EVALUATION OF DIFFERENT ENERGY SOURCES ON GROWTH PERFORMANCE, EGG PRODUCTION AND HEAMATOLOGICAL PARAMETERS OF JAPANESE QUAILS

(*Cortunix cortunix japonica*)

BY

ABDULLAHI OLALEKAN ISMAIL

SPS/11/MAS/00001

A DISSERTATION SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, BAYERO UNIVERSITY KANO, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF MASTER OF SCIENCE ANIMAL SCIENCE.

DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, BAYERO UNIVERSITY, KANO.

MAY, 2015.

DECLARATION

I hereby declared that the work in this thesis entitled "EVALUATION OF DIFFERENT ENERGY SOURCES ON GROWTH PERFORMANCE, EGG PRODUCTION AND HEAMATOLOGICAL PARAMETERS OF JAPANESE QUAILS (Cortunix cortunix japonica)" was carried out by me in the Department of Animal Science, Faculty of Agriculture, Bayero University, Kano, under the supervision of Prof. M. Abubakar and Prof. I.R. Mohammed. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

ABDULLAHI OLALEKAN ISMAIL

SPS/11/MAS/00001

CERTIFICATION

This is to certify that the research work for this thesis and the subsequent preparation of this thesis by ABDULLAHI OLALEKAN ISMAIL (SPS/11/MAS/00001) were carried out under my supervision

----

Prof. M. Abubakar
Supervisor

Dr. M. Baba
Head of Department

APPROVAL PAGE

This is to certify that the research work report titled "EVALUATION OF DIFFERENT ENERGY SOURCES ON GROWTH PERFORMANCE, EGG PRODUCTION AND HEAMATOLOGICAL PARAMETERS OF JAPANESE QUAILS (*Cortunix cortunix japonica*)" by ABDULLAHI OLALEKAN ISMAIL (SPS/II/MAS/00001) has been examined and approved for the award of the Degree of Master of science in Animal Science of Bayero University, Kano, Nigeria.

____________________________ _______________
EXTERNAL EXAMINER Date

____________________________ _______________
Professor I.R. Muhammmad Date
INTERNAL EXAMINER

____________________________ _______________
Professor M. Abubakar Date
SUPEVISOR

____________________________ _______________
Dr. M. Baba Date
Head of Department

____________________________ _______________
Dr. A. Mustapha Date
REPRESENTATIVE BOARD OF
POST GRADUATE SCHOOL.

DEDICATION

This thesis is dedicated to the Almighty Allah, who has been my helper, strengthener and provider. He is the giver of wisdom and knowledge, whose protection, love and grace saw me through the period of this study.

ACKNOWLEDGEMENT

I thank Almighty Allah who gave me the opportunity and courage to accomplish this project. May the peace and mercy of Allah be upon His Prophet Mohammad (S.A.W) his household, companions and all those that follow his footsteps till the Day of Judgment.

I wish to express my sincere gratitude and profound appreciation to my supervisors, the best combination of supervisors one can ever have, Prof. M. Abubakar and Prof. I.R. Mohammed for their inspiration, close supervision of this work, encouragement and sacrifice of their time and resources for the successful completion of this work. There supervisory attention given to me throughout the duration of this work is highly appreciated.

I am also grateful to the field staff of the Department of Animal Science for their assistance throughout the conduct of the experiments. I am equally grateful to Mal. Aminu and all other staff of Animal Science Department laboratory. My special appreciation goes to my friends and brothers, Al-Qazim Badmus, Abduldrazaq Ajadi, Isah Alabi, Ali baba and Mudashir for all their sacrifice for the completion of the work.

My profound appreciation goes to my wife, Tayyibah for her love, encouragement and moral support, and also by brothers Alh. Suleiman Abubakar and Murtala Abdullahi.

TABLE OF CONTENTS

CHAPTER THREE

MATERIALS AND METHODS

CHAPTER FIVE

SUMMARY, CONCLUSSION AND RECOMMENDATION

LIST OF TABLES

ABSTRACT

A thirteen-week feeding trial was conducted to evaluate the effects of different energy sources (maize, sorghum, millet, cassava and sweet potato) on growth performance, carcass characteristics, egg quality traits and heamatological parameters of Japanese quails. Three hundred (one week old) quails were divided into 5 dietary groups and each group replicated thrice with 20 quails each in a completely randomized design (CRD). Five iso-nitrogenous and isocarloric diets containing (20% CP; 2,800 kcal/ME) and (18% CP; 2,600 kcal/ME) for growing and laying phase respectively were formulated. Feed and water were provided *ad libitum* throughout the experimental period. Results showed that feed intake, body weight, average daily weight gain, Feed Conversion Ratio (FCR), Carcass weight (CW), Hen Housed Egg Production (HHEP) and Hen Day Egg Production (HDEP) were significantly different ($P < 0.05$) across the treatments. Birds fed diet 1 (maize) had highest body weight gain (211.87g) and best FCR while birds on diets 5 (sweet potato) had lowest body weight gain (158.73g) and poor FCR. Carcass weight for T_1 (maize) and T_2 (sorghum) are statistically similar while T_3 (millet) and T_4 (cassava) are statistically similar. Though, significant differences were not observed for Dressing Percentage (DP) which ranged from 82.6% in T_2 (sorghum) to 85.65% in T_1 (maize). Birds fed cassava recorded the lowest HHEP (61.56%) while maize (72.74%), sorghum (67.94%) and millet (67.25%) are statistically similar. There were no significant ($P > 0.05$) differences in the egg weight, egg shell thickness, albumen weight and albumen index across the treatments, however, significant ($P < 0.05$) differences were observed in yolk weight, egg shell weight and Haugh unit. Birds fed diet 3 (millet) and diet 4 (cassava) had the highest yolk weight. The result also showed that significant ($P < 0.05$) difference was observed in all the heamatological parameters. Birds fed diet 3 (millet) recorded the highest heamoglobin (16.34 g/dl) and lowest for birds fed sweet potato (6.33 g/dl). Pack Cell Volume (PCV) value was highest for diet 5 (19.05%) and lowest for diet 2 (12.41%). Based on this study, it is concluded that all the energy sources had no adverse effects on the performance of quails while Cassava meal and sweet potato meal can be successfully be used as substitute for conventional feed stuff in poultry ration. However, diet containing maize had highest feed intake and weight gain compared to others and can be more recommended for quails.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

In terms of total cost, energy is the most expensive item in poultry diets because of the amount required (Olomu, 1995). Maize is a conventional energy source and is currently the most widely used grain crop in the Nigerian poultry industry, because it provides the bulk of most poultry diets. The ever increasing competition between man and animals for available grains (Egbunike *et al*., 2009), the inadequate production of farm crops to meet the needs of man and his livestock and ever increasing cost of maize had made it necessary to critically evaluate some other energy sources like sorghum, millet, cassava and sweet potato as energy sources in poultry production. (Nyannor *et al*., 2007).

Sorghum and millet are widely grown cereal crops that have been successfully cultivated in the semi-arid regions of Asia and Africa and their costs are relatively less in the areas of high cultivation with little industrial uses in Nigeria (Nyannor *et al*., 2007). In terms of energy value, sorghum has been rated as high as 90 to 100% of maize while its crude protein content is higher than maize. Also, the protein content of millet is high of about 12 to 14 % with a well balanced essential amino acids profile than maize (Adeola *et al*., 1994).

Sweet potato (*Ipomea batatas*) and cassava (*Manihot esculenta*) are produced in large quantities in Nigeria and they form important energy sources for human and livestock feeding, hence, their uses as a replacement for maize in animal feeds has been advocated (Aina and Fanimo, 1997). Sweet potato is a good source of nutritionally important dietary factors such as vitamin A, ascorbic acid, thiamin, Riboflavin and Niacin. Although, low protein, fat and fiber levels were found in the tubers, but the high Nitrogen-Free-Extract fraction in the tuber is indicative of its main potential value as an energy source (Aina and Fanimo, 1997). Cassava is highly riched in carbohydrate but low in protein, amino acids and other nutrients and thus is used mainly as energy sources. However, their uses have been limited by anti nutritional factors such as tannins, phytins, oxalates which may affect nutrients utilization (Aina and Fanimo, 1997).

1.2 Problem Statement

Conventional feed ingredients such as maize are more expensive and not readily available to all producers at all locations due to competing demands for the commodity between man and livestock and adverse climatic conditions. This has stimulated the search for alternative feed ingredients particularly energy sources for poultry (Iji *et al.,* 2011). Generally, inadequate supply of feeds, nutritionally unbalanced rations, adulterated ingredients or stale feeds are some of the factors responsible for low productivity of livestock in Nigeria (Ogundipe *et al.,* 2003). In order to address such problems, different ingredients are investigated with the aim of replacing all or some of the conventional ingredients.

However, with alternative feed ingredients, poultry productivity is often poor due to deficiencies in nutrients such as amino acids and minerals, imbalances in energy to protein ratios (Dilger and Baker, 2008) or anti-nutritive factors such as non-starch polysaccharides (NSPs), polyphenols or phytic acid (Olukosi *et al*., 2011). Also, there is paucity of information on the nutrient composition of many alternative feed ingredients. Although, producers had strived to improve the quality of alternative feed ingredients through variety of practices, including feed sun drying feed processing and supplementation with nutrients (Chauynarong *et al*., 2009).

1.3 Justification

Going by the fundamental roles of energy in animal nutrition and the fact that it constitutes 35-60% of rations for different species and classes of livestock, the sustenance and expansion of the livestock industry, particularly in developing countries, depends to a large extent on the availability of the dietary energy sources used in compounding concentrated rations for various classes of livestock (Aina and Fanimo, 1997). The scarcity and high cost of cereal grains, especially maize has necessitated research into alternative energy sources for feeding all classes of quails.

1.4 Objectives of the Study

The main aim of this study was to investigate the dietary effects of different energy sources; maize, sorghum, millet, cassava meal, sweet potato meal in the diets of Japanese quails (*Cortunix cortunix japonica*).

While the specific objectives of the study are to determine the effects of different energy sources on:

i. The growth Performance and carcass characteristics of Japanese quail.

ii. Egg production and quality of Japanese quail.

iii. Heamatological parameters of Japanese quails.

CHAPTER TWO

LITERATURE REVIEW

2.1 Japanese Quail

Quails belong to the family Phasianoidea of order Galliformes of the class Aves of the Animal Kingdom with chickens, Pheasants, Duck, Ostrich (Shim, 2004). Species or subspecies of the genus *coturnix* are native to all continents except America. One of them *Coturnix coturnix* or common quail are migratory birds of Asia, Africa and Europe. The domesticated subspecies, *Coturnix coturnix japonica*, is called Japanese quail but is also known by other names such as common quail, Eastern quail, pharaoh's quail, Japanese quail, King quail (Shim, 2004).

2.1.0 Description

2.1.1 Quail Chicks

Young quails are yellowish in appearance with stripes of brown and have resemblance to turkey poults except for size. The newly hatched chicks weigh about 6 – 7g but grow rapidly during the first few days. After three days flight feathers begin to appear and the birds on fully feathered at about four weeks of age. Partial sexing is possible by three weeks of age by the cinnamon-coloured feathers on the breast of the male bird, but there are some birds that defy definite sexing by this method, even when they are adults (Shim, 2004).

2.1.2 Adult Male Quail

The adult male quail weighs about 100 – 140g. The male birds can be identified readily by the rusty brown coloured feathers on the upper throat and lower breast region. Males also have a cloaca gland, a bulbous structure located at the upper edge of the vent which secretes a white, foamy sticky material. The young birds begin to crow at 5 – 6 weeks old (Change *et al*. 1985). Sanford (1957) described the voice of the male as a loud, castanet – like crow, producing sound as “pick – per a wick” or ko – turro – neex”. During the height of the normal breeding season, coturnix males will crow throughout the night (Shim, 2004).

2.1.3 Adult Females Quail

The adult female is slightly heavier than the male, weighing from 120 to 160g. The body coloration of the female bird is similar to that of male except that the feathers on the throat and upper breast are long, pointed, and lighter cinnamon. Also, the light tan breast feathers are characteristically black – stippled (Shim, 2004).

2.1.4 Quail Eggs

Quail eggs are characterized by a variety of colour patterns. They range from snow white to completely brown more commonly they are tan and dark brown speckled or mottled brown with a chalky blue covering. The average eggs from mature female weigh about 10g that is 8% of the body weight of the quail hen as compared to 3% for chicken. The egg of Japanese quail contains 158 calories of energy, 74.6% water, 13.1% protein, 11.2% fat, and 1.1% total ash. The mineral content includes 0.59mg calcium, 220mg phosphorus and 3.8mg iron. The vitamin content is 300 i.u of vitamin A, 0.12mg of vitamin B, 0.85mg of vitamin B_2 and 0.10mg nicotinic acid (Shim, 2004).

2.2.0 Nutrients Requirement of Japanese Quails

2.2.1 Energy

Feed intake depends upon the amount of metabolizable energy (ME) content of the diet, age of the birds, their reproductive status and the ambient temperatures (Shim and Vohra, 1984). Bawa (2012) reported that the dietary energy level of 2800 kcal/kg ME is required for optimum performance of Japanese quail chicks. An energy requirement of 2,600 – 3,000 kcal ME/kg diet for growing quails has been reported for temperate region (Farrell *et al*., 1982), whereas, findings under tropic condition indicated an energy requirement of about 2,800 kcal ME/kg for growing quails and 2,550kcal ME/kg for laying quails (Shim and Lee, 1982). Though raising the dietary energy level from 2600 to 2800kcal ME/kg did not influence the gain in weight, it affected significantly the efficiency of feed utilization as the feed consumption was reduced significantly (Shrivastav and Panda, 1982). Shrivastav and Johri (1993) reported 2,750kcal/kg ME adequate for quail layers and breeders.

Olubamiwa *et al*., (1999) observed that dietary energy level of 2,550 – 2,800 kcal/kg diet supported optimum performance of growing quails in the tropics while Dafwang (2006) suggested a metabolizable energy of 2,700 kcal/kg for both growing and laying quails.

2.2.2 Proteins

According to Oluyemi and Roberts (1979), protein is useful mainly for synthesis of body tissues and also for egg formation. The authors noted that retardation in growth, poor feathering and vice habits can be traced to protein deficiency in the diets. Bawa *et al.,* (2012) reported a dietary protein requirement of 26% for Japanese quail chicks. In a review of the nutrition of Japanese quails, Shim and Vohra (1984) reviewed and summarized the studies of several researchers on the dietary metabolizable energy and protein requirement of Japanese quails. The data for growing quails ranged between 2800 and 3200kcal/kg ME, while crude protein content of diets varies from 24 - 32.2%. The authors showed that metabolizable energy requirements for laying quails varies between 2600 to 3000 kcal ME, while crude protein content of diets ranged from 16 and 24%. Tom (2011) reported dietary protein requirement of 24% CP for quail starter and 18% crude protein for quail finisher, breeders and layers respectively.

2.2.3 Minerals

Phosphorus is a key component of the bone, along with calcium. High level of phosphorus in the blood will inhibit metabolization of calcium from the bone. Manganese interferes with the metabolism of calcium and causes poor shell quality, if it is in excess in the diet. Excess calcium causes reduced feed intake which affects shell quality as well as production (North, 1984). Selenium deficiency in the chicken, especially in combination with low vitamin E supply is responsible for the development of a range of diseases including exudative diathesis (Bartholomew *et al*., 1998). Nutritional pancreatic atrophy in chicks may be overcome by feeding vitamin E at 15 – 20 times the levels normally regarded as nutritionally adequate (Whitacre *et al.,* 1987). Selenium supplemental can also decrease the incidence of nutritional muscular dystrophy in the chick (Bartholomew *et al*., 1998).

2.2.4 Water

Water functions in the body of animals includes; regulation of body temperature, transportation of nutrients and taking part in numerous chemical reactions in the body (Smith, 1990). Water requirement of poultry are often crudely estimated by multiplying the amount of feed eaten by two. However, under hot conditions, animals drink substantially more water.

Farrell *et al*., (1982) found that the water intake for quail's chicks was 4.2g, 3.1g and 2.7g per body weight during 12 to 15, 19 to 22, and 26 to29 days of age respectively. And that water/feed ratios for these respective periods were 2:3, 2:0 and 1:7. Oluyemi and Roberts (1979) reported that, water consumption increases the amount of feed intake by layers which results in increased egg sizes.

2.2.5 Vitamins

The principal feature of vitamin A is its function in ensuring adequate growth and its role as a means of assisting in the birds' resistance to diseases. Vitamin A is essential for normal vision, egg production and reproduction. Laying quail receiving insufficient vitamin A produce fewer eggs and egg produced frequently do not hatch. For egg production and fertility of females, a level of 2,500 i.u vitamin A/kg diet was required (Singh, 1990). National Research Council (1994) recommended 1650 i.u per kg vitamin A for the starter and grower phase of quails and 3300 i.u. per kg for breeding quail.

Vitamin D is vital in the absorption and mobilization of calcium during shell synthesis (North, 1984). Shim (2004) reported that, deficiency of vitamin E in Semi-purified diets containing isolated soybean protein and starch did not affect the body weight, feed consumption, or egg production of Japanese quail. However, it caused sterility in males, which was overcome by restoring 40 i.u vitamins E/kg to the diet after 2 weeks. Prolong deficiencies of vitamin A and E adversely affects spermatogenesis and storage of the follicle stimulating hormone in the pituitary gland which in turn affects fertility and hatchability (Singh, 1990).

2.3 Factors Affecting Egg Production

Egg number is the major index of performance of commercial layers. It accounts for about 90% of the income in egg production farm (Oluyemi and Roberts 1979). Egg qualities particularly egg size is another important economic trait, it determines to a large extent the price received in any market and standard range should be between 53 and 63 grams (Obioha, 1992). Oluyemi and Roberts (1979) indicated that egg number and quality are affected by some environment factors such as nutrition, ambient temperature and humidity.

2.3.1 Temperature and Humidity

The maximum temperature associated with satisfactory laying performance of hens is approximately 30^0C at a high relative humidity of 75% (Daghir, 2008). Gilbert (1980) observed that temperature between 13^0C and 21^0 are recommended for optimal egg production though higher temperature may lead to increased production figures. Altitude, gaseous environment, humidity and noise may also effect egg production (Gilbert, 1980). Egg production is highest when temperatures are within range (Smith, 1990). Munir and Mohammed (2010) report that, ambient temperatures above 30^0C are considered to have detrimental effect on the performance of laying hens. The authors observed that ambient temperatures of 21^0C and 30^0C at a high relative humidity of 75% within the poultry house enhanced egg production compared to birds housed in an ambient temperature of 35^0C.

2.3.2 Nutrition

Claudia (2009) reported rickets, caged layer fatigue and fatty liver syndrome as nutritional diseases that affect laying hens and account for a high percentage of the flock mortality. Altering the diet by replacing some of the lower energy feedstuff such as wheat bran can help treat fatty liver syndrome. Munir and Mohammed (2010) reported a decline in egg production and egg weights to be responsible for reduced feed intake resulting from exposure to high environment temperatures.

2.3.3 Body Weight

Lacin *et el.,* (2008) studied the effect of initial body weight on laying performance of groups of 24 weeks old Lohman White layers grouped into light (1400 to 1500g), medium (1500 to 1600g) and heavy hens (above 1600g). The author observed higher egg production in the light group than those of other weight groups. Duplessis and Erasmus (1972) indicated that larger hens within a bloodline laid larger egg than those with smaller body weights.

2.4 Feeding Value and Attributes of Alternative Energy Sources In Poultry

2.4.1 Feeding Value of Maize

In poultry, maize is appreciated for its highly digestible starch, low fibre and relatively high oil content resulting in high metabolizable energy values of 3350 Kcal/kg (Sauvant *et al.,* 2004). It is fed at high levels in broilers and laying hens. In hot climates it is often possible to replace maize by less expensive and more easily available feedstuffs. Barley is able to totally replace maize in broilers diets as well as sorghum grain, pearl millet and broken rice while triticale could only partially replace maize since it alters growth performances (Daghir, 2008).

In poultry, white and yellow maize have equivalent energy, protein and mineral values. Yellow maize contains more carotene and cryptoxanthin which are beneficial to yolk pigmentation. Moreover, birds are attracted to the yellow colour of the grain that can be ground medium-size or fine for inclusion in pelleted diets (Sauvant *et al.,* 2004). The seed is high in starch (65-70%), but low in protein (8.8%), fibre and minerals. Maize protein is mainly deficient in tryptophan and lysine. The energy value of corn is contributed by the starchy endosperm (65-70%), which is comprised mainly of amylopectin and the germ, which contains most of the oil. Most corn contains three to four per cent oil. The protein in corn is mainly as prolamin (Zein) and as such amino acid profile is not ideal for poultry (Sauvant *et al.,* 2004).

2.4.2 Nutritional Attributes of Maize

Maize grain is palatable and suitable to every livestock. It is the most valuable energy source among cereals. It has a high starch content of about 65%, about 4% oil and a low fibre content 10% NDF. (Sauvant *et al*., 2004). Maize grain is low in calcium and supplementation is required. 75% of phosphorus is bound in phytate which is not readily available to livestock and also reduces calcium availability (Sauvant *et al.*, 2004). Low-phytate hybrids have been developed to increase P availability in monogastrics (Veum *et al*., 2001).

Yellow maize has higher vitamin A content than white maize. Vitamin A deficiency is of little importance in ruminants but it may have deleterious effect on poultry if not adequately supplemented with other vitamin A sources. Maize grain is generally poor in available niacin (Veum *et al*., 2001).

2.4.3 Potential Constraints of Maize

Phytic acid is present in maize and binds about 60 - 75 % of the phosphorus in the form of phytate (NRC, 1994). Because of phytate binding, bioavailability of phosphorus in maize is less than 15% for non-ruminant animals. Ruminants utilize considerably more phosphorus since the rumen microbes produce the enzyme phytase that breaks down phytate and releases phosphorus (Ensminger *et al*., 1990). It is becoming common for feed formulators to add phytase to poultry diets to improve the utilization of phosphorus. Maize contains low levels of trypsin and chymotrypsin inhibitors, neither of which is considered nutritionally significant (Sauvant *et al.*, 2004). In considering the anti-nutrients and natural toxins in maize, only phytic acid is significant to the animal feed. With the use of the enzyme phytase, it is possible to break down part of the phytic acid and release bound phosphorus and calcium (Veum *et al*., 2001).

2.5.1 Feeding Value of Sorghum

Considering the nutritive value, cost and availability, sorghum grain is the next alternative to maize in poultry feed (Maunder, 2002). Spiridon *et al.,* (1979) observed no depressive effect of sorghum on growth and feed efficiency even at 100% replacement of maize with sorghum in meat chickens; however, carcasses of birds fed most sorghum diets were lighter than the control. Cullison (1987) nevertheless, reported that sorghum can replace 50% of maize with no adverse effect on animal performance though weight gain was reduced by 10% or more with higher levels. Farmers have the notion that sorghum has tannin and has low energy compared to maize grain. 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 did not exert any appreciable influence on nutrient utilization, blood biochemical, enzymes and gross pathological changes even at 100% replacement of maize.

Luis (1980) noted 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%), there was no significant differences in body weight gain or feed efficiency. Feed intake followed the same trend (33.48 kg *vs.* 26.36 kg) for sorghum and maize, respectively.

Edache *et al*., (2005) reported highest total weight gain (140.43 g), best feed/gain ratio (3.14) and lowest feed cost per kilograms weight gain at 15% dietary level of sorghum replacing about 35.7% maize in quail diet. Quails fed 42% dietary level (100% maize replacement) of sorghum according to them recorded the highest feed cost per kilogramme weight gain (N134.81), lowest feed cost per kilogramme (N31.18) and poorest feed/gain ratio (4.84). Nevertheless, weight gain was not depressed.

2.5.2 Nutritional Attributes of sorghum

The nutrient composition of sorghum has been well documented (NRC, 1984; Aduku, 1993). Whole grains of sorghum contain approximately 89 to 90% Dry Matter (DM), 8.9 to 15% crude protein (CP), 2.8% ether extract (EE), 1.5 to 1.7% Ash, 2.1 to 2.3% crude fibre (CF), and 71.7 to 72.3% nitrogen free extract (NFE) (Ensminger *et al.,* 1990). The crude Protein content of sorghum is higher than that of maize but about equal to wheat. In terms of energy value, sorghum is rated as high as 90 to 100% of maize depending on the livestock specie. Ensminger *et al.,* (1990) reported metabolisable energy (ME) value of 13.96, 14.04 and 13.70 MJ/kg, respectively for all grains, kaffir and milo types of sorghum. Abubakar *et al*., (2006) reported a slightly lower calculated value of 12.15 MJ/kg and 12.92 MJ/kg ME energy for unmalted and malted sorghum, respectively.

Sorghum contains low levels of lysine but high tryptophan content relative to maize (Olomu, 1995). McDonald *et al*., (2000) reported that both maize and sorghum have the main limiting indispensable amino acids, arginine, lysine, methionine, cystine and tryptophan. Xanthophylls and linoleic acids are much lower in sorghum than in maize and yellow endosperm with carotene and xanthophylls increases the nutritive value of sorghum (Olomu, 1995). Protein, oil, niacin and pyridoxine content of sorghum are highest in the germ fraction and lowest in the bran while the endosperm contains the highest level of starch. Sorghum leaves are reported to have a haematinic property in ethno-veterinary treatment in combination with *Telfaria occidentalis* (Adedapo *et al*., 2002).

2.5.3 Potential Constraints of Sorghum

Condensed tannins are only partially responsible for variation in nutrient digestibility in sorghum grain cultivars. McDonald *et al*., (2000) reported that amino acid ideal digestibly for non-tannin sorghum in poultry varied from 73 to 82% with poor digestibility of cysteine (53%), histidine (69%), threonine (63%), and tryptophan (71%). Likewise, Vasan *et al.,* (2008) reported amino acid digestibilities of 85% in corn and 73% in sorghum with lower values observed for cysteine, histidine, threonine, and arginine in sorghum.

Oria *et al.,* (2000) demonstrated that protein body shape and exposure and β- and λ-kafirin location are key factors in sorghum protein digestibility. Ravindran *et al*., (2006) suggested that amino acid digestibility is high in tannin-free or very low-tannin sorghums compared to tannin sorghums and an increase of 0.1% in tannin can induce a decrease of 10% in digestibility of most amino acids with twice that much reduction for sulfur amino acids and lysine. Additionally, an increase of 0.35% dietary phytate reduced amino acid digestibility by 3.6% (Ravindran *et al.*, 2006).

Tannins and phytate have the capacity to alter Na metabolism which may impair intestinal nutrient absorption. Ravidran *et al*., (2006) reported more Na excretion by broilers fed high phytate diets. Inclusion of phytase helped to alleviate the loss of sodium. Supplementation with sodium bicarbonate improved dietary electrolyte balance and prevented the adverse effects of tannins.

2.5.4 Digestibility of Sorghum Based Diets

The digestibility of cereals varies tremendously based on genetic background. In the opinion of Rooney and Pflugtelder (1986) among cereals, sorghum has the lowest starch digestibility due to the resistance to digestive enzymes of the hard peripheral endosperm layer. Cousins *et al*., (1981) noted that variations exist among sorghum cultivars, especially those low in tannin which appears to have the same digestibility as maize. There are also large differences between animal species in their capacity to digest cereal starch. The digestibility of sorghum starch across the whole digestive tract of poultry is 99% compared with 87% for cattle (Rowe *et al*., 1999).

Dowling *et al.,* (2002) reported that the overall total digestible nutrients in sorghum are roughly 95% of those in dry rolled yellow dent maize; this is due to lower starch availability because sorghum starch content varies and is bound in a thicker protein matrix .The chemical nature of the starch, particularly amylose and amylopectin content, is yet another factor that affects its digestibility. Nutrient digestibility of sorghum is influenced by the level of tannin concentration in the grain. It is probable that tannins stimulate an increased pancreatic secretion of all digestive enzymes but have little affinity for lipase in the gut. Both enzyme inhibition and formation of complexes of dietary tannins with proteins and carbohydrate may cause reduction in digestibility (Kumar, 1992).

However, the digestibility reducing effects of tannins are not uniform, the diversity of effects may arise in part due to the differences in chemical nature of tannins and in part due to physiological capabilities of animals to handle tannins (Kumar, 1992).

2.5.5 Treatment and Processing of Sorghum to Enhance its Nutritional Value

Early sorghum processing methods consisted essentially of chemical and mechanical detoxification as well as amino acid and mineral supplementation. However, during the last two decades processing sorghum grain by grinding, crumbling, pelleting, expanding, extruding, and steam flaking has become popular. Alkali treatments to improve nutritional value of tannin sorghum include use of sodium or potassium hydroxide, sodium bicarbonate, and wood ash (Amstrong *et al*., 1974). Price and Butler (1978) used ammonia concentrate (350g NH3/kg) at room temperature for 7 days to reduce tannin concentration in high-tannin sorghum.

Kyarissima *et al*., (2004) reported a 62% tannin reduction with the wood ash method, however sprouting after wood ash treatment improved tannin reduction to 85%. Supplementing the diet with 0.15 to 0.30% methionine or choline prevented the deleterious tannin effects (Sell *et al*., 1984). Douglas *et al.,* (1990) reported that adding 1 to 2.5% fat was needed in sorghum-based diets with variable tannin content to achieve ME content similar to that of corn-based diets fed to broilers.

2.6.1 Feeding Value of Millet

Millet grain could potentially be successfully incorporated into poultry diets while according to Olomu (1995) millet has a Metabolizable Energy of 2555 kcal/kg and high percent crude fibre. A study by Davis *et al.*, 2003 has shown that the inclusion of pearl millet in broiler chicken diets at levels up to 50% resulted in performance and carcass quality similar to or better than corn-based diets. On the other hand, Kumar *et al*., (1991) evaluated levels of 0, 30 and 60% of corn replacement by pearl millet in laying hen diets and reported no negative effects in egg production, feed intake, feed conversion and body weight. Furthermore, higher pearl millet inclusion levels increased egg weight.

Davis *et al.*, 2003 had also reported that feeding pearl millet to laying hens has an added benefit, although there are no adverse effects on egg production or feed efficiency as long as the pearl millet is grounded, the fatty acid profile of the eggs is altered, and the eggs from hens receiving the diets based on pearl millet are generally higher in omega-3 fatty acids and lower in omega-6s than eggs from hens receiving a corn-based diet.

2.6.2 Nutritional Attributes of Millet

The protein content of millet, although variable, is higher than maize of about 12 to 14% and the essential amino acid profile is more balanced than maize (Adeola and Rogler, 1994). Millet also has higher oil content than other common cereal grains (Adeola and Rogler, 1994). At 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. Davis *et al.*, (2003) gives the following composition of pearl millet as; Dry matter 90%, Metabolizable energy 3240 kcal/kg, Crude protein 12.0, Methionine 0.28%,Cysteine 0.24%,lysine 0.35%,Tryptophan 0.20%,Threonine 0.44%,Crude fat 4.2%,Crude fiber 1.8%,Ash 2.5%, Calcium 0.05%,Total phosphorus 0.30% , and Non-phytate phosphorus 0.10%.

2.6.3 Potential Constraints of Millet

Millet does not contain any condensed Poly-phenols such as the tannins in sorghum that can interfere with or slow down digestibility. Pearl millet grain does not have many of the antinutritional factors that other alternative grains do and when compared to sorghum, pearl millet is low in tannins (Davis *et al.*, 2003). Pearl millet grain does, however, contain saponins, which are known to damage the lining of the digestive tract.

2.6.4 Treatment and Processing of Millet to Enhance its Nutritional Value

Malting reduces anti-nutritional factors and imparts desirable flavor and taste. Shelf life of pearl millet flour is also increased by malting as this lowers the levels of lipids that are responsible for off-flavors. Blanching and heat treatment improve the storability and stability of flour. Acid treatment of grain may bleach grey colour, remove anti-nutritional factors and improve digestibility and shelf life of pearl millet flour (Kyarissima *et al.* 2004).

2.7.1 Feeding Value of Cassava

The Metabolizable energy of cassava meal is 3317 kcal/kg and similar to that of potatoes with a dry matter of 880 g/kg and crude protein of 30 g/kg, (McDonald *et al.,* 2002). Longe and Oluyemi (1979) reported that 50% dietary cassava meal gave similar feed efficiency to the same quantity of maize and that weight loss of chicks at 6 weeks was less with cassava or maize than with guinea corn. This recommendation level was less than that reported by Agudu and Okeke (2005) for chicks. They recommended that 42% cassava meal can replace all the maize in the diet for pullet chicks with no significant adverse effect on performance.

However, in some experiments, performance decreased with 5% cassava peal meal in the diets (Egbunike *et al*., 2009). This can be due to problems in feed formulation since there is evidence that performance is degraded with inadequate protein inclusion (Egbunike *et al*., 2009). The recommendation in broilers is to limit the incorporation of cassava peal meal to 5-10% depending on its quality, with an appropriate feed formulation. Higher levels of cassava peel meal could be fed to slow growing chicken or in situations where depression in growth performance is counterbalanced by a lower feed cost. Sun-dried cassava peels at 10 to 40% inclusion rates resulted in significantly lower productive performance in layers, with an average of 15% less egg-lay when 20% cassava peel meal was included in the diet (Salami and Odunsi, 2003). The effect on feed intake was not constant in these studies.

Cassava root meals contain a range of metabolizable energy values for poultry from 2.87 to 4.27 kcal ME/g of dry matter. They also contain very low levels of protein (2.5% of DM) and are deficient in all other nutrients. In formulating a balanced poultry ration, there is therefore need to supplement the root products with protein, amino acids, fat, minerals and vitamins at higher levels than when using cereal-based diets.

2.7.2 Nutritional Attributes of Cassava

Cassava meal has low protein content (< 6% DM) and high and variable crude fibre content 10-30% DM range. (Ubalua, 2007). It is widely known that cassava root products are rich in carbohydrates but low in protein, amino acids and all other nutrients and thus are used mainly as sources of energy. In using cassava root products as cereal substitutes, approximately 15 to 20% extra protein source is needed. Cassava leaf Meal (CLM) and Cassava foliage meal (CFM) contain moderate levels of crude protein and amino acids, mineral, vitamins and carotene but are rather high in crude fibre making them only fair sources of protein for non-ruminants (Ubalua, 2007).

2.7.3 Potential Constraint of Cassava

Fresh cassava has 3 main deficiencies; they spoil very quickly, they contain phytates and large amounts of cyanogenic glycosides. They should thus be processed in order to reduce cyanogenic potential and phytate content and to preserve their nutritive quality (Salami *et al.*, 2003). There are two cyanogenic glycosides in cassava, linamarin (80% of total glycosides) and lotaustralin (20%). A cell-wall enzyme liberates hydrogen cyanide (HCN), which is lethal to animals. Hydrogen cyanide concentrations depend on cultivar, environmental conditions, plant age, number of harvest (foliage) and on the plant component that is being considered, and there is a continuous gradient of HCN content between varieties (Peroni *et al*., 2007), and these are usually divided into two groups namely, bitter varieties with roots containing 0.02-0.03% HCN (DM basis) and leaves containing up to 0.2% HCN (fresh basis) while the Sweet varieties with roots containing less than 0.01% HCN (DM basis) and leaves 0.1% HCN (DM basis) (Peroni *et al*., 2007). Well-processed cassava has generally acceptable levels, below 50 mg/kg (Osei and Twumasi, 1989). Cassava have a high phytate content (up to 1% DM), resulting in low P availability in non-ruminants (Ubalua, 2007).

2.7.4. Processing of Cassava Roots to Enhance its Nutritional Value

Different processes are effective in reducing cyanogenic glycoside including sun-drying, ensiling, and soaking plus sun-drying. All these methods have yielded satisfactory results (Salami and Odunsi, 2003). Method of fermentation of cassava has been tested by several authors, either to lower HCN or fibre content (Osei and Twumasi, 1989) or to increase crude protein content (Buitrago, 1990), but the results are inconclusive.

2.8.1 Feeding Value of Sweet Potato

Maize and sweet potato have comparable metabolizable values of 14.5 and 14.8, respectively (Woolfe, 1992). Sweet potato is also a very valuable feed for all classes of livestock and it can be used successfully as a substitute for maize in broiler diets, but in most cases the highest substitution levels decrease performances (Woolfe, 1992). Though, relationship between sweet potato level and performance is generally negative (Agwunobi, 1999). In some cases, inclusion levels higher than 10% reduced performances (Ravindran *et al.* 1995).

Sweet potato has also been used in layer diets and safe inclusion rates should be limited 10 to 15% sweet potato meal in the diet, with proper protein and vitamin A supplementation (Ravindran *et al*. 1995). Agwunobi, 1999 reported that 15% inclusion of peeled sun-dried sweet potato meal maintained egg production while higher rates tended to alter performances negatively though only significantly at rates higher than 45%. Woolfe (1992) reported having replaced 50 to 75% of maize in poultry feed with dried sweet potato flour without adverse effects on the growth of broilers.

2.8.2 Nutritional Attributes of Sweet Potato

Sweet potato tubers are mainly an energy source due to their high carbohydrate content, which accounts for 80-90 % of the dry weight, these carbohydrates consist of starch, sugars and small amounts of pectin, hemicelluloses and cellulose (Lebot, 2009). Starch is the main carbohydrate in sweet potato (about 75% DM) and is very resistant to amylase hydrolysis. Cooking increases the easily hydrolysable starch fraction of sweet potato from 4 % to 55 % (Dominguez, 1992). Sugar content can be extremely variable, usually between 1 and 12 % DM. The sugar composition of a cultivar, especially the sucrose values, gives a reliable indication of its sweetness (Lebot, 2009).

Sweet potato are poor protein source, as they contain about 4% DM of crude protein, less than half that of maize grain and are low in lysine and sulphur amino acids, also they have low contents of fibre (7% DM of NDF), fat and ash (Dominguez,1992). Sweet potato can also be a source of other nutritionally important dietary factors, such as vitamin A, ascorbic acid, thiamin, riboflavin and niacin (Lebot, 2009).

2.8.3 Constraints of Sweet Potatoes

Sweet potatoes have also been reported to exhibit trypsin inhibitor activity ranging from 20 to 90 % inhibition (Woolfe, 1992). However, Ravindran (1995) reported that trypsin inhibitor levels present in sweet potato tubers are low and should not be a cause for concern under practical situations.This trypsin inhibitor can be destroyed or reduced by preheating the raw sweet potato roots. Cooking sweet potato is therefore necessary on account of two factors, i.e. starch digestibility and the presence of trypsin inhibitors (Dominguez, 1992). Moist heat treatment (MHT) at temperatures above 80°C is effective in eliminating trypsin inhibitor activity in sweet potatoes (Zhang *et al*., 2001).

2.8.4 Processing of Sweet Potato to Enhance Its Nutritional Value

The uncooked starch of the sweet potatoes is very resistant to the hydrolysis by amylase. When cooked, their susceptibility to the enzyme increases. Thus after cooking the easily hydrolysable starch fraction of sweet potato increases from 4% to 55% (Cerning-Beroard and Le Dividich, 1976). Cooking improves the feeding value of the tubers since it reduces trypsin inhibitors and improves starch digestibility (Dominguez, 1992). In the USA, tubers used for animal feed are cleaned, shredded or sliced, treated with sulphur dioxyde and dried rapidly, in sun or in heated air at 80°C or higher.

2.8.5 Digestibility of Sweet Potato Meal

The digestibility of sweet potato carbohydrate fraction is reported to be above 90 % (Ravindran *et al.,* 1995). However, the level of starch decreases with period of storage and instead the level of reducing sugars, total sugars and total dextrin increases (Woolfe, 1992). Protein degradability of fresh sweet potato forage was found to be quite high (about 70%), but the undegradable dietary protein was lower than that of protein supplements of similar degradability (cottonseed meal and *Gliricidia sepium*) so that less digestible true protein is available to the animal for metabolism after digestion and absorption (Ravindran *et al*., 1995).

2.9.1. Nutrition and Heamatology

The blood transports or conveys nutrients and materials to different parts of the body. Therefore, whatever affects the blood; drugs, pathogenic organism or nutrition will certainly affect the entire body adversely or moderately in terms of health, growth, maintenance and reproduction (Oke *et al.,* 2007). A readily available and fast means of assessing clinical and nutritional health status of animals on feeding trials may be the use of blood analysis, because Ingestion of dietary components has measurable effects on blood composition (Maxwell, 1993) and may be considered as appropriate measure of long term nutritional status (Olabanji *et al*., 2007). Adamu *et al*. (2006) observed that nutrition had significant effect on haematological values like PCV, Hb and RBC while Togue *et al.* (2007) reported that when the haematological values fall within the normal range reported for the animal, it is an indication that diets not show any adverse effect on haematological parameters during the experimental period but when the values fall below the normal range, it is an indication of anaemia. Low values for haematological parameters as reported by Bawala *et al.,* (2007) could be due to the harmful effects of high dietary contents. Physiological and nutritional status of animals could cause differences in values observed for PCV and MCV. When WBC (leucocytes), neutrophils and lymphocytes fall within the normal range, it indicates the feeding patterns do not affect the immune system (Ameen *et al*., 2007).

2.9.2 Avian Haematology

Avian haematologies demonstrates a high intra and inter specific variability under physiologic conditions which is caused by the richness in species and the high diversity of metabolic activity due to gender, age, reproductive status and season. Analysis of normal haematological parameters of poultry is essential for the diagnosis of various pathological and metabolic disorders (Elagib and Ahmed 2011). It can be used as a diagnostic tool in order to assess the impact of environmental, nutritional and or pathological stresses (Elagib and Ahmed 2011). According to Forbes (2008) the average blood volume of most birds is approximately 10% of body weight.

2.9.3. Quail Haematology

Campbell (1988) reported the following range of values for haematological parameters of female quail.

PARAMETERS	Normal range
Mean Corpuscular Volume (MCV)	78 to 101 fL
Mean Corp. Heamoglobin Concentration (MCHC)	31.35gm/dL
Packed Cell Volume (PVC)	37 to 69 %
Haemoglobin (Hb)	12.0 to 15.2gm/dL
Red Blood Cell (RBC)	3.8 to 5.5 × 10^6 /uL
White Blood Cell (WBC)	4.1 to 10.9 × 10^3 /uL
Neutrophils	0 to 10%
Lymphocytees	20 to 50 %
Monocytes	2 to 12 %
Eosinophils	0 to 7 %
Basophils	0 to 2 %

Adapted from: Campbell 1988

2.10. Effects of Different Diets on Heamatolgy of Different Species of Poultry

In a study carried out by Aro and Ojo (2013) on blood viscosity of finisher cockerel fed dietary inclusions of fermented cassava tuber wastes. Seven experimental diets were fed to the birds, diet with 0% microbial fermented cassava tuber wastes (MFCTW), 20% microbial fermented cassava peel (MFCP), 40% MFCP, 60% MFCP, 20% Microbial fermented Cassava Starch Residue (MFCSR), 40% MFCSR and 60% MFCSR. The results showed that the whole blood viscosities were statistically similar while plasma viscosities were influenced significantly in all the treatments. The whole blood and plasma viscosities, however, showed a gradual decline in value as the level of inclusion of the two types of fermented cassava tuber waste (FCTWs) increased in the diets. Aro and Ojo (2013) stated that cassava tuber wastes may decrease both plasma and whole blood viscosity and significantly so if plasma viscosity is taken into consideration, they further reported that the lower viscosity of birds fed CTW at a higher inclusion is suggestive of a positive influence of the CTW at a higher inclusion is suggestive of a positive influence of the CTW diets on the mechanical and geometric properties of the red blood cells.

Similarly, Aro *et al*. (2013) carried out a trial on the haematology of finisher cockerel fed graded level of microbially enhanced cassava tuber diets. The birds were fed with seven different cassava tuber waste based (CTW) diets containing 0% CTW (control diet), 20% microbially fermented cassava peel (MFCP), 40% MFCP, 60% MFCP, 20% microbially fermented cassava starch peel (MFCSR), 40% MFCSR and 60% MFCSR. The cassava tuber wastes were inoculated with Lactobacilli (*L. delbruecki* and *L. coryneformis*) and one fungus (*Aspergillus fumigatus*) for their protein enrichment and fibre degradation. The results showed that the MCV was highest in birds fed 40% MFCP and 40% MFCSR diets with significant differences among diets, levels of inclusion and interactions between diets versus levels of inclusion. Birds fed MFCP had higher MCH than those fed MFCSR diets. The MFCR diets were, however, better in

PCV, RBC and Hb. They also reported that the use of CTW in cockerel rations would not compromise the haematological status of cockerel birds.

CHAPTER THREE

MATERIALS AND METHOD

3.1 The Experimental Site

The experiment was conducted at Dandagoro farm, Katsina, Katsina State. Katsina State is located 160 miles East of Sokoto State and 34 miles North West of Kano State with land mass of 24,192 km^2.Found in Sahel savannah and lies between latitudes (11° and 12° N) and longitudes (7° and 8° E) with an altitude of 481m above sea level (Ovimaps, 2012). Average annual rainfall and mean temperature is 697mm and 38°C respectively, while the experiment was conducted between July to October, 2014.

3.2 Experimental Birds and Design

A total of 300 Japanese quail chicks at one week old (7 days) were obtained from National Veterinary Research Institute, Vom, Jos. The experiment was conducted in a completely randomized design (CRD), with 5 treatments of 3 replicates and 20 birds per replicate.

Phase I: Growth trial phase (2-6 weeks).

Phase II**:** Egg production phase (6-13 weeks).

3.3 Experimental Diets

Five (5) experimental diets (treatments) were formulated to be isonitrogeous and isocaloric diets containing 20% CP and 2800 kcal/kg ME for the Growth phase and 18% CP, 2600 Kcal/kg ME for Egg production Phase. The treatments are as follows:

Treatment I: White maize as sole energy source.

Treatment II: White sorghum as sole energy source.

Treatment III: Pearl millet as sole energy source.

Treatment IV: Dried sweet cassava meal as sole energy source.

Treatment V: Dried sweet potatoes meal as sole energy source.

Cassava and sweet potato were peeled and chopped into smaller piece which were sundried for a week to reduce the Hydrogen cyanide (HCN) content, while palm oil was added to reduce the dustiness of the feed. The diets were compounded to meet nutrient requirements of quails (NRC, 1994), while proximate composition of the diets were determined at the laboratory according to the method described by A.O.A.C. (1995).

Table 3.1 and 3.2 below shows the composition of experimental diets for growth phase and egg production phase respectively.

Table 3.1: Composition of experimental diets for growth phase (2-6 weeks)

INGREDIENTS (kg)	Treatments				
	T_1 (maize)	T_2 (sorghum)	T_3 (millet)	T_4 (cassava)	T_5 (s. potato)
White maize	50.0	-	-	-	-
White sorghum	-	50.0	-	-	-
Pearl millet	-	-	50.0	-	-
Dried cassava	-	-	-	50.0	-
Sweet potato	-	-	-	-	50.0
Maize offal	17.2	19.0	18.2	6.8	9.1
Ground nut cake	19.3	16.5	16.3	27.7	25.4
Soy meal cake	10.0	10.0	10.0	10.0	10.0
Lime stone	0.5	0.5	0.5	0.5	0.5
Bone meal	2.0	2.0	2.0	2.0	2.0
Palm oil	-	1.0	-	2.0	2.0
Table salt	0.25	0.25	0.25	0.25	0.25
Vit./ m. premix	0.25	0.25	0.25	0.25	0.25
L-lysine	0.25	0.25	0.25	0.25	0.25
L-Methionine	0.25	0.25	0.25	0.25	0.25
	100	100	100	100	100
Cal. Analysis					
ME (kcal/kg)	2819	2785	2785	2831	2847
Crude protein(%)	20.0	19.93	20.0	20.0	19.9
Crude Fiber (%)	4.01	3.58	6.04	6.16	3.72
ME / CP ratio	140.95	139.90	139.3	141.5	142.5

Table 3.2: Composition of experimental diets for egg production phases (6-13 weeks)

INGREDIETS (kg)	Treatments				
	T_1 (maize)	T_2 (sorghum)	T_3 (millet)	T_4 (cassava)	T_5 (S. Potato)
White maize	45.0	-	-	-	-
White sorghum	-	45.0	-	-	-
Pearl millet	-	-	45.0	-	-
Dried Cassava	-	-	-	45.0	-
Sweet potato	-	-	-	-	45
Maize offal	22.0	22.8	22.2	10.2	14.0
Groundnut cake	13.3	10.4	11.0	23.0	19.3
Soy meal cake	10.0	10.0	10.0	10.0	10.0
Lime stone	3.0	3.0	3.0	3.0	3.0
Bone meal	5.0	5.0	5.0	5.0	5.0
Palm oil	-	2.0	2.0	2.0	2.0
Table salt	0.25	0.25	0.25	0.25	0.25
Vit./ m. premix	0.25	0.25	0.25	0.25	0.25
L-lysine	0.50	0.50	0.50	0.50	0.50
L-Methionine	0.50	0.50	0.50	0.50	0.50
	100	100	100	100	100
Cal. Analysis					
ME (kcal/kg)	2607	2602	2588	2630	2623
Crude protein (%)	18.02	17.67	17.99	18.00	18.04
Crude fiber (%)	4.42	3.77	5.20	6.08	4.04
ME / CP Ratio	144.7	147.0	144.0	146.0	145.4

3.4.0 Experimental Procedure

3.4.1 Growth Phase

A total of three hundred (300) one week old Japanese quails were used for the study. The chicks were weighed and randomly allocated into five groups of 60 birds each. Each group was subdivided into 3 replicates of 20 birds in a completely randomized design (CRD). Each group was assigned its respective diet. The birds were kept in a deep litter cage and brooded at a temperature of 36-38 ^{0}C for a week using charcoal pot as source of heat.

3.4.2 Management and Feeding of Experimental Birds

Feed were supplied in a chick tray feeders and fountain drinkers were used to supplied water with small pebbles put all around to prevent drowning. Feed and water were supplied *ad-libitum* throughout the experimental period. Daily feed supplied was weighed and the left over was measured to determined the average daily feed intake of the birds. The birds were weighed on weekly basis and the following parameters were measured : average daily feed intake, average daily weight gain, feed conversion ratio, mortality rate.

NRC (1994) reported that quails were very resistant to the devastating diseases of poultry and most viral diseases. Therefore, no vaccine was administered during these period of experiment except antibiotics and anti stress (multi vitamins) given at arrival day.

3.4.3 Egg production Phase

Experimental diets for egg production phase were allocated to the birds bases on their initial energy sources at the 6th week. Eggs were collected twice daily, at 8.00 hr and 14.00 hr

They were counted, weighed and labeled according to their treatments. Hen-day egg production, Hen-housed egg production and Feed efficiency were calculated as follows:

Hen-day egg production (HDEP) on daily basis was calculated by adopting the formula given by North (1984),

$$\text{HDEP} = \frac{\text{Number of eggs produced on daily basis}}{\text{Number of birds available in the flock on that day}}$$

Hen-day egg production for the whole period was worked out by summing up the daily Hen-day egg production of the flock

Hen-housed egg production (HHEP) was worked out using the following formula given by North (1984);

$$\text{HHEP} = \frac{\text{Total number of egg produced by a flock}}{\text{Total number of hens housed}}$$

$$\text{Feed efficiency} = \frac{\text{Kg of feed consumed}}{\text{Kg of egg produced}}$$

3.4 Determination of Egg Quality Parameters

On the 12th and 13th week of egg production phase, 5 eggs (15 egg/treatment) were randomly picked from each replicate to determine the egg quality parameters. The eggs were weighed using sensitive electronic scale to nearest 0.01. Each egg length and width were measured with Vernier caliper and the values were used to calculate the Egg shape index using the formula described by Sauveur (1988)

$$\text{ESI} = \text{EW/EL}$$

Where ESI –Egg shape index

EW- Egg width (mm)

3.4.0 Experimental Procedure

3.4.1 Growth Phase

A total of three hundred (300) one week old Japanese quails were used for the study. The chicks were weighed and randomly allocated into five groups of 60 birds each. Each group was subdivided into 3 replicates of 20 birds in a completely randomized design (CRD). Each group was assigned its respective diet. The birds were kept in a deep litter cage and brooded at a temperature of 36-38°C for a week using charcoal pot as source of heat.

3.4.2 Management and Feeding of Experimental Birds

Feed were supplied in a chick tray feeders and fountain drinkers were used to supply water with small pebbles put all round to prevent drowning. Feed and water were supplied *ad-libitum* throughout the experimental period. Daily Feed supplied was weighed and the left over was measured to determine the average daily feed intake of the birds. The birds were weighed on weekly basis and the following parameters were measured: average daily feed intake, average daily weight gain, feed conversion ratio, mortality rate.

NRC (1994) reported that quails were very resistant to the devastating diseases of poultry and most viral diseases. Therefore, no vaccine was administered during these period of experiment except antibiotics and anti-stress (multi vitamins) given at arrival day.

3.4.3 Egg Production Phase

Experimental diets for egg production phase were allocated to the birds based on their initial energy sources at the 6th week. Eggs were collected twice daily, at 8.0` 0 am to 2.00 pm.

EL –Egg length (mm)

They were counted, weighed and labeled according to their treatments. Hen-day egg production, Hen-housed egg production and Feed efficiency were calculated as follows:

Hen-day egg production (HDEP) on daily basis was calculated by adopting the formula given by North (1984),

$$HDEP = \frac{\text{Number of eggs produced on daily basis}}{\text{Number of birds available in the flock on that day}}$$

Hen-day egg production for the whole period was worked out by summing up the daily Hen-day egg production of the flock

Hen-housed egg production (HHEP) was worked out using the following formula given by North (1984);

$$HHEP = \frac{\text{Total number of egg produced by a flock}}{\text{Total number of hens housed}}$$

$$\text{Feed efficiency} = \frac{\text{Kg of feed consumed}}{\text{Kg of egg produced}}$$

3.4 Determination of Egg Quality Parameters

On the 12th and 13th week of egg production phase, 5 eggs (15 egg/treatment) were randomly picked from each replicate to determine the egg quality parameters. The eggs were weighed using sensitive electronic scale to nearest 0.01. Each egg length and width were measured with Vernier caliper and the values were used to calculate the Egg shape index using the formula described by Sauveur (1988)

$$ESI = EW/EL$$

Where ESI –Egg shape index

EW- Egg width (mm)

Each egg was broken around the equator, care was taken to keep the yolk intact. The height of the albumen was taken at its widest expanse and midway between the yolk edge and the external edge of the thick albumen using a tripod micrometer (Adeyemo and Longe, 2008). Yolk height was measured at the highest point using a tripod micrometer. The values obtained were used to calculate Haugh unit for each egg, according to the formula outlined by Haugh (1937).

$$HU = 100 \log (H - 1.7 W^{0.37} + 7.6)$$

Where HU = Haugh unit

H= Albumen height (mm)

W= Egg weight (g)

Each egg shell was dried in an oven for 5 minutes and weighed to determine the shell weight. This was used to calculate the Egg shell index (I) using the formula described by Iposu *et al*., (1994).

$$I = 100SW/S$$

Where SW = shell weight (g)

S = surface area (cm)

S = K.EW. 2/3

Where K has value of 4.67 for egg weight less than 60 g and EW is the egg weight.

Shell thickness was measured using a micrometer screw gauge. Yolk index (YI) was calculated with the formula;

$$YI = YW/YH$$

Where YW = yolk weight (mm)

YH = yolk height (mm)

While Egg specific gravity (ESG) was calculated based on egg weight (EW) and shell.

$$ESG = EW/ ((0.9680 (EW-SW) + (04921))$$

Where EW = Egg weight

SW = shell weight

3.4.5 Carcass Evaluation

At the end of the feeding trial (13th weeks), three (3) birds from each replicate (9birds/treatment) were selected, starved overnight so as to allow for the emptying of the crop and excretion of the undigested feed residue, the birds were weighed, slaughtered, and de-feathered. Each bird was cut into their different parts and the following were recorded: dressing weight, breast weight, thigh weight, liver, heart, gizzard, back muscle, leg weight.

3.4.6 Heamatological Parameters

At the end of the experiment, two quails from each replicate (6 birds/treatment) were selected and bled via wing vein. Blood sample (2ml) was collected from each bird using a sterile syringe into a tube containing anticoagulant; sodium salt of ethylene diaminetetraacetic acid

(EDTA) for the determination of heamatological parameters as described by Oyewale (1992), while the following were analyzed ; Heamoglobin (Hb), Pack cell Volume (PCV), Red Blood Cell (RBC), Mean corpuscular Volume (MCV), White Blood Cell (WBC).

3.9.1 Statistical Analysis

All data collected were statically analyzed using the General linear model procedure, (SAS, 2013). And the differences in means were separated using least Significant Differences at 5 %.

CHAPTER 4

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Proximate Composition of Experimental Diets for Growing Phase

The results of proximate composition of the experimental diets for the growing phase are presented in Table 4.1. The Dry Matter (DM) ranged from 92.28% in T_4 (cassava meal) to 93.86% in T_2 (sorghum). The Crude protein ranged from 19.56% in T_5 (sweet potato meal) to 20.15% in T_2 (sorghum meal). The Crude fibre ranged from 4.60% in T_2 (sorghum meal) to 5.38% in T_3 (millet meal) while the Metabolizable Energy (kcal/kg) ranged from 2768 in T_2 (sorghum meal) to 2846 in T_5 (sweet potato).

Table 4.1 Proximate composition of experimental diets for growing phase

	TREATMENTS				
PARAMETERS	T_1	T_2	T_3	T_4	T_5
Dry Matter (%)	93.48	93.86	92.40	92.28	92.87
Crude Protein (%)	19.78	20.15	20.03	19.84	19.56
Crude Fibre (%)	4.89	4.60	5.38	5.10	4.79
Ether Extract (%)	3.16	3.15	3.26	3.32	3.71
Ash (%)	7.35	7.64	8.23	8.39	8.38
Nitrogen Free Extract (%)	50.39	49.78	50.50	50.51	51.31
Metabolizable Energy (Kcal/kg)	2776	2768	2798	2796	2846

4.1.2 Proximate Compositions of Experimental Diets For Laying Phase

The results of proximate composition of the experimental diets for laying phase is presented in Table 4.2. The Dry matter (DM) ranged from 92.57% in T_3 (millet meal) to 95.31% T_5 (sweet potato meal). The Crude protein ranged from 17.81% in T_4 (cassava meal) to 18.4% in T_3 (millet meal), the Crude fiber ranged from 4.42% in T_3 (millet meal) to 5.42% in T_4 (cassava meal). Metabolizable Energy (kcal/kg) ranged from 2581 in T_1 (maize) to 2621 in T_4 (cassava meal).

Table 4.2 Proximate composition of experimental diets for laying phase

	TREATMENTS				
PARAMETERS	T_1	T_2	T_3	T_4	T_5
Dry Matters (%)	92.57	92.81	92.57	93.89	95.31
Crude Protein (%)	17.95	17.95	18.11	17.81	18.09
Crude Fibre (%)	4.36	4.65	4.42	5.42	5.18
Ether Extract (%)	3.10	2.87	3.04	3.38	2.92
Ash (%)	7.41	7.36	8.23	8.62	8.31
Nitrogen Free Extract (%)	46.93	47.52	46.95	47.57	47.66
Metabolizable Energy (kcal/kg)	2581	2584	2583	2621	2598

4.1.3. Performance Characteristics of Japanese Quails Fed Diets Containing Different Energy Sources (2- 6 weeks)

The results of performance characteristics of Japanese Quails fed diets containing different energy sources are presented in Table 4.3. Significant difference ($P < 0.05$) was observed among the treatments for Final body weight (FBW) ranged from 93.20g in T_5 (sweet potato) to 114.13g in T_1 (maize). FBW for T_2 (sorghum) and T_4 (cassava) are statistically similar while T_1 (maize) and T_3 (millet) are also statistically similar. The average daily feed intake (ADFI) ranged from 11.43g/bird/day in T_5 (sweet potato) to 13.77g/bird/day in T_3 (millet), however, there were significant difference ($P < 0.05$) across the treatments. ADFI for T_4 (cassava) and T_5 are statistically similar. Significant difference ($P < 0.05$) was observed among the treatments for Average daily weight gain (ADWG) ranged from 1.93g/day in T_5 (sweet potato) to 2.58g/day in T_1 (maize). ADWG was statistically similar for T_1 (maize) and T_3 (millet).

Table 4.3. Performance characteristics of Japanese quails fed diets containing different energy sources (2- 6 weeks)

	TREATMENTS					
PARAMETERS	T_1	T_2	T_3	T_4	T_5	LSD
Av. Daily Feed Intake (g/bird/day)	12.58^b	13.03^{ab}	13.77^a	11.57^c	11.43^c	0.99
Av. Total Feed Intake (g/bird/day)	440.37^b	456.37^{ab}	482.00^a	404.87^c	400.17^c	34.76
Av. Initial Live Weight (g)	24.00	24.93	24.40	25.30	24.60	1.44
Av. Final Live Weight (g)	114.13^a	105.90^b	111.67^a	103.73^b	93.20^c	4.99
Av. Daily Weight Gain (g/bird)	2.58^a	2.31^b	2.49^a	2.23^b	1.93^c	0.15
Av. Total Weight Gain (g/bird)	90.13^a	80.97^b	87.27^a	78.43^a	68.63^c	5.81
Feed Conversion Ratio	4.87^c	5.64^a	5.53^{ab}	5.19^{bc}	5.91^a	0.43

LSD= Least Significant Differences
a ,b, c- Means with different superscripts on the same row differ significantly ($p< 0.05$)
Av. = average

4.1.4. Performance Characteristics of Japanese Quails Fed Diets Containing Different Energy Sources during Laying Phase (6- 13 weeks)

The results of performance characteristics of Japanese Quails fed diets containing different energy sources during the laying phase is presented in Table 4.4. Significant difference ($P < 0.05$) was observed among the treatments for Final body weight (FBW) ranged from 158.73g/bird in T_5 (sweet potato) to 211.87g/bird in T_1 (maize). FBW was statistically similar for T_2 (sorghum) and T_3 (millet). The average daily feed intake (ADFI) ranged from 33.61g/bird/day in T_1 (maize) to 34.83g/bird/day in T_2 (sorghum), however, there was no significant difference ($P > 0.05$) across the dietary treatments. Significant difference ($P < 0.05$) was observed among the treatments for Average daily weight gain (ADWG) ranged from 1.34g/bird/day in T_5 (sweet potato) to 1.99g/bird/day in T_1 (maize). ADWG for T_3 (millet) and T_4 (cassava) are statistically similar. There were significant difference ($P < 0.05$) among the treatments for Housed-Hen Egg production (HHEP) and Housed day egg production (HDEP). HHEP ranged from 60.67% in T_4 (cassava) to 72.74% in T_1 (maize), while HHEP for T_1 (maize), T_2 (sorghum) and T_3 (millet) are statistically similar.

Table 4.4. Performance characteristics of Japanese quails fed diets containing different energy sources during laying phase (6- 13 weeks)

	TREATMENTS					
PARAMETERS	T_1	T_2	T_3	T_4	T_5	LSD
Av. Daily Feed Intake (g/bird/day)	33.61	34.83	34.42	33.81	33.74	1.37
Av. Total Feed Intake (g/bird/)	1.65	1.71	1.69	1.66	1.65	0.07
A v. Initial Live Weight (g)	114.13	105.90	111.67	103.73	93.20	4.99
Av. Final Live Weight (g)	211.87^{a}	188.60^{b}	188.13^{b}	175.83^{c}	158.73^{d}	7.25
Av. Daily Weight Gain (g/bird/day)	1.99^{a}	1.69^{b}	1.56^{c}	1.47^{c}	1.34^{d}	0.10
Av. Total Weight Gain (g/bird)	97.73^{a}	82.70^{b}	76.47^{c}	72.10^{c}	65.53^{d}	4.72
Housed-Hen Egg Production (%)	72.74^{a}	67.94^{a}	67.25^{ab}	60.67^{c}	61.56^{bc}	5.93
Housed-Day Egg Production (%)	74.65^{a}	69.72^{b}	68.93^{b}	62.38^{c}	63.12^{c}	4.82
Feed Conversion Ratio	1.02^{d}	1.24^{c}	1.33^{bc}	1.39^{b}	1.52^{a}	0.12

LSD= Least Significant Differences
a ,b, c, d - Means with different superscripts on the same row differ significantly ($p < 0.05$)
Av. = average

4.1.5 Carcass and Organs Characteristics of Japanese Quails fed Diets Containing Different Energy Sources

The results of the experimental diets on carcass and organs characteristics of quails fed diets containing different energy sources are presented in Table 4.5. Significant difference ($P < 0.05$) was observed among the treatments for Live weight (LW) ranged from 158.73g in T_5 (sweet potato) to 211.87g in T_1 (maize). LW for T_2 (sorghum) and T_3 (millet) are statistically similar. The carcass weight (CW) ranged from 121.22g in T_5 (sweet potato) to 154.29g in T_2 (millet), however, there was a significant difference ($P < 0.05$) across the diets. Carcass weight for T_1 (maize) and T_2 (sorghum) are statistically similar while T_3 (millet) and T_4 (cassava) are statistically similar. Significant difference ($P < 0.05$) was observed among the treatments for Breast weight (BW) ranged from 29.51g in T_5 (sweet potato) to 59.15g in T_1 (maize). There was no significant difference in the Dressing percentage (DP) ranged from 82.6% in T_2 (sorghum) to 85.65% in T_1 (maize). The heart weight (HW) ranged from 2.23g in T_5 (sweet potato) to 3.43g in T_1 (maize) while the liver weight ranged from 4.11g in T_5 (sweet potato) to 6.35g in T_1 (maize). No significant difference across the treatments for liver weight and Heart weight. There was significant difference ($P > 0.05$) for back weight (BW), range from 10.91g in T_5 (sweet potato) to 16.78g in T_1 (maize), BW for T_1, T_2 and T_3 are statistically similar while T_4 and T_5 are statistically similar.

Table 4.5 Carcass and organs characteristics of Japanese quails fed diets containing different energy sources

	TREATMENTS					
PARAMETERS	T_1	T_2	T_3	T_4	T_5	LSD
Live Weight (g)	211.87a	188.60^{b}	188.13^{b}	175.83^{c}	158.73^{d}	7.25
Slaughter Weight (g)	205.17^{a}	186.07^{b}	185.70^{b}	172.70^{b}	155.68^{d}	10.44
Dressing Weight (g)	173.69^{b}	153.70^{b}	153.13^{b}	145.15^{b}	128.98^{c}	9.85
Dressing Percent (%)	85.65	82.60	82.47	84.08	82.84	3.14
Carcass Weight (g)	154.29^{a}	157.26^{a}	137.49^{b}	129.35^{bc}	121.22^{c}	9.51
Breast Weight (g)	59.15^{a}	45.30^{b}	37.96^{c}	31.87^{d}	29.51^{d}	5.68
Back Weight (g)	16.78^{a}	15.81^{a}	15.74^{a}	12.73^{b}	10.91^{b}	2.22
Rib Cage (g)	14.39^{a}	13.30^{ab}	12.22^{bc}	12.37^{bc}	11.49^{c}	1.67
Wing Weight (g)	11.52^{a}	10.40^{b}	9.36^{c}	9.19^{c}	9.18^{c}	0.81
Neck Weight (g)	10.53^{a}	8.17^{b}	8.43^{b}	7.33^{c}	7.43^{c}	0.45
Head Weight (g)	8.35^{a}	7.16^{b}	7.11^{b}	7.40^{b}	7.09^{b}	0.36
Liver Weight (g)	6.35	4.43	4.29	4.15	4.11	0.48
Heart Weight (g)	3.43	2.45	2.61	2.26	2.23	0.39
Gizzard Weight (g)	6.46^{a}	5.18^{b}	4.91^{b}	4.46^{c}	4.23^{c}	0.40

LSD= Least Significant Differences

a ,b, c, d - Means with different superscripts on the same row differ significantly ($p< 0.05$)

4.1.6 External Egg Quality Characteristics of Japanese Quails fed Diets Containing Different Energy Sources

The effects of different energy sources on external egg qualities are presented in Table 4.6. There were no significant difference ($P > 0.05$) observed among the treatments for egg weight, ranged from 8.50g in T_2 (sorghum) to 9.50g in T_3 (millet). The egg shape index ranged from 0.80 in T_5 (sweet potato) to 0.85 in T_3 (millet), however, there was significant difference ($P < 0.05$) across the diets, though T_1, T_2 and T_4 are statistically similar. Significant difference ($P < 0.05$) was observed among the treatments for egg shell weight, ranged from 0.89g in T_3 (millet) to 1.08g in T_1 (maize), While T_2, T_3, T_4 and T_5 are statistically similar. Significant difference was observed among the treatments for egg specific gravity, ranged from 1.08 in T_3 (millet) and T_4 (cassava) to 1.10 in T_1 (maize). However, there were no significant difference in the egg shell thickness across the treatments, ranged from 0.29g in T_3 to 0.34g in T_1 and T_2 (sorghum).

Table 4.6: External egg quality characteristics of Japanese quails fed diets containing different energy sources

	TREATMENTS					
PARAMETERS	T_1	T_2	T_3	T_4	T_5	LSD
Egg Weight (g)	9.17	8.50	9.50	9.53	8.90	1.08
Egg Height (mm)	24.10^{a}	22.67^{b}	24.57^{a}	24.17^{a}	22.77^{b}	0.89
Egg Length (mm)	29.33^{ab}	28.20^{b}	29.00^{ab}	29.67^{a}	28.50^{ab}	1.33
Egg Shape Index	0.82^{ab}	$0.81a^{b}$	0.85^{a}	0.81^{ab}	0.80^{b}	0.05
Egg Shell Weight (g)	1.08^{a}	0.94^{b}	0.89^{b}	0.91^{b}	0.93^{b}	0.12
Egg Shell Thickness (g)	0.34	0.34	0.29	0.33	0.31	0.06
Egg Shell Index	3.78^{a}	3.54^{ab}	3.00^{c}	3.07^{c}	3.37^{bc}	0.39
Egg Specific Gravity	1.10^{a}	1.09^{b}	1.08^{b}	1.08^{b}	1.09^{b}	0.01

LSD= Least Significant Differences
a ,b, c- Means with different superscripts on the same row differ significantly ($p < 0.05$)

4.1.7 Internal Egg Quality Characteristics of Japanese Quails Fed Diets Containing Different Energy Sources

The effects of different energy sources on internal egg qualities are presented in Table 4.7. There were no significant difference ($P > 0.05$) observed in the Albumen height, ranged from 0.33mm in T_3 (millet) to 0.36mm in T_2 (sorghum) and T_5 (sweet potato). Also, significant different ($P > 0.05$) was not observed in Albumen weight, ranged from 3.30g in T_3 (millet) to 3.69g in T_1 (maize). Yolk weight ranged from 4.08g in T_2 (sorghum) to 4.61g in T_3 (millet), though there were significant difference among the treatments. Yolk weight for T_1 (maize), T_3 (millet) and T_4 (cassava) are statistically similar. Also, Significant difference ($P < 0.05$) was observed across the treatments for Haugh unit, ranged from 60.36 in T_4 (cassava) to 62.40 in T_2. Haugh unit are statistically similar for T_1 (maize), T_2 (sorghum) and T_5 (sweet potato) while T_3 (millet) and T_4 (cassava) are statistically similar.

Table 4.7: Internal egg quality characteristics of Japanese quails fed diets containing different energy sources

	TREATMENTS					
PARAMETERS	T_1	T_2	T_3	T_4	T_5	LSD
Egg Weight (g)	9.17	8.50	9.50	9.53	8.90	1.08
Albumen Height (mm)	0.35	0.36	0.33	0.34	0.36	0.05
Albumen Weight (g)	3.69	3.53	3.30	3.31	3.64	0.52
Yolk Height (mm)	0.86^{a}	0.84^{ab}	0.86^{a}	0.81^{ab}	0.78^{b}	0.06
Yolk Weight (g)	4.32^{ab}	4.08^{b}	4.61^{a}	4.60^{a}	3.94^{b}	0.45
Yolk Index	5.03^{ab}	4.88^{b}	5.43^{ab}	5.70^{a}	5.04^{ab}	0.72
Haugh Unit	61.99^{a}	62.40^{a}	60.39^{b}	60.36^{b}	61.74^{ab}	1.48

LSD= Least Significant Differences

a ,b, c- Means with different superscripts on the same row differ significantly ($p< 0.05$)

4.1.8. Heamatological Effects of Diets Containing Different Energy Sources on Japanese Quails

The results of heamatological parameters of Quails fed diets containing different energy sources are presented in Table 4.8. Significant difference ($P < 0.05$) was observed among the treatments for heamoglobin (Hb), ranged from 6.33 in T_5 (sweet potato) to 16.34 in T_3 (millet). There was significant difference ($P < 0.05$) across the treatments for Pack cell volume (PVC), ranged from 12.41% in T_2 (millet) to 19.05% in T_5 (sweet potato), PVC for T_2 (sorghum) and T_4 (cassava) are statistically similar. The Red Blood Cell (RBC) ranged from 6.24 in T_5 (sweet potato) to 8.27 in T_2 (sorghum). RBC for T_2 (sorghum) and T_4 (cassava) are statistically similar ($P > 0.05$).

The MCV ranged from 30.11 in T_5 (sweet potato) to 50.26 in T_4 (cassava), significant difference was observed across the treatments. MCV for T_1 (maize) and T_2 (sorghum) are statistically similar while MCV for T_3 (millet) and T_5 (sweet potato) are also statistically similar. Significant difference ($P > 0.05$) was observed for White blood cell (WBC), ranged from 3.04 in T_2 (sorghum) to 9.40 in T_5 (sweet Potato). WBC for T_4 (cassava) and T_5 (sweet potato) are statistically similar.

Table 4.8.Heamatological profile of Japanese quails fed diets containing different energy sources

	TREATMENT					
	T_1	T_2	T_3	T_4	T_5	LSD
Heamoglobin (gm/dL)	11.34^c	14.34^b	16.34^a	9.63^d	6.33^e	0.59
Pack Cell Volume (%)	15.13^c	12.41^e	13.28^d	16.18^b	19.05^a	0.34
Red Blood Cell (106/uL)	7.72^b	8.27^a	7.22^c	8.09^a	6.24^d	0.26
Mean Corpuscular Vol. (fL)	40.36^b	40.40^b	30.37^c	50.26^a	30.11^c	0.88
MCHC (%)	36.39^c	38.14^a	37.36^b	30.30^d	38.26^a	0.63
MCH (%)	29.55^b	30.23^a	29.64^b	30.35^a	18.31^c	0.57
White Blood Cell (%)	6.63^b	3.04^d	4.36^c	9.15^a	9.4^a	0.39
Neutrophils (%)	45.38^d	60.18^a	39.66^e	50.32^c	51.40^b	0.93
Lymphocyte (%)	55.98^a	40.40^d	55.72^a	54.59^b	49.21^c	0.92
Eosinophil (%)	3.08^a	2.22^b	1.30^c	2.16^b	2.10^b	0.29
Basophils (%)	1.62^c	0.27^d	3.38^a	2.49^b	2.80^{ab}	0.60
Monocytes (%)	3.76^a	1.67^c	2.57^b	1.42^c	0.73^d	0.26

LSD= Least Significant Differences
a ,b, c, d ,e- Means with different superscripts on the same row differ significantly ($p < 0.05$)
MCHC (mean corpuscular haemoglobin concentration)
MCH (mean corpuscular haemoglobin)
MCV (mean corpuscular volume)

4.2 DISCUSSION

4.2.1 Proximate Composition of Experimental Diets

The proximate composition of the Dry matter, Crude protein, Crude fibre, Ether extract and Nitrogen Free Extract (NFE) in the compounded diets for the growing phase and laying phase are presented in Table 4.1 and 4.2 respectively. There were similarities between the analyzed values and calculated values, which indicated adequacy in the composition of the experimental diets. The diets were formulated to be isonitrogenous and isocarloric. The crude protein for growing phase (starter mash) ranged from 19.56 – 20.5% while the crude protein for laying phase ranged from 17.95 to 18.11%, which were within the recommended range (NRC, 1984) and that of Tom (2011) who reported dietary protein requirement of 20% crude protein for quail starter and 18% crude protein for quail finisher, breeders and layers respectively. The metabolizeble energy for growing phase ranged from 2768 – 2846 kcal/kg across the treatments. This was in conformity with the report of Olubamiwa *et al*., (1999), who observed that dietary energy level of 2550 to 2800 kcal/kg diet supported optimum performance of growing quails in the tropics. Also, Bawa (2012) reported that dietary energy level of 2800 kcal/kg ME is required for optimum performance of Japanese quail chicks. The metabolizable energy for the laying phase ranged from 2581–2621kcal/kg which agreed with the recommendation of Shim and Vohra (1984), who showed that metabolizable energy requirements for laying quails varies between 2600 and 3000 kcal/ME, while crude protein content of diets ranged from 16 and 24%.

4.2.2 Performance Characteristics of Japanese Quails Fed Diets Containing Different Energy Sources (2- 6 weeks).

The productive performance of quails fed diets containing different energy sources during the growth phase are presented in Table 4.3. The feed intake differed significantly ($P < 0.05$) among the dietary treatments with quails on T_3 (millet) and T_2 (sorghum) are significantly ($P < 0.05$) higher than those on T_4 (cassava) and T_5 (sweet potato). Quails on T_1 (maize) and T_2 (sorghum) had similar ($P < 0.05$) daily feed consumption. The values recorded in this study were within the range reported by Ekin and Oruwari (2007), when fed quails corn meal and oil based diet. The higher feed intake by quails on T_3 (millet) based diet could be as a result of the low dietary energy content, while the lower feed intake by quails on T_4 (cassava) and T_5 (sweet potato) could be explained by both physical form of cassava and sweet potato meal i.e. dustiness, loose in texture and higher dietary fiber. Daily weight gain during this period ranged from 1.93 to 2.58 g/day/quail. This was in disagreement with the value of 4.9g/day/quail found by Ozbey *et al.,* (2006). Significant difference ($P < 0.05$) was observed among the treatments for final body weight (FBW). Birds on T_1 (maize) and T_3 (millet) had significantly higher body weight. This agreed with the findings of Umoren and Ojo (2007) who confirmed that maize was the best energy source in the diets of growing rabbits in their study with cassava, cocoyam and *Jacinia naanni*. Earlier, Peterson (1969) had reported that maize promoted better growth rate than guinea corn, oat or barley. However, the significantly lower body weight of quails on T_5 (sweet potato) could be attributed to the findings of Amuchie (2001), who reported that antinutritional factors in the diets of any livestock specie may have negative effects such as reduction in palatability, digestibility and utilization of ration.

4.2.3 Performance Characteristics of Japanese Quails Fed Diets Containing Different Energy Sources during Laying Phase (6- 13 weeks).

Data on feed consumption, weight gain, Hen-day egg production (HDEP) and Hen-housed egg production (HHEP) are presented in Table 4.4. All the groups on the different treatments started to lay by the 6th week of life, which confirmed the report of Martins (1987). There were numerical differences in the feed intake across the treatments, but the differences were not significant. This may be attributed to the observed ability of quails to adjust feed intake with time over a wide range of dietary energy content (Olubamiwa *et al*., 1999). The average daily feed intake in this study ranged from 33.61 – 34.83g/day/quail and was in contrast with the findings of Ani *et al.,* (2009) who recorded an average daily feed intake of 20 – 25g/day for Japanese quails. Animal feed intake varies with many factors such as their age (Almeida *et al.,* 2002), feed chemical composition (Verdelhan, 2006) and the ambient temperature (Lebas, 2004). The different energy sources had significant effects on hen-day egg and hen-housed egg production among the dietary treatments. Hen day production showed that layer quails on T_1 (maize) performed best, while quails on T_2 (sorghum) and T_3 (millet) performed better than those on T_4 (cassava) and T_5 (sweet potato). The Hen day production value ranged between 62.38 – 74.65% which is considerably higher than values recorded by Olubamiwa *et al.,* (1999). The observed improvement in hen-day egg production and hen-housed egg production (HHEP) on T_1 (maize) could be attributed to the enhanced quality of the dietary treatment. And the higher hen-day production for quails on T_2 (sorghum) diet might be related to the low egg weight laid, it has been postulated that there is an inverse relationship between egg weight and egg number, the larger the egg size, the lower the egg number (Odunsi *et al*., 2002). While the low HDEP observed on T_4 (cassava) and T_5 (sweet potato) could be attributed to the report of Amuchie

(2001), that anti-nutritional factors in the diet of any livestock species may have negative effects such as decreased production of animal and reduction in quality of meat, eggs and milk products.

4.2.4. Carcass and Organs Characteristics of Japanese Quails fed Diets Containing Different Energy Sources

The results of carcass and organs characteristics is presented in Table 4.5.The slaughter weight, dressing weight, carcass weight, breast weight, back weight, were significantly different across the dietary treatments. The values obtained for dressing percentage in this study were statistically similar (82.60 – 85.65 %) and were higher than (65.43 – 70.43%) reported by Adesiji *et al*., (2012). This could be due to slaughter age differences. The results of the live weight, eviscerated weight and carcass weight were in agreement with the findings of Hazim *et al*., (2011) who observed effect of different fat on carcass trait of Japanese quails. The result of the gizzard weight is significant ($P < 0.05$), this is in agreement with the findings of Rama Rao *et al*., (2005) who studied performance, serum lipid profile and immune competence of broilers fed graded levels of finger millet and found significant difference for kidney, gizzard and spleen weight, this also agreed with the finding of Rama Rao *et al.,* (2004) who reported significant difference in relative weight of spleen weight as influenced by variation in different energy sources.

The low carcass weight observed in T_5 (sweet potato) might probably be attributed to low protein content and presence of tannin which depress nutrient digestion and utilization as reported by widodo *et al*. (1996).

Dressing percentage, liver weight and heart weight were not significantly influenced by the dietary treatments, this was in conformity with the result of Bai (2012) who reported no significant difference in carcass yield and abdominal fat percentage of broiler when normal maize was replaced by quality protein maize, this was also in conformity with the findings of the Rama Rao *et al*., (2004) who reported that the relative weight and length of intestine were not significantly affected by variation in dietary energy sources.

4.2.5 Internal and External Egg Quality Characteristics of Japanese Quails Fed Diets Containing Different Energy Sources.

The descriptive statistics related to the External and Internal qualities traits of eggs from quails fed diets containing different energy sources are presented in Table 4.6 and 4.7 respectively. Statistical analysis revealed that there were no significant difference ($P < 0.05$) across the treatments with respect to egg weight, Albumen height, Albumen weight and egg shell thickness. Bawa *et al*., (2011) reported that egg mass or weight can be used as criterion in assessment of nutritional status, especially if they are obtained from birds of the same age, breed and health status. Akinwunmi *et al*., (2011) reported that initial egg weight of quail is 9.3 – 10.2g/egg. This result was similar to the average egg weight of this study but differs from that recorded by Randall and Bolla (2008) which is about 10g, about 8% of the body weight of quail hen, and also differs from Elnaga and Abd – Elhady (2009), who reported an average of about 10.89g/egg. The low egg weight in this study might be due to environmental factors and parental average body weight (Yakubu *et al.,* 2008). Higher values were recorded for shell thickness than those (0.18 – 0.19mm) reported by Odunsi *et al*., (2007). The shell thickness value were numerically difference and higher for quails fed maize (T_1) and sorghum (T_2). Quails fed T_3 (millet), T_4 (cassava) and T_5 (sweet potato) had a lower shell thickness which could have been attributed to the reported cases of tannin affecting calcium and phosphorus metabolism in these diets (Butler *et al*., 1984). While higher mineral content in maize impacted positively on the shell thickness and shell weight. The egg shape index observed in this trial ranged from 80 – 85, which agreed with the findings of Punya *et al*., (2008) who studied Brown Japanese quail and recorded 79.57, as well as that recorded by Selim and Ibrahim (2004) who recorded egg shape index of 67.42 – 83.28. The egg length and width recorded in this trial ranged from 28.2 – 29.67mm and 22.67 – 24.17mm respectively, similar results for these traits were reported by kul and seker (2004) who evaluated eggs from 20 weeks old pharaoh quails (33.4mm long, 25.0mm wide).

Haugh unit recorded in this study ranged from 60.36 to 62.40%, which is lower than the minimum of 75% recommended for excellent quality egg, as reported by Babangida and Ubosi (2006). The lower Haugh unit value across the treatments could be attributed to be findings of Panigraphic *et al.,* (1989), who reported that parameters for measuring quality traits of all eggs are at maximum when the eggs are freshly laid and decrease with increased storage time.

4.2.6 Heamatological Effects of Diets Containing Different Energy Sources on Japanese Quails

The effects of the diets containing different energy sources on hematological indices of quails are presented in Table 4.8. All the hematological parameters differs significantly ($P < 0.05$) across the treatments. From the values presented, there were perceptible differences in the Hb, PCV and RBC indices across the groups. This is in conformity with the report of Adamu *et al.,* (2006) who observed that nutrition had significant effects on hematological values like PVC, Hb and RBC. Campbell (1988) reported Hb value of 12.0 to 15.2 gm/dl and PCV (3.8 to 5.5×10^6/ul) for healthy quail, this is in agreement with the Hb value of birds fed T_2 (sorghum). While birds fed T_4 (cassava) and T_5 (sweet Potato) fell below the normal range. This could be attributed to the findings of Apata (2014) who reported that the reduction in the blood cellular components could be due to the inherent anti-nutritional factors and/or restricted intake of nutrients. Higher values for RBC count in this trial could be attributed to the fast growth rate of quails, this agreed with the findings of Bayyari *et al*., (1997) and Maxwell M.H (1993) who reported significant increase in RBC in turkey and fast growing chicken respectively. While Brown *et al.,* (2000) opined that increased RBC values are associated with high quality dietary protein and with disease free animals. The MCV value recorded across the treatments fell below the normal range (78 to 101 fl) reported by Campbell (1988), the significant reduction in the values of MCV observed may be due to accelerated erythropoiesis which significantly increases the demand for iron during hemoglobin formation (Oluwasanmi and Temitayo, 2014).

The WBC value ranged from 3.40 to 9.4 x 10^3/ul which falls within the normal range reported by Campbell (1998) for healthy quail (4.1 to 10.9 x 10^3/ul). The higher values of WBC in birds fed T_4 (cassava) and T_5 (sweet potato) might be attributed to better immune profile as compared to the T_1 (maize), T_2 (sorghum) and T_3 (millet). This also agreed with the report of Reilly (1993) who reported that normal range of values for WBC indicated that the animal were healthy because decrease in number of WBC below the normal range is an indication of allergic condition, Anaphylactic shock and certain parasitism. Clinically, the birds appeared apparently healthy during period of the trial and there was neither remarkable change in weight or decrease in production across the groups.

The lymphocyte, Eosinophil and Basophils values recorded in this feeding trial ranged from 40.40 to 55.98%, 1.3 to 3.08% and 0.27 to 3.38% respectively and fell within the normal range of 20 to 50% (for lymphocyte), 0 to 7% (Eosinophil) and 0 to 2% (Basophils) reported by Campbell (1998). Thus, significant differences ($P < 0.05$) were observed across the treatments without detrimental effect on the health of the birds. This agreed with the report of Toqun *et al*., (2006), who reported that when the hematological values fall within the normal ranged, it is an indication that the diets shows no adverse effect on hematological parameter. And also agreed with the findings of Etim *et al.,* (2014) that when WBC (leucocytes), Neutrophils and Lymphocytes fall within the normal range, it indicate that the feeding pattern do not affect the immune system.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

This research was conducted to evaluate the effects of complete replacement of maize with sorghum, millet, cassava meal and sweet potato meal on growth performance, carcass characteristics, egg qualities and heamatological parameters of Japanese quails. Three hundred (one week old) quails were divided into five dietary groups and each group replicated thrice with 20 birds each in a completely randomized design. Five isonitrogenous and isocaloric diets (20% CP; 2800 Kcal/kg ME) and (18% CP; 2600 kcal/kg ME) for growing and laying phase respectively were formulated.

The study revealed that growth performance, egg production, egg quality, hen-day egg production was not significantly affected across the treatments.

5.2 CONCLUSION

It was observed that quails can easily tolerate any of the sources without deleterious effects on growth performance, Hen day egg production, egg quality and haematological parameters. Cassava meal and sweet potato meal can successfully be used as substitutes for the conventional feed stuff in quail rations, provided that they are duly balanced for all nutrients and are fed in appropriate forms to assure an adequate feed intake. In view of the high cost of maize and the uncertainty about their sustainable supply as energy sources for livestock and poultry, it was concluded that these alternative energy sources can be use as replacement for maize in quail. This will obviously improve on the productively.

5.3 RECOMMENDATION

Based on the findings of this study, Sorghum and millet can be recommended for complete replace of maize as sole energy sources without negatively affecting the growth performance, carcass quality and egg production of Japanese quails, while cassava and sweet potato could completely replace maize when egg production is of interest.

REFERENCES

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 Resources and Rurul Development, 18(5). Article 65 Retrieved November 28, 006,* from http://www.cipav.org.co/lrrd18/5/abub18065.htm

Adamu, S., Thomas, A., Isah, N. M., Fatihumi, M. Y. and Esieno, K. A. N. (2006). Normal value of heamatology of Nigeria adopted albino rats (*Rattus norvegicus*) in Zaria. *Procedes of 31st Annual Conference of Nigeria Society for Animimal Production* (NSAP).

Adedapo, A.A., Dina, O.A., Saba, A.B. and Oladipo, O.D. (2002). Evaluation of *Telfaria occidentalis* and *Sorghum bicolor* extracts as potent haematinics in domestic rabbits. *Nigeri Jornal of Animal Production. 29 (1): 88 – 93.*

Adeola, O., Rogler, J.C. and Sullivan, T.W., (1994). Pearl millet in diets of white pekin ducks. *Poultry science,* 73 (3) : 425-435

Aderemi, F.A., Lawal, T.E., Alabi, O.M., Ladokun, O.A. and Adeyemo, G.O. (2000). Effect of enzyme supplemented cassava root sieviate on egg quality gut morphology and performance of type chickens. *International journal of science.* 5 (6) : 526-529

Adesiji, M. A., Ijaiya, A. T., Aremu, A,. Jiya, E. Z., Egena, S.S. A., Shittu, A. and Ladon, J. N. (2012). Growth Performance, Nutrient Digestibility and Carcass Characteristics of Japanese Quails Fed Graded Levels of Cooked Tallow *(Detarium microcarpum)* Seed Meal. *Savannah Journal of Agriculture* Volume 7(1) 65-69.

Aduku, A.O. (1993). Tropical feedstuff – analysis table. Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Samaru, Zaria, Nigeria.

Agudu, G.O. and Okeke, G.C. (2005). The effects of replacing maize with cassava root meal in the diets of pullet chicks. In: *Proceedings of 30th Annual Conference of Nigeria Society of Animal Production.*

Agwunobi, L.N. (1999). Performance of broiler chickens fed sweet potato meal (*Ipomoca batatas L.*) diets. *Tropical Animal Health and Production* ***31*** *(6) 383-9.*

Aina, A.B.J. and fanimo, A.O. (1997). Substitution of maize with cassava and sweet potato meal as the energy source in the rotation of layer birds. Department of animal production and health university of agriculture Abeokuta, Nigeria, *tropical Agricutural science 20(2/3):63-67.*

Almeida, M.I.M., Oliveira, E.G., Ramos, P.R., Veiga, N. and Dias, K. (2002). Growth Performance of male (*Coturnix sp*) of two lines nutritional environments.

Arch.Vetenary Science. http://ojs.c3sl.ufpr.br/ojs2/index.php/veterinary/article

Ameen, S.A., Adedeyi, O.S., Akingbade, A.A., Olayemi, T.B., Oyedapo, L.O. and Aderinola, A. (2007). The effect of different feeding regimes on haematological parameters and immune status of commercial broilers in derived Savannah zone of Nigeria. *Proceedings of 32 Annual Conference of the Nigeria Society for Animal Production.* 146-148.

Amuchie, E.C. JR. (2001). Anti nutritional factors in feeds and their effects on Livestock Production. Seminar presentation to the Dept. of Animal production, University of Agriculture, Makurdi pp 243-252.

Ani, A.O., Okeke, G.C. and Emeh, M.B., (2009). Response of growing Japanese quail (*Coturnix coturnix japonica*) chicks to diets containing different energy and protein levels. *Proceedings 34th Annual Conference of Nigeria Society for Animal Production* 15th – 18th March, Uyo. pp. 328 –331.

Akinwunmi, A.O., Odunsi, A.A., and Falana, O.L., (2011). Replacement value of hatchery waste meal for fish meal for fish meal in the diet of laying Japanese quail (*Coturnix coturnix japonica).Proceedings36th Conference of Nigeria Society for Animal Production* 13 – 16 March 2011. University of Abuja, Nigeria. Pp 321-323.

Apata, D.F. (2004). Egg production and Heamatological profile of laying hens fed dietary raw or processed Prosopis Africana seeds. *Journal of Agricultural Resources and development.*

Armstrong, W.D., Featherston, W.R. and Rogler, J.C., (1974). Influence of methionine and other dietary additions on the performance of chick fed bird resistant sorghum grain diets. *Poultry Science 52, 1592-1599.* 235-237.

Aro, S.O., Ogunwale, F.F. and Falade, O.A. (2013). Blood viscosity of finisher cockerels fed Dietary Inclusions level of microbially cassava tuber wastes. *Proceedings of the Annual Conference of Animal Science Association of Nigeria.* pp. 74.

Aro, S.O. and Ojo, B.A. (2013). Haematology and gonadal morphometry of finisher cockerets of the graded level of microbially enhanced cassava tuber waste diet. *Proceeding of the 18th Animal Science Association of Nigeria.* 2013;70-73.

Association of Official Analytical Chemistry (1995). 0fficial Method of Analysis, 25th edn Washington D.C., U.SA.

Babangida, S. and Ubosi, C.O. (2006). Effects of varying dietary protein levels on the performance of laying quail (*Coturnix coturnix japonica*) in a semi-arid environment. *Nigerian Journal of Animal Production.* 33(1):45-52.

Bai, Xue-Feng, (2012). Nutritional evaluation and utilization of quality protein maize. Zhong Dan in broiler feed, MSc Thesis, Chinese Academy of Agriculture Science, Beijing, PR China.

Bawa, G.S. (2012). Response of Japanese quail chicks (*Coturnix coturnix japonica*) to various dietary energy level in a tropical environment. *Nigeria Journal of Animal Production,* 39: 37-45.

Bawa, G.S., Lombin, L.H., karsin, P., Musa, U., Payi, E., and Shamaki, D. (2011). Response of Japanese breeder quails to varying dietary protein levels in the tropics. *Nigerian Journal of Animal production.* 38(1):43-53.

Bawa, G.S., Lombin, L.H., Shamaki, D. Karsin, P. and Musa, U. (2012). Proteins requirement of Japanese quail (*Coturnix coturnix japonica*) chicks in Nigeria. *Nigeria Journal of Animal Production,* 39:159-160.

Bawala, T.O., Akpan U., Ogunnowo, A.O., Fasae, O.A. and Sogunle, O.M. (2007). Influence of Mg supplementation on the heamatological profile of young West African Dwarf goats. *Proceedings of the 32nd Conference of the Nigeria Society for Animal Production*.;76-78.

Barthelomew, A., Latsaw, D. and Swayne, D.E. (1998). Changes in blood chemistry, hematology And histology caused by a selenium / vitamins E deficiency and recovery in chicks. Biological Trace Element Research 62: 7-16. In: Surai, P.F. (2002). Selenium in poultry nutrition. *World's Poultry Science.* 58:333-348.

Bayyari, G.R., Huff, W. E., and Rath,N.C. (1997). Effect of the Genetic Selection of Turkeys for Increased Body Weight and Egg Production on Immune and Physiological Responses," *Poultry Science,* volume 76. pp. 289-296.

Brown, D. L. and Chavalimu, E. (2000). Effects of ensiling or drying on five forage species in western Kenya : *Zea may (*maize stover), *Pennisetum batatas* (sweet potato vines) and *Cajanus cajan* (pigeon pea leaves). *Animal Feed Science of Technolology,* 13 (1-2): 1-6.

Buitrago, J.A. (1990). The use of cassava in animal feedings. Centro International De Agricultural Tropical (CIAT). Coli (Colombia), pp 446.

Butler, L.G., Lebryk, D.G and Blytt, H.J., (1984). Interaction of protein with sorghum Tanning, mechanism, specificity and significance. *Journal of Animal Society,*61:916-920.

Campbell, T.W. (1988). Avian Haematology and Cytology (1st Edition) Iowa State University Press, Ames, USA.

Cerning-Beroard, J. and Dividich, J. (1976). Valeur alimentaire de quelques produits amylaces d'origine tropicale. *Annales Zootechnique* 25(2): 155–168.

Change, K.M., Kickman, A.R. and McIntyre, R. (1985). Function of foam from the protodeal gland of the male Japanese quail. *Poultry Scienece,* 64: 78.

Chauynarong, N., Elangovan, A.V. and Iji P.A., (2009). The potential of cassava product in diet For poultry worlds. *Journal of Poultry science X*. 65 - 23 -35.

Claudia, D. (2009). Important nutritional diseases that affect laying hens. Poultry Health Feature Articles.

Cousin, B.W., Tanskley, T.D., Knabe, D.A. and Zebrowska, Z. (1981). Nutrient Digestibility and Performance of Pigs fed Sorghum Varying in Tannin Concentration. *Journal of Animal Science* 53: 1524 – 1537

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

Dafwang, I. I. (2006). Nutrient Requirement and Feeding Regime in Quail Production. In: A Training Manual of Quail Production for Sustainable Household Protein intake. By NAERLS, Ahmadu Bello University, Zaria, Nigeria 11^{TH-} 13^{TH} September, Pp. 59-62.

Daghir, N. J., (2008). Poultry production in hot climates. Second Edition, Cabi Series, CABI

Davis, A.J., Dale, N.M. and Ferreira, F.J. (2003). Pearl millets as an alternative feed ingredient in broiler diets. *Journal Applied Poultry Research* 2003; 12 : 137144

Dilger, R.N. and Baker, D.H. (2008) cysteine and imbalance and it effect on methionine precursor utilization in chicks. *Journal of animal science* 86, 1832 -1840

Dominguez, P.L. (1992). Feeding of sweet potato to monogastrics. In: *Roots,Tubers, Plantains and Bananas in Animal Feeding,* edited by Machin D and Nyvold S, FAQ Animal production and health. pp 95, FAQ.

Douglas, J. H., Sullivan, T. W., Bond, P. L., Stuwe, F. J., Baier, J. G. and Robeson, L. G. (1990). Influence of grinding, rolling and pelleting on the nutritional value of grain sorghums and yellow corn for broilers *Poultry Science* 69:2150-2156.

Dowling L.F., Arndt C. and Hamaker, B.R. (2002). Economic viability of high digestibility sorghum as feed for market broilers. *Agronomy Journal, 94: 1050 – 1058*.

Duplessis, P.H.C. and Erasmus, J. (1972). The relationship between egg production, egg weight and body weight in laying hens. *World's Poultry Science Journal,* 28:301-310.

Edache, J.A., Musa, U., Haruna R.S., Karsin P.D., Esilonu J.O. and Jibrin I.I. (2005). Calcium requirement of Japanese quail *(Coturnix coturnix japonica)* chicks in Plateau State, Nigeria. *Nigeria Journal of Animal Production*. 32: 246-252.

Egbunike, G.N., Agiang, E.A., Owqsibo, A.O. and Fatufe, A.A. (2009). Effects of protein on performance and heamatology of broilers fed cassava peel based diets. *Arch Zootec*. 58: 655-662.

Ekine, O.A. and Oruwari, B.M. (2007). Effects of different dietary energy sources on the egg production of Japanese quail. *Proceedings 32nd Annual Conference of NSAP, Calabar. pp 356-358*

Elagib, H.A.A. and Ahmed, A.O.A. (2011). Comparative study on heamatological values of Blood for indigenous chickens in Sudan, *Asian Journal of Poultry Science,* 41-45.

Elnagar, S. and Elhady, A.M., (2009). Exogenous Estradiol: Productive and Reproductive Performance and Physiological Profile of Japanese Quail Hens. *International Journal of Poultry Science* 8(7):634-641.

Ensminger, M. E., Oldfield, J. E. and Heinemann, W.W. (1990). Feeds and Nutrition (2nd edit.). The Ensminger Publishing Co., Clovis, CA, USA.

Etim, N.N. and Oguike, M.A., (2014). Egg production of the domestic fowls (*Gallus gallus)*. Factors affecting it and implications for food security. *Proceedings of the 35th Annual Conference for the Nigeria Society for Animal Production. (NSAP). Pp 660.*

Farrell, D.J., Atmamihardia, S.I. and Pym, R.A.E. (1982). Calorimetric measurement of the energy and nitrogen metabolism of Japanese quail. *Poultry Science*, 23. 375-382

Forbes, N. (2008). Avian haematology, Avian Medicine: General Avian Medicine. Lafebert.com; 2008.

Gilbert, A.B. (1980). Reproduction in farm Animal. *International Journal of Poultry Science,* pp. 423-446.

Haugh, R. R. (1937). The haugh uint for measuring egg quality. *US poultry magazine*. 43:552-555.

Hazim, J., Daraji, A.I., Al Mashadani, H.A. Mirza, H.I., Al Hayani,W.K., and Al Hassani, A.S., (2011). Effect of feeds containing different fats on certain carcass parameters of Japanese Quails. Department of Animal Production, College of Agriculture, University of Baghdad, Iraq. ARP. J*ournal of Agriculture And Biological Science,* 6: 6-11.

Iji, P.A., Bhuiyan, M.M., Chauynarong, N., Barekatain, M.R., and Widodo, A. P. (2011). Improving the nutritive value of alternative feed ingredient for poultry, published 09/14/2011. University of England.

Iposu, S.O., Onwuka, C.F.I. and Eruvbetin, D. (1994). The relationship between selected egg quality traits and egg size. *Nigeria journal of Animal Production*. 21 (1& 2) : 156- 160.

Kul, S., and Seker, I. (2004). Phenotypic correlations between some external and internal egg quality traits in the Japanese quail (*Coturnix coturnix japonical*). *International Journal of*

Poultry Science 3:400-405.

Kumar, R. (1992). *Propopis cinerania* Leaf Tannins: Their inhibitory effect upon ruminal cellulose and the recovery of inhibition by polyethylene glycol - 4000. In: Plant polyhenols, synthesis, properties and significance. Heningway RW and Laks PE (eds). Plennum Press, New York, pp. 699 – 704.

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. *British Poultry Science* 48 (2) 198 – 204.

Kurma, M.R.A., Reddy, V.R., Reddy, P.V.V.S.N., and Sudhakar R.P. (1991). Utilization of pearl millet (*Pennisetum typhoides*) for egg production. *British Poultry Science*. 32: 463-469.

Kyarissiima, C.C., Okot,M.W., and Svihus, S. (2004). Use of wood ash in the treatment of high tannin sorghum for poultry feeding. *African Journal of Animal Science* 34:110-115.

Lacin, E., Yildiz, A., Esenbuga, N. and Macit, M. (2008). Effects of differences in the initial body weight of groups on laying performance and egg quality parameters of Lohmann laying hens *Czech Journal of Animal Science,* 53(11):446-471.

Lebas, F., (2004). L'elevage du lapin en zone tropicale. Cniculture Magazine, 31, pp: 3-10. http://www.cuniculture.info/Docs/Elevage/Histori-01.htm consulte le 15/09/12.

Lebot, V. (2009). Tropical root and tuber crops: cassava, sweet potato, yams and aroids. *Crops Production Science in Horticulture* (CAB books) CABI, Wallingford, UK (17).)

Longe, O.G. and Oluyemi, J.A. (1979). Comparative use of cassava meal maize and guinea corn as the major dietary sources of carbohydrate for chicks. *Journal of the Association for the advancement of Agricultural Sciences in Africa,* 4(2):47-52.

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

Martins, B. (1987). Guinness World birds, Guinness super latives Ltd, pp. 158.

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

Maxwell, M. H. (1993). Avian blood leukocytes response to stress. *World Poultry Science Of Journal,* volume: 49, pp. 34-43, 1993.

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.

McDonald, P., Edwards, R. A. and Greenhalgh, J. F. D., (2002). Animal Nutrition. 6th Edition. Longman, London and New York. 543 pp

Munir, M.A. and Mohammed, S.A. (2010). Effect of Ambient Temperature, flock Age and Breeding stock on Egg production and Hatchability of Broiler hatching eggs. *Europeen. Journal of Biological Science,* 2(3): 55-66.

National Research Council (1994). Nutrient requirement of poultry. 9th revised edition, National Academy press., Washington, D.C.

National Research Council (1984) Nutrient Requirement of poultry. 9th Eds. National Research Council, Washington.

North, M.O. (1984). Commercial production manual, third edition, Van Nostrand Reinhold, New york.

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

Obioha, F.C. (1992). A guide to poultry production in the tropics. Acena publishers, Enugu Nigeria, pp 40-48.

Odunsi, A.A., Ogunleke, M. O., Alagbe, O.S. and Ajani, T.O. (2002). Effect of feeding *Gliricidia* septum leaf meal on the performance and egg quality of layers. *International Journal of Poultry Science* 1:26-28.

Odunsi, A.A., Rotimi, A.A. and Ameo, E.A. (2007). Effect of different vegetable protein sources on growth and laying performance of Japanese quails (*Coturnix coturnix*) in a derive Savannah Zone of Nigeria. *World Applied Sciences Journal.* 3(5):567-571.

Oke, U.K., Herbert, U., Ebuzoeme, C.O. and Nwachukwu, E.N., (2007). Effect of genotype on the heamatology of Nigeria local chickens in humid tropical environment. *Proceeding of 32nd Annual Conference of the Nigeria Society for Animal Production.* Pp 18-21.

Olabanji, R.O., Farinu, G.O., Akinlade, J.A. and Ojebiyi, O.O. (2007). Growth performance and haematological characteristics of weaner rabbits fed different levels of wild sunflower (*Tithonia diversifolia HemsL A. Gray*) leaf blood meal mixture. *Proceedings of 32nd Annual Conference of the Nigeria Society of Animal Production.* Pp 297-209.

Olomu, J.M. (1995). Monogastric Animal Nutrition Principles and Practices, a Jachem publication. Benin City. Pp 320.

Olubamiwa, O. Harunna, E.S., Musa, V., Akinwale, T. O, Lombin, L.H. and Longe, O.G.

(1999). Effect of different energy levels of cocoa based rations on productive performance of Japanese quails. *Nigeria Journal Animal Production*. 26:88-92.

Oluwasanmi, O.A. and Temitayo, A. (2014). Age-related changes haematological parameters of cage-raised Japanese quails (Cortunix Japonica). *Journal of vetenary Medicine and Animal Health.*

Olukosi, O.A., Cowieson, A.J. and Adeola, O. (2011). Broiler responses to supplementation of Phytase and admixture of carbohydrate without maize distillers dried grain with solubles. *British poultry science* pp 52,434 -443

Oluyemi, J.A. and Roberts, F.A. (1979). Poultry Production is warm, wet climates. Macmillan Press Ltd. London: 29-31.

Oria, M.P., Hamaker, B.R., Axtell, J.D. and Huang, C. H. (2000). A high digestible mutant Cultivar exhibits a unique folded structure of endosperm protein body. *Proceedings of National Academic of Scienc.* 10:5065-5070.

Osei, S.A. and Twumasi, I.K., (1989). Effects of oven dried cassava peel meal on the performance and carcass characteristics of broiler chickens. *Animal feed science technology, 24 (3-4) : 247- 252.*

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

Oyewale, J.O. (1992). Changes in Osmotic resistance of Erythrocytes of cattle, pigs, rats and rabbits during variation in Temperature and Relative humidity. *Journals of vetenary Medicine, 39: 93-104.*

Ozbey, O., Yildiz, N. and Esen, F. (2006). The effects of high temperature on breeding characteristics and the living strength of the Japanese quail (*Coturnix coturnix japonica). International Journal of Poultry Science,* 5: 56-59.

Panigraphi S., Plumb V.F. and Mantrin., D.H. (1989). Effect of dietary cotton seed meal with and without non-treatment on laying hens. *British Poutry Science,* (30): 641-649.

Peroni, N., Kageyama, P.Y. and Begossi, A. (2007). Molecular differentiation, diversity and folk classification of sweet and bitter cassava (Manihot esculenta) in Caicara and Caboclo management systems (Brazil). *Genetic Resources and Crop Evolution* 54 (6) : 1333- 1349.

Peterson, V.E. (1969). A composition of the feeding value for broilers of corn, grain sorghum, barley, wheat and oats and the influence of the various grains in the composition and taste of broiler meat. *Poultry Science*,48:2006-2013.

Price, M. L. and Butler, L.G. (1978). A critical evaluation of the vanillim reaction as an assay for tannin in sorghum grain. *Journal of Agricutural Food Chemistry,*. 26:1214-1218.

Punya Kamari, I, B., Ramesh Gupta, B., Gnana Prakash, M. and Rajasekhar Reddy, A.

(2008). A Study on Egg Quality Traits in Japanese Quails (*Coturnix coturnix japonica).* Tamilnadu. *Journal Veternary & Animal Science,* 4 (6) 227-231.

Randall, M. and Bolla, G. (2008). Raising apanese quail. 2nd edition.

Rama Rao, S.V., Raju, M.M.L.N., Reddy, R. M. and Panda, A. K. (2005). Utilization of graded levels of finger millets (Eleucine coracana) in place of yellow maize in commercial broiler chicken diets. Asian-Aust. *Jounrnal Animal Science,* 18: 80-84.

Rama Rao, S.V., Raju, M.V.L.N. Reddy, M.R., and Panda, A.K. (2004). Replacement of yellow maize with pearl millet (*Pennissetum typhoides*), Foxtail millet *(Seteria italic)* or finger millet (*Eleucine coracana*) in broiler chicken diet containing supplemental enzymes. Asian-Aust. *Journal of Aminal Science,* 17: 836-842.

Ravindran V., Ravindran G., Sivakanesan R. and Rajaguru S.B. (1995).Biochemical and Nutritional assessment of tubers from 16 cultivars of sweet potato (*Ipomoea batatas L.*). *Journal of Agricultural and Food Chemistry* **43**(10) 2646-2651.

Ravindran, V., Ravindran, G., Sivakanesan, R. and Rajaguru, S.B. (1995). Biochemical and nutritional assessment of tubers from 16 cultivars of sweet potato (*Ipomoea batatas L.*). *Journal of Agricultural and Food Chemistry* **43**(10) 2646-2651.

Ravindran, V., Morel, ., P.C.H., Partridge, G.G., Hruby, M. and Sands, J.S. (2006). Influence of An *Escherichia coli* - derived phytase on nutrients utilization in broiler chicken starter diets fed diets containing varying concentrations of phytic acid. *Poultry Science,* 85: 82-89.

Reilly, J. S. (1993). Euthanasia of animals used for scientific purposes. ANZCCART, Glen Osmond South Australia, 7(4): pp 76

Rooney, L.W. and Pflugfelder, R.L. (1986). Factors affecting starch digestibility with special emphasis on sorghum and corn. *Journal of Animal Science,* 63: 1607 – 1623.

Rowe J.B., Choct M. and Pethich D.W. (1999). Quality of feed grains. Aust *Journal of Agricultural Resources*, 50: 721 – 736.

Salami, R.I. and Odunsi, A.A., (2003). Evaluation of processed cassava peels meals as substitutes for maize in the diets of layers. *International journal of poultry science*. 2(2): 112-116.

Sanford, J.A. (1957). A progress report of *Coturnix* quail investigations in Missouri. *Proceedings of Northern American Wildlife Conference.* 22nd Conference. pp. 316-359.

Sauvant D. Perez, J. M. and Tran, G., (2004). Tables INRA-AFZ de composition et de valeur nutritive des matières premières destinées aux animaux d'élevage: 2ème édition. ISBN 2738011586, 306 p. INRA Editions Versailles.

Sauveur, B. (1988). Reproduction des volailles et prodrection d' oeufs, INRA Paris. Pp 385-391

Selim, K. and Ibrahim, S. (2004). Phenotypic Correlations Between Some External and Internal Egg Quality Traits in the Japanese Quail (*Coturnixcoturnixjaponical*). *International Journal Poultry Science,* 3 (6): 400-406.

Sell, D. R., J. C. Rogler, and W. R. Featherston. (1984). The effect of sorghum tannin and methionine level on the performance of laying hens maintained in two temperature environments. *Poultry Science,* 62:2420-2428.

Shim, K.F. (2004). Nutrition and Management of Japanese *Coturnix* Quails in the Tropics. That quail place, all about quail birds.

Shim, K. F. and Vohra, P. (1984). A review of the nutrition of Japanese quail. *World's Poult. Sci.,* 261-275. SPSS (2007). Statistical package for Social Science. Release 17.0. User Mannual. Microsoft Corp; U.S.A.

Shrivstav, A.K. and Panda, B. (1982). Effect of increasing calories-protein ratio during growing period (4-5 week) on dressing yield and chemical composition of quail meat. *Indian Journal of Poultry Science,* 17: 253-256.

Shrivastav, A.K. and Johri, J.S. (1993). Evaluation of different feeding schedules during starting and growing period in Japanese quail. *Indian, Journal of Poultry Science,* 28 :183-189.

Singh, R.A. (1990). Poultry Production. Kalyani Publishers New Delhi, LIUDIHIANA, pp 84-115.

Smith, A.E. (1990). General nutrition, University of Saskatchewan Canada, pp 30-45.

Spiridon, G., Dexamir, A., Inculet ,E., Visan, I., Popeseu, A. and Ciupercesan, V. (1979). Efficiency Of mixed feeds with different amounts of maize and sorghum for meat chickens. Inst. of Agronomy, Nicolae Balceseu, Bucharest, Romania, pp. 91 – 94.

Statistical Analysis System (2013). Guide for personal computer version 9. SAS Institute, Inc. carry, NC, USA.

Shim, K.F. and Lee, T.K, (1982). Least-cost ration formulation for Japanese quail, Coturnix Coturnix *Japanica.* and Layer diet for laying quail. *Singapore Journal of Primary Industries*, 10: 89-96.

Togun, V.A., Farinu, G.O., Oyebiyi, O.O., Akinlade, J.A., Ajibok, H.O. and Olaniyonu, B.I. (2006). Comparative study of the effect of dietary replacement of 15% maize offal with pigeon pea (*Cajanus cajan)* grain or leaf meal on performance of weaners, rabbits. *Proc. of 32nd Annual Conference of the Nigeria Society for Animal Prod*uction

217-219.

Togun V.A., Farinu G.O., Oyebiyi O.O., AkinladeJ.A. and Ajibok H.O.(2007). Olaniyonu B.I. Comparative study of the effect of dietary replacement of 15% maize offal with pigeon pea (Cajanus cajan) grain or leaf meal on performance of weaners, rabbits. *Proc. of 32nd Annual Conference of the Nigeria Society for Animal Production,* 217-219.

Tom, W.S. (2011). Feed and Nutrition featured Articles. In: Mississippi State University Extension Service-2004.

Ubalua, A.O. (2007). Cassava waste: Treatment options and Value addition alternatives. *African Journal Biotech*. 6 (18): 2065-2073.

Umoren, U.E, and Ojo, T.J. (2007). Comparative evaluation of maize, cassava, cocoyam and *Icacinia manni* as energy sources for growing rabbits. *Proc. 32nd Annual conference of Nigeria Society of Animal Production.* Calabar March 18-21,2007.pp 299-302.

Vasan, P., Narayan Dutta, Mandal, A.B. and Sharma, K., (2008). Effect of grindings of apparent and true digestibilities of Amino acids of pearl millet (*Pennisetum typhoides*) in adult roosters. *Animal Nutrition feed Technology,* 8(1) 111-114.

Verdelhan, S. (2006). Quel apport d'energie pour ameliorer les poids de vente ? *Journee nationale ITAVI elevage du lapin de chair*, 28 nov 2006, Pace (France), pp: 60-65.

Veum, T. L., Ledoux, D. R., Raboy, V. and Ertl, D. S., (2001). Low-phytic acid corn improves nutrient utilization for growing pigs. *Journal of Animal Science*, 79: 2873-2880

Whitacre, M.E., Combs, G.F., Combs, S.B. and Parker, R.S. (1987). Influence of dietary vitamin E on nutritional pancreatic atrophy in selenium deficient chicks. *Journal of Nutrition 17:460-467.* In: Surai, P.F. (2002). Selenium in poultry nutrition 1. *World's Poultry Science* 58:333-348.

Widodo, W.K., Kamal, M. and Ardhana, M.M. (1996). The effect of levels of two varieties of sorghum in diets on broiler performance. Agrivita, 19: 107-109.

Woolfe, J.A. (1992). Sweet potato, an untapped feed resource: university press, Cambride, UK. pp 643.

Wright A. F. (1994). Animal Feeds: Combining the best of both World Bulletin of the Frank Wright Group United Kingdom, pp 94-96

Yakubu, A., Ogah, D.M. and Barde, R.E. (2008). Productivity and egg characteristics of free range naked neck and normal feathered Nigerian indigenous chickens. *International Journal of Poultry Science.* 7(6):579-585.

Zhang, D.P., Cipriani,G., Rety, I., Golmirzaie,A., Smit,N. and Michaud, D. (2000).

Expression of protease inhibitors in sweetpotato. In: Recombinant Protease Inhibitors in Plants (ed. D. Michaud). Landes Bioscience, Georgetown, TX, USA. pp. 167–178

.