consumption adding that it was economically efficient (Jayanaik et al., 2008).

Davis et al. (2003) also reported that at day 1 to 42, birds fed 100% pearl millet (PM) diet had greater body weight, feed intake, and feed conversion ratio than birds fed the maize based diet. At 14, 28, and 42 days of age, birds fed the pearl millet based diet were consistently heavier than birds fed the maize based diet, pearl millet 25%, and pearl millet 75% diets. Birds fed the PM 50% diet were also heavier at day 14 and 28 than those fed the pearl millet 25% diet. However, increased body weight occurred among birds fed the pearl millet 50% diet compared with those fed the pearl millet 75% diet, but only at day 14. Body weight did not differ between birds fed the pearl millet 100 and pearl millet 50 diets at any time point.

The report of Flurharty and Loerch (1996) showed that high energy finisher diets results in high performance with no detrimental effect on birds in the tropics when finger millet was used as component part of feed in diets. Davis et al. (2003) reported that inclusion of 500g/kg of millet cultivars resulted in no loss of performance of broiler chickens. Similarly, Singh et al. (2000) reported that inclusion of millet up to 600g/kg gave excellent egg production and better feed conversion ratio.

Mammo and Sultan (2010) reported that there were significant differences in average feed intake and body weight gain when using selected energy sources on the performance and carcass characteristics of broiler chickens and no significant difference in feed conversion ratio of all the treatment groups.
Some workers reported that low tannin sorghum is similar to maize in nutritional value and responded equally to that observed in maize based diets (Gualitteieri and Rapacci, 1990; Jacob et al., 1996).

Fuller et al. (1996) reported variation in tannins from 0.2 to 20% and ME from 2617 to 3516 kcal/kg for sorghum. Gowda et al. (1984) reported 0.55% tannins in sorghum, while Sharma et al. (1979) recorded none.

Lucberd and Castain (1986) stated that the nutritional value of sorghum with a tannin content of lower than 10g/kg was similar to that of maize. These findings were confirmed by Reza and Edriss (1997) who stated that all the dietary maize portion of broiler diets can be replaced with low-tannin sorghum without adverse effects on live weight gain, feed intake and feed conversion ratio.

Table 2.2 Shows the productive performance of broiler chickens fed maize, millet, high-and-low tannin sorghum-basal diets.
Table 2.2: Performance of Broiler Chickens Fed Maize, Millet, low and high Tannin Sorghum

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Maize</th>
<th>Millet</th>
<th>Low-tannin Sorghum (“chakalere”)</th>
<th>High-tannin Sorghum (“jigari”)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial weight (g)</td>
<td>353.30</td>
<td>350.33</td>
<td>343.33</td>
<td>353.33</td>
</tr>
<tr>
<td>Final body weight (g)</td>
<td>2142.00</td>
<td>2218.67</td>
<td>2112.00</td>
<td>1931.33</td>
</tr>
<tr>
<td>Daily weight gain (g)</td>
<td>41.39</td>
<td>43.17</td>
<td>39.66</td>
<td>34.44</td>
</tr>
<tr>
<td>Daily feed intake (g)</td>
<td>97.41</td>
<td>94.03</td>
<td>98.79</td>
<td>100.71</td>
</tr>
<tr>
<td>FCR</td>
<td>2.45</td>
<td>2.24</td>
<td>2.88</td>
<td>2.94</td>
</tr>
</tbody>
</table>

Source: Medugu et al. (2010)

FCR: feed conversion ratio
2.13 Millet Utilization in Layers Diet

Rama Rao et al. (2000) reported that egg production, egg weight and efficiency of feed utilization were not affected in layers during the laying periods when fed finger millet at 32-60% as a principal source of energy compared to those fed maize based diets. Singh et al. (2000a) observed that inclusion of millet up to 600g/kg gave excellent egg production and better feed conversion ratio (FCR). Café et al. (1999) assessed performance and egg quality of commercial laying hens fed diets with increasing substitution levels of metabolizable energy of pearl millet for maize and there was no statistical differences in egg production, feed intake, feed conversion, mean egg weight and percentage of shell, yolk and albumin. Table 2.3 shows the performance of laying hens fed diets formulated on a total of digestible Amino acid basis with increasing levels of pearl millet (25-45 weeks) as reported by Rostagno et al. (2000).
Table 2.3:  Performance of laying hens fed diets formulated on a total of digestible Amino acid basis with increasing levels of pearl millet (25-45 weeks)

<table>
<thead>
<tr>
<th>Pearl millet substitution for maize</th>
<th>Feed intake (g/day)</th>
<th>Egg-production (%)</th>
<th>Feedconversion ratio</th>
<th>Egg weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>94.86</td>
<td>87.56</td>
<td>1.82</td>
<td>59.65</td>
</tr>
<tr>
<td>25</td>
<td>92.25</td>
<td>84.34</td>
<td>1.86</td>
<td>59.10</td>
</tr>
<tr>
<td>50</td>
<td>87.74</td>
<td>81.61</td>
<td>1.88</td>
<td>57.72</td>
</tr>
<tr>
<td>75</td>
<td>86.69</td>
<td>82.42</td>
<td>1.85</td>
<td>57.12</td>
</tr>
<tr>
<td>100%</td>
<td>86.61</td>
<td>79.72</td>
<td>1.90</td>
<td>57.37</td>
</tr>
</tbody>
</table>

Source: Rostagno et al. (2000)
2.14. Nutrient Requirements of Broiler Chickens

There is need to formulate rations that will fulfill all the nutrient requirements, including energy and protein, for growth. Often, energy requirements in poultry are expressed in terms of metabolisable energy per day (Smith, 1990). Nutritional diseases can attack birds, if the diets are not appropriately balanced. The accurate quantity of these nutrients required in diets depends on the type, age, and production category.

Poultry are supplied enough feed to meet their energy requirements since the control of feed intake is believed to be based on the amount of energy in the diet (Nahashon et al., 2006). Increasing the dietary energy concentration leads to a decrease in feed intake and vice versa (Veldkamp et al., 2005), thus affecting growth. However, as suggested by Smith (1990), this is valid as long as the diet is adequate in all other essential nutrients, and that nutrient density, accessibility and palatability do not limit feed intake. On the other hand, dietary requirements for protein are actually requirements for the amino acids contained in the protein (NRC, 1994). Amino acids obtained from dietary protein are used by chickens to fulfill a diversity of functions such as growth, meat or egg production. Protein deficiency in a feed reduces growth. Harper and Rogers (1965) reported that protein deficiency in a feed reduced growth in broiler chickens as a consequence of depressed appetite and, thus, intake of nutrients. Feeding animals below their energy or protein requirements thus reduces growth and efficiency of nutrient utilization.

2.14.1 Energy Requirement of Broiler Chickens

Energy is one of the critical nutrients in ration which is required by all animals. Its requirement is the amount of available energy that will provide for growth, maintenance of body tissues, egg production, regulation of body temperature and
activity (Pond et al., 2005). Major sources of energy for poultry rations in Nigeria are sourced from cereal grains such as maize, millet, guinea corn, wheat and broken rice, cereal-by-products such as maize bran or offal, millet bran, wheat bran or offal, rice bran or offal, brewers’ dried grain, guinea-corn offal and starchy roots and tubers which includes cassava flour, cassava chips and sweet potato (Ajayi et al., 2005; Aderemi et al., 2006).

Metabolizable energy (ME) measured in kilocalorie per kg diet (kcal/kg), has been found most reliable for evaluating energy needs in the poultry ration above other systems such as gross energy (GE) and net energy (Ensminger, 1991). Carbohydrates are the major sources of energy in poultry diets although fats supply concentrated form of energy (2.23 times more energy than carbohydrate), their inclusion as true fats or oils in the ration is seldom practiced in Nigeria because of high cost and the risk of rancidity which develops on prolong exposure to air, heat, sunlight (NRC, 1994).

Energy feed ingredient sources from grain contain 2 to 5 per cent fat and that is enough for the inclusion of one essential fatty acid (Linoleic acid), which must be present in the diet of young growing chicks to prevent poor growth, accumulation of liver fat and susceptibility to respiratory infection (NRC, 1994). An increase in the energy level made the chicks to grow faster with a drop in their feed intake (NRC, 1996). In the tropics, ME of 2800Kcal/kg of chick starter is needed for optimum performance (Olomu, 1995).

Fisher and Wilson (1994) reported that feed intake of birds increased with a low energy diet as the birds will eat to meet its energy requirement. Loosli et al. (1993) reported that within the temperature range of “thermal neutrality” (i.e. between about 13°C and 31°C) energy requirements are reduced by approximately one percent for each one degree centigrade rise in temperature.
2.14.2 Protein Requirement of Broiler Chickens

Documented evidence abounds to show that protein like energy is one of the critical nutrients in poultry rations (Mander, 1980). Protein requirement of poultry are met by using protein from plant and animal origins. Potential sources of plant protein include soyabean meal, groundnut cake, cowpea, bambara nut, canola meal, sunflower meal and palm kernel meal. Vegetable and plant feedstuffs have a good potential of supplying birds essential amino acids, vitamins, minerals, antioxidants and enzymes (Omenka and Anyasor, 2010).

The animal sources are chiefly fish meal, meat meal, blood meal, milk powder and to some extent bone meal (Ogundipe, 2003). Olomu (1995) reported that all animals require protein for growth, reproduction and production, depending on the age, productivity of the animal and their environment. However, protein requirement drops as the chicken gets older (Olomu, 1995).

It is important to supply protein to animal as it is component part of all living cells and often undergo continuous degradation and disintegration. Defang et al. (2008) reported that the broiler starter should have a higher protein (20-24%) than the finisher (20%). Ensminger (1991), Aduku (1993) and Oluyemi and Robert (2000) reported that broiler starter and finisher rations must contain 23% and 20% of crude protein respectively for optimum production level of the animal.

A typical broiler starter ration should contain from 21-24% protein and a typical laying ration from 15-17% protein (Ensminger et al., 1990). Aduku (1992) reported 23% and 20% for broiler starter and finisher respectively. Swatson et al. (2000) and Swatson et al. (2002a and b) reported that altering the dietary energy to protein ratio levels in broiler chicken diets affected weight gain, feed conversion ratio as well as the efficiency of utilization of dietary protein in the chickens. However, other reports
have shown no effect of dietary metabolisable energy to crude protein ratio on dietary feed intake by broiler chickens (Summers et al., 1992).

2.14.3 Amino acid (AA) Requirements of Broiler Chickens

In broiler production, meeting the protein needs is much more complex than that of other nutrients. In addition, ingredients that are used primarily to supply dietary protein are among the most expensive ingredients in broiler diet (Ojano – Dirain and Waldroup, 2002). The birds need amino acids for numerous metabolic functions other than protein synthesis. As a nutritionist, it is assumed that the estimated need of the limiting amino acids determined by dose-response measurements reflect the quantitative need of the bird (Eits et al., 2002).

The global competitiveness of broiler meat production and the variable sometimes narrow, profit margins have strengthened the need to feed birds well balanced diets that meet rather than exceed the amino acid needs. The ideal protein is the exact balance of AA that precisely meets the animal’s needs. According to Ogundipe (2003) there are twenty amino acids required by the animal body, out of which ten (10) are essential and therefore must be supplied in the feed. The remaining can be synthesized directly in the body. Four or five of these essential amino acids are very critical in poultry rations and so require special attention in feed formulation.

Lysine, methionne, threonine and tryptophan and sometimes arginine are the critical amino acids as they are the most difficult to supply in proper amounts in feed proteins (Ogundipe, 2003). Today, ideal amino acids ratio, with lysine as the reference amino acids, are increasingly used for poultry especially broilers (Baker and Han, 1994; Baker, 1997; Emmert and Baker, 1997; Mack et al., 1999; Baker et al., 2002). Baker and Han (1994) reported that the recommended amino acids requirements could not apply to all birds under all dietary, sex and body compositional circumstances.
The use of ideal amino acids concept allows formulating very low protein diets, which is useful in several ways. In practice, it is very difficult if not impossible to formulate diets with natural feed ingredients that will provide the entire amino acids needed by chickens in adequate quantities and also to maintain an optimal amino acids balance with minimal excesses (Han et al., 1992).

However, the use of commercially available synthetic essential acids in broiler feeds can satisfy the broiler requirements for them (Moran and Stillborn, 1996). Nutritionist have utilized methionine, followed by lysine and more recently, threonine and tryptophan in poultry diets on a cost–effective basis (Waldroup, 2000).

The positive effect of lysine and other AA with and without AA ratios above NRC (1994) recommendations have been reported by certain authors on growth (Roth et al., 2001; Koch et al., 2002; Baker et al., 2002) and immunological responses (Corzo et al., 2006). Different AA ratios have been suggested by various authors depending upon the environment, diet type and the age of the bird (NRC, 1984; Baker and Han, 1994; Baker, 1997; Mack et al., 1999; Roth et al., 2001., Leeson and Summers, 2001., Baker et al., 2002). However, the most widely used ratio is that proposed by Baker and Han (1994) and also confirmed by Araujo et al. (2002).

Labadan et al.(2001) used a single basal diet 3,200Kcal/kg ME, 22%CP that was deficient in lysine to estimate the dietary lysine requirement of broilers to 14 day of age with graded supplementation using L-lysine having lysine content from 0.96 to 1.46% (0.86 to 1.36% digestible lysine). They reported 1.28, 1.32 and 1.21% requirement for body weight gain, breast meat yield and feed conversion ratio, respectively. Kidd and Fancher (2001) used similar dose response methodology to estimate the lysine requirement of broiler chicks from 1 to 18 day of age in two separate trials in diets containing 21.5% CP and 3200 kcal/ kg ME and 0.88% lysine.
balanced with other AA. The responses were evaluated by the multiple regression models. They estimated the total lysine requirement for body weight gain to lie between 1.19 and 1.22 and between 1.17 and 1.21% when feed: gain was used as the response variable.

Leitgeb et al. (2003) fed diets to broilers from 14 to 34 day that were balanced using an ideal ratio for all essential AA. Performance measured as body weight gain and feed: gain responded linearly to increasing concentrations of ideal protein up to the highest level. A second study from 24 to 34 day of age was conducted to investigate whether the linear response to increasing concentrations was dependent on an ideal profile of all essential AA or if only the first four limiting AA could be supplemented without concurrent increases to the dietary crude protein.

2.14.4 Factors Influencing Broiler Response to Ideal Amino-acids

The ideal AA ratio has been stated for a specific age of birds. However, there were conflicting evidences of broiler responses to ideal AA ratios with age, strain, environment and type of diet offered and/or carcass composition. Table 2.4 shows the ideal amino acid ratios: percent essential amino acid for broilers as proposed by various investigators.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Methionine</td>
<td>36</td>
<td>36</td>
<td>42</td>
<td>40</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Cystine</td>
<td>36</td>
<td>36</td>
<td>33</td>
<td>28</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Threonine</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>58</td>
<td>59</td>
<td>56</td>
</tr>
<tr>
<td>Valine</td>
<td>77</td>
<td>77</td>
<td>75</td>
<td>67</td>
<td>76</td>
<td>78</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>63</td>
<td>66</td>
<td>61</td>
</tr>
<tr>
<td>Leucine</td>
<td>109</td>
<td>109</td>
<td>100</td>
<td>117</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>16</td>
<td>16</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Arginine</td>
<td>105</td>
<td>105</td>
<td>104</td>
<td>100</td>
<td>104</td>
<td>105</td>
</tr>
<tr>
<td>Histidine</td>
<td>32</td>
<td>35</td>
<td>29</td>
<td>33</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Phy + Tyr</td>
<td>105</td>
<td>105</td>
<td>112</td>
<td>117</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

ND= not determined
It has been well established that the proportional partitioning of dietary AA requirements into components for maintenance and growth changed with age and body weight of the animal, with a steady increase in the proportion of dietary AA required for maintenance as birds grow in age (Emmert and Baker, 1997; Leeson and Summers, 2001).

Baker and Han (1994) suggested that the optimum ratio of the essential AA methionine, cysteine, threonine and tryptophan must increase in proportion to the progressively higher maintenance AA requirements of broilers beyond 3 wk of age. Mack et al. (1999) also suggested the application of several different diets between hatching and slaughter to accommodate a changing ideal AA profile. Because the requirement of lysine for maintenance is considerably lower than the maintenance requirement for other AA, the ideal ratio of other AA to lysine increases as the bird grows (Emmert and Baker, 1997; Edwards et al., 1999). However, Eits et al. (2002) estimated the efficiency of lysine utilization for protein deposition to decrease with increasing body weight and reported large differences in the maintenance requirement for lysine with increasing body weight. Based on results from the study of Corzo et al. (2006), high-yield male broilers should be fed a minimum of 0.93% total dietary lysine (0.85% calculated digestible) from 42 to 56 day of age. Lack of response by female broilers suggested that less dietary lysine may be needed for adequate growth and meat yield. In contrast, estimates of the tryptophan, threonine, isoleucine and valine requirements to maximize both body weight gain and FCR have been shown to be almost identical (Baker et al., 2002).

Considerable differences also exist in the literature with regards to the effect of broiler strain on lysine requirements and ideal AA profile. Han and Baker (1991) showed the lysine requirement, expressed as a percentage of the diet, to be the same for a slow –
The best growing strain was fully able to compensate for the higher AA requirements for all AA with the consequence that the ideal AA profile would also be similar between different broiler strains. Jorgensen et al. (1990) showed fast-growing broiler strains to retain more dietary energy as fat and less energy as protein, resulting in the carcass of fast-growing strains to have a lower protein content and higher fat content than their slow-growing counterparts at both 13 and 46 day of age. The observations were confirmed by many authors where lean chickens were shown to be more sensitive to low dietary protein independent of dietary AA (Leclerq, 1998; Alleman et al., 2000). Response criteria, sex and age of the bird are also contributory factors in broilers response to dietary lysine.

2.14.5 Fat Requirement of Broilers

The fat requirements of broiler birds are 5 – 6% (Olomu, 1995). Lipids are essential because they provide the body with maximum energy, approximately twice the energy of protein or carbohydrate facilitate intestinal absorption and transportation of fat-soluble vitamins namely A, D, E and K. Leeson and Summers (2001) reported that fats are widely used as energy sources in addition to improving the consistency and palatability of mash feeds. Carcass fat content is one of the main concerns of poultry companies as increasing awareness of consumers on health problems has generated rejection of fat carcasses. The different types of oil that have been or can be used to increase the energy in poultry diets include palm oil/ oil sludge, groundnut oil, melon seed oil and palm kernel oil.

2.14.6 Dietary Metabolizable Energy Requirements of Broilers

The nutrient requirements of broilers have frequently been expressed per unit of dietary metabolizable energy (Gonzalez and Pesti, 1993). This practice was based on the theory that birds will adjust their feed intake according to their ME requirement.
It was summarized by the NRC (1984) as “an absolute requirement for energy in terms of Kilocalories per kilogramme of diet cannot be stated because poultry adjust their feed intake to obtain their necessary daily requirement”.

Leeson et al. (1996) showed that broilers fed for 25 and 49 day of age were able to adjust their feed intake to a constant energy intake over a range of dietary ME from 2700 to 3300 Kcal/kg. A significant higher feed intake was noticed only in low ME diets (2700 Kcal/kg) than higher ME diets (2900 to 3300 Kcal/kg) which indicated that broilers have an innate ability to eat to a fixed energy requirement rather than to physical capacity as was suggested by Newcombe and Summers (1984). This led to the overall conclusion by these authors that broilers do indeed eat to a constant ME intake when viewed over the entire 49 day growing period. Based on these principles, Gonzalez and Pesti (1993) evaluated the concept of an optimum ME:CP ratio in broilers by a statistical evaluation of published data to determine if this ratio was a good predictor of body weight. The data reveal that while there was no single optimum ME:CP ratio. The body weight gain and feed intake could best be predicted as a quadratic functions of both CP and ME levels.

2.15 Response trends of Chickens to differing Feed Energy and Protein levels

2.15.1 Feed intake

The earlier theory that poultry adjust their feed intake to maintain a constant ME intake was the basis of the premise that the CP and AA concentrations of the diet should be increased in direct proportion to dietary ME in order to maintain a constant CP intake. While the concept of a constant ME:CP ratio in modern broilers was shown to be questionable (Pesti and Fletcher, 1983; Gonzalez and Pesti, 1993).

The consideration of feed intake in the expression of the AA requirements has been shown to be important. Gous (2007) suggested that where feed intake is seen as an
input, as is most often the case, it is not possible to optimize feeding programs successfully since the composition of the feed offered has a very important effect on voluntary feed intake.

Emmans and Fisher (1986) suggested that appetite is dependent on the nutrient requirements of the animal and the nutrient contents in the feed. Consequently, responses in feed intake may therefore be dependent on nutrient composition of the feed and the strain of chicken contrary to the previous belief expressed by Hill and Dansky (1954).

The theory of feed intake and growth in birds proposed by Emmans (1987) was based on the premise that birds attempt to grow at their genetic potential, which would imply that they would attempt to eat as much of a given feed as would be necessary to grow at that rate. Factors that would prevent them from achieving this goal would be the bulkiness of the feed or the inability to lose sufficient heat to the environment in order to enable those remains in thermal balance. This theory has been shown to predict feed intake and hence growth and carcass composition with considerable accuracy in birds (Ferguson and Gous, 1997).

Additionally, Cobb 500 broiler chickens (Burnham et al., 1992) and laying hens (Gous et al., 1987) have been shown to increase feed intake as dietary protein content in the feed is reduced, attempting thereby, to obtain more of the limiting protein irrespective of the feed energy level until a dietary concentration is reached where performance is so constrained that feed intake falls. However, Ross 308 strain of broiler chickens did not apparently conform to this theory (Kemp et al., 2005; Berhe and Gous, 2005). Instead of increasing feed intake as dietary protein content is reduced these birds reduced feed intake, resulting in lower growth rate than the Cobb 500 strain whose feed intake increased as dietary protein was reduced. These authors
concluded that the Ross 308 broiler chickens were selected for improved growth and feed efficiency using high protein feeds. Such selection results in leaner carcasses (Pym and Solvens, 1979) and perhaps a reduced ability to fatten when faced with feeds marginally deficient in protein. These observations on limitations in feed intake response patterns in Ross 308 broiler chickens and Cobb 500 chickens contradict the strongly held theory that chickens eat to satisfy their energy requirements (Hill and Dansky, 1954; Leeson et al., 1996; Scott et al., 1982) or that chickens will eat less of a feed higher in energy content than the one having a lower energy concentration (Nahashon et al., 2006; Plavik et al., 1997; Veldkamp et al., 2005). In fact, the factors involved in broiler chicken feed intake control mechanisms are not completely understood. However, it has been shown that chickens will increase their feed intake in response to marginal levels of first limiting feed nutrient, independent of the diet energy level (Boarman, 1986), since appetite is assumed to be dependent on the nutrient requirements of the animal and the contents of those nutrients in the feed (Emmans and Fisher, 1986). As such, some other macronutrients apart from energy may influence feeding behaviour in chickens (Buyse et al., 1992). Importantly, it is interesting to note that these differing feed intake response patterns to limiting feed protein content were achieved regardless of the energy value of the feed.

### 2.15.2 Environmental Temperatures

Environmental temperatures may be another factor that dictates the AA requirement of the birds. High temperature environments have been shown to reduce feed intake, body weight, egg production and hatchability (Smith et al., 1983; Sinurat and Balnave, 1985; Geraert et al., 2006).
2.15.3 Amino-acid Antagonism

Studies in young chicks and turkeys have shown interdependence in the requirements for the branched chain amino acids namely leucine, isoleucine and valine (Baker, 1997; D’Mello, 2003). Such interdependence was found to be based on the fact that these amino acids were sharing similar membrane transporters. The limited availability of transporters resulted in an excess of any single branched chain AA, reducing the relative absorption of the other two (Leeson and Summers, 2001).

D’ Mello and Lewis (1970) concluded that the antagonistic effects of leucine on the valine requirement were considerably greater than that of excess leucine on the isoleucine requirement. In the same study, excess valine did not show the same negative effects on performance that were noticed by excessive leucine or isoleucine. D’ Mello (2003) further showed the minimum isoleucine, leucine and valine requirements to be as low as 0.52%, 0.98% and 0.63% of the diet respectively, but that dietary excesses of either isoleucine or leucine resulted in substantially impaired growth that was restored once dietary concentrations of all branched chain AA were increased proportionately.

An antagonism with arginine by excess dietary lysine has also been well established in poultry nutrition (Labadan et al., 2001; D’Mello, 2003). Supplementation of excess L-lysine to a diet causes a reduction in body weight gain, increased feed: gain ratio and poor feathering, all of which have been shown to be the result of an induced arginine deficiency (Kadirvel et al., 1974). The mode of action of this antagonism was thought to be most likely attributable to an excess of lysine relative to arginine in the diet causing a reduction in the reabsorption of arginine from the glomerular filtrate in the kidney tubules (Boorman et al., 1986). In addition, lysine
also directly increases renal arginase activity, thereby resulting in increases rate of arginine catabolism (Nesheim, 1968).

2.15.4 Mineral and Vitamin Requirements of Broiler Chickens

Minerals are inorganic nutrients known to be required by animals in small quantities for optimum performance. Minerals are required in the body of the animal for skeletal tissue development and maintenance. They are also found in soft tissues and in the blood cells. Minerals are classified into two broad groups known as major or macro minerals which are needed in relatively large amounts and trace or micro minerals which are needed in very small minute amounts.

Ensminger (1991) and Oluyemi and Robert (2000) reported that broiler birds require ample amount of minerals and vitamins in their feed for proper functioning. In addition, minerals also exist as components of vitamins, enzymes and hormones. Minerals make the body fluids physiologically compactible with the tissues and help to maintain the acid base balance of body fluids.

Sources of the major minerals for poultry rations include di-calcium phosphate, defluorinated rock phosphate, limestone or oyster shell, bone meal and sodium chloride. Ensminger (1991) and Oluyemi and Robert (2000) recommended the following minerals for broiler chickens namely calcium (Ca) 0.80%, phosphorus (P) 0.35 – 0.45%, sodium (Na) 0.15%, potassium (K) 0.30 – 0.40%, magnesium (mg) 600mg, chlorine (Cl) 0.15%, Iron (Fe) 80mg, manganese (Mn) 60mg, copper (Cu) 80mg, molybdenum (Mo) 0.35mg, iodine (I) 0.35mg, zinc (Zn) 40mg and selenium (Se) 0.15mg.

Oluyemi and Robert (2000) also reported that vitamins are organic substances required by animals in very small amounts which help in regulating various body processes to maintain normal health, healthy growth, production and reproduction.
There are about 13 vitamins listed as required by the chicken. Vitamins are classified as fat soluble (which include Vitamins A, D, E, & K) and water soluble that is the B-complex vitamins and vitamin C. According to Ogundipe (2003) feedstuff do not usually contain enough of these vitamins to meet the requirements of the birds. Therefore, there is need to meet the requirements by supplementation with specially prepared vitamin and trace-mineral premixes. Ensminger (1991) and Oluyemi and Robert (2000) recommended the following vitamins for an effective performance of a broiler chicken namely vitamin A 1500 iu, vit. D 200 iu, vit. E 10 iu, vit. K 0.5mg, biotin 0.15mg, choline 500-1300mg, folacin (folic acid) 0.25-0.55mg, niacin (nicotinic acid, nicotinamide) 11.0-27.0mg, pantothenic acid (vitamin B3) 10.0mg, riboflavin (vitamin B2) 3.60mg, Thiamine (vitamin B1) 1.74mg, cyanocobalamin (vitamin B12) 0.003-0.009mg.

2.15.5 Water Requirements of Chickens

Initially, little attention was given to water requirement of poultry probably because this nutrient is available at little or no cost. The chicken needs water for its metabolic functions, osmoregulation and for optimum performance in terms of growth and production. The water requirement of chickens became apparent when it was realized that the body of chicken and its eggs are composed of at least 70% water (Obioha, 1992). Ensminger et al. (1990) reported that water is the largest single constituent of poultry tissue. It constitutes 85% of the body weight of a young chicken, 50% of the body of an adult bird and 66% of an egg. Yet water is often neglected. Obioha (1992) reported that birds can lose 98% of their body fat or 50% of their body protein and still survive. However, a 10% loss in the body water will cause serious physiological disorder and 20% loss in body water will cause death. It has been observed that chicken survive for a longer time without feed than they can
without water. Chicken may die in a matter of hours when completely deprived of water (Olomu, 1995). Although most feedstuffs in the form they are fed to the chicken contain substantial amounts of water. However, the most important source of water to the chicken is the one supplied separately as drinking water.

Water consumption of poultry increases with increasing ambient temperature which may exceed 35°C. Water supply to chicken is very important for thermoregulation as well as feed utilization (Obioha, 1992). Some factors such as age, breed, type of feed consumed and their composition are known to affect water consumption by chickens. The quantity increase with age, when dry mashes are fed and when such salt as sodium chloride (NaCl) is high in the feed (Obioha, 1992). High protein feeds are also shown to increase water consumption ability of the chickens than lower protein diet.
CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of the Study

The study was conducted at the Poultry Research Unit of the Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria located within the Northern Guinea Savanna zone on latitude 11° 9’ 45” N and longitude 7° 38’ 8” E, at an altitude of 610 m above sea level (Ovimaps, 2012).

3.2 Sources of the Experimental Materials

The guinea corn and millet grains used in these studies were purchased from the local market in Samaru, Zaria while other ingredients were sourced from Rebson feed mill, Samaru, Zaria, Kaduna State.

3.3 Determination of the Proximate Composition of Feed Ingredients Used

Proximate compositions of the feed ingredients as well as the experimental diets were determined in the Animal Science Biochemical Laboratory using the methods described by A.O.A.C. (1990). The following parameters were determined viz; % Dry Matter (DM), % Crude Protein (CP), % Crude Fiber (CF), % Ether Extract (EE), and % Nitrogen Free Extract (NFE). Dry matter was determined by oven drying the samples at 100°C over a 12-hour period. Crude protein was determined by the Kjedahl procedure, Ether extract was determined by subjecting the samples to petroleum ether extraction at 60-80°C using the Soxhlet extraction apparatus.

Crude fibre was determined by boiling the sample under reflux in weak sulphuric acid (0.25N H₂SO₄), then in weak sodium hydroxide solution (0.31 NaOH) for 1 hour. The residue which consists of cellulose, lignin and mineral matter was dried and weighed. The ash content was determined by igniting a weighed sample in a Muffle furnace at 600°C. Nitrogen free extract (NFE) was obtained by difference after the
percentages of the other fractions were subtracted from 100%. Gross Energy (GE) was calculated using the method described by Pauzenga (1985); ME (Kcal/kg) = 37 x % CP + 81.8 x % EE + 35.5 X % NFE.

3.4 Experiment 1: Performance of Broiler Chickens Fed Two Varieties Each of Guineacorn and Millet as Replacements for Dietary Maize

3.4.1 Preparation of Experiment 1 diets

Five isonitrogenous and isocaloric diets (23.5% CP; 2900 Kcal/kg ME) and (21.00% CP; 3000 Kcal/kg) for the broiler starter and finisher phases respectively were formulated as follows:

Diet 1: (Control) contained maize as the main energy source in the diet
Diet 2: contained white guinea corn as the main energy source in the diet
Diet 3: contained short kaura guinea corn as the main energy source in the diet
Diet 4: contained pearl millet as the main energy source in the diet and
Diet 5: contained finger millet as the main energy source in the diet.

Compositions of the experimental diets are presented in Tables 3.1 and 3.2 respectively. Both starter and finisher diets were formulated to meet nutrient requirement standards for broilers (NRC, 1994). The proximate analysis of the experimental diets is presented in Table 3.3.
Table 3.1: Percentage Composition of the Experimental Broiler Starter Diets for Experiment 1 (0 - 4 weeks)

<table>
<thead>
<tr>
<th>Ingredients (%)</th>
<th>T1 Maize</th>
<th>T2 White G’corn</th>
<th>T3 Short kaura</th>
<th>T4 Pearl millet</th>
<th>T5 Finger millet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>48.50</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>White Guinea corn</td>
<td>0.00</td>
<td>47.50</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Short kaura</td>
<td>0.00</td>
<td>0.00</td>
<td>47.50</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Pearl millet</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>49.50</td>
<td>0.00</td>
</tr>
<tr>
<td>Finger millet</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>49.50</td>
</tr>
<tr>
<td>Maize offal</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>GNC</td>
<td>24.75</td>
<td>24.85</td>
<td>24.85</td>
<td>21.00</td>
<td>21.00</td>
</tr>
<tr>
<td>Soya cake</td>
<td>12.00</td>
<td>12.00</td>
<td>12.00</td>
<td>12.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Fish meal</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.60</td>
<td>0.60</td>
<td>0.60</td>
<td>0.60</td>
<td>0.60</td>
</tr>
<tr>
<td>Bone meal</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Palm oil</td>
<td>1.10</td>
<td>2.00</td>
<td>2.00</td>
<td>3.05</td>
<td>3.05</td>
</tr>
<tr>
<td>Common salt</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Vit/mineral premix*</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>L- Lysine</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>DL-methionine</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Calculated Analysis:**

- ME(Kcal/kg) 2900  2900  2900  2900  2900
- Crude protein (%) 23.50  23.50  23.50  23.50  23.50
- Ether extract (%) 5.68  6.03  6.03  7.75  6.11
- Crude fibre (%) 4.10  4.16  4.16  4.64  4.59
- Calcium (%) 1.30  1.31  1.31  1.34  1.36
- Avail. P. (%) 0.69  0.68  0.71  0.74  0.75
- Lysine (%) 1.28  1.29  1.29  1.31  1.31
- Methionine (%) 0.46  0.46  0.47  0.46  0.47
- Meth. + Cyst. (%) 0.93  0.90  0.90  0.97  0.97
- Feed cost/kg (₦/kg) 97.99  100.96  100.96  106.83  126.63

*Vitamin/mineral premix from Bio-mix Broiler starter supplied per kg of diet: Vit. A, 10,000 i.u; Vit. D₃, 2000 i.u; Vit. E 3mg; Vit. K, 2 mg; Vit. B₁ (Thiamine), 1.8mg; Vit B₂ (Riboflavin), 5.5mg; Vit. B₆ (Pyridoxine), 3mg; Vit. B₁₂ 0.015mg; Pantothenic acid 7.5mg; Folic acid 0.75mg; Niacin 27.5mg; Biotin 0.6mg; Choline chloride 300mg; Cobalt 0.2mg; Copper 3mg; Iodine 1mg; Iron 20mg; Manganese 40mg; Selenium 0.2mg; Zinc 30mg; Antioxidant 1.25mg; ME= Metabolisable Energy.
Table 3.2: Percentage Composition of the Experimental Broiler Finisher Diets for Experiment 1 (5 - 9 weeks)

<table>
<thead>
<tr>
<th>Ingredients (%)</th>
<th>T1 Maize</th>
<th>T2 White G’corn</th>
<th>T3 Short kaura</th>
<th>T4 Pearl millet</th>
<th>T5 Finger millet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>53.74</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>White Guinea corn</td>
<td>0.00</td>
<td>54.20</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Short kaura</td>
<td>0.00</td>
<td>0.00</td>
<td>54.20</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Pearl millet</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>54.90</td>
<td>0.00</td>
</tr>
<tr>
<td>Finger millet</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>54.90</td>
</tr>
<tr>
<td>Maize offal</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Groundnut cake</td>
<td>22.50</td>
<td>21.00</td>
<td>21.00</td>
<td>18.40</td>
<td>18.40</td>
</tr>
<tr>
<td>Soya cake</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Fish meal</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
</tr>
<tr>
<td>Bone meal</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Palm oil</td>
<td>1.05</td>
<td>2.10</td>
<td>2.10</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Common salt</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Vit/mineral premix*</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>L-Lysine</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Dl- methionine</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Calculated Analysis:**

- **ME (Kcal/kg):** 3000 3000 3000 3000 3000
- **Crude protein (%):** 21.00 21.00 21.00 21.00 21.00
- **Ether extract (%):** 5.48 5.92 5.92 9.06 9.06
- **Crude fibre (%):** 3.91 3.96 3.96 5.49 5.49
- **Calcium (%):** 1.25 1.25 1.25 1.25 1.25
- **Avail. P. (%):** 0.65 0.65 0.67 0.69 0.71
- **Lysine (%):** 1.15 1.14 1.14 1.17 1.17
- **Methionine (%):** 0.46 0.46 0.47 0.47 0.46
- **Meth. + Cystine (%):** 0.87 0.84 0.84 0.92 0.92
- **Feed cost/kg (₦/kg):** 90.30 93.80 93.80 103.70 124.80

*Vitamin/mineral premix from Bio-mix Broiler finisher supplied per kg of diet: Vit. A, 10,000 i.u; Vit.D3, 2000 i.u; Vit. E 23mg; Vit. K, 2mg; Vit. B1 (Thiamine) 1.8mg; Vit. B2 (Riboflavin) 5.5mg; Vit. B6 (Pyridoxine), 3.0mg; Vit. B12 0.015mg; Pantothenic acid 7.5mg; Folic acid 0.75mg; Niacin 27.5mg; Biotin 0.6mg; Choline chloride 300mg; Cobalt 0.2mg; Copper 3mg; Iodine 1mg; Iron 20mg; Manganese 40mg; Selenium 0.2mg; Zinc 30mg; Antioxidant 1.25mg; ME= Metabolisable Energy.
Table 3.3: Proximate Analysis of Broiler Starter Diets for Experiment 1

<table>
<thead>
<tr>
<th>Nutrients (%)</th>
<th>T1 Maize Diet</th>
<th>T2 White G’ corn Diet</th>
<th>T3 Short Kaura Diet</th>
<th>T4 Pearl millet Diet</th>
<th>T5 Finger millet Diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter</td>
<td>94.96</td>
<td>94.42</td>
<td>90.70</td>
<td>94.96</td>
<td>93.00</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>23.25</td>
<td>23.48</td>
<td>23.22</td>
<td>23.91</td>
<td>23.38</td>
</tr>
<tr>
<td>Ether Extract</td>
<td>5.88</td>
<td>5.55</td>
<td>4.08</td>
<td>4.16</td>
<td>5.17</td>
</tr>
<tr>
<td>Crude Fibre</td>
<td>7.31</td>
<td>7.47</td>
<td>7.00</td>
<td>7.57</td>
<td>7.33</td>
</tr>
<tr>
<td>Ash</td>
<td>6.79</td>
<td>6.30</td>
<td>5.00</td>
<td>6.19</td>
<td>6.89</td>
</tr>
<tr>
<td>NFE</td>
<td>56.77</td>
<td>57.20</td>
<td>60.78</td>
<td>59.17</td>
<td>57.22</td>
</tr>
<tr>
<td>ME(Kcal/kg) *</td>
<td>2975.34</td>
<td>2970.06</td>
<td>2968.58</td>
<td>2970.75</td>
<td>2968.70</td>
</tr>
</tbody>
</table>

NFE = Nitrogen Free Extract.
*ME = Metabolizable energy were calculated using the method of Pauzenga (1985),
ME (Kcal/kg) = 37x % CP + 81.8 x % EE + 35x % NFE
Determination done at the Biochemical Laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria.
3.4.2 Experimental Design and Management of Birds

A total of two hundred and twenty five (225) day-old Marshal broiler chicks (of mixed sexes) purchased from a reputable Hatchery were used for this study. On arrival, the chicks were weighed and randomly assigned into five groups of 45 birds each. Each group was subdivided into three (3) replicates of 15 birds in a completely randomized design (CRD). Each group was randomly assigned to the 5 experimental diets that constitute the treatment. The birds were reared on deep litter system. All necessary routine management practices and the recommended vaccinations were strictly observed throughout the period of this study. Feed and water were provided *ad libitum* during the trial period. The experiment lasted for 9 weeks. The starter phase lasted from 0 to 4 weeks. At the end of the starter phase, the birds were fed on common diets for one week, the runts were removed while the healthy birds were randomized (balanced for weights) and assigned into five groups of thirty six (36) birds per treatment which was subdivided into three (3) replicates of 12 birds. Each group was randomly assigned to the 5 experimental diets that constitute the treatment. The finisher phase lasted from 5 to 9 weeks.

3.4.3 Data Collection

The birds were weighed at the beginning of the experiment and weekly thereafter. Data were collected on initial weight, final body weight, average daily weight gain, leftover feed and feed intake were measured. Feed conversion ratio, feed cost per kilogramme and the cost of feed per kilogramme weight gain (₦/kg) were calculated. Mortalities were recorded as they occurred.

3.4.4 Evaluation of Carcass

At the end of the feeding trial (56 days), three birds per replicate, which represented the average weight of the group were randomly selected, starved of feed overnight so
as to allow for the emptying of the crop and excretion of the undigested feed residue. Each bird was weighed, slaughtered, eviscerated and cut into parts to record the dressing weight, breast weight, thigh weight, liver, heart, gizzard and intestine.

Cut parts were expressed as percentages of dressed weights of birds slaughtered while the organ weights were expressed as percentages of the live weights. The carcass evaluation was done at the Meat Products Laboratory, of the Department of Animal Science, Ahmadu Bello University, Zaria.

### 3.4.5 Nutrient Digestibility Trial

At the end of feeding trial, four birds each from the five treatment groups were randomly selected from each replicate and then transferred into metabolic cages for individual feeding and faecal collections. The birds were placed in metabolic cages with facilities for separate feeding and watering. They were allowed to acclimatize for a period of three days. Each group was fed their respective experimental diets.

Known quantities of the diets were served to birds and the left over feeds were properly accounted for. Faecal samples were collected for seven days by placing clean trays under the cages.

Faecal samples were separated from feeds and other foreign materials, weighed, bulked together and kept in deep freezer. The total sample were thawed and weighed after they were mixed together and oven dried for 72 hours at 60°C. The faecal collections for each diet fed was bulked and finely ground along with the samples of feeds given and analyzed for proximate compositions namely dry matter, crude protein, nitrogen free extract, ether extract, crude fibre and ash in the Biochemical Laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria using the method described by A.O.A.C (1990).

The percentage nutrient retention was calculated using the equation below;
Nutrient Digestibility = \( \frac{\text{Nutrient intake} - \text{Nutrient in Excreta}}{\text{Nutrient intake}} \times 100 \)

Where; Nutrient intake (g) = Dry feed intake \( \times \) Nutrient in diet

Nutrient output (g) = Dry faecal output \( \times \) Nutrient in faeces

3.5 **Experiment 2: Performance of Broiler Chickens Fed Graded Levels of White Guineacorn as Replacement for Dietary Maize**

3.5.1 **Experimental Diets for Feeding Trial 2**

Five isonitrogenous and isocaloric diets (23.5% CP; 2900 Kcal/kg ME) and (21% CP; 3000 Kcal/kg) for the broiler starter and finisher phases were formulated as follows:

- Diet 1 (Control) contained 100% of the maize component in the ration
- Diet 2 contained 25% of the maize component replaced by white Guineacorn
- Diet 3 contained 50% of the maize component replaced by white Guineacorn
- Diet 4 contained 75% of the maize component replaced by white Guineacorn
- Diet 5 contained 100% of the maize component replaced by white Guineacorn

The diets were formulated to be iso-nitrogenous and iso-caloric (23.5% CP; 2900 Kcal/kg ME) and (21% CP; 3000 Kcal/kg) for the broiler starter and finisher phases respectively (Table 3.4 and 3.5).
### Table 3.4: Percentage Composition of the Experimental Broiler Starter Diets for Feeding Trial 2 (0-4 weeks)

Levels of maize replacement by white guinea corn

<table>
<thead>
<tr>
<th>Ingredients (%)</th>
<th>T1 (0%)</th>
<th>T2 (25%)</th>
<th>T3 (50%)</th>
<th>T4 (75%)</th>
<th>T5 (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>47.35</td>
<td>35.52</td>
<td>23.68</td>
<td>11.84</td>
<td>0.00</td>
</tr>
<tr>
<td>White G’ corn</td>
<td>0.00</td>
<td>11.84</td>
<td>23.68</td>
<td>35.52</td>
<td>47.35</td>
</tr>
<tr>
<td>Maize offal</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>GNC</td>
<td>25.00</td>
<td>25.00</td>
<td>25.00</td>
<td>25.00</td>
<td>25.00</td>
</tr>
<tr>
<td>Soya cake</td>
<td>12.00</td>
<td>12.00</td>
<td>12.00</td>
<td>12.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Fish meal</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.60</td>
<td>0.60</td>
<td>0.60</td>
<td>0.60</td>
<td>0.60</td>
</tr>
<tr>
<td>Bone meal</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Palm oil</td>
<td>1.05</td>
<td>1.50</td>
<td>1.79</td>
<td>1.87</td>
<td>2.00</td>
</tr>
<tr>
<td>Common salt</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Vit/mineral premix*</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>L-lysine</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>DL-methionine</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
</tbody>
</table>

**Total** | 100 | 100 | 100 | 100 | 100

**Calculated Analysis:**

- **ME (Kcal/kg)**: 2900, 2900, 2900, 2900, 2900
- **Crude protein (%)**: 23.50, 23.50, 23.50, 23.50, 23.50
- **Ether extract (%)**: 5.60, 6.03, 6.07, 6.03, 6.03
- **Crude fibre (%)**: 3.90, 3.92, 3.93, 3.94, 3.96
- **Calcium (%)**: 1.29, 1.29, 1.29, 1.29, 1.30
- **Avail. P (%)**: 0.63, 0.63, 0.63, 0.63, 0.64
- **Lysine (%)**: 1.28, 1.28, 1.28, 1.28, 1.27
- **Methionine (%)**: 0.46, 0.46, 0.46, 0.46, 0.46
- **Meth. + Cyst. (%)**: 0.93, 0.92, 0.92, 0.91, 0.90
- **Feed cost/kg (₦/kg)**: 94.77, 96.68, 96.05, 95.41, 96.82

*Vitamin/mineral premix from Bio-mix starter supplied per kg of diet: Vit. A, 10,000 i.u; Vit.D3, 2000 i.u; Vit. E 23mg; Vit. K, 2mg; Vit. B1 (Thiamine), 1.8mg; Vit B2 (Riboflavin), 5.5mg; Vit. B6 (Pyridoxine), 3 mg; Vit. B12 0.015mg; Pantothenic acid 7.5mg; Folic acid 0.75mg; Niacin 27.5mg; Biotin 0.6mg; Choline chloride 300mg; Cobalt 0.2mg; Copper 3mg; Iodine 1mg; Iron 20mg; Manganese 40mg; Selenium 0.2mg; Zinc 30mg; Antioxidant 1.25mg; ME= Metabolisable Energy.*
Table 3.5: Percentage Composition of the Experimental Broiler Finisher Diets for Feeding Trial 2 (5-9 weeks)

Levels of maize replacement by white guinea corn

<table>
<thead>
<tr>
<th>Ingredients (%)</th>
<th>T1 (0%)</th>
<th>T2 (25%)</th>
<th>T3 (50%)</th>
<th>T4 (75%)</th>
<th>T5 (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>52.70</td>
<td>39.53</td>
<td>26.35</td>
<td>13.17</td>
<td>0.00</td>
</tr>
<tr>
<td>White guinea corn</td>
<td>0.00</td>
<td>13.17</td>
<td>26.35</td>
<td>39.53</td>
<td>52.70</td>
</tr>
<tr>
<td>Maize offal</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>GNC</td>
<td>22.50</td>
<td>22.50</td>
<td>22.50</td>
<td>22.50</td>
<td>22.50</td>
</tr>
<tr>
<td>Soya cake</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Fish meal</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
<td>0.65</td>
</tr>
<tr>
<td>Bone meal</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Palm oil</td>
<td>1.05</td>
<td>1.50</td>
<td>1.73</td>
<td>1.96</td>
<td>2.10</td>
</tr>
<tr>
<td>Common salt</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Vit/mineral premix*</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>L-Lysine</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>DL-methionine</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Total 100 100 100 100 100

Calculated Analysis:
- ME (Kcal/kg): 3000 3000 3000 3000 3000
- Crude protein (%): 21.00 21.00 21.00 21.00 21.00
- Ether extract (%): 5.88 6.08 5.99 5.96 5.92
- Crude fibre (%): 4.13 4.13 4.14 4.15 4.16
- Calcium (%): 1.25 1.25 1.25 1.25 1.25
- Avail. P. (%): 0.60 0.60 0.60 0.60 0.60
- Lysine (%): 1.15 1.15 1.15 1.15 1.14
- Methionine (%): 0.46 0.46 0.47 0.46 0.46
- Meth + Cyst. (%): 0.87 0.86 0.86 0.85 0.84
- Feed cost/kg (₦/kg): 92.16 92.56 92.96 93.36 93.75

*Vitamin/mineral premix from Bio-mix Broiler finisher supplied per kg of diet: Vit. A, 10,000 i.u; Vit.D3, 2000 i.u; Vit. E 23mg; Vit. K, 2 mg; Vit. B1 (Thiamine), 1.8mg; Vit. B2 (Riboflavin), 5.5mg; Vit. B6 (Pyridoxine), 3 mg; Vit. B12 0.015mg; Pantothenic acid 7.5mg; Folic acid 0.75mg; Niacin 27.5mg; Biotin 0.6mg; Choline chloride 300 mg; Cobalt 0.2mg; Copper 3mg; Iodine 1mg; Iron 20mg; Manganese 40mg; Selenium 0.2mg; Zinc 30mg; Antioxidant 1.25mg; ME= Metabolisable Energy.
Table 3.6: Proximate Composition of the Experimental Broiler Finisher Diets for Experiment 2

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>T1 (0%)</th>
<th>T2 (25%)</th>
<th>T3 (50%)</th>
<th>T4 (75%)</th>
<th>T5 (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter (%)</td>
<td>92.93</td>
<td>93.48</td>
<td>94.51</td>
<td>93.68</td>
<td>92.13</td>
</tr>
<tr>
<td>Crude Protein (%)</td>
<td>20.12</td>
<td>21.58</td>
<td>20.02</td>
<td>20.26</td>
<td>19.94</td>
</tr>
<tr>
<td>Ether Extract (%)</td>
<td>4.08</td>
<td>5.88</td>
<td>4.00</td>
<td>4.16</td>
<td>5.76</td>
</tr>
<tr>
<td>Crude Fibre (%)</td>
<td>8.33</td>
<td>8.00</td>
<td>7.56</td>
<td>7.20</td>
<td>8.77</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>6.66</td>
<td>5.08</td>
<td>6.50</td>
<td>6.55</td>
<td>6.72</td>
</tr>
<tr>
<td>NFE (%)</td>
<td>60.81</td>
<td>59.46</td>
<td>61.92</td>
<td>61.83</td>
<td>58.81</td>
</tr>
<tr>
<td>ME(Kcal/kg) *</td>
<td>3203.27</td>
<td>3385.57</td>
<td>3262.90</td>
<td>3281.54</td>
<td>3292.09</td>
</tr>
</tbody>
</table>

NFE = Nitrogen Free Extract.

*ME = Metabolizable energy were calculated using the method of Pauzenga (1985),
ME (Kcal/kg) = 37 x % CP + 81.8 x % EE+35 x %NFE
Determination done at the Biochemical Laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria.
3.5.2 Experimental Design and Management of Birds

A total of two hundred and twenty five (225) day-old Marshal broiler chicks (of mixed sex) were used for this study. The management of the birds and experimental design for this experiment were as described for experiment 1. The birds were randomly assigned five groups of forty five (45) each which was subdivided into three replicates of fifteen (15) birds each in a completely randomized design (CRD). The experiment lasted for 9 weeks. 0 to 4 weeks for the starter phase and 5 to 9 weeks for the finisher phase.

The experiment lasted for 9 weeks. The starter phase lasted from 0 to 4 weeks. At the end of the starter phase, the birds were fed on common diets for one week and were randomized (balanced for weights) and assigned into five groups of forty two (42) birds per treatment which was subdivided into three (3) replicates of fourteen (14) birds. Each group was randomly assigned to the 5 experimental diets that constitute the treatment. The finisher phase lasted from 5 to 9 weeks.

3.5.3 Data Collection

The birds were weighed at the beginning of the experiment and weekly thereafter. Data were collected on initial weight, final body weight, average daily weight gain, leftover feed feed intake were measured. Feed conversion ratio, feed cost per kilogramme and the cost of feed per kilogramme weight gain (₦/kg) were calculated and no mortality was recorded during the experiment.

3.5.4 Evaluation of Carcass

At the end of the feeding trial, three birds per replicate, which represented the average weight of the group were randomly selected, starved overnight so as to allow for the emptying of the crop and intestine. Each bird was weighed, slaughtered, eviscerated
and cut into parts to record the dressing weight, breast weight, thigh weight, liver, heart, gizzard and intestine. Cut parts were expressed as percentage of dressed weight of birds slaughtered while the organ weights were expressed as percentage of the live weight. The carcass evaluation was done in the Meat Products Laboratory, of the Department of Animal Science, Ahmadu Bello University, Zaria.

3.5.5 Nutrient Digestibility Trial

This was done as described in experiment 1.

3.6 Statistical Analysis

All the data collected in Experiments 1 and 2 were statistically analyzed using the General Linear Model Procedure of Statistical Analysis (SAS, 2002) software package. Significant difference between treatments means were separated by Duncan’s Multiple Range Test.

The model used for this design is as follows:

\[ Y_{ij} = \mu + t_i + e_{ij} \]

Where \( Y_{ij} \) = Individual observation.

\( \mu \) = Overall mean.

\( t_i \) = Effect of treatment diets.

\( e_{ij} \) = Experimental error.
CHAPTER FOUR

4.0 RESULTS

4.1 Proximate Composition

Table 4.1 shows the results of the proximate analysis of the test ingredients. Maize was higher in dry matter (DM), nitrogen free extract (NFE) and ME (kcal/kg) when compared with guinea corn and millets respectively.

The percent crude protein was found to be higher in Pearl and finger millets (12.02 and 12.14 % respectively) compared to the values for maize, white guinea corn and Short kaura (8.60, 10.04 and 10.27 % respectively).

The percent ether extract were similar for maize, white guinea corn, Short kaura, pearl millet and finger millets (with 3.82, 3.06, 3.19, 3.78 and 3.54 % respectively).

Crude fibre was found to be higher in pearl and finger millets respectively (6.01 and 6.30 %) compared to the values for maize, white guinea corn and Short kaura (with 3.20, 4.69 and 4.78 % respectively).

The percent ash was found to be higher in finger millet (3.2 %) compared to the values for maize, white guinea corn, Short kaura and pearl millets (with 1.81, 1.86, 1.89 and 1.62 % respectively).

The percent nitrogen free extract was found to be higher in maize 80.60% compared to the values for white guinea corn, Short kaura, pearl millet and finger millets respectively (with 78.80, 78.92, 72.20 and 68.06% respectively).
4.2 Anti-nutritional Factors in Feed Ingredients

Table 4.2 shows the levels of anti-nutritional factors found in the test ingredients. The values recorded for tannins were within the range of 0.10 - 0.16 g/Kg, phytate was within the range of 0.33- 0.66 g/Kg. Cyanide was within the range of 0.16- 3.60 g/Kg. Maize was found to be significantly (p<0.05) higher in cyanide compared to guinea corn and millets. Oxalate was within the range of 6.72- 13.44 g/Kg which was found to be significantly (p<0.05) higher in white guinea corn compared to maize, Short kaura guinea corn and millets respectively.
<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Maize (Yellow)</th>
<th>White G’corn</th>
<th>Short kaura</th>
<th>Pearl millet</th>
<th>Finger Millet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter (%)</td>
<td>94.10</td>
<td>90.31</td>
<td>91.86</td>
<td>91.76</td>
<td>89.13</td>
</tr>
<tr>
<td>Crude Protein (%)</td>
<td>8.60</td>
<td>10.04</td>
<td>10.27</td>
<td>12.02</td>
<td>12.14</td>
</tr>
<tr>
<td>Ether Extract (%)</td>
<td>3.82</td>
<td>3.06</td>
<td>3.19</td>
<td>3.78</td>
<td>3.54</td>
</tr>
<tr>
<td>Crude Fibre (%)</td>
<td>3.20</td>
<td>4.69</td>
<td>4.78</td>
<td>6.01</td>
<td>6.30</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>1.81</td>
<td>1.86</td>
<td>1.89</td>
<td>1.62</td>
<td>3.24</td>
</tr>
<tr>
<td>NFE (%)</td>
<td>80.60</td>
<td>78.80</td>
<td>78.92</td>
<td>72.20</td>
<td>68.06</td>
</tr>
<tr>
<td>ME(Kcal/kg) *</td>
<td>3451.68</td>
<td>3379.79</td>
<td>3403.13</td>
<td>3280.94</td>
<td>3120.85</td>
</tr>
</tbody>
</table>

NFE: Nitrogen Free Extract =100-(%CP+%CF+%EE+%Ash)

*ME: Metabolizable Energy ME (Kcal/kg) = 37 x % CP + 81.8 x % EE + 35.5 x %NFE (Pauzenga, 1985). Determination done at the Biochemical Laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria.
Table 4.2  Anti-nutritional Factors in Feed Ingredients and their Concentrations (g/kg)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>T1 Maize</th>
<th>T2 White G’corn</th>
<th>T3 Short Kaura</th>
<th>T4 Pearl millet</th>
<th>T5 Finger Millet</th>
<th>SEM</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tannin</td>
<td>0.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.02</td>
<td>*</td>
</tr>
<tr>
<td>Phytate</td>
<td>0.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.68&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.66&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>0.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.15</td>
<td>*</td>
</tr>
<tr>
<td>Cyanide</td>
<td>3.60&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.48&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.88&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.08</td>
<td>*</td>
</tr>
<tr>
<td>Oxalate</td>
<td>6.72&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.44&lt;sup&gt;d&lt;/sup&gt;</td>
<td>7.84&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.77&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.84&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.02</td>
<td>*</td>
</tr>
</tbody>
</table>

Determination done at the Biochemical Laboratory, Food Science and Technology Research programme. Institute for Agricultural Research (IAR) Samaru, Zaria.

<sup>abcd</sup> Means on the same row with different superscripts are significantly (p<0.05) different

SEM: standard error of mean.
LOS: Level of significance

* Significant difference (p<0.05)
4.3 Experiment 1: Performance of Broiler Chickens Fed Two Varieties Each of Guineacorn and Millet as Replacements for Dietary Maize

4.3.1 Performance of Broiler Chicks Fed two varieties each of Guineacorn and Millet as Replacements for Dietary Maize (0-4 weeks).

Table 4.3 shows the performance of broiler chicks fed the experimental diets. There were significant (p<0.05) differences in the final body weight, daily weight gain, daily feed intake and feed conversion ratios of broiler chicks. Birds fed Short Kaura guinea corn (diet T3) had significantly (p<0.05) the highest value of feed intake compared to those fed other diets. Birds fed diet T1 (control) had similar values of feed intake as those fed pearl and finger millet based diets (diets T4 and T5) and their feed intakes were all significantly (p<0.05) higher than those birds fed white guinea corn based diet (T2). Birds on pearl and finger millet diets had similar final live weight (580.44 g and 573.33 g) respectively and the daily weight gain (19.20 g and 18.95 g). These values were significantly (p<0.05) higher than others.

Both the pearl and finger millet based diets had higher final weights and average daily weight gains (p<0.05) compared to the values for the control, white guinea corn and short kaura based diets with final weights and average daily weight gain values of 520g and 17.04 g respectively for the control diet, 478g and 15.56 g respectively for white guinea corn based diet.

The birds fed white guinea corn based diet had significantly (p<0.05) lowest mean value of daily weight gain compared to those birds fed other diets.
Table 4.3: Performance of Broilers Starter Chickens Fed Maize, Guinea corn and Millet Diets (0-4 weeks)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>T1 Maize</th>
<th>T2 White Guinea corn</th>
<th>T3 Short-Kaura</th>
<th>T4 Pearl Millet</th>
<th>T5 Finger Millet</th>
<th>SEM</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial weight (g/bird)</td>
<td>42.69</td>
<td>42.66</td>
<td>42.69</td>
<td>42.62</td>
<td>42.60</td>
<td>0.14</td>
<td>NS</td>
</tr>
<tr>
<td>Final live weight (g/bird)</td>
<td>520.00^b</td>
<td>478.33^c</td>
<td>536.00^b</td>
<td>580.44^a</td>
<td>573.33^a</td>
<td>17.93</td>
<td>*</td>
</tr>
<tr>
<td>Total weight gain (g/bird)</td>
<td>477.31^b</td>
<td>435.67^c</td>
<td>493.97^b</td>
<td>537.83^a</td>
<td>530.73^a</td>
<td>17.93</td>
<td>*</td>
</tr>
<tr>
<td>Av. Daily weight gain (g/bird/day)</td>
<td>17.04^b</td>
<td>15.56^c</td>
<td>17.64^b</td>
<td>19.20^a</td>
<td>18.95^a</td>
<td>0.64</td>
<td>*</td>
</tr>
<tr>
<td>Total feed intake (g/bird)</td>
<td>1188.27^b</td>
<td>1019.91^c</td>
<td>1244.20^a</td>
<td>1177.40^b</td>
<td>1167.78^b</td>
<td>27.65</td>
<td>*</td>
</tr>
<tr>
<td>Daily feed intake (g/bird/day)</td>
<td>42.43^b</td>
<td>36.42^c</td>
<td>44.43^a</td>
<td>42.05^b</td>
<td>41.70^b</td>
<td>0.99</td>
<td>*</td>
</tr>
<tr>
<td>Feed conversion ratio</td>
<td>2.50^c</td>
<td>2.34^b</td>
<td>2.52^c</td>
<td>2.18^a</td>
<td>2.19^a</td>
<td>0.07</td>
<td>*</td>
</tr>
<tr>
<td>Cost of feed/kg weight (₦)</td>
<td>245.47^b</td>
<td>236.41^ab</td>
<td>254.70^b</td>
<td>233.93^a</td>
<td>278.51^c</td>
<td>7.08</td>
<td>*</td>
</tr>
<tr>
<td>Mortality rate (%)</td>
<td>4.44</td>
<td>6.67</td>
<td>6.60</td>
<td>2.22</td>
<td>4.40</td>
<td>0.68</td>
<td>NS</td>
</tr>
</tbody>
</table>

SEM: standard error of mean.
abc Means on the same row with different superscripts are significantly (P<0.05) different
SEM: standard error of mean.
LOS: Level of significance
* Significant difference (p<0.05)
NS: Non significant difference (p>0.05)
The feed conversion ratio of birds fed pearl and finger millet diets ($T_4$ and $T_5$) were similar and significantly ($p<0.05$) lower and better (2.18 and 2.19) when compared with those birds fed diet $T_1$ (control), white guinea corn and short kaura diets with values of 2.50, 2.34, and 2.52 respectively.

Feed cost in Naira per kilogramme weight gain showed that birds fed pearl millet diet had significantly ($p<0.05$) lowest feed cost per kilogramme gain ($₦233.93$) compared to other treatments while finger millet had significant ($p<0.05$) highest feed cost per kilogramme weight gain ($₦278.51$). Mortality rate of the birds was not significantly ($p>0.05$) affected by dietary treatments.
4.3.2 Performance of Broiler Finisher Chickens Fed Maize, Guinea corn and Millet Diets (5 - 9 weeks)

The performance characteristics of broiler finisher chickens fed maize, guinea corn and millet diets between 5 and 8 weeks of age are presented in Table 4.4. There were significant (p<0.05) differences across treatment means for final weight, daily weight gain, feed intake and feed conversion ratios. Feed intakes were similar and significantly (p<0.05) higher for birds fed pearl and finger millet diets compared to the control and guinea corn diets. Birds fed control diet had similar feed intake (P<0.05) as those fed white guinea corn and short kaura guinea corn based diets.

There were significant (p<0.05) differences in weight gain of birds fed the experimental diets. Final live weight and average daily weight gain showed that birds fed pearl and finger millet diets were similar and significantly (p<0.05) higher compared to those fed other diets.

Feed conversion ratios of birds fed pearl and finger millet diets were similar significantly (p<0.05) lower and better (2.41 and 2.51 respectively) compared to birds fed diets T1 (control), white guinea corn and Short Kaura diets (with 2.85, 3.61 and 2.95 respectively).

In terms of feed cost required to produce one kilogram of meat, white guinea corn and finger millet diets (T2 and T3) resulted in higher cost of production (₦338.65 and ₦314.54) per kilogramme meat produced while pearl millet diet (T4) recorded significantly (P<0.05) the lowest feed cost per kg gain (₦250.21).
### Table 4.4  Performance Characteristics of Broiler Finisher Chickens Fed Maize, Guineacorn and Millet Diets (5-9 weeks)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>T1 Maize</th>
<th>T2 White G’ corn</th>
<th>T3 Short-Kaura</th>
<th>T4 Pearl Millet</th>
<th>T5 Finger Millet</th>
<th>SEM</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial weight (g/bird)</td>
<td>819.58</td>
<td>819.47</td>
<td>819.67</td>
<td>819.43</td>
<td>819.53</td>
<td>0.08</td>
<td>NS</td>
</tr>
<tr>
<td>Final live weight (g/bird)</td>
<td>2051.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1810.8&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2037.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2451.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2343.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>90.87</td>
<td>*</td>
</tr>
<tr>
<td>Total weight gain (g/bird)</td>
<td>1232.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>991.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1217.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1631.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1524.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>90.84</td>
<td>*</td>
</tr>
<tr>
<td>Av. Daily weight gain (g/bird/day)</td>
<td>44.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>35.40&lt;sup&gt;c&lt;/sup&gt;</td>
<td>43.47&lt;sup&gt;b&lt;/sup&gt;</td>
<td>58.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>54.43&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.24</td>
<td>*</td>
</tr>
<tr>
<td>Total feed intake (g/bird)</td>
<td>3506.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3574.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3596.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3885.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3811.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>47.23</td>
<td>*</td>
</tr>
<tr>
<td>Daily feed intake (g/bird/day)</td>
<td>125.23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>127.66&lt;sup&gt;b&lt;/sup&gt;</td>
<td>128.46&lt;sup&gt;b&lt;/sup&gt;</td>
<td>138.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>136.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.69</td>
<td>*</td>
</tr>
<tr>
<td>Feed conversion ratio</td>
<td>2.51&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.68&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.53&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.41&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.45&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.10</td>
<td>*</td>
</tr>
<tr>
<td>Cost of feed/kg weight (₦)</td>
<td>257.22&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>338.65&lt;sup&gt;c&lt;/sup&gt;</td>
<td>277.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>250.21&lt;sup&gt;a&lt;/sup&gt;</td>
<td>314.54&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14.88</td>
<td>*</td>
</tr>
<tr>
<td>Mortality rate (%)</td>
<td>2.22</td>
<td>4.40</td>
<td>4.20</td>
<td>2.10</td>
<td>2.21</td>
<td>0.62</td>
<td>NS</td>
</tr>
</tbody>
</table>

SEM: standard error of mean.
<sup>abc</sup> Means on the same row with different superscripts are significantly (P<0.05) different

LOS: Level of significance

NS: Non significant difference (p>0.05)

*: Significant difference (p<0.05)

g/bird: gramme per bird
4.3.3 Carcass Characteristics and Organ Weights of Broiler Birds Fed Maize, Guinea corn and Millet Diets.

The results of the carcass evaluation are shown in Table 4.5. The carcass evaluations were expressed as the percentage of live weight of the birds while the organ weights were expressed as the percentage of dressed weights. There were no significant (p>0.05) differences in dressing percent, thigh weight, back weight and intestine length across dietary treatments. Live weight, dressed weight and the breast weight of birds fed pearl and finger millet diets were significantly (p<0.05) higher compared to those fed control and guinea corn diets. Birds fed Short Kaura guinea corn had better (P<0.05) dressed and breast weights than those fed white guinea corn diet. There were no significant differences (p>0.05) in organs weights such as heart, kidney, gizzard and intestine length except for liver and intestine weight across dietary treatments.
Table 4.5  Carcass Characteristics and Organs Weights of Broilers Fed Maize, Guinea corn and Millet Based Diets

<table>
<thead>
<tr>
<th>Parameters</th>
<th>T1 Maize</th>
<th>T2 White G’ corn</th>
<th>T3 Short Kaura</th>
<th>T4 Pearl millet</th>
<th>T5 Finger millet</th>
<th>SEM</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live weight (g)</td>
<td>2049.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1808.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2035.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2449.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2340.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>72.47</td>
<td>*</td>
</tr>
<tr>
<td>Dressed weight (g)</td>
<td>1785.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1587.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1814.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2093.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2031.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>91.36</td>
<td>*</td>
</tr>
<tr>
<td>Dressing percent (%)</td>
<td>68.19</td>
<td>63.89</td>
<td>68.10</td>
<td>66.86</td>
<td>67.62</td>
<td>2.43</td>
<td>*</td>
</tr>
<tr>
<td>Carcass weight (g)</td>
<td>1398.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1156.67&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1383.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1637.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1581.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>67.28</td>
<td>*</td>
</tr>
<tr>
<td>Breast weight (%)</td>
<td>18.29&lt;sup&gt;b&lt;/sup&gt;</td>
<td>18.04&lt;sup&gt;c&lt;/sup&gt;</td>
<td>21.19&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.49&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.91</td>
<td>*</td>
</tr>
<tr>
<td>Thigh + Drumstick (%)</td>
<td>24.27</td>
<td>23.36</td>
<td>23.42</td>
<td>25.59</td>
<td>24.44</td>
<td>1.98</td>
<td>*</td>
</tr>
<tr>
<td>Back weight (%)</td>
<td>16.57</td>
<td>16.49</td>
<td>16.62</td>
<td>18.04</td>
<td>17.89</td>
<td>0.86</td>
<td>*</td>
</tr>
</tbody>
</table>

**Organ weights**

| Heart weight (%)                | 0.52      | 0.47           | 0.46          | 0.51          | 0.46          | 0.03  | NS |
| Kidney weight (%)               | 0.42      | 0.34           | 0.39          | 0.41          | 0.41          | 0.06  | NS |
| Liver weight (%)                | 1.91<sup>b</sup> | 2.21<sup>a</sup> | 2.16<sup>ab</sup> | 1.97<sup>ab</sup> | 1.91<sup>b</sup> | 0.14  | *   |
| Gizzard weight (%)              | 2.30      | 2.48           | 2.43          | 2.47          | 2.49          | 0.15  | NS |
| Intestine weight (%)            | 3.60<sup>b</sup> | 3.56<sup>b</sup> | 3.66<sup>b</sup> | 4.00<sup>ab</sup> | 4.40<sup>a</sup> | 0.28  | *   |
| Intestine length (cm)           | 10.84     | 10.86          | 10.96         | 10.99         | 11.10         | 0.63  | NS |

SEM: standard error of mean.
<sup>abc</sup> Means on the same row with different superscripts are significantly (P<0.05) different.
LOS= Level of Significance. NS: Non significant difference (p>0.05). * Significant difference (p<0.05)
Organ weights: expressed as percent of live weight. Cut parts: expressed as % of dressed weight.
4.3.4 Nutrient Digestibility of Broilers Fed Maize, Guinea corn and Millet Based Broiler Finisher Diets.

Table 4.6 shows the results of dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract digestibility by broilers fed maize, guinea corn and millet based broiler finisher diets. There were significant (p<0.05) differences in all the parameters analyzed except for percent ether extract digestibility across treatments. The values obtained for percent dry matter, crude protein, crude fibre, ash and nitrogen free extract digestibilities were significantly (p<0.05) lower for birds fed white guinea corn diet (T2) compared to those fed other diets.
Table 4.6  Nutrient Digestibility of Broilers Finisher ChickenFed Maize, Guinea corn and Millet Based Diets

<table>
<thead>
<tr>
<th>Parameters (% )</th>
<th>T1 Maize</th>
<th>T2 G’corn (white)</th>
<th>T3 G’corn (S’kaura)</th>
<th>T4 Pearl millet</th>
<th>T5 Finger millet</th>
<th>SEM</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>89.29\textsuperscript{a}</td>
<td>80.90\textsuperscript{b}</td>
<td>87.09\textsuperscript{ab}</td>
<td>89.86\textsuperscript{a}</td>
<td>88.40\textsuperscript{a}</td>
<td>3.86</td>
<td>*</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>93.88\textsuperscript{ab}</td>
<td>88.40\textsuperscript{b}</td>
<td>92.71\textsuperscript{ab}</td>
<td>97.07\textsuperscript{a}</td>
<td>95.41\textsuperscript{ab}</td>
<td>4.01</td>
<td>*</td>
</tr>
<tr>
<td>Crude Fibre</td>
<td>80.38\textsuperscript{a}</td>
<td>65.64\textsuperscript{b}</td>
<td>79.56\textsuperscript{ab}</td>
<td>87.38\textsuperscript{a}</td>
<td>82.24\textsuperscript{a}</td>
<td>7.00</td>
<td>*</td>
</tr>
<tr>
<td>Ether Extract</td>
<td>94.60</td>
<td>91.08</td>
<td>92.46</td>
<td>95.33</td>
<td>94.96</td>
<td>2.89</td>
<td>NS</td>
</tr>
<tr>
<td>Ash</td>
<td>90.53\textsuperscript{a}</td>
<td>84.67\textsuperscript{b}</td>
<td>84.67\textsuperscript{b}</td>
<td>90.86\textsuperscript{a}</td>
<td>92.79\textsuperscript{a}</td>
<td>2.98</td>
<td>*</td>
</tr>
<tr>
<td>NFE</td>
<td>86.06\textsuperscript{a}</td>
<td>78.31\textsuperscript{b}</td>
<td>84.13\textsuperscript{ab}</td>
<td>88.59\textsuperscript{a}</td>
<td>85.71\textsuperscript{a}</td>
<td>5.01</td>
<td>*</td>
</tr>
</tbody>
</table>

SEM: standard error of mean.
\textsuperscript{ab}: Means on the same row with different superscripts are significantly (P<0.05) different.
LOS: Level of significance
NS: Non significant difference (p>0.05)
*: Significant difference (p<0.05)
4.4 Experiment 2

4.4.1 Performance of Broilers Fed Graded Levels of White Guinea corn as Replacement for Dietary Maize (0-4 weeks)

Table 4.7 shows the performance of broiler starter chicks fed graded levels of white guinea corn as replacements for maize. Substituting maize with white guinea corn did not adversely (p>0.05) affect daily feed intake and total feed intake across dietary treatments. There was no significant (p>0.05) difference between the birds fed the control diet and those fed 25%, 50% and 75% replacement of maize with white guinea corn for final live weight and daily weight gain. There were however significant decrease in final weight and weight gain for birds fed 100% replacement of maize by white guinea corn. Cost of feed per kg gains was also significantly (P<0.05) higher and FCR poorer for birds fed 100% replacement of maize by white guinea corn.

The feed conversion ratio (FCR) for birds fed control diet, 25% and 50% replacement of maize by white guinea corn were similar and significantly (P<0.05) better than 75% and 100% respectively.
Table 4.7  Performance of Broiler Starter Chicks Fed Graded Levels of White Guineacorn as Replacement for Dietary Maize (0-4 weeks)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Dietary treatments/replacement levels</th>
<th>SEM</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1 (0%)</td>
<td>T2 (25%)</td>
<td>T3 (50%)</td>
</tr>
<tr>
<td>Initial weight (g/bird)</td>
<td>40.63</td>
<td>40.57</td>
<td>40.68</td>
</tr>
<tr>
<td>Final live weight (g/bird)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1031.11a</td>
<td>999.44a</td>
<td>978.68ab</td>
</tr>
<tr>
<td>Total weight gain (g/bird)</td>
<td>990.48a</td>
<td>958.87a</td>
<td>938.00ab</td>
</tr>
<tr>
<td>Av. Daily weight gain (g/bird/day)</td>
<td>35.37a</td>
<td>34.24a</td>
<td>33.50ab</td>
</tr>
<tr>
<td>Total feed intake (g/bird)</td>
<td>1585.56</td>
<td>1550.11</td>
<td>1546.67</td>
</tr>
<tr>
<td>Daily feed intake (g/bird/day)</td>
<td>56.62</td>
<td>55.36</td>
<td>55.23</td>
</tr>
<tr>
<td>Feed conversion ratio</td>
<td>1.61a</td>
<td>1.61a</td>
<td>1.67a</td>
</tr>
<tr>
<td>Cost of feed/kg weight gain (₦/kg)</td>
<td>152.66a</td>
<td>156.40a</td>
<td>160.65ab</td>
</tr>
</tbody>
</table>

SEM: standard error of mean.

\(^{ab}\)Means on the same row with different superscripts are significantly (P<0.05) different.

LOS: Level of significance

NS: Non significant difference (p>0.05)

*: Significant difference (p< 0.05)
4.4.2 Performance of Broilers Finisher Chicken Fed Graded Levels of White Guinea corn as Replacement for Dietary Maize (5-9 weeks)

The performances of broilers fed graded levels of white guinea corn are shown in Table 4.8. Feed intake did not differ (p>0.05) significantly across dietary treatments. Birds fed diet T1 (control diet) gave similar (p>0.05) values of weight gain as those fed diets T2, T3 and T4 (with 25, 50 and 75% replacement of maize with white guinea corn). Birds fed 50% replacement of maize with white guinea corn had numerically the highest daily weight gain (60.64 g). Birds fed 100% replacement of maize with white guinea corn had significantly (p<0.05) lower weight gain compared to other treatments.

The feed conversion ratio of birds fed 50% replacement of maize with white guinea corn was the best (2.27) but was not significantly (p>0.05) different from those fed control diet (2.33) and those fed 25% and 75% replacement of maize with white guinea corn (2.41 and 2.45) respectively. The poorest feed conversion ratio was recorded in birds fed 100% replacement of maize with white guinea corn (2.63).

Feed cost in Naira per kilogramme weight gain was lowest in birds fed 50% replacement of maize with white guinea corn (₦ 211.41) but the value was similar (P>0.05) to those of birds fed the control diet (₦ 215.38) and those fed 25% and 75% replacement of maize with white guinea corn (₦ 223.19 and ₦ 229.14) respectively. Birds fed diet 100% replacement of maize with white guinea corn had the highest (p<0.05) cost of feed per kilogramme weight gain (₦ 246.95).
Table 4.8 Performance of Broiler Finisher Fed Graded Levels of White Guinea corn as Replacement for Maize (5-9 weeks)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Dietary treatments/replacement levels</th>
<th>T1 (0%)</th>
<th>T2 (25%)</th>
<th>T3 (50%)</th>
<th>T4 (75%)</th>
<th>T5 (100%)</th>
<th>SEM</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial weight (g/bird)</td>
<td></td>
<td>1007.33</td>
<td>1009.71</td>
<td>1008.14</td>
<td>1009.77</td>
<td>1008.67</td>
<td>0.97</td>
<td>NS</td>
</tr>
<tr>
<td>Final live weight (g/bird)</td>
<td></td>
<td>2275.56a</td>
<td>2241.11a</td>
<td>2281.66a</td>
<td>2205.66ab</td>
<td>2114.44b</td>
<td>54.10</td>
<td>*</td>
</tr>
<tr>
<td>Total weight gain (g/bird)</td>
<td></td>
<td>1268.22a</td>
<td>1231.40a</td>
<td>1273.52a</td>
<td>1196.88ab</td>
<td>1105.77b</td>
<td>54.20</td>
<td>*</td>
</tr>
<tr>
<td>Av. Daily weight gain (g/bird/day)</td>
<td></td>
<td>60.39a</td>
<td>58.63a</td>
<td>60.64a</td>
<td>56.99ab</td>
<td>52.66b</td>
<td>2.58</td>
<td>*</td>
</tr>
<tr>
<td>Total feed intake (g/bird)</td>
<td></td>
<td>2960.6</td>
<td>2963.3</td>
<td>2879.4</td>
<td>2908.3</td>
<td>2915.6</td>
<td>104.1</td>
<td>NS</td>
</tr>
<tr>
<td>Daily feed intake (g/bird/day)</td>
<td></td>
<td>140.98</td>
<td>141.11</td>
<td>137.11</td>
<td>138.49</td>
<td>138.83</td>
<td>4.96</td>
<td>NS</td>
</tr>
<tr>
<td>Feed conversion ratio</td>
<td></td>
<td>2.33a</td>
<td>2.41a</td>
<td>2.27a</td>
<td>2.45ab</td>
<td>2.63b</td>
<td>0.09</td>
<td>*</td>
</tr>
<tr>
<td>Cost of feed/kg weight gain (₦/kg)</td>
<td></td>
<td>215.38a</td>
<td>223.19ab</td>
<td>211.41a</td>
<td>229.14ab</td>
<td>246.95b</td>
<td>9.23</td>
<td>*</td>
</tr>
</tbody>
</table>

SEM: standard error of mean.
*Means on the same row with different superscripts are significantly (P<0.05) different.
LOS: Level of significance
NS: Non significant difference (p>0.05);
* : Significant difference (p< 0.05)
4.4.3 Carcass Characteristics and Organ Weights of Broilers Fed Graded Levels of White Guinea corn as Replacement for Maize.

Final live weight, carcass weight and dressing percent were significantly (p<0.05) lower in birds fed diet $T_5$ (100% replacement of maize with white guinea corn) compared to birds fed other diets (Table 4.9). Birds fed 50% replacement of maize with white guinea corn had the highest carcass weight and dressing percent. The primal cuts (the breast, thigh and back) expressed as percentage of dressed weight of experimental birds were significantly (P<0.05) affected by the treatment diets.

Birds fed 100% replacement of maize with white guinea corn had similar weight of breast as birds fed diet $T_1$ (control) which was also not significantly (p>0.05) different from the values obtained with other diets. There were no significant (p<0.05) differences among treatment means for organs weights such as heart, kidney and gizzard. The intestine length and weight significantly (p<0.05) increased as the level of guinea corn increased in the diets.

The weight of liver was significantly (p<0.05) higher in birds fed 100% replacement of maize with white guinea corn compared to other treatments.
Table 4.9 Carcass Characteristics and Organ Weights of Broilers Fed Graded Levels of White Guinea corn as Replacement for Maize

<table>
<thead>
<tr>
<th>Parameters</th>
<th>T1 (0%)</th>
<th>T2 (25%)</th>
<th>T3 (50%)</th>
<th>T4 (75%)</th>
<th>T5 (100%)</th>
<th>SEM</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live weight (g)</td>
<td>2274.00a</td>
<td>2238.00a</td>
<td>2278.33a</td>
<td>2203.67a</td>
<td>2112.33b</td>
<td>41.79</td>
<td></td>
</tr>
<tr>
<td>Dressed weight (g)</td>
<td>2030.00a</td>
<td>2017.00a</td>
<td>2041.00a</td>
<td>1945.00ab</td>
<td>1887.33b</td>
<td>48.03</td>
<td></td>
</tr>
<tr>
<td>Dressing Percent (%)</td>
<td>73.13ab</td>
<td>72.17ab</td>
<td>76.37a</td>
<td>70.22ab</td>
<td>69.85b</td>
<td>3.24</td>
<td></td>
</tr>
<tr>
<td>Carcass weight (g)</td>
<td>1663.33ab</td>
<td>1616.67ab</td>
<td>1733.33a</td>
<td>1571.67b</td>
<td>1495.00b</td>
<td>64.45</td>
<td></td>
</tr>
<tr>
<td>Breast weight (%)</td>
<td>22.34a</td>
<td>18.89b</td>
<td>18.23b</td>
<td>18.42b</td>
<td>20.63ab</td>
<td>1.37</td>
<td></td>
</tr>
<tr>
<td>Thigh +Drumstick (%)</td>
<td>25.81a</td>
<td>22.93b</td>
<td>22.77b</td>
<td>21.41c</td>
<td>23.84ab</td>
<td>1.06</td>
<td></td>
</tr>
<tr>
<td>Back weight (%)</td>
<td>16.81a</td>
<td>15.86ab</td>
<td>16.53ab</td>
<td>15.99ab</td>
<td>15.54b</td>
<td>0.51</td>
<td></td>
</tr>
</tbody>
</table>

**Organ Weights:**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>T1 (0%)</th>
<th>T2 (25%)</th>
<th>T3 (50%)</th>
<th>T4 (75%)</th>
<th>T5 (100%)</th>
<th>SEM</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver weight (%)</td>
<td>1.66b</td>
<td>1.69b</td>
<td>1.77b</td>
<td>1.80b</td>
<td>2.11a</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Kidney weight (%)</td>
<td>0.50</td>
<td>0.49</td>
<td>0.52</td>
<td>0.54</td>
<td>0.56</td>
<td>0.06</td>
<td>NS</td>
</tr>
<tr>
<td>Heart weight (%)</td>
<td>0.50</td>
<td>0.52</td>
<td>0.53</td>
<td>0.53</td>
<td>0.55</td>
<td>0.06</td>
<td>NS</td>
</tr>
<tr>
<td>Gizzard weight (%)</td>
<td>1.91</td>
<td>1.93</td>
<td>2.18</td>
<td>2.13</td>
<td>2.20</td>
<td>0.20</td>
<td>NS</td>
</tr>
<tr>
<td>Intestine weight (%)</td>
<td>4.10b</td>
<td>3.86b</td>
<td>3.96b</td>
<td>4.97a</td>
<td>5.28a</td>
<td>0.36</td>
<td></td>
</tr>
<tr>
<td>Intestine length (cm)</td>
<td>9.57c</td>
<td>10.45b</td>
<td>10.45b</td>
<td>11.07ab</td>
<td>11.92a</td>
<td>0.49</td>
<td></td>
</tr>
</tbody>
</table>

SEM: standard error of mean
abc Means on the same row with different superscripts are significantly (P<0.05) different.
LOS: Level of significance
NS: Non significant difference (p>0.05)
*: Significant difference (p<0.05)
Cut parts: expressed as % of dressed weight
Organ weights: expressed as percent of live weight
4.4.4 Nutrient Digestibility of Broiler Birds Fed Graded Levels of White Guinea corn as Replacement for Maize in Broiler Finisher Diets

The results of nutrient digestibility of broilers birds fed graded level of white guinea corn as replacement for maize in broiler finisher diets are presented in Table 4.10. There was no significant (p>0.05) differences in the percent ether extract and ash digestibility across dietary treatments but percent dry matter, crude protein, crude fibre and nitrogen free extract digestibility significantly (p<0.05) reduced as the level of white guinea corn increased up to 100% in the diet.
Table 4.10: Nutrient Digestibility of Broilers Fed Graded Levels of White Guinea corn as Replacement for Maize

<table>
<thead>
<tr>
<th>Parameters (%)</th>
<th>T1 (0%)</th>
<th>T2 (25%)</th>
<th>T3 (50%)</th>
<th>T4 (75%)</th>
<th>T5 (100%)</th>
<th>SEM</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>89.74&lt;sup&gt;a&lt;/sup&gt;</td>
<td>88.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>86.67&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>83.31&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>79.45&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.66</td>
<td>*</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>91.37&lt;sup&gt;a&lt;/sup&gt;</td>
<td>91.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>89.43&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>86.28&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>83.61&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.85</td>
<td>*</td>
</tr>
<tr>
<td>Crude Fibre</td>
<td>85.14&lt;sup&gt;a&lt;/sup&gt;</td>
<td>81.31&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>78.81&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>69.20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>71.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.52</td>
<td>*</td>
</tr>
<tr>
<td>Ether Extract</td>
<td>95.30</td>
<td>95.93</td>
<td>93.29</td>
<td>92.54</td>
<td>93.40</td>
<td>5.39</td>
<td>NS</td>
</tr>
<tr>
<td>Ash</td>
<td>91.62</td>
<td>90.30</td>
<td>88.13</td>
<td>85.10</td>
<td>84.87</td>
<td>3.92</td>
<td>NS</td>
</tr>
<tr>
<td>NFE</td>
<td>88.81&lt;sup&gt;a&lt;/sup&gt;</td>
<td>87.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>85.59&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>82.46&lt;sup&gt;b&lt;/sup&gt;</td>
<td>77.34&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.72</td>
<td>*</td>
</tr>
</tbody>
</table>

SEM: standard error of mean.
<sup>abc</sup> Means on the same row with different superscripts are significantly (P<0.05) different.

LOS: Level of significance
NS: Non significant difference (p<0.05)
* : Significant difference (p>0.05)
CHAPTER FIVE

5.0 DISCUSSIONS

5.1 Proximate Composition of the Test Ingredients

The percent dry matter (DM), ether extract and nitrogen free extract (NFE) was found to be high in maize. This may be responsible for the high value of ME (kcal/kg) compared to the values recorded for guinea corn and millets respectively. This finding is in agreement with the reports of Aduku (1993); Olomu (1995); and NRC (1996). These workers reported higher value of maize compared to guinea corn and millets.

The higher percent crude protein found in Pearl and finger millets compared to the values for maize, white guinea corn and Short kaura were within the ranges reported by Olomu (1995); Ojewola and Oyim (2006).

The similar values recorded for percent ether extract of maize, white guinea corn, Short kaura, pearl millet and finger millets respectively were within the ranges of 2.50 to 4.10% recorded by Olomu (1995); Subramanian and Metta (2000); Abubakar et al. (2006); Etuk and Ukaejiofo (2007).

The high Crude fibre found in pearl and finger millets (6.01 and 6.10%) agrees with Olomu (1995); Ojewola and Oyim (2006) who reported ranges of 5.8- 7.92 crude fibre (CF) for millets and contradicts that of Ravindran (1991); Sripriya et al. (2007); Adamu et al. (2013) who obtained 2.8 and 4.3% crude fibre respectively for pearl and finger millets.

The percent ash was found to be high in finger millet (3.2 %) compared to the values for maize, white guinea corn, Short kaura and pearl millets respectively. This result agrees with the reports of Gomez (1993); Olomu (1995); NRC (1996); Ojewola and Oyim (2006) who reported 3.83% ash for finger millet and classified it as a good
source of calcium 5-30 times more than in most cereals making it an important food for pregnant women, nursing mothers and children.

5.2 Anti-nutritional Factors in the Test Ingredients

The values recorded for tannins were within the range of 0.10 - 0.16 g/Kg, which was below 2.6 g/Kg reported by Reza and Edriss (1997) for low tannins guinea corn that were reported as tolerable for broiler chicken and cause no adverse effects on their performance. Also Barry and McNabb (1999) reported above 50 g/kg DM for high tannin guinea corn in animals. Phytate was within the range of 0.33- 0.66 g/Kg. Cyanide was within the range of 0.16- 3.60 g/Kg. Maize was found to be significantly (p<0.05) higher in cyanide compared to guinea corn and millets. Oxalate was within the range of 6.72- 13.44 g/Kg which was found to be significantly (p<0.05) higher in white guinea corn compared to maize, Short kaura guinea corn and millets respectively.

5.3 Experiment 1: Performance of Broiler Chickens Fed Two Varieties Each of Guinea corn and Millet as Replacements for Dietary Maize

5.3.1 Performance of Broiler Chicks Fed Maize, Guinea corn and Millet Based Diets (0-4 weeks).

The similar (p>0.05) values of feed intake of birds fed control diet (maize) and those fed pearl and finger millet diets (T₄ and T₅) respectively agreed with the reports of Rama Rao et al. (2002) who reported similar values of feed intake in broilers fed millets and maize. This observation is not surprising since the metabolizable energy concentrations of the diets were similar and birds are known for eating eat to satisfy their energy requirements. The high feed intake recorded in birds fed Short Kaura guinea corn diet (T₃) agreed with the reports of Nagra et al. (1990) who reported
higher feed intake in broiler starter birds fed yellow guinea corn compared to maize-fed counterparts.

The decrease in daily feed intake observed in the birds fed white guinea corn diet may be due to the high level of oxalate found in the white guinea corn grains and this could be the cause of low performance of birds. This finding agrees with the reports of Ibitoye et al. (2012) who observed low feed intake in broilers fed diets containing white guinea corn as replacement for maize.

The poorer growth rate and feed conversion ratio observed in birds fed white guinea corn based diet could be attributed to the lower feed intake and poor utilization of nutrients as a result of high levels of oxalates found in the grains. This finding is in agreement with the reports of Adeola (2006) who observed poor performance of broilers fed 100% white guinea corn as replacement for maize. Also, Oke (1969) and Oboh (1986) observed that oxalates affects calcium and magnesium metabolism and it reacts with protein to form complexes which have an inhibitory effect on peptic digestion.

The observed improvement in weight gain (p<0.05) of birds fed pearl and finger millet diets agrees with NRC (1994) which stated that weight gain in broilers was directly related to feed intake. This might be due to more balanced nutrient combination in millets since adequate amount of the essential amino acids is necessary for protein synthesis which results in increased weight gain. This corroborates with the reports of Rooney (1990) that millets contain higher crude protein and well balanced amino acids than other common cereal grains which may enhance growth, feed intake and feed conversion ratio. Similarly, Davis et al. (2003) stated that at day 1 to 42, birds fed 100% pearl millet diet had greater body weight and feed conversion ratio than birds fed maize and guinea corn based diets.
The feed conversion ratio of birds fed pearl and finger millet diets ($T_4$ and $T_5$) were significantly ($p<0.05$) lower and better compared to birds fed diet $T_1$ (control) and guinea corn diets. This means that pearl and finger millet diets were properly utilized by the birds. This finding agrees with the reports of Jambunathan and Subramanian (1988) and Rooney (1990). The mortality rate of the birds was not significantly ($p>0.05$) affected by the dietary treatments.

Feed cost in Naira per kilogramme weight gain showed that birds fed pearl millet diet had significantly ($p<0.05$) lower cost of production ($₦233.93$) compared to other treatments while finger millet had the highest ($p<0.05$) feed cost per kilogramme weight gain ($₦278.51$). The higher feed cost for finger millet diet was due to flood disaster that occurred in Zaria and other parts of the country as at the time of the study that led to sharp increase in market value for finger millet than the maize, guinea corn and pearl millet in the market.

5.3.2 Performance of Broilers Finisher Chicken Fed Maize, Guinea corn and Millet Based Diets (5-9 weeks)

Final weight and average daily weight gain showed that birds fed pearl and finger millet diets were significantly ($p<0.05$) higher compared to those fed other diets. This finding agreed with the report of Luis et al. (1982) and Andrews and Kumar, (1992) who reported that birds fed millet gave better performance than the maize and sorghum groups.

The significant ($P<0.05$) lower in weight gain of birds fed white guinea corn diet ($T_2$) compared to birds fed other diets is probably due to poor nutrient retention and utilization due to the high level of oxalates found in white guinea corn grain. This finding is in agreement with the reports of Cao, et al. (1998), who stated that
digestibility of nutrients were less for soft sorghum (white guinea corn) than for medium (red or yellow) and hard (cream) sorghum.

Birds fed Short kaura diet had similar feed intake and body weight gain as those fed the control diet. This observation perhaps may be that the metabolizable energy concentration of the diets were similar and for the fact that birds eat to satisfy their energy requirements. This finding is in agreement with the reports of Nagra et al. (1990); Rama Rao et al. (2002) and Tyagi et al. (2003). These workers reported that replacement of maize with low tannin guinea corn did not reduce the live body weight (LBW), live body weight gain (LBWG), feed intake and feed conversion ratio compared to maize based diet.

Feed conversion ratios of birds fed pearl and finger millet diets were significantly (p<0.05) better compared to birds fed other diets. This may have contributed to the observed enhanced weight gain of the birds fed these diets. This observation agrees with the reports of Davis et al. (2003) that birds fed 100% pearl millet diet had greater body weight, feed intake, and feed conversion ratio than birds fed yellow maize.

5.3.3 Carcass Characteristics and Organ Weights of Broilers Fed Maize, Guinea corn and Millet Based Diets.

The carcass evaluation of broilers showed similar trend as that of growth performance. The birds fed pearl and finger millet diet had higher live weights and carcass weights compared to those on other diets. This conforms to the reports of Davis et al. (2003) and Medugu et al. (2010) that millets can be well-utilized to produce broiler chickens with superior carcass quality compared to maize and guinea corn based diet. There were no significant (p>0.05) differences in dressing percent across dietary treatments. The percentages of primal cut (thigh and back) except breast muscle were not significantly affected by the treatments.
The values obtained for the internal offals such as the gizzard, heart, kidney and intestinal length were not significantly (p>0.05) affected by dietary treatment, indicating that there were no abnormalities in these organs. The weights of liver and intestine were significantly affected by the dietary treatments. Birds fed finger millet diets recorded significantly (p<0.05) higher weight of intestine compared to birds fed other diets. This finding agrees with the report of Rama Rao et al. (2002). This could be as a result of slightly high level of fibre found in finger millet.

5.3.4 Nutrient Digestibility by Broilers Fed Maize, Guinea corn and Millet Diets

There was no significant differences in percent ether extract digestibility across the treatment diets. The values obtained for percent dry matter, crude protein, crude fibre, ash and nitrogen free extract digestibility was significantly (p<0.05) lower for birds fed white guinea corn diet (T2) when compared with those fed other diets. This might have contributed to the poor performance observed in birds fed white guinea corn diet. This finding is in agreement with the reports of Cao et al. (1998), who stated that digestibility of nutrients were less for soft sorghum (white sorghum) than for medium (red or yellow) and hard (cream) sorghum. Similarly, Oke (1969) and Oboh (1986) observed that oxalates affects calcium and magnesium metabolism mainly by reducing the utilisation of the protein and the activity of the digestive enzymes.
5.4 Experiment 2:

5.4.1 Performance of Broiler Chicks Fed Graded Level of White Guinea corn as Replacement for Dietary Maize (0-4 weeks)

Substituting maize with white guinea corn did not adversely (p>0.05) affect daily feed intake across treatments. Birds fed 100% replacement of maize with white guinea corn had poor performance in all the parameters measured. There were no significant (p>0.05) difference from the control diet for feed conversion ratios of birds fed up to 50% of maize replacement by white guinea corn. These observations agreed with the reports of Cullison (1987) and Reddy et al. (2008). These authors reported that 50% replacement of maize with guinea corn did not impair body weight gain, feed intake and feed conversion ratio of broiler starter chicks when compared with maize based diet. Also, Makled and Afifi (2001) indicated that feed conversion ratio of broiler chicks at 6 weeks of age showed that 50% of the dietary maize can be replaced by guinea corn.

The poor performance of birds fed diet T₅ (with 100% replacement of maize with white guinea corn) might be due to poor nutrient digestibility as a result of the presence of antinutritional factor (oxalate) compared to the maize based diet. This observation is in agreement with the reports of Cao et al. (1998), which stated that digestibility of nutrients were less for soft guinea corn (white guinea corn) than for medium (red or yellow) and hard (cream) guinea corn. The result also confirms the findings of Adeola (2006) that growing chicks fed 100% guinea corn based diet had the lowest growth performance. However, Thakur et al. (1985) and Elkin et al. (1991) reported a contrary observation that there were no adverse effects of low-tannin guinea corn on broiler performance.
5.4.2 Performance of Broilers Fed Graded Levels of White Guineacorn as Replacement for Maize during the Finisher Phase (5-9 weeks).

Birds fed up to 75% replacement of maize with white guinea corn was comparable to those fed control diet in final live weight, daily weight gain, feed conversion ratio and feed cost per kilogramme gain. The daily weight gain of birds fed 100% replacement of maize with white guinea corn was lower (p<0.05). This result agrees with Thakur et al. (1985); Rama Rao et al. (1995) and Jayanaik et al. (2008) who reported that 75% substitution of maize with guinea corn in broilers diet did not affect body weight gain, feed intake and feed conversion ratio. The poor feed conversion ratio and significant (p<0.05) lower in weight gain of birds fed 100% replacement of maize with white guinea corn could also be due to the high levels of oxalate found in the white guinea corn grain. The results agree with the report of Adeola (2006) who observed lowest performance of broiler chickens fed 100% guinea corn and also the reports of Oke (1969) and Oboh (1986) who reported that oxalates affects calcium and magnesium metabolism. Oxalate also reacts with protein to form complexes which have an inhibitory effect on peptic digestion. Similarly, Attia (1998) reported that Giza-15 SG containing 0.397 % tannins had insignificant effect on broiler growth from 4 to 45 days of age.

5.4.3 Carcass Characteristics and Organ Weights of Broilers Fed Graded Levels of White Guinea Corn as Replacement for Maize.

Live weight, carcass weight and dressing percent were significantly (p<0.05) lower in birds fed diet T₃ (100% replacement of maize with white guinea corn) compared to birds fed other diets. Birds fed 50% replacement of maize with white guinea corn had the highest carcass weight and dressing percent. The primal cuts (the breast, thigh and back) expressed as percentage of dressed weight of experimental birds were significantly (P<0.05) affected by dietary treatments. Birds fed 100% replacement of
maize with white guinea corn had similar weight of breast as birds fed the control diet. There were no significant (p<0.05) differences among treatments for organs weights such as heart, kidney and gizzard. The intestine length and weight significantly (p<0.05) increased as the level of guinea corn increased. The weight of liver was significantly (p<0.05) higher in birds fed 100% replacement of maize with white guinea corn compared to other treatments.

The above-mentioned findings agreed with the reports of (Makled and Afifi, 2001; Adamu et al., 2012) that yellow maize could completely be substituted with sorghum without any adverse effects on carcass and organs characteristics. However, the poor performance observed in birds fed 100% replacement of maize with white guinea corn was in agreement with the report of (Adeola, 2006). This could be attributed to the high levels of oxalate found in the white guinea corn.

5.4.4 Nutrient Digestibility of Broilers Fed Graded Levels of White Guinea corn as Replacement for maize

There were no significant (p>0.05) differences in the percent ether extract and Ash digestibility across the dietary treatments but percent dry matter, crude fibre and nitrogen free extract digestibility significantly (p<0.05) reduced as the level of white guinea corn increased up to 100% replacement of maize. This finding agrees with Bach Knudsen et al. (1988) who reported low digestibility of starch in white guinea corn. Similarly, Cao et al. (1998), stated that digestibility of nutrients were less for soft guinea corn (white guinea corn) fed to broilers at 100% level replacement of maize.
CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary of major findings

The study was carried out to evaluate the effects of complete replacement of maize with two varieties of guinea corn and two varieties of millets on the growth performance, carcass characteristics and nutrient digestibility of broiler chickens. Each treatment consisted of 45 birds with three replicates of fifteen birds each in a completely randomized design (CRD). The proximate composition of the test ingredients showed that guinea corn and millets were slightly higher in percent crude protein and crude fibres while maize was higher in NFE and in ME (kcal/kg). Percent ash was higher in finger millet compared to others.

Tannin and phytates of both the white guinea corn and the Short kaura guinea corn were found to be much higher than those of maize and the millets but the levels contained appeared to be tolerable for broiler chickens as growth rates were not adversely affected. Oxalate was found to be the major anti-nutritional factor limiting the performance of broilers fed white guinea corn based diets.

At the end of the first experiment, it was observed that final body weights and weight gains were significantly (p<0.05) higher in birds fed pearl and finger millet diets respectively than other treatments at the starter and finisher phases. Pearl millet based diet recorded significantly (p<0.05) the best feed conversion ratio and the lowest feed cost per unit weight gain. Those birds fed the control (maize based diet) gave similar (p>0.05) values as those fed Short kaura based diet in all the parameters measured. Birds fed white guinea corn based diet had the least (p<0.05) and poor performance.

The second trial was conducted to evaluate the effects of replacing 0, 25, 50, 75 and 100% levels of maize in the diet with white guinea corn on the growth performance,
nutrient digestibility and carcass characteristics of broilers. In this experiment, there were no significant (p>0.05) difference for final weight, daily weight gain, feed conversion ratio and cost of feed per kilogramme weight gain of birds fed control (maize based diet) and those of birds fed 25%, 50% and 75% maize replacement by white guinea corn. Birds fed 100% replacement of maize by white guinea corn gave significantly (p<0.05) lowest values in all parameters measured and also the poorest feed conversion ratio.

6.2 Conclusion

1. The Crude Protein contents of pearl and finger millets were found to be considerably higher than the Crude Protein contents of maize and guinea corn.

2. Oxalate was found to be the major anti-nutritional factor limiting the performance of broilers fed white guinea corn based diets.

3. Tannin and Phytates of both the white guinea corn and the Short kaura guinea corn were found to be much higher than those of maize and the millets but the levels contained appeared to be tolerable for broiler chickens as growth rates were not adversely affected.

4. The nutrient digestibility of broilers fed graded levels of white guinea corn as replacement for maize did not show any significant difference for percent ether extract and ash digestibility across the treatments.

5. Complete replacement of maize with millets (pearl and finger) and guinea corn (Short kaura) did not impair body weight, feed intake, feed conversion ratio, nutrient digestibilities, carcass and organ weights in broiler starter and finisher diets.
6. Results for broiler starter and finisher studies revealed that white guinea corn could replace 75% of maize in broiler starter and finisher diets respectively without any adverse effect on performance.

6.3 Recommendations

Based on the findings of these studies, the following recommendations are made:

1. Maize can be completely replaced with pearl and finger millets in broilers starter and finisher diets without any nutritional defects on the birds growth performance.

2. White guinea corn can substitute 50% to 75% of dietary maize in broiler starter and finisher diets without any adverse effects on growth performance and carcass characteristics of broiler chickens.
REFERENCES


Ovimaps, (2012). Ovi location map; Ovi earth imagery date; May 20th, 2012.


