PERFORMANCE AND CARCASS TRAITS OF BROILER CHICKENS FED AIR-DRIED BITTER KOLA (*Garcinia kola*) SEED MEAL UNDER SINGLE PHASE FEEDING

BY

ABDULSALAM, Teslim Oyetola
MTech/SAAT/2018/8036

DEPARTMENT OF ANIMAL PRODUCTION
FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA

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**A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY IN ANIMAL PRODUCTION**

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DECLARATION

I hereby declare that this thesis titled "**Performance and carcass traits of broiler chickens fed air-dried bitter kola (*Garcinia kola*) seed meal under single phase feeding**" is a collection of my original research work and it has not been presented for any other qualification anywhere. Information from other sources (published or unpublished) has been duly acknowledge.

ABDULSALAM, Teslim Oyetola
MTech/SAAT/2018/8036
FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA, NIGERIA

SIGNATURE/DATE

CERTIFICATION

The thesis titled **"Performance and carcass traits of broiler chickens fed air-dried bitter kola (*Garcinia kola*) seed meal under single phase feeding"** by ABDULSALAM, Teslim Oyetola (MTech/SAAT/2018/8036) meets the regulations governing the award of the degree of Master of Technology of Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

DR. Y. S. KUDU MAJOR SUPERVISOR	--------------------------------- SIGNATURE & DATE
DR. (MRS). K.E. AKANDE CO-SUPERVISOR	-------------------------------- SIGNATURE & DATE
PROF. D. N. TSADO HEAD OF DEPARTMENT	------------------------------- SIGNATURE & DATE
PROF. J. H. TSADO DEAN, SCHOOL OF AGRICULTURE AND AGRICULTURAL TECHNOLOGY	-------------------------------- SIGNATURE & DATE
ENGR. PROF. O. K. ABUBAKRE DEAN, POSTGRADUATE SCHOOL	-------------------------------- SIGNATURE & DATE

DEDICATION

This project work is dedicated to Allah, the one and only Most Kind and Most Compassionate. Also to my parents, teachers/tutors, friends and well-wishers.

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All praises and adoration be to Almighty God, the Most Kind and Merciful who has always been so kind and merciful to me all through in achieving this goal. My salutation goes to the noblest among the messengers and servants of Allah, Muhammad (Peace be Upon Him) who was sent as a mercy to mankind. I appreciate and thankful to the Head of Department, Prof. D.N. Tsado for his fatherly concern and guidance. I am sincerely grateful to my supervisors; Dr. Y. S. Kudu and Dr. (Mrs). K. E. Akande, I do greatly appreciate their expertise input, guidance, assistance, patience and resilience in ensuring the success of this study, your relentless effort cannot be over emphasized. In addition, I am extending my profound gratitude Prof. B.A. Ayanwale for his unquantifiable support and guidance in getting the work set as required. I pray that God Almighty will continually bless you in all your endeavours. All other lecturers and academic and non-academic staff members of the department, Animal Production, are also recognized and appreciated for their contribution towards the success of this study.

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ABSTRACT

Herbal plants like bitter kola *Garcinia kola* seed meal can be used as additive for gut microflora manipulation in improving nutrient digestibility, feed intake and efficient feed utilization. Therefore, this study was carried out to determine the performance characteristics and carcass traits of broiler chickens fed diets containing varying levels of air-dried bitter kola (ADBK) under single phase feeding. A total of 180 day old chicks with 15 birds per replicate of 45 birds per treatment were used in a completely randomized design. The experiment lasted for 8 weeks. The diets formulated contained 0, 5, 10, 15 and 20% inclusion levels of ADBK as treatments 1, 2, 3, 4 and 5 respectively. The results showed that the feed intake varied significantly ($p<0.05$) with lowest (4130.30g) and highest (4658.65g) feed intakes recorded with birds fed 0% and 15% ADBK respectively. Significant differences ($p<0.05$) were also observed in the final weight with highest value at control diet (1726.78g) compared to other treatments. The better cost effectiveness (₦127/bird) was observed with the birds fed 0% ADBK compared to ₦198.02/bird observed with birds fed 15% ADBK. The carcass traits observed indicated significant difference ($p<0.05$) in the eviscerated weight with highest value of 88.80% recorded in birds fed 15% ADBK while lowest value was obtained with birds fed 5% ADBK inclusion level. No significant difference ($p>0.05$) was observed in the cooking loss, juiciness, tenderness, flavour but the best overall acceptability was obtained with birds fed 10% ADBK. The results of this research study have shown that air-dried bitter kola in the diet of broiler chickens under single phase feeding, nutritionally, has no improvement on broilers growth performance. The weight gains depressed progressively in all the treated treatments as the inclusion level of ADBK increased. On the contrary, the feed intake progressed with increase in the level of ADBK inclusion. Broilers chickens fed diet with 0 % inclusion level of air-dried bitter kola performed best as they consumed the least amount of feed had the highest feed conversion ratio, highest total body weight gain and the lowest feed cost per body weight gain. Bitter kola included in the diet of broiler chicken increased their feed intake, feed cost and feed cost per body weight gain while it decreased their total body weight gain. It was therefore concluded that the inclusion of air-dried bitter kola seed meal did not improve the performance characteristics and cost effectiveness of broiler chicken production but increased the eviscerated weight and overall meat acceptability.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Poultry refers to the domesticated birds raised for egg, meat, and feather, it covers a wide range of birds, from indigenous and commercial breeds of chickens to Muscovy ducks, mallard ducks, guinea fowl, turkeys, geese, quail, pigeons, ostriches, and pheasants, (FAO, 2019). Throughout the world, poultry are raised and among all the domesticated avian species raised, chickens are the most common everywhere.

In poultry farming, more chickens are kept worldwide than any other type of poultry, with more than 50 billion birds raised annually as sources of meat and eggs (Ibitoye, 2012). These birds are usually kept extensively in small flocks, fed during the day and lodged at night. This is still the case in developing countries, where women often make significant contributions to family living through poultry rearing (Amakari and Owen, 2011). Nevertheless, growing world populations and urbanization have resulted in large, more intensive specialist units being created. These are often located close to where the food is grown or where the meat is needed, leading to the availability of cheap, safe food for urban communities (Browne, 2002). The birds will live freely outdoors in free-range husbandry for at least a part of the day. This is always in large enclosures, but the birds have exposure to natural environments and can exhaust their usual behaviours. Battery cages are the most intensive device for chickens laying eggs, often placed in multiple strata. Several birds are housed in small cage compartment that limits their ability to move about and behave normally. The eggs when laid on the cage floor roll into outside troughs for easy collection (Browne, 2002). Chickens raised for their meat intensively are known as 'broilers'. They are special breeds that can grow to an acceptable carcass size in eight weeks or less (Farrell, 2010).

Chickens are of high importance in poultry production. In 2016, chickens accounted for ninety-one percent (91 %) of world's poultry's production, followed by ducks, five percent (5 %) and turkeys two percent (2 %). Others, such as geese and guinea fowl, made up the remaining two percent (2 %). Chickens contribute eighty-nine percent (89 %) of world poultry meat production and ninety-two percent (92 %) of world egg production, (FAO, 2019).

Nutrition of poultry birds plays important role in their productivity especially in terms of growth and reproductive performance. The faster a bird grows the earlier it reaches its maturity. Delayed or poor growth could limit productivity.

Farmers have been using growth promoters to enhance growth rate, overall efficiency and productivity in livestock. Various compounds have been tried for growth promotion, including hormones and antimicrobial agents. Natural hormones such as oestradiol (estrogen), progesterone, testosterone, or synthetic hormones such as Zeranol, melengestrol acetate are widely used as growth promoters in animals (Hassan *et al*., 2008).

A recent report by Livestock and Aquaculture Watch (2018) indicated a complete ban on use of antibiotics (growth promoter and mould inhibitors) in livestock industry. However, phytobiotics have been growing in popularity as feed additives due to their beneficial effect on growth performance. Phytobiotics are the plant derived products, added to feed in order to improve performance. They originate from leaves, roots tubers or fruits of herbs, spices and other plants. These plant-derived products may be available in solids, dried and ground forms, or as extracted essential oils.

Bitter kola (*Garcinia kola*) is a phytobiotic source, beneficial in improving growth performance of broiler chickens and rabbits. It is a flowering plant found mostly in the tropical rain forest region of Central and West Africa. It is a perennial crop growing attaining a height of thirty-five to fourty metres (Adedeji *et al*., 2006). It belongs to the family *Gutifecae,* genus *Garcinia* and to the specie of tropical flowering plants. The brown nut-like seeds similar in appearance to kidney beans characterize it physically. It is a traditional fruit common in Nigeria rural areas (Adedeji *et al*., 2006).

1.2 Statement of the Research Problem

Substantial evidence that antibiotics residues in meat and meat products of animals treated with antibiotics may pose a risk to the consumers (Adedeji *et al*., 2006 and Livestock and Aquaculture Watch, 2018). In addition, indiscriminate and inappropriate use of antibiotics (growth promoter and mould inhibitor) as feed additives in animal feed had resulted in diseases such as cancer, kidney, and other organ failure in Nigeria.

Feeding cost in poultry production accounts for about seventy percent (70 %) of the cost of production (Aliyu and AbdulMalik, 2013). Limited research work on the best level of inclusion of bitter kola in the broiler diet (Iwuji and Herbert, 2012). Awareness on the benefit of bitter kola as feed additives on the growth performance of broiler chicken has not been widely given.

1.3 Justification for the Study

i. Using bitter kola as a feed additive in promoting the broiler performances (Aliyu and AbdulMalik, 2013).
ii. Utilizing bitter kola as an alternative to in-feed antibiotics (Adedeji *et al*., 2006).

iii. Bridging the gap between the demand and supply of animal protein through increased broiler production.

iv. Bitter kola is readily available and affordable, thus its usage will reduce the poultry production costs (Mazi *et al*., 2013).

v. There is need to determine the extent to which bitter kola can be utilized by broiler chicks (Aliyu and AbdulMalik, 2013).

vi. Lower inclusion level up to 7.5 % air-dried bitter kola have been reported having least body weight gained value (Adedeji *et al*., 2008), however, higher inclusion may be needed to ascertain the claim particularly under single phase feeding.

1.4 Aim and Objectives of the Study

The aim of the study is to:

Evaluate the performance of broiler chickens fed air-dried bitter kola meal at varying inclusion levels in promoting growth in broiler chickens.

The objectives of the study are to:

i. determine the proximate composition of air-dried bitter kola (*Garcinia kola*)

ii. evaluate growth performance of the broiler chickens fed diet containing air-dried bitter kola at varying inclusion levels (0%, 5%, 10% and 15%)

iii. evaluate the nutrient digestibility of the broiler chicken fed diets containing air-dried bitter kola at varying inclusion levels

iv. determine the carcass characteristics of the broiler chickens fed diet containing air-dried bitter kola at varying inclusion levels

v. evaluate the economy of feed conversion of broiler chickens fed diet containing varying levels of inclusion of air-dried bitter kola (feed cost/weight gain, ₦/kg).

vi. evaluate the sensory characteristics of the broiler chickens fed varying inclusion level of air-dried bitter kola.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Broiler Chicken Production

Broiler chickens are usually reared for meat. They originate from the jungle fowl of the Indian Subcontinent. The broiler industry has grown due to consumer demand for affordable poultry meat. Breeding for particular traits and improved nutrition have been used to increase the weight of the breast-muscle. Commercial broiler chickens are bred to be very fast growing in order to gain weight quickly. In their natural environment, they are highly motivated to perform species-specific behaviours that are typical for chickens (natural behaviours), such as foraging, pecking and scratching and feather maintenance behaviours like preening and dust bathing. The life of chickens destined for meat production consists of two distinct phases. They are born in a hatchery and moved to a growing farm at 1 day-old. They remain here until they are heavy enough to be slaughtered. Broiler parent birds (broiler breeders) are the ones used to breed the chicks that become broiler meat chickens (De Jong and Swalander, 2012).

2.2 Management and Diets of Broiler Chickens

Broiler chicks were shown to benefit from immediate feed access. Although the focus of nutrition was on energy supply, a balanced nutrient profile would be more beneficial to the chicks, especially protein and amino acids. Modern broiler chickens reach table size each year to cope with market demand for meat (Schwartz, 2008). The overarching goal for broiler chicken producers is to produce meat with leaner tissue and appropriate lipid content to meet the demands of modern consumers as per the Hazard Analysis and Critical Control Points (HACCP) approach (Weltzien, 2009). Because feed expenses often account for 80 % of the production costs of broiler chicken, decisions on ration composition have a huge effect on the competitiveness of any broiler manufacturing undertaken. To ensure a rapid growth rate and an efficient conversion of feed into broiler chickens, good management practices involving effective disease prevention and control, flock maintenance under continuous illumination and the provision of high quality feed and water (*ad libitum*) are all necessary (Amakari and Owen, 2011).

Broiler diets are formulated to provide the energy and nutrients that are essential for health and efficient production of broilers (Arbor Acres, 2009). Amino acids, energy, water, vitamins and minerals are the essential nutrients that broiler chickens need to ensure proper skeletal growth and muscle deposition (Appleby, 2010). Chicken meat is known as white meat and is differentiated by its lower iron content from other meats such as beef and lamb (0.7 mg/100g as compared to 2 mg/100 g in beef and lamb) (Farrell, 2010). About half of the chicken meat fat consists of desirable monounsaturated fats, MUFA (e.g. palmitoleic acid, oleic acid, heptaecenoic acid, gadoleic acid, etc.) and only one-third of the less healthy saturated fats, SFA (e.g. palmitic acid, stearic acid, margaric acid, arachidic acid etc.). (Farrell, 2010). Poultry meat is an important provider of the essential polyunsaturated fatty acids (PUFAs), especially the omega (n)-3 fatty acids (Ravindran, 2010). Omega-3 fatty acids are said to be beneficial to human health because they reduce the risk of heart disease (Wahrburg, 2004). The quantities of these important fatty acids in chicken meat can be increased more easily than in other livestock meats; so can some trace minerals and vitamins (Farrell, 2010). The research by Yu *et al.* (2008) showed that adding 0.24 mg of selenium (as organic selenium) per kilogram of feed, the selenium content of breast meat can be increased from 8.6 μg to 41 μg/100g, which is more than 65 percent of the Recommended Dietary Intake (RDI). The main emphasis in the formulation of broiler diets is on crude protein (CP) because protein is the critical component of poultry diets and together with other major nutrients such as carbohydrates, fat, water, vitamins and minerals are essential for animal performance (Chen and Liu, 2005).

An economical decision on the dietary nutrient levels, particularly for dietary proteins and amino acids, is needed when formulating broiler diets to control high digestibility and efficient feed conversion (Amakari and Owen, 2011). The energy levels that will yield the best economic return depend mostly on the local conditions under which the broiler chickens are raised (Choct, 2012). The quality of protein in feeds, however, is based on the presence and balance of essential amino acids in the feed ingredients, but not on crude protein levels in the diet (Appleby, 2010). Hence, the availability of these essential amino acids when formulating broiler diets is considered. Protein is a polymer composed of α-amino acid, which is connected by peptide bonds. Protein is broken down and is hydrolyzed into amino acids in the digestive system.

The actual protein levels and macro minerals such as calcium, phosphorus, magnesium, sodium, potassium and chloride used in broiler diets will differ depending on the ingredients of the feed and will be guided by the first restricting critical amino acid not available in a synthetic form (Teeter and Wiernusz, 2003). An ideal amino acid profile (IAAP) can be used to ensure adequate balance of digestible amino acids (Appleby, 2010). Especially under hot weather conditions, high quality protein sources are required (West, 1999). Therefore, calcium in the broiler diets affects growth, feeding efficiency, bone development, led health, nerve function and the immune system, so it is vital that calcium is in adequate quantities and consistently to achieve optimum performance (Weltzien, 2009). Just like calcium, phosphorus is required in the right form and quantity to maximize digestibility of broilers. Hence, calcium: available phosphorus of 2:1 is appropriate for broiler diets (Choct, 2012).

2.3 Nutritional Requirements for Broiler Starter (day old – 4 weeks)

Metabolizable Energy (ME) required for broiler starter is 2900-3100 Kcal/kg, crude protein (CP) 21-24 %, crude fibre (CF) 5 %, calcium 0.85-1.05 %, methionine 0.37 %, lysine 1.10 % and sodium 0.01-0.30 % (Akinbobola, 2018)

2.4 Nutritional Requirement for Broiler Grower (4 – 8 weeks)

Metabolizable Energy (ME) required for broiler grower is 3000-3300 Kcal/kg, crude protein (CP) 18-23 %, crude fibre (CF) 8 %, calcium 0.80-1.00 %, methionine 0.33 %, lysine 0.85 % min. and sodium 0.01-0.30 % (Akinbobola, 2018).

2.5 Feed Intake of Broiler Birds

Broiler (meat-type chickens) are the most efficient terrestrial animals in converting nutrients present in the feed into muscle. In the mid 80's, under good husbandry and good nutrition practices, a 1.4 kg broiler would be produced with 3.2 kg of feed. This represents a feed conversion ratio (FCR) of 2.3 at 35 days of age. In 2010, at the same age, a 2.4 kg bird could be reared with as little as 3.7 kg of feed, displaying a 65% lower FCR (Siegel, 2014).

Voluntary feed intake of chickens determines the levels of nutrient intake and thus has a major impact on the poultry production quality. Suitable feed intake is often difficult to maintain in many poultry operations in several farms and thus becomes an important factor in limiting productivity. Stressors such as high weather, elevated storage density and decreased health status, along with genotype, affect feed intake and thus development (Mbajiorgu *et al.,* 2011).

2.6 Broiler Feed Efficiency and Feed Conversion Ratio

Feed efficiency is a major variable to determine the cost of a kilogram of poultry meat (chicken, turkey, geese, guinea fowl, duck, etc.) in poultry production. The proportion of feed in the ration of a broiler ranges from 40 to 70% of the cost of production. Regardless of the birds' species raised, improving feed efficiency is critical when attempting to master production costs in poultry. The feed conversion ratio (FCR) is the amount of feed ingested by an animal, which can be converted into one kilo of live weight. It is a mathematical relationship between the quantities of feed provided (fed) and the weight gained by consuming it. It can be calculated by dividing the total input of the given feed by the total weight gain. Feed conversion ratios are important because they help the farmer to know how much amount of feed will be required in the growth cycle of animals (Lee *et. al*., 2015).

Feed conversion ratio and maximum yield feed conversion ratio is measured by the division of mass of the input by mass of output. Animals that have lower feed conversion ratios are considered as the most efficient consumers of feed. This technique does not only work in poultry farming but all kinds of farming benefit from it and it is a great way to determine how efficient the feeding strategy is. Feed conversion ratio is the input of feed/weight gained by the animal. The feed conversion ratio, which varies depending on the type of production applied, is always a very helpful standard by which the profitability of a farm is evaluated. Should a poultry farmer aim to increase the revenue of his poultry venture, it is important to know how to improve the feed conversion ratio and how to reduce the feed costs. FCR in poultry is calculated by dividing the total input of the feed from the weight gained by animals or by the number of produced eggs. To be more precise, the input is divided by the output.

2.7 Meat and Meat Quality

Meat (the flesh or other edible parts of animals used for food) including not only the muscles and fat but also the tendons and ligaments. It is valued as a complete protein food containing all the amino acids necessary for the human body. Meat is a basic portion of sound and all-round balanced diet due to its nutritional richness. Meat is a valuable wellspring of high natural quality protein and also other B complex vitamins, zinc, selenium, iron, vitamin B12 and phosphorus (Pereira and Vicente, 2013). Offal meats like liver are also vital sources of vitamin A and folic acid (Biesalski, 2005). Meat is a complex food with a structured nutritional composition (Białobrzewski, *et. al*., 2010). The fat of meat, which varies widely with the species, quality, and cut, is a valuable source of energy and also influences the flavour, juiciness, and tenderness of the lean. Parts such as livers, kidneys, hearts, and other portions are excellent sources of vitamins and of essential minerals easily assimilated by the human system (Adam, 2021). Meat is a basic portion of sound and all-round balanced diet due to its nutritional richness. Meat is a valuable wellspring of high natural quality protein and also other B complex vitamins, zinc, selenium, iron, vitamin B_{12} and phosphorus (Pereira and Vicente, 2013). Offal meats like liver are also vital sources of vitamin A and folic acid (Biesalski, 2005). Meat is a complex food with a structured nutritional composition (Białobrzewski *et al.,* 2010).

Meat digests slowly, but 95 % of meat protein and 96 % of the fat are digested. Fats tend to retard the digestion of other foods; thus, meat with a reasonable proportion of fat remains longer in the stomach, delaying hunger and giving “staying power”. Extractives in meat cause a flow of saliva and gastric juices, creating the desire to eat and ensuring ease of digestion.

The meat-products industry, though called meatpacking, includes the slaughtering of animals. The steps in this process generally include stunning, bleeding, eviscerating, and skinning. Carcasses are then inspected and graded according to set standards of quality.

The usual methods of preserving meat from bacteria and decay are refrigerating, freezing, curing, freeze-drying, and canning. Meats are marketed as fresh or processed goods or become ingredients of various meat products, including many types of sausages and luncheon meats. They also yield a number of important by-products

A technological definition of meat quality is, through necessity, more complex than a consumer definition and because of this complexity becomes too broad to have real significance. The consumer uses certain criteria for selecting meat even though there may be little evidence to substantiate them, for example, a consumer selects meat cuts with a bright red colour when there is little evidence for a direct relationship between colour and palatability. Because the quality factors of fresh and cured meat differ in some respects, they will be discussed individually.

Appearance, texture, juiciness, wateriness, firmness, tenderness, odour and flavour are the most important and perceptible meat features that influence the initial and final quality judgment by consumers before and after purchasing a meat product. The quantifiable properties of meat such as water holding capacity, shear force, drip loss, cook loss, pH, shelf life, collagen content, protein solubility, cohesiveness, and fat binding capacity are indispensable for processors involved in the manufacture of value-added meat products. Nutrition of birds has a significant impact on poultry meat quality and safety (Nasir, 2017).

In fresh meat, tenderness is associated with is the amount of marbling. Marbling is the fat within the muscle, also called intramuscular fat. Marbling provides juiciness and flavour to meat. Meat with adequate marbling is less likely to be tough. Most definitions of quality in meat will include the desirability of ample amounts of intramuscular fat and a limited amount of external finish. Unfortunately, the relationship between marbling and tenderness does not always hold true deposits of fat in the muscle. When the association between tenderness and marbling breaks down the technologist may still justify the need for intra- muscular fat on the basis that marbling makes for a firmer, juicier, more appetizing cut of meat. Some beef and most pork, veal, and lamb is tender without having juiciness and flavour are interrelated and the latter must be included in a technical definition of meat quality. Fresh meat is defined more by the absence of off-flavours than the presence of desirable ones.

Texture must also be included in a definition of quality. There is evidence that a fine texture (large muscle bundles) is associated with tenderness but, as in the case of marbling and tenderness, the correlation between bundle size and tenderness under certain conditions is quite low. Although it is not known to possess any intrinsic value as a part of quality, the colour of meat does have a psychological and commercial significance and cannot be omitted from a discussion of this nature freshness and wholesomeness but if ascorbic acid and/or nicotinic acid came into common use we other indexes of freshness and wholesomeness may be used. Colour is an indication of the age of the animal from which the meat comes. In each class and grade there appears to be an optimum amount of pigment. A good colour is associated with freshness.

Quality in cured whole cuts, such as hams and picnics, can be defined in the same vague terminology as fresh meat. Flavour is somewhat better defined in cured hams but again it is largely in terms of the absence of off-flavours, (Dah-Nouvlessounon *et al*., 2015).

Physical properties and eating quality of meat are affected by cooking temperature and time. During cooking, the distinctive meat proteins are denatured and this reasons structural changes in the meat textural profile. These resulted in destruction of cell membranes, shrinkage of meat fibres, the aggregation and gel formation of myofibrillar and sarcoplasmic proteins, and shrinkage and solubilization of the connective tissue (Tornberg, 2005). Heat treatment can result to undesirable meat quality changes, such as nutritive value loss because of lipid oxidation and changes in a few segments of the protein fraction (Rodriguez-Estrada *et. al*., 1997).

Meat and meat-based products are cooked before being eaten. Cooking step is critical for destroying food borne pathogens, assuring microbial safety and achieving meat quality. Cooking also has an important effect on the nutritional properties and same time on its possible toxicity (Kondjoyan *et al.,* 2014). Generally, consumer chooses a cooking method that produces high-quality meat products having favourable texture and taste (King and Whyte, 2006). The United States Department of Agriculture (USDA, 2014) recommended the internal temperature for different meat such as 62.8 ℃ for steaks, roasts and fish, 71.1 ℃ for pork and ground beef, 76.7 ℃ for chicken breasts and 82 ℃ for whole chicken (King and Whyte, 2006).

Pearce *et al*. (2011), defined Water Holding Capacity as the ability of meat and its products to bind water storage, processing, and cooking during slicing, mincing, and pressing and also during transport, Water-holding capacity of meat is defined as the ability of the postmortem muscle (meat) to retain water even though external pressures (e.g. gravity, heating) are applied to it. Water-holding capacity of fresh meat (ability to retain inherent water) is an important property of fresh meat as it affects both the yield and the quality of the product. This characteristic can be described in several ways, but in fresh products that have not been extensively processed, it is often described as drip loss or purge. The mechanism by which drip or purge is lost from meat is influenced by both the pH of the tissue and by the amount of space in the muscle cell and particularly the myobril that exists for water to reside. Numerous factors can affect both the rate and the amount of drip or purge that is obtained from the product. These factors can include how the product is handled and processed i.e. number of cuts made and size of resulting meat pieces, orientation of the cuts with respect to the axis of the muscle cell, rate of temperature decline after harvest, temperature during storage and even the rate of freezing and temperature of frozen storage.

Also, the metabolic state of the live animal at the time of harvest is of high importance. This can be influenced by the genetic make-up of the animal and by the way the animal was handled. Muscle contains approximately 75% water. The other main components include protein (approximately 20%), lipids or fat (approximately 5%), carbohydrates (approximately 1%) and vitamins and minerals (often analysed as ash, approximately 1 %). The majority of water in muscle is held within the structure of the muscle itself, either within the myobrils, between the myobrils themselves and between the myobrils and the cell membrane (sarcolemma), between muscle cells and between muscles bundles (groups of muscle cells). Once muscle is harvested the amount of water in meat can change depending on numerous factors related to the tissue itself and how the product is handled (Huff-Lonergan, 2019).

Higher water holding capacity is usually derived by firmer meeat, less pale lean colour, less drip loss, better processing and cooking yield more juiceness and tenderness, better protein functionality, less purge in packages, more brine and marinade retention, more competitive advantage and fewer consumer complaints.

2.8 Sensory Evaluation

The sensory characteristics that can be quantified include all the aroma, appearance, flavor, texture, after-taste, and even sound properties of the product that distinguish it from other products.

2.8.1 Types of sensory evaluation

There are different types of sensory evaluation used in the assessment of meat.

2.8.1.1 *Single sample*

Single sample tests are carried out by offering the evaluator one single sample of a meat/food item at a time. As this test only measures one food item at a time, it not considered the most efficient.

2.8.1.2 *Duo-trio test*

Foods can be evaluated together, known as a paired comparison. One type of a paired comparison test is a duo-trio test, where items have one ingredient or component changed, and then is evaluated together. During a duo-trio test, the evaluator is blinded as to what the samples are. In this test, evaluator might use 80 % dark coloured meat or food as a sample of reference, comparing it to another sample of the same 80 % dark meat or food and a sample of 80% dark meat or food with added salt. He would then state which sample matches the reference sample.

2.8.1.3 *Triangle test*

A triangle test consists of three samples, two of which are the same and one that is different. For example, testing two pieces of 80 % white meat, and one piece of 70 % white meat. It would determine which of the samples the odd one out is. It is another type of paired comparison test. The evaluator who wants to determine if there is a noticeable difference between two products would likely conduct a triangle test. The triangle test can be used to create statistical data if administered to a large sample size of evaluators (also called panel of judges), and can be evaluated using evaluator skilled panel list.

2.8.1.4 *Descriptive sensory analysis*

Descriptive analysis is more subjective than the paired comparison tests. During a descriptive analysis, a team of evaluators is chosen based on their sensory abilities and their motivation to participate. The panel is given a sensory vocabulary that they use to describe food items. The panel then completes an evaluation of the food item, using their shared terms to come to an agreement.

2.8.1.5 *Hedonic sensory testing*

Hedonic sensory testing also belongs to the field of food sensory analysis. Here, the food and its properties are evaluated with the sensory organs. The special feature here is that untrained personnel or normal consumers carry out these tests. The food products to be tested are classified and finally evaluated on a so-called hedonic scale based on subjective criteria.

2.9 Anti-Nutritional factors

These are compounds that impede the intake, metabolism and availability of feed nutrients in animals. Their effect, even at low intake, range from a mild reduction in animal performance to death (Casimir, 2018). Specie and age of animals determine the response and the complication extent of the anti-nutritional factors in the affected animal. They are many types of anti-nutritional substances, the common ones are: saponins, protease inhibitors, lectins, phytic acid, rachitogenic factors, goitrogenic factors

2.9.1 Saponins

Saponins are plants metabolites found mostly in herbs, vegetables and beans. They are bitter, reducing feed intake of livestock including poultry. Their high level in poultry diets leads to decrease in performance and rate of growth (Jacob *et al.*, 2018), although they appear in low levels they can decrease feed palatability. Saponins are of different types, some are harmful while some are harmless in their level found in plants. Saponins are beneficial with their binding ability in binding with bile salt and cholesterol in the digestive tract. The inhibited cholesterol absorption results in a reduction of the level of cholesterol in blood (Chen and Chiang, 2014).

2.9.2 Protease inhibitors

These are small molecules of protein having the ability of interfering with the action of enzymes involved in breaking down protein into amino acid components.

2.9.3 Lectins

They are glycoproteins noted for their capability to agglutinate erythrocytes and bind sugar components. Lectin content in beans ranges from one to three percent. Lectins are not broken down in the gut, attach to mucosa cells damaging the intestinal wall and reducing the absorption of nutrients. Heat treatment is very effective and necessary in the inactivation of lectins.

2.9.4 Phytic acid

They are complexes with certain minerals - such as calcium, phosphorus, magnesium, copper, iron and zinc - reducing their bioavailability. Levels of phytate in soybeans range from 1.0 - 2.3 percent.

2.9.5 Rachitogenic factors

These factors are associated principally with genistin (about 0.10% of raw soybeans) which interfere with calcification of bone. Turkeys are particularly sensitive.

2.9.6 Goitrogenic factors

These, similarly, are glycosides belonging to the is flavonic group, some of which like genistin; have goitrogenic activity resulting in enlargement of the thyroid gland and a reduction in the activity of thyroxine secreted by the thyroid itself.

2.10 Bitter Kola (*Garcinia kola)*

Bitter kola, as shown in Plate I, is a medium-sized large evergreen flowering tree belonging to the family *Clusiaceae.* It is cultivated commonly in West Africa and Central Africa (Dranca and Oroian, 2018). It is with a heavy, spreading crown and can grow up to 30m in height. The trunk is straight with brown bark. The leaves are leathery. The flowers are greenish-white. The seeds (Plate II) can be eaten raw. The reddish-yellow fruits are extremely sour but are edible. Its parts such as bark, fruit, seeds and nuts have been used in traditional medicine for the treatment of various conditions like coughs, fever, gonorrhoea, wounds, malignant tumours, chronic urethral discharge, stomach pains, pulmonary and gastro-intestinal conditions, and general body pain. The seed has a bitter astringent, aromatic flavour; somewhat resembling that of a raw coffee bean.

Bitter kola has been gaining attention in recent times due to its richness in flavonoids and other important phenols (Kanmegne *et. al.*, 2010), The bioflavonoid content of bitter kola posseses antibacterial, antimicrobial, antihepatoxic, antioxidant, growth-enhancing, radical scanvenging, hepatoprotective properties (Yakubu and Quadri, 2012). Also, according to Arogba (2000), it contains 1.5 % ash, 3.5 % crude protein (CP), 6.2 % ether extract (EE), 9.4 % crude fibre (CF), 65 % nitrogen-free extract (NFE) and 70 % moisture.

Plate I: Bitter kola plant with fruits

Plate II: Bitter kola fruit with seeds exposed.

2.10.1 Nutritive features of bitter kola seed

Nutritional analysis of bitter kola seed is shown in Table 2.1 it indicated that carbohydrate is at the highest percentage. The moisture content was higher than ash, crude fibre, ether extract and crude protein values, (Mazi *et al*., 2013). The vitamins and minerals constituent analysis of bitter kola seed as shown in Table 2.2, revealing that, vitamin C, calcium, potassium and iron were present in the quantity reported (Mazi *et al*., 2013). Dah-Nouvlessounon *et al*. (2015), compared the nutritional and antinutritional composition of kola nuts (*Garcinia kola*, *Cola acuminata* and *Kola nitida*) it was concluded that protein content of the three kola nuts ranges from 4.95% (*G. kola*) to 10.64 % (*C. acuminata*) whereas fat content ranges from 0.2 ± 0.00 (*Kola nitida*) to 2.5 ± 0.42 (G. kola). Total phenolics abounded (2444.96 ± 81.56 μgEqAG/100g) in *C. acuminata*, while flavonoids predominated (561.69-± 22.10 μgEqQ/100g) in *G. kola*. The three species are a good source of magnesium and a copper provider was lowest in *K. nitida* (0.59 ± 0.08 mg/g) and in *C. acuminate* (0.65 ± 0.02mg/g). The dominant total essential amino acids were threonine (*C. acuminata*) and methionine (*C. acuminata* and *G. kola*), while the predominant non-essential total amino acids according to species were arginine (*K. nitida* and *G. kola*), proline (*C. acuminata*) and cysteine (*G. kola*). For the anti-nutrients factors, saponins were in great proportion (8.33% ± 0.25%), while the oxalates were in small proportion (0.44% ± 0.04%). The three species have an interesting nutritional composition, but these seeds have the relatively lowest amino acids content.

Table 2.1 Proximate Composition of Bitter Kola Seed

Nutrient	% Composition
Moisture	9.28
Crude protein	11.27
Crude fibre	3.94
Ether extract	1.03
Ash	4.17
Nitrogen free extract	70.31

Mazi *et al*. (2013).

Table 2.2 Vitamins and Minerals Composition of Bitter Kola Seed

Parameters	Composition value
Vitamin B1 (thiamine) (%)	0.6433
Vitamin B2 (riboflavin) (%)	0.2767
Vitamin B3 (Niacin) (%)	1.6800
Vitamin C (ascorbic acid) mg/100g)	12.6333
Vitamin E (tocopherol) (mg/100g)	2.5400
Vitamin A (retinol (mg/g)	1.3600
Phosphorus (%)	0.3800
Calcium (%)	1.8333
Magnesium (%)	0.4333
Potassium (%)	2.7367
Sodium (%)	0.7533
Iron (%)	3.5067

(Mazi *et al*., 2013)

2.10.2 The phytochemical analysis of bitter kola seed

Phytochemicals are bioactive chemical compounds which significantly contributing to the protection of the biological systems against degenerative diseases (Dreosti, 2000). The phytochemical (Table 2.3) analysis conducted showed that tannin, saponin, phytate, alkaloid, and oxalate. Bitter kola (*Garcinia kola*) has low quantity of antinutritional factors such as tannins, oxalate and phytate in its composition. This indicates non-toxicity in its consumption with no detrimental effect on animals.

2.10.3 Addition of bitter kola in the broiler chickens diet as a replacement of synthetic antibiotic

In recent years, local plants materials are been used as additives in poultry feed to overcome major side effects of synthetic antibiotics and its influence on body weight, digestibility and carcass characteristics (Shahyar *et al.,* 2012). Phytogenic feed additives have attracted increasing interest as an alternative feeding strategy to replace antibiotics and inorganic growth promoters (Windisch *et al.,* 2008).

Bitter kola has commonly been used as a substitute for antibiotic in the diet of poultry. They act as digestibility enhancers, stimulating the secretion of endogenous digestive enzymes (Williams and Losa, 2001), due to their antimicrobial, antiviral and antioxidant properties, and many other biological activities within the bitter kola (Lovkova *et al.,* 2001). It is known to have an elaborate complex of phenolic compounds including bioflavonoids, xanthones and benzophenones (Iwu, 1993). The bioflavonoids possess anti-inflammatory, anti-microbial, anti-viral and anti-diabetic properties (Adedeji *et al.,* 2008). Alkaloids and flavonoids, which are the major constituents of bitter kola, were reported to stimulate an increase in gastric acid secretions (Oluwole, 2013).

2.11 Effect of Bitter kola on Broiler Performances

Adedeji *et al*. (2006) reported the effect of different inclusion levels of air-dried bitter kola seeds on the feed intake, body weight gain/week, feed efficiency/week and carcass characteristics of broiler chicks 0 - 4 weeks of age and concluded that feed intake was significantly ($p<0.05$) different with highest feed intake from birds in the treatments fed 5 % and 7 % inclusion levels of bitter kola and the least feed intake from the birds in the treatment fed 0 % inclusion level. Body weight gained values obtained is highest in the treatment fed 10 % inclusion level and the least value from the treatment fed 7.5 % bitter kola. Feed efficiency was also significantly ($p<0.05$) different, the feed efficiency values obtained from the diets containing 0 %, 2.5 % and 10 % bitter kola inclusion levels are higher than those from diets containing 5 % and 7.5 % bitter kola inclusion levels (Adedeji *et al.*, 2006).

Aliyu and AbdulMalik (2013) reported the effect of bitter kola as a dietary additive on the performance of broiler chicks (0-4 weeks) of age and concluded that there were differences in terms of final weight (FW), weight gain (WG), average daily weight gain (ADWG), feed gain ratio (FGR) and cost of feed per kilogram gain (CFG) when dried bitter kola was added to their diets. Birds fed 10 % bitter kola inclusion level had higher final weight, weight gain, and average daily weight gain. Birds fed on diet of 5 % bitter kola inclusion level had better feed gain ratio (FGR) and cost of feeding per kg gain (CFG). In addition, birds on 10 % bitter kola inclusion level had slightly better feed gain ratio (FGR) than birds on diet 0 % bitter kola inclusion level. However, birds on diet 0 % bitter kola had slightly lower cost of feed per kg gain (CFG) than birds on diet 10% bitter kola inclusion level. No differences exist in all performance parameters measured between treatments on diet 5 % bitter kola and those on diet 10 % bitter kola. However, birds on 5 % bitter kola had slightly higher FW, WG and ADWG (Aliyu and AbdulMalik, 2013).

Ibekwe and Agiop (2018) reported the effects of boiled bitter kola seeds on growth performance, of broiler chickens and concluded that there were significant decrease in body weight of broilers treated with boiled *Garcinia kola* seeds. Significantly reduced at 20g inclusion of boiled bitter kola seeds relative to control and 10g inclusions. The live weight of birds fed at the two levels of *Garcinia kola* seed inclusions (10g and 20g inclusion level) neither showed positive nor negative response due to non-significant changes observed (Ibekwe and Agiop, 2018).

The results from this experiment indicated that broilers had better growth performance potentials in terms of final weight, weight gain, feed intake, feed conversion ratio and feed cost of production when dried bitter kola was added to the proprietary feed as a feed additive at 15g/kg level over the control for 28 days (4 weeks).

Abdulmalik *et al* (2013) reported that sundried ground bitter kola must have some active components that might have enhanced the physiology of the birds that fed on it to give them their superior performances. In addition, these authors concluded that 5g/kg diet of dried ground bitter kola could be used in broiler starter diets for improved FW, FGR and better CFG.

Owen *et al*., (2019) concluded in the research conducted on the performance of broiler chickens administered graded levels of bitter kola (*Garcinia kola*) as feed additive that 5-15g air-dried bitter kola/kg feed can be used in broiler chicken finisher diets in order to improve performance.

Esiegwu and Udedibie (2009) conducted a research on the growth performance and microbial activities of broilers fed supplementary bitter kola (*Garcinia kola*). These authors reported that there were no significant differences in feed intake among the different treatment groups ($p>0.05$) but the group on 2.5% bitter kola diet had significantly ($p<0.05$) heavier body weight and superior feed conversion ratio. The groups on bitter kola diets developed significantly ($p<0.05$) heavier livers than the control. There were no significant differences among the groups in most of the haematological indices but bitter kola at 5.0% and 7.5% dietary levels inhibited the growth of *Salmonella species*, but had no effects on *E. coli*.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Ethical Approval

All procedures for the conduct of this experimental research followed the approved guidelines of the review Committee of Animal Care and Use of the Department of Animal Production, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Nigeria.

3.2 Study Period and Experimental Location

The experiment lasted for 56 days (8 weeks) and was conducted in May and June, 2021 at the Monogastric unit of the Teaching and Research Farm, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Gidan Kwano Area, Niger State. It is located within latitude 09^0 30′ and 09^0 45′ and longitude 06^0 30′ and 06 45′ E with an altitude of 1475m above sea level, whose vegetation is mainly of Southern Guinea Savannah grassland. The mean annual rainfall is 1200mm–1300mm (Weather Spark, 2019).

3.3 Procurement of the Experimental Materials

A total of 180-day-old broiler chickens were procured from Chikun farm sales agent within Minna. The bitter kola was purchased in a local market at Owena in Ondo State. Other feed ingredients (maize, maize offal, groundnut cake, bone meal, fishmeal, oil, lysine, methionine and premix) were sourced for from Kure market, Minna.

3.4 Processing of the Bitter kola seeds

The bitter kola seeds were sliced in their fresh state, air-dried at room temperature for six weeks during the dry season of cool dry winds (commonly called harmattan) after which the thin exocarp were removed (decorticated). It was ground using a hammer mill with a sieve of size 3mm in airtight bags until ready for use, the method used by Uko *et al*. (2001) and adopted by Iwuji and Herbert (2012).

3.4.1 Determination of the phytochemical composition of the air-dried bitter kola

The ground air-dried bitter kola seed was investigated for its phytochemical contents. Quantitative test of alkanoid, oxalate, phytate, saponin and tannin were carried out in the laboratory using standard method of quantitative analysis.

3.5 Preparation of the Experimental Diets

The bitter kola powder was thoroughly mixed with other ingredients in varying levels as shown in Table 3.1. Four isocaloric and isonitrogenous experimental diets were formulated and designated T1 (control treatment of 0 % inclusion level of air-dried bitter kola), T2 (5 % inclusion level of air-dried bitter kola), T3 (10 % inclusion level of air-dried bitter kola), T4 (15 % inclusion level of air-dried bitter kola). The nutrients composition and the calculated value of the treatments are presented in Table 3.1.

3.6 Proximate Analysis

The proximate composition of the experimental diets was carried out at the Department of Animal Production Laboratory using AOAC (2005) to determine crude protein (CP), crude fibre (CF), fat, ash, NFE (nitrogen free extract) while metabolizable energy (ME) was calculated using the formula

ME/Kcal/Kg = (35 X % CP) + (81.8 X % EE) + (35.5 X % NFE)

Table 3.1: Feed Composition and Calculated Nutrient Content of Broiler Chicken Under Single Phase of Feeding

Ingredients (%)	T1	T2	T3	T4
Maize	50.36	45.54	40.74	35.92
GNC	36.89	36.71	36.51	36.33
ADBK	0.00	5.00	10.00	15.00
Maize offal	3.00	3.00	3.00	3.00
Fish meal	3.00	3.00	3.00	3.00
Bone meal	2.00	2.00	2.00	2.00
Oil	3.00	3.00	3.00	3.00
Limestone	1.00	1.00	1.00	1.00
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
*Premix	0.25	0.25	0.25	0.25
Total	100	100	100	100
Calculated nutrients				
CP	24.01	24.01	24.00	24.00
CF	4.85	4.89	4.93	4.95
Ca	1.17	1.26	1.36	1.45
EE	4.54	4.39	4.24	4.09
P % (available)	1.23	0.57	0.57	0.58
Methionine	1.23	0.54	0.53	0.51
Lysine	1.09	1.08	1.07	1.07
ME (Kcal/Kg)	3091.75	2962.67	2927.50	2890.50

Key: * = premix will provide the following per kilogram of feed: Vit. A, 10,000 i.u; Vit.D3, 2000 i.u; Vit.E 23mg; Vit.K, 2 mg; Vit. B1 (Thiamine), 1.8mg; Vit B2 (Riboflavin), 5.5mg; Vit.B6 (Pyridoxine), 3mg; Vit. B12 0.015mg; Pantothenic acid 7.5mg; Folic acid 0.75mg; Niacin 27.5mg; Biotin 0.6mg; Choline chloride 300mg; Cobalt 0.2mg; Copper 3mg; Iodine 1mg; Iron 20mg; Manganese 40mg; Selenium 0.2mg; Zinc 30mg; Antioxidant1.25mg. GNC =Groundnut cake, ADBK = air-dried bitter kola, CP = Crude Protein, CF = Crude fibre, Ca = Calcium, EE = Ether Extract, P = Phosphorus,
ME = Metabolisable Energy.

3.7 Experimental Design

The Completely Randomized Experimental Design (CRD) was used in this experiment. The 180 broiler chickens were completely selected at random into four treatments, Treatment 1 (T1), Treatment 2 (T2), Treatment 3 (T3) and Treatment 4 (T4). Each treatment was replicated thrice with fifteen birds per replicate. This sum all birds in a treatment into fourty-five birds.

3.8 Management of the Experimental Birds

The pen, feeders and drinkers were thoroughly cleaned (using detergent) and disinfected with izal, and sun dried, two weeks before the arrival of the birds. Wood shaves were spread on the pen floor and old newspapers were spread on the shaves to avoid pinching of the legs of the birds. Feeders and drinkers were properly placed in the suitable position. Electric bulbs as a source of light and charcoal as heat source, sacks were used to cover the windows during the brooding period and also as guard against rain splashes and too much air inflow. A total of one-hundred-and-eighty-day old broiler chickens were used. A complete randomized experimental design was used. The birds were divided into four treatments; each treatment was sub divided into three replicates with fifteen birds per replicate. Water and feed were given *ad libitum* during the brooding period.

3.9 Data Collection

3.9.1 Average initial weight

The average initial body weight of all birds in each treatment was taken using a sensitive Camry scale (20kg model) on arrival.

3.9.2 Average weekly body weight (AWBW)

This was obtained by weighing the birds in a replicate and dividing the weight obtained by the number of birds (replicates) in that treatment weekly i.e.

$$\text{AWBW} = \frac{\text{Total weights of the birds (g)}}{\text{Number of the birds in the treatment}} \qquad \textit{Eq. 3.1}$$

3.9.3 Feed intake (FI)

This was obtained by finding the difference between the known-quantity of the feed served and the leftover feed on daily basis i.e.

Feed intake (g) (FI) = feed quantity served (g) - feed quantity left over (g) *Eq. 3.2*

3.9.4 Feed conversion ratio (FCR)

$$\text{Feed conversion ratio (FCR)} = \frac{\text{average weekly feed intake (g)}}{\text{average weekly weight gain (g)}} \qquad \textit{Eq. 3.3}$$

3.9.5 Protein efficiency ratio (PER):

$$\text{Protein efficiency ratio (PER)} = \frac{\text{body weight gain (g)}}{\text{CP \% intake diet (g)x feed intake}} \times 100 \qquad \textit{Eq. 3.4}$$

3.9.6 Energy efficiency ratio (EER)

3.9.7 Apparent nutrient digestibility trial (ANDT)

This was carried out for the assessment of the metabolic response of the broiler chickens on the experimental diets**.** Two birds were taken from each replicate at 7th week and housed in metabolic cages for five (5) days, two (2) days for adjustment periods after which faecal samples were collected for the remaining three (3) days for the finisher digestibility trial. All birds were given equal quantity of feed. Collection of total faecal droppings from each replicates was carried for three days of the trial. This was in accordance to the method used by Ayanwale and Aya (2006). AOAC (2005) method was used in determining the proximate composition of analysis of the faecal droppings. The digestibility of the Crude Protein (CP), Crude Fibre, Dry Matter, Ether Extract, Total Ash and Nitrogen Free Extract (NFE), in percentage (%), was calculated as follows:

$$\text{Digestibility} = \frac{\text{Nutrient intake in feed – nutrient voided in faeces}}{\text{intake in feed}} \qquad \textit{Eq. 3.5}$$

$$\textbf{Total Digestibility Nutrient (TDN)} = \text{Digestible CP} + \text{Digestible CF} + \text{Digestible NFE} + (\text{EE} \times 2.25) \times 100 \qquad \textit{Eq. 3.6}$$

3.9.8 Carcass characteristics evaluation

The carcass characteristics were determined at the end of the experiment. Two birds from each replicate were randomly selected and weighed to obtain their final live weight. The birds were slaughtered with sharp knife by cutting their jugular veins. Scalding, defeathering and washing followed. The visceral contents were removed and weighed. Snithing of the carcass into small parts and weighed. Dressing weights were taken and expressed as percentages of the live weight. It was calculated excluding heart, gizzard and liver and the weight of each cut organ was calculated as percentage of the carcass weight (Kafi *et al*., 2017) using the formula:

$$\textbf{Dressing percentage} \ (\%) = \frac{\text{Dressed weight (g)}}{\text{Live weight (g)}} \times 100 \qquad \textit{Eq. 3.7}$$

$$\textbf{Carcass percentage} \ (\%) = \frac{\text{Cut−up weight (g)}}{\text{Live weight (g)}} \times 100 \qquad \textit{Eq. 3.8}$$

3.9.9 Meat quality evaluation

This was evaluated by assessing the following:

i. The Meat pH
ii. The Meat Cooking Yield and Loss
iii. The Meat Water Holding Capacity

The pH of the breast meat from each sample was measured in duplicate by a Digital pH Meter. Beforehand, the pH-meter was calibrated using standardized buffers of pH 4.0, 6.9 as recommended by Siekmann (1985) and used by Taer and Taer (2019). Approximately 10 g of ground meat was mixed with 100 ml distilled water and blended for 30 seconds at a high speed and pH meter electrode was immediately inserted after the blended sample was poured into a clear glass. Cooking loss percentage determination was done by oven cooking of breast meat samples. The 10 g samples were subjected to a maximum oven temperature of 150^0C and were allowed to cool until the temperature became normal. The weight of raw and cooked samples was recorded. The followings are the formulae used to determine the percentage cooking yield and loss:

$$\text{Cooking Yield} = \frac{\text{Cooked meat sample weight (g)}}{\text{Raw/fresh meat sample weight (g)}} \times 100 \qquad \textit{Eq. 3.9}$$

$$\text{Cooking loss \%} = \frac{\text{Raw/fresh meat sample – cooked meat sample weight}}{\text{Weight of raw meat}} \times 100 \qquad \textit{Eq. 3.10}$$

3.9.10 Sensory evaluation

This was determined using Hedonic scale ranking rated on a 7-point sensory evaluation scale. It is as follows*;*

1 = *dislike very much,* 2 = *dislike moderately,*

3 = *dislike slightly,* 4 = *neither like nor dislike,*

5 = *like slightly,* 6 = *like moderately,*

7 = *like very much.*

Bite portions of the broiler-cooked meat weighing 5g were served to the 10 randomly selected experienced panelists. Results obtained from the ranking scale were collected on the colour, texture, odour, taste, overall choice and acceptability.

3.10 Economy of Feed Conversion Ratio

This was calculated using the formula:

$$\text{FCR} \times \text{FC/kg} \qquad \textit{Eq. 3.11}$$

Where FCR = feed conversion ratio, FC/kg = feed cost/kg

3.11 Data Analysis

All the data collected from this experiment were subjected to analysis of variance (ANOVA) using statistical package (SAS, 2015) version 9.3.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

4.1.1 Phytochemical composition of the air-dried bitter kola

Table 4.1 shows the phytochemical composition of the air-dried bitter kola. The result showed the amount of alkanoids (1.06mg/100g), oxalate (2.06mg/100g), Phytate (1.72mg/100g), saponin (1.81mg/100g) and Tannin (0.62mg/100g).

4.1.2 Proximate composition of the experimental diets containing varying inclusion level of air-dried bitter kola

Table 4.2 shows the proximate nutrient composition of the experimental diets with the crude protein ranging from 23.98 % in T1 (0 % inclusion level of ADBK) to 23.72 % in T2 (5 % inclusion level of ADBK), while the crude fibre range from 6.05 % in T3 (10 % inclusion level of ADBK) to 6.84 % in T1. Fat ranges from 5.02 % in T2 and 4.78 % in T3. Ash of T1 was the highest value 13.42 % and the lowest value of 13.05 % in T3 while the highest value of NFE 47.69 % was in T4 and the lowest value of 45.27 % in T1.

Table 4.1 Phytochemical Composition of the Air-Dried Bitter Kola

Phytochemical (mg/100)	Quantity	Tolerable levels (mg/100)
Tannin	0.62	≤ (Kumar *et al*., 2007)
Saponin	1.81	7.50 (Gaurav, 2015)
Phytate	1.72	≥ Mammo and Wude (2018)
Alkaloid	1.06	≤ 1.5 (Kovatsis *et al*., 1994)
Oxalate	2.06	≤ 1.5 (Rahman *et al*., 2013)

Table 4.2 Proximate Composition of the Experimental Diets Containing Varying Inclusion Level of Air-Dried Bitter Kola

Parameters	T1	T2	T3	T4
Dry matter (%)	94.40	94.21	94.27	95.48
Crude protein (%)	23.98	23.72	23.83	23.68
Crude fibre (%)	6.84	6.36	6.05	6.14
Ether extract (%)	4.89	5.02	4.78	4.86
Ash (%)	13.42	13.39	13.05	13.11
Nitrogen Free Extract (%)	45.27	45.72	47.56	47.69
Metabolizable energy (ME/kcal/kg)	2902.34	2958.70	2928.78	2941.73

T1= 0 % Inclusion level of ADBK
T2= 5 % Inclusion level of ADBK,
T3= 10 % Inclusion level of ADBK,
T4= 15 % Inclusion level of ADBK,

4.1.3 Growth performance of the broiler chickens fed diets containing varying inclusion level of air-dried bitter kola.

Table 4.3 shows the growth performance of the broiler chickens fed diet containing varying inclusion levels of air-dried bitter kola. Treatment 1 (0 % inclusion level of ADBK) has highest final body weight (1747.20g), daily weight gain (30.84g), weekly weight gain (215.85g) and total weight gain (1726.78g). Yet, the treatment showed least daily feed intake (73.76g), weekly feed intake (516.29g) and total feed intake (4130.30g) values.

Feed intake and feed conversion ratio also recorded a significant difference across the treatments. Treatment 4 (15 % inclusion level of ADBK) recorded the highest feed intake (4658.65) while treatment 1 (0 % inclusion level of ADBK) recorded the least feed intake (4130.30). The Treatment 1 also recorded the highest feed conversion ratio (2.39) and was significantly different ($p < 0.05$) from treatment 2, which recorded the least feed conversion ratio (3.28).

Comparing the results obtained in all the treatments fed the diets containing air-dried bitter kola i.e. T2, T3 and T4, it showed T4 recorded higher daily weight gain (26.62g), weekly weight gain (186.32g) and total weight gain (1490.59g) and final body weight (1511.03g) when compared to T3. T2 had the least value of daily weight gain (24.37g), weekly weight gain (170.58g), total weight gain (1364.59g) and final body weight (1385.03g).

Table 4.3: Growth Performance of the Broiler Chickens Fed Diets Containing Varying Inclusion Level of Air-Dried Bitter Kola.

Parameters	T1	T2	T3	T4	SEM	P-Value
AIBW (g)	20.42	20.43	20.42	20.44	0.00	0.58
AFBW (g)	1747.20^{a}	1385.03^{d}	1405.41^{c}	1511.03^{b}	43.38	0.00
ADWG (g)	30.84^{a}	24.37^{d}	24.73^{c}	26.62^{b}	0.77	0.00
AWWG (g)	215.85^{a}	170.58^{d}	173.12^{c}	186.32^{b}	5.40	0.00
ATWG (g)	1726.78^{a}	1364.59^{d}	1384.99^{c}	1490.59^{b}	43.36	0.00
ADFI (g)	73.76^{d}	79.81^{c}	80.32^{b}	83.19^{a}	1.03	0.00
AWFI(g)	516.29^{d}	558.69^{c}	562.24^{b}	582.33^{a}	14.49	0.00
ATFI (g)	4130.30^{d}	4469.55^{c}	4497.93^{b}	4658.65^{a}	57.98	0.00
Feed Conversion Ratio	2.39^{d}	3.28^{a}	3.25^{b}	3.13^{c}	0.10	0.00
Protein Efficiency Ratio	1.76^{a}	1.27^{c}	1.28^{c}	1.33^{b}	0.06	0.00
Energy Efficiency Ratio	0.0136^{a}	0.0100^{c}	0.0106^{c}	0.0106^{b}	0.00	0.58

$^{a, b, c, d}$ means with different superscript on same row differ significantly ($p < 0.05$)

T1= Treatment 1 (control treatment fed 0 % inclusion level of Air-dried bitter kola)

T2 = Treatment 2 (the treatment fed 5% inclusion level of Air dried Bitter Kola)

T3 = Treatment 3 (the treatment fed 10% inclusion level of Air dried Bitter Kola)

T4 = Treatment 4 (the treatment fed 15% inclusion level of Air dried Bitter Kola)

SEM = Standard error of means LS – Level of significance, NS – Not significant

AIBW = average initial body weight

AFBW= average final body weight

ADWG = average daily weight gain

AWWG = average weekly weight gain

ATWG – average total weight gain

ADFI – average daily feed intake

AWFI – average weekly feed intake

ATFI – average total feed intake

4.1.4 Apparent nutrient digestibility of the broiler chicken fed varying inclusion levels of air-dried bitter kola

The nutrient digestibility of broiler chicken fed different inclusion levels of air-dried bitter kola is shown in Table 4.4. The result showed that dry matter, crude fibre, ether extract, ash and nitrogen free extract digestibility were all influenced significantly ($p < 0.05$). However, the crude protein digestibility was not affected by inclusion of bitter kola diets. Birds in Treatment 4 (15 %) showed the highest value of ether extract and crude protein digestibility while treatment T1 (control) showed the least digestibility of crude protein. Both T1 and T4 had superior crude fibre digestible than T2 and T4.

4.1.5 Carcass (cut-up parts %) of the broiler chickens fed diets of varying inclusion levels of air-dried bitter kola

Table 4.5 shows the result of the cut-up parts of the carcass of various treatment groups. The eviscerated weight, shank weight and drumstick weight showed significant difference ($P<0.05$) among treatment groups. However, the thigh, head, wing, breast, back and neck weight showed no significant difference ($P>0.05$).

4.1.6 Characteristics of the internal organ of broiler chickens fed different inclusion levels of air-dried bitter kola.

Table 4.6 shows the relative weight of the internal organs of the carcass of the experimental broiler birds. The proportional weight of the heart, lungs, spleen, abdominal fat, gizzard, proventiculus and gall bladder Showed no significant difference ($P<0.05$) among treatment groups, whereas the weights of the liver and intestine showed significant difference ($P<0.05$) among groups. For example, the intestine weight of T4 and T1 differed significantly ($P<0.05$). While T3 and T2 are not significantly different ($P>0.05$).

Table 4.4: Apparent Nutrient Digestibility of the Broiler Chicken Fed Varying Inclusion Levels of Air-Dried Bitter Kola

Parameters (%)	T1	T2	T3	T4	SEM	LS	P-value
Crude protein	79.65b	80.21b	80.29b	82.21a	0.72	*	0.00
Dry matter	88.77^{a}	85.39^{b}	91.17^{a}	90.27a	0.76	*	0.04
Crude fibre	66.56^{a}	57.87^{b}	62.47^{c}	65.50^{a}	1.23	*	0.03
Ash	65.03^{a}	59.13^{b}	64.67^{a}	64.23^{a}	0.93	*	0.05
Ether extract	90.24^{b}	82.90^{d}	83.97^{c}	91.57^{a}	1.45	*	0.04
Nitrogen free extract	82.21^{a}	75.86^{b}	81.10^{a}	82.29^{a}	0.89	*	0.00
Total digestible nutrient	76.05^{a}	71.24^{b}	71.06^{b}	76.86^{a}	0.95	*	0.01

$^{a, b, c}$ means with different superscript on same row differ significantly ($p < 0.05$)
T1 – control treatment fed Diet 1 (0 % inclusion level of Air-dried bitter kola
T2 –the treatment fed Diet 2 (5% inclusion level of Air-dried Bitter Kola
T3 –the treatment fed Diet 3 (10% inclusion level of Air-dried Bitter Kola
T4 –the treatment fed Diet 4 (15% inclusion level of Air-dried Bitter Kola
SEM – Standard error of means
LS – Level of significance
NS – Not significant

Table 4.5: Carcass (Cut-Up Parts) Characteristics of The Broiler Chickens Fed Diets of Varying inclusion Levels of Air-Dried Bitter Kola

Parameters	T1	T2	T3	T4	SEM	LS	P-V
Live weight (g)	1495.67	1484.00	1470.67	1578.00	2.04	NS	0.59
Dressed weight (g)	83.08	85.62	86.01	87.69	1.17	NS	0.64
Eviscerated weight (g)	84.91^{ab}	80.22^{b}	82.02^{b}	88.86^{a}	1.19	*	0.02
Head weight (%)	4.03	3.22	3.22	4.06	0.17	NS	0.09
Neck weight (%)	7.30	6.61	6.52	7.32	0.16	NS	0.10
Breast weight (%)	18.90	20.60	21.39	22.11	0.70	NS	0.40
Wing weight (%)	12.27	13.91	12.96	13.20	0.39	NS	0.61
Thigh weight (%)	14.77	13.42	15.05	15.82	0.39	NS	0.16
Drumstick weight (%)	12.05^{a}	10.18^{b}	10.10^{b}	12.18^{a}	0.35	*	0.01
Shank weight (%)	5.05^{a}	3.67^{b}	4.78^{a}	5.81^{a}	0.27	*	0.01

T1 – the control treatment fed Diet 1 of 0 % inclusion level of Air-dried bitter kola
T2 – the treatment fed Diet 2 of 5% inclusion level of Air-dried Bitter Kola
T3 – the treatment fed Diet 3 of 10% inclusion level of Air-dried Bitter Kola
T4 – the treatment fed Diet 4 of 15% inclusion level of Air-dried Bitter Kola
SEM – Standard error of means
LS – Level of significance
NS – Not significant
P-V- Probability value

Table 4.6 Relative Weight of Internal Organs of Broiler Chickens Fed Varying Inclusion Levels of Air-Dried Bitter Kola

Parameters	T1	T2	T3	T4	SEM	P-value
Heart weight (%)	0.36	0.47	0.53	0.55	0.04	0.48
Lung weight (%)	0.57	0.62	0.50	0.54	0.04	0.77
Liver weight (%)	1.33^{b}	1.91^{a}	1.61^{ab}	1.97^{a}	0.10	0.03
Spleen weight (%)	0.07	0.08	0.05	0.12	0.01	0.17
Gall bladder weight (%)	0.08	0.10	0.10	0.09	0.30	0.84
Gizzard weight (%)	2.24	2.51	2.51	2.27	0.09	0.65
Abdominal fat (%)	0.83	1.77	1.41	1.67	0.14	0.05
Proventiculum weight (%)	0.55	0.46	0.63	0.57	0.03	0.50
Crop weight (%)	1.71	2.15	2.30	1.74	0.20	0.63
Intestine weight (%)	4.85^{a}	3.57^{b}	3.77^{b}	5.09^{a}	0.24	0.02

$^{a,\ b,}$ means with different superscript on same row differ significantly ($p < 0.05$)
T1 – control treatment fed Diet 1 of 0 % inclusion level of Air-dried bitter kola
T2 – the treatment fed Diet 2 of 5% inclusion level of Air-dried Bitter Kola
T3 – the treatment fed Diet 3 of 10% inclusion level of Air-dried Bitter Kola
T4 – the treatment fed Diet 4 of 15% inclusion level of Air-dried Bitter Kola
SEM – Standard error of means
LS – Level of significance
NS – Not significant

4.1.7 Meat quality of broiler chickens fed air-dried bitter kola at varying inclusion levels.

Table 4.7 showed the result of the effect of inclusion of air-dried bitter kola seed at varying inclusion level in the broiler chicken diet on their meat cooking yield (CY), cooking loss, water-holding capacity (WHC) and pH level. The result showed that the inclusion of the bitter kola at different levels has no significant effect on the meat-cooking yield, cooking loss, water holding capacity and pH value across the treatments.

4.1.8 Sensory evaluation of the meat of the broiler chickens fed diets containing air-dried bitter kola at varying inclusion levels.

Table 4.8 showed the effect of inclusion of air-dried bitter kola at varying levels of inclusion on sensory properties of the meat on the fed the diet. The result showed that including air-dried bitter kola in the broiler diet has no significant effect ($p>0.05$) on the colour, tenderness, juiciness and flavor of the broiler meat. It (i.e. inclusion of air-dried bitter kola) only affected the overall acceptability of the broiler meat. Broiler chicken fed air-dried bitter kola at 10 % inclusion level (i.e. T3 broiler chickens) had the highest overall acceptability followed by T1 broiler birds (control treatment) fed at 0 % inclusion level of air-dried bitter kola. The value obtained for broiler chickens in T2 and T4 fed 5 % and 15 % inclusion level of air-dried bitter kola lower in overall meat acceptability.

Table 4.7: Meat Quality of Broiler Chickens Fed Diets Containing Air-Dried Bitter Kola at Varying Inclusion Levels

Parameters	T1	T2	T3	T4	SEM	P-value
pH	6.80	6.61	6.64	6.51	0.05	0.16
Water holding capacity	4.72	6.38	5.10	5.10	0.34	0.15
Cooking yield	60.20	66.70	68.22	71.47	2.09	0.10
Cooking loss	39.80	33.32	31.80	24.04	2.63	0.06

T1 – Treatment 1 (control treatment fed diet of 0 % inclusion level of Air-dried bitter kola)
T2 – Treatment 2 (the treatment fed diet of 5% inclusion level of Air-dried Bitter Kola)
T3 – Treatment 3 (the treatment fed diet of 10% inclusion level of Air-dried Bitter Kola)
T4 – Treatment 4 (the treatment fed diet of 15% inclusion level of Air-dried Bitter Kola)
SEM – Standard error of means
LS – Level of significance
NS – Not significant

Table 4.8: Sensory Evaluation of the Meat of Broiler Chickens Fed Diets Containing Air-Dried Bitter Kola at Varying Inclusion Levels

Parameters	T1	T2	T3	T4	SEM	P-value
Colour	6.40	6.70	6.20	6.30	0.11	0.39
Tenderness	6.40	6.00	6.00	6.60	0.12	0.18
Juiciness	6.70	6.30	6.30	5.60	0.18	0.20
Flavour	6.10	6.50	6.50	6.10	0.11	0.35
General acceptability	6.30ab	5.80b	6.8oa	6.20b	0.06	0.01

T1 – control treatment fed Diet 1 of 0 % inclusion level of Air-dried bitter kola
T2 – the treatment fed Diet 2 of 5% inclusion level of Air-dried Bitter Kola
T3 – the treatment fed Diet 3 of 10% inclusion level of Air-dried Bitter Kola
T4 – the treatment fed Diet 4 of 15% inclusion level of Air-dried Bitter Kola
SEM – Standard error of means
LS – Level of significance
NS – Not significant

4.1.9 Economy of feed conversion efficiency for broiler chicken

Table 4.9 showed a significant difference across all treatments ($p < 0.05$) on Economy of feed conversion efficiency. The result on economy of feed conversion showed that feed cost per kilogram (₦127), cost of feed intake per kilogram (₦524.55) and feed cost per weight gain (₦303.53) were lower in T1 compared to other treatments. T4 had the highest feed cost per kilogram (₦198.02) and cost of feed intake per kilogram (₦922.51). T1 had the best-feed cost per kilogram and cost of feed intake per kilogram and progressively increased across the other treatments. Feed cost per kilogram was higher in T2 and T3 respectively (₦183.64 and ₦192.78). They also had a higher cost of feed intake per kilogram (₦820.79 and ₦867.11). Feed cost per weight gain was significantly lower ($p < 0.05$) in T1 with a value of ₦303.53. T2 was higher with a value of ₦602.34. T3 had the highest value of feed cost per body weight gain with ₦626.54.

Table 4.9: Economy of Feed Conversion of Broiler Chicken Fed Diet Containing Air-Dried Bitter Kola at Varying Inclusion Levels

Parameters	T1	T2	T3	T4	SEM	P-value
Total feed consumed (g)	4130.30^{d}	4469.55^{c}	4497.93^{b}	4658.65^{a}	57.98	0.00
Feed cost /Kg (₦ /kg)	127.00^{d}	183.64^{c}	192.78^{b}	198.02^{a}	28.39	0.00
Feed intake total cost (₦ /kg)	524.55^{d}	820.79^{c}	867.11^{b}	922.51^{a}	40.56	0.00
Final body weight (g)	1747.20^{a}	1385.02^{d}	1405.41^{c}	1511.03^{b}	43.38	0.00
Feed conversion	2.39^{a}	3.28^{c}	3.25^{c}	3.13^{a}	0.10	0.00

$^{a, b, c, d}$ means with different superscript on same row differ significantly ($p < 0.05$)
T1 (control treatment) - fed 0 % ADBK inclusion level
T2 (treatment 2) – fed 5 % ADBK inclusion level
T3 (treatment 3) – fed D3 10% ADBK inclusion level
T4 (treatment 4) - fed 15% ADBK inclusion level.
SEM – Standard error of mean
Means with the same superscripts in the same row are not significantly different ($p>0.05$) while means in the same row not followed by the same superscripts are significantly different ($p<0.05$). T1 (control treatment) - fed 0 % ADBK inclusion level T2 (treatment 2) – fed D2 (i.e. diet 2) of 5 % ADBK* inclusion level, T3 (treatment 3) – fed D3 (diet 3) of 10% ADBK inclusion level, T4 (treatment 4) - fed 15 % ADBK inclusion level

4.2 Discussion

4.2.1 Phytochemical analysis of the air-dried bitter kola

The phytochemical composition result of the Air-dried bitter kola presented in Table 4.3 showed that it contained small amount of alkaloid (1.06mg/100g), oxalate (2.06mg/100g), phytate (1.72mg/100g), saponin (1.81mg/100g) and tannin (0.62mg/100g). this analysis results values are lower than the result obtained in the nutritional and phytochemical screening of bitter kola conducted by Adesuyi *et al*. (2012) in which alkanoids, oxalate, phytate, and tannin were found to be 0.647g/100g, 0.423g/100g, 0.57g/100g, 2.47g/100g and 0.34g/100g respectively. The difference might be due to the different source of the kola seed, the drying method, the season's variation and the stage of harvesting the seed.

4.2.2 Proximate compositions of the experimental diets

The result of the proximate composition of the experimental diets, are shown in Table 4.2, the crude protein ranged from 23.98 % in T1 to the 23.72 % in T2, while crude fibre range from 6.05 % in T3 to 6.84 % in T1, ether extract ranged from 5.02 % in T2 and 4.78 % in T3. Ash had the highest value of 13.42 % in T1 and the lowest value of 13.05 % in T3. The NFE was the highest in T4 with the value of 47.69 % and the lowest value of 45.27 % in T1.

4.2.3 Performance characteristics

The results obtained in this study indicated that broiler chickens fed Air-Dried Bitter Kola had less performance in growth, as shown in Table 4.4, the varying inclusion level of Air-dried bitter kola had a significant ($p<0.05$) effect on the average final body weight (AFBW), average daily, weekly and total weight gains. Also, there is significancy

(P<0.05) in average daily, weekly and total feed intakes and feed conversion ratio (FCR) across the treatments. The average final, daily, weekly and total body weight gains were highest in T1 (control treatment) followed by T4, T3 and T2 broilers. The weight gain trend was T1 greater than T4 greater than T3 greater than T2. This result is in conformity with the findings of Ibekwe and Orok (2010) who reported a significant decrease in the live body weight of birds given graded level of bitter kola at inclusion level of 10 % and above. In addition, the result obtained disagree with the finding of Owen *et al.* (2019) in his research on the effect of bitter kola powder as growth promoter in broiler chickens. He obtained high mean total weight gain in broiler birds fed 15g/kg and least average final body weight in broiler not fed ADBK. The difference may be due to the different levels of inclusion of the bitter kola in the diet and the commercial feed utilized and added to the bitter kola seed.

On feed intake, the progressive increase in the intake of the feed was observed at highest level of inclusion of ADBK but depressed at lower level of inclusion. This agrees with the finding of Noboru *et al*. (2001) who reported that the progression in the feed intake indicate the tolerance level of the broiler chickens to bitterness and enhanced their intake at higher inclusion level as shown in the broiler chickens in Treatment 4 (15 % inclusion level of ADBK), but depressed at lower inclusion levels (i.e. 0 %, 5 %, 10 % inclusion levels of ADBK). The feed intake progression indicates the tolerance level of the broiler chickens to bitterness at higher inclusion level but depressed at lower inclusion level. This is in contrary to the conclusion of Adedeji *et al*. (2008), who concluded that progressive feed intake of the broiler chicks fed bitter kola dry seed powder as a natural growth promoting agent showed ability of the birds to tolerate the bitterness levels but depression in the intake at the highest level of 10% inclusion level. Nevertheless, the progression in the feed intake does not translate into higher weight gain (Ibekwe and Orok, 2010) as observed in the control treatment (T1) having lowest feed intake with corresponding highest body weight gain. Yahya (2014), asseverated that birds will tend to consume more feed to meet up the required energy as observed in this research study. In addition, the progressive intake of feed recorded is in accordance with the finding of Esiegwu *et al.* (2012), reported that feed intake tended to increase with increase in dietary bitter kola seed meal.

The high feed intake of the treated treatments (T2, T3 and T4) respectively, agree with the conclusion of Esiegwu *et al.* (2012) on his research conducted on the value of bitter kola as feed ingredient and anti-microbial agent for layers and rabbits. He concluded that the bitter kola treated treatments consumed significantly. Comparing the results obtained in the treated groups (T2, T3 and T4) fed ADBK at varying inclusion levels; T4 has higher average final body weight, daily, weekly and total body weight gains. This could be compared with the research work of Owen *et al*. (2019) who obtained highest average final body weight, total and daily weight gains in the broiler chickens fed highest dose of ABDK. In plus, the treatment (T4) recorded higher protein and energy efficiency compared to other treatments, T2 and T3 (of 5 % and 10 % ADBK inclusion level respectively). On feed conversion ratio (FCR), the control treatment (T1) recorded the lowest value therefore had better performance in feed conversion. This result obtained disagreed with Sayda *et al*. (2012), using bitter apple (*Citrullus colocynnthis*) seed meal, which is also another phytogenic on broiler, as reported by Aliyu and AbdulMalik (2013), who observed better FCR in broilers fed the seed meal than the broilers in the control treatment T1. The birds of T2 and T3 had the lowest feed conversion, protein and energy efficiency ratio i.e. significantly lower than that of broilers of T1 (the control treatment). The significant difference across the four (4) treatments was ascribable to the different amount of ADBK included in the experimental diets. However, the determined feed conversion ratio from the birds fed diets containing ADBK could be compared with the results obtained in the research experiment conducted by Adedeji *et al*. (2006) who find highest feed efficiency from broiler chicken fed diet of 25g/kg inclusion level of ADBK over broiler chickens fed diet containing 0 % inclusion level of ADBK.

However, the feed conversion ratio obtained in the treated treatments could be compared with the work of Adedeji *et al.* (2006) who obtained highest feed efficiency from broiler chicken fed highest ADBK inclusion level among the ADBK treated groups in his experiment.

4.2.4 Protein and energy efficiency

In addition, result obtained from the analysis on protein and energy efficiency across the treatments showed significant ($p< 0.05$) difference. It was observed that energy and protein efficiency of broiler chicken fed diets containing different inclusion level of air-dried bitter kola were lower in values compared to the control treatment (T1) which recorded highest.

4.2.5 Apparent nutrient digestibility of broiler chickens fed diets containing air-dried bitter kola at varying inclusion levels.

Apparent nutrient digestibility of broiler chickens fed diets containing air-dried bitter kolanut at varying inclusion levels were significantly difference ($p<0.05$), however crude protein digestibility was not affected. The birds fed

with15 % inclusion level of air-dried bitter kola nut diet, though statistically having the same significance level with the control treatment, is slightly highest in total digestible nutrient value which is in conformity with the result of the experimental research conducted by Amad and Zentek (2011) on phytogenic feed additives effects on nutrient digestibility in broiler, it was observed that the means nutrient digestibility were significantly higher in birds fed phytogenic feed additives. However, this highest value obtained in total nutrient digestibility disagree with the findings of Kavouridou *et al*. (2008), who stated that diet containing phytogenic plant extract, palm oil, had the lowest digestibility.

4.2.6 The cut-up body parts of broilers fed diets containing air-dried bitter kola at varying inclusion levels

The result obtained in this study on the carcass (cut-up parts) characteristics of the broilers fed diets containing air-dried bitter kola at varying inclusion levels ($p>0.05$) difference but inclusion of air-dried bitter kola on T4 (15 % inclusion level of ADBK) resulted to increase in dress percentage, breast, wing and thigh weights when compared with the control level, T1 (0 % inclusion level of ADBK). This agreed with the report of Sobayo and Adeyemi (2013) which. However, the eviscerated weight, shank weight, head weight and drumstick weight were significantly affected by the inclusion of air-dried bitter kola in the diets of the broilers. This in line with the report of Welsey *et al,* (1980) and stated by Nwabunwanne (2010) that the cut-up pieces of meat yield in broilers is significantly influenced by the diets.

4.2.7 Internal organ of broiler chickens fed diets containing different inclusion levels of air-dried bitter kola.

The result of the internal organs from the carcass of the broilers showed that the liverweight and the intestine weight showed significant differences between dietary treatment groups. T4 experimental birds (15% inclusion level of ADBK) had the highest value of liver while T1 (control diet) recorded the lowest value. This agrees with the report of Esiegwu and Udedibie (2009) which states that birds fed bitter kola-based diets developed significantly heavier liver weight compared to the control diet. The highest value of the intestinal weight (T4) may be due to high inclusion level of bitter kola, this agrees with Tancharoenrat *et al*. (2014) which stated that breakdown and absorption of dietary fats in broilers transpire into the small intestine. Non-significance levels obtained in the internal organs weight characteristics in this study showed that the inclusion of phytogenic feed additives broiler diet had no significant level on broiler heart, lung, spleen, gall bladder, gizzard, abdominal fat, and proventiculum and crop weights. This conforms to the observation of Amad and Zentek (2011) on their research on effect of phytogenic feed additives inclusion in broiler diet.

4.2.8 Meat quality of broiler chickens fed diets containing varying inclusion levels of air-dried bitter kola.

The results gotten in this study showed that including air-dried bitter kola in the diets of broiler at different inclusion levels chickens has no significance difference on the cooking yield and loss water holding capacity and pH of the meat of the birds across the treatments. However, the values recorded for cooking yield, cooking loss, water holding capacity and pH in each treatment are slightly different. Broiler birds in Treatment 4 (fed 15 % inclusion level of ADBK) has highest value (71.47 %) of yield, followed by T3 (fed 10 % inclusion level of ADBK) with the value (68.22 %) and T2 (5 % inclusion level of ADBK). The control treatment, T1 (0 % inclusion level of ADBK) has the lowest value (60.20 %) of yield. In contrast, the cooking loss is lowest in T4, lower in T3, low in T2 but highest in T1 (control treatment). Water Holding Capacity (WHC) of the meat across the treatments is non-significance, likewise the pH values.

4.2.9 Meat sensory evaluation of the broiler chickens fed diets containing air-dried bitter kola at varying inclusion levels.

Result of this study showed that feeding broiler birds diets containing air-dried bitter kola at inclusion levels of up to 15 % level exert no effect on colour, tenderness, juiciness and flavour of their meat. It is overall acceptability of their meat that is significantly different. Birds in treatment 3, T3 highest value of overall acceptability followed by T1 (control treatment)

4.2.10 Economy of feed conversion

As shown in Table 4.8, the economy of feed conversion efficiency of the broiler chickens fed diet containing different levels of air-dried bitter kola, Feed cost per kilogram ranges from ₦127 in T1 to ₦198.02 in T4. T1 had a lower cost of feed per Kg of price (₦127). T2 had a higher cost of feed per Kg than T1 (₦183.64) but was lower than T3 (₦192.78). T4 had the highest cost of feed per kilogram of price (₦198.02). Concerning cost of feed consumed per bird, T4 had a higher cost of feed consumed per bird, having ₦922.51, then T3 with ₦867.11, followed by T2 with ₦820.79 while T1 had ₦524.55. T3 had a higher feed cost per body weight gain, having ₦626.54/kg, followed by T4 and T2 with ₦619.80/kg and ₦602.34/kg respectively while T1 had a feed cost per weight gain of ₦303.53/kg.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The proximate composition of the air-dried bitter kola indicated that most of the phytochemical compounds particularly, the tannin, saponin, phytate and alkanoid were within the tolerable levels to broiler chickens, except for the oxalate which did not reduce by air-drying process, the performance of the birds might be attributed to accumulative effect of the oxalate in the diet as endured in treatment 4.

The results of this research study have shown that air-dried bitter kola in the diet of broiler chickens under single phase feeding, nutritionally, has no improvement on broilers growth performance. The weight gains depressed progressively in all the treated treatments as the inclusion level of ADBK increased. On the contrary, the feed intake progressed with increase in the level of ADBK inclusion. Broilers chickens fed diet with 0 % inclusion level of air-dried bitter kola performed best as they consumed the least amount of feed had the highest feed conversion ratio, highest total body weight gain and the lowest feed cost per body weight gain. Bitter kola included in the diet of broiler chicken increased their feed intake, feed cost and feed cost per body weight gain while it decreased their total body weight gain.

Furthermore, the results obtained on the nutrient digestibility, of inclusion levels of air-dried bitter kola in the diets of the broiler chickens significantly ($p<0.05$) affected their nutrient digestibility, with 15 % inclusion recorded the highest total digestible nutrient.

The carcass composition of the cut-up parts and internal organs of the broilers, indicated that T4 (15% ADBK inclusion level) with the highest inclusion level of bitter kola have the highest cut-up parts with specific reference to the drumstick and the thighs.

The economy of feed conversion ratio was highest in T1 (control treatment of 0 % inclusion level of ADBK), cost parameters; such as feed cost/kg weight gain and cost of total feed consumed were higher in the treated treatments which decrease as the level of inclusion increased compared to the control treatment, thus reducing the profitability in poultry production. It was therefore concluded that nutritionists and poultry farmers not to include bitter kola seeds from 5% and above when formulating diets for broiler best performances and profitability.

5.2 Recommendations

Based on the findings of this experimental research study, the following are recommended.

i. The inclusion of bitter kola in broiler chicken diets should be below 5% as it increases their feed intake and feed cost per body weight gain, but decreases their total body weight gain.

ii. Farmers should be educated on the use of bitter kola in formulating their poultry feed as it has impact on the digestibility, carcass composition and the internal organ.

iii. There is need to further carry out research to ascertain the best processing method for bitter kola before its inclusion in the diets of broiler chickens for optimal nutrient digestibility and utilization.

5.3 Contribution to Knowledge

The research study uncovered, nutritionally, no improvement on growth performance in broiler chickens fed diet containing air-dried bitter kola seed under single phase feeding compared to those fed control diet (containing 0 % inclusion of air-dried bitter kola). It revealed progressive depression in weight gain in broiler chickens fed diet containing air-dried bitter kola seed at the range of inclusion.

It was revealed in this research study that broiler chickens fed diet containing air-dried bitter kola seed had high feed intake with low feed conversion ratio compared to those fed diet with no inclusion of air-dried bitter kola seed having low feed intake with high feed conversion ratio. In addition, feed cost per kilogram (₦127), cost of feed intake per kilogram (₦524.55) and feed cost per weight gain (₦303.53) were lower in broiler chickens fed 0 % inclusion level of air-dried bitter kola seed compared to other tretaed broiler chickens. Broiler chickens fed diet of air-dried bitter kola seed at 15 % inclusion level had the highest feed cost per kilogram (₦198.02) and cost of feed intake per kilogram (₦922.51). However, the inclusion levels (5 %, 10 %, and 15 %) of air-dried bitter kola seed in broiler chickens diet significantly ($p<0.05$) affected their nutrient digestibility, with 15 % inclusion level recorded highest total digestible nutrient.

Noticeable information deduced from this study showed that including air-dried bitter kola seed in broiler chickens diet resulted in an increase in broiler chickens feed cost, feed cost per body weight gain, feed intake, low feed conversion ratio with no improvement in growth performance, thus reducing the profitability in poultry production.

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