PERFORMANCE OF BROILER CHICKENS FED KAPOK (*Ceiba pentandra*) SEED CAKE FERMENTED OR NON-FERMENTED AS REPLACEMENTS FOR GROUNDNUT CAKE IN BROILER CHICKEN DIETS

BY

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M.Sc/AGRIC/1856/2009-2010

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS DEGREE IN ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE,

FACULTY OF AGRICULTURE,

AHMADU BELLO UNIVERSITY, ZARIA

NIGERIA

SEPTEMBER, 2015

DECLARATION

I hereby declare that the work in this thesis titled **"Performance of Broiler Chickens Fed Kapok (*Ceiba Pentandra*) Seed Cake Fermented or Non-fermented as Replacements for Groundnut Cake in Broiler Chicken Diets"** was performed by me in the Department of Animal Science under the supervision of Prof. S. O. Ogundipe and Dr. T. S. Olugbemi. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis has been presented for another degree or diploma at any institution.

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CERTIFICATION

This thesis titled **"Performance of Broiler Chickens Fed Kapok (*Ceiba Pentandra*) Seed Cake Fermented or Non-fermented As Replacements For Groundnut Cake In Broiler Diets"** by **Olugbenga David OYEBODE** meets the regulation governing the award of a Master of Science degree in Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This project is dedicated to God Almighty who gave me the grace and strength to complete this study successfully and to my precious wife Martina Oyebode and my wonderful children Morola, Temiloluwa and Olafimihan Oyebode for their love and support.

ACKNOWLEDGEMENT

I am most grateful to God Almighty for His immeasurable favour throughout my period of study in A.B.U. Zaria. I wish to express my appreciation to my project supervisors Prof. S.O. Ogundipe and Dr. T. S. Olugbemi for taking time to go through the work to ensure that it becomes a success. Their concern, advice, rebuke, understanding and provisions cannot be over emphasized. I am also grateful to all my lecturers for their contributions towards the realization of my academic pursuit.

Special thanks to my wife Martina Oyebode, for her love and care for me and the children, Morola, Temiloluwa and Bethel Oyebode, 'I love you.' Thanks to my parents for being good and caring parents. I want to thank my siblings Mr. Sampson Oyebode, Barr.Wale Oyebode, Mrs Bose Kuti and Pastor (Mrs) Bukola Kajogbola for their expressions of love. I also want to remember Pastor Solomon Kajogbola for his spiritual and moral support as well as Mr Toyin Kuti. I wish to remember my late beloved brother Olalekan Oyebode, your sweet memories can't be forgotten in a hurry.

Special gratitude goes to my spiritual mentors Rev. Tunde and Pastor Tina Bolanta including the pastoral team of the Restoration Ministries for guiding me in the way of the LORD. I want to use this medium to express my heart to a friend, brother, mentor and an encourager Samson Ayuba and his family for their support. Express my gratitude to Pastor Chris Udama and family, you are a pillar of support. Gratitude to everyone that has contributed one way or the other to the successful completion of my academic pursuit, I say 'thank you.'

ABSTRACT

Two experiments were conducted to evaluate performance of broiler chickens fed Kapok seed cake (KSC) fermented (FKSC) or non-fermented (NFKSC) as replacements for groundnut cake (GNC) in broiler diets. In each experiment, 225 day old broiler chicks were randomly allotted to five dietary treatments in a completely randomized design with 15 birds per replicate. Graded levels of NFKSC at 0, 5, 10, 15 and 20% were fed in the first trial. Results showed that NFKSC at 5% level in dietary inclusion had no adverse effects on final live weight, weight gain and feed conversion ratio at both starter and finisher phases. However, levels above 5% showed adverse effects. The following average final weights were recorded 1028, 1027, 986, 934 and 865kg (starter phase) and 2221, 2193, 2088, 1959 and 1870kg (finisher phase), respectively, for 0, 5, 10, 15 and 20% NFKSC levels. Mortality increased with increase in the levels of NFKSC. Most visceral organs showed no significant differences between treatment means. Primal cuts such as drumstick, thigh and breast decreased ($P<0.05$) significantly with increase in NFKSC level. Liver weight increased with increase in NFKSC levels. Crude protein digestibility was not affected up to 5% inclusion, although higher levels decreased protein digestibility. Haemoglobin and Total protein were not affected at 5% NFKSC level but decreased significantly at higher levels. Packed cell volume decreased with increase in the level of NFKSC. In the second experiment, KSC (fermented/ non-fermented) were incorporated into diets at 10 and 15% with 0% KSC (Control). Results showed that fermentation improved FKSC utilization resulting in increased final weight and weight gain up to 10% dietary inclusion for both starter and finisher phases. Mortality was not affected up to 10% inclusion of FKSC. Fermentation also improved protein digestibility up to 10% inclusion level while no significant effects on Hemoglobin, Total protein and Packed cell volume up to 10% FKSC were observed. It can be concluded that levels of up 5% NFKSC and

10% FKSC can be incorporated into practical broiler rations without deleterious effects on the performance of broiler starter and finisher chickens, respectively.

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CHAPTER ONE

INTRODUCTION

The level of animal protein consumption in most developing countries of the world including Nigeria is very low. This low intake can be linked to high cost of the products arising mainly from high cost of production inputs, especially feed. Acute shortage and high cost of feedstuffs have been identified among other challenges as a major obstacle to the expansion of the poultry industry in Nigeria (Abeke *et al*., 2003; Bawa *et al*., 2003). In recent times, there has been a wide gap between production and supply of animal protein to feed the ever increasing population of over 140 million Nigerians (NPC, 2006) resulting in low per capita consumption of the product (Christopher *et al*., 1997). According to (FAO, 1997) , an average consumption of 10g animal protein per head per day was reported for Nigerians as against the 35g per head per day recommended as the minimum requirement for growth and development of the body.

The cost of conventional feed ingredients such as maize, groundnut cake, fish meal, soya bean and by-products of food processing industries etc. has been on the increase from year to year leading to increase in the price of animal products especially animal protein (Adejinmi *et al*., 2007). The competition between man and livestock for some of these feed ingredients coupled with high cost, has necessitated the search for alternative, non-conventional feed ingredients that would suitably replace the conventional ones used in formulating poultry diets (Dafwang *et al*., 2001). The main aim of using these non-conventional feed ingredients is to reduce the cost of production thus making it possible for an average Nigerian to be able to afford animal protein in their meals (Ojebiyi *et al.*, 2006; Olabanji *et al*., 2009). Narahari and Rajini (2003) also reported that the use of non-conventional

ingredients generally reduces feed cost and cost per kg gain resulting in cheaper animal products at affordable prices. However, the use of some non-conventional feedstuffs could lead to poor nutrition arising from the effects of anti-nutrients, poor nutrient qualities and nutrient-imbalances.

1.1 Justification of the Study

The ever increasing competition between man and livestock for cereals and oil-seeds like soya bean cake and groundnut cake necessitate the search for alternative sources that will guarantee cheaper cost of production if the target of 65g protein consumption per day recommended by the FAO is to be attained. This forms the basis for the search for non-conventional feed materials which are not consumed directly by man but have the potentials to serve as feed ingredients for poultry diets. Generally, plant proteins are cheaper and more abundant than animal proteins, hence, plant proteins are normally used to maximise profit in poultry diets (Adeola and Olukosi, 2008). Kapok seed cake (KSC) is abundantly produced as an agro-industrial by-product of oil-extraction in the tropics (Narahari and Rajini, 2003). It costs about one fifth of the cost of groundnut cake and one sixth of the cost of soybean cake, KSC is undoubtedly a potential feed resource that could be used as a cheap protein source for economic poultry feed.

1.2 Objectives of the Study

The following were the objectives of this study:

i. To evaluate the effects of dietary levels of non-fermented or fermented KSC as replacement for groundnut cake on growth performance characteristics of broiler chickens.

ii. To evaluate the economic benefit of dietary levels of non-fermented or fermented KSC as replacement for groundnut cake in broiler diets.

iii. To evaluate the effect of dietary levels of non-fermented KSC as replacement for groundnut cake in broiler chicken diets on carcass quality.

iv. To evaluate the effect of dietary levels of fermented KSC as replacement for groundnut cake in broiler chicken diets on carcass quality.

v. To evaluate the effect of incorporating dietary levels of non-fermented KSC as replacement for groundnut cake on digestibility of broiler chickens.

vi. To evaluate the effect of incorporating dietary levels of non-fermented KSC as replacement for groundnut cake on digestibility of broiler chickens.

1.3 Hypotheses

H_{a1} = Non-fermented Kapok seed cake can be used as a protein source to replace groundnut cake in broiler chicken diets.

H_{a2} = Feeding non-fermented or fermented Kapok seed cake as a replacement for groundnut cake in broiler diets have no negative effects on broiler chicken performance.

H_{a3} = Feeding non-fermented or fermented Kapok seed cake as a replacement for groundnut cake in broiler diets have no negative effects on economic benefit of broiler chicken.

H_{a4} = Feeding non-fermented or fermented Kapok seed cake as a replacement for groundnut cake in broiler diets have no negative effects on digestibility of broiler chicken.

H_{a4} = Feeding non-fermented or fermented Kapok seed cake as a replacement for groundnut cake in broiler diets have no negative effects on carcass quality of broiler chicken.

CHAPTER TWO

LITERATURE REVIEW

2.1 Nutrient Requirement of Broiler Chickens

Nutrient requirement refers to the minimum amount of nutrient required by broiler chickens for maximum growth and feed efficiency (Laohakaset, 1997) and also for maintaining body functions (Chinrasri, 2004).

2.1.1 Water requirement

Water represents about 70 percent of the total body weight of broiler birds and it also makes up about 65 percent of the total weight of eggs (Scott and Kenneth, 2000). It is the least expensive, and usually the most neglected nutrient required in broiler production (Scott and Kenneth, 2000). It performs definite functions in the body such as regulation of body temperature, transportation of nutrients through-out the body, it serves as a major component of the blood, helps in waste elimination and plays a vital role in reproduction (Carter and Sneed, 1997). Amongst other factors, its requirement by broiler birds is mostly related to the nature of feed consumed and the ambient temperatures (Ward and McKague, 2007). Talha *et al.* (2008) reported that long periods of water deprivation (6 hrs limit and above) affected broiler performance more than its occurrence with long periods of feed deprivation (12 hrs). Consequently, for a flock to achieve maximum production, water should be readily available, free of pathogenic microorganisms and toxic levels of minerals (Talha *et al.*, 2008).

2.1.2 Vitamin requirement

Vitamins are organic compounds found in food in small quantities. They are very essential in a good nutrition program (Scott and Kenneth, 2000). Vitamins are primarily divided into two classes: fat soluble and water soluble vitamins. The fat soluble vitamins include vitamin A, D, E, and K while the water-soluble vitamins include vitamin C and the B-complex vitamins (vitamin B12, biotin, choline, folacin, niacin, pantothenic acid, pyridoxine, riboflavin, and thiamine). They are required in small amounts and they represent about 0.05% of the total weight of the feed and about 1.5% of the feed cost (Coelho and McNaughton, 1995). Vitamin requirement of poultry is usually affected by several factors such as age, breed/strain, diet composition, disease, minerals –vitamin bioavailability, physiological condition and stress (McNaughton, 1990). Acamovic (2001) reported that optimum vitamin nutrition in broilers diets have shown increased growth rate, improved feed efficiency and increased oxidative stability of meat and better resistance to high density stress conditions.

2.1.3 Mineral requirement

Minerals are involved in the formation of structural components in the skeleton. Some minerals also form integral parts of amino acids, vitamins and hormones (Irish, 2009). They are two types based on the levels of requirements namely macro and trace minerals. Levels of major minerals (macro minerals) are critical, especially for young growing poultry. Calcium and phosphorus are two macro minerals of great importance in poultry production (Underwood and Suttle, 1999). The skeleton accounts for about 99% calcium and 80% phosphorus in the body (Theerachai, 2006). Most cereal grains and their by-products are deficient in calcium though they contain notable quantities of iron ranging between 60-210ppm

(Drinceanu *et al.,* 2009). NRC (1994) recommendation for calcium in broiler diet are as shown on the nutrient requirement (Table 7.0). Young chicks (meat and egg types) require calcium and phosphorus in relatively large amounts for bone growth. A calcium to phosphorus ratio of 2:1 was best for adequate mineral absorption and metabolism (Chiba, 2007). Poultry requirement for calcium and phosphorus were influenced by the amount of vitamin D in the diet (Smith, 1990). Excess supply of calcium in poultry diets may lead to serious problems of mineral interaction as it would interfere with the availability of other minerals such as phosphorus, magnesium, manganese, and zinc (NRC, 1994). In general, the need for calcium and phosphorus increases as the level of vitamin D decreases and vice versa (Smith, 1990). Cereal grains are poor sources of manganese with concentration ranging between 0.13-0.23% (Drinceanu *et al.,* 2009). Consequently, nutritionists use trace mineral premixes when formulating diets to supply the required amount of micro minerals needed for maintenance and production (Scott and Kenneth, 2000). Other important minerals in broiler nutrition include chlorine which is necessary in digestion as a component of hydrochloric acid, sodium and potassium serve as electrolytes important for metabolic, muscle, and nerve functions.

Magnesium is needed for metabolic and muscle functions (Scott and Kenneth, 2000). Others are manganese which is essential in egg shell production, iodine necessary for the production of thyroid hormones, zinc is involved in enzymatic processes and iron for oxygen transportation within the body.

2.1.4 Protein requirement

Several studies have been carried out to determine the protein requirement of broiler chickens (Olomu and Offiong, 1980; Onwudike, 1983; Fetuga, 1984; Ojewola and Longe,1999; NRC, 1994). Olomu and Offiong (1980) reported that 23% CP for broiler starter and 20% CP for broiler finisher were adequate for optimum performance. Onwudike (1983) recommended 22% CP for broiler starter diet, Fetuga (1984) recommended 23-24% CP for broiler starter, while NRC (1994) recommended 23% CP for broiler chicks of 0-3 weeks old, 20% CP for birds 3-6 weeks of age and 18% CP for birds 6-8 weeks of age. Though there are variations in the reported requirements, the NRC report has been accepted by many nutritionists (Leeson and Summers, 1997). Excess protein in broiler diet has been reported to be dissipated as heat increment after consumption usually in the order of protein-carbohydrate-fat (Musharaf and Latshaw, 1999; Gous and Morris, 2005).

There was a threshold above and below in which protein concentration as a nutrient was not justifiable (Si *et al*., 2001), hence no positive result was expected in terms of growth and other performance indices if this limit was exceeded. Protein is made up of amino acids and there are about twenty two amino acids in feed ingredients, eleven of which are essential and must be provided in poultry diets (Leeson and Summers, 1997). They are referred to as essential amino acids since they are not synthesized in adequate amounts by the host animal (Scott and Kenneth, 2000). Lysine and methionine are the two most critical amino acids in poultry nutrition. A deficiency of these two amino acids would lead to a significant loss in productive efficiency (Irish, 2009).

2.1.5 Energy requirements

The energy contribution in poultry diets is usually described in terms of Metabolizable energy (ME) and/or net energy (NE). Metabolizable energy can be accurately determined from the difference between the gross energy of the feed and the gross energy of the excreta derived from such feed (NRC, 1994). The concentration of energy in a diet will greatly influence the intake of all other nutrients; as a result broilers tend to adjust their feed intake as dietary energy concentration changes (Leeson and Summers, 1997). NRC (1994) recommended 2800-3000 kcal/kg M.E for broiler starter diet and 3200 kcal/kg M.E for broiler finisher diet. Carbohydrates and fats are the major sources of energy in broiler nutrition (Scott and Kenneth, 2000). Carbohydrates sources commonly used in poultry diets are starch, sugars, cellulose, and other non-starch compounds.

2.1.6 Fats and fatty acids requirements

Broilers have a dietary requirement for essential fatty acids (EFA). The main essential fatty acid is linoleic acid which acts as a precursor for other members of the n-6 series such as arachidonic acid and derived prostaglandins (Scott and Kenneth, 2000). Specific lesions, particularly in the skin, can result from essential fatty acid deficiency if the dietary content of linoleic acid falls below the requirement of about 10g/kg (NRC, 1994). Fat has 2¼ times more energy than carbohydrates on an equal-weight basis (Chiba, 2007). It is important in broiler nutrition as it performs certain physiological functions such as insulation against temperature extremes, protection of vital organs etc. Addition of fat to broiler diet during hot weather should be accompanied with the use of an antioxidant as it will help to prevent rancidity of the fat (Chiba, 2007).

2.2 Factors Affecting Nutrient Requirement of Broiler Chickens

2.2.1 Sex

At the early stage of growth, both sexes have little differences in their nutrient requirements. However, their nutrient requirements change as they advance into sexual maturity due to variation in nutrient requirements at various stages of growth and development. Both males and females can be fed the same diet to achieve acceptable growth rates.

2.2.2 Housing system

Genetics and nutritional improvements in broiler production have been extremely important to the efficiency of poultry meat production; however, the full genetic potential of broilers cannot be reached unless the proper environment is maintained in the broiler house. The fast growing, modern broiler lines are more dependent on proper environmental conditions than birds from lines raised just a few years ago (Fairchild, 2005). The type of housing system will influence the level of activity of the birds and therefore their energy requirements and consequently, their general well-being (Oluyemi and Roberts, 2000). Broilers (young meat chickens) are not raised in cages. They are raised in large, open structures known as grow-out houses. These houses should be well-designed and equipped with facilities to deliver feed and water to the birds and have environmental systems to provide a comfortable and protective environment, including ventilation systems that would prevent ammonia build-up. High ammonia levels have been shown to reduce the body weight gains of seven-day chicks by 20 percent. The earthen floor of the house should be covered with bedding material consisting of organic matter such as wood chips, rice hulls, or peanut shells. Dry bedding helps maintain flock health, hence, most grow-out houses are designed and constructed to prevent rain

water from splashing into the poultry house which helps to keep the litter dry (Barnett *et al.,* 2001). Keeping birds inside a house protects them from predators such as hawks and foxes. Some houses are equipped with curtain walls, which can be rolled up in good weather to admit natural light and fresh air. In that case, a fine mesh screen keeps insects, rodents and wild birds out of the house and away from the broilers. Such bio-security measures are critical to ensuring the health of the flock (Sainsbury, 1988).

In semi-commercial and large-scale operations, lights are needed along the brooding area above the heat source in the house, to attract chicks to the feed and water. These lights should be used during the first five days after the chicks arrive, after which background lights should be gradually increased, to reach normal lighting by the tenth day. A well-insulated roof reduces solar heat penetration into the house on warm days, thus decreasing the heat load on the birds. In village settings, many farmers use discarded iron for roofing, but local leaf material made into thatch is preferable (especially in tropical countries), as it insulates the building from extreme heat. In cold weather, a well-insulated roof reduces heat loss and the energy consumption needed to maintain the correct environment for broiler chicks during the brooding phase. In poorly insulated buildings, an area can be set up inside the shed where temperature fluctuations can be minimized by using curtains and a false ceiling running from eave to eave, to reduce heat loss and make temperature control easier.

2.2.3 Health status

High morbidity and mortality from diseases with the consequent loss of production in poultry from day-old to adult life continue to be one of the serious constraints to the growth of poultry industry in Nigeria (Olomu, 1980). The need to implement a carefully planned disease prevention programme therefore becomes necessary as the concentration of birds increases (Gous and Morris, 2005). Ill-health or disease can affect birds in a number of ways. Depending on the severity, cause, or duration, a bird may die or recover partially or recover fully from a disease condition. Disease is always accompanied by loss in productivity and it is it is primarily due to this economic significance that diseases in poultry must be adequately prevented. Disease may be infectious or non-infectious depending on the causative agent. Causes of disease in poultry includes pathogens, nutritional deficiencies, environmental stresses, poisons and toxicants, congenital abnormalities/ hereditary e.t.c. Birds experiencing a nutritional related disease may benefit from an increase in the intake of some nutrients, most commonly vitamins and essential amino acids (Ferket, 2000).

2.2.4 Production aims

Optimum nutrient composition of a diet will vary according to production aims such as optimizing weight gain or carcass composition, egg numbers or egg size etc. Birds raised for breeding purposes may need to have their energy intake restricted to ensure that they do not become obese (Gous, 1998).

2.2.5 Ambient temperature

Poultry have increased energy requirement to maintain normal body temperature in cold ambient temperatures and the opposite in hot ambient

temperatures. The process of digestion of food produces body heat and the amount of heat produced will vary according to the nutrient composition of the diet, for example carbohydrate, protein, fat and oil. This is called the heat increment of the diet. In cold environments it may be desirable to formulate a diet with a higher heat increment and the opposite in hot environments (Gous and Morris, 2005). The most important aspect of broiler chick management is producing an environment without temperature fluctuations. This is difficult to achieve in village operations, but commercial systems can do so in a number of ways, through whole-house brooding, or partial house brooding to conserve heat and reduce energy costs (Sainsbury, 1988). Correct temperatures are more easily maintained in a small area. Ventilation also needs to be considered, as it distributes heat to the birds and helps maintain good air quality in the brooding area. Chicks are more susceptible to poor air quality than older birds are.

2.2.6 Age

Nutrient requirements of poultry birds are also related to both body weight and the physiological stage of growth and development. Broiler chicks need higher crude proteins level (22-24%) than finisher chickens which requires 19-21% crude protein (Kwari, *et al.,* 2011; NRC, 1994). Several studies have shown that dietary metabolizable energy increases as birds age (Sell, 1996; Batal and Parsons, 2002). Shires *et al.* (1987) found lower feed passage rates in older birds, and suggested that the exposure of the diet for a longer period to microbial fermentation in the caeca may increase dietary fibre digestibility. On the other hand, Siregar and Farrel (1980) observed that metabolizable energy values were not influenced by broiler age, whereas Batov (1988) reported metabolizable energy decrease with age. The performance of broiler chicks were evaluated by Olomu and Offiong (1980) and

reported that 23% crude protein with either 2800 or 3000 kcal/kg metabolizable energy was adequate as the requirement for starter broiler chicks while Onwudike (1983) recommended a range of 23-24% crude protein and 2800-3000 kcal/kg metabolizable energy for starter broiler chicks and 19-21% crude protein with same energy level for the finisher phase.

Traditionally in most research conducted on poultry feeding, dietary fibre has been considered as a diluents of the diet (Rougiere and Carre, 2010), with negative connotation in relation to voluntary and nutrient digestibility (Mateos *et al.,* 2002; Janssen and Carre, 1985). Consequently, commercial diets, especially those for young broilers, were formulated to contain less than 3% crude fibre. However, it has been demonstrated based on research conducted in recent years that the inclusion of moderate amount of different fibre sources in the diet improves digestives organ development (Hetland *et al.,* 2005) and increases hydrochloric acid, by-acids and enzyme secretion (Svihus, 2011). These changes might result in improvement in nutrient digestibility (Rogel *et al.,* 1987), growth performance (Sklan, 2003), gastrointestinal tract health (Kalmendal, *et al.,* 2011; Montagne, 2003), and eventually animal welfare (Aerni, *et al.,* ,2000). In addition, depending on the amount and type of dietary fibre as well as on the composition of the basal diet, the profile of the existing microbiota in the distal part of the gastrointestinal tract might be affected (Shakouri, *et al.,* 2006). Older birds have also been reported to handle more volume of fibre than younger ones (Svihus, 2011).

2.3 Non-Conventional Feedstuffs in Poultry Nutrition

Alternative feedstuffs are often referred to as ‘non-conventional feedstuffs’ because they have not been used traditionally in animal feed or they are not normally used in commercial animal diets (Sonaiya, 1995). These include all types

of feedstuffs from animal (termite, silkworm, maggot, grub earthworm, snail, tadpoles etc.), plant wastes (jack bean, cottonseed meal, cajanus, rice bran, palm kernel cake, brewers waste etc.) and waste from animal sources and processing of food for human consumption such as animal dung, offal, visceral, feathers, fish silage, bone, blood (Devendra, 1988). Non-conventional feed stuffs also known as non-conventional feed resources (NCFR) refer to all those feeds that have not been traditionally used in animal feeding and or are not normally used in commercially produced rations for livestock (Jakmola, 2005). NCFR include commonly, a variety of feeds from perennial crops and feeds of animal and industrial origin. The term NCFR has been frequently used to describe such new sources of feedstuffs as palm press fibre (oil palm by-products), single cell proteins, and feed material derived from agro industrial by-products of plant and animal origin and from other agro-industrial by-products such as slaughter-house by-products and those from the processing of sugar, cereal grains, citrus fruits and vegetables from the processing of food for human consumption also comes under this category (Mekashaa, *et al.,* 2002). Non-conventional feedstuffs are known to sometimes contain anti-nutritional factors which lower their biological value and poor digestion when fed raw to monogatric animals (Umar *et al.,* 2007; Dublecz, 2003; Viera *et al.,* 2003). The anti-nutrients contained in alternative feed resources are known to interfere with digestion, absorption and utilization of nutrients (Warenham *et al.,* 1994; Ogundipe *et al.,* 2003; Akande *et al.,* 2010). According to Hossain *et al.,* (2011) utilization of non-conventional feed materials by birds can be improved by proper processing to enhance their nutritive values. Huisman and Tolman (1992) and Sing and Panda (1992) reported that processing methods such as heat treatment, autoclaving, water extraction, drying and cooking can be employed to improve the utilization of non-

conventional feedstuffs containing anti-nutrients, when fed to birds. Other methods include use of enzymes (Classen and Bedford, 1991), salting, blanching and ammonia treatment (Classen, 1996) sterilization and ensiling (Leeson and Summers, 2001).

2.3.1 Factors limiting the use of non-conventional feed ingredients in poultry feed formulation

It is widely recognized that in developing African and Asian countries, existing feed resources in many circumstances are either unutilized and wasted or used inefficiently (Abeke *et al.,* 2003). Most of these alternative feedstuffs have obvious potential, but their use has been negligible owing to constraints imposed by certain factors that pose negative effects on poultry performance (Bawa *et al.,* 2003). Two major criteria determine the regular use of non-conventional feedstuffs in poultry diets. These factors can be grouped based on nutritional and technical aspects.

***Nutritional aspect*:** Most non-traditional feedstuffs contain anti-nutritional factors that interfere with the utilization of dietary nutrients. Some of such anti-nutritional factors include tannin in sorghum, phytic acid in sesame seed, gossypol in cottonseed, glucosinolate in Indian mustard etc. Also, most non-conventional feedstuffs used in poultry diets contain high amounts of non-starch polysaccharides that cannot be hydrolyzed by simple stomach animals (Morgan and Bedford, 1995). These non-starch polysaccharides (NSPs) are polymeric carbohydrates which differ in composition and structure from starch (Morgan and Bedford, 1995). They also possess chemical crosses that link them together thereby making them difficult to hydrolyze by simple stomach animals like poultry (Adams and Pough, 1993; Annison, 1993). Other nutritive factors limiting the use of non-conventional

feedstuffs in poultry diet include: variability or inconsistency in nutrient quality, limited information on the availability of nutrients and the need for nutrient supplementation to improve the nutritive value of the feedstuff used.

***Technical aspect*:** Technical limitations to the use of non-traditional feedstuff in poultry diet include seasonality and unreliability of supply of some alternative feedstuffs. This is so because some feedstuffs are not available all year round and as such poultry farmers may have to resort to feeding conventional feed sources for which an ever increasing competition with humans exists. Other technical limitations include the bulky nature of feed materials, limited research and development facilities for determining nutrient composition and inclusion levels in poultry diets and the cost incurred in processing the feedstuff to enhance utilization (Velmurugu, 1990).

2.4 Strategies to Improve the Quality of Non-Conventional Feedstuffs for Incorporation in Poultry Diets

2.4.1 Feed processing

Feed processing is important when diets containing anti-nutrients are being fed to monogastric animals (Akande *et al*., 2010). Feed processing can help to reduce the level of anti-nutrients in plant feed sources to levels that can be tolerated by animals particularly in monogastric nutrition (Fasuyi and Aletor, 2005).

2.4.2 Nutrient Supplementation

Diet formulation with non-conventional feedstuffs containing high level of tannin can inhibit endogenous enzyme action, thereby slowing down digestibility by broiler chickens (Velmurugu, 1990); it can also bind nutrients in feed material (Narahari and Rajini, 2003). The use of exogenous enzymes such as xylanase, glycanse, proteases, phytase e.t.c ; fats or oil to reduce dustiness of dusty non conventional feed stuffs and sometimes to increase the calorie value of low energy diets . Some of the enzymes that have been used over the past several years in the feed industry include cellulase (ß-glucanases), xylanases and associated enzymes, phytases, proteases, lipases, and galactosidases (Annison and Choct, 1993). Some commercial packages have been introduced into the Nigerian market such as Maxigrain^{R}, Rovabio^{R}, Allzyme^{R}, Vegpro 5X^{R}, Fullzyme^{R} etc. Enzymes in the feed industry have mostly been used for poultry to neutralize the effects of the viscous, non starch polysaccharides used in poultry feeds (Allen *et al.,* 1995). These antinutritive carbohydrates are undesirable, as they reduce digestion and absorption of all nutrients in the diet, especially fat and protein (Adams and Pough, 1993). Recently, considerable interest has been shown in the use of phytase as a feed additive, as it not only increases the availability of phosphate in plants but also reduces environmental pollution (Bedford, 1995). . Several other enzyme products are currently being evaluated in the feed industry, including protease to enhance protein digestion, lipases to enhance lipid digestion, ß-galactosidases to neutralize certain antinutritive factors in non cereal feedstuffs, and amylase to assist in the digestion of starch in early-weaned animals (Annison.and Choct, 1991).

The use of fats and oil has also been explored especially when dusty unconventional feedstuffs are incorporated in rations; they also complement calorie value of low

calorie unconventional feedstuffs. Synthetic amino acids like methionine and lysine, vitamin-mineral premixes, growth promoters, fishmeal and other plant protein sources such as soya meal which has more qualitative plant protein with better amino acid profile can help to enhance the nutritional quality of the feed produced from non-conventional feedstuffs (Rosen, 2006).

2.5 Kapok Seed as a Non-Conventional Feedstuff in Poultry Diets

2.5.1 Kapok or silk cotton tree (Ceiba pentandra)

Silk cotton tree is native to tropical America, but is now cultivated mostly in Southeast Asia. It was also reported to have adapted to other tropical environments including tropical Africa where it grows well under wild forest conditions but is also cultivated commercially for its silk and seeds (Narahari and Rajini, 2003). Kapok seed cake is a by-product of oil-seed extraction from the seed of a tropical tree known as the silk cotton tree (*Ceiba pentandra).* The tree is said to have originated from the American tropics but has also been described as been introduced by humans in tropical Africa; although, there is no historical evidence of such introduction (Chudnoff, 1980). Burkil (1985) reported that there is a strong ecological, botanical and cytological evidence that the tree is native to the western and central Africa but it is now cultivated all over the tropics, including South-East Asian regions of Indonesia and Thailand, in particular. It is also grown in other tropical African countries as well. It has now been naturalised throughout the tropical world where it grows well under wild forest conditions but also cultivated commercially for its silk and seeds (Chudnoff, 1980).

2.5.2 Nutrient composition of kapok seed cake

When kapok seed is mechanically pressed, it yields about 150g oil and 850g KSC per kilogramme (Narahari and Rajini, 2003). Nutrient levels of 28.2% Crude

Protein, 22.6% Ether Extract, 25.2% Crude Fibre, 3480 Kcal/Kg Metabolizable Energy, 0.71% Lysine and 0.25% Methionine have been reported for kapok seed by Narahari, 1997. Oil seed cakes were reported to account for a large proportion of the cost in any poultry feed production enterprise (Refstie *et al.,* 1999). Alternative replacements for the major oil seed cakes in poultry nutrition will continue to attract attention from all stakeholders. These alternative replacements must however be nutritionally rich, have cost and availability advantages and should be less competitive than the major oilseeds like the soya bean and groundnut cakes (Ari *et al.,* 2011; Nyamambi *et al.,* 2007). Result from other researchers revealed that kapok seed was a rich source of protein, ether extract and metabolisable energy (Narahari and Rajini, 2003). Some researchers (Sahai and Kehar, 1968; Katgile *et al.*, 1978; Thanu *et al*., 1983) reported poor performance of KSC as a feedstuff for livestock and poultry which they attributed to the effect of poor amino acid profile and the presence of tannins. Narahari (1997) reported the following parameters for kapok seed meal: 32.4% Crude Protein, 9.7% Ether Extract, 25.5% Crude Fibre, 9.4% Ash, 12.8% available carbohydrate 0.38% Calcium, 1.1% Total Phosphorus, 1.19% lysine, 0.31% methionine and 2568 Kcal/kg metabolisable energy. Aduku (2005) reported crude protein of 29.0% and 29.8% crude fibre for KSC, while Rajaguru and Ravindran (1985) reported a metabolisable energy value of 8.8MJ/kg for KSC.

It was reported that the protein content of silk cotton meal was fairly good but it is low in cystine and methionine (Morgan and Bedford, 1995). It also contained essential minerals and trace elements that promote well-being (Obiajunwa *et al.,* 2005). However, certain fatty acids, glycosides, saponins and

steroids were reported to limit its usefulness as an alternative feedstuff (Sarkiyayi *et al.,* 2009; Friday *et al.,* 2011).

2.5.3 Anti-nutritional factors found in kapok seed and cake

ANFs and bioactive compounds present in silk cotton seed as reported by Narahari and Rajini, (2003), Edeoga *et al*. (2006) and Diarra *et al.* (2010) include tannins and fatty acids with cyclopropene rings. Tannin level of 15.8mg/g was reported for KSC (Thanu, 1981). Silk cotton seed contains a yellow pigment known as gossypol that is particularly toxic to animals (Ari *et al*., 2011). The general symptoms associated with this anti-nutritional factor in poultry nutrition included depressed appetite, loss of weight, growth depression in chicks and discoloration of the egg yolk in layers (Narahari and Rajini, 2003). Thanu (1981) found that raw kapok seed was toxic to chicks which he attributed to the effects of cyclopropenoid fatty acids and tannins which were anti-nutrients contained in kapok seeds. Narahari and Rajini (2003) reported that the level of the cyclopropenoid fatty acids was significantly reduced after mechanical extraction. Berry (1979) suggested that cyclopropenoid fatty acids may undergo partial polymerization when heated and thus reduce the toxic effect of the seeds. Siriwardene and Manamperi (1979) concluded from their experiment that KSC could be an ideal substitute for sunflower meal in practical poultry diets. Kategile *et al*. (1978) and Kadirvel *et al*. (1986) on the other hand observed growth depression in chicks fed diets containing KSC, which was linked to higher dietary inclusion levels and poor amino acid profile (particularly, low level of methionine and lysine), high fibre content and the presence of tannins. In contrast, Narahari and Rajini, (2003) obtained similar growth rates and feed conversion ratios that were comparable with the control diet when birds were fed KSC containing diets. These researchers also postulated that

amino acid fortification with enzyme supplementation could greatly improve digestion and nutrients utilization of KSC based diets if appropriate levels are included in practical poultry rations. Although some of these ANFs (cyanogenic glycoside, trypsin inhibitors, hemagglutinin , phytate and oxalate) are of low values which implied that the plant should be safe for human and animal feeding (Friday *et al.,* 2011). Other studies have also shown that saponin, although present in kapok seed, the concentration is not up to the level that should be harmful to the point of generating adverse physiological responses in the animals consuming them (Iniaghe *et al.,* 2009). This report is in agreement with that of Sarkiyayi *et al*. (2009) on the acute and chronic toxicity profile studies of *C. Pentandra* which showed that all the parameters studied (serum bilirubin, Packed Cell Volume and creatinine) were affected but within the physiologically acceptable ranges with advancement in age. Even though Narahari and Rajini (2003) reported good replacement potentials for the silk cotton seed cake as replacement for sunflower meals in broiler feeds, the need for adequate processing to reduce the ANFs contents to make it safe for use as human foods and animal feeds was, therefore, necessary (Maker and Becker,1999; Soetan and Oyewole, 2009).

Sorrel seed meal which one of the non-conventional feedstuffs being investigated by many researchers for its nutritional benefits in livestock nutrition also contain moderate level of tannin reported as tannic acid (3.29 mg/g) which is reduced by 30.4% when subjected to 72hrs of fermentation (Appendix 2).

2.5.4 Tannin as an anti-nutrient in kapok seed and its effect on the performance of broiler chicken

Tannins are present in a wide range of plant species used in poultry feeding which include sorghum, peas and cottonseed (Farrell *et al.* 1999). Tannins are well

known as anti-nutritive factors that hinder the utilization of feeds by the monogastric animals especially poultry (Olomu, 1995). The inclusion of sorghum grain which is high in condensed tannins in poultry feeds has been shown to have negative effects on performance of broiler chicks (Armstrong and Featherston, 1974; Rubio *et al.,* 1989). These negative effects have been show to include reduced body weight gain and feed efficiency (Douglas *et al.,* 1990; Elkin *et al.,* 1990) and it has been attributed to the ability of tannins to bind, coagulate and precipitate protein (Butler *et al.,* 1986) including digestive enzymes and proteins in nutrients (Hagerman and Butler, 1981), thereby reducing digestion and absorption of nutrients (Farrell *et al.,* 1999). Another anti-nutrient also reported by Narahari and Rajini (2003) was the presence of trypsin inhibitor activity in the raw seed. This compound was destroyed by the friction and heat generated during mechanical oil extraction. The samples of kapok seed and KSC assayed in their study were found to be free from saponins and aflatoxins although no literature values were available for comparison.

In a study with chicks and rats given diets high in freeze-dried tannins extracted from faba beans (*Viciafaba),* Ortiz *et al.* (1994) found histological lesions in the ileum and liver suggesting a loss in absorptive capacity. In the liver, degeneration of hepatocytes was observed. They attributed this to the high tannin content of the diet, which was estimated to be 16 g dried tannin/kg DM. It was however reported that the levels of tannin fed in the experiment reported above were not set at practical dietary levels for broiler feeding (Farrell *et al.,* 1999). It is expected that the concentration of dietary sorghum tannins will be much less than the value reported above and consequently the effects may be milder or negligible. Results obtained by Oh *et al.* (1980) using high and low tannin sorghums for rats

and laying hens revealed milder negative effects. Examination of the distal digestive tract under light microscope showed normal cells but the only reported effect appeared to be a mild reduction in intestinal wall thickness and an increase in mucus secretion in the intestinal tract. According to Farrell *et al.* (1999) this could reduce the absorptive capacity of the gut. The integral function of the epithelial layer is fundamental to digestion and absorption of nutrients from the intestinal lumen which is covered by a layer of mucus composed of mucin and glycoproteins that are synthesised by goblet cells which acts as a layer of protection, lubrication and transport between luminal contents and epithelial cells. Changes in the properties of this epithelial layer due to certain undesirable chemical reactions such as tannin-protein interaction could affect the absorption of both dietary and endogenous macromolecules and ions (Ahmed *et al.,* 1991). Ahmed *et al*. (1991) also deduced that this might have been the result of either direct complex formation between enzymes and tannins or through secondary effects, which led to diminished activity such as change in the gut wall morphology. Butler (1992) suggested that high levels of tannins can cause gastroenteritis and congestion of the intestinal wall in rats.

2.5.5 Cyclopropenoid fatty acids found in kapok seed

While researchers such as Akindahunsi and Salawu (2005) and Kategile *et al*. (1978) reported the presence of cyclopropenoid fatty acids in kapok seed, Thanu *et al.* (1983) reported that cyclopropenoid fatty acids underwent partial polymerization when subjected to heat and thus reduce the toxic effect of kapok seed. Narahari and Rajinin (2003) in their study noticed a lower value of cyclopropenoid fatty acids when compared with values reported by Berry (1979) in which a reduction from 28.0 to 10.4g/kg was observed. It was postulated that the

difference may be due to the varieties and oil contents of the seeds tested (Narahari and Rajini, 2003).

2.5.6 Effects of incorporating KSC in diets on broiler chicken performance

The data on growth rate, feed consumption and feed conversion ratio (FCR) revealed KSC to be an ideal substitute for sunflower seed meal which contains 92.7-93.5% dry matter, 32.1-34.6% CP, 25.8-26.8% CF, 2.05% methionine and lysine 3.15% (Narahari and Rajini, 2003). Similarly, Siriwardene and Manamperi (1979) concluded that KSM could replace coconut meal in broiler diets up to 10.0 % inclusion level without any adverse effect on performance. Kategile *et al.* (1978) and Kadirvel *et al.* (1986) however, observed growth depression in chicks fed diets containing KSM, which they attributed to the higher dietary inclusion levels. They also linked the growth depression to lower levels of lysine, methionine and the presence of cyclopropenoid fatty acids. However, in the study above Kadirvel *et al.* (1986) reported low tannins and cyclopropenoid fatty acids and the absence of trypsin inhibitors, saponins and aflatoxin in KSC. These may have resulted in comparable growth rates and feed conversion efficiencies recorded. Variations in the amino acid profile between sunflower and KSC did not affect any growth performance variables, probably because the overall amino acid profile of the compounded feeds were sufficient to meet the requirements of the birds.

According to the report of Narahari and Rajini (2003) mortality pattern did not reveal any significant variation between dietary treatments, indicating that KSC up to 9.0% dietary level is not toxic to broiler chicks. Siriwardene and Manamperi (1979) also observed that KSC had no adverse effect at 10.0% level but increased mortality at higher dietary levels were observed. Kadirvel *et al.* (1986) noticed that KSC at concentrations of 20% and more in chick mash was highly toxic. However,

Thanu (1981) observed an increase in the weight of liver, but not the spleen and heart with KSC inclusion. He suggested that the increase in size of the liver may have been due to the enlargement of gall bladder with bile, as well as due to compensatory growth due to damage of the liver cells.

Thanu *et al*. (1983) observed that birds fed raw seeds at 5% dietary level showed a significant reduction in weight gain while supplementing heat-processed seeds with additional vitamins or oleic acid or lysine and methionine, or all the four nutrients together improved growth rate significantly. Evans *et al*. (1962) and Schneider *et al*. (1962) incriminated the poor performance to the deficiency the amino acids lysine and methionine in the KSC based diets and that the addition of these amino acids might have helped to overcome a possible deficiency of these amino acids. Thanu *et al*. (1983) also suggested the possibility that methionine might have been useful in detoxifying tannins to some extent. They however, concluded that the poor performance associated with feeding of kapok seeds may be due to the aforementioned factors, resulting in decreased nutrient utilisation. They also reported that kapok seeds reduced haemoglobin content of the blood which they attributed to the effect of tannins and poor protein quality, but nutrient supplementations overcame these adverse effects. They concluded by recommending 5% inclusion of kapok seed in poultry diets without nutrient supplementation for raw seeds. Higher levels than 5% for raw seeds or even 5% of heat processed seeds will require nutrient supplementations to overcome adverse effect of poor nutrient utilisation.

2.6 Methods of Reducing the Level of Tannin in KSC and its Effect on Broiler Chicken Performance

Unlike ruminant animals, poultry do not have microbes in their gastrointestinal tract to detoxify or reduce the effect of tannins, but several methods have been used to reduce the tannin content of poultry feeds for better utilization. These methods are mainly physical and chemical in nature. The physical methods are cooking, dehulling, autoclaving, toasting / roasting and soaking, while the chemical methods include, use of wood ash, addition of tallow, addition of tannin binding agents, use of enzymes, germination and urea treatments. The choice of method(s) will depend on their effectiveness in reducing tannin and the cost involved (Akinmutimi *et al*., 2000).

2.6.1 Effect of fermentation on tannin level of feedstuffs

The amounts of tannins in some foods can be reduced by fermentation by wet incubation of a feedstuff (Dei *et al.,* 2008) although the mechanism by which these components are eliminated was not fully understood (Reddy and Pierson, 1994). The fermentation process can create conditions for the growth of microbes (*Bacillus, Corynebacterium, Klebsiella, Aspergillus, Penicillium, Fusarium, and Candida*) that can help to break down tannins (Reddy and Pierson, 1994). Reichert *et al.* (1980) suggested that, during incubation, tannins may react to form higher oligomeric polymers that were not readily soluble in water and, therefore, were less likely to interfere with digestive enzymes or other proteins.

Fermentation is a unique process with great potential for recycling some agricultural products (Dei *et al.,* 2008). According to Smulikowska *et al.* (2001) the traditional fermentation of foods served several functions which included enrichment of the diet, development of a diversity of flavours, aroma, and texture in

food substrate, enrichment of the food substrate biologically with protein, essential amino acids, essential fatty acids and vitamins, detoxification during food fermentation processing, preservation of substantial amount of food through lactic acid, alcoholic, acetic acid and alkaline fermentation and decrease in cooking times, and fuel requirement. During fermentation, microorganisms particularly fungi are known to breakdown fibres. Moreover, it has been demonstrated that fermentation in the presence of limited quantity of moisture referred to as solid state fermentation (SSF) could induce degradation of anti-nutrients and toxic components in plant feedstuffs (Iluyemi *et al.,* 2006). It was also discovered that sorghum *in vitro* digestibility of protein all occurred at above 90% in 2 hours and this showed that sorghum grain was almost digested *in vitro* after 2 hours in normal conditions. Also based on the result obtained, the processing of sorghum significantly increased protein digestibility. Fermentation treatment of the sorghum grain, from the results obtained significantly reduced the tannin content of the grain. This was in agreement with the work of Hibberd *et al*. (2003).

Fermentation of shea nut meal using *A. niger* resulted in significant reductions in total soluble phenolics (34.5% of soluble pro-anthocyanindins), and appreciable reduction (52.9%) in hydrolysable tannins (Pinto *et al.,* 2001; Butler, 1992). The fermentation of the shea nut meal resulted in an appreciable increase (24%) in feed intake compared to the unfermented meal where the feed intake of the birds fed the fermented shea nut meal was similar to that of the control diet (Dei *et al.,* 2008). This was a clear indication of reduction in the adverse effect of anti-nutritive factors such as tannins in the shea nut meal on feed intake of broilers (Annongu *et al.,* 1996). This could be attributed to the lower concentrations of tannins in the fermented meal diet than in the unfermented meal diet. The

unfermented and fermented shea nut meal samples had similar proximate nutrient compositions as well as amino acid profiles as KSC (Dei *et al.,* 2008).

2.6.2 Effects of fermentation on broiler chickens performance

Protein digestibility studies conducted showed that processing by fermentation increased protein in vitro digestibility as reported by Pederson *et al*. (2000). It was also discovered that *in vitro* digestibility of sorghum protein all occurred at above 90% in 2 hours and this showed that sorghum grain was almost digested *in vitro* after 2 hours in normal conditions. They also reported that fermentation of sorghum significantly increased protein digestibility.

2.7 Haematological Profile and Health Status Of Monogastric Animals

The optimum haemoglobin and packed cell volume required for normal physiological function in table sized broiler chicken is given as 9.33-10.21 g/dl and 28.10-30.67 % respectively (Ahaotu *et al.,* 2013). Lower concentrations of haemoglobin and packed cell volume (5.5-7.0 g/dl and 20.0-23.1 %, respectively) for broilers fed diets containing high levels of castor oil beam meal had been reported (Ani and Adiegwu, 2005). In a study on effects of phyto-toxins on blood parameters, it was observed that there were decrease in haemoglobin, packed cell volume and red blood cell values which were attributed to the destruction of the red blood cells by the anti-nutritional factors (ANFs) and toxicants such as cyanogens, tannins and lactins in the raw Moringa seed waste based diet (Ahaotu *et al.,* 2013). Total protein value of 65.5-79.2 g/dl had been reported for table sized broiler chicken (Nkwocha *et al.,* 2014) which was in agreement with report given by Agbabiaka *et al.* (2013) where a range of 63-69 g/dl total protein value was reported for a healthy adult catfish.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental Site

This study was carried out at the Teaching and Research Farm, Department of Animal Science, Ahmadu Bello University, Samaru-Zaria, located within the Northern Guinea Savannah zone (latitude 11^{o} 12′ N and longitude 7^{o} 53′ E) with an altitude of 640m above sea level. The climate is relatively dry with a mean annual rainfall of 1100mm and mean relative humidity of 21% and 72% for dry and wet seasons, respectively. The maximum temperature varies within the range of 26-32^{o}C (Ovimaps, 2012).

3.2 Source of Experimental material

Mechanically extracted KSC was purchased from an oil-extraction and refining mill based in Kano (Sharada oil mills Co-operative).

3.3 Experiment 1: Performance of Broiler Chickens Fed Non-Fermented KSC Diets as Replacements for Groundnut Cake

This experiment was in two phases, the starter phase which lasted from zero to four weeks, followed by a week of re-randomisation during which the birds were fed on common diet and re-allotted to the various treatment groups for the finisher phase which lasted for three weeks (commenced at the end of the fifth week up to the end of the eighth week).

3.3.1 Experimental design and management of birds at the starter phase (0-4 weeks)

A total of 225 day-old broiler chicks purchased from Agrited hatchery, Ibadan south- west Nigeria, were used for this experiment. The birds were assigned to five dietary treatments with three replicates in a completely randomised design. Five diets were formulated with KSC inclusion at levels of 0, 5, 10 15 and 20% dietary inclusion. Tables 3.1 and 3.2 show the ingredients and nutrients composition of the starter and finisher diets, respectively. The diets were formulated to meet the nutrient requirements of the birds according to the recommendations of NRC(1994). The chicks were weighed at the commencement of the trial and weekly thereafter to determine weight gain. Fresh feed and water were offered and th*e* left over feeds were weighed to determine feed intake on weekly basis. Mortality was also recorded as it occurred.

3.3.2 Experimental design and management of birds at the finisher phase (5-8 weeks)

At the end of the starter phase the birds were pooled together and fed a common diet for one week after which they were randomized for the finisher phase (5-8weeks). A total of one hundred and ninety five finisher broiler chickens were used for the finisher phase. The birds were allotted to five experimental treatments. Each treatment was replicated three times with fourteen birds per replicate in a completely randomized design.

3.3.3 Data collection

Initial and final weights were taken at the beginning and end of each phase. Weight gain and feed intake were measured weekly. Feed conversion, mortality and cost/kg

gain were all computed. Chickens meant for carcass analysis were weighed after which they were bled and their feathers removed by scalding. The head, neck, shank, and viscera were removed to get the dressed weight. Dressing percentage was also calculated. Weight of the breast, thigh, wing and back were also taken. Also internal organs like the heart, kidney, liver and gizzard were weighed and expressed as percentages of the live weights.

3.3.4 Statistical Analysis

Data obtained from all the experiments were subjected to the analysis of variance using the general linear model procedure of SAS (1993). Significant differences in means were separated using Duncan's Multiple Range Test according to procedures described by Steel and Torrie (1980).

Table 3.1 Composition of Broiler Starter Diets Containing Non-fermented KSC as Replacement for Groundnut Cake (0 to 4 weeks)

	NFKSC (%)				
Ingredient (%)	**0**	**5**	**10**	**15**	**20**
Maize	49.25	49.35	48.40	46.70	45.98
Groundnut cake	25.00	20.00	15.00	10.00	5.00
Kapok seed cake	-	5.00	10.00	15.00	20.00
Soya Cake	15.00	15.00	15.00	15.00	15.00
Fishmeal	4.00	4.15	4.30	4.45	4.60
Bone ash	3.20	3.20	3.20	3.20	3.20
Limestone	1.50	1.50	1.50	1.50	1.50
*Vitamin/Mineral Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Common Salt	0.30	0.30	0.30	0.30	0.30
Palm oil	1.00	1.65	2.45	3.10	3.70
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis					
ME (Kcal/kg)	2800	2800	2800	2800	2800
Crude Protein (%)	23.50	23.50	23.50	23.50	23.50
Crude Fibre (%)	3.97	4.58	5.72	6.57	7.42
Ether Extract (%)	4.40	4.48	4.52	4.63	4.68
Calcium (%)	1.45	1.41	1.36	1.30	1.28
Avail Phosphorus (%)	0.57	0.56	0.56	0.56	0.55
Methionine + Cysteine (%)	0.96	0.95	0.93	0.92	0.90
Lysine (%)	1.28	1.26	1.25	1.23	1.21
Cost/Kg diet (₦)	80.00	79.20	78.60	78.10	77.60

*Vitamin/Mineral Premix is composed of the following per kg diet: Vitamin A 8000 IU;Vitamin D_3 1600 IU; Vitamin E 5.0 IU; Vitamin K 0.2mg; Thiamine 0.5mg; Riboflavin 4mg; Pyridoxine 0.015mg; Niacin 0.015mg; B_{12} 0.01mg; Pantothenic acid 0.5mg; Folic acid 0.5mg; Biotin 0.02mg; Choline chloride 0.02mg; Anti-oxidant 0.125g and Minerals (Mn, Zn, Fe, Cu, I, Co) 0.156g.
NFKSC= Non-fermented Kapok seed cake.

Table 3.2 Composition of Broiler Finisher Diets Containing Non-fermented KSC as Replacement for Groundnut Cake (5 to 8 weeks)

	NFKSC (%)				
Ingredient (%)	**0**	**5**	**10**	**15**	**20**
Maize	56.05	55.05	54.00	53.05	52.10
Groundnut cake	20.00	15.00	10.00	5.00	-
Kapok seed cake	-	5.00	10.00	15.00	20.00
Soya Cake	14.00	14.00	14.00	14.00	14.00
Fishmeal	4.00	4.10	4.20	4.30	4.40
Bone ash	3.00	3.00	3.00	3.00	3.00
Limestone	1.00	1.00	1.00	1.00	1.00
*Vitamin/Mineral Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20	0.20
Table Salt	0.30	0.30	0.30	0.30	0.30
Palm oil	1.00	1.90	2.85	3.70	4.55
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis					
ME (Kcal/kg)	3000	3000	3000	3000	3000
Crude Protein (%)	21.00	21.00	21.00	21.00	21.00
Crude Fibre (%)	3.81	4.66	5.51	6.36	7.21
Ether Extract (%)	4.40	4.45	4.53	4.58	4.61
Calcium (%)	1.40	1.39	1.37	1.35	1.34
Avail Phosphorus (%)	0.65	0.61	0.58	0.56	0.53
Methionine + Cysteine (%)	0.86	0.85	0.83	0.82	0.80
Lysine (%)	1.12	1.10	1.09	1.08	1.07
Cost/Kg diet (₦)	78.14	77.60	77.01	76.40	75.85

*Vitamin/Mineral Premix is composed of the following per kg diet: Vitamin A 8000 IU;Vitamin D_3 1600 IU; Vitamin E 5.0 IU; Vitamin K 0.2mg; Thiamine 0.5mg; Riboflavin 4mg; Pyridoxine 0.015mg; Niacin 0.015mg; B_{12} 0.01mg; Pantothenic acid 0.5mg; Folic acid 0.5mg; Biotin 0.02mg; Choline chloride 0.02mg; Anti-oxidant 0.125g and Minerals (Mn, Zn, Fe, Cu, I, Co) 0.156g.

NFKSC= Non-fermented Kapok seed cake

3.4 Experiment 2: Performance of Broiler Chickens Fed Diets Containing Fermented or Non-Fermented KSC as Replacement for Groundnut Cake

3.4.1 *Fermentation of KSC Sample*

Kapok seed cake for this study was subjected to anaerobic fermentation after being moistened with hot water and later covered up in an air tight container to exclude air as much as possible following the procedure outlined by Hesseltine (1983). Four batches of KSC were moistened with water as described above and left under atmospheric condition for about 3hr after which they were packaged in four air-tight plastic containers and allowed to ferment for 48, 72, 96 and 120 hrs. Fermented materials were sundried for three days to reduce their moisture contents. Samples were taken from each batch and subjected to laboratory analysis at the National animal Production Research Institute, Shika- Zaria, for proximate compositions and tannin levels. The period of fermentation that resulted in the least tannin level and also maintained the nutritional value of the KSC was chosen and used for the second phase of the experiment. The 96 hrs fermentation resulted in the least tannin level and was chosen for the study. At the end of the fermentation period the fermented samples were sun-dried for 3 days to reduce moisture content for storage and for subsequent ration formulations.

3.4.2. Experimental Design and Management of Birds at the Starter Phase (0 - 4 weeks)

A total of 225 day-old broiler chicks were purchased from the same source as in the first experiment. The birds were assigned to five dietary treatments with three replicates each. The diets were formulated with fermented seed cake (FKSC) and non-fermented (NFKSC) inclusion at levels of 0, 10 and 15% as replacements

for groundnut cake as shown in Table 3.3. Each treatment had forty five birds assigned in a completely randomized design (CRD). Routine health and management practices were duly, observed. The birds were weighed at the beginning of the trial and weekly thereafter to determine weight gain. Feed and water were offered *ad libitum* and the left over feeds were weighed weekly to determine feed intake. This feeding trial lasted for a period of four weeks, after which the birds were fed on a common diet for a week in preparation for the finisher phase of the feeding trial.

3.4.3 Experimental Design and Management of Birds at the Finisher Phase (5 to 8 weeks)

At the end of the starter phase the birds were pooled together and fed a common diet for one week after which they were randomized for the finisher phase (5-8weeks). A total of two hundred and ten broiler finisher birds were used in this phase. The birds were allotted to five experimental diets. The diets were formulated with fermented kapok seed cake (FKSC) and non-fermented kapok seed cake (NFKSC) inclusion at levels of 0, 10 and 15% as replacements for groundnut cake. Each dietary treatment was replicated three times with fourteen birds per replicate in a completely randomized design. The diets were formulated according to NRC (1994) recommendations as shown in Table 3.4.

Table 3.3 Composition of Broiler Starter Diets Containing Fermented or Non-fermented KSC as Replacement for Groundnut Cake (0 to 4 weeks)

	KSC (%)				
Ingredient (%)	**0**	**10NF**	**10F**	**15NF**	**15F**
Maize	49.25	48.40	48.40	46.70	46.70
Groundnut cake	25.00	15.00	15.00	10.00	10.00
KSC (fermented)	-	10.00	10.00	15.00	15.00
Soya Cake	15.00	15.00	15.00	15.00	15.00
Fishmeal	4.00	4.30	4.30	4.45	4.45
Bone ash	3.20	3.20	3.20	3.20	3.20
Limestone	1.50	1.50	1.50	1.50	1.50
*Vit/Mineral Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Table Salt	0.30	0.30	0.30	0.30	0.30
Palm oil	1.00	2.45	2.45	3.10	3.10
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis					
ME (Kcal/kg)	2800	2800	2800	2800	2800
Crude Protein (%)	23.50	23.50	23.50	23.50	23.50
Crude Fibre (%)	3.97	4.58	5.72	6.57	7.42
Ether Extract (%)	4.40	4.48	4.52	4.63	4.68
Calcium (%)	1.45	1.41	1.36	1.30	1.28
Avail Phosphorus (%)	0.57	0.56	0.56	0.56	0.55
Methionine + Cysteine (%)	0.96	0.95	0.93	0.92	0.90
Lysine (%)	1.28	1.26	1.25	1.23	1.21
Cost/Kg diet (₦)	80.25	78.80	78.90	78.00	78.10

*Vitamin/Mineral Premix is composed of the following per kg diet: Vitamin A 8000 IU;Vitamin D_3 1600 IU; Vitamin E 5.0 IU; Vitamin K 0.2mg; Thiamine 0.5mg; Riboflavin 4mg; Pyridoxine 0.015mg; Niacin 0.015mg; B_{12} 0.01mg; Pantothenic acid 0.5mg; Folic acid 0.5mg; Biotin 0.02mg; Choline chloride 0.02mg; Anti-oxidant 0.125g and Minerals (Mn, Zn, Fe, Cu, I, Co) 0.156g.

KSC= Kapok seed cake; **NF=** Non-fermented; **F=** Fermented

Table 3.4 Composition of Broiler Finisher Diets for Fermented or Non-fermented KSC as Replacement for Groundnut Cake (6 to 8 weeks)

	KSC (%)				
Ingredient (%)	**0**	**10NF**	**10F**	**15NF**	**15F**
Maize	56.05	54.00	54.00	53.05	53.05
Groundnut cake	20.00	10.00	10.00	5.00	5.00
KSC (fermented)	-	10.00	10.00	15.00	15.00
Soya Cake	14.00	14.00	14.00	14.00	14.00
Fishmeal	4.00	4.20	4.20	4.30	4.30
Bone ash	3.00	3.00	3.00	3.00	3.00
Limestone	1.00	1.00	1.00	1.00	1.00
*Vit/Mineral Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20	0.20
Table Salt	0.30	0.30	0.30	0.30	0.30
Palm oil	1.00	2.85	2.85	3.70	3.70
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis					
ME (Kcal/kg)	3000	3000	3000	3000	3000
Crude Protein (%)	21.00	21.00	21.00	21.00	21.00
Crude Fibre (%)	3.81	4.66	5.51	6.36	7.21
Ether Extract (%)	4.40	4.45	4.53	4.58	4.61
Calcium (%)	1.40	1.39	1.37	1.35	1.34
Avail Phosphorus (%)	0.65	0.61	0.58	0.56	0.53
Methionine + Cysteine (%)	0.86	0.85	0.83	0.82	0.80
Lysine (%)	1.12	1.10	1.09	1.08	1.07
Cost/Kg diet (₦)	78.14	77.58	77.05	76.65	76.16

*Vitamin/Mineral Premix is composed of the following per kg diet: Vitamin A 8000 IU;Vitamin D_3 1600 IU; Vitamin E 5.0 IU; Vitamin K 0.2mg; Thiamine 0.5mg; Riboflavin 4mg; Pyridoxine 0.015mg; Niacin 0.015mg; B_{12} 0.01mg; Pantothenic acid 0.5mg; Folic acid 0.5mg; Biotin 0.02mg; Choline chloride 0.02mg; Anti-oxidant 0.125g and Minerals (Mn, Zn, Fe, Cu, I, Co) 0.156g.
KSC= Kapok seed cake; **NF=** Non-fermented; **F=** Fermented

3.5 Data Collection

Initial and final weights were taken at the beginning and end of each phase. Weight gain and feed intake were measured weekly. Feed conversion, mortality and cost/kg gain were all computed. Chickens meant for carcass analysis were weighed after which they were bled and their feathers removed by scalding. The head, neck, shank, and viscera were removed to get the dressed weight. Dressing percentage was also calculated. Weight of the breast, thigh, wing and back were also taken. Also internal organs like the heart, kidney, liver and gizzard were weighed and expressed as percentages of the live weights.

3.5.1 Analysis of some haematological parameters

At the end of the finisher phase, six samples of birds were randomly selected from each treatment group (i.e. two birds per replicate) and 2mls of blood sample was collected from each of them via the wing vein and put into a sample bottle containing anti-coagulant (Ethylene Di-amine Tetra Acetic Acid -EDTA) and later analyzed for packed cell volume (PCV), Haemoglobin level (HB) and total protein (TP) according to the methods described by Lamb (1991) at the haematological laboratory of Veterinary Teaching Hospital, Ahmadu Bello University, Zaria

3.5.2 Evaluation of carcass characteristics of broiler chickens

At the end of the finisher phase, evaluation of carcass was carried out using six birds per treatment (i.e. two birds per replicate). The weights of the selected birds were closed as much as possible to the mean weight of each replicate. The selected birds were fasted overnight but they were supplied with water *ad libitum*. Their live weights were taken after which they were bled and their feathers removed by scalding. The head, neck, shank, and viscera were removed to get the dressed

weight. Dressing percentage was also calculated. Weight of the breast, thigh, wing and back were also taken. Also internal organs like the heart, kidney, liver and gizzard were weighed and expressed as percentages of the live weights.

3.5.3 Digestibility study

At the end of the finisher phase six birds were randomly selected from each treatment group (i.e. two birds per replicate). They were transferred to battery cages for faecal collection. Five days of acclimatization period was observed followed by a day of fasting before the commencement of the trial which lasted for seven days. Feed and water were provided *ad libitum*. Faecal samples were collected and preserved in a deep freezer till the trial was over. They were then oven dried at temperature of 60^{o}C for 72hrs after which they were weighed, ground and samples were taken to the laboratory for analysis according to the A.O.A.C, (1990) methods. Nutrient retention was determined for crude protein, ether extract and crude fibre. Nitrogen free extract was also determined by calculation.

$$\text{Digestibility coefficient (\%)} = \frac{\text{nutrient in feed x FI} - \text{nutrient in faeces x FO}}{\text{\% nutrient in feed x FI}}$$

Where FI =Feed intake (on dry matter basis); FO = Faecal output (on dry matter basis).

3.5.4 Analysis of feed and faecal samples

The analysis was carried out according to methods described by Lamb (1991) while proximate analysis of feed and faecal samples were carried out at the biochemistry laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria, according to the methods described by (A.O.A.C., 1990)

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3.5.5 Statistical analysis

Data obtained from all the experiments were subjected to the analysis of variance using the general linear model procedure of SAS (1993). Significant differences in means were separated using Duncan's Multiple Range Test according to procedures described by Steel and Torrie (1980).

CHAPTER FOUR

RESULTS

4.1 Chemical Composition of Kapok Seed Cake

Table 4.1 shows the proximate composition of groundnut cake, non-fermented Kapok seed cake (NFKSC) and fermented Kapok seed cake (FKSC). Dry matter (%) were 89.60, 90.04 and 88.95; crude protein (%) 44.32, 29.50 and 30.25; ether extract (%) 6.23, 6.5 and 6.10; crude fibre (%) 16.50, 28.50 and 26.25; ash (%) 8.82, 9.4 and 9.31, nitrogen free extract (%) 32.21, 17.64 and 17.30 while metabolizable energy values were calculated as 2482, 2249 and 2232 Kcal/kg for groundnut cake, non-fermented KSC and fermented KSC respectively. Tannin values were 18.60 and 10.23 g/kg, Phytic acid 2.50 and 0.22 g/kg and Oxalate 1.20 and 0.25 g/kg for non-fermented and fermented KSC, respectively.

Table 4.1: Chemical Composition of Fermented and Non-fermented KSC

Nutrient	GNC**	Non-fermented KSC	Fermented KSC
Dry Matter (%)	89.60	90.04	88.95
Crude protein (%)	45.32	29.50	30.25
Ether Extract (%)	6.23	6.50	6.10
Crude Fibre (%)	7.50	28.50	26.25
Ash (%)	5.82	9.4	9.31
NFE (%)	22.65	17.64	17.30
ME (Kcal/kg)	2540	2249*	2232
Tannin (g/kg)	nd	**18.60**	**10.23**
Phytic acid (g/kg)*	nd	2.50	0.22
Oxalate (g/kg)	nd	1.20	0.25

KSC= Kapok seed cake; GNC= groundnut cake; ME= metabolisable energy; NFE= nitrogen free extract; nd= not determined; *ME (kcal/kg) = [(37 x % CP) + (81 x % EE) + (35.5 x % NFE)] Pauzenga (1985)**Aduku (2005)

4.2 Performance of Broiler Starter Chicks Fed Diets Containing Non-Fermented KSC as Replacement for Groundnut Cake (0 to 4 weeks)

The result of the performance of broiler chicks fed diets containing non-fermented KSC as replacement for groundnut cake (0-4 weeks) is shown in Table 4.2. It was observed that the final live weight, weight gain decreased and feed conversion ratio increased significantly ($P<0.05$) with increase in the levels of non-fermented KSC in the diets. The birds on 0 and 5% NFKSC diets had similar live weights, weight gain and feed conversion ratio. In contrast, mortality rate increased significantly ($P<0.05$) with increasing level of NFKSC in the diets. The birds on 5% NFKSC had the highest ($P<0.05$) feed intake. At levels higher than 5% dietary inclusion of NFKSC, feed intake decreased with increase in the level of NFKSC in the diets. Twenty percent NFKSC diet had the least value for feed intake. The mortality rate was significantly increased ($P< 0.05$) across the treatments with the highest mean value recorded by the birds fed 20% NFKSC. The least value was recorded by birds fed the control (0% KSC) diet. Cost per skg gain analysis result showed that birds fed the 0 and 5% NFKSC diets had the least values that were similar ($P>0.05$) but significantly lower $P<0.05$) than values recorded for birds fed the 10 and 15% NFKSC diets which both recorded values that were similar ($P>0.05$) while the birds fed the 20% NFKSC diet had the highest ($P<0.05$) significant value that is significantly higher than the values recorded for all other levels.

Table 4.2 Performance of Broiler Starter Chicks Fed Diets Containing Non-fermented KSC as Replacement for Groundnut Cake (0 to 4 weeks)

	NFKSC (%)					
Parameters	**0**	**5**	**10**	**15**	**20**	**SEM**
Av. Initial Wt (g/bird)	38.60	38.61	38.60	38.60	38.61	0.02
Av. Final Wt (g/bird)	1028[a]	1027[a]	986[b]	934[c]	865[d]	0.30
Av. Wt. gain (g/bird)	989.70[a]	989.66[a]	948.00[b]	896.33[c]	826.66[d]	0.41
Av. Feed Intake (g/bird)	1546.41[b]	1572.21[a]	1579.15[a]	1520.09[c]	1447.19[d]	1.63
Feed Conversion Ratio	1.59[a]	1.59[a]	1.65[b]	1.73[c]	1.79[d]	0.01
Mortality (%)	0.01[a]	0.01[a]	1.00[b]	1.3[b]	5.33[c]	0.001
Cost/kg gain (₦/kg)	125.57[a]	125.82[a]	130.53b	132.45[b]	135.85[c]	1.02

SEM = Standard Error of Mean; **NFKSC=** Non-fermented Kapok seed cake

4.3 Performance of Broiler Finisher Chickens Fed Diets Containing Non-Fermented KSC as Replacement for Groundnut Cake (5 to 8 weeks)

The results of the performance of broiler finisher birds (5-8 weeks) fed diets containing NFKSC as replacement for groundnut cake is presented in Table 4.3.

There were significant differences ($P<0.05$) in the mean values of all parameters considered. Average feed intake, final live weight and weight gain decreased ($P<0.05$) with increase in the levels of NFKSC in the diets. Final weight, weight gain, feed intake, feed conversion ratio and feed cost per kg gain were similar for birds fed the 0 and 5% non-fermented KSC diets. Feed conversion ratio (FCR) and mortality rate increased significantly ($P< 0.05$) with increasing levels of NFKSC in the diet. Feed cost per kg gain indicated that the birds fed the 10% NFKSC diet had the least feed cost per kg gain, followed by birds fed the 0 and 5% NFKSC diets which both had similar values ($P>0.05$). This is followed by the value recorded by birds fed the 15% NFKSC diet while birds fed the 20% NFKSC diet recorded the highest significant value that is significantly higher ($P< 0.05$) than values recorded for all other treatment values.

Table 4.3 Performance of Broiler Finisher Chickens Fed Diets Containing Non-fermented KSC as Replacement for Groundnut Cake (5- 8 weeks)

	NFKSC (%)					
Parameters	**0**	**5**	**10**	**15**	**20**	**SEM**
Av. Initial Wt (g)	1010.33	1010.33	1011.67	1010.67	1011.00	1.39
Av. Final Wt (g)	2221[a]	2193.67[a]	2088.00[b]	1959.00[c]	1870.00[d]	27.80
Av. Wt. gain (g/bird)	1211.00[a]	1183.34[a]	1076.33[b]	948.30[c]	859.00[d]	27.68
Av. Feed Intake (g/bird)	2871.86[a]	2889.48[a]	2731.94[b]	2659.98[c]	2607.05[d]	22.35
Feed Conversion Ratio	2.37[a]	2.35[a]	2.54[b]	2.80[c]	3.03[d]	0.05
Mortality (%)	0.00[a]	0.67[b]	1.33[c]	2.00[d]	3.33[e]	0.44
Cost/kg gain (₦/kg)	174.14[b]	173.88[b]	170.01[a]	177.23[c]	183.45[d]	2.15

SEM = Standard Error of Mean; **NFKSC=** Non-fermented Kapok seed cake

4.4 Carcass Characteristics of Broiler Finisher Chickens Fed Diets Containing Non-Fermented KSC as Replacement for Groundnut Cake

Table 4.4 showed the results of carcass characteristic of broiler finisher fed graded levels of non-fermented KSC diets. The weights of the organs expressed relative to the body weights for heart, gizzard, kidney and lungs showed no significant differences between means ($P>0.05$), although, liver and small intestine increased as level of NFKSC increased in diets. Other parameters such as live weights, carcass weights and dressing percentage showed significant difference ($P<0.05$) across means. Primal cuts like % drum stick, % thigh and % breast also showed significant differences ($P<0.05$) between means, although, % back were similar across treatment means. It was observed that live weights, carcass weights, dressing % and % drum stick decreased with increase in the dietary NFKSC levels while % liver and the proportion by weight of the small intestine increased significantly as dietary levels of NFKSC increased. Carcass weights, dressing %, % drum stick,% breast and % thigh for birds fed 0 and 5% NFKSC diets were similar ($P>0.05$). Birds fed 0 and 5% NFKSC had the highest breast yield and thigh, followed by those fed 10 and 15% NFKSC diets which were both similar while those fed 20% NFKSC diet had the least breast yield. Result for drum stick showed that birds fed the 0 and 5% NFKSC diets had the highest significant values that were similar ($P>0.05$) but higher than the value recorded by those fed the 10% NFKSC diet which also had a value significantly higher ($P<0.05$) than that recorded by birds fed the 15% NFKSC diet while birds fed the 20% NFKSC diet recorded the least significant value. Length of small intestine showed that birds fed 20% NFKSC diet had the longest length, followed significantly ($P<0.05$) by those fed the 10 and 15% NFKSC diets which both had similar ($P>0.05$) values that were

significantly higher than value recorded for those fed the 5% NFKSC diet while birds fed the 0% KSC diet had the least significant ($P<0.05$) value.

Table 4.4 Carcass Characteristics of Broiler Finisher Chickens Fed Diets Containing Non-fermented KSC as Replacement for Groundnut Cake

	NFKSC (%)					
Parameter	**0**	**5**	**10**	**15**	**20**	**SEM**
Live weight (%)	2220[a]	2218[a]	2101[b]	2085[c]	2065[d]	2.74
Carcass weight (g)	1566.43[a]	1560.58[a]	1419.86[b]	1385.48[c]	1371.78[d]	6.10
Dressing (%)	70.56[a]	70.36[a]	67.58[b]	66.45[c]	66.43[d]	0.59
Back (dw %)	29.24	29.29	30.14	30.70	30.51	0.36
Breast (% dw)	37.70[a]	37.78[a]	35.58[b]	33.95[b]	23.38[c]	0.02
Drum Stick (% dw)	23.03[a]	22.51[a]	20.23[b]	18.28[c]	17.82[d]	1.02
Thigh (% dw)	26.43[a]	25.67[a]	24.47[b]	24.02[b]	18.74[c]	0.98
Gizzard wt. (%)	4.87	4.83	4.83	4.83	4.83	0.04
Liver wt. (%)	2.71[d]	2.76[c]	2.98[b]	3.00[b]	3.23[a]	0.02
Heart wt. (%)	0.52	0.51	0.52	0.51	0.53	0.02
Kidney wt. (%)	0.33	0.34	0.35	0.35	0.35	0.03
Lungs wt. (%)	0.81	0.81	0.79	0.79	0.77	0.097
S/Intestine (%)	328[d]	334[c]	342[b]	344[b]	350[a]	5.20

SEM = Standard Error of Mean; **NFKSC=** Non-fermented Kapok seed cake; **dw**= dress weight

4.5 Digestibility of Broiler Finisher Chickens Fed Diets Containing Non-Fermented KSC as Replacement for Groundnut Cake

The results of the digestibility study of broiler finisher birds fed graded levels of non-fermented KSC as replacement for groundnut cake is presented in Table 4.5. The results revealed that digestibility values for dry matter, crude fibre, ether extract and ash were not significantly different ($P>0.05$) between treatment means, while the digestibility for the crude protein and Nitrogen free extract were significantly ($P<0.05$) different between treatment means. The crude protein digestibility reduced across the dietary treatments as dietary levels of non-fermented KSC increased. The digestibility for crude protein at 0 and 5% levels of non-fermented KSC diets were similar and both were significantly higher ($P<0.05$) than the values for those fed 10, 15 and 20% non-fermented KSC diets. The lowest crude protein digestibility was observed for the 20% non- fermented KSC diet. Nitrogen free extract digestibility showed similar results for birds fed 0, 5 and 10% non-fermented KSC diets and their values were significantly($P<0.05$) higher than the values for the 15 and 20% non-fermented KSC diets. The birds fed 20% non-fermented KSC diet had significantly the lowest NFE digestibility ($P<0.05$).

Table 4.5 Nutrient Digestibility Study Carried-out on Broiler Finisher Chickens Fed Diets Containing Non-fermented KSC as Replacement for Groundnut Cake

	NFKSC (%)					
Parameter	**0**	**5**	**10**	**15**	**20**	**SEM**
Dry Matter (%)	68.52	68.19	67.73	66.38	65.51	3.14
Crude Protein (%)	80.11[a]	77.95[a]	75.65[b]	65.41[c]	62.38[d]	2.11
Crude Fibre (%)	60.78	60.47	58.47	58.25	58.18	2.60
Ether Extract (%)	89.78	88.32	88.73	87.50	86.45	3.39
Ash (%)	46.63	47.70	49.54	45.70	46.15	3.84
Nitrogen Free Extract (%)	85.08[a]	84.85[a]	85.06[a]	73.40[b]	72.73[c]	0.28

SEM= Standard Error of Mean; **NFKSC=** Non-fermented Kapok seed cake

4.6 Some Haematological Parameters of Broiler Finisher Chickens Fed Diets Containing Non-Fermented KSC as Replacement for Groundnut Cake

The results of analysis of some haematological parameters of broiler finisher chickens fed diets containing non-fermented KSC as replacement for groundnut cake is shown in Table 4.6. The values for haemoglobin, packed cell volume and total protein were significantly different ($P< 0.05$). The result showed that birds fed 0 and 5% non-fermented KSC diets had similar values for the haemoglobin and total protein and their values were significantly higher than for those fed diets containing higher levels of non-fermented KSC in their diets. The result obtained for packed cell volume showed that the birds fed the control (0% KSC) diet had the highest mean value. The values for PCV decreased significantly ($P<0.05$) as the non-fermented KSC levels increased in the diets. The 20% non-fermented KSC diets recorded the least PCV value.

Table 4.6 Some Haematological Parameters of Broiler Finisher Chickens Fed Diets Containing Non-fermented KSC as Replacement for Groundnut Cake

	NFKSC (%)					
Parameter	0	5	10	15	20	SEM
Hb (g/dl)	10.65^{a}	10.60^{a}	10.01^{b}	8.92^{c}	8.67^{d}	0.052
TP (g/dl)	2.66^{a}	2.64^{a}	2.60^{b}	2.52^{c}	2.46^{d}	0.024
PCV (%)	29.55^{a}	29.33^{b}	28.66^{c}	26.52^{d}	24.33^{e}	0.214

Hb = Haemoglobin; **TP** =Total Protein; **PCV**=Packed Cell Volume; **SEM** = Standard Error of Mean

4.7 Performance of Broiler Starter Chicks Fed Diets Containing Fermented or Non-Fermented KSC as Replacement for Groundnut Cake (0 - 4 weeks)

The performance of broiler starter birds fed fermented or non-fermented KSC in their diets is presented in Table 4.7. Average final live weight and average weight gain of birds on 0% KSC diet were comparable to the values of those fed on 10% fermented KSC diet but significantly higher than the values of birds fed 15% fermented KSC diet Birds fed fermented KSC diets performed significantly better than those fed non-fermented KSC diets at 10 and 15% dietary inclusion levels for final weights, feed intake. The same trend was observed with mortality rate. Birds fed 10-percent fermented KSC diet also performed significantly better ($P<0.05$) than those fed 15-percent fermented KSC diet for final weight, weight gain and feed intake. The best feed conversion ratio was observed for the 0% KSC diet and the worst value was obtained from the 15% KSM diet. The result for mortality also revealed that birds fed fermented KSC diets had significantly ($P<0.05$) lower death rate than those fed non-fermented KSC diets. The lowest mortality was recorded for the control diet and the highest was recorded for the 15-percent KSC diet. Cost per kg gain showed significantly ($P<0.05$) across the dietary treatments with birds fed the 15% NFKSC and FKSC diets recording the least significant values that were similar ($P>0.05$), followed by value recorded by those fed the 10% NFKSC diet which had a value significantly higher than those recorded by birds fed the 15% NFKSC and FKSC diets but lower ($P<0.05$) than value recorded for those fed the 10 FKSC diet. Birds fed the 0% KSC diet, however, had the highest ($P<0.05$) significant cost per kg value.

Table 4.7 Performance of Broiler Chicks Fed Diets Containing Fermented or Non-fermented KSC as Replacement for Groundnut Cake (0 to 4 weeks)

	KSC (%)					
Parameter	**0**	**10NF**	**10F**	**15NF**	**15F**	**SEM**
Av. Initial Wt (g/bird)	40.28	40.28	40.27	40.28	40.27	0.01
Av. Final Wt (g/bird)	1032.57[a]	988.28[c]	1025.56[a]	956.94[d]	1012.58[b]	9.47
Av. Wt. gain (g/bird)	992.29[a]	948.00[c]	985.29[a]	916.67[d]	972.31[b]	8.61
Av. Feed Intake (g/bird)	1571.33[c]	1598.15[d]	1592.00[a]	1574.50[e]	1602.33[b]	7.47
Feed Conversion Ratio	1.58[a]	1.66[b]	1.65[b]	1.70[c]	1.65[b]	0.06
Mortality (%)	0.00[a]	1.00[b]	0.33[a]	5.33[c]	0.33[a]	0.36
Cost/kg gain (₦/kg)	133.09[d]	129.77[b]	131.85[c]	125.75[a]	125.25[a]	0.64

SEM = Standard Error of Mean; **NF**= Non-fermented; **F** = Fermented; **KSC=** Kapok seed cake.

4.8 Performance of Broiler Finisher Chickens Fed Diets Containing Fermented or Non-Fermented KSC as Replacement for Groundnut Cake (5 - 8 weeks)

The performance of broiler finisher chickens fed either fermented or non-fermented KSC as replacement for groundnut cake is presented in Table 4.8. The final live weights and average weight gain of both birds fed with the 0 KSC and 10% fermented KSC diets were similar and their values were significantly higher than those of birds fed 10% non-fermented KSC diet ($P<0.05$). The values were also significantly ($P< 0.05$) better than those of birds fed fermented or non-fermented 15% KSC diets. Result for feed intake showed that birds fed the 10% fermented KSC diet had significantly ($P<0.05$) highest feed intake, which was higher than the value of those birds fed the control (0% KSC) diet. The fermented KSC diets at 10 or 15% dietary level resulted in significantly higher feed intakes than those fed the 10 and 15% non-fermented KSC diets. The lowest feed intake was recorded by the birds fed 15% non-fermented KSC diet. The result for feed conversion ratio showed that birds fed the 0 and 10% fermented KSC diets had the best values. Similarly, feed conversion ratio for those fed 10% fermented KSC diet was similar to those fed the 15% fermented KSC diet. The birds fed 15% non-fermented KSC diet had significantly ($P < 0.05$) poorest feed conversion ratio. Result for mortality showed that birds fed the control diet had the least mortality rate. Mortality rate for birds fed 10% fermented KSC diet gave significantly higher mortality ($P< 0.05$) than those fed the control diet but significantly lower than those of birds fed 10% non-fermented KSC diets and those fed 15% fermented or non-fermented KSC diets.

The highest mortality was recorded for the birds fed 15% non-fermented KSC diet. Cost per kilogram analysis revealed that fermentation increased the economic value

of FKSC in diet as broiler chickens fed the 15% FKSC diet showed the lowest ($P<0.05$) significant cost per kg gain which is significantly lower than value recorded by those fed the 0 and 10% NFKSC diets which had similar ($P>0.05$) values that were significantly lower that values recorded by birds the 10% FKSC and 15% NFKSC diets which had the least significant values that were similar ($P>0.05$).

Table 4.8 Performance of Broiler Finisher Chickens Fed Diets Containing Fermented or Non-fermented KSC as Replacement for Groundnut Cake (5 -8 weeks)

	KSC (%)					
Parameters	**0**	**10NF**	**10F**	**15NF**	**15F**	**SEM**
Av. Initial Wt (g/bird)	1114.00	1113.95	1114.00	1113.98	1114.01	0.39
Av. Final Wt (g/bird)	2342.33^{a}	2210.33^{c}	2339.00^{a}	2130.67^{d}	2307.33^{b}	3.55
Av. Wt. gain (g/bird)	1228.33^{a}	1096.38^{c}	1225.00^{a}	1016.69^{d}	1193.32^{b}	8.80
Av. Feed Intk (g/bird)	2901.99^{c}	2862.67^{d}	2933.33^{a}	2757.71^{e}	2917.70^{b}	12.35
FCR	2.36^{a}	2.61^{c}	2.40^{ab}	2.71^{d}	2.45^{b}	0.05
Mortality (%)	0.00^{a}	3.33^{c}	0.67^{b}	3.67^{c}	2.00^{bc}	1.02
Cost/kg gain (₦/kg)	184.61^{a}	205.56^{b}	184.50^{a}	207.91^{b}	186.21^{a}	1.65

SEM = Standard Error of Mean; **NF**= Non-fermented; **F**= Fermented; **KSC=** Kapok seed cake

4.9 Pooled Effect of Fermentation on the Performance of Broiler Starter Chicks Fed Diets Containing Non-fermented or Fermented KSC as Replacement for Groundnut Cake (0-4 weeks)

The pooled effect of fermentation on the performance of broiler starter Chicks (0-4 weeks) fed diets containing non-fermented or fermented KSC as replacement for groundnut cake is shown in Table 4.9. All the dietary treatments showed significant differences ($P<0.05$) in final weight, feed intake, weight gain, feed conversion ratio, mortality and cost/kg gain. The control diet (0%) had the highest numerical efficiency for final weight, weight gain, feed conversion ratio, mortality and cost/kg gain. The dietary treatment with FKSC had better performance compared to the dietary treatment with NFKSC for final weight, feed intake, weight gain, feed conversion ratio, mortality and cost/kg gain. Cost per kilogram gain showed that birds fed the FKSC diets had the least cost that was significantly lower ($P<0.05$) than values obtained for those fed the control (0%) diet. The highest cost was recorded by those fed the NFKSC diets

Table 4.9: Comparison of the Pooled Effect of Fermentation or Non-fermentation on the Utilisation of KSC by Broiler Starter Chicks (0 to 4 weeks)

Parameter	KSC (%) 0	NFKSC	FKSC	SEM
Av. Initial Wt (g)	40.28	40.28	40.27	0.01
Av. Final Wt (g)	1032.57[a]	969.28[b]	1022.56[a]	18.47
Av. Feed Intake (g/bird)	1570.33[b]	1563.15[b]	1618.67a	36.89
Av. Wt. gain (g/bird)	996.29[a]	931.00[b]	980.29[a]	17.33
Feed Conversion Ratio	1.58[a]	1.67[c]	1.62[b]	0.01
Mortality (%)	0.0033[a]	3.16[c]	0.29[b]	0.02
Cost/kg gain (₦/kg)	124.00[a]	134.67[b]	125.67[a]	6.22

SEM = Standard Error of Mean; **NFKSC**= Non-fermented kapok seed cake; **FKSC**= fermented kapok seed cake; **KSC=** Kapok seed cake

4.10 Pooled Effect of Fermentation on the Performance of Broiler Finisher Birds Fed Diets Containing Non-fermented or Fermented KSC as Replacement for Groundnut Cake (5-8 weeks)

The pooled effect of fermentation on the performance of broiler finisher chickens fed diets containing non-fermented or fermented KSC as replacement for groundnut cake is shown in Table 4.10. All the dietary treatments showed significant differences ($P<0.05$) on final weight, feed intake, weight gain, feed conversion ratio, mortality and cost/kg gain. The control diet (0%) had the highest numerical efficiency for final weight, weight gain, feed conversion ratio, mortality and cost/kg gain. The dietary treatment with FKSC had better performance compared to the dietary treatment with NKFSC for final weight, feed intake, weight gain, feed conversion ratio, mortality and cost/kg gain.

Table 4.10: Comparison of the Pooled Effect of Fermentation or Non-fermentation on the Utilisation of Kapok Seed Cake by Broiler Finisher Chickens (5 -8 weeks)

Parameter	KSC (%) 0	NFKSC	FKSC	SEM
Av. Initial Wt (g)	1010.33	1010.25	1010.43	1.365
Av. Final Wt (g)	2346.00[a]	2170.33[b]	2332.24[a]	30.89
Av. Feed Intake (g/bird)	2909.67[a]	2805[b]	2915[a]	96.56
Av. Wt. gain (g/bird)	1230.00[a]	1055.33[b]	1228.88[a]	31.22
Feed Conversion Ratio	2.367[a]	2.653[c]	2.423[b]	0.000067
Mortality (%)	0.00[a]	3.51[c]	1.33[b]	0.000056
Cost/kg gain (₦/kg)	167.67[a]	177.67[b]	167.89[a]	3.56

SEM = Standard Error of Mean; **NFKSC**= Non-fermented kapok seed cake; **FKSC**= fermented kapok seed cake; **KSC=** Kapok seed cake

4.11 Carcass Characteristics of Broiler Finisher Chickens Fed Diets Containing Fermented or Non-Fermented KSC as Replacement for Groundnut Cake

Table 4.11 shows the carcass characteristics of birds fed diets containing fermented or non-fermented KSC as replacement for groundnut cake. The result of the visceral organs revealed that dietary treatments had no significant (P>0.05) effects on organs such as heart, kidneys and lungs. There were however significant effect (P<0.05) of treatments on live weights, carcass weights, dressing %, % liver, % gizzard, % breast, % drum stick and length of small intestine. Breast muscle yield showed that birds fed 0, 10 and 15% FKSC diets had the highest values that were similar but significantly higher (P<0.05) than the value for birds fed the 10% NFKSC diet which had similar value with those fed the 15% FKSC diet, while birds fed the 15% NFKSC diet had the least breast muscle yield. Drum stick evaluation showed that birds fed the 0 and 15% FKSC diets had the highest mean that were similar but significantly higher than value recorded for birds fed the 10% FKSC diet which also had a mean value similar (P>0.05) to that of birds fed the 15% FKSC diet. Birds fed the 10% NFKSC diet had the next significantly different mean value (P<0.05) while those fed the 15% NFKSC diet had the least significantly different value. Thigh muscle yield showed that birds fed the 0 and 10% FKSC diets had the highest values that were similar (P>0.05) but significantly higher than the values recorded by those fed the 10 and 15% NFKSC and15% FKSC diets which all had similar mean values (P>0.05). Birds fed 10 and 15% NFKSC diets performed significantly (P<0.05) poorer in most of the organ and carcass weight measurements when compared with those fed the control diets. Fermentation generally improved utilization of FKSC diets at both 10 and 15% dietary inclusion levels. The 15% NFKSC diet resulted in significantly (P< 0.05) lowest values for most of the organ

weight and primal-cut parts measurement such as live weight, carcass weight, dressing %, % breast, % drumstick and % thigh. Length of small intestine showed that birds fed 10 and 15% FKSC diets had the longest ($P<0.05$) significant value that were also similar ($P>0.05$) followed by value recorded for those fed the 0 and 15% NFKSC diets which were also similar ($P>0.05$). Birds fed the 10% NFKSC diet had the least value which is similar ($P>0.05$) to value recorded for those fed the 0% KSC diet.

Table 4.11 Carcass Characteristics of Broiler Finisher Chickens Fed Diets Containing Fermented or Non-fermented KSM as Replacement for Groundnut Cake

	KSC (%)					
Parameter	**0**	**10NF**	**10F**	**15NF**	**15F**	**SEM**
Live weight (%)	2420.00^{a}	2301.50^{b}	2393.56^{a}	2240.44^{c}	2310.33^{b}	28.74
Carcass weight (g)	1745.30^{a}	1587.57^{b}	1722.17^{a}	1421.56^{c}	1576.11^{b}	24.40
Dressing (%)	72.12^{a}	68.98^{b}	71.95^{a}	63.45^{c}	68.94^{b}	0.59
Back (% dw)	36.38	37.67	36.65	41.13	38.1	2.73
Breast (% dw)	38.17^{a}	37.50^{b}	37.97^{a}	33.45^{c}	37.74^{ab}	0.23
Drum Stick (% dw)	22.68^{a}	20.66^{c}	21.39^{b}	19.09^{d}	21.73^{ab}	1.02
Thigh (% dw)	24.89^{a}	23.28^{b}	25.07^{a}	22.00^{b}	23.05^{b}	0.98
Gizzard wt. (%)	3.84^{c}	3.85^{c}	3.89^{b}	3.82^{c}	3.94^{a}	0.03
Liver wt. (%)	3.66^{c}	3.80^{b}	3.70^{c}	3.98^{a}	3.82^{b}	0.06
Heart wt. (%)	0.51	0.51	0.51	0.52	0.52	0.02
Kidney wt. (%)	0.33	0.33	0.34	0.34	0.35	0.02
Lungs (%)	0.84	0.82	0.83	0.85	0.80	0.05
S/Int (mm)	341^{bc}	338^{c}	348^{a}	342^{b}	351^{a}	3.04

SEM = Standard Error of Mean; **NF**= Non-fermented; **F**= Fermented; **KSC=** Kapok seed cake

4.12 Effects of Feeding Diets Containing Fermented or Non-Fermented KSC as Replacement for Groundnut Cake on Nutrient Digestibility of Broiler Finisher Chickens

Crude fibre digestibility also showed that birds fed the control (0% KSC) and the 10% fermented KSC diets had similar values which were also the highest digestibility values recorded (Table 4.12). Their values were also significantly higher ($P<0.05$) than values obtained for the birds fed other diets (10 and 15% non-fermented KSC and 15% fermented KSC diets). Ether extract digestibility showed results similar to those described for the crude fibre digestibility. The birds fed 0% KSC and the 10% FKSC diets had similar values and both were significantly higher ($P< 0.05$) than the values recorded for those fed the 10 and 15% NFKSC and 15% FKSC diets which were all similar. Ash digestibility showed that results obtained were similar to those of the crude protein digestibility. The birds fed the control (0% KSC) diet and those fed the 10% fermented KSC diet had similar values and both were significantly higher ($P< 0.05$) than the values recorded for those fed the 10 and 15% NFKSC and 15% FKSC diets. The values obtained for birds fed 10 and 15% non-FKSC and the 15% FKSC diets were all similar ($P> 0.05$).

The result for nitrogen free extract digestibility showed that the birds fed the 0% KSC, 10% non-fermented KSC and the 10% fermented KSC diets recorded the highest values which were all similar ($P> 0.05$) and higher than the values recorded for birds fed the 15% NFKSC and the 15% FKSC diets. However, values for bird fed the 15% NFKSC and FKSC diets were not significantly ($P> 0.05$) different from each other.

Table 4.12 Effects of Feeding Diets Containing Fermented or Non-fermented KSC as Replacement for Groundnut Cake on Nutrient Digestibility of Broiler Finisher Chickens

	KSC (%)					
Parameter (Nutrient)	**0**	**10NF**	**10F**	**15NF**	**15F**	**SEM**
Dry Matter (%)	65.76	63.01	66.98	60.25	64.41	3.54
Crude Protein (%)	85.11^{a}	77.65^{b}	84.85^{a}	70.61^{c}	77.88^{b}	0.21
Crude Fibre (%)	40.78^{a}	38.47^{b}	40.67^{a}	38.25^{b}	38.18^{b}	0.32
Ether Extract (%)	90.58^{a}	81.52^{b}	90.98^{a}	80.82^{b}	79.63^{b}	1.19
Ash (%)	48.63^{a}	46.70^{b}	48.54^{a}	44.70^{c}	46.15^{b}	0.28
Nitrogen Free Extract (%)	85.08^{a}	84.85^{a}	85.06^{a}	73.40^{b}	72.73^{b}	0.68

SEM = Standard Error of Mean; **NF**= Non-fermented; **F**= Fermented

4.13 Results Of Some Haematological Parameters Of Broiler Finisher Chickens Fed Diets Containing Fermented Or Non-Fermented KSC As Replacement For Groundnut Cake

The results of the haematological study presented in Table 4.13 showed that dietary treatments had significant effects ($P< 0.05$) on haemoglobin, packed cell volume and on total protein. The result for haemoglobin level showed that birds fed 0% KSC (control) and the 10% fermented KSC diets had the highest haemoglobin values of 10.55g and 10.45g per decilitre and their values were significantly higher ($P< 0.05$) than those of the birds fed the 10% NFKSC and the 15% FKSC or NFKSC diets. The birds fed on 15% NFKSC diet had least value which was lowest. For the total protein the birds fed 0% KSM and 10% FKSC diets had the highest values that were similar to each other but significantly higher ($P<0.05$) than the values for birds fed the 10 and 15% NFKSC and the 15% FKSC diets. The least value for total protein was recorded by the birds fed the 15% NFKSC diet. Result of PCV showed that birds fed 0% KSC (control) and 10% FKSC diets had significantly ($P < 0.05$) highest values compare to the values recorded for other diets. The least value for PCV was recorded for those birds fed on the 15% non-fermented KSC diet.

Table 4.13: Some Haematological Parameters of Broiler Finisher Chickens Fed Diets Containing Fermented or Non-fermented KSC as Replacement for Groundnut Cake

	KSC (%)					
Parameter	**0**	**10NF**	**10F**	**15NF**	**15F**	**SEM**
Haemoglobin (g/dl)	10.55^{a}	9.91^{b}	10.45^{a}	8.48^{c}	10.04^{b}	0.17
Total Protein (g/dl)	2.68^{a}	2.61^{b}	2.66^{a}	2.45^{c}	2.60^{b}	0.02
PCV (%)	29.55^{a}	28.23^{c}	29.48^{a}	26.72^{d}	28.75^{b}	0.07

SEM = Standard Error of Mean; **PCV** = Packed Cell Volume; **NF**= Non-fermented; **F**= Fermented

CHAPTER FIVE

DISCUSSION

5.1 Chemical Composition Of Kapok Seed Cake

The crude protein content obtained from the proximate analysis of the non-fermented KSC was comparable to the value of 29.0% crude protein reported by Aduku (2005), but lower than the value of 32.1-34.6% reported by Narahari and Rajini (2003). The crude fibre result (28.5%) was comparable to the value (28.9%) reported by Aduku (2005) but slightly higher than the value (25.8-26.8%) reported by Narahari and Rajini (2003). These differences could be linked with variations in varieties of seeds, growing condition and/or processing methods. The type and level of tannin found were slightly higher than the value of 15.8mg/g reported by Thanu (1981). Significant reduction (45%) recorded in tannin content of kapok seed meal after fermentation is comparable with the reduction value of (30.4%) recorded for tannin content of fermented sorrel seed meal (Isidahomen, *et al.,* 2006).

5.2 Performance of Broiler Chickens Fed Diets Containing Non Fermented KSC as Replacement for Groundnut Cake

5.2.1 Performance of broiler starter chicks fed diets containing non-fermented KSC as replacement for groundnut cake (0 - 4 weeks)

Decrease in final live weights and weight gains with increase in dietary levels of NFKSC in the broiler diets are in agreement with the reports of Narahari and Rajini (2003) and Thanu *et al.* (1983), in which poor digestion and utilisation of protein were reported to be responsible for the poor growth. Reduction in the feed intake with incremental level of NFKSC could be linked with the presence of tannin in the KSC which led to reduction in appetite as reported by Armstrong *et al.*

(1974). The lower weight gain observed with increase in the dietary level of the NFKSC can be attributed, partly, to the lower feed intake observed with increasing level of NFKSC in the diets, but largely due to the negative effect of tannin which was the major anti-nutrient found in the NFKSC as reported by Edeoga *et al.* (2006) and Diarra *et al.* (2010). This result was supported by the reports of Kategile *et al.* (1978); Siriwardene and Manamperi (1979); Kadirvel *et al.* **(**1986) and Narahari and Rajini (2003). Researchers listed above all reported reduction in feed intake, poorer feed conversion and consequently poorer body weight gain with increase in the dietary level of NFKSC in broiler diets. The poor results they observed were attributed largely to the presence of tannin in the diets. Toxic effects of increasing level of tannin appeared to be responsible for the significant increase in the mortality rate observed in this study. Narahari and Rajini (2003) reported that 9% NFKSC was the dietary limit beyond which toxicity began to show in chicks. Siriwardene and Manamperi (1979) however observed that NFKSC had no adverse effect at 10% inclusion level, but increased mortality at higher levels were recorded. Kadirvel *et al.* (1986) also observed that NFKSC at concentrations of 20% and above in chick diet was highly toxic. Cost per kilogram gain also revealed that feeding NFKSC in diet above 5% replacement of GNC level resulted in negative economic return.

5.2.2 Performance of broiler finisher chickens fed diets containing non-fermented KSC as replacement for groundnut cake (5-8 weeks)

Results of feeding broilers finishers graded levels of NFKSC in diets showed that broiler finisher birds could not adapt favourably to the adverse effect of anti-nutrients in the diets even at the older age. The only form of adaptation noticed was a reduction in the mortality level which could be traced to report given by

Sarkiyayi *et* al. (2009) where they reported that advancement in age helped to create a physiological balance in birds administered tannin rich diets.

As in the starter feeding trial, it was observed that the final live weights and weight gains decreased significantly (P<0.05) with increase in the levels of NFKSC in the diets. These observations were in agreement with the reports of Kategile *et al.* (1978); Siriwardene and Manamperi (1979); Kadirvel *et al.* **(**1986) and Narahari and Rajini (2003). Feed intake, final live weight and weight gain also decreased with increase in the dietary levels of NFKSC (P<0.05) which also agreed with the report of Thanu *et al.* (1983) and Narahari and Rajini (2003). However, cost per kilogram gain analysis showed that incorporation of NFKSC in broiler finisher diet above 5% replacement of GNC exerts negative economic influence.

5.3 Carcass Characteristics of Broilers Finisher Chickens Fed Diets Containing Non-Fermented KSC as Replacements for Groundnut Cake.

It was also observed that increase in NFKSC levels in the diets resulted in significant reductions in final weights and carcass yields. These findings agreed with the reports of Narahari and Rajini (2003) and Thanu *et al.* (1983). On the contrary, the mean values for liver showed significant increase in weight (P< 0.05) with increase in the NFKSC level, which was also in agreement with the reports of Narahari and Rajini (2003) and Kadirvel *et al.* (1986). The former also observed enlargement of the gall bladder which they attributed to the damage done to liver cells. Increase in size of liver with incremental dietary NFKSC could linked to hypertrophy of the liver due to compensatory growth as a result of damages caused to the organ due to effect of toxins, particularly, tannin (Narahari and Rajini, 2003). The non-significant differences (P>0.05) noticed with most of the visceral organs (i.e heart, gizzard, kidney and lung) showed that toxicity of NFKSC did not affect

these organs negatively as reported by Narahari and Rajini (2003). On the other hand, mean intestinal length of birds fed 10% and 15% NFKSC diets were similar. The significant increase ($P< 0.05$) observed in the intestinal length occurred probably as a result of increase in the dietary KSC level which might have stimulated higher metabolic activities in the intestine as reported by Butler (1986).

5.4 Effects of feeding Diets Containing Non-Fermented KSC as Replacement for Groundnut Cake on Nutrient Digestibility of Broiler Finisher Chickens

Result obtained from digestibility study revealed that crude protein digestibility reduced significantly ($P< 0.05$) across dietary treatments with increase in dietary NFKSC level, a trend similar to what was reported by Kategile *et al*. (1978) and Kadirvel *et al*. (1986) where growth depression in chicks fed diets containing NFKSC were observed, which were linked partly to high fibre content of the diets and largely to poor digestion due to detrimental effect of tannins which did not only bind proteins in diet but also inhibit the action of digestive enzyme on ingested feed. Detrimental effects of tannins on protein digestibility of chicken as well as its capacity to bind nutrients especially proteins and carbohydrates have been reported by numerous researchers including Armstrong *et al.* (1974); Rubio *et al.* (1989) and Olomu (1995).

5.5 Some Haematological Parameters of Broiler Finisher Chickens Fed Diets Containing Non-Fermented KSC as Replacement for Groundnut Cake

Results obtained for haemoglobin and packed cell volume for birds fed 0-10% NFKSC were within normal ranges and in agreement with studies by Issa *et al.* (2007) and Ahaotu *et al.* (2013) in which they report ranges of 9.33-10.2 g/dl and 28.10-30.67% respectively, for both parameters. Results obtained for total protein were also in agreement with reports given by Thanu *et a.*, (1983) and Narahari and

Rajini, (2003) in which they reported decline in total protein level with increase in level of kapok meal in poultry diet. Parameters like haemoglobin and PCV gave values that were within the ranges that can be considered as normal physiologically acceptable levels up to 10% dietary NFKSC inclusion level. Higher dietary NFKSC levels were reported to be toxic, as they tend to compromise the health status of the birds. Reports of studies carried out by Sarkiyayi *et al.* (2009) on acute and chronic toxicity profile of *Ceiba pentandra* showed that all the parameters studied (serum, bilirubin, PCV and creatinine) were affected but the values recorded were still within the normal physiological ranges, revealing that the health status of birds may not be compromised.

5.6. Performance of Broiler Chickens Fed Diets Containing Fermented or Non-fermented KSC as Replacement for Groundnut Cake

5.6.1 Performance of broiler starter chicks fed diets containing fermented or non-fermented KSC as replacement for groundnut cake (0-4 weeks)

The result for feed intake revealed that birds fed on 10% fermented KSC had the highest ($P< 0.05$) mean value for feed intake. This response may be attributed partly, to the lower tannin levels of the fermented KSC diets which appeared to have led to increase in feed intake. The improvement in feed intake for the fermented KSC diets could also be as a result of fermentation process that improved the palatability of the fermented KSC diets (Dei *et al.*, 2008; Iyayi and Aderolu, 2004). A similar report was given by Annongu *et al.* (1996) where a reduction in the adverse effect of anti-nutritive factors such as tannins led to increased feed intake in a fermented shea nut meal feeding trial with broilers. The lower feed intake recorded from birds fed diet containing 15% NFKSC may be attributed to higher levels of tannin in the diet which was in agreement with the reports given by

Armstrong *et al.* (1974) and Rubio *et al.* (1989). The destruction of tannin and improvement in the acceptability of the fermented KSC diet stood out as the overall benefit. Better average weight gain, feed conversion ratio, improved health and efficiency of feed utilisation were noticed with the fermented KSC diets when compared with the NFKSC diets. These occurred probably due to higher feed intake and better nutrients utilisation (Perderson *et al.,* 2000; Iyayi and Aderolu, 2004). Higher performance recorded for the dietary treatment with fermentation and the treatment without fermentation was due to the fact that fermentation has reduced the effect of antinutritional factors such as tannin in the starter phase; This observation agree with the reports of several researchers (Narahari and Rajini, 2003; Thanu *et al.* 1983). Cost benefit analysis based on cost per kilogram gain showed that birds GNC can be replaced with FKSC in starter diet up to 15% substitution level without negative economic impact.

5.6.2 Performance of broiler finisher chickens fed diets containing fermented or non-fermented KSC as replacement for groundnut cake (5-8 weeks)

In this feeding trial, optimum growth in terms of average weight gain and final body weight recorded for birds fed control (0% KSC) and 10% FKSC diets were similar and in agreement with reports of Pederson *et al.,* (2000) and Dei *et al.,* (2008) in which they observed improved growth and better digestion and nutrient utilisation. Improved growth and reduced mortality also indicate vigour and healthier condition as reported by Annongu *et al.,* (1996) and Olorede *et al.,* (1999). Pederson *et al.,* (2000) also reported better protein digestion due to fermentation while studies by Iyayi and Aderolu (2004) showed that diets containing fermented fibrous agro-industrial by- products significantly enhanced growth and laying

performance. On the contrary, results obtained by Armstrong *et al.,* (1974) did not show any improvement in the growth of birds fed fermented shea nut diet, although the tannin level was reduced, they however reported that the level of the residual tannin after fermentation of the shea nut was sufficient to inhibit growth.

Higher performance recorded for the dietary treatment with fermentation and the treatment without fermentation was due to the fact that fermentation has reduced the effect of antinutritional factors such as tannin in the finisher phase. This observation agrees with the reports of several researchers Thanu *et al.* (1983) and Narahari and Rajini (2003). Result obtained on cost per kilogram gain revealed that fermentation improved the utilization of FKSC in diet by birds. Hence, it allowed up to 15% of replacement of GNC without affecting cost per kilogram gain, negatively. This could have been possible due to reduction in tannin level (about 45%) which was observed after fermentation.

5.7 Carcass Characteristics of Broiler Finisher Chickens Fed Diets Containing Fermented or Non-Fermented KSM as Replacement for Groundnut Cake

The observation made in this study was that birds fed with diet containing 10% fermented KSC level yielded carcass comparable with those fed with the control diet. This result was in agreement with reports given by Akande *et al.,* (2010) and Ari *et al.,* (2011). These researchers attributed their result to the lowering of the tannin level in the experimental diets and this led to better digestibility and nutrient utilisation. Some prime-cuts like the breast and the drum stick of the birds fed 10% fermented KSC diets compared favourably with those of the birds fed the control diet and this could be an indication of better feed digestion, absorption and nutrient utilisation leading to better growth and improved weight

gain as reported by Narahari and Rajini (2003) and Ari *et al.* (2011). Visceral organs such as the liver, heart, lungs, gizzard and kidneys gave values that were within the normal sizes, across the dietary treatments. These could be an indication of safety of the birds produced for human consumption and better health status of the birds. This result was supported by the report of Narahari and Rajini (2003).

5.8 Nutrient Digestibility of Broiler Finisher Chickens Fed Diets Containing Fermented or Non-Fermented KSC as Replacement for Groundnut Cake

Results of the digestibility study revealed that fermentation greatly improved nutrient digestibility of the KSC diets. The improvement observed could partly be due to lower tannin level as reported by Nelson *et al.* (1975); Smulikowska *et al.* (2001); Narahari and Rajini (2003) and Dei *et al.* (2008). It could also be partly due to microbial activities during the process of fermentation which improved the efficiency of breaking down the complex feed structural materials like the fibres and at the same time increasing the bacterial protein for digestion and utilization as reported by Pederson *et al*. (2000); Iyayi and Aderolu (2004); Akande *et al.* (2010) and Ari *et al.* (2011). According to Butler *et al.* (1986), the traditional fermentation of foods serves several functions which included development of a diversity of flavour (aroma), enrichment of the food substrate biologically with microbial proteins, essential amino acids, essential fatty acids and vitamins, as well as detoxification during food fermentation processing.

5.9 Some Haematological Parameters of Broiler Finisher Chickens Fed Diets Containing Fermented or Non-Fermented KSC as Replacement For Groundnut Cake

The haemoglobin and packed cell volume recorded in birds fed 0 and 10% FKSC are similar and in agreement with values recorded by Ahaogu (2013) which reported 9.33-10.1 g/dl and 28.1-30.67 %, respectively for haemoglobin and packed cell volume. Total protein value of 65.5-79.2 g/dl was reported by Nkwocha *et al.* (2014) which is in agreement with values recorded for birds fed 0 and 10% FKSC diets indicating better protein metabolism resulting from reduced effect of tannin on protein digestion and utilization. Total Protein levels recorded for the birds fed 10% FKSC diet when compared with the values obtained for the (0% KSC) control diet showed that fermentation has positive effects on KSC utilization. This observation was also in agreement with report given by David *et al*, (2003) who reported that total protein, albumin, and globulin values were comparable ($P>0.05$*)* with the control, for birds fed fermented tannin-rich *Terminalia catappa* fruit meal up to 60% replacement of maize in broiler diet. However, total protein, albumin, and globulin decreased when higher dietary inclusion level of the test ingredient was fed which is in agreement with report given by Ahaotu *et al.* (2013).

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

The need to make animal protein affordable in the meals of average Nigerians cannot be over-emphasized. Since feed accounts for about 60 to 70% of the total cost of production, it is imperative that cost of feeding must be reduced to allow for cheaper affordable animal products to meet nutritional needs. In view of this fact, Kapok seed cake (a non conventional feedstuff) which is a cheap and abundant by-product of the oil-milling industries was considered for this study. It was subjected to proximate analysis to determine its nutritional value. The results showed that KSC has some potential as a feed ingredient in broiler diet formulations. It was however found to contain some anti-nutritional factors principally, tannin which limits its usefulness as poultry feed ingredient.

Two feeding trials were conducted to evaluate the nutritive value of Kapok seed cake (KSC) in broiler diets. In the first feeding trial, graded levels of NFKSC was, incorporated as a replacement for the groundnut cake in broiler chicken starter and finisher diets at 0, 5, 15 and 20% levels. The results obtained showed that 5% NFKSC could effectively replace groundnut cake in broiler diets without adversely affecting growth performance, carcass characteristics and vital blood chemistry. In the second feeding trial, NFKSC and FKSC were fed at 0, 10 and 15% dietary levels as replacements for the groundnut cake in broiler chicken diets. The results showed that 96hrs of fermentation reduced the tannin content of the KSC to the lowest level possible (45%) and also preserved its nutritional value. Broiler chickens were able to efficiently utilise fermented KSC up to 10% dietary level

without adversely affecting growth performance, carcass characteristics and vital blood chemistry.

6.2 Conclusion

1. NFKSC can be incorporated at 5% dietary level in broiler starter and finisher diets without negative effect on growth performance and economic viability; which represents 20 and 25% replacement of groundnut cake, respectively.

2. Fermentation for 96 hrs improved the utilization of KSC up to 10% dietary inclusion for both starter and finisher diets without adversely affecting growth performance and economics of production; which represents 40 and 50% groundnut cake replacement, respectively.

3. That a feeding standard can be developed for the use of KSC in poultry diets since its proximate composition is known as well as the various anti-nutrients present in KSC. Hence, the common practice of using it to adulterate other oil seed cakes (like groundnut and sesame seed cakes) can be discouraged.

4. Cost benefit analysis revealed that fermentation improved utilization of
5. FKSC by both broiler starter and finisher chickens up 10% inclusion.

6.3 Recommendations

It is therefore, recommended that 5% NFKSC and 10% FKSC may be incorporated into both starter and finisher diets for optimum growth performance and economic benefit.

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APPENDIX

Appendix1: Nutrient Requirements of Broilers as Percentages or Units per Kilogramme of Diet (90% dry matter)

Nutrient	Unit	0-3wks	3-6wks	6-8wks
Protein/amino acids				
Crude protein	%	23.00	20.00	18.00
Arginine	%	1.25	1.10	1.00
Glysine+serine	%	1.25	1.14	0.97
Histidine	%	0.35	0.32	0.27
Isoleucine	%	0.80	0.73	0.62
Leucine	%	1.20	1.09	0.93
Lysine	%	1.10	1.00	0.85
Methionine	%	0.50	0.38	0.32
Methionine+cyctine	%	0.90	0.72	0.60
Phenylalanine	%	0.72	0.65	0.56
Phenylalanine+tyrosine	%	1.34	1.22	1.04
Proline	%	0.60	0.55	0.46
Threonine	%	0.80	0.74	0.68
Tryptophan	%	0.20	0.18	0.16
Valine	%	0.90	0.82	0.70
Fat				
Linoleic acid	%	1.00	1.00	1.00
Macro-minerals				
Calcium	%	1.00	0.90	0.80
Magnesium	mg	600	600	600
Potassium	%	0.30	0.30	0.30
Sodium	%	0.20	0.15	0.12
Trace minerals				
Iron	mg	80	80	80
Manganese	mg	60	60	60
Selenium	mg	0.15	0.15	0.15
Zinc		40	40	40
Fat soluble vitamins				
A	IU	1,500	1,500	1,500
D_3	ICU	200	200	200
E	IU	10	10	10
K	mg	0.15	0.15	0.15
Water soluble vitamins				
B_{12}	mg	0.01	0.01	0.007
Biotin	mg	0.15	0.15	0.12
Choline	mg	1,300	1000	750
Niacin	mg	35	30	25
Pantothenic acid	mg	10	10	10
Pyridoxin	mg	3.5	3.5	3.0
Riboflavin	mg	3.6	3.6	3.0
Thiamine	mg	1.80	1.80	1.80

Source: National research council (NRC) 1994.

Appendix 2: Chemical Composition Of Fermented and Non-Fermented Sorrel Seed Meal Compared With Full-Fat Soyabean Meal.

Parameter	RSSM	FSSM	Soyabean meal
Crude protein (%)	38.57	38.59	37.00
Crude fibre (%)	13.50	15.25	5.50
ME (kcal/kg)	3500.10	3563.04	3300.00
Calcium (%)	0.33	0.31	0.25
Phosphorus (%)	0.55	0.51	0.58
Lysine (%)	2.58	2.64	2.4
Methionine (%)	1.33	1.20	1.51
Tannic acid (mg/g)	3.29	2.59	NR
Tannin reduction (%)	Not determined	30.40	Not determined

RSSM = Raw Sorrel Seed Meal; FSSM = Fermented sorrel seed meal; * Metabolizable Energy calculated according to Pauzenga, (1985) as ME = 37 x % CP + 81 x % EE + 35.50 x % NFE; NR = Not reported.
Source: (Isidahomen, *et al.*, 2006)