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

BY

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DEPARTMENT OF ANIMAL SCIENCE,
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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.

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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.

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ABSTRACT

Two studies were carried out to evaluate the effects of complete replacement of maize with two varieties of guineacorn 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; 3000Kcal/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 guineacorn, yellow guineacorn (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 (T_4 and T_5) respectively than other treatments. T_4 (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 T_1) gave similar ($p>0.05$) values as those fed T_3 (Short kaura based diet) in all the parameters measured. Birds fed diet T_2 (white guineacorn) 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 guineacorn on the growth performance, nutrient digestibility and carcass characteristics of broilers. Substituting maize with white guineacorn did not adversely ($p>0.05$) affect feed intake across the dietary treatments. At the starter phase, birds fed 25% and 50% guineacorn diet as

replacements for maize gave comparable results as those fed diet T_1(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 1diets ……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 (5-9weeks) **…..…….... 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 Guinea corn 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 L**evels 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 Characteristcs 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 Guinea corn 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 **Page**

2.1 Nutrient Composition of Maize and Guinea corn …….....8

2.2 Performance of Broiler Chickens Fed Maize, Millet, Low and High Tannin Sorghum 29

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) ……31

2.4 Ideal Amino acid Ratios: Percent Essential Amino acids for Broilers as Proposed by Various Investigators ……. 38

3.1 Percentage Composition of the Experimental Broiler Starter Diets for Experiment 1 (0-4 weeks) ……50

3.2 Percentage Composition of the Experimental Broiler Finisher Diets for Experiment 1 (5-9 weeks) ……51

3.3 Proximate Analysis of Broiler Starter Diets for Experiment 1 ……..... 52

3.4 Percentage Composition of the Experimental Broiler Starter Diets For Feeding Trial 2 (0-4 weeks) ……56

3.5 Percentage Composition of the Experimental Broiler Finisher Diets for Feeding Trial 2 (5-9 weeks) ……..57

3.6 Proximate Composition of the Experimental Broiler Finisher Diets for Experiment 2 ……..... 58

4.1 Proximate Composition of the Feed Ingredients …….....63

4.2 Anti-nutritional Factors in Feed Ingredients …….. 64

4.3 Performance of Broilers Starter Chickens Fed Maize, Guineacorn and Millet Diets (0-4 weeks) ……...66

4.4 Performance Characteristics of Broiler Finisher Chickens Fed Maize, Guinea corn and Millet Diets (5- 9 weeks) ……. 69

4.5 Carcass Characteristics and Organ Weights of Broilers Fed Maize, Guineacorn and Millet Based Diets …….....71

4.6 Nutrient Digestibility of Broilers Finisher Chicken Fed Maize, Guineacorn and Millet Based Diets 73

4.7 Performance of Broiler Starter Chicks Fed Graded Levels of White Guineacorn as Replacement for Maize (0-4 weeks) 75

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 (H_0): 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 (H_A): 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 virtualy 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 (%)

Components	maize [a]	G' corn [c] (white dawa)	G' corn [d] (yellow)	G' corn [b] (Indian)	G' corn [b] (ICSVII2)
Dry matter	91.80	93.31	88.94	92.50	-
Organic matter	90.53	93.06	93.06	-	-
Crude protein	8.8	10.48	14.84	9.50	8.9
Ether Extract	4.10	2.97	3.30	2.50	3.7
Crude Fibre	2.10	2.01	3.01	2.70	1.2
Ash	1.00	6.94	2.59	1.20	1.7
NFE	75.80	61.24	65.16	76.60	73.50

Sources: [a] Olomu (1995)
[b] Subramanian and Metta (2000)
[c] Abubakar *et al*. (2006)
[d] 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_{12} and good source of tocopherols (FAO, 1995, 2012). Other B-complex vitamins present in guinea corn in significant amounts are vitamin B_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 Liebman, 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 $70^{o}C$ for 8 minutes followed by washing with hot water ($60^{o}C$).

c) Soaking grain in 0.05M sodium hydroxide and potassium hydroxide or sodium carbonate at $100^{o}C$ 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 $25^{o}C$ 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 immunodulating 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).

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 significantl 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 3516kcal/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

Parameters	Maize	Millet	Low-tannin Sorghum ("chakalere")	High-tannin Sorghum ("jigari")
Initial weight (g)	353.30	350.33	343.33	353.33
Final body weight (g)	2142.00	2218.67	2112.00	1931.33
Daily weight gain (g)	41.39	43.17	39.66	34.44
Daily feed intake (g)	97.41	94.03	98.79	100.71
FCR	2.45	2.24	2.88	2.94

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)

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

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 (Linoieic 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 13^0C and 31^0C) 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 2.4: Ideal Amino acid Ratios: Percent Essential Amino acid for Broilers as Proposed by Various Investigators

Amino acids	Han and Baker (1994)	Baker (1997)	NRC (1994)	Lesson and Summers (2001)	Mack *et al.* (1999)	Baker *et al.* (2002)
Lysine	100	100	100	100	100	100
Methionine	36	36	42	40	ND	ND
Cystine	36	36	33	28	ND	ND
Threonine	67	67	67	58	59	56
Valine	77	77	75	67	76	78
Isoleucine	67	67	67	63	66	61
Leucine	109	109	100	117	ND	ND
Tryptophan	16	16	17	17	17	17
Arginine	105	105	104	100	104	105
Histidine	32	35	29	33	ND	ND
Phy + Tyr	105	105	112	117	ND	ND

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, isoleusine 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 –

growing strain. 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 (1) 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 B_2) 3.60mg.Thiamine (vitamin B_1)1.74mg, cyanocobalamin (vitamin B_{12}) 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 loose 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 35^0C. 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 11^0 9' 45'' N and longitude 7^o 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^oC 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^oC using the Soxhlet extraction apparatus.

Crude fibre was determined by boiling the sample under reflux in weak sulphuric acid (0.25N H_2S04), 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 furnance at 600^oC. 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)

Ingredients (%)	T1 Maize	T2 White G'corn	T3 Short kaura	T4 Pearl millet	T5 Finger millet
Maize	48.50	0.00	0.00	0.00	0.00
White Guinea corn	0.00	47.50	0.00	0.00	0.00
Short kaura	0.00	0.00	47.50	0.00	0.00
Pearl millet	0.00	0.00	0.00	49.50	0.00
Finger millet	0.00	0.00	0.00	0.00	49.50
Maize offal	5.00	5.00	5.00	5.00	5.00
GNC	24.75	24.85	24.85	21.00	21.00
Soya cake	12.00	12.00	12.00	12.00	12.00
Fish meal	4.00	4.00	4.00	4.00	4.00
Limestone	0.60	0.60	0.60	0.60	0.60
Bone meal	3.00	3.00	3.00	3.00	3.00
Palm oil	1.10	2.00	2.00	3.05	3.05
Common salt	0.30	0.30	0.30	0.30	0.30
Vit/mineral premix*	0.25	0.25	0.25	0.25	0.25
L- Lysine	0.25	0.25	0.25	0.25	0.25
Dl-methionine	0.25	0.25	0.25	0.25	0.25
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 (%)	5.68	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. D_3, 2000 i.u; Vit. E 3mg; Vit. K, 2 mg; Vit. B_1 (Thiamine), 1.8mg; Vit B_2 (Riboflavin), 5.5mg; Vit. B_6 (Pyridoxine), 3mg; Vit. B_{12} 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)

Ingredients (%)	T1 Maize	T2 White G'corn	T3 Short kaura	T4 Pearl millet	T5 Finger millet
Maize	53.74	0.00	0.00	0.00	0.00
White Guinea corn	0.00	54.20	0.00	0.00	0.00
Short kaura	0.00	0.00	54.20	0.00	0.00
Pearl millet	0.00	0.00	0.00	54.90	0.00
Finger millet	0.00	0.00	0.00	0.00	54.90
Maize offal	5.00	5.00	5.00	5.00	5.00
Groundnut cake	22.50	21.00	21.00	18.40	18.40
Soya cake	10.00	10.00	10.00	10.00	10.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Limestone	0.65	0.65	0.65	0.65	0.65
Bone meal	3.00	3.00	3.00	3.00	3.00
Palm oil	1.05	2.10	2.10	4.00	4.00
Common salt	0.30	0.30	0.30	0.30	0.30
Vit/mineral premix*	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.25	0.25	0.25	0.25	0.25
Dl- methionine	0.25	0.25	0.25	0.25	0.25
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 (%)	5.48	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. B_1 (Thiamine) 1.8mg; Vit B_2 (Riboflavin) 5.5mg; Vit. B_6 (Pyridoxine), 3.0mg; Vit. B_{12} 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

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

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^{o}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;

$$\text{Nutrient Digestibility} = \frac{\text{Nutrient intake} - \text{Nutrient in Excreta}}{\text{Nutrient intake}} \times 100$$

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

Nutrient output (g) = Dry faecal output × 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				
Ingredients (%)	**T1 (0%)**	**T2 (25%)**	**T3 (50%)**	**T4 (75%)**	**T5 (100%)**
Maize	47.35	35.52	23.68	11.84	0.00
White G' corn	0.00	11.84	23.68	35.52	47.35
Maize offal	5.00	5.00	5.00	5.00	5.00
GNC	25.00	25.00	25.00	25.00	25.00
Soya cake	12.00	12.00	12.00	12.00	12.00
Fish meal	4.00	4.00	4.00	4.00	4.00
Limestone	0.60	0.60	0.60	0.60	0.60
Bone meal	3.00	3.00	3.00	3.00	3.00
Palm oil	1.05	1.50	1.79	1.87	2.00
Common salt	0.30	0.30	0.30	0.30	0.30
Vit/mineral premix*	0.25	0.25	0.25	0.25	0.25
L-lysine	0.25	0.25	0.25	0.25	0.25
Dl-methionine	0.25	0.25	0.25	0.25	0.25
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. B_1 (Thiamine), 1.8mg; Vit B_2 (Riboflavin), 5.5mg; Vit. B_6 (Pyridoxine), 3 mg; Vit. B_{12} 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				
Ingredients (%)	**T1 (0%)**	**T2 (25%)**	**T3 (50%)**	**T4 (75%)**	**T5 (100%)**
Maize	52.70	39.53	26.35	13.17	0.00
White guinea corn	0.00	13.17	26.35	39.53	52.70
Maize offal	5.00	5.00	5.00	5.00	5.00
GNC	22.50	22.50	22.50	22.50	22.50
Soya cake	10.00	10.00	10.00	10.00	10.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Limestone	0.65	0.65	0.65	0.65	0.65
Bone meal	3.00	3.00	3.00	3.00	3.00
Palm oil	1.05	1.50	1.73	1.96	2.10
Common salt	0.30	0.30	0.30	0.30	0.30
Vit/mineral premix*	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.25	0.25	0.25	0.25	0.25
Dl- methionine	0.25	0.25	0.25	0.25	0.25
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. B_1 (Thiamine), 1.8mg; Vit B_2 (Riboflavin), 5.5mg; Vit. B_6 (Pyridoxine), 3 mg; Vit. B_{12} 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

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

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.

μ = 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 4.1 Proximate Compositions of Maize, Guinea- corn and Millet Grains

Nutrients	Maize (Yellow)	White G'corn	Short kaura	Pearl millet	Finger Millet
Dry Matter (%)	94.10	90.31	91.86	91.76	89.13
Crude Protein (%)	8.60	10.04	10.27	12.02	12.14
Ether Extract (%)	3.82	3.06	3.19	3.78	3.54
Crude Fibre (%)	3.20	4.69	4.78	6.01	6.30
Ash (%)	1.81	1.86	1.89	1.62	3.24
NFE (%)	80.60	78.80	78.92	72.20	68.06
ME(Kcal/kg) *	3451.68	3379.79	3403.13	3280.94	3120.85

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)

Parameters	T1 Maize	T2 White G'corn	T3 Short Kaura	T4 Pearl millet	T5 Finger Millet	SEM	LOS
Tannin	0.10^{a}	0.16^{b}	0.16^{b}	0.11^{a}	0.10^{a}	0.02	*
Phytate	0.33^{a}	0.68^{c}	0.66^{bc}	0.33^{a}	0.36^{b}	0.15	*
Cyanide	3.60^{d}	1.36^{b}	1.48^{b}	0.16^{a}	2.88^{c}	0.08	*
Oxalate	6.72^{a}	13.44^{d}	7.84^{c}	7.77^{b}	7.84^{c}	0.02	*

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

^{abcd} 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 ($p<0.05$)

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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 T_3) had significantly ($p<0.05$) the highest value of feed intake compared to those fed other diets. Birds fed diet T_1 (control) had similar values of feed intake as those fed pearl and finger millet based diets (diets T_4 and T_5) and their feed intakes were all significantly ($p<0.05$) higher than those birds fed white guinea corn based diet (T_2). 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)

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

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 T_1 (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 (T_2 and T_5) resulted in higher cost of production (₦338.65 and ₦314.54) per kilogramme meat produced while pearl millet diet (T_4) 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)

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

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 ($p<0.05$)
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

Parameters	T1 Maize	T2 White G' corn	T3 Short Kaura	T4 Pearl millet	T5 Finger millet	SEM	LOS
Live weight (g)	2049.5^{b}	1808.7^{c}	2035.5^{b}	2449.0^{a}	2340.2^{a}	72.47	*
Dressed weight (g)	1785.0^{b}	1587.0^{c}	1814.7^{b}	2093.3^{a}	2031.7^{a}	91.36	*
Dressing percent (%)	68.19	63.89	68.10	66.86	67.62	2.43	*
Carcass weight (g)	1398.33^{b}	1156.67^{c}	1383.33^{b}	1637.33^{a}	1581.67^{a}	67.28	*
Breast weight (%)	18.29^{b}	18.04^{c}	21.19^{a}	20.00^{a}	20.49^{a}	0.91	*
Thigh + Drumstick (%)	24.27	23.36	23.42	25.59	24.44	1.98	*
Back weight (%)	16.57	16.49	16.62	18.04	17.89	0.86	*
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^{b}	2.21^{a}	2.16^{ab}	1.97^{ab}	1.91^{b}	0.14	*
Gizzard weight (%)	2.30	2.48	2.43	2.47	2.49	0.15	NS
Intestine weight (%)	3.60^{b}	3.56^{b}	3.66^{b}	4.00^{ab}	4.40^{a}	0.28	*
Intestine length (cm)	10.84	10.86	10.96	10.99	11.10	0.63	NS

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)

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 (T_2) compared to those fed other diets.

Table 4.6 Nutrient Digestibility of Broilers Finisher ChickenFed Maize, Guinea corn and Millet Based Diets

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

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 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)

Parameters	Dietary treatments/replacement levels T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)	SEM	LOS
Initial weight (g/bird)	40.63	40.57	40.68	40.64	40.66	0.08	NS
Final live weight (g/bird)	1031.11^{a}	999.44^{a}	978.68^{ab}	910.00^{ab}	860.00^{b}	63.70	*
Total weight gain (g/bird)	990.48^{a}	958.87^{a}	938.00^{ab}	869.35^{ab}	819.34^{b}	63.67	*
Av. Daily weight gain (g/bird/day)	35.37^{a}	34.24^{a}	33.50^{ab}	31.04^{ab}	29.26^{b}	2.27	*
Total feed intake (g/bird)	1585.56	1550.11	1546.67	1546.11	1535.56	47.39	NS
Daily feed intake (g/bird/day)	56.62	55.36	55.23	55.21	54.84	1.69	NS
Feed conversion ratio	1.61^{a}	1.61^{a}	1.67^{a}	1.79^{b}	1.88^{b}	0.11	*
Cost of feed/kg weight gain (₦/kg)	152.66^{a}	156.40^{a}	160.65^{ab}	171.10^{b}	182.00^{b}	11.67	*

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 T_1 (control diet) gave similar ($p>0.05$) values of weight gain as those fed diets T_2, T_3 and T_4 (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)

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

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)

4.4.3 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

	Dietary treatments						
Parameters	**T1 (0%)**	**T2 (25%)**	**T3 (50%)**	**T4 (75%)**	**T5 (100%)**	**SEM**	**LOS**
Live weight (g)	2274.00a	2238.00a	2278.33a	2203.67a	2112.33b	41.79	*
Dressed weight (g)	2030.00^{a}	2017.00^{a}	2041.00^{a}	1945.00^{ab}	1887.33^{b}	48.03	*
Dressing Percent (%)	73.13^{ab}	72.17^{ab}	76.37^{a}	70.22^{ab}	69.85^{b}	3.24	*
Carcass weight (g)	1663.33^{ab}	1616.67^{ab}	1733.33^{a}	1571.67^{b}	1495.00^{b}	64.45	*
Breast weight (%)	22.34^{a}	18.89^{b}	18.23^{b}	18.42^{b}	20.63^{ab}	1.37	*
Thigh +Drumstick (%)	25.81^{a}	22.93^{b}	22.77^{b}	21.41^{c}	23.84^{ab}	1.06	*
Back weight (%)	16.81^{a}	15.86^{ab}	16.53^{ab}	15.99^{ab}	15.54^{b}	0.51	*
Organ Weights:							
Liver weight (%)	1.66^{b}	1.69^{b}	1.77^{b}	1.80^{b}	2.11^{a}	0.14	*
Kidney weight (%)	0.50	0.49	0.52	0.54	0.56	0.06	NS
Heart weight (%)	0.50	0.52	0.53	0.53	0.55	0.06	NS
Gizzard weight (%)	1.91	1.93	2.18	2.13	2.20	0.20	NS
Intestine weight (%)	4.10^{b}	3.86^{b}	3.96^{b}	4.97^{a}	5.28^{a}	0.36	*
Intestine length (cm)	9.57^{c}	10.45^{b}	10.45^{b}	11.07^{ab}	11.92^{a}	0.49	*

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

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

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)

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 (T_4 and T_5) 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 (T_3) 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 (T_2) 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 T_5 (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 oxalates found in the white guinea corn grain. The results agrees 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 T_5 (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

Abd El-Hakim A. S., Abdel-Wahed, H. M, and Namra, M. M. (2003). Effect of replacing yellow corn by sorghum grains in Japanese quail diets. *Egyptian Journal of Nutrition and Feeds, 6 (Special Issue)*: 157-167.

Abubakar, M., Doma, U. D., Kalla, D.J.U., Ngele, M.B. and Augustine, C.L.D. (2006). Effects of dietary replacement of maize with malted and unmalted sorghum on performance of weaner rabbits. *Livestock Resource and Rural Development*, 18(5). Article #65 Retrieved November 28, 2006, from http://www.cipav.org.co/lrrd18/5/abub18065.htm.

Adamu, S. B., Yaya, N. and Alade, N. K. (2001). Effects of Different Energy Sources on finishing and carcass characteristics of broiler chickens under a semi-arid condition. *Journal of Sustainable Agriculture and Environment*, 3(2): 232-238.

Adamu, M. S., Nafarnda, W. D., Iliya, D. S. and Kubkomawa, H. I. (2006). Repacement value of yellow sorghum (*Sorghum bicolor*) for maize in broiler diets. *Global Journal of Agricultural Science*, 5(2): 151-154.

Adamu, M.S., Kubkomawa, H.I., Doma, U.D. and Duduwa., A.T. (2012). Carcass and Gut Characteristics of Broilers Fed Diets Containing Yellow Sorghum (*Sorghum bicolor*) Variety in Place of Maize. *International Journal of Sustainable Agriculture* 4 (1): 08-11. ISSN 2079-2107© IDOSI Publications.

Adegbola, T.A. (2004). Utilizing Proven Alternative Feed Ingredients in the Livestock Industry. *Proceedings of the 27th Annual Conference of the Nigerian Society for Animal Production*, March 17-21, 2004, Akure, pp: 431-43

Adejinmi, O.O., Hamazat, R.A. and Fapohunda, J.B. (2007). Performance and Nutrient Digestibility of Rabbits. *Nigerian Journal for Animal Production*, 34(1): 63-68.

Adeola, O. and Rogler, J.C. (1994). Pearl millet in diets of white Pekin ducks. *Journal of Poultry Science*, 73: 425–435.

Adeola, O., and Orban, J. I. (1995). Chemical composition and nutrient digestibility pearl millet (*Pennisetum glaucum*) fed to growing pigs. *Journal of Cereal Science*, 22: 177–184.

Adeola, O. (2006). Amino acid digestibility of corn, pearl millet and sorghum for White pekin ducks, Anas Platyrinchos domesticus. *Journal of Poultry Science*, 43: 357-346.

Aderemi, F.A., Alabe, O.M. and Lawal, T.E. (2006). Utilization of Whole Cassava meal by egg type chicken. *Proceedings of 11th Annual Conference of Animal Science Association of Nigeria (ASAN),* Sept. 18th – 21st 2006, held at IAR and T, Ibadan, Nigeria. Pp: 73-75.

Aderolu, A.Z., Iyayi, E.A. and Onilude A.A. (2007). Performance, organ relative weight, serum and haematology parameters in broiler finisher fed biodegraded brewers dried grain. *Pakistan Journal of Nutrition,* 6: 204-208.

Aduku, A.O. (1992). Practical Livestock Feeds Production in the Tropics. S. Asekome and Co. Publishers, P.O.Box 15, Samaru, Zaria.

Aduku, A.O. (1993). Tropical Feedstuff-Analysis Table. Department of Animal Science, Faculty of Agriculture. Ahmadu Bello University, Samaru, Zaria, Nigeria.

Agbede, J.O., Ajaja, K.E. and Aletor, V.A. (2002). Influence of Roxazyme G supplementation on the utilization of sorghum dust-based diets for broiler-chicks. *Proceedings of the 27th Annual Conference of Nigerian Society for Animal Production (NSAP),* Akure, pp. 105-108.

Ahmed, S. M., Saleh, Qing Zhang., Jing, C. and Qun S. (2013). Millet grains: Nutritional quality, processing, and potential health benefits. Institute of Food Technologists. *Comprehensive Reviews in Food Science and Food Safety (12).* doi: 10.1111/1541-4337.

Ajayi, F., Balogun, O. O., Ovuru, S. S. and Mgbere, O. O. (2005). Reproductive Performance of Rabbits fed maize milling waste-based diets. *African Journal of Biotechnology,* 4(5): 439-443.

Ali, M. A. M., El Tinay, A. H. and Abdalla, A. H. (2003). Effect of fermentation on the invitro protein digestibility of pearl millet. *Food Chemistry,* 80(1): 51-54.

Alleman, F., Michael, J. M.; Changneau, A. M. and Ledercq, B. (2000). The effects of dietary protein independent of essential amino acids on growth and body composition of genetically lean and fat chickens. *British Poultry Science,* 41: 214-218.

Amadou, I., Gbadamosi, O. S. and Le, G. W. (2011). Millet based traditional processed foods and beverages – a review. *Cereal Foods World,* 56: 115–121.

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

Andrew, D.J. and Kumar, K.A. (1992). Pearl Millet for Food, Feed and Forage. *Advanced Agronomy,* 48: 89-139.

Appa-Rao, S., House, L.R. and Gupta, S.C. (1989). Review of Sorghum, Pearl Millet and Finger Millet Improvement. *Journal of Sustainable Agricultural Development C.L./ICRISAT Bulawayo, Zimbabwe.* Pp 170-180.

Araujo, L. F., Jungueira, O.M., Arau-jo, C.S., Artoni, S.M. and Faria Filho D.E. (2002). Different Criteria of Food Formulation for Broilers in the period of 1 to 21 days of age. *Review of Brassica Cien Avian*, 4: 195-202.

Asha Rajini, R., Rukmagadha, S., Ravindran, R., Mohan, B., Murugandhan, B. and Vedhanayagam, K. (1986). Replacing maize with other grains in broiler diet. *Indian Journal of Poultry Science*, 21: 343-344.

Association of Official Analytical Chemistry (AOAC, 1990). Official Method of Analysis, 15th Edn. Washington D.C., USA.

Atteh, J.O. (2002). Principles and Practice of Livestock Feed Manufacturing. Adlek Printers. 64, Sabon-Line, Ilorin, Kwara State, Nigeria. Pp. 217.

Atteh, J.O. and Ologbenla F. D. (1993). Replacement of Fish Meal with Maggots in Broiler Diets. Effects on Performance and Nutrient Retention. *Nigerian Journal of Animal Production.* 20: 44-49.

Attia, Y.A. (1998). Evaluation of the Egyptian white sorghum grain (Giza-15) as a feedstuff for broiler chick rations. *Egyptian Poultry Science Journal*, 18: 311-336.

Awika, J. M., Roony, L. W., and Waniska, R. D. (2000). Sorghum brans high in anthocyanins and tannins had higher antioxidant powers than blueberries and garlic. *American Association of Cereal Chemists (AACC).* Annual Meeting Kansas City, 14; 52 (14): 4388-4394.

Bach Knudsen, K.E., Kirleis, A.W., Eggum, B.O. and Munck, L. (1988). Carbohydrate composition and nutritional quality for rats of sorghum to prepared from decorticated white and whole grain red flour. *Journal of Nutrition,* 118 (5): 588-597.

Baker, D. H. and Han, Y. (1994). Ideal amino acid profile for chicks during the 1st three weeks post hatching. *Journal of Poultry Science,* 73: 1441-1447.

Baker, D. H. (1997). Ideal amino acid profile for swine and poultry and their application in feed formulation. *Biokyowa Technology Review,* 9: 1-24.

Baker, D. H., Batal, A. B., Par, T. M.; Augspurger, N. R. and Parsons, C. M. (2002). Ideal ratio (relatively to lysine) of tryphtophan, threonine, isoleucine and valine for chicks during the second and third weeks post hatch. *Journal of British Poultry Science,* 81: 485-494.

Banda – Nyirenda, D. B. C. and Vobra, P. (1990). Nutritional improvement of tannin-containing sorghum (*Sorghum bicolor*) by sodium bicarbonate. *Journal of Cereal Chemistry*, 67: 533 – 577.

Barrett, M. A. and Larkin, P. J. (1974). Milk production in the tropics. Oxford University Press, London, pp. 55 – 57.

Barry, T. N. and McNabb, W. C. (1999). The implications of condensed tannins on the nutritive value of temperate forages fed to ruminants. *British Journal of Nutrition (doi: 10.1017/S0007114599000501)*, 81: 263-272.

Basak, B. Pramanik A. H. Rahmnan, M. S. Taradar, S. U. and Roy, B. C. (2002). Azolla (Azolla pinnata) as feed ingredients in broiler ration. *International Journal of Poultry Science*, 1: 29 – 42.

Bendich, A. (2004). Functions and actions of retinoids and carotenoids: Building on the vision of James Allen Olson. *Journal of Nutrition*, 134: 225S-230S.

Berhe, E. T. and Gous, R. M. (2005). Effect of dietary protein content on allometric relationships between carcass portions and body protein in Cobb and Ross broilers. *Proceedings of the 24th conference of South African branch of WPSA, Pretoria.*

Blaha, J., Saleh-el Dis, H. M., Christodoulou, V. and Mudrik, Z. (1984). The possibility of replacing maize by sorghum in broiler chick feed mixtures. *Agricultura-Tropica et-Subtropica*, 17: 175-187.

Bohoua, G. C. and Yelakan, K.K. (2007). Effect of germinated sorghum flour on laying hens (warren). *International Journal of Poultry Science*, 6 (2): 122-124.

Boarman, K. W. (1979). Regulation of protein and amino acid intake. Pages 87-126 in: Feed intake Regulation in Poultry. K.W.

Boarman, K. N. and Burgess, A. D. (1986). Responses to amino acids. In C. Fisher and K. N. Boorman (eds.) Nutrients requirements of poultry and Nutritional Research, pp. 99 – 123. *Butterworth's, London*.

Bond, D. N., Whicher, J. T. and Lee, K. E. (1989). In: Recent Advances of Research in Antinutritional Factors in Legumes Seeds. Edited by J. Husinan, A. F. B. Vander Poel and I. E. Linear, Pudoc Wagennigen. Pp. 285 – 296.

Bouis, H. E. (2000). Enrichment of food staples through plant breeding: a new strategy for fighting micronutrient malnutrition. *Journal of Nutrition*, 16: 701-704.

Bravo, L. (1998). Polyphenols: chemistry, dietary sources, metabolism and nutritional significance. *Nutrition Reviews*, 56: 317–333.

Buerkert, A., M., Moser, A. K., Kumar, P., Furst, and Becker, K. (2001). Variation in grain quality of pearl millet from Sahelian West Africa. *Field Crops Research*, 69: 1–11.

Burnham, D., Emmans, G. C. and Gous, R. (1992). Isoleucine responses in broiler chickens. Interactions with leucine and valine. *British Poultry Science*, 33: 71-87.

Buyse, J., Decuypere, E., Berghman, L., Kuhn, E. R. and Vandesande, F. (1992). The effect of dietary protein content on episodic growth hormone secretion and on heat production of male 223 broilers. *British Poultry Science,* 33: 1101-1109.

Café, M. B., Stringhini, J. H. Mogyca, N. S., Franca, A. F. S. and Milheto – Grao, A. (1999). (*Pennisetum glancum*) (L) (Leeke). Comosubsetitutodo Milho emracoes para poedeiras commercials. *Arquivos Brasileiros de medicine veterinaria e Zootechnia,* 51: 171 – 176.

Calder, A. (1960). The value of rupoko (millet) for pig feeding. Rhodesia, *Journal of Agriculture,* 57: 116-119.

Cao, H., Hancock, J.D., Hines, R.H., Behnke, K.C., Park, J.S., Senne, B.W., Jiang, J.M., Froetschner, J.R. and Sorrell, P. (1998). Effects of sorghum endosperm hardness and processing on growth performance and nutrient digestibility in pigs and broiler chickens. Swine Day. KSU, Pp. 251-255.

CGIAR (2001) Consultative group on international agricultural research (GIAR research: areas of research – millet (online) www.cgiar.org/research, 10 April 2004.

Chai, W. and Liebman, M. (2004). Assessment of oxalate absorption from Almonds and Black beans with and without the use of an extrinsic label. *Journal of Urology,* 172: 953-957.

Chandrasekara, A. and Shahidi, F. (2011). Determination of antioxidant activity in free and hydrolyzed fractions of millet grains and characterization of their phenolic profiles by HPLC-DAD-ESI-MSn. *Journal of Functional Foods,* 3: 144-158.

Chandrasekara, A. and Shahidi, F. (2012). Bioaccessibility and antioxidant potential of millet grain phenolics as affected by simulated in vitro digestion and microbial fermentation. *Journal of Functional Foods*, 4: 226-237.

Choct, M. (2006). Enzymes for the feed industry: Past, present and future. *World's Poultry Science Journal*, 62: 5-15.

Chung, K. T., Wong, T. Y., Wei, C. I., Huang, Y. W. and Lin, Y. (1998). Tannins and human health. *Critical Reviews in Food Science and Nutrition,* 38(6): 421-464.

Conolly, A. (2012). Seminar presentation on "Pushing the boundaries – Performance and profitability". Poultry International Magazine, Mark Clement (ed). January 2012. p.18 www.WATTAgNet.com

Corzo, A. W. Dozier, A. I and Kid, M. T. (2006). Dietary lysine needs of late developing heavy broilers. *Poultry Science,* 85: 457 – 461.

Cullison, E.A. (1987). Air-dry Energy Feeds. Feeds and Feeding, 2nd Edition. Reston Publishing Company Inc., pp. 161 – 163.

Daiber, K.H. and Taylor, J.R.N. (1995). Opaque beers. Dendy, D.A.V. (ed.) Sorghum and Millets: Chemistry and Technology. St. Paul, MN: *American Association of Cereal Chemists*. Pp. 299- 323.

David, A. V. (1995). Sorghum and Millets Chemistry and Technology 406 pp. USA, St. Paul, Minnesota, American Association of Cereal Chemists, Inc. *American Journal of Botany,* 71: 350 – 557.

Davis, A. J., Dale, N. M. and Rerreira, F. J. (2003). Pearl millet as an alternative feed in broiler chickens diets. *Journal of Applied Poultry Research,* 12: 137 – 144.

Defang, H .F; Teguia, J., Awah, N. A; Kenfack, F. N., and Metuga, F. (2008). Performance and carcass characteristics of broilers fed boiled cowpea (*Vigna unguiculata* L Walp) and or black common bean (*Phaseolus vulgaris*) meal diets. *African Journal of Biological Technology,* 7: 1351-1356.

Derman, D. P., Bothwell, T. H., Torrance, J. D., Bezwoda, W. R., MacPhail, A. P., Kew, M. C., Sayers, M. H., Disler, P. B. and Charlton, R.W. (1980). Iron absorption from maize (*Zea mays*) and sorghum (*Sorghum vulgare*) beer. *British Journal of Nutrition,* 43: 271-279.

de Wet, J. M. Prasada, Rao J. K. E., Brink De and Mengesha, M. H. (1986). Systematics and evolution of Eleusine coracana (*Graminea*). *American Journal of Botany*, 71: 350-557.

de Wet, J. M. J. (2006). Eleusine coracana (L.) Gaertn. Record from protabase. Brink,M. and Belay, G. (Editors). PROTA (Plant Resources of Tropical Africa/ Resources vegetales de 1' Afrique tropicale), Wageningen Netherlands.

D'Mello, J. P. F. and Lewis, D. (1970). Amino acid interactions in chick nutrition. 3. Interdependence in amino acid requirements. *British Poultry Science,* 11: 367-376.

D'Mello, J. P. F and Devendra, C. (1995). Tropical Legumes in Animal Nutrition. CAB International, Wallingford UK, pp. 135-172.

D'Mello, J. P. F. (2003). Responses of growing poultry to Amino acids. In: Amino Acids in Animal nutrition. D'Mello, J.P.F. (ed). 2nd Edition.*CAB international, UK*..

Douglas, J. H., Sullivan, T. W., Gonzalez, N. J. and Beck, M. M. (1993). Differential age response of turkeys to protein and sorghum tannin levels. *Journal of Poultry Science,* 72: 1944-1951.

Duru, S., and Dafwang, I. I. (2010). Effect of Maxigrain Supplementation of diets with or without rice offal on the performance of broiler chicks. *International Journal of Poultry Science,* 9: 761-764.

Edwards, H. M. III, Fernandez, S. R. and Baker, D. H. (1999). Maintenance lysine requirement and efficiency of using lysine for accretion of whole – body lysine and protein in young chicks. *Journal of Poultry Science*, 78: 1412 – 1417.

Eits, R. M., Kwakkel, R. P. Verstegen, M. W. Stoutjesdijk, P. and Greef K. H. (2002). Protein and lipid deposition rates in male broiler chickens. Separate responses to amino acids and protein free energy. *Journal of Poultry Science*, 472 – 480.

El-Ful Ensaf, A., Asker, N. E. Aly, M. M., Hala,A. M., Abdel-Wahed, M. and Omar, E.M. (1998). The use of sorghum in broiler and layer diets with reference to enzyme supplementation. *Journal of Agricultural Science.* Mansoura University, 23: 5307-5323.

El-Khalifa, A. O., and El-Tinay, A. H. (1994). Effect of fermentation on protein fractions and tannin content of low- and high tannin cultivars of sorghum. *Journal of Food Chemistry*, 49: 265–269.

Elkin, R.G., Rogler, J. C. and Sullivan, T. W. (1991). Differential response of ducks and chicks to dietary sorghum tannins. *Journal of Science Food Agriculture*, 57: 543-553.

Elkin, R. G., Freed, M. B., Hamaker, B. R., Ye Zhang., Parson, C. M and Zhang, Y. (1996). Condensed tannins are only partially responsible for variations in nutrient digestibilities of sorghum grain cultivars. *Journal of Agriculture and Food Chemistry*, 44: 848-853.

ElShazali, A. M., Nahid, A. A, Salma, H. A. and Elfadil, E. B. (2011). Effect of radiation process on antinutrients, protein digestibility and sensory quality of pearl millet flour during processing and storage. *International Food Research Journal*, 18(4): 1401–1407.

Emmans, G. C. (1987). Growth, body composition and feed intake. *World's Poultry Science Journal*, 43: 208-227.

Emmans, G .C. and Fisher, C. (1986). Problems in nutritional theory. In Nutrient Requirements of Poultry and Nutritional Research. Pp. 9-39. (Fisher, C. and Boorman, K.N. eds), London, Butterworths.

Emmert, J. L. and Baker, D. H. (1997). Use of the ideal protein concept for precision formulation of amino acids levels in broiler diets. *Journal of Applied Poultry Resources*, 6: 462 – 470.

Ensminger, M. E. and Olentine Jnr. C. G. (1978). Feeds and Nutrition – Abridged. 1st Edition. The Ensminger Publishing Company, Covis, Carlifornia.

Ensminger, M. E. Oldfield, J. E. and Heinemann, W. W. (1990). Feed and Nutrition 2nd editionPp. 64 and 1009 – 1040. The Ensminger publishing company U.S.A.

Ensminger, M. E. (1991). Animal Science (9th edn.) Interstate publisher inc. Dancille, USA.

Etuk, E. B. and Ukaejiofo, U. R. (2007). Tannin content and dietary effects of brown coat coloured sorghum on the performance of young local turkey. *Journal of Animal Production Research Advances,* 3(2): 86 – 90.

FAO (1995). Food and Agriculture Organization. Sorghum and Millet in Human Nutrition. Food and Nutrition Series. No.27. Food and Agriculture Organisation, Rome/WHO p. 333 Retrieved on July 12, 2005 from http://www.fao.org/ DOCREP/TO818e/TOP18Eoo.html.

FAO (1996). Food and Agriculture organization. The world sorghum and millet economies. Fact, trends and autlook. A joint study by the Basic Foodstuffs Service FAO Commodities and Trade Division and the Socioeconomics and Policy Division. International Crops Research Institute for the Semi-Arid Tropics.

FAO (1997). Food and Agriculture Organization *Production Year Book*. Vol. 50. Pp. 118-122.

FAO (2004). Food and Agriculture organization of the United Nations. Website www.fao.org

FAO (2006). Food and Agriculture organization of the United Nations. Village chicken production systems in Rural African House, Food security (edns). Agricultural Department, FAO Corporate Document Repository, pp. 9 – 11.

FAO (2012). Food and Agriculture Organization. Grassland Index. A searchable catalogue of grass and forage legumes.

FAOSTAT (2005) http://FAO.ORG/FAOSTAT/ last updated in February 2005.

FAO/WEP/ (2000), FAO/WEP Crop and food supply assessment mission to Sudan. Special report: Sudan, January, 2002. FAO Global Information and Early Warning System on Food and Agriculture, World Food programme.

Ferguson, N. S. and Gous, R. M. (1997). The influence of heat production on voluntary food intake in growing pigs given protein deficient diets. *Animal Science*, 64: 365-378.

Ferguson, N. S., Gous, R. M. and Emmans, G. C. (1997). Predicting the effects of animal variation on growth and food intake in growing pigs using stimulation modeling. *Journal of Animal Science,* 64: 513-522.

Fisher, C. and Wilson, B. J. (1994). Responses to dietary energy concentration by growing chickens. In: T. R. Morris and B. M. Freeman (Eds) Energy requirement of poultry. *Journal of British Poultry Science, Edinburgh,* 151 - 184.

Flurharty F. L. and Loerch, S. C. (1996). Effects of dietary energy sources and levels of Performance of newly arrived feedlot calves. *Journal of Animal Science*, 74: 504 – 513.

Fuller, H. J., Potter, D. K. and Brown, A. R. (1996). The feeding value of grain sorghum in relation to tannin contents. Bulletin, No. 176, Georgia, USA. College of Agriculture Experimental Station, University of Georgia, USA.

Geraert, P. A., Padiha, J. C. F. and Gullaumin, S. (2006). Metabolic and endocrine changes induced by chronic heat exposure in broiler chicken: Growth performance, body composition and the retention. *British Journal of Nutrition*, 75: 195-204.

Gomez, M. I. (1993). Preliminary studies on grain quality evolution for finger millet for food and beverage use in the Southern African region. Pp. 289 – 296 in advances in small millets (Riley K. W., Gupta Sc. Seetharam A. and Mushonga, J. N. eds) New Delhi, India: Oxford and IBH publishing.

Gonzalez- A. M. and Pesti, G. M. (1993). Evaluation of the protein to energy ratio concept in broiler and turkey nutrition. *Poultry Science*, 72: 2115-2123.

Gous, R. M., Griessel, M. and Morris, T. R. (1987). Effect of dietary energy concentration on the response of laying hens to amino acids. *British Poultry Science*, 28: 427-436.

Gous, R. M. (2007). Predicting nutrient responses in poultry: future challenges. *Animal Science*, 1: 57- 65.

Gowda, D. R., Devegoda, G. and Ramapa, B. S. (1984). Effects of subabul leaf meal (*Leucocephala*) and sorghum in layer diets. *Indian Journal of Poultry Science*, 19: 180-186.

Grewal, A. and Jood, S. (2006). Effect of processing treatments on nutritional and antinutritional contents of green gram. *Journal of Food Biochemistry*, 30: 535-46.

Gualitieni, M. and Rapaccinni, S. (1990). Sorghum grains in poultry feeding. *World's Poultry Science Journal*, 46: 246-254.

Gupta, N., Srivastava, A. K. and Pandey, V. N. (2012). Biodiversity and nutraceutical quality of some indian millets. Proceedings of the National Academy of Sciences, India Section B: *Biological Science*. [DOI: 10.1007/s40011-012-0035-z]. Available from Springer [http://www.springerlink.com].

Hadimani, N. A., Muralikrishna, G., Tharanathan, R. N and Malleshi, N.G. (2001). Nature of carbohydrates and proteins in three pearl millet varieties varying in processing characteristics and kernel texture. *Journal of Cereal Science,* 33:17–25.

Hala, M. A. (1998). The use of sorghum or rice bran in broiler and layer diets with reference to enzyme supplementation. Ph. D. Thesis, Faculty of Agriculture, Fayoum, Cairo University, Egypt.

Han, Y. and Baker, D. H. (1991). Lysine requirement of fast and slow growing broiler chicks. *Journal of Poultry Science,* 70: 2108-2114.

Han, Y., Suzuki, H., Parsons, C. M. and Baker, D. H. (1992). Amino acid fortification of a low protein maize – soya bean meal diet for maximal weight gain and feed efficiency of chicks. *Journal of Poultry Science*, 71: 1168 – 1178.

Han, Y. and Baker, D. H. (1993). Effects of sex, heat stress body weight and genetic strain on the dietary lysine requirement of broiler chicks, *Poultry Science Journal*, 72: 701 – 708.

Harper, A. E. and Rogers, Q. R. (1965). Amino acid imbalance. *Proceedings of Nutritional Societies*, 24: 173-190.

Hidalgo, M. A., Davis, A. J., Dale, N. M and Dozier III, W. A. (2004). Use of whole pearl millet in broiler diets. *Journal of Applied Poultry Research,* 13: 229–234.

Hill, F.W. and Dansky, L.M. (1954). Studies on the energy requirements of chickens. 1. The effect of dietary energy level on growth and feed consumption. *Poultry Science Journal*, 33: 112-116.

Hill, G. M. and Hanna, W.W. (1990). Nutritive characteristics of pearl millet grain in beef cattle diets. *Journal of Animal Science,* 68: 2061–2066.

Hoste, H., Jackson, F., Athanasiadou, S., Thamsborg, S.M. and Hoskin, S.O. (2006).The effects of tannin-rich plants on parasitic nematodes in ruminants. *Trends in Parasitology*, 22(6): 253-261.

Hotz, C. and Gibson, R. S. (2007). Traditional food-processing and preparation practices to enhance the bioavailability of micronutrients in plant-based diets. *Journal of Nutrition*, 37: 1097-100.

Hulse, J. H., Laing, E.M. and Pearson, O. E. (1980). Sorghum and the millets: their composition and nutritive value. New York, Academic Press. Pp. 997.

Ibitoye, E. B., Olorede, B. R., Jimoh, A.A. and Abubakar, H. (2012). Comparative performance and organ relative weight of broiler chickens fed three sources of energy diet. *Journal of Animal Production*, 2(5): 233-238.

Ibrahim, S. Fisher, C. Alaily, H. E. Solomon H. and Anwar, A. (1998). Improvement of the nutritional quality of Egyptian and Sudanese grains by the addition of phosphorus. *Journal of British Poultry Science*, 29: 721 – 728.

Igwebuike, J. U., Kwari, I. D., Ubosi, C. O. and Alade, N. K. (2001). Replacement Value of Spent Sorghum Grains for Maize in Broiler Finisher Diets. *Journal of Sustainable Agricultural Environment*, 3: 224-233.

Improta, F. and Kellems, R. O. (2001). Comparison of raw, washed and polished Quinoa (*Chenopodium quinoa* willd.) to wheat, sorghum or maize based diets on growth and survival of broiler Chicks. Livestock Resources and Rural

Development. 13 (1), retrieved May 16, 2007 from http://www.cipar.org.co/irrd/irrd13/1/impr13.htm.

Jacob, J. P., Mitaru, N., Mbugu, P. N. and Blair, R. (1996). The effect of substituting Kenyan serena sorghum for maize in broiler chickens starter diets with different dietary protein and methionine levels. *Journal of Animal Feed Science Technology*, 61: 41-56.

Jambunathan, R. and Subramanian, V. (1988). Grain quality and utilization in sorghum and pearl millet. *Proceedings Workshop on Biotechnology for Tropical Crop Improvement*, ICRISAT, Patancheru, India. Pp. 1330-1339.

Jayanaik, U. B., Venkatareddy, K., Murthy, H. N. N. and Reddy, B.S.V. (2008). Effect of replacement of maize by finger millet (*Eleusine coracana*) and sorghum (*Sorghum bicolor*) with and without supplementation of enzymes in broiler diets on dry matter metabolizable energy and performance of broilers. *Mygore Journal of Agricultural Science*, 42 (3): 502-509.

Jorgensen, H. P., Sorensen, P. and Egum, B. O. (1990). Protein and energy metabolism in broiler chickens selected for either body weight gain or feed efficiency. *Journal of British Poultry Science*, 31: 517 – 524.

Kadirvel, R. L., Vohra, R . P. and kraser, F. H. (1974). Arginine, lysine and glycine interaction in the nutrition of chick. *Journal of nutrition*, 104: 1127-1134.

Kaur, K. D., Jha, A., Sabikhi, L. and Singh, A. K. (2012). Significance of coarse cereals in health and nutrition: a review. *Journal of Food Science and Technology*, DOI: 10.1007/s13197-011-0612-0619.

Kemp, C., Fisher, C. and Kenny, M. (2005). Genotype – nutrition interactions in broilers response to balanced protein in two commercial strains. *Proceedings of the 15th European symposium on poultry nutrition*. Balatonfured, Hungary, pp. 54-56.

Kidd, N. L. and Fancher, B. I. (2001). Lysine needs of starting chicks and subsequent effects during the growing period. *Journal of Applied Poultry Resources,* 10: 385-393.

Kim, I. H., Cao, H., Hancock, J. D., Park, J. S. and Li., D. F. (2000). Effects of processing and genetics on the nutritional value of sorghum in chicks and pigs. *Asian-Australian. Journal of Animal Science*, 13:1337-1344.

Koch, F. P., Wijtten, J. A., Lemme, A. A. and Langhout, D. J. (2002). Impact of a balanced amino acid profile on broiler performance. *Journal of Veterinarian Zootechnology,* 70 – 75.

Koong, L. J., Farcell, C. C. and Nienata, S. A. (1985). Assessment of Interrelationship among Levels of Intake and Production, Organ Size and Fasting Heat Production in Animals. *Journal of Nutrition,* 115: 1383 – 1390.

Krishnan, R., Dharmaraj, U. and Malleshi, N. G. (2012). Influence of decortication, popping and malting on bioaccessibility of calcium, iron and zinc in finger millet. *LWT-Food Science and Technology*, 48: 169-74.

Kubiezek, R.P., Obilana, A.T. and Okoli, P.N. (1984). Improvement of the nutritional quality of Nigeria sorghum for human food: Pre-germination effect on quality of protein. *Paper presented at the 8th Annual Conference of Nigerian Institute of Science and Technology*, 18 – 22 November, 1984.

Kumar, V., Elangovan, A.V., Mandal, A.B., Tyagi, P.K., Bhanja, S.K. and Dash, B.B. (2007). Effects of feeding raw or reconstituted high tannin red sorghum on nutrient utilisation and certain welfare parameters of broiler chickens. *Journal of British Poultry Science*, 48 (2): 198 – 204.

Labadan, M. C. Hsu, N. and Austic R. E. (2001). Lysine and arginine requirements of broiler chickens at two – to three week intervals to eight weeks of age. *Poultry Science Journal*, 80: 599 – 606.

Leclerq, B. (1998). Specific effects of lysine on broiler production: comparison with threonine and valine. *Poultry Science Journal*, 77: 118 – 123.

Leeson, S., Caston, L. and summers, J. D. (1996). Broiler response to diet energy. *Poultry Science Journal*, 75: 529-535.

Leeson, S. and summers, J. D. (2001). Nutrition of the chicken 4th edn, Unversity books, Ontario pp. 413.

Leitgeb, R. C., Raffaseder, C. C. Ruckenbauer, P. Lemmens, M. Bohm, J. Wagner, E. Krska, R. and Parich, A. (2003). Impact of Fusarium toxins on growth and slaughter Performance of broilers and turkeys. *Mycotoxin Resources*, 19: 180 – 184.

Liu, J., Tang, X., Zhang, Y. and Zhao, W. (2012). Determination of the volatile composition in brown millet, milled millet and millet bran by gas chromatography/ mass spectrometry. *Molecules*, 17: 2271– 2282.

Loosli, J. K. Oyenuga, V. A. and Babatunde, G. M. (1993). *Proceedings of the Inter symposium on Animal Production in the tropics.* University of Heinemann Educational books Nigeria Ltd. Ibadan.

Lucberd, J. and Castain, J. (1986). Utilization de sorghums differentes teneurs en tannins pour palimentation des poulets de chair. *Proceedings of the 7th European Poultry Conference.* France. 1: 472.

Luis, E.S. (1980). Nutrient composition and feeding value of millets, sorghum grains and corn in poultry diets. PhD Dissertation, University of Nebraska, Lincoln (Abstract) Retrieved 05/06/07 from http://digitalcommons.unl.ed/v dissertations/AAI81105771

Mack, S. D., Bercovici, G. D., Groote, B., Leclercq, M., Lippens, M., Pack, J. B., Schutte, B. and Cauwenberghe, S. V. (1999). Ideal amino acid profile and dietary lysine specification for broiler chickens of 20 to 40 days of age. *Journal of British Poultry Science,* 40: 257 – 265.

Magness, J. R, Markle, G. M. and Compton, C. C. (1971). Food and feed crops of the United States – A descriptive list classified according to potential for pesticides and residues. International Research Project IR – 4, IR. Bull 1 (Bulletin 828) New Jersey Agricultural Experiment Station, Retrieved on June, 15th, 2007 from http://www.hort.pordune.edu/newcrop/crops/grain= sorghum.html.

Makled, M. N. and Afifi, O. S. (2001). Sorghum plus methionine supplementation as substituent for yellow corn in broiler diets. *Egyptian Poultry Science Journal,* 21: 381-397.

Makokha, A. O., Oniango, R. K., Njoroge, S. M., and Kamar, O. K. (2002). Effect of traditional fermentation and malting on phytic acid and mineral availability from sorghum and millet grain varieties grown in Kenya. *Food Nutrition Bulletin,* 233 (Suppl.): 241–245.

Mammo, M. and Sultan, A. (2010). Performance and carcass characteristics of broiler chicken fed selected energy feed sources. *Research Journal of Poultry Sciences*, 3(3): 54- 57.

Mander, F. and Tomora, D. (1980). Effects of the amount of protein and energy in mixed feeds and the productivity of broilers. *Zhivotor chon Namki,* 17(6): 75 – 78.

Maunder, B. (2002). Sorghum - The global grain of the future. Retrieved November 30, 2004 from http://www.sorghumgrowers.com/maunder.htm.

Manwar, S. J. and Mandal, A. B. (2009). Effect of high moisture storageof pearl millet (*Pennisetum typhoides*) with or without feed enzymes on growth and nutrient utilization in broiler chickens. *Animal Science Journal,* 80: 438-445.

McDonald, P., Edward, R. A., Greenhalgh, J.F.D. and Morgan, E.A. (2000). Animal Nutrition, 5th Edition. Longman Scientific and Technical UK, pp. 476-530.

Medugu, C. I., Kwari, I. D. Igwebuike J. U., Nkamer. I., Mohammed, I. D. and Hamker, B. (2010). Performance and economics of production of broiler chickens fed sorghum or millet as replacement for maize in the semi-arid one of Nigeria. *Agriculture and Biology Journal of North America,* 1(3): 321 – 325.

Moran, E. T. and Stilborn, H. L. (1996). Effect of glutamic acid on broilers given submarginal crude protein with adequate essential amino acids using feeds high and low in potassium. *Poultry Science Journal,* 75: 120-129.

Mustafa, A. F., Seguin, P., Belair, G. and Kumar, A. (2008). Chemicalcomposition and ruminal degradability of grain pearl milletgrown in southwestern Quebec. *Canadian Journal of Animal Science,* 88: 71–77.

Myer, R. O., Gorbet, D. W. and Combs, G. E. (1986). "Nutritive value of high and low tannin grain sorghums harvested and stored in the high-moisture state for growing-finishing swine" *Journal of Animal Science*, 62 (3): 1290-1297.

Nagra, S. S., Chawla, J. S. and Phaul, P. S. (1990). Effect of feeding sorghum on growth performance of broilers. *Indian Journal of Poultry Science,* 25: 138- 144.

Nahashon, S. N., Adefope, N., Amenyenu, A. and Wright, D. (2006). Effect of varying Metabolisable energy and crude protein concentrations in diets of pearl gray guinea fowl pullets 1. Growth performance. *Poultry Science Journal,* 85: 1847-1854

Nesheim, M. C. (1968). Kidney argininase activity and lysine tolerance in strains of chickens selected for a high or low requirement of arginine. *Journal of Nutrition*, 95: 79-87.

Newcombe, M. C. and summers, J. D. (1984). Feed intake and gastro intestinal parameters of broiler and leghorn chicks in response to dietary energy concentration. *Nutrition Report International*, 29: 1127 – 1136.

NPC (2006). National Population Commission, National Population Census Headquarters, Abuja, Nigeria.

NRC (1984). Nutrient Requirements of Poultry, 9th Revised Edn. National Academy of Service Washington DC.

NRC (1994). National Research council. Nutrient requirements of poultry 9th Rev. Edn. National Academy press, Washington, D. C.

NRC (1996). National Research Council, Nutrient requirements of poultry. The nutrient requirements of farm animals, 9th edn. National Academy of Science USA. Pp.497-500.

Nworgu, F. C., Adebowale, E. A., Oredein, O. A., and Oni, A. (1999). Prospects and Economics of Broiler Production Using Two Plant Protein Sources. *Tropical Journal of Animal Science*, 2:159-166.

Nyachoti, C. M., Atkinson, J. L. and Lesson, S. (1997). *World's Poultry Science Journal*, 53: 5-21.

Nyannor, E. K., Adedokun, S. A., Hamaker, B. R.., Ejeta, G. and Adeola, O. (2007). Nutritional evaluation of high- digestible sorghum for pigs and broiler chicks. *Journal of Animal Science,* 85:196-203.

Nzelibe, H. C., Obaleye, S. and Onyenekwe, P. C. (2000). Malting characteristics of different varieties of fonio millet (*Digitaria exilis*). *European Food Research and Technology*, 211: 126-129.

Obilana, A.B. and Manyasa, E. (2002). Millets. In 'Pseudocereals and less common cereals: grain properties and utilization potential' (Belton, P.S. and Taylor, J.R.N. eds), Springer-Verlag, Berlin Heidelberg New York. Pp. 177-217.

Obioha, F. C. (1992). A guide to poultry production in the tropics 1st (ed.) Accra Publishers, Enugu, Nigeria. Pp. 121-122.

Oboh, S. O. (1986). Biochemical composition and utilization of sweet potato (*Ipomoea batatas*) in ruminant rations. Ph.D. Thesis. University of Ibadan, Ibadan,Nigeria.

Ogundipe, S.O. (1987). Non-Conventional Poultry Feedstuffs. Farm Research to Poultry Practice, Poultry Farmers Workshop. A.E.R.S. Ahmadu Bello University, Zaria, Nigeria, Pp. 69.

Ogundipe, S.O. (1996). Management of Broilers. NAERLS Extension Guide. No.40, *Poultry Series* No.4. Ahmadu Bello University, Zaria.

Ogundipe, S. O. and Sanni S. A. (2002). Economics of poultry production in Nigeria. *A training workshop manual. National Animal Production Research Institute,* A.B.U. Shika, Zaria. Pp. 27 – 45.

Ogundipe, S. O. (2003).Techniques of ration formulation for Poultry. In Poultry Research Programme National Animal Production Research Institute, Shika. Ahmadu Bello University, PMB 1096, Zaria, Nigeria. Pp 115.

Ogundipe, S.O., Abeke, F. O., Sekoni, A. A., Dafwang, I. I., and Adeyinka, A. I. (2003). Effect of duration of cooking on the utilization of lab lab purpureus by pullet chicks. In*: Proceedings of the 28th Annual conference of the Nigerian Society for Animal Production held at Ibadan, Nigeria.* Pp 233-235.

Ojano – Dirain, C. P. and Waldroup, P. W. (2002). Evaluation of lysine, methionine and threonine needs of broilers three to six week of age under moderate temperature stress. *International Journal of Poultry Science,* 1: 16– 21.

Ojewola, G. S. and Oyim, S. (2006). Comparative evaluation of maize sorghum and millet in growing cockerel's ration. *Agricultural Science Journal*, 1(3): 176–179.

Ojo, S. O. (2003). Productivity and technical efficiency of poultry egg production in Nigeria. *International Journal of Poultry Science,* 2: 459-464.

Oke, O. L. (1969). Oxalic acid in plants and in nutrition. *World Review of Nutrition and Dietetics*, 10: 263-303.

Olomu, J. M. (1995). Monogastric animal nutrition, principles and practice. Jackem Publications, Benin City, Nigeria pp. 69 – 104.

Oluyemi, J. A. (1985). Danger in low protein intake. Daily Times, 16 July 1985 p. 8.

Oluyemi, J. A. and Robert, F. A. (2000). Poultry production in warm wet climate (2nd edn). Spectrum books Ltd. Ibadan Nigeria.

Omenka, R. O. and Anyasor, G. N. (2010). Vegtable-based feed formulation on poultry meat quality. African *Journal of Food, Agriculture, Nutrition and Development,* 10 (1): 2001- 2010.

Oniang'o R. K. (1996). Effect of traditional fermentation and malting on phytic acid and mineral availability from sorghum (Sorghum bicolor) and finger millet (*Eleusine coracana*) grain varities grown in Kenya. *Food Nutrition Bulletin*. 2002 September; 23(3 Suppl.): 241-245.

Onu, P. N. and Madubuike, F. N. (2006). Effects of raw and cooked wiled cocoyam (Caladium bicolor) on the performance of broiler chicks. *Agricultural Tropical. Et Subtropics,* 39: 268– 272.

Oria, M. P., Hamaker, B. R., and Schull, J. M. (1995). *In vitro protein digestibility of developing and mature sorghum grain in relation to α –β-γ-kafirin disulfide crosslinking. Journal of Cereal Science*, 22: 85-93.

Oryokot, J. (2001). Finger Millet (*Eleusine coracana* (L.) (Gaertn.). Pp. 429-41. In: Agriculture in Uganda, Vol. 2, Mukiibi J.K. (ed). Kampala, Uganda: Fountain Publishers Ltd/CTA National Agricultural Research Organization.

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

Oyenuga, V. A. (1995). Nigerian feeds and feeding stuffs. Their chemistry and nutritive value 93rd Ed. Ibadan.

Pesti, G. M. and Fletcher, D. L. (1983). The response of male broiler chickens to diets with various protein and energy contents during the growing phase. *British Poultry Science,* 24: 91-99.

Plavik, I., Waxe, E., Sklan, D., Bartov, I. and Hurwitz, S. (1997).The response of broiler chickens and turkey poults to dietary energy supplied either by fat or carbohydrates. *Poultry Science Journal*, 76: 1000-1005.

Pond, W.G., Church, D.C. and Pond, K.R. (2005). Basic animal nutrition and feeding, J.W and Sons, USA. Pp. 483-486.

Pro, M.A. and Cuca, M. (1968). La Utilization del Trigo Como Fuente de Energia en la Alimentacion de Pavos en Iniciacion. Tec. Pec. en Mex., 11: 44 – 45.

Purseglove, J. W. (1972). Tropical Crops – Monocotyledons, Longman Group Ltd., UK, pp 261 – 286.

Pym, R. A. E. and Solvens, A. J. (1979). Selection for food conversion in broilers; body composition of birds selected for increased body weight gain, food consumption and feed conversion ratio. *Journal of British Poultry Science,* 20: 87-97.

Quentin, M. I. Bouvarel, I, and Picard, M. (2005). Effects of crude protein and lysine contents of the diet on growth and body composition of slow-growing commercial broilers from 42 to 77 days of age. *Animal Resources Journal*, 54: 113-122.

Rachie, K. O. and Peters, L. V. (1997). The *Eleusine* – A review of the world literature. International Crops Research Institute for semi-arid Tropics, Hyderabad, India.

Ragab, M. S. (2001). A study of substituting yellow corn and soybean meal by sorghum grains and raw sunflower on the performance of Japanese quail. Ph. D. Thesis, Faculty of Agriculture, Cairo University, Fayoum.

Ragaee, S., Abdel-Aal, E. M. and Noaman, M. (2006). Antioxidant activity and nutrient composition of selected cereals for food use. *Food Chemistry*, 98(1): 32-38.

Raju, M.V., Shyamsunder, G., Elangovan, A. V., Reddy, M. R., Sadagopan, V. R. and Rama Rao, S. V (2003). Sorghum, bajra and ragi vis-à-vis maize as energy sources in broiler chicken diets. *Indian Journal of Animal Nutrition,* 20: 185-192.

Raju, M.V., Shyamsunder, G., Sadagopan, V. R., Elangovan, A. V., Reddy, M. R. and Rama Rao, S. V (2004). Replacement of maize with jowar, bajra or ragi in broiler chicken diets. *Journal of Animal Nutrition and Feed Technology,* 4 (1): 53- 61.

Rama Rao, S., Praharaj, N.K, Raju, M.V., Mohapara, S.C, Chava, M.M. and Mishra, S.K. (1995). Replacement of yellow maize with tannin tree sorghum in white leghorn layer diet. *Indian Journal of Poultry Science*, 30: 76-78.

Rama Rao, S. V; Reddy, M.R; Praharray, N. K; and Shyam sunder, G. I. (2000). Laying Performance of broiler breeder chickens fed various millets or broken rice as a source of energy at a constant nutrient intake. *Journal of Tropical Animal Health Production,* 32: 329-338.

Rama Rao, S. V; Shyam Sunder, G. I; Reddy, M. R; Praharaj, N. K; Raju, M.V. and Panda, A. K. (2001). Effect of supplementary choline on the Performance of broiler breeders fed on different energy sources. *Journal of British Poultry Science,* 42: 362-367.

Rama Rao, S. V., Shyamsunder, A. K., Reddy, M. R., Raju, M. V., and Praharaj, N. K. (2002). Utilization of different millets replacing maize in coloured broiler chicken diet. *Indian Journal of Animal Nutrition*, 19: 353-358.

Ravindran, V. and Blair, R. (1991). Feed Resources for Poultry Production in Asia and Pacific 1. Energy sources. *World's Poultry Science Journal*, 47: 213-231.

Reddy V. K., Malathi, V., Venkatarami, B. S., Reddy, K., Pratap Kumar, S., and Jayanaik, B. (2008). Effect of finger millet and sorghum replacing corn in presence of soy oil/ fish oil and enzymes on performance of broilers. *International Journal of Poultry Science,* 7 (6): 560-546.

Reichert, R. D. (1979). The pH-sensitive pigments in pearl millet. *Journal of Cereal Chemistry*, 5 6(4): 291-294.

Reichert, R. P. and Young, C. C. (1977). Dehulling cereal grains and grain legumes for developing countries: II-Chemical composition of mechanically and traditionally dehulled sorghum and millet. *Journal of Cereal Chemistry*, 54(1): 174-178.

Reichert, R. D., Lorer, E. F., Youngs, C. G. (1979). Village-scale mechanical dehulling of cowpeas. *Cereal Chemistry*, 56(3): 181-184.

Reza, J. and Edriss, M. A. (1997). Effects of dietary sorghum of different tannin concentration and tallow supplementation on the performance of broiler chicks. *British Poultry Science,* 38: 512.

Rooney, L. W. (1978). Sorghum and Pearl millet lipids. *Journal of Cereal Chemistry,* 55: 584-590.

Rooney, L. W. (1990)**.** Processing methods to improve nutritional value of sorghum for livestock. Pp. 206– 210 In: Sorghum Nutritional Quality. *Proceedings of International Conference, W. Lafayette, IN. Purdue University, West Lafayette, IN.*

Rooney, L. W. (1992). Methods of processing sorghum for livestock feeds: In Utilization of sorhum and millets (Gomez, M. I; House, L. W., and Dendy, D. A. V., Eds.). Patancheru 502 324, Andhra Pradesh, India: *International Crops Research Institute for the Semi-Arid Tropics.*

Rostagno, H. S., Featherstone, W. R., Rogler, J. C. (1973). Studies on the nutritional value of sorghum grains with varying tannin contents for chick. I. Growth studies. *Poultry Science Journal,* 52: 765– 772.

Rostagno, H. S. (1997). Energia metabolizável do milho e do sorgo comdiferentes conteúdos de tanino para aves. *Revista Brasileira de Zootecnia,* 6(2): 304-318.

Rostagno, H. S., Albino, L. T., Donzele, J. L., Gomes, P. C., Ferreira, A. S., Olivera, R.F. and Lopes, C. D. (2000). Tabelas Brasileiras paraves e suinos (composicao de alimentos e exigencies nutricisionalis de aves e suinos). Vicosa (MG): UFA, Impresa Universitaria. Pp: 141-142.

Roth, F. X., Guber, K. and Kirchgessner, M. (2001). The ideal dietary amino acid pattern for broiler- chicks of age 7 to 28 days. *Arch. Geflugelkunde,* 65: 199-206.

Sanni, S. A. and Ogundipe, S. O. (2005). Economics of some modules of poultry production in Kaduna State, Nigeria. *Nigerian Journal of Animal Production,* 32(1): 102 – 107.

Salunkhe, D. K., Chavan, J. K. and Kadams, S. (1990). Dietary Tannin. Consequencies and Remedies, CRC, Press, Boca Raton, Florida, USA.

SAS (2002). Statistical Analysis System Institute. Users Guide Version 9 for Windows. Cary North Carolina USA.

Scott, M. L., Nesheim, M. C. and Young, R. J. (1982). Nutrition of the chicken. 3rd Edn. M.L. Scott and Associates, publishers Ithaca, New York, pp: 1- 406.

Selle, P. H., Ravindran, V., Ravindran, G., Pittolo, P. H and Bryden, W. L. (2003a). Influence of phytase and xylanase supplementation on growth performance and nutrient utilization of broilers offered wheat-based diets. *Asian-Australian Journal of Animal Science*, 16(3): 394-402.

Selle, P. H., Ravindran, V., Pittolo, P. H and Bryden, W. L. (2003b). Effects of phytase supplementation of diets with two tiers of nutrient specifications on growth performance and protein efficiency ratios of broiler chickens. *Asian-Australian Journal of Animal Science*, 16(8): 1158-1164.

Sharma, B. D., Sadagopan, V. R. and Reddy, V. R. (1979). Utilization of different cereals in broiler chickens ration. *British Poultry Science*, 20: 371-388.

Sheorain, V. S. and Wagle, D. S. (1973). Beta-amylase activity in germinated bajra and barley varities. *Journal of Food Science Technology, 10: 184-186.*

Shobana, S., Sreerama, Y. N. and Malleshi, N. G. (2009). Composition and enzyme inhibitory properties of finger millet (*Eleusine coracana* L.) seed coat phenolics: mode of inhibition of a-glucosidase and pancreatic amylase. *Food Chemistry,* 115(4): 1268–73.

Singh, D.N., Perez, M. R.., Mannion, P.F., Marthin, P. and Palmer, C.P. (2000a). Nutritive value of pearl millet grown in Australia. *Proceedings of the Australian Poultry Science Symposium* 12: 204.

Singh, P. and Raghuvanshi, R. S. (2012). Finger millet for food and nutritional security. *African Journal of Food Science,* 6(4): 77–84.

Sinurat, A. P. and Balnave, D. L. (1985). Effects of dietary amino acids and metabolizable energy on the performance of broilers kept at high temperatures. *Journal of British Poultry Science*, 26: 117-128.

Slavin, J. (2010). Whole grains and digestive health. *Cereal Chemistry*, 87: 292-296.

Smith, M. O., Teeter, R. G., Hintz, R. L., Murrey, E., Campbell, J. R. and Melouk, A. (1983). Feed intake and environmental temperature effects upon growth, carcass traits, ration.

Smith, A. J. (1990). The integration of rural production into the family food security system. CTA – Seminar proceedings on Smallholder rural Poultry production 9 –13 October, 1990. Thessaloniki, Greece.

Smithhard, R. (2002). Secondary Plant Metabolites in Poultry Nutrition. In: Poultry Feedstuff: Supply, Composition and Nutritive Value. McNab, J. M and Boorman, K. N (eds.) CAB International, Wallingford, UK, p. 254.

Srilatha Rani, P. (1995). Effect of replacement of maize with finger millet (ground and unground) on growth and egg production in chicken. M. V. Sc. Thesis, Andhra Pradesh Agricultural University Hyderabad, India.

Sripriya, G., Antony, U. and Chandra, T. S. (1997). Changes in carbohydrate, free amino acids, organic acids, phytate and HCl extractability of minerals during germination and fermentation of finger millet (*Eleusine coracana*). *Food Chemistry*, 58(4): 345-50.

Subramanian, S. and Viswanathan, R. (2007). Bulk density and friction coefficients of selected minor millet grains and flours. *Journal of Food Engineering*, 81(1): 118-26.

Steel, R.G.D. and Torries, J.H. (1980). Principles of Procedures of Statistics. A Biometrical Approach. (2nd ed). McGraw Hill Book Coy, N.Y., Pp. 633.

Subramanian, V. and Metta, V.C. (2000). Sorghum grain for poultry feed. In: Technical and Institution Options for Sorghum Grain Mold Management. Proc. International Consultation. Chandrasher A, Bandyopadhayi R and Hall AJ (eds.). *International Crop Research for the Semi-Arid Tropics* (ICRISAT). Patacheru 502 – 504, Andhra Pradesh, India, pp. 242 – 247.

Sullivan, T. W., Douglas, J. H., Andrews, D. J., Bowland, P. L., Hancock, J. D., Bramel-Cox, P.J., Stegmeier, W. D. and Brethour, J. R. (1990). Nutritional value of pearl millet for food and feed. Pages 83–94 in: Proceedings of International Conference. Sorghum Nutritional Quality, Purdue University, West Lafayette, IN.

Summers, J. D., Spratt, D. and Atkinson, J. L. (1992). Broiler weight gain and Carcass composition when fed diets varying in amino acid balance, dietary energy and protein level. *Journal of Poultry Science*, 71: 263-273.

Swatson, H. K., Gous, R. M. and Iji, P. A. (2000). Biological performance and gastrointestinal development of broiler chicks fed diets varying in energy: protein ratio. *South African Journal of Animal Sciences*, 30: 136-137.

Swatson, H. K., Gous, R. M., Iji, P. A. and Zarrinkala, R. (2002a). Proceedings of the 11th European Poultry Science Congress 6 to 10th August 2002. Bremen, Germany. *Animal Research*, 51: 501-515.

Swatson, H.K., Gous, R. M. and Iji, P. A. (2002b). *Proceedings of the 11th European Poultry Science Congress* 6 to 10th August 2002. Bremen, Germany (ABS, 8819-00108): 71-72.

Tackie, A. M. and Flenscher, J. E. (1995). Nutrient value of wild sorghum fortified with (*Leucana leucocepphala*) (Wh. Lam). *Bulletin of Animal for Africa,* 47: 223-375.

Taur, A. T., Pawar, V. D. and Ingle, U. M. (1984). Effect of fermentation on nutritional improvement of grain sorghum (*Sorghum bicolor* (L.) Moench). *India Journal of Nutrition Diet*, 21: 129-136.

Taylor, J.N., Schober, T. J. and Bean, S.R. (2006). Novel food and non-food uses for sorghum and millets. *Journal of Cereal Science,* 44: 252-271.

Taylor, J.R.N. and Emmambux, M.N. (2008a) Products containing other specialty grains: sorghum, the millets and pseudo cereals. Hamaker, B.R. (ed.) *Technology of Functional Cereal Products*. Cambridge: Woodhead Publishing. Pp 281-335.

Taylor, J. R. N. and Emmambux, M. N. (2008b) Gluten-free foods and beverages from millets. Arendt, E. and Dal Bello, F. (eds). Gluten Free Cereal Products and Beverages. London: Elsevier. Pp 119-148.

Thakur, R. S., Gupta, P. C. and Lodhi, G. P. (1984). Feeding value of different varieties of sorghum in broiler ration. *Indian Journal of Poultry Science,* 19: 103-107.

Thakur, R. S. and Prasad, D. (1992). Comparative feeding value of different cereals and their combinations for broilers. *Indian Journal of Poultry Science,* 27(4): 232-234.

Travis, D. K., Mitchell, R. T. and Joe, D. H. (2006). Variation in nutritional value of sorghum hybrids with contrasting seed weight characteristics and comparisons with maize in broiler chickens. *Journal of Crop Science*, 46: 695-699.

Truswell, A. S. (2002). Cereal grain and coronary heart disease. *European Journal of Clinical Nutrition*, 56(1): 1–4.

Tyagi, P. K., Elangovan, A.V., Mandal, A.B., Pramod, K., Tyagi, S. K and Johri, A.K. (2003). Effects of feeding low tannin sorghum grain to broiler chickens. *Indian Journal of Animal Nutrition.* 20: 322-326.

United States National Research Council/ National Academy of Sciences (1982). United States Canadian tables of feed Composition. Washington, DC, National Academy Press. 3e review.

Vankateswara Rao, M. (1995). Studies on utilization of ragi (*Eleusine coracana*) in broiler diets. M. V. Sc. Thesis, Andhra Pradesh Agricultural University, Hyderabad, India.

Van Wyk, B. E. and Gericke N. (2000). People's plants: a guide to useful plants of Southern Africa. Arcadia, Pretoria, South Africa: Briza publications.

Veldkamp, T., Kwakkel, R.P., Ferket, P.R. and Verstegen, M.W.A. (2005). Growth response to dietary energy and lysine at high and low ambient temperature in male turkeys. *Poultry Science Journal*, 84: 273-282.

Vinod Kumar1., Elangovan, A.V. and Mandal, A. B. (2005). Avian Nutrition and Feed Technology Division, Central Avian Research Institute, Izatnagar (UP), 243122, India Utilization of Reconstituted High-tannin Sorghum in the Diets of Broiler Chickens. *Asian-Australian Journal of Animal Science*, 18(4): 538-544.

Viswanath, V, Urooj, A., Malleshi, N. G. (2009). Evaluation of antioxidant and antimicrobial properties of finger millet polyphenols (*Eleusine coracana*). *Food Chemistry*, 114(1): 340–346.

Wadikar, D. D., Vasudish, C. R., Premavalli, K. S. and Bawa, A. S. (2006). Effect of variety and processing on ant- nutrients in finger millet. *Journal of Food Science and Technology*, 43: 370-373.

Waldroup, P.W., Greene, D.E., Harris, R.H., Maxey, J.F. and Stephenson, E.L. (1967). Comparison of Corn, Wheat and Milo in Turkey Diets. *Poultry Science Journal*, 46: 1581-1585.

Waldroup, P. W. (2000). Present status of the use of digestible amino acid values in formulation of broiler diets: Opportunities and obstacles. Aumaitre, A., Lee, B.D and Ha, J.K. (Eds.). *Asian- Australian Journal of Animal Science*, 13: 76-87.

Wu, Y. and Well, J. S. (1980). Lysine content of protein increased by germination of normal and high lysine sorghum. *Nutritional Abstract and Review*. B. Series 53 (11): 24- 32.

Yin, Y. L., Gurung, N. K., Jeaurond, E. A., Sharpe, P. H. and de Lange, C. F. M. (2002). Digestible energy and amino acid contents in Canadian varieties of sorghum, pearl millet, high-oil corn, high oil- high-protein corn and regular corn samples for growing pigs. *Canadian Journal of Animal Science*, 82: 385-391.

Yokozawa, T., Dong, E., Nakagawa, T., Kashiwagi, H., Nakagawa, H., Takeuchi, S. and Chung, H. Y. (1998). In vitro and in vivo studies on the radical-scavenging activity of tea. *Journal of Agriculture and Food Chemistry*, 46: 2143-2150.