COMPARATIVE EVALUATION OF THREE SEED CAKES PARTLY SUBSTITUTING SOYA BEAN CAKE IN BROILER CHICKENS DIET WITH AND WITHOUT MULTIENZYMES SUPPLEMENTATION

BY

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THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS DEGREE IN ANIMAL SCIENCE

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DECLARATION

I declare that the work in this thesis titled "COMPARATIVE EVALUATION OF THREE SEED CAKES PARTLY SUBSTITUTING SOYA BEAN CAKEIN BROILER CHICKENS DIET WITH AND WITHOUT MULTIENZYMES SUPPLEMENTATION" has been carried out by me in the Department of Animal Science, Ahmadu Bello University, under the supervision of Prof.P. A. Onimisi and Prof. A. A. Sekoni. The Information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other institution.

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CERTIFICATION

This thesis titled **"**COMPARATIVE EVALUATION OF THREE SEED CAKES PARTLY SUBSTITUTING SOYA BEAN CAKEIN BROILER CHICKENS DIET WITH AND WITHOUT MULTIENZYMES SUPPLEMENTATION" by Fadila Nuhu SHEHUmet the regulation governing the award of 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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ABSTRACT

Two feeding trials were conducted to evaluate the growth performance, nutrient digestibility, haematological profile, lipid profile, liver function and economic benefit of feeding groundnut cake(GNC), roselle seed cake(RSC) and baobab seed cake (BSC) partly substituting soya bean cake(SBC)to broiler chickens with and without multienzymes supplementation. A total of 352Cobb500 broiler chicks were used for the first feeding trial, they were randomly assigned into four dietary treatments each replicated four times with 22 birds in a completely randomized design (CRD). The same breed of broiler chicks were used for the second trial, they were randomly allotted into five dietary treatments each replicated three times with 22 birds and the experimental design was the same as in the first trial.Maize-soya bean cake diet served as control T1 for both trials, GNC, RSC and BSC partly substituting soya bean cake at 20% in the first trial served as T2, T3 and T4for starter and finisher phases respectively. In the second trial, RSC and BSC partly substituting soya bean cake at 20% inclusion with and without multienzymes supplementation served as T2, T3, T4 and T5for starter and finisher phases respectively. Data generated were analyzed using analysis of variance (ANOVA)and means were separated using least significant difference(LSD). The growth performance of birds on SBC diet for the first trial was significantly (P<0.05) better than other groups on final weight (959.81g), weight gain (909.12g), feed cost per kg gain (195:86 ₦/kg) and feed conversion ratio (1.77) at starter phase. At finisher phase, performance of birds on SBC was similar (P>0.05) to GNC group on final weight (2.672 and 2.52 kg), weight gain (1790.57 and 1688.97g) and feed conversion ratio (2.29 and 2.26). Feed cost/kg gain (FC/kgG) was significantly (P<0.05) better for SBC(195:86 ₦/kg)at starter phase while at finisher phase, birds on GNC had the least value (229:50 ₦/kg).Digestibility of all nutrients was higher (P<0.05) for birds on RSC diet. Breast weight was higher (P<0.05) for SBC (29.03%) and RSC (30.55%) and gizzard weight was significantly (P<0.05) highfor birds fed diet containing BSC (3.41%).Haematological profile analysis indicated that the birds were in good health condition. Lipid profile of the birds showed that birds fed RSC had least (P<0.05) cholesterol (79.60 mmol/L) and low density lipoprotein levels(13.30 mmol/L). However, higher gross margin was realized for treatment groups fed SBC (₦ 1090:40) and GNC (₦1076:65) diets. Result on growth performance in the second trial for both starter and finisher phases showed that birds on SBC diet performed significantly (P<0.05) better than other treatment groups. Supplementation with multienzymes did not significantly (P>0.05) improved the final weight and weight gain for bird on RSC and BSC diet at starter and finisher phases. Carcass characteristics of some cut parts (breast and back), organs (liver, heart, gizzard and lungs) and abdominal fat were significant (P<0.05) with multienzymes addition. Haematological profile, liver function indices and lipid profile of the birds were not significantly (P>0.05) affected with multienzymes supplementation. Addition of multienzymes significantly (P<0.05) improved the digestibility of all nutrients except for crude fiber and ether extract. Birds fed SBC diet had the highest gross margin (₦1052:36), but birds on BSC + E and BSC groups had better return/₦ invested (₦ 2.50 and 2.40). Supplementation of RSC and BSC with multienzymes partly substituting SBC at 20% in broiler chickens diet did not improve the final weight and weight gain for the birds but it slightly improved return/₦ invested for BSC + E and BSC groups by ₦ 0.13 and 0.03. Therefore, GNC at 20% can partly substitute SBC in finisher diet for improved performance, to reduce production cost and to increase profit. Also RSC at 20 % can partly substitute SBC for bigger breast muscle yield and BSC at 20% to reduce feed cost/kg gain at starter phase.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Population growth in developed countries is stabilizing and that of less developed countries including Nigeria is increasing rapidly (Mailafia *et al*., 2010), therefore agricultural outputs such as livestock and food-crops need to be increased through local production rather than through importation into such countries (Allen, 1993). Livestock species that play a major role in animal production within these countries need to be explored and evaluated to meet up with the population challenge, because the population trend continues as indicated by the economic indices (Mailafia *et al*., 2010). Low animal protein intake is a major nutritional problem in Nigeria, especially for the low income and non-wage earners (Amaefule and Obioha, 2005), and according to FAO (2011) report, poultry products make up 0.60 % of the average 2077 kcals per person per day in Africa

Livestock products such as poultry (chicken, turkey, guinea fowl etc), sheep, goat and cattle meat are mostly consumed as animal protein by humans. In Nigeria, poultry production especially broiler chicken has improved with increase in human population and the number of people that need to be fed. They are commonly raised by small holder farmers and large scale intensive enterprises, they are efficient in utilizing feed and gain weight within a short period, they serve as a source of protein to man. Broiler chickens possess a number of features that is of advantage to the small-scale integrated farmer as it also serves as a source of income (Mapiye *et al*., 2008; Mwale*et al*., 2008).They require protein of both plant and animal origin for proper growth and development, but the amino acid balance in animal protein is higher than that of plant sources, and they are more expensive. To bridge the gap for protein deficiency and to maximize animal protein supply and consumption in Nigeria, broiler chicken production need to improve by reducing the cost of feeding (feed ingredients), which will in turn reduce the cost of production.

Oil-seed cakes are obtained as by-products after oil extraction and are valuable animal feed materials (Groundnut Hand Book, 1984), they are the largest cost item by volume in poultry feed milling plants (Refstie *et al*., 1999). Soyabean (*Glyciine max*) and Groundnut (*Arachishypogaea L*) are conventional feed materials; their cakes are among the major plant protein sources used for chicken diet. Soya bean is an important source of protein for chicken due to its excellent amino acid composition and high level of digestibility (Sara Willis, 2003), but it is expensive and highly consumed by humans. In relation to the nutritive requirement of monogastric animals, groundnut is deficient in methionine, cystein and lysine, however, it is not good for chicks and young pigs (Groundnut Handbook, 1984).

The major constraint in chicken production is the use of conventional feedstuffs that are costly and not readily available (Ravindran, *et al*., 1982) and are consumed by humans. To increase growth rate, reduce the cost of feeding and production, there is a need to look for locally available and cheap non-conventional feed ingredients such as leaf meals and cakes (Leakey, 1999), particularly those with low cost. Rosell seed cake (RSC) and Baobab seed cake (BSC) are non-conventional feed materials with low cost compared to groundnut cake (GNC) and soya bean cake (SBC).

Roselle (*Hibiscus sabdariffa L.*) is cultivated in countries such as Egypt, India, Mali, Malaysia, Nigeria, and Sudan, it has been found to contain high amount of protein, dietary fiber, lipids, and minerals (Balogun and Olatidoye, 2012). Ahmed (1980) stated that the seeds contain 17.80 – 21% non-edible oil and 20% protein, Ahmed and Noor (1981) reported that they were sometimes used for animal feed. The raw roselle seed have bitter taste and anti-nutritional components like tannins.

Baobab (*Adansonia digitata*) also called “Kuka“ in Hausa Languageaccording to Sidibe and Williams(2002) is rich in protein (20-36 % CP) and energy (1898 - 4465 KCal/kg), it provides fiber, vitamins, minerals and amino acids, particularly, lysine and methionine which are limiting in most cereals and are essential for livestock growth and development (Glew*et al*.,1997; Murray *et al*., 2001) . They are also rich in lysine, thiamine, minerals like calcium and iron (Booth and Wickens, 1988). Baobab seed cake contains some anti-nutritional factors (such as oxalate, phytate, saponins, amylase inhibitors and tannins) but their levels are below the toxic levels for most livestock species, including poultry (D’Mello, 1995; Nkafamiya*et al*., 2007). The seed cake left after extraction of the oil, is usually fed to animals (Sidibé and Williams, 2002).

The conventional and non-conventional feed materials contain anti- nutritional factors that are undesirable and affect the bioavailability of the nutrient in feed. The anti-nutritive carbohydrates reduce digestion and absorption of all nutrients in the diet, especially that of fat and protein (Adams and Pough, 1993). Diets with these feed materials containing high level of tannin could hinder endogenous enzyme action, there by slowing the rate of digestion by broiler chickens (Velmurugu, 1990) and it could bond with nutrients in feed material (Narahari and Rajini, 2003). These anti-nutritional components could be deactivated by processing methods such as moist heat treatment, dry heat treatment and soaking in water (Yacoub and Abdalla, 2007) and by enzyme addition in poultry feeds (Allen *et al*.,1995).

Exogenous enzymes such as xylanase, glycanase, protease and phytase etc could be used to improve digestion (Oyebode, 2015), some of them that have been used over several years in the feed milling industries include cellulase (ß-glucanases), xylanases and associated enzymes, phytases, proteases, lipases, and galactosidases (Annison and Choct, 1993). Commercial packages introduced into Nigerian market include; Maxigrain, Rovabio , Allzyme and Fullzyme (Oyebode, 2015). They have mostly been used in the feed for poultry to neutralize the effects of the viscous, non-starch polysaccharides used in the feeds (Allen *et al*., 1995).

1.1 Justification

For Nigeria to rank among the top chicken consuming countries in the world, broiler chicken production need to be exploited and evaluated, to meet the protein requirement of average Nigerians as protein deficiency is a problem in most developing countries like Nigeria; with increase in population as more people are needed to be fed (Mailafia*et al*., 2010). One of the limiting factors in chicken production is that they require feeds ingredients which are expensive and are consumed by man e.g soya bean meal is used as protein source in chicken diet (Sara Willis, 2003). This attracts competition with other animal and man for food, and leads to increase in cost of feedstuffs. Hence there is need to substitute these ingredients with cheaper and more available plant proteins like roselle seeds cake and baobab seed cake. Baobab and roselle seed cakes contain some anti-nutritional factors (such as oxalate, phytate, saponins, and tannins) but their levels are generally below the toxic levels for most livestock species, including poultry (Nkafamiya*et al*., 2007). Anti-nutrients, diet energy, fiber content and palatability are important factors impacting feed consumption and performance in poultry. Therefore, commercial packages containing endogenous enzyme such as xylanase, glycanase, protease and phytase etc could be utilized to neutralize the effect of anti-nutrient (Allen *et al*., 1995) and other factors that affects poultry production.

1.2 Objectives

The main objectives of the study were to:

1. Evaluate the growth performance and nutrient digestibility of groundnut, roselle and baobab seedcakes partly substituting soya bean cake in broiler chickens diet with and without multienzymes supplementation.
2. Assess the haematological profile, liver function indices and lipid profile of the broiler chickens fed groundnut, roselle and baobab seed cake diets partly substituting soya bean cake with and without multienzymes supplmentation.
3. Evaluate the economic benefit of feeding groundnut, roselle and baobab seed cakes diets partly substituting soya bean cake with and without multienzymes supplmentation to the broiler chickens.

1.3 Hypothesis

H_o There is no difference in growth performance and nutrient digestibility of groundnut, roselle and baobab seed cakes partly substituting soya bean cake in broiler chickens diet with and without multienzymes supplementation.

H_a There is difference in growth performance and nutrient digestibility of groundnut, roselle and baobab seed cakes partly substituting soya bean cake in broiler chickens with and without multienzymes supplementation.

H_oThere is no difference in the haematological profile, liver function indices and lipid profile of the broiler chickens fed groundnut, roselle and baobab seed cake diets partly substituting soya bean cake with and without multienzymes supplementation.

H_aThere is difference in the haematological profile, liver function indices and lipid profile of the broiler chickens fed groundnut, roselle and baobab seed cake diets partly substituting soya bean cake with and without multienzymes supplementation.

H_o There is no difference in economic benefit of feeding groundnut, roselle and baobab seed cakes diets partly substituting soya bean cake with and without multienzymes supplmentation to the broiler chickens.

H_a There is difference in economic benefit of feeding groundnut, roselle and baobab seed cakes diets partly substituting soya bean cake with and without multienzymes supplmentation to the broiler chickens.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Conventional Feed Ingredients and Non-Conventional Feed Ingredients

Soya bean meal, groundnut and roselle seed cakes respectively are the three most commonly used protein supplements/sources for broiler chickens diet in Nigeria. These seed cakes are becoming more expensive due to increase in production and high demand for meat, egg and feed ingredients and are referred to as conventional feed ingredients.

Soya bean cake is ideal source of protein in monogastric animals feeding with high energy due to significant fat content and low fiber content(Nahashon and Kilonzo-Nthenge, 2013).Sontakke *et al.*(2014) described the term non-conventional feed ingredients (NCFIs) to as all feeds that have not been utilized traditionally or are not practically used in animal feeding and in commercial rations produced for livestock. They are mostly from variety of crops that are perennial or feeds of animal and industrial origin.The term NCFIs has been used to describe novel ingredients such as oilseed by-products, single cell proteins, feed material derived from agro-industrial by-products of plant origin like; by-products from the processing of sugar, cereal grains, citrus fruits, poor-quality farm aftermaths such as stubbles, haulms, vines and vegetables from the processing of food for human consumption and animal origin such as; slaughter-house by-products. Conventional feed materials like soya bean, groundnut and roselle seed cakes that are commonly used as protein source and can be replaced with other non-conventional feed material. Non-conventioanal ingredients like kapok, jastropha, baobab, and cotton seed cakes etc can be used to reduce cost of production and marginalize profit since they are less expensive compared to the conventional ingredients.

Batal *et al*. (2005) revealed that groundnut cake corrected metabolizable energy ranged from 2,273-3,009 kcal/kg with a mean of 2,664 kcal/kg while the crude protein ranged from 40.10 to 50.90% with a mean of 45.60 %. It has comparable crude protein content with soya bean meal (Adeniji, 2008). Groundnut cake and soya bean meal can be replaced at 50 and 75% by Roselle seed cake in broiler starter and finisher diets (16 and 24% dietary RSC inclusion) for better performance (Ojile, 2017).

2.1.1 Leaf meals

These are obtained from local indigenous multipurpose trees such as *Moringa olifera*, Neem, and curry leaf (Leakey, 1999). Their utilization will reduce the cost of feed and maximize profit from poultry farming since most of them are not edible to man but are readily available. Most of the leaf meals incorporated into poultry diets are used as additives to serve as an antioxidant or antibiotics.

2.1.2 Seed meals

They are by-products of indigenous tree products (Leakey, 1999) that serve as potential source of plant protein for chickens. They include all seed meals of such products like; roselle, baobab, soya bean and groundnut. They are processed and incorporated into animal feed without extracting oil from the seeds. Utilization of non-conventional feedstuffs especially when it encourages a shift to other ingredients (leaf meals and tree seed cakes) that are not edible to man and are locally available will reduce feed cost and maximize returns from poultry farming.

2.1.3 Oilseed cakes

Chimvuramahwe *et al.* (2011) described seed cakes as low-cost and locally available protein sources in livestock diets for African Agriculture. Most of them are not edible to man but are locally available, reduce production cost and maximize profit. Oil cakes areindustrial by-products that areextensively used in livestock and poultry feeds due to their rich content of essential amino acids (Tekeli, 2014). Many reasons may cause variations in chemical (proximate) composition of oil seed cakes (Babiker *et al*., 2009) such as soil type, season of growing and harvesting, variety, type of storage and the degree of processing, dehulling degree and method of oil extraction.

2.1.3.1Roselle seed cake

It belongs to the family Malvaceae, it is locally called “karkade” (Copley, 1975) and is an annual erect shrub (Bailey and Bailey, 1976). The two botanical types of roselle are *Hibiscus sabdariffa var. sabdariffa* and *Hibiscus sabdariffa var. altissima* (Purseglove, 1974). Rosell seed cake (RSC) is one of the NCFIs that is not traditionally used for feeding of livestock, but with increase awareness, it is gaining more importance in poultry feed industries to reduce feed cost.

Roselle seeds are rich in proteins, dietary fibre, carbohydrates and fats as reported by Abu Tarboush *et al.* (1997). They contain high level of minerals such as calcium, magnesium and phosphorus, roselle seed has recently been foundto contain 38.57%CP, 13.50 % EE, 16.50 % CF, 5.18% Arginine, 2.58% Lysine and 1.33% Methionine (Kwari *et al*., 2011). Igoche (2015) fed diet containing graded levels of roselle seed cake with and without amino acid supplementation to broilers chickens and reported that roselle seed cake significantly improved feed intake, increased weight gain, average daily gain and final weight across the treatment groups.

2.1.3.2Baobab seed cake

Baobab plant belongs to the family Malvaceae (De Caluwé *et al*., 2010), it is distributed throughout the hot and drier regions of tropical Africa (FAO, 1988). The seed has high crude protein and essential amino acid (Chimvuramahwe*et al.*, 2011), the seed and seed cake contains anti-nutritional factors such as oxalates, phytates, saponins, and tannins, but are generally below the toxic levels for most livestock species and poultry inclusive (D'Mello, 1995; Nkafamiya *et al*., 2007). It produces seeds that are rich in protein

(20-36 % CP) and energy (1 898 - 4 465 kCal/kg), it also provides some necessary fiber, vitamins, minerals and amino acids, particularly, lysine and methionine which are limited in most cereals and are essential for livestock growth and development (Glew *et al*., 1997; Murray *et al*., 2001).

Chimvuramahwe *et al*. (2011) and Saulawa *et al*. (2014) also reported that baobab seedcake could be used in broiler diet without negative effect on productive performance, and it has good aroma that improved feed intake. Biochemical analyses by many researchers showed that the seeds from baobab are rich in nutrients (Diop *et al*., 2005; Nkafamiya *et al*., 2007; Chadare *et al*., 2009). A great variation was revealed by literatures on the nutrient contents of baobab parts which may be due to many factors such as, storage conditions, processing techniques, quality and treatment of the sample before analysis, age of the sample, soil quality and genetic variation (Chadare*et al*., 2009).

The seeds have also been used for their anti-pyretic properties (Wickens and Lowe, 2008);they also have shown antiviral activity against some viruses like; influenza virus, herpes simplex virus and respiratory syncytial virus (Vimalanathan and Hudson, 2009) and polio (Anani *et al*., 2000). It contains various bioactive ingredients including triterpenoids, flavonoids and phenolic compounds (Chadare *et al*., 2009). The seeds contain an antidote to poisoning by *Strophanthus* species (Sidibe and Williams, 2002). Kabore *et al*. (2011) also reported that the seeds contain the alkaloid "adansonin", which has a strophanthus-like action. Seeds are used in cases of diarrhea, seedcake left after pounding to extract seed oil are usually fed to animal and other livestock (Sidibé and Williams, 2002).

It can maximize financial returns for poultry producers because it is less expensive and can be taken as an advantage at low inclusion levels to lower the cost of broiler diets. The seed has a relatively thick shell and the kernel is edible but decortication seems to be difficult, therefore the seed cake is underutilized and its use as food or feed is limited and consequently large quantities go into waste (Muataz, 2019). Chimvuramahwe *et al*. (2011) reported that high crude protein and essential amino acid levels in baobab seed cake could be taken as an advantage to cut down the cost of broiler feeds at low inclusion levels. They reported that it economically reduced the total feed cost in broiler chick diets. Therefore it could be a valuable ingredient in broiler chick diets at 10 % inclusion level as it maximized financial returns.

2.1.3.3Kapok seed cake

Kapok seed also known as silk cotton seed contain 0.30 to 20g/kg DM of a yellow pigment known as gossypol that is particularly toxic to animals. Orwa *et al.* (2009) stated that the pressed kapox cake contained about 26% crude protein and could be fed to cattle and other livestock could utilize it as a protein source. Ari *et al.* (2011) who fed diet containing toasted and untoasted kapok seed to broilers concluded that, 50% replacement of soyabeans with toasted kapok seed meal is a desirable substitute for soya bean. Oyebode (2015) who fed fermented and non-fermented kapok seed cake as replacement for groundnut cake to broiler chicken also concluded that fermented seed could be included at 10% while non-fermented at 5% for both starter and finisher phases.

2.1.3.4Jatropha seed cake

This is a by-product of bio-fuel that is rich in protein (56.40 %), if not contaminated by the shell during processing as stated by Makkar and Becker (1999). The protein content is higher than that of soybean meal (48%). Contamination with the shell lowers protein and increase fiber and lignin contents. Its utilization is limited by the presence of several anti-nutritive and toxic compounds like; lectin, trypsin inhibitor (anti-trypsin), saponin, phytate, and forbolester (Makkar *et al*., 1998), which is considered as the most toxic compound. Pasaribu *et al.* (2010) fed processed Jatropha seed cake to broiler chickens and reported that the processing technology of the seed cake using combined physical and chemical treatments gave better performance without mortality compared to other techniques employed in their experiment.

2.1.3.5Cotton seed cake

Lysine is the first limiting amino acid in cotton seed cake and it is a high protein level feed ingredient (Muataz, 2019). The meal contains about 2110 kcal/kg metabolizable energy and 40-46% crude protein.However, Muataz (2019) stated that its utilization in poultry feed was limited because of the presence of gossypol, high fibre contents and low lysine. The chemical composition of cotton seed cake (CSC) reported by Muataz (2019) is as follows: 21.10 % crude protein, 22.20% crude fiber, 8.50%, 34.60% (NFE) and 6.10 % (Ash). Digestibility of CSC is said to be low because of the presence of gossypol and increased amounts of cell walls.

2.1.4 Method of producing oilseed cakes

Oilseed processing relates to the treatment of thioglucoside-containing oilseeds, such as soya bean, baobab, roselle and groundnut. Certain oilseeds contain thioglucoside which by means of endogenic enzymes are split into the deleterious substances, glucose and bisulphate. Others present in the seed include phenolics such as tannins, and saponin, all of which have negative/positive sensory and nutritional effects depending on their levels in feed. It is also known that these substances could be removed from processed oilseed by aqueous extraction. Seed cake is obtained by extracting oil from oilseeds by two general methods: mechanical pressing and extracting with volatile solvents (hexane) which is employed in large-scale operations for a complete extraction than is possible with mechanical pressing. Mechanical oil expression is mostly preferred by small processors because of its low capital cost and it is not widely used due to low oil output. However, solvent extraction with hexane is the standard practice in most oilseed-processing plants, their capacities range from 100 to 9000 metric tons per day.

2.1.4.1 Mechanical extraction

Mechanical expellers or press are used in this method which is either manual press or engine- driven screw press. This is achieved by exerting sufficient force on confined seed, oil escapes from the ruptured seed cells pressed under high pressure. A small container with perforations either round or slotted that allows liquid component to escape is used to accomplish extraction by compressing the material. It is done either in batch or continuous process; in batch oil is extracted from one batch completely before cleaning and starting over while for continuous process, seeds are continually fed into the machine and as long as the machine is on, oil continues to press out (Herkes *et al*., 2019).

2.1.4.2 Chemical extraction

This process is carried out using a solvent, and the solvent is being recovered either through conventional process or hybrid combining nanofiltration and distillation process. For the conventional process, two distillation columns are used inthis process. The first column concentrates the oil to about 75 % wt which is sent to a second distillation column that operates under a vacuum to avoid oil denaturation. The oil is concentrated to a high purity in this column. In the hybrid process, a nonafiltration unit operating at 20 bar preconcentrates the oil before it is being sent to distillation. It has a retentate and permeatestreams and a distillation column. Oil is concentrated to 10% wt in retentate stream and at permeate stream solvent is almost pure while at the distillation column pure oil is being produced(Baskar, 2019).

2.1.5 Usesof non-conventional feed ingredients

The NCFIs could partly reduce the shortage for conventional type of animal feed materials, decrease competition between humans and animals for food, reduce production cost by lowering feed cost, and provide self- sufficiency in nutrients from locally available feed material (Sontakke *et al.*, 2014). This will help to fill the gap for feed supply as stated by the authors above.

2.1.6 Anti-nutritional factors in non-conventional feed ingredients

Anti-nutritional factors (ANFs) are components of the feed that may have negative effects on the absorption or utilization of nutrients and micronutrients, or that may be toxic when ingested (Liebler, 1993). However, some may exert beneficial health effects at low concentrations and the mechanisms by which adverse and beneficial effects of anti-nutrients in feed operate are the same. They contain secondary metabolites that serve as defense against predators like; herbivores, insects, pathogens or adverse growing conditions (Herbourne, 1989). Many feeds, such as legume seeds, rangeland plants and cereal grains contain ANFs, phytochemicals or toxins. The most important ones are alkaloids, haemagglutinins (lectins), phenolics, phytates, phytooestrogens, saponins, tannins and trypsin inhibitors. The overall efficiency ofnutrient utilization is affected by the levels of phytate in poultry feedby increasing endogenous secretions, decreasing mineral and protein digestibility and solubility (Singh, 2008).

2.1.6.1 Saponin

Saponin content of grain legumes varies between 0.5 and 5% dry weight. They occur widely in plant species and are steroidal or triterpenoid glycosides with considerable biological properties: both beneficial and deleterious, they have bitter taste, have the ability to foam in aqueous solution, hemolyse red blood cell and reduce the palatability of feeds (Liebler, 1993). It may also alter the digestion and absorption of nutrients by inhibiting metabolic and digestive enzymes as well as binding with nutrients such as zinc. Saponins lyse with erthrocytes in the erythrocyte membrane due to their interaction with cholesterol (Birk and Peri, 1980 as cited in Shahidi 1997).Ingestion of saponin containing feed materials by animals has been associated with both deleterious and beneficial effects, for example reduced weight and hypocholesterolemic effects. These effects occur primarily in simple stomach animals.

Saponins are glycosides of high molecular weight and are group of natural products capable of producing lather or foam when shaken with water. Toxic saponin can be eliminated by soaking prior to cooking. Legume saponins cause problem only when in higher concentrations in the diet and have a moderate toxicity (Jansman *et al.,* 1998 as cited in Bora 2014). They can be considered as the resistant factor in legumes against microbial infection and herbivores. Processing has a significant effect on the quality of the processed products due to change in structure of saponin as a result of partial hydrolysis during processing (Bora, 2014). Saponins occurs in broad range of plant including root crops (potato and yam) legumes (soy, peas and beans) as well as in oats and sugarbeet.

2.1.6.2 Phytates

They are divalent mineral ions complexed with organic phosphorus in seeds. Most (50–70%) of the phosphorus in cereal grains are in the form of phytic acid and their concentrations are higher than 10% of dry matter (Bisby *et al.,* 1994). Phytates complexes with phytic acid and inositol in cereal grains to form chelates, these further bind much of the phosphorus, and zinc in grains and to a lesser extent, it complexes with copper, cobalt, magnesium and calcium. Phosphorus deficiency leads to reduced weight gains, distorted appetite and impaired reproduction, while zinc deficiency cause skin lesions and reduced weight gains.

Phytates reduce the solubility and digestibility of protein and starch. They are important for plant nutrition and especially vulnerable during germination and are regarded as stores for phosphate and mineral nutrients (Jansman *et al.,* 1998).

The beneficial effects of some anti-nutrients such as phytic acid and tannin relates to their ability to lower the rate of starch digestion, this may results to lower blood glucose response to starchy feeds (Yoon *et al*., 1983) and may have a significant effect on reducing plasma cholesterol and levels of triacylglycerols (Shamsuddin*et al*.**,**1989)by the same mechanism that makes them antinutrients. It may also help to reduce the formation of free radicals and aid in breakdown of cellular membranes that encourage cell proliferation (Fraf and Eaton, 1990) by binding with iron, which serves as a catalyst of lipid peroxidation. Phosphorus is relatively expensive to supplement and Liebler (1993) suggested that adding the enzyme phytase to poultry rations may be economically feasible, because it hydrolyzed the phytate in the diet and reduced phosphorus elimination in faeces.

2.1.6.3 Protease inhibitors

Lectins and trypsin inhibitors, can lead to damage of the absorptive surfaces of the gut, impairing nutrient digestion (Sheppy, 2003). They are found in large quantity in raw cereals and legumes. They may be easily denatured by heat treatment due to their particular protein nature although some residual activity may still remain in the processed products (Hathcock, 1991). It is abundant in raw cereals and legumes, especially soybean. Protease inhibitors are associated with growth inhibition and pancreatic hypertrophy (Hathcock, 1991). Trypsin inhibitor in soybean for example leads to inactivation and loss of intestinal trypsin, this triggers the release of cholecystokinin which induces pancreatic synthesis of excess trypsin and burden sulfur-containing amino acids requirement of the body.

2.1.6.4 Phyto-heamaglutinins

They are sometimes referred to as heamaglutinins or lectins and are proteinous in nature, they are sugar-binding proteins which may bind and agglutinate red blood cells. Most legumes commonly containing glycoproteins are called lectins. Many lectins may cause infiltration of bacteria into the blood stream by binding to epithelial cells of the intestine, thereby impairing with nutrient absorption and causing damage. It may lead to endogenous loss of nitrogen and protein utilization, it may cause systemic effects such as increased protein catabolism and breakdown of stored fat and glycogen, and disturbance in mineral metabolism. Lectins in soybeans and peanuts are not toxic when taken orally (Liener, 1989).

2.1.6.5 Cynogenic glycosidases

They complexes with ligands and are anions with carbon and nitrogen. In nature, it occurs as hydrogen cyanide which dissolves in water to form hydrocyanic acid. Cynogens can serve as mobile nitrogen storage compounds in seeds which are important during germination .It serves as a defence mechanism for plants in case of emergency, the cellular compartmentation of the plant when wounded by herbivores or other organisms break down and cynogenic glycosides come into contact with active B-glucosidase which hydrolyses them to yield 2-hydroxynitrile. It is extremely toxic and causes pulmonary failure as it bind with cytochrome oxidase and reduce the oxygen-carrying capacity of the cells (Segal and Their, 1989). Cassava is rich in cyanogenic glycoside and the “bitter” variety is the most commonly used for feed production. Tylleskar *et al.*(1992) suggested that improved detoxification procedures may be more effective for prevention of cyanide poisoning than through development of “low cyanide” cultivars.

2.1.6.6 Tannins

Tannins are phenolic compounds with high molecular weight that bind strongly with proteins and other macromolecules such as starch, cellulose or minerals. It has two major classes which are hydrolysable and condensed tannins. It lowers feed intake due to reduced acceptability of feed and forms large indigestible complexes in the digestive tract which affects digestibility. Deleterious effects vary depending on the type and tolerance of the animal. Mono-gastric animals may have retarded growth rates with low (i.e. $< 5\%$) concentrations, higher concentrations may be fatal (Liebler, 1993). They are common in plants, occurring in both gymnosperms and angiosperms.

2.1.6.7 Gossypol

Is a yellow phenolic compound naturally found in the pigment glands of cotton (*Gossypium* spp). It bind to proteins reducing their bio availability, it also binds with iron. General effect includes; depressed appetite, loss of body weight, cardiac irregularity, laboured breathing and impaired reproduction in both males and females. Gossypol may be found in cotton seed meal used as a protein supplement. Gossypol toxicity in poultry causes olive-green yolks in eggs and decreased egg hatchability. Addition of iron salt help to bind gossypol and limit the depletion of minerals and the use of whole cotton seed or cottonseed meal should be restricted as recommended by Gohl (1981).

2.1.7 Effect of processing on anti-nutrient contents of non-conventional feed ingredients

To improve digestibility and optimize utilization of grains, they need to be processed e.g. rolled or cracked. It is estimated that only 60% of starch is digested when grains are not processed due to their anti-nutritional factors (Sneath and McIntosh, 2003). Anti-nutritional factors (ANFs) can be detrimental to animal growth and performance by lowering intake, uptake or utilization of other feed components or by causing discomfort and stress.

They mainly occur in diets compounded from legume and cereal grains (Friedman, 2001). Based on their chemical and physical properties, they can be divided into several groups such as; non-protein amino acids, alkaloids, cyanogenic glycosides, tannins, oligosaccharides, saponnins, phytates, lectins or protease inhibitor. Structure and chemical properties especially heat lability helps to determine which process will be more effective in their reduction or removal, thereby decreasing adverse biological effects (Shahidi, 1997). They can be eliminated or reduced through physical and chemical methods; selective extraction of plant genotype with low levels of such factors or through post-harvest processing such as soaking, cooking, germination, fermentation, irradiation and enzymatic treatment.

A single technique is sometimes insufficient for effective treatment and so combination of two or more are commonly employed. Example, soaking followed by germination or sprouting of grains through hydroponic growing process improves the quantity and quality of some of the nutrients into their simpler forms, for example, starch changes to sugars (Helal and Hassan, 2013). A range of chemical and structural changes occurred during the growing process, and these led to hydrolysis of some of the nutrients into their simpler components (Dung *et al*., 2010; Helal and Hassan, 2013)

2.2 Exogenous Enzymes in Poultry Nutrition

Feed enzymes are produced under controlled conditions from microorganisms like bacteria; *Bacillus subtilis* and *Bacillus lentus, fungi; Triochoderma longibrachiatum, Asperigillus oryzae* and *Asperigillus niger*) and Yeast (*S. cerevisiae*) that are carefully selected for the task (Wallis, 1996). Enzymes are not living organisms and the main aim of adding enzymes into poultry feed is to improve the nutritive quality of the feed and performance of the birds.

Consistent use of enzyme in poultry feed help to reduce feed cost and improve the quality of non-conventional feed ingredients that are continually replacing the conventional once used in feed industries in most of the developing countries. The non-conventional ingredients contain higher percentage of the soluble and insoluble/crude fiber, non-starch polysaccharides along with starch. Annison (1993) reported that Non-Starch Polysaccharides (NSPs) are not well digested by poultry,they are polymeric carbohydrates that differ in composition and structure from starch (Morgan and Bedford,1995 as cited in Khattak *et al*., 2006). They are water-soluble and they reduce gut performance and are also known to for forming a gel like viscous consistency in the intestinal tract (Ward, 1995). Water soluble and viscous arabinoxylans that belong to pentosan group are assumed to be the factor responsible.

Dunn (1996) also added that they increased water intake by birds and lead to unmanageable litter problems caused by wet and sticky droppings. This degrades the hygienic conditions and carcass quality and thisis more common in birds fed roselle in their diets. Xylans and ß-glucans exist in nature as principal components of plant cell wall (Theander *et al.*,1993) and serve as substrates for many organisms that derive energy through metabolism of their constituent sugars (xylose, glucose and arabinose). Response to the effect of multienzye complex depends on numerous factors such as feed type, nutrient level in the diet, enzyme dose, genetic strain and age of bird (Cowieson *et al*., 2006)

2.2.1 Importanceof exogenous enzymes in poultry nutrition

Enzymes catalyze the rate of chemical reaction without being altered, they are specific in their actions; acting on a single or limited group of compounds and they are involved in all the digestive pathways (anabolic and catabolic pathways) and metabolism (Khattak e*t al*., 2006). They help in the reduction of foregut digesta viscosity through hydrolysis of complex substances into smaller compounds, they also help to reduce variability in the nutritive value between batches of ingredients. Recently, interest has been shown in the use of phytase as a feed additive, as it reduces environmental pollution and increases the availability of phosphate in feed.

Enzymes aids in improving diet utilization, they increase the bioavailability of starch, proteins and minerals that are either enclosed within fibre-rich cell walls or bound up in a chemical form (e.g. phosphorus as phytic acid), and therefore not accessible to the animal’s own digestive enzymes and the animal is unable to digest the feed material (Sheppy, 2003).They are incorporated into feed to breakdown anti-nutrients that interfere with normal digestion and are not susceptible to digestion by the animal’s endogenous enzymes, leading to digestive upsets and poor performance (Sheppy, 2003). They break down specific chemical bonds in feed materials that are not usually broken down by the animal's own enzymes, there by releasing more nutrients.

In addition, enzyme can reduce the variability in nutritive value between feed materials and improve the accuracy of feed formulations. Sheppy (2003) stated that trials have shown that by ensuring feed consistency with enzymes supplementation, uniformity of groups of animals was achieved, management and profitability was also improved. Enzymes help to increase feed intake by birds, reduce water intake and water content of excreta, reduce digesta viscosity and enhance digestion and absorption of nutrients especially fat and protein, they improve apparent metabolizable energy (AME) value of diets, weight gain, and feed-gain ratio, reduce beak impaction and vent plugging, decrease the size of gastrointestinal tract (GIT) and alter population of beneficial microorganisms in GIT, reduce ammonia composition of excreta and output, including reduced N and P (Khattak *et al*., 2006).

Nadeem *et al*. (2005) stated that the feed efficiency of broilers during the starter phase was enhanced by supplementation non-starch polysaccharides degrading enzymes. Shirley and Edwards (2003) stated that the effects of anti-nutritional factors could be mitigated and bird performance could be improved with addition of phytase in their feed, also weight gain of broiler chickens significantly increased when phytase was added with a phosphorus insufficient diet (Karimi *et al*., 2013).

2.2.2 Effectof exogenous enzymes in digestion

Monogastrics like pigs and poultry do not produce enzymes that digest fibre. Anti-nutritive carbohydrates are undesirable and are not well digested by poultry as stated by Adams and Pough (1993) and Annison and Choct (1993)as cited in (Khattak *et al*., 2006).The chemistry of NSP in different ingredients varies widely and may respond differently to enzyme supplementation. Such differences arise from accessibility or solubility of the NSP,their location in the ingredient matrix and presence of other limiting factors (Ravindran, 2013).The principal rationale behind the use of exogenous enzymes is to improve the breakdown of undigested feed ingredients (Ravindran, 2013). Digestion and absorption of all nutrients are reduced in the diet, especially fat and protein. Utilization of all nutrients especially protein and starch are affected by anti-nutrients like ß-glucans, it gives rise to a highly viscous conditions in the small intestine of chicks (Hasselman and Aman, 1986).

Enzymes are highly specific in nature and they break down specific substrates at specific reaction sites. In addition, enzymes should be chosen based on the substrates in the ingredients used in feed formulations. For enzyme to act, several reaction conditions needs to be met, these include moisture content, temperature, pH, enzyme concentrationand substrate concentration (Aehle, 2004).Findings on digesta viscosity were reported by Dunn (1996) and Bedford and Classen (1993)as cited in Khattak *et al*. (2006) who inferred that increased water intake of the birds was due to high viscosity in the gut contents caused by the pentosans, which resulted in the wet and sticky droppings. Bedford and Classen (1993) as cited inKhattak *et al*. (2006) further explained that foregut digesta viscosity was directly proportional to the molecular weight of wheat arabinoxylans, the reduction in foregut digesta viscosity was achieved through hydrolysis by reducing the molecular weight of xylan backbone by endo-xylanase into smaller compounds, and thus reduction in viscous effects of the feed. As a result of enzyme supplementation, the long backbones of the arabinoxylans and ß-glucans are cleaved into shorter units, and thus reducing their viscosity Khattak *et al*. (2006). Enzyme system comprising a ß-1,4endoxylanase and a ß-D-xylosidase are required for hydrolysis of xylan (which cleaves the internal linkages of the xylan backbone and hydrolyses short oligosaccharides to release xylose) and enzymes designed to release the substituent.

The goal is to provide sugars for organisms that produce them, such sugars depending on the requirements of the organism involved may be in the form of oligomers or single sugars. Hartini and Purwaningsih (2017) reported that the digestibility of NSP was not significantly influenced with supplementation of cellulase or phytase alone or both of them while Meng *et al*. (2005) illustrated that digestibility of NSP were statistically improved with multi-enzyme preparations.

2.2.3 Impact of Exogenousenzymes on feed efficiency

Enzymes improve the digestibility of nutrients, decrease intestinal viscosity and improve gut performance by breaking down the NSPs. Poultry in general do not produce enzymes that hydrolyze NSPs present in the cell wall of grains which result in low feed efficiency. Several enzyme products are being evaluated in the feed industry, including protease that enhance protein digestion, lipases which enhance lipid digestion, ß-galactosidases that neutralizes certain anti-nutrients in non-cereal feed material and amylase that assist in the digestion of starch in young animals. Research work has suggested that the effects of NSPs could be tackled by dietary modifications with suitable exogenous enzyme preparation (Creswell, 1994).

These anti-nutritive carbohydrates (NSPs) are undesirable, and enzymes are used to neutralize their viscous effect in cereals such as barley, wheat, rye, and triticale. The adverse effects of some of these harmful compounds could be reduced by supplementation of diets containing anti-nutrients with exogenous enzymes (Iyayi and Losel, 2000; Oliveira *et al*., 2007; Nazar and Mukhtar, 2017). Berwanger *et al*., (2017) pointed that enzymes could improve nutrient utilization and increase available energy for monogastrics animals that were not able to digest non-starch polysaccharides. Sredanovic *et al*. (2012) stated that supplementation of enzymes in poultry diets alleviated the negative impacts of anti-nutrients, increased available phosphorus and promoted protein digestibility thereby improving performance.Slominski (2011) reported that the use of commercial non-specific enzyme preparations (protease, amylase, and xylanase) to target NSPs and the two main nutrients of maize-soybean diet and its components has been unsuccessful.

2.3 Impactof Feeding Non-Conventional Feed Ingredients with Multienzymes Supplementation on Growth Performance of Broiler Chickens

It is expected that the body weight gain, final weight, feed conversion ratio and overall performance of broiler chicken could be improved with supplementation of multienzymes to broiler chickens diet. Several researches have reported improved performance of birds andfeed efficiency while some reported decrease or no improvement in the overall performance. Kocher *et al*. (2015) showed that supplementation of enzyme mixture (xylanase and protease) to broiler diet improved performance during the first three weeks of age.

Little improvement on growth performance was reported by Kocher *et al*. (2003)with exogenous complex enzyme (protease, xylanase, and amylase) addition to broiler chickens' diets. Feed consumption significantly increased when different enzyme preparations were supplemented in broiler chickens diets, this was reported by Anuradha and Roy (2015) and Zeng *et al*. (2015). Multienzymes (enzyme combinations: xylanase, glucanase, protease, and amylase) supplementation to broiler diets showed no improvement in body weight (Shalash *et al*., 2009).A study conducted by Lu *et al*.**(**2013) in broiler chickens showed that feed intake was not affected by the enhancement of exogenous enzymes. Feed conversion and body weight gain of broilers were significantly improvements with multicarbohydrase combinations containing xylanase, protease, and amylase (Cowieson, 2005). Woyengo *et al*. (2010) reported that nutrient utilization and growth performance of broiler chickens was improved with multicarbohydrase nons-starch polysaccharide-degrading enzymes, phytases and proteases.

On the contrary, Hashish *et al*. (1995) as cited in Alagawany *et al*. (2018) noticed a significant decrease in daily feed consumption for broiler chicks fed diets supplemented with Kemzyme® (0.5 or 1.0 g/kg) and using Roxazym®. There was no improvement in nutrient digestibility as stated by Sharifi *et al*.(2012) with enzyme supplementation to broiler chickens diets. Chimvuramahwe *et al*. (2011) reported that total feed cost was reduced economically with incorporation of baobab seed cake at 10 % inclusion level in broiler chick diets.

Protein efficiency ratio (PER) is the qualitative method of estimating protein quality eventhough it has been severely criticized in spite of its simplicity (Hegsted and Chang, 1965). The most common criticisms have been that in the measurement of PER, some of the dietary protein required for the maintenance of the animal was not credited to protein and that nitrogen retention measurement may not be adequate because of variation in body composition. Itwas related to the weight gain, the amount of feed consumed,the amountof protein in the diet, and the nutritive quality of the protein in the diet but was not a direct function of the nutritive value of protein. Kamran(2008) reported that PER and energy efficiency ratio (EER) of broiler chickens decreased with reduced crude protein (CP) and metabolizable energy (ME) diets during the overall experimental period, he added that although they consumed the same amount of protein and energy due to increased intake, there was a significant depression in weight gain of the birds.

2.4 Effect of feeding Non-Conventional Feed ingredients with MultienzymesSupplementation on Carcass Yield of Broiler Chickens

Carcass is the mean yield of dressed eviscerated chicken and the yield obtained differs with age at slaughter, plain of nutrition and breed and sex. Salami *et al.* (2004) reported a carcass yield of 60-70% for broiler chickens.In a study conducted by Ojile(2017), who replaced GNC and SBC with graded levels of roselle at 0, 8, 16, 24 and 32 % reported significant difference among the dietary treatment for some of the cut parts and organ weights, similar breast weights were reported across the treatments. Muataz(2019), who fed non-conventional protein sources to broiler chickens fortified with enzyme reported a highly significant impact on all cut part proportions.

2.5 Effect of feeding Feeding Non-Conventional Feed Ingredients with Multienzymes Supplementation on Liver Function Indices, Heamatological and Lipid Profiles of Broiler Chickens

Heamatological changes were routinely used to determine environmental, nutritional and pathological factors in domesticated animals (Graczyk*et al*., 2003) and some of the factors include; nutrient conditions and feed restriction (Etim *et al*., 2014), water restriction (Boostani *et al*., 2010), age (Talebi *et al*., 2005), continuous supplementation of vitamin E (Tras*et al*., 2000), administration of drugs (Suresh*et al*., 2012), breed (Mushi *et al*., 1999 as cited in Onyishi *et al*., 2017) and aflatoxin (Oguz *et al*., 2000).Adejumo (2004) stated that the nutritional status of an animal was correlated withheamoglobin (Hb) and packed cell volume (PCV),and a normal range of 7-15 g/dL and 24-40 % respectively was reported by Mitruka and Rawnsely (1997). High PCV and high Hb were indicators of oxygen carrying capacity in the blood. Also a high or low white blood cell count against the normal range of 1.9-9.5 $\times 10^9$/L (Simrak*et al*., 2004) was an indication of the degree of response and or resistance of an animal to disease infection (Soetan *et al*., 2013).

2.6 Effect of feeding Feeding Non-Conventional Feed Ingredients with Multienzymes Supplementation on Liver Function Indices of Broiler Chickens

Alkaline amino transferase (ALT), alkaline phosphatase(ALP)and aspartate amino transferase (AST) are liver enzymes which can also be found in some parts of the body like brain, kidney, digestive system and the blood cells etc. Their levels were normally low in the blood and higher value above the normal ranges were an indication of impaired or damage muscle or liver(WebMed, 2016).

2.7 Effect of feeding Feeding Non-Conventional Feed Ingredients with Multienzymes Supplementation on Lipid Profiles of Broiler Chickens

Elevated levels of cholesterol could be seen in birds on high-fat diets while low levels could be seen in birds with liver and kidney disease(Sakas, 2002). High level in blood results to accumulation in meat and the person that consumes it, normal range for broiler reported by Manoppo *et al*. (2002) was 52-148 mg/dL. Normal high density lipoprotein (HDL), low density lipoprotein (LDL) and triglyceride in livestock according to Basmacioglu and Ergul (2005) were ≤130, ≥22 mg/dL and 150 mg/dL, lower level of LDL in broiler was better because higher levels led to deposition of cholesterol in blood.

Significant effects in blood parameters of layers and guinea fowls, respectively fed baobab seed cake based diets ware reported in various studies (Sola-Ojo *et al*., 2011,Alli *et al*., 2011). However, they wereat variance with the report of Yusuf *et al*.(2008) who reported that all haematological parameters with respect to baobab seed inclusion in albino rats had no significant impacts.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Experimental Site

The research was conducted at the Poultry Unit of the Teaching and Research Farm, Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria. The area is located in the Northern Guinea Savannah of Nigeria on longitude 11°09' 01.78' N and latitude 7° 39'14.79' E (Ovimaps, 2018), at an elevation of 671m above sea level with an average annual rainfall of about 700-1100mm. It has an ambient temperature ranging from 26-32^{o}C Institute for Agricultural Research (IAR Meteorological Unit, 2018).

3.2 Source of Experimental Feed Ingredients and Birds

Baobab seed cake was purchased from National Research Institute of Chemical Technology (NARICT) Basawa, Zaria. Other feed ingredients were purchased from reputable feed mills in Samaru, Zaria, and the birds were purchased from Olam farm in Kaduna State.

3.3 First Feeding Trial: Effect of feeding Groundnut Roselle and Baobab Seed Cake Diets to Broiler Chickens Partly Substituting Soya Bean Cake

It was conducted in two phases; the starter phase lasted for four week followed by re-randomization and balancing of weight and number of birds within their various treatments (between replicates) for the finisher phase which also lasted for four weeks.

3.3.1 Experimental design and management of birds

Three hundred and fifty two (352) Cobb 500 day-old broiler chicks were used for the study. They were assigned to four dietary treatments with eighty eight (88) chicks replicated four times each with twenty two (22) chicks in a completely randomized design

(CRD). Proper sanitary condition was maintained throughout the experimental period. The chickens were fed starter diet from 0- 4 weeks and finisher diets from5-8 weeks.

3.3.2 Experimental diets

Four nitrogenous diets with 23% and 20% crude protein (CP) were formulated for the starter and finisher phases respectively. Groundnut, Roselle and Baobab seed cakes at 20% inclusion level were partially substituted with soya bean cake and they served as the treatment diets for the starter and finisher phases. Maize-soya bean cake based diet served as the control. The birds were fed starter diet for a period of 0-4 weeks. At the end of the starter phase, they were re-randomized and re-assigned within their treatments (between replicates) to balance the weight and number of birds for each treatment. They were fed finisher diet from5-8 weeks.

Diet 1: Maize-soya bean cake based diet (Control diet)

Diet 2: 20% Groundnut cake partly substituted with SBC

Diet 3: 20% Roselle seed cake partly substituted with SBC

Diet 4: 20% Baobab seed cake partly substituted with SBC

The diets were formulated to meet nutrient requirement for broilers (NRC, 1994). Composition of the experimental diets for both starter and finisher phases are presented in Tables 3.1 and 3.2.

3.3.3 Growth study

The feed intake was recorded for all the treatments weekly. The initial weight of birds was taken at the beginning of the experiment and then every week to determine the weight gain per week, final weight was taken at 8 weeks. Feed conversion ratio (FCR), feed cost (₦), feed cost/kg gain (₦) and protein efficiency ratio (PER) were also determined. Mortality

Table 3.1: Composition of Broiler Starter Chicken Diets Containing Groundnut Roselle and Baobab Seed Cakes Partly Substituting Soya Bean Cake

	Diets			
Ingredients	**SBC**	**GNC**	**RSC**	**BSC**
Maize	58.80	58.70	55.90	56.80
Soya bean cake	35.00	15.00	15.00	15.00
Groundnut cake	0.00	20.00	0.00	0.00
Roselle seedcake	0.00	0.00	20.00	0.00
Baobab seed cake	0.00	0.00	0.00	20.00
Blood meal	2.00	2.00	5.00	4.00
Bone meal	3.00	3.00	3.20	3.00
Limestone	0.50	0.50	0.20	0.50
Common salt	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20
Lysine	0.00	0.10	0.00	0.00
*Vit- min premix	0.25	0.25	0.25	0.25
TOTAL	**100**	**100**	**100**	**100**
Calculated analysis				
ME (kcal/kg)	2900	2900	3000	3000
Crude protein (%)	23.00	23.00	22.00	22.00
Ether extract (%)	2.60	3.86	4.32	3.52
Crude fibre(%)	2.69	4.27	4.24	3.35
Calcium (%)	1.32	1.32	1.37	1.33
Phosphorus (%)	0.85	0.85	0.81	0.85
Lysine (%)	1.51	1.27	1.28	1.46
Methionine (%)	0.51	0.50	0.51	0.53
Cost/kg (₦)	110.66	105.78	107.16	91.58

Bio-mix broiler finisher premix per kg diet: Vit A, 10 I.U; Vit D3, 2 I.U; Vit E, 23mg; Vit K3, 2 mg; Vit B1, 1.8mg; VitB2, 5.5mg; Niacin, 27.5mg; Panthonenic acid, 7.5mg; Vit B6, 3mg; Vit B12, 0.015mg; Folic acid, 7.5mg; Biotin , 0.06mg; Cholin Chloride, 0.3mg; Cobalt, 0.2mg; Copper 3mg; Iodine 3mg; Iron,1mg; Manganese, 20mg; Selenium, 40mg; Zinc, 30mg; Antioxidant,1,250mg, *Vit-min Premix: Vitamin Mineral Premix. SBC= Soya Bean cake, GNC=Groundnut Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake ME= Metabolizable Energy.

Table 3.2: Composition of Broiler Finisher Chicken Diets Containing Groundnut Roselle and Baobab Seed Cakes Partly Substituting Soya Bean Cake

	Diets			
Ingredients	**SBC**	**GNC**	**RSC**	**BSC**
Maize	59.00	58.8	56.80	57.00
Soya bean cake	29.00	10.00	10.00	10.00
Groundnut cake	0.00	20.00	0.00	0.00
Roselle seed cake	0.00	0.00	20.00	0.00
Baobab seed cake	0.00	0.00	0.00	20.00
Maize offal	7.00	6.00	5.00	7.00
Blood meal	1.00	1.00	4.00	2.00
Bone meal	3.00	3.00	3.00	3.00
Limestone	0.25	0.25	0.25	0.20
Common salt	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20
Lysine	0.00	0.20	0.20	0.00
*Vit-min premix	0.25	0.25	0.25	0.25
TOTAL	**100**	**100**	**100**	**100**
Calculated Analysis				
ME (kcal/kg)	2900	2900	3000	3000
Crude protein (%)	20.00	20.00	20.00	20.00
Crude fiber (%)	3.21	3.80	4.59	3.46
Ether extract (%)	2.54	3.80	4.30	3.90
Calcium (%)	1.23	1.23	1.32	1.25
Phosphorus (%)	0.88	0.87	0.79	0.88
Methionine (%)	0.5	0.48	0.49	0.51
Lysine (%)	1.28	1.16	1.27	1.19
Cost/kg (₦)	104.57	101.55	103.87	85.82

*Bio-mix broiler finisher premix per kg diet: Vit A, 10I.U; Vit D3, 2I.U; Vit E, 23mg; Vit K3, 2 mg; Vit B1, 1.8mg; VitB2, 5.5mg; Niacin, 27.5mg; Panthonenic acid, 7.5mg; Vit B6, 3mg; Vit B12, 0.015mg; Folic acid, 7.5mg; Biotin , 0.06mg; Cholin Chloride, 0.3mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 3mg;Iron, 1mg; Manganese, 20mg; Selenium, 40mg; Zinc, 30mg; Antioxidant,1,250mg, *Vit-min Premix: Vitamin Mineral Premix. SBC= Soya Bean cake, GNC=Groundnut Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake ME= Metabolizable Energy.

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was recorded as it occurred. The experiment lasted for eight (8) weeks and was conducted from 17th August to 16th October. The following formulae were used;

$$\text{Weight Gained (g)} = \text{Final Weight (g)} - \text{Initial Weight (g)}$$

$$\text{Feed Consumed (g)} = \text{Feed Supplied (g)} - \text{leftover (g)}$$

$$\text{Feed Conversion Ratio} = \frac{\text{Feed Consumed (g)}}{\text{Weight Gain (g)}}$$

$$\text{Feed Cost per Kg Gain} = \text{Feed Cost Per Kg (₦/kg)} \times \text{Feed Conversion Ratio}$$

$$\text{Protein Efficiency Ratio (PER)} = \frac{\text{Grams of gain [weight](g)}}{\text{Grams of protein (g)}}$$

$$\text{Grams of protein} = \text{\% CP in Diet} \times \text{Feed Consumed}$$

3.3.4 Digestibilitystudy

A digestibility study was conducted; four birds (one bird from each replicate) were randomly selected from each treatment at 8 weeks. They were housed in a battery cage, allowed for adjustment period of three days to the cage andeach bird was offered 1 kg of the experimental diet. Collection tray was placed under the cages and total droppings were collected and weighed daily for five days. At the end of the collection period, droppings were bulked for each replicate and a sub sample was taken to the laboratory for proximate analysis using the methods described by AOAC (2005) at the Biochemical Laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria.

$$\text{Digestibility coefficient (\%)} = \frac{\text{Nutrient in feed x FI – nutrient in droppings x DO}}{\text{\% nutrient in feed x FI}} \text{ x } 100$$

Where

FI = Feed intake (on dry matter basis)

DO = Droppings output (on dry matter basis)

3.3.5 Carcass analysis

Four (4) chickens having weight as close to the average weight of the group from each treatment at 9 weeks were selected for carcass evaluation. The selected birds were starved of feed, bled by severing the jugular vein and then scalded in hot water to remove the feathers. Live weight for each chicken was taken before slaughter, dressed weight, weight of organs and standard cut parts were measured while dressing percentage was calculated. The organs were expressed as percentages of live weight while the cut parts were expressed as percentages of dressed weight.

3.3.6 Haematological study

At 9 weeks, 2.0ml blood samples were collected from each treatment(four 4 birds from each treatment) by severing the jugular vein, blood was collected using sterile bottles containing anticoagulant ethylene diamine tetra acetic acid (EDTA) for haematological evaluation. The packed cellvolume (PCV), Red Blood Cell Count (RBC), White Blood Cell Count (WBC) and Haemoglobin(Hb) were determined using Wintrobe micro-haematocrit, Neubehaematocyatometer and cyanohaemoglobin procedures as described by Coles (1986).The analyses were conducted at the Clinical Pathology Laboratory of Ahmadu Bello University Teaching Hospital, Zaria.

3.3.7 Liver function test

At 9 weeks, 2.0 ml of blood samples were collected from same set of birds that were used for carcass, intoa sterile bottles without anticoagulant for serological studies to determine the lipid profile and liver function indices of the broiler chickens. The analyses were conducted at the Clinical Pathology Laboratory of Ahmadu Bello University Teaching Hospital. Total serum protein and albumin were determined using methods described by

Peters *et al*. (1982) while the globulin was obtained by difference. Transaminase enzyme activities, alanine transaminase (ALT), alkaline phosphatase (ALP) and aspartate transaminase (AST) were determined according to the method of Reitman and Frankel (1957). Serum creatinine was determined by Jeffe reaction and serum urea was determined by dimethyl monoxide method (Baily*et el*., 1967).

3.3.8 Lipid profile

Blood samples (2 mls) were taken from same set of birds that were used for carcass at 9 weeks, into sterilized sample bottles without anticoagulant and were taken to the Clinical Pathology Laboratory of Ahmadu Bello University Teaching Hospital, Zaria for determination of lipid profile (cholesterol, triglyceride, high density lipoprotein and low density lipoprotein) using standard laboratory procedures (Lamb, 1991).

3.3.9 Chemical analyses

Samples of soya beans cake, groundnut cake, roselle seed cake, baobab seed cake and experimental diets were analyzed prior to the feeding trial for chemical composition at the Biochemical Laboratory of the Department of Animal science, Faculty of Agriculture, Ahmadu Bello University, Zaria. Dry matter (DM), crude proteins (CP), crude fiber (CF), ether extract (EE) and ash weredetermined using the AOAC(2005) procedure, while nitrogen free extract (NFE) was calculated by difference. The anti-nutritional factors were determined at the Analytical Laboratory, Product Development Research Programme, Institute for Agricultural Research, Samaru, Zaria.

The metabolizable energy (ME) was calculated using:

$$ME = 1.549 + 0.0103\,(CP) + 0.0275\,(EE) + 0.0148(NFE) + 0.034\,(CF)$$

3.3.10 Statistical analysis

Data generated from the study were analyzed using the ANOVA procedure of Statistical Analysis System (SAS, 2002) and treatment means were compared using Least Significant Difference (LSD). The following model was used;

$Y_{ik} = \mu + S_i + e_{ij}$

Where:

Y_{ik}= Effect of the ith protein sources (GNC, RSC and BSC)

μ= Overall mean

S_i= Effect of the ith protein sources (GNC, RSC and BSC) on the experimental birds.

e_{ij}= Random error .

3.3.11 Economic benefit

The feedstuffs were costed according to the prices they were purchased from the commercial feed mill; the amount of each feedstuff in kilogram was multiplied by its prevailing prices at the time of this experiment to calculate the cost of kilogram feed. The miscellaneous expenses (ME) was pegged at 10% of total feed cost (TFC) and other expenses (OE).Other expenses (OE) were cost of medication and items used for brooding, while the total variable cost was the total of ME+TFC+OE.Total income was calculated by multiplying final weight and cost/kg of meat (700/kg) while a comparison was done among cost results for all treatments.

Cost of Feeding = feed cost (₦/kg) × feed intake (g)

Total Variable Cost = ME+TFC+OE

Revenue = average weight of bird (kg) × cost/kg live weight

Gross Margin = revenue - total variable cost

Return/₦ Invested = $\frac{\text{revenue}}{\text{total variable cost}}$

3.4 Second Feeding Trial: Response of Broiler Chickens to the Seed Cake Based Dietspartly Substituting Soya Bean Cake with and without Multienzymes supplementation.

In this trial, treatments with the least performance from the first feeding trial were selected and multienzymes was added to improve their quality.The treatments were compared with the control to determine their performance.

3.5.1 Experimental design and management of birds

Three hundred and thirty (330) Cobb 500 broiler chicks were randomly assignedto five dietary treatments with sixty six chicks and each replicated three times with twenty two chicks in a completely randomized design (CRD). Feeding and management of the birds was the same as in first feeding trial.

3.5.2 Experimentaldiets

Five starter and finisher diets with 23% and 20% crude protein (CP) respectively were formulated. Roselle and Baobab seed cakes at 20% with or without multienzymes partially substituted with soya bean cakeserved as the treatment diets for the starter and finisher phases respectively.Maize-soya bean cake based diet served as the control. The starter phase lasted for a period of 0-4 weeks while the finisher phase was from week 5-7 and diets were administered same as the first feeding trial for the starter and finisher diets respectively. The diets were formulated to meet nutrient requirement for broilers chickens (NRC, 1994) in tropical region. The multienzymes (Maxigrain (E); protease 4000 IU, xylanace10000IU, phytase 2500 FTU and cellulase 10000 IU) were purchased and incorporated into the diet based on the manufacturer's dose (100g/1000kg diet).

Diet 1: Maize-soya bean cake based diet (Control diet)

Diet 2: 20% Roselle seed cake partly substituted with SBC + E (100g/1000kg)

Diet 3: 20% Roselle seed cake partly substituted with SBC

Diet 4: 20% Baobab seed cake partly substituted with SBC + E (100g/1000kg)

Diet 5: 20% Baobab seed cake partly substituted with SBC

Composition of the experimental diets for both starter and finisher phases are presented in Tables 3.3 and 3.4.

3.5.3 Growth study

It lasted for 7 weeks, from 16th December to 3rd February. Records were taken for all the same parameters as stated in first feeding trial.

3.5.4 Digestibility study

It was conducted as in first feeding trial.

3.4.5 Carcass analysis

Same as in first feeding trial.

3.5.6 Haematological study

Same as in first feeding trial.

3.5.7 Liver function test

Same as in first feeding trial.

3.5.8 Lipid profile

Same as in first feeding trial.

3.5.9 Chemical analysis

Same as in first feeding trial.

3.5.10 Statistical analysis

Data generated was analyzed using the same procedure as that of first feeding trial. The model was;

$Yik = \mu + Si + eik$

Table 3.3: Composition of Broiler Starter Chicken Diets Fed Seed Cake-Based Diets Partly Substituted with Soya Bean Cake with or without Multienzymes Supplementation

	Diets				
Ingredients	**SBC**	**RSC +E**	**RSC**	**BSC +E**	**BSC**
Maize	58.80	55.90	55.90	56.80	56.80
Soya bean cake	35.00	15.00	15.00	15.00	15.00
Roselle seed cake	0.00	20.00	20.00	0.00	0.00
Baobab seed cake	0.00	0.00	0.00	20.00	20.00
Blood meal	2.00	5.00	5.00	4.00	4.00
Bone eal	3.00	3.20	3.20	3.00	3.00
limestone	0.50	0.20	0.20	0.50	0.50
Common salt	0.25	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.00	0.00	0.00	0.00	0.00
*Vit- min premix	0.25	0.25	0.25	0.25	0.25
TOTAL	**100**	**100**	**100**	**100**	**100**
Calculated analysis					
ME (kcal/kg)	2900	3000	3000	3000	3000
Crude protein (%)	23.00	22.00	22.00	22.00	22.00
Crude fiber (%)	2.60	4.32	4.32	3.52	3.52
Ether extract (%)	2.69	4.24	4.24	3.35	3.35
Calcium (%)	1.32	1.37	1.37	1.33	1.33
Phosphorus (%)	0.85	0.81	0.81	0.85	0.85
Methionine (%)	1.51	1.28	1.28	1.46	1.46
Lysine (%)	0.51	0.51	0.51	0.53	0.53
Cost/kg (₦)	110.45	108.36	107.56	93.87	93.07

*Bio-mix broiler starter premix per kg diet: Vit A, 10 I.U; Vit D3, 2 I.U; Vit E, 23mg; Vit K3, 2 mg; Vit B1, 1.8mg; VitB2, 5.5mg; Niacin, 27.5mg; Panthonenic acid, 7.5mg; Vit B6, 3mg; Vit B12, 0.015mg; Folic acid, 7.5mg; Biotin , 0.06mg; Cholin Chloride, 0.3mg; Cobalt, 0.2mg; Copper 3mg; Iodine 3mg;Iron,1mg; Manganese, 20mg; Selenium, 40mg; Zinc, 30mg; Antioxidant,1.25mg, *Vit-min Premix: Vitamin Mineral Premix. SBC= Soya Bean cake, GNC=Groundnut Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake ME= Metabolizable Energy, E=Multienzymes.

Table 3.4: Composition of Broiler Finisher Chicken Diets Fed Seed Cake-Based Diets Partly Substituted with Soya Bean Cake with or without Multienzymes Supplementation

Ingredients	Diets				
	SBC	RSC +E	RSC	BSC +E	BSC
Maize	59.00	56.80	56.80	57.00	57.00
Soya bean cake	29.00	10.00	10.00	10.00	10.00
Groundnut cake	0.00	0.00	0.00	0.00	0.00
Roselle seed cake	0.00	20.00	20.00	0.00	0.00
Baobab seed cake	0.00	0.00	0.00	20.00	20.00
Maize offal	7.00	5.00	5.00	7.00	7.00
Blood meal	1.00	4.00	4.00	2.00	2.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Limestone	0.25	0.25	0.25	0.20	0.20
Common salt	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.00	0.20	0.20	0.00	0.00
*Vit-min premix	0.25	0.25	0.25	0.25	0.25
TOTAL	**100**	**100**	**100**	**100**	**100**
Calculated analysis					
ME (kcal/kg)	2900	3000	3000	3000	3000
Crude protein (%)	20.00	20.00	20.00	20.00	20.00
Crude fiber (%)	3.21	4.59	4.59	3.46	3.46
Ether extract (%)	2.54	4.30	4.30	3.90	3.90
Calcium (%)	1.23	1.32	1.32	1.25	1.25
Phosphorus (%)	0.88	0.79	0.79	0.88	0.88
Methionine (%)	0.5	0.49	0.49	0.51	0.51
Lysine (%)	1.28	1.27	1.27	1.19	1.19
Cost/kg (₦)	104.91	105.61	104.81	88.57	87.77

*Bio-mix broiler finisher premix per kg diet: Vit A, 10 I.U; Vit D3, 2 I.U; Vit E, 23mg; Vit K3, 2 mg; Vit B1, 1.8mg; VitB2, 5.5mg; Niacin, 27.5mg; Panthonenic acid, 7.5mg; Vit B6, 3mg; Vit B12, 0.015mg; Folic acid, 7.5mg; Biotin , 0.06mg; Cholin Chloride, 0.3mg; Cobalt, 0.2mg; Copper 3mg; Iodine 3mg;Iron,1mg; Manganese, 20mg; Selenium, 40mg; Zinc, 30mg; Antioxidant,1.25mg, *Vit-min Premix: Vitamin Mineral Premix. SBC= Soya Bean cake, GNC=Groundnut Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake ME= Metabolizable Energy, E=Multienzymes.

Where:

Y_{ik} = Effect of the i^{th} protein sources (RSC and BSC with E)

μ = Overall mean

S_i= Effect of the i^{th} protein sources (RSC and BSC with E) on the experimental birds.

e_{ik} = Random error .

3.5.11 Economic benefit

Same as first feeding trial.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Amino Acid Profile of the Seed Cakes (SBM, GNC, RSC and BSC)

The amino acid profiles (AAP) of the experimental seed cakes are presented in Table 4.1. GNC has higher values for Phenylalanine (4.52), Histidine (2.26), Lysine (5.35), Valine (4.01), Alanine (4.72) and Threonine (4.01), while RSC has the highest values for Leucine (8.00), Isoleucine (4.02), Methionine (2.23), Tyrosine (3.61) and Glysine (4.02). Higher values for most of the amino acids were recorded for GNC, followed by RSC, SBC and least values were observed for BSC.

The values of SBM for threonine (3.99), phenylalanine (4.93) and lysine (6.49) reported by Banaszkiewicz (2000) were higher than the values obtained in this studies, while higher level was recorded for methionine (2.02) compared to the value reported by Banaszkiewicz (2000). Adeniji (2008) stated that in Nigeria groundnut cake was readily available and has a comparable crude protein content with soybean meal, though deficient in lysine and methionine (Mezou, 1984). The result obtained for some of the amino acid profile of GNC for this experiment was similar to that reported by Eyo and Olatunde (1998) who stated that GNC protein wass known to be deficient in methionine and also has a limited amount of tryptophan and threonine. Also, Singh *et al*. (1981) stated that it was deficient in methionine, tryptophan and tyrosine. In a comparative trial by Ayman (2002) the researcher found GNC to be the highest in its protein content followed by the sesame seed cake, SBC and cotton seed cake. The values of lysine, methionine and thrionine 0.66, 0.19 and 0.39% respectively reported by Babiker (2012) for BSC were lower than the levels obtained in this experiment. Baobab seed cake is rich in most essential amino acids, including lysine Glew *et al*. (1997). However, protein and

Table 4.1: Amino Acid Profile of the Experimental Seed Cakes

Essential Amino Acids (g/100g)	Experimental Seed Cakes			
	SBC	**GNC**	**RSC**	**BSC**
Phenylalanine	3.36	4.52	3.61	4.11
Histidine	1.62	2.26	2.02	1.55
Isoleucine	3.62	4.00	4.02	3.12
Lysine	4.54	5.35	5.04	3.23
Leucine	7.41	7.90	8.00	6.21
Methionine	2.02	2.2	2.23	1.40
Tyrosine	3.21	3.51	3.61	2.61
Valine	3.41	4.01	3.40	3.10
Alanine	4.21	4.72	4.55	4.04
Threonine	3.22	4.01	3.5	3.01
Glysine	3.60	3.83	4.02	2.81

RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, SBC= Soya Bean Cake.

methionine content of BSC was lower when compared with other seedcakes (Babiker, 2012). Variation in the value and amount of amino acids observed in different researches may be due to difference in variety of seed and the level of oil extraction.

4.2 Anti-nutritional Factors of the Seed Cakes (SBM, GNC, RSC and BSC)

The anti-nutritional factors of SBM, GNC, RSC and BSC are shown in Table 4.2. Soya bean cake had relatively higher saponin value than GNC and BSC while RSC had the least value. Tannin concentration was lower in GNC and higher in BSC; RSC had the highest level and the least was recorded in SBC.

The values of GNC and RSC for saponin (24.35, 15.80), tannin (1.60, 2.30) and phytate (0.09, 0.19) in this experiment were lower than the values reported by (Igoche, 2015). The lower values may be due to the level of oil extraction, variety of the seed and .Nkafamiya *et al.* (2007)reported thatalthough, BSC contains some anti-nutritional factors such as oxalate, phytate, saponins, and tannins, their levels were below the toxic levels for most livestock species, including poultry. Phytates may results to lower blood glucose response to starchy feeds (Yoon *et al*., 1983) and may have a significant effect on reducing plasma cholesterol and levels of triacylglycerols (Shamsuddin*et al*.**,**1989) by the same mechanism that makes them antinutrients. Tannin can forms large indigestible complexes in the digestive tract which affects digestibility.

4.3 Proximate Composition of the Experimental Seed Cakes

The proximate composition of the experimental seed cakes is presented in Table 4.3. The highest dry matter content (94.12%) was recorded for BSC, followed by SBC (91.42%), GNC(89.90 %) and the least was observed in RSC (89.60 %). Crude protein for SBC was 49.69%, GNC (44.09%), RSC (43.15%) and the least was recorded in BSC (38.71%). Crude fiber and ether extract for SBC were 7.17 and 3.78%, GNC (7.96 and 7.15%),

Table 4.2: Anti-nutritional Factors in the Experimental Seed Cakes

Seed Cakes	Anti-nutritional Factors		
	Saponin	**Tannin**	**Phytates**
Soya Beans Cake	44.65	2.02	0.07
Groundnut Seed Cake	24.35	1.60	0.09
Roselle Seed Cake	15.80	2.30	0.19
Baobab Seed Cake	16.70	2.55	0.14

Table 4.3: Proximate Composition of Experimental Seed Cakes

	Experimental Seed Cakes			
Parameters	**SBC**	**GNC**	**RSC**	**BSC**
Dry Matter (%)	91.42	89.90	89.60	94.12
Crude Protein (%)	46.69	44.09	43.15	38.71
Crude Fiber (%)	7.17	7.96	8.75	7.51
Ether Extract (%)	3.78	7.15	6.71	5.86
Ash (%)	8.5	4.91	5.46	4.61
Nitrogen Free Extract (%)	33.86	35.89	35.93	43.31
ME (kcal/kg)	2654.69	2699.45	2675.66	2720.44

SBC= Soya Bean cake, GNC=Groundnut Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake ME= Metabolizable energy, calculated according to Lodhi *et al.* (1976).

RSC (8.75 and 6.71 %) and BSC (7.51 and 5.86 %). The values for ash and nitrogen free extract for SBC were 8.50 and 33.86%, GNC (4.91 and 35.89%), RSC (5.46 and 35.93%) and BSC (4.61 and 43.31%). The highest metabolizable energy was recorded for BSC 2720.44 Kcal/kg, whileGNC was (2699.45 Kcal/kg), RSC (2675.66 Kcal/kg) and the least was recorded for SBC (2654.69 Kcal/kg).

Warnick (1966) reported crude protein (CP) of about 40-49% and 40% for SBC and GNC respectively, Batal *et al*. (2005) also reported CP range for GNC ofabout 40.10 - 50.90% with a mean of 45.60 %.The values obtained in this study were in line with their values and was in line with the statement of Adeniji (2008) that GNC had comparable CP content with SBC. Metabolizable energy (ME)for GNC (2699.45 Kcal/kg)was within the range of 2,664.00 and 2660.44 kcal/kg reported byBatal *et al*. (2005) and Muataz (2019),dry matter content (DM), crude fiber (CF), ether extract (EE) and ash for GNC were lower than the values (91.50, 9.50, 8.10 and 9.00 %) reported by Muataz (2019) while CP (44.09 %) and nitrogen free extract NFE (35.89%) were higher than the values (41.90 and 23.00%) reported by Muataz (2019). Dry matter, EE, NFE, ME and ash for RSC in this study were lower than the values reported by Ojile (2017), CF (8.75 %) and CP (43.15 %) were higher than the values (4.2 and 30.45 %) reported by Ojileh (2017). The values of CP (11.3%) and ME (2171.13 Kcal/kg) for BSC recorded by Muataz (2019) were lower than the values (38.71 % and 2720.44 Kcal/kg) for BSC in this study, but EE was comparable with the value (5.4 %) reported by Muataz (2019). The variation in the composition of the cakes could be due to variety differences, processing methods, chemical structure and levels of antinutrients. This was in agreement with the statement of Babiker *et al*. (2009) that variations in chemical (proximate) composition of oil seed cakes could be due to many reasons such as soil type, season of growing and harvesting, variety, type of storage and the degree of processing, dehulling degree and method of oil extraction.

4.2 First Feeding Trial: Effect of Feeding Groundnut, Roselle and Baobab Seed Cake Diets to Broiler Chickens Partly Substituting Soya Bean Cake

4.2.1 Growth performance of broiler starter chickens fed groundnut, roselle and baobab seed cake diets partly substituting soya bean cake (0 – 4 weeks)

Table 4.2 presents the growth performance of broiler starter chickens fed GNC, RSC andBSC partly substituting soya bean cake. The final weight (FW) 959.81 g and weight gain(WG) 909.12g were significantly ($P<0.05$) higher for chickens fed SBC (959.81 and 909.12g) and lower for birds fed GNC, RSC and BSC.Feed consumed (FC) washigher ($P>0.05$)among SBC, RSC and BSC groups and least was observed for the group fed GNC diet. The least feed conversion ratio (FCR) was recorded for birds fed BSC diets (2.25) and was significantly ($P<0.05$) better in birds fed diets containing SBC (1.77) and GNC (1.93). Birds fed SBC, GNC and BSC had significantly ($P<0.05$) best feed cost/kg gain (FC/kgG) compared to those fed RSC diet. The dietary treatment with SBC had highest ($P<0.05$) protein efficiency ratio (PER) and the least was recorded for BSC group. Birds on SBCdiet performed better than other treatments and they recorded the highest FW (959.81 g) and WG (909.12 g); this is in agreement with the work of Ghadge *et al*. (2009) who stated that chickens performed better when soya bean cake was included in their diets at 75 and 100 % and is also in line with the statement of Sara Willis (2003) that soya bean meal was an important protein source for chickens. Furthermore, it was not in agreement with the findings of Ojile (2017) that birds on SBC diet which served as the control had lower FW and WG compared to those fed RSC diet replacing SBC at 24 %.

Variation in FW and WG could be due to differences in ingredient composition of the diet, inclusion levels and level of antinutrients, which consequently affected the birds' performance. From the result, FW and WG of birds fed GNC in their diet was lower than those fed SBC, RSC and BSC diets, this indicated that it was not good for the young chicks (Groundnut Handbook, 1984) in relation to their nutritive requirement. At the

Table 4.4: Growth Performance of Broiler Starter Chickens Fed Groundnut, Roselle and Baobab Seed Cake Diets Partly Substituting Soya Bean Cake(0-4 weeks)

	Dietary Levels of the Seed Cakes (kg/100kg diet)				
Parameters	**SBC**	**GNC**	**RSC**	**BSC**	**LSD**
Initial weight (g/bird)	50.69	52.04	51.93	51.70	4.79
Final weight (g/bird)	959.81^{a}	721.40^{c}	875.65^{b}	820.86^{b}	66.93
Weight gain(g/bird)	909.12^{a}	669.36^{c}	823.72^{b}	769.15^{b}	68.62
Feed consumed(g/bird)	1610.62^{a}	1290.47^{b}	1673.49^{a}	1728.58^{a}	147.75
Feed conversion Ratio	1.77^{a}	1.93^{ab}	2.03^{b}	2.25^{c}	0.19
Feed cost (₦/kg)	110.66	105.78	107.16	91.58	-
Feed cost/kg Gain (₦/kg)	195.92^{a}	204.68^{ab}	217.66^{c}	206.39^{ab}	19.45
Protein efficiency ratio	2.45^{a}	2.25^{ab}	2.24^{b}	2.22^{c}	0.02
Mortality (%)	0.33	0.38	0.05	0.16	0.36

^{abc}= Means with different superscripts on the same row are significantly different P< 0.05, GNC= Groundnut Seed Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, SBC= Soya Bean Cake, LSD= Least Significant Difference.

starter phase, birds on that diet had the least performance. Costa *et al*. (2001) reported that GNC is limited in methionine, lysine and threonine, and poor performance of broiler chickens was limited to amino acid content and was not resolved with threonine supplementation. Low intake by the birds fed GNC diet could be linked to aflatoxin contamination, it could also be attributed to high fiber content of the diet which was discouraged in poultry diets (Mapiye *et al*., 2008). At the starter phase, the chicks had a premature digestive tract and an under developed system of enzymatic secretion. Therefore, feeding GNC at high level resulted in negative effect on final weight but as age advanced, the digestive system became well developed.

Final weight and average weight gain of birds fed RSC diet was in line the with the result obtained by Ojile (2017) who fed graded levels of Roselle seed cake as replacement for soya bean cake to broiler chickens, and reported that RSC at 24% improved body weight. The statement of Saulawa *et al*. (2014) that 10% BSC could be used in broiler starter diet without adverse effect on productive performance was alsoin line with this study. Muataz (2019) indicated that high score of body weight gain was observed in the starter phase with 33 and 25% baobab inclusion, this was similar to the findings of this study because birds on BSC and RSC diets performed next to those fed SBC diet, in spite the antinutrients and fiber content of baobab seed cake amongothers, their effect could be accumulative or their levels seemed to be below the toxic level and this agreed with the reports of D'mello (1995), Nkafamiya *et al*. (2007). It is known that the use of many sources of protein in poultry diet was preferable to integrate each other and cover the deficiency of some of the limiting amino acids which caused depressed growth and poor performance of birds.

The amount of feed consumed for RSC diet was in line with the findings of Igoche (2015) who reported that daily feed intake increased when inclusion level of RSC increased. The result of feed consumed for BSC diet was not supported by the report of Mwale *et al*. (2008), who stated that baobab seed inclusion beyond 10% in the diet caused a decline in feed consumed, this could be because they used the raw seed and not the seed cake. The result of feed consumed was in line with the findings ofSaulawa *et al.* (2014) reported that BSC has good aroma that improved intake.Even though FCR and PER were not significant between GNC (2.25) and SBC (2.45), their means were lower when compared with PER of 3.80 for egg (Tome, 2002). Result obtained on FCR and PER for BSC was the leastcompared to other treatments, this showed that the protein was not efficiently utilized andwas similar to the report ofKamran (2008) that PER decreased with reduced CP and ME diets during the overall experimental periodeven though the broiler chickens consumed the same amount of protein and energy, weight gain was significantly depressed.

4.2.2 Growth performance of broiler finisher chickens fed groundnut, roselle and baobab seed cake diets partly substituting soya bean cake (5-8 Weeks)

The growth performance of broiler finisher chickens fed GNC, RSC and BSCpartly substitutingsoya bean cake is presented in Table 4.5. The results obtained showed that there weresignificant ($P<0.05$) effects in FW, WG, FCR, FC/kgG and PERacross the dietary treatments.Birds fed SBC and GNC in their diets had significantly ($P<0.05$) better FW (2.67 and 2.52 kg), WG (1790.57 and 1688.67 g), FCR (2.29 and 2.26), FC/kgG (₦239.46 and ₦229.50) and PER compared to other treatment groups.

The findings on growth performance for SBC and GNC diets in this study are in line with the statement of Omer (1989) that with the exception of soybean meal among different oil cakes, GNC was the second plantprotein source that produced better animal performance. Final weight, weight gain and protein efficiency ratio of GNC and RSC were similar, and

Table 4.5: Growth Performance of Broiler Finisher Chickens Fed Groundnut, Roselle and Baobab Seed Cake Diets Partly Substituting Soya Bean Cake (5 – 8 weeks)

	Dietary Levels of the Seed Cakes (kg/100kg diet)				
Parameters	**SBC**	**GNC**	**RSC**	**BSC**	**LSD**
Initial weight (g/bird)	881.06	833.29	864.86	831.13	52.22
Final weight (g/bird)	2671.63[a]	2522.26[ab]	2441.64[b]	1996.18[c]	202.4
Weight gain(g/bird)	1790.57[a]	1688.97[ab]	1576.78[b]	1165.05[b]	171.54
Feed consumed(g/bird)	4108.2	3824.4	4165.2	4076.5	372.79
Feed conversion Ratio	2.29[a]	2.26[a]	2.64[b]	3.49[c]	0.15
Feed cost (₦/kg)	104.57	101.55	103.87	85.82	-
Feed cost/kg gain (₦/kg)	240.34[a]	230.02[a]	274.94[b]	300.32[c]	15.10
Protein efficiency ratio	2.17[a]	2.21[a]	1.89[b]	1.43[c]	0.22
Mortality (%)	0.20[ab]	0.05[ab]	0.00[a]	0.31[c]	0.28

[abc]= Means with different superscripts on the same row are significantly different P< 0.05, GNC= Groundnut Seed Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, SBC= Soya Bean Cake, LSD= Least Significant Difference.

were contrary to the report of Ojile (2017) that final body weight and overall performance was higher with birds on 24 % RSC diet. Feed intake for BSC was similar (P>0.05) to other treatment diets; the finding was not in agreement with Murale *et al.* (2008) who testedfeed intake in guinea fowls fed BSC and found that intake decreased at 10 and 15% inclusion. Several studies have reported lower intake due to high fiber level for BSC in rat and poultry diets as stated by Adewusi and Matthew (1994) and Mapiye *et al*. (2008). Higher intake observed could be due to good aroma of BSC diet which was consistent with the report of Chimvuramahwe*et al*. (2011) and Saulawa *et al*. (2014), it could also be due to difference in specie of the animals.

The least body weight was observed in birds fed BSC based diet, the observation was supported by the report of Murale *et al.* (2008) that growth rate in guinea fowlwas not affected by BSC at 5 % inclusion but decreased at 10 and 15%, with an average body weight reduction of 9 % at 6 weeks of age.

Feed conversion ratio for BSC was in line with Adewusi and Matthew (1994) and Mapiye *et al*. (2008). High mortality reported by Nkafamiya *et al.*(2007) in birds fed the highest BSC inclusion level in their diets was in agreement with mortality observed for birds fed BSC in this experiment, because BSC group had the highest mortality compared toother treatment, this could be attributed to the cummulative effect of anti-nutritional (level oftannin and phytate in BSC) factors which can lower blood glucose response to starchy feeds (Yoon *et al.,* 1983), affect digestion and can also tie down some of the important nutrients like vitamins and minerals in the diet. Relatively high fiber content of BSC could be one of the reasons why the highest mortality was recorded in this study, andit also agreed with the statement of Mapiye *et al*.(2008) that high fiber content in poultry diets is discouraged.

4.2.3 Nutrient digestibility of broiler chickens fed groundnut, roselle and baobab seed cake diets partly substituting soya bean cake

The results of nutrient digestibility in Table 4.6 showed that dietary treatments had significant ($P < 0.05$) effect on birds fed the seed cake diets in all the parameters tested. The results revealed that the digestibility values of EE, DM, CP, CF and NFE were significantly ($P<0.05$) higher for chickens fed RSC and the least means were recorded for those fed BSC. Digestibility of nutrient by birds fed diets containing SBC and GNC were similar ($P>0.05$). Higher digestibility values reported for RSC could be due to high nutrient released and better amino acid profile as a result of substitution with SBC which had a good amino acid profile. This agreed with the findings of Ojile (2017) who fed RSC at graded levels to broiler chicken and reported that birds fed RSC at 24 % substituted with SBC had the best digestibility values.

Baobab Seed Cake diet had the least digestibility mean compared to other treatment means. This showed that digestibility of BSC was lower compared to other treatment groups and could be as a result of its thick shell (Muataz (2017) and fiber (Murray *et al*., 2001) which is discouraged in poultry diets (Mapiye *et al*., 2008). Though, the levels of phytate in poultry feed in literature are variable, it exerts a negative effect on the overall efficiency ofnutrient utilization by increasing endogenous secretions, decreasing mineral and protein digestibility and solubility (Singh, 2008). The accumulative effect of these anti-nutritional factors could occur and affects the performance of birds on BSC diet. Table 4.2 showed the level of phytate in BSC which was slightly high and this could be one of the reasons why it had the least digestibility.

4.2.4 Carcass characteristics of broiler chickens fed GNC, RSC and BSC diets partly substituting soya bean cake

Table 4.7 shows the carcass characteristics of broiler chickens fed SBC, GNC, RSC and

Table 4.6: Nutrient digestibility of Groundnut, Roselle and Baobab Seed Cake Diets of Broiler Chickens Partly Substituting Soya Bean Cake

	Dietary Levels of the Seed Cakes (kg/100kg diet)				
Parameters	**SBC**	**GNC**	**RSC**	**BSC**	**LSD**
Dry matter (%)	79.06[b]	78.39[b]	85.62[a]	72.73[c]	5.48
Crude protein (%)	82.62[b]	83.31[b]	88.33[a]	79.63[b]	3.78
Crude fibre (%)	68.93[a]	72.74[a]	75.70[a]	55.95[b]	9.62
Ether extract (%)	83.34[b]	81.27[bc]	89.52[a]	78.18[c]	4.38
Nitrogen free extract (%)	81.97[b]	80.04[bc]	87.65[a]	75.34[c]	5.18

[abc]= Means with different superscripts on the same row are significantly different $P < 0.05$, SBC= Soya Bean Cake, GNC= Groundnut Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, LSD= Least Significant Difference.

Table 4.7: Carcass Characteristics of Broiler Chickens Fed Groundnut, Roselle and Baobab Seed Cake Diets Partly Substituting Soya Bean Cake

	Dietary Levels of the Seed Cakes (kg/100kg diet)				
parameters	**SBC**	**GNC**	**RSC**	**BSC**	**LSD**
Live weight (g)	3450.00[a]	3195.00[b]	3166.67[b]	2450.00[c]	209.91
Dressed weight (g)	3143.75[a]	2900.00[b]	2833.33[b]	2211.25[c]	172.63
Dressing percentage (%)	81.53[a]	80.15[ab]	84.76[a]	76.50[b]	4.837
Major cuts expressed as percentage of dressed weight					
Thigh (%)	13.31	13.40	12.76	12.86	1.00
Breast (%)	29.03[ab]	27.61[b]	30.55[a]	25.03[c]	1.80
Drumstick (%)	11.16	10.52	10.33	11.09	0.95
Back (%)	12.25	12.91	12.27	12.26	0.83
Organs expressed as percentage of live weight					
Liver (%)	1.85	1.99	1.91	2.02	0.40
Heart (%)	0.39	0.44	0.38	0.42	0.08
Kidney (%)	0.48	0.60	0.63	0.53	0.16
Spleen (%)	0.13	0.11	0.11	0.10	0.05
Gizzard (%)	2.15[b]	2.31[b]	2.30[b]	3.41[a]	0.29
Lung (%)	0.59	0.56	0.46	0.63	0.20
Abdominal fat (%)	1.03	1.19	1.37	1.59	0.86

[abc]= Means with different superscripts on the same row are significantly different $P < 0.05$, SBC= Soya Bean Cake, GNC= Groundnut Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, LSD= Least Significant Difference.

BSC diets. The live weight and dressed weight for birds fed SBC were significantly (P<0.05) higher than other treatments and the least mean was recorded for those fed BSC, and they followed the same trend across the dietary groups. Dressing percentage was significantly (P<0.05) higher in birds fed SBC, GNC and RSC and the least was observe for those fed BSC. In addition, there were significant (P<0.05) effects of dietary treatments in major cuts for breast yield and in organs weight for gizzard. This indicated that the dietary treatments had no significant effect on other cut parts and organ weights.

Bigger breast muscle yield was recorded in birds fed SBC and RSC their diets and this could be an indication that they had the ability to improve breast yield in chickens. Larger gizzard reported for birds fed BSC might be due to higher muscular activities in the gizzard as a result of undigested part of the ingested BSC in the diet which had a hard outer coat that was not easily digestible and higher tannin level as presented in Table 4.2 that forms large indigestible complexes in the digestive tract which affects digestibility. The result isnot in agreement with that of Mateos *et al*., (2012) who reported that fiber level affect gizzard yield/proportion.

4.2.5 Haematological profile of broiler chickens fed GNC RSC and BSC diets partly substituting soya bean cake

Table 4.8 shows the blood haematological profile of birds fed GNC, RSC and BSC dietspartlysubstituting soya bean cake. The result showed that the dietary treatments had no significant (P>0.05) effect on some blood profiles of the bird. However, significant (P<0.05) difference was observed in the level of basophils across the treatments.

Most of the parameters measured were within the normal range reported for healthy birds by Mitruka and Rawnsely (1997). The observation in packed cell volume (PCV) andhaemoglobin (Hb) counts showed that all values were near the upper limits of PVC and

Table 4.8: Haematological profile of Broiler Chickens Fed Groundnut, Roselle and Baobab Seed Cake Diets Partly Substituting Soya Bean Cake

	Dietary Levels of the Seed Cakes (kg/100kg diet)					
Parameters	**SBC**	**GNC**	**RSC**	**BSC**	**LSD**	**Reference Values**
PCV (%)	29.32	32.55	31.95	34.60	8.48	24.00-40.00*
Hb(g/dl)	9.15	10.32	10.12	10.72	2.65	7.00-15.00*
RBC ($\times 10^{12}$/L)	2.08	2.29	2.27	2.46	0.64	1.59-4.10*
WBC ($\times 10^{9}$/L)	7.78	8.67	8.02	8.95	24.96	1.90-9.50**
Lymphocytes (%)	88.22	89.40	90.02	89.87	3.70	40.00-100.00**
Monocytes (%)	3.00	2.87	2.17	2.37	1.99	1.00-7.00****
Eosinophils (%)	4.62	4.57	4.00	4.25	1.73	1.50-6.00**
Basophils (%)	0.10^{b}	0.25^{ab}	0.97^{a}	0.25^{ab}	0.86	0.10-2.00*

^{ab}= Means with different superscripts on the same row are significantly different $P < 0.05$, GNC=Groundnut Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, SBC= Soya Beans Cake, LSD= Least Significant Difference,PCV= Packed Cell Volume, Hb= Haemoglobin, WBC= White Blood Cell, RBC= Red Blood Cell, *Mitruka and Rawnsely, (1997), **Simrak *et al*., (2004), ***Jain, (1986), ****Jain, (1993).

Hb range for normal healthy birds, and were in accordance with normal ranges of 7-15 g/dL and 24-40 % forPVC and Hb respectively (Mitruka and Rawnsely, 1997). This was an indication that oxygen circulation and feed efficiency were not impaired by feeding the seed cakes to the birds. White blood cell (WBC) count was within normal range 1.90 - 9.50 $\times 10^9$/L reported by Simrak *et al*. (2004) and this showed that all the birds had good immune system. Those fed SBC diet had the least basophil count compared to other treatments. However, higher value within the normal range showed the level of immunity in the bird and this indicated that birds on SBC diets had less immunity and were more exposed to high risk of disease infection (Soetan *et al*., 2013). In trials conducted by Abdulazeez *et al*. (2016) and Muataz (2019) birds fed BSC at 25% recorded higher white blood cell (WBC) counts and their results were similar to the values obtained in this study.

4.2.6 Liver function indices of broiler chickens fed GNC, RSC and BSC diets partly substituting SBC

The liver function indices of birds fed GNC, RSC and BSC diets are presented in Table 4.9. The seed cakes had no significant (P>0.05) effect in all the parameters tested but alkaline Phosphatase (ALP) was significant (P<0.05) across the treatments.

All ALP values across the treatment means were within normal range 10-106 µL (Bounous and Stedman 2000) and the least was in birds fed BSC in their diet. The result revealed that the protein in the diets was efficiently utilized and the seed cakes did not contain toxic substances that interfered with activities of the enzymes in the liver to cause damage. Total protein, albumin and globulin were within normal range for healthy birds and their levels were indicating high clotting ability of the blood and protein retention in the birds (Esonu *et al*., 2001). Elevated level of creatinine and low glucose were observed across the groups. Fasting of the birds before slaughter and high temperature considering

Table 4.9: Liver Function Indices of Broiler Chickens Fed Groundnut, Roselle and Baobab Seed Cake Diets Partly Substituting Soya Bean Cake

	Dietary Levels of the Seed Cakes (kg/100kg diet)					
Parameters	**SBC**	**GNC**	**RSC**	**BSC**	**LSD**	**Reference Ranges**
Glucose (g/dL)	98.75	87.92	89.73	91.25	14.07	199.00-348.00**
Blood urea nitrogen (mg/100ml)	3.52	4.17	3.67	4.25	1.00	1.50-8.30*
Albumin(g/L)	1.97	2.00	2.13	2.25	0.54	1.10-2.20***
Globulin (g/L)	3.40	3.35	2.83	3.45	0.91	1.20-3.20****
Total protein(g/L)	5.37	5.35	4.96	5.70	0.86	3.60-5.50***
Creatinine (mg/100ml)	0.82	0.82	0.70	0.80	0.17	0.10-0.40[M]
Aspartate amino transferase(µL)	53.87	51.60	54.96	57.12	11.23	150.00-278.00**
Alkaline phosphatase (µL)	86.00[ab]	90.72[a]	93.70[a]	79.02[b]	11.38	10.00-106.00*****
Alanine amino transferase (µL)	16.55	15.82	17.70	17.22	2.51	9.50-37.20*

[ab]= Means with different superscripts on the same row are significantly different P < 0.05, SBC= Soya Bean Cake, GNC= Groundnut Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, LSD= Least Significant Difference, *Mitruka and Rawnsley, (1997), **CDD (1990), ***Ross *et al*. (1976), ****LAVC (2009), ****Bounous and Stedman (2000), [M] Merck (2012).

the time the study was conducted could be the reason for glucose level to fall below normal range across the dietary groups. Higher creatinine levels for all the groups could be due to dehydration and feed restriction before slaughter. It has been established that feed restriction for a longer period could lead to utilization of reserved energy by animals and this could be the reason for lower blood glucose. This was supported by Etim *et al*. (2014) and Boostani *et al*. (2010) that feed and water restriction can affect the haematological changes of domesticated animals (Graczyk *et al*., 2003). The result was also in agreement with Sands *et al.* (1999) who reported decrease in plasma glucose level of broiler under heat stress. Abdalla (2009) reported decrease in plasma glucose concentration in broiler chickens during summer as compared to winter.

4.2.7 Lipid profile of broiler chickens fed GNC RSC and BSC partly substituting SBC

Result of lipid profile of broiler chickens fed GNC, RSC and BSC diets is shown in Table 4.10. Triglycerides and high density lipoprotein were not significant (P>0.05) for all the treatments. Cholesterol and Low density lipoprotein were significantly higher (P<0.05) for birds fed SBM, GNC and BSC while the least was observed in those fed RSC, and they followed the same pattern for all the groups.

The normal range for cholesterol was 52-148 mg/dl (Basmacioglu and Erglu, 2005) and all values obtained were within normal range but RCS was lowest when compared with other diets. Plane of nutrition, feed type, ingredients used, anti-nutrients, amount of crude fiber, breed of chicken and environmental factors could be the reason for variations in cholesterol levels. This was consistent with Sutrihadi *et al.* (2013) that dietary crude fiber could affect blood cholesterol and was also similar to Haryanto *et al.* (2016) who fed banana peel meal at 10% to broiler and concluded that it lowered serum cholesterol due to high amount of crude fiber. They further explained that the crude fiber reduced nutrient

Table 4.10: Lipid Profile of Broiler Chickens Fed Groundnut, Roselle and Baobab Seed Cake Diets Partly Substituting Soya Bean Cake

	Dietary Levels of the Seed Cakes (kg/100kg diet)					
Parameters	**SBC**	**GNC**	**RSC**	**BSC**	**LSD**	**Reference Range**
Triglycerides(mmol/L)	66.85	64.78	86.63	82.30	25.35	<150.00**
Total cholesterol(mmol/L)	110.02[a]	104.55[a]	79.60[b]	106.22[a]	17.19	52.00-148.00*
High density lipoprotein (mmol/L)	44.38	48.63	28.93	52.20	39.55	≥22.00**
Low density lipoprotein (mmol/L)	23.350[a]	28.15[a]	13.300[b]	26.150[a]	9.35	≤130.00**

[ab]= Means with different superscripts on the same row are significantly different $P < 0.05$, SBC= Soya Bean Cake, GNC= Groundnut Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, LSD= Least Significant Difference, *Basmacioglu and Ergul, (2005), **Manoppo *et al*., (2007).

and cholesterol absorption in the intestine. Low levels of low density lipoprotein and cholesterol for RSC showed that the fat in birds fed RSC diet was healthier for consumption than other groups. This was consistent with Sutrihadi *et al.* (2013) that dietary crude fiber could affect blood cholesterol and was also similar to Haryanto *et al*. (2016) who fed banana peel meal at 10 % to broiler and concluded that it lowered serum cholesterol due to high amount of crude fiber. They further explained that the crude fiber reduced nutrient and cholesterol absorption in the intestine. Low levels of low density lipoprotein and cholesterol for RSC showed that the fat in birds fed RSC diet was healthier for consumption than other groups.

4.2.8 Economic benefit of feeding GNC, RSC and BSC diets to broiler chickens partly substituting SBC

The economics of feeding the seed cakes is shown in Table 4.11. Dietary inclusion of soya bean cake in broiler chickens diet without substitution of the diets with other legume grains raised the feeding cost. On the other hand 20 % GNC and BSC inclusion levels reduced the feeding cost of broiler chickens by 13.64 and 16.39 %, respectively. A similar result was reported by Chisorol *et al*. (2018) who stated that increasing levels of BSC reduced feed costs especially in the starter phase. Since the average live weight of bird for control was higher, gross margin (GM) was also high because it was determined as a product of average live weight of bird by over the experimental period to the cost of meat per kg, but there was slight difference in average live weight of bird between birds fed SBC and GNC diets. Those fed GNC consumed less feed (5114.87 g) compared to SBC (5718.82 g), birds fed GNC had similar weight (2.52 kg) to those fed SBC (2.67 g) at lower feed cost and production cost (₦ 524.87, ₦ 687.36) compared to SBC (₦ 607.82, ₦ 778.60) with a very close GM. Birds on SBC group recorded higher revenue, GM and return/₦ invested (₦ 1869.00, ₦ 1090.40 and 2.4), and GNC group was closer

Table 4.11: Economic Benefit of Broiler Chickens Fed Diets Containing Groundnut, Roselle and Baobab Seed Cakes Partly Substituting Soya Bean Cake (0 - 8 Weeks)

	Dietary Levels of the Seed Cakes (kg/100kg diet)			
Parameters	**SBC**	**GNC**	**RSC**	**BSC**
Feed intake (g)	5718.82	5114.87	5838.69	5805.08
Feed cost (₦/bird)	607.82	524.87	611.97	508.14
Other expenses (₦)	100.00	100.00	100.00	100.00
Miscellaneous expenses (₦)	70.78	62.48	71.19	60.81
Total variable cost (₦/bird)	778.60	687.35	783.16	668.95
Average live weight (kg/bird)	2.67	2.52	2.44	1.99
Cost/kg live weight (₦/kg)	700.00	700.00	700.00	700.00
Revenue (₦/bird)	1869.00	1764.00	1708.00	1393.00
Gross margin (₦)	1090.40	1076.65	924.84	724.05
Return/₦ invested	2.40	2.50	2,18	2.08

SBC= Soya Bean Cake, GNC= Groundnut Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, Gross Margin= (Revenue - Total variable cost), Return/₦ invested= (Revenue / Total variable cost).

with ₦ 1764.00 revenue, ₦ 1076.65 GM and 2.50 return/₦ invested**.** Chimvuramahwe *et al*. (2011) reported that high crude protein and essential amino acid feeds at low inclusion levels. They reported that it economically reduced the total feed cost in broiler chick diets. Therefore it could be a valuable ingredient in broiler chick diets at 10 % inclusion level as it maximized financial returns.

4.3 Second Feeding Trial: Response of Broiler Chickens to Two Dietary Plant Protein Levels Partly substituting Soya Bean Cake with and without Multienzymes.

In the first experiment, performance and economic returns of feeding SBC and GNC diets were slightly similar and birds fed RSC and BSC had the least results, therefore multienzymes (Maxigrain®; protease 4000 IU, xylanase10000IU, phytase 2500 FTU and cellulase 10000 IU) were supplemented to improve nutrient utilization and performance of birds.

4.3.1 Growth performance of broiler starter chickens fed RSC and BSC diets partly substituting SBC with and without multienzymes supplementation (0 – 4 weeks)

The growth performance of broiler starter chickens fed RSC and BSC diets with and without multienzymes supplementation is presented in Table 4.12. Weight gain (886.90g), feed consumed (1728.01g)and final weight (932.81g) of birds fed SBC diet were significantly (P<0.05) higher than the other experimental diets, enzyme supplementation had significant (P<0.05) effect on WG and FW of birds fed BSC, and they followed the same trend. Feed cost per kg gain was significant (P<0.05) and SBC, BSC + E and BSC had the least means. Feed cost/kg was significantly (P<0.05) higher for birds fed RSC + E and RSC , mortality and PER record were not significant (P>0.05) for all the treatments.

Table 4.12: Performance of Broiler Starter Chickens Fed Roselle and Baobab Seed Cakes Diets Partly substituting Soya Bean Cake with and without Multienzymes (0 – 4 weeks).

	Dietary Levels of the Seed Cakes (kg/100kg diet)					
Parameters	**SBC**	**RSC +E**	**RSC**	**BSC +E**	**BSC**	**LSD**
Initial weight (g/bird)	45.91	45.91	45.91	45.91	45.91	0.00
Final weight (g/bird)	932.81^{a}	733.26^{c}	760.00^{bc}	756.11^{c}	804.87^{b}	45.60
Weight gain(g/bird)	886.90^{a}	687.35^{c}	714.09^{bc}	710.20^{c}	758.96^{b}	45.60
Feed consumed(g/bird)	1728.01^{c}	1476.13^{a}	1558.62^{ab}	1527.41^{a}	1660.98^{bc}	121.81
Feed conversion Ratio	1.94^{a}	2.15^{ab}	2.18^{b}	2.15^{ab}	2.18^{b}	0.21
Feed cost (₦/kg)	110.45	108.36	107.56	93.87	93.07	-
Feed cost/kg gain (₦/kg)	215.26^{ab}	233.00^{b}	235.11^{b}	201.94^{a}	203.73^{a}	34.05
Protein efficiency ratio	2.23	2.12	2.08	2.11	2.07	0.20
Mortality (%)	0.30	0.39	0.40	0.08	0.23	0.45

^{abc}= Means with different superscripts on the same row are significantly different P < 0.05, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, SBC= Soya Bean Cake, LSD= Least Significant Difference, E= Multienzymes.

Multienzymes supplementation lowered feed intake for BSC, this was similar to report of Hashish *et al*. (1995) who fed diets supplemented with Kemzyme (0.5 or 1.0 g/kg) and Roxazym, they noticed a significant decrease in daily feed consumption for the broiler chicks.Nahashon *et al*. (2006) and Nkafamiya *et al*. (2007) stated that both body weight gain and feed conversion rate were influenced by feed intake in meat-type poultry, this was consistent with Plavnik *et al*. (1997) and Nahashon *et al*. (2006) who suggested that birds decrease their feed intake to satisfy their energy needs as dietary energy increases.

Higher feed intake for bird fed BSC without multienzyme, could be due to palatability and good aroma of the diet (Chimvuramahwe *et al*., 2011 and Saulawa *et al.,* 2014).It could also be due to the amount of anti-nutrients in the diets, which could lower the bioavailability of nutrient in the diets and this made them to consume more feed to satisfy their dietary needs. This agrees with the statement of Veldkamp *et al*. (2005) and Nahashon *et al*. (2005) that birds tend to consume more to meet their energy requirement. Research has shown that nutrient requirements of protein and energy for growth and development (Pal and Singh, 1997) in poultry increases with age, thus feed intake was increased by broiler chicks to meet their requirement. Increased in passage rate of feed, digestion and absorption of nutrients could consequently be the reason for increase in final weight observed in RSC and BSC groups. At the starter phase, the chicks had a premature digestive tract and an under developed system of enzymatic secretion, therefore, feeding RSC and BSC at high levels increased intake due to the level of anti-nutritional factors and bioavailability of nutrients to meet their nutritional requirements. At this phase, the effect of enzyme supplementation on improvement and uniformity in growth was not well reflected. Food conversion ratio was better in birds fed SBC diet, Kaczmarek *et al*. (2009) and Subha (2013) stated that feed conversion ratio was improved significantly with supplementation of enzymes to broiler chicken diet, this was contrary to result obtained for feed conversion ratio of RSC and BSC in this study. Feed cost/kg gain was better for SBC, BSC + E and BSC.

4.3.2 Growthperformance of broiler finisher chickens fed RSC and BSC diets partly substituting SBC with and without multienzymes (5 – 8 weeks)

The growth performance of broilerfinisher chickens fed RSC and BSC Diets with and without multienzymes supplementation is presented in Table 4.13. Birds fed SBC performed significantly (P<0.05) higher than all other treatments. The result showed that final weight and weight gain (2.64kg and 1719.21g) for SBC was the best (P<0.05).Total feed consumed by birds were not significant (P>0.05), feed cost per kg gain and mortality were affected (P<0.05) by dietary treatment and multienzymes addition. The least feed conversion ratiowas observed in birds fed BSC + E (2.64) and BSC (2.90) while birds with SBC in their diet had better feed conversion ratio (2.25).Protein efficiency ratio for SBC was better when compared to other dietary treatments.

Final weight and WG were not affected by multienzymes supplementation and were in line with the report of Shalash *et al*. (2009) that multienzymes (enzyme combinations: xylanase, glucanase, protease, and amylase) supplementation to broiler diets showed no improvement in body weight. Feed intake in this study was not significant across the dietary treatments with and without multienzymes addition; it was in line with the findings of Lu *et al*. **(**2013) that feed intake was not affected by the enhancement of exogenous enzymes in broiler chickens. On the contrary, Woyengo *et al*. (2010) reported that multicarbohydrase non starch polysaccharide-degrading enzymes, phytases and proteases improved nutrient utilization and growth performance of broiler chickens. Raza *et al*. (2009) and coweison, (2009) in their separate studies reported significant improvement in body weight gain which was not in agreement with the findings in this study.

Table 4.13: Performance of Broiler Finisher Chickens Fed Roselle and Baobab Seed Cakes Diets Partly substitutingSoya Bean Cake with and without Multienzymes (5 – 8 weeks).

	Dietary Levels of the Seed Cakes (kg/100kg diet)					
Parameters	**SBC**	**RSC +E**	**RSC**	**BSC +E**	**BSC**	**LSD**
Initial weight (g/bird)	925.45	892.42	887.87	876.05	905.75	58.24
Final weight (g/bird)	2644.66^{a}	2386.97^{b}	2400.81^{b}	2357.24^{b}	2233.64^{b}	169.26
Weight gain(g/bird)	1719.21^{a}	1494.55^{b}	1512.93^{b}	1481.19^{bc}	1327.88^{c}	153.88
Feed consumed(g/bird)	3879.6	3830.6	3901.4	3907.4	3827.9	347.13
Feed conversion Ratio	2.25^{a}	2.56^{ab}	2.58^{ab}	2.64^{b}	2.90^{b}	0.37
Feed cost (₦/kg)	104.91	105.61	104.81	88.57	87.77	-
Feed cost/kg gain(₦/kg)	236.79^{ab}	271.04^{c}	270.62^{bc}	234.17^{a}	254.62^{abc}	15.22
Protein efficiency ratio	2.21^{a}	1.95^{b}	1.93^{b}	1.90^{b}	1.73^{b}	0.24
Mortality (%)	0.07	0.14	0.14	0.14	0.00	0.32

^{abc}= Means with different superscripts on the same row are significantly different P < 0.05, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, SBC= Soya Bean Cake, LSD= Least Significant Difference, E= Multienzymes.

Supplementation of RSC and BSC with multienzymes did not improve FCR and was contrary to the report of Cowieson (2005) that multicarbohydrase combinations containing xylanase, protease, and amylase improved feed conversion ratio. Feed type, nutrient levelin the diet, enzyme potency and dose, genetic strain and age of bird could be the reason forthe variation and this was supported by Cowieson *et al*.(2006).

4.3.3 Nutrient digestibility of RSC and BSC Diets of broiler chickens with and without multienzymes partly substituting SBC

The result of digestibility for broiler chickens fed roselle and baobab seed cake-based diets with and without multienzyme partly substitutingSBC is presented in Table 4.14. Digestibility of dry matter and nitrogen free extract were not affected (P>0.05) by dietary traetments and multienzymes supplementation.Digestibility of crude protein, crude fiber and ether extract were significant (P<0.05).

The observations on DM and NFE in this study were contrary to the work of Kaczmarek *et al*. (2009) and Subha (2013) who stated that digestibility of all nutrients were improved significantly withsupplementation of multienzymes to the diets except ether extract. Sharifi *et al*. (2012) reported no improvement in nutrient digestibility with enzyme supplementation to broiler chickens diets. Positive or negative impact of enzyme in digestibility reported by different researchers and this work could be due to adulteration of the enzyme or reduction in potency due to storage under different temperature and p^H that was not favourable for the enzyme.

4.3.4 Carcass characteristics of broiler finisher chickens fed roselle and baobab seed cake diets with and without multienzyme

The carcass characteristics of broiler chickens fed RSC and BCS with and without multienzymes partly substituting SBC is presented in Table 4.15. Live weight and dressed weight were significantly (P<0.05) affected for all the groups, but were similar (P>0.05)

Table 4.14: Nutrient Digestibility of Roselle and Baobab Seed Cake Diets of Broiler Chickens Partly substitutingSoya Bean Cake with and without Multienzymes

	Dietary Levels of the Seed Cakes (kg/100kg diet)					
Parameters	**SBC**	**RSC +E**	**RSC**	**BSC +E**	**BSC**	**LSD**
Dry matter (%)	74.20	67.53	65.52	65.45	73.61	10.75
Crude protein (%)	77.89[ab]	73.62[b]	76.26[ab]	73.96[ab]	80.67[a]	6.88
Crude fibre (%)	68.64[a]	40.39[c]	51.49[b]	47.36[bc]	56.54[b]	11.07
Ether extract (%)	79.98[a]	75.23[ab]	76.57[ab]	70.23[b]	79.63[a]	7.33
Nitrogen free extract (%)	70.93	70.93	73.18	65.82	74.40	9.15

[ab]= Means with different superscripts on the same row are significantly different P < 0.05, SBC= Soya Bean Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, LSD= Least Significant Difference, E= Multienzymes.

Table 4.15: Carcass Characteristics of Broiler Finisher Chickens Fed Roselle and Baobab Seed Cake Diets Partly Substituting Soya Bean Cake with and without Multienzymes

	Dietary Levels of the Seed Cakes (kg/100kg diet)					
Parameters	**SBC**	**RSC +E**	**RSC**	**BSC +E**	**BSC**	**LSD**
Live weight (g)	3126.7[a]	2860.0[ab]	2700.0[bc]	2473.3[c]	2633.3[bc]	281.72
Dressed weight (g)	2793.3[a]	2583.3[ab]	2433.3[bc]	2300.0[c]	2383.3[bc]	280.82
Dressing percentage (%)	76.202	76.358	77.778	75.096	75.114	5.5547
Expressed as percentage of dressed weight						
Thigh (%)	12.03	12.14	12.78	12.49	11.79	1.64
Breast (%)	31.16[a]	27.02[bc]	28.74[ab]	23.94[c]	25.79[bc]	3.65
Drumstick (%)	10.03	10.79	10.55	10.40	10.33	1.77
Back (%)	12.48[b]	12.80[ab]	13.39[ab]	13.64[a]	12.97[ab]	1.10
Expressed as percentage of live weight						
Liver (%)	1.62[b]	2.08[ab]	1.76[ab]	2.26[a]	1.80[ab]	0.56
Heart (%)	0.39[b]	0.47[ab]	0.53[a]	0.49[ab]	0.45[ab]	0.11
Kidney (%)	0.53	0.48	0.54	0.56	0.43	0.17
Spleen (%)	0.11	0.10	0.08	0.06	0.10	0.05
Gizzard (%)	2.33[b]	2.71[a]	2.72[a]	2.92[a]	2.94[a]	0.36
Lung (%)	0.48[a]	0.45[ab]	0.53[a]	0.49[a]	0.40[b]	0.07
Abdominal fat (%)	1.11[b]	1.70[ab]	1.77[ab]	3.18[a]	2.32[ab]	1.81

[abc]= Means with different superscripts on the same row are significantly different $P < 0.05$, SBC= Soya Bean Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, LSD= Least Significant Difference, E= Multienzymes.

between SBC and RSC + E and they followed the same pattern. Live weight and dressed weight were significantly higher (P<0.05) for birds fed SBC diet (3.12 and 2.79 kg) but was similar (P>0.05) to RSC + E (2.86 and 2.58 kg). Dressing percentage was not significant (P>0.05) for all dietary groups. For major cuts, breast and back %were significant P<0.05 while thigh and drumstick %were not significant (P>0.05). Carcass characteristics of all the organs were significant (P<0.05) except for kidney and spleen.

The breast% for SBC and RSCwere similar and was comparable to the findings of Ojile (2017), that the breast cuts showed no significant difference when broiler chickens were fed RSC replaced with SBC at 24%. Muataz (2019) also reported that enzyme supplementation had a highly significant impact in all cut part proportions of broiler chikens, with negative breast and positive thigh, but had no effect in drumstick proportion. The finding of Muataz (2019) on the effect of enzyme supplementation in breast and drumstickproportion were similar to the results in this study, but was contrary to thigh percentage. Addition of enzyme also had significant effect in liver, heart, gizzard and lung proportions (%) for RSC and BSC. High abdominal fat was seen in broilers fed all dietary treatments except SBC, this could be due to the conversion of excess energy to fat which acted as reserve energy for the chickens (Fouad and El-Senousey, 2014). Although in broiler industry excessive fat deposition is an unfavorable trait but its organoleptic effect confers favorable flavor to the meat.

4.3.5 Haematological profile of broiler chickens fed RSC and BSC with and without multienzyme supplementation partly substituting soya bean cake

Haematological profile for broiler chickens fed RSC and BSC with and without multienzyme partly substituting SBC is presented in Table 4.16. Dietary inclusion did not affect (P>0.05) PCV and Hb of the birds, but multienzymes supplementation significantly (P<0.05) affected their counts and they followed the same pattern.

Table 4.16: Haematological Profile of BroilerChickens Fed Roselle and Baobab Seed Cakes Partly Substituting Soya Bean Cake with and without Multiemzymes

	Dietary Levels of the Seed Cakes (kg/100kg diet)						
Parameters	**SBC**	**RSC +E**	**RSC**	**BSC +E**	**BSC**	**LSD**	**Normal Range**
PCV (%)	40.93[a]	35.40[b]	36.93[ab]	35.80[b]	37.96[ab]	4.83	24.00-40.00*
Hb(g/dl)	12.06[a]	10.60[b]	11.03[ab]	10.40[b]	11.06[ab]	1.30	7.00-15.00*
RBC ($\times 10^{12}$/L)	2.93	2.61	2.66	2.68	2.77	0.36	1.59-4.10*
WBC ($\times 10^{9}$/L)	8.85	8.41	8.54	8.74	8.20	8.55	1.50-9.50**
Lymphocytes (%)	89.56	90.06	88.86	86.26	91.70	6.40	40.00-100.00***
Monocytes (%)	4.20	3.36	3.56	6.36	3.13	3.74	1.00-7.00****
Eosinophils (%)	3.46[ab]	3.80[ab]	4.80[a]	3.06[b]	3.13[b]	1.58	1.50-6.00**
Basophils (%)	0.36	0.23	0.36	0.56	0.10	0.54	0.10-2.00*

[ab]= Means with different superscripts on the same row are significantly different P < 0.05, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, SBC= Soya Beans Cake, LSD= Least Significant Difference, E= Multienzymes, PCV= Packed Cell Volume, Hb= Haemoglobin, WBC= White Blood Cell, RBC= Red Blood Cell,*Mitrkuka and Rawnsley, (1997), **Simrak*et al*., (2004), ***Jain, (1986), ****Jain, (1993).

Eosinophil level was significantly (P<0.05) affected by dietary inclusion across the treatments, red blood cell, WBC, lymphocytes, basophils and monocytes were not significantly (P>0.05) affected. Muataz (2019) reported that neither dietary inclusion nor the addition of commercial enzymes affected Hb and PCV of broiler chickens. The result was similar to PVC and Hbmeans observed in this study. All values obtained in this study were within normal range according to the values reported by Mitrkuka and Rawnsley (1997).Adejumo (2004) stated that Hb and PCV were correlated with the nutritional status of the animal. This was an indication that feeding the seed cakes to the birds did not impair with nutrient transport and was also an indicator for good health status of the birds. Lymphocytes, basophils and monocytes were within the normal range for healthy birds. White blood cell was also normal and eosinophils values were significant (P<0.05) for the groups and werewithin normal range. Elevated level of eosinophil is an indication for viral infection and level of resistance or response of the birds to infection or diseases Soetan *etal*. (2013) and may be slightly elevated in the presence of some certain parasites.

4.3.6 Liver function of broiler chickens fed RSC and BSC with and without multienzymes partly substituting SBC

Table 4.17 present the liver function of broiler chickens fed RSC and BSC with and withoutmultienzymes partly substituting SBC. Albumin, globulin, total protein, ALP and ALT were significant (P<0.05), blood glucose, urea, creatinine and AST were not significant (P>0.05). Dietary inclusion and multienzymes supplementation did not significantly affectthe liver function indices of the birds. Glucose level was lower and creatinine was higher than the normal ranges for broiler chickens, elevated levels could be due fasting, dehydration or poor nutrient utilization before slaughter as a result of muscle degeneration and utilization of stored energy to produce adenosine triphosphate (ATP). This agreed with Onyishi *et al*. (2017) that nutrient conditions and feed restriction, water restriction, age and breed are factors that affect the blood profile of domesticated animals.

Table 4.17: Liver function indices of Broiler Chickens Fed Roselle and Baobab Seed Cake Diets Partly substituting Soya Bean Cake with and without Multienzymes

	Dietary Levels of the Seed Cakes (kg/100kg diet)						
Parameters	**SBC**	**RSC +E**	**RSC**	**BSC +E**	**BSC**	**LSD**	**Normal Range**
Glucose (g/dL)	89.97	87.49	88.80	94.79	88.43	10.72	199.00-348.00**
Blood urea nitrogen (mg/100ml)	4.24	3.88	3.84	3.85	3.70	0.59	1.50-8.30*
Albumin(g/L)	1.05[ab]	1.13[ab]	1.43[a]	1.26[ab]	0.87[b]	0.43	1.10-2.20***
Globulin (g/L)	5.53[ab]	4.43[b]	4.21[b]	6.08[a]	6.11[a]	1.61	1.20-3.20****
Total protein(g/L)	6.59[ab]	5.56[b]	5.64[b]	7.44[a]	7.05[ab]	1.59	3.60-5.50***
Creatinine (mg/100ml)	0.73	0.78	0.92	0.79	0.91	0.21	0.10-0.40[M]
Aspartate amino transferase(µL)	52.73	51.50	51.56	59.66	58.29	11.19	150.00-278.00**
Alkaline phosphatase (µL)	70.36[b]	72.23[ab]	79.13[ab]	84.70[a]	82.33[ab]	12.72	10.00-106.00*****
Alanine amino transferase (µL)	20.50[b]	20.86[b]	19.46[b]	24.63[a]	21.70[ab]	3.56	9.50-37.20*

[ab]= Means with different superscripts on the same row are significantly different $P < 0.05$ SBC= Soya Bean Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Meal, E= Multienzyme, LSD= Least Significant Difference, *Mitruka and Rawnsley 1997, **CDD (1990), ***Ross *et al*. (1976), ****LAVC (2009) *****Bounous and Stedman (2000), [M]Merck (2012).

Alanine amino transeferase and ALP were within normal range for all groups and were lower for SBC, RSC + E and RSC, higher level within normal range compared to other treatment means for BSC and BSC + E could be indicating lower protein metabolism in the blood tissue for birds fed those diets. From the result, the liver was in good state and was not affected by the dietary treatments and enzyme supplementation.

4.3.7 Lipid Profile of Broiler Chickens Fed RSC and BSC with and without Multienzymes

Lipid profile of broiler chickens fed RSC and BSC with or without multienzymes partly substituting SBC is shown in Table 4.18. All parameters tested were not significant (P>0.05) and were within normal range for cholesterol (52-148 mg/dL), triglcerides (<150 mg/dL), LDL (≤130 mg/dL) and HDL (≥22 mg/dL) reported by Basmacioglu and Ergul (2005) and Manoppo *et al*. (2007). Reduced level of low density lipoprotein and elevated level of high density lipoprotein indicated more amount ofprotein in the lipid content of the birds. Muataz (2019) studied the biochemical profile of broiler chickens and reported that cholesterol levels varied significantly with and without mltienzymes supplementation of dietary seed cakes.

4.3.8 Economic Benefit of Broiler Chickens Fed Diets Containing Roselle and Baobab Seed Cakes Partly substituting Soya Bean Cake with and without Multienzyme

Table 4.19 shows the economic benefits of feeding RSC and BSC with and without multienzymes. Gross margin analysis was used to evaluate the benefit of producing broiler chickens fed RSC and BSC supplemented with multienzymes. Birds fed SBC had the highest average live weight (2.64kg) followed by those fed RSC, RSC +E and BSC +E(2.40, 2.38 and 2.35kg), those fed BSC had the least value (2.23kg). Total feed intake was comparable across the treatment groups among RSC, BSC + E and BSC (5460.62, 5434.81 and 5488.88g), SBC (5607.61g) had the highest intake value while RSC +E (5306.73g) had the least. The gross margin for BSC + E (₦996.60) was next to SBC

Table 4.18: Lipid Profile of Broiler Chickens Fed Roselle and Baobab Seed Cake Diets Partly substituting Soya BeanCake with and without Multienzymes

	Dietary Levels of the Seed Cakes (kg/100kg diet)						
Parameters	**SBC**	**RSC+E**	**RSC**	**BSC +E**	**BSC**	**LSD**	**Reference Value**
Triglycerides(mmol/L)	68.59	68.54	65.13	63.63	67.67	10.75	<150.00**
Total cholesterol(mmol/L)	105.79	102.15	112.38	97.44	102.06	16.97	52.00-148.00*
High density lipoprotein (mmol/L)	52.80	57.36	53.92	57.83	47.80	17.53	≥22.00**
Low density lipoprotein (mmol/L)	39.27	31.03	45.43	33.11	40.73	22.10	≤130.00**

SBC= Soya Bean Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, LSD= Least Significant Difference, E= Multienzymes, *Basmacioglu and Ergul, 2005, **Manoppo *et al*., 2007.

Table 4.19: Economic Benefit of Broiler Finisher Chickens Fed Diets Containing Roselle and Baobab Seed Cakes Partly substituting Soya Bean Cake with and without Multienzymes

	Dietary Levels of the Seed Cakes (kg/100kg diet)				
Parameters	**SBC**	**RSC +E**	**RSC**	**BSC +E**	**BSC**
Average weight of bird (kg)	2.64	2.38	2.40	2.35	2.23
Total feed intake (g)	5607.61	5306.73	5460.02	5434.81	5488.88
Total feed cost (₦)	597.86	564.50	576.55	489.45	490.56
Miscellaneous expenditure (₦)	69.78	66.45	67.65	58.94	59.05
Other expenses (₦)	100.00	100.00	100.00	100.00	100.00
Total variable cost (₦)	767.64	730.95	744.20	648.40	649.61
Revenue (₦)	1820.00	1666.00	1680.00	1645.00	1561.00
Gross margin	1052.36	935.05	935.80	996.60	911.39
Return/₦ invested	2.37	2.27	2.25	2.50	2.40

SBC= Soya Bean Cake, GNC= Groundnut Cake, RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, E= Multienzyme, Gross Margin= (Revenue - Total variable cost), Return/₦ invested= (Revenue / Total variable cost).

(₦1052.36) at lower cost of production ₦649.61 when compared to SBC (₦767.64). The revenue for RSC +E, RSC and BSC +Ewere slightly similar (₦1666.00, ₦1680.00 and ₦1645.00), while SBC recorded the highest revenue (₦1820.00). Birds fed baobab seed cake supplemented with multienzymes, had the highest return/₦ invested (₦2.50) when compared to control (₦2.37) and other treatments. This is consistent with Chimvuramahwe *et al*. (2011) that total feed cost was reduced economically with incorporation of BSC in broiler chick diets.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 Summary

The study was conducted to evaluate the growth performance, haematological profile, carcass characteristics, nutrient digestibility, liver function indices, lipid profile and economic benefit of feeding groundnut cake (GNC), roselle seed cake (RSC) and baobab seed cake (BSC) partly substituting Soya bean cake (SBC) in broiler chickens diet with and without multienzymes supplementation. Result for the first feeding trial showed that birds fed SBC diet performed better than other treatment groupsat the starter phase while at the finisher phase, growth performance was not significantbetween GNC and SBC groups. Digestibility of all nutrients was significant for RSC diet, breast weight was not significant between SBC and RSC groups, gizzard weight was higher for birds on BSC diet. Dietary inclusion of the seed cakes did not affect the haematological profile and liver function indices of the birds but lowered the cholesterol and low density lipoprotein levels of birds fed RSC diet. Financial return of feeding GNC diet was slightly higher and comparable to SBC diet.

In the second feeding trial, the treatments that had the least performance (RSC and BSC) were partly substitutedwith SBC at 20% with and without multienzymes supplementation. Multienzymes addition significantly affectedthe amount of feed consumed and final weightofbirds fed BSC at starter phase, it also lowered the cost of feedper kg gain of BSC diet in both phases, birds fed SBC diet had the highestweight (2.64 kg) at finisher phase. Carcass characteristics of some cut parts, abdominal fat and organs weight were significantly improved, haematological profile, liver function indices and lipid profile were notaffected. FeedingGNC partly substituting SBC at 20% in finisher phase couldlower production costand improve growth performance, and supplementation of multienzymes to RSC and BSC was not necessary in broiler chickens diet.

5.2 Conclusions

It was concluded that dietary inclusion of the seed cakes and multienzymessupplementation significantly:

1. Improvedthe final weight of birds fed GNC (2.52) whencompared with those fed SBC(2.67) in their diets at finisher phase, improved digestibility of all nutrients for birds fed RSC in their diet and addition of multienzymes improved digestibility of all nutrients for RSC and BSC diets except DM and NFE digestibility.
2. Had no effect on the haematological profile and liver function indices of the broiler chickens, decreased blood cholesterol and LDL levels for birds fed RSC.
3. Decreased the gross margin for RSC (₦924.84) and BSC (₦724.05) when compared to SBC (₦1090.40) and GNC (₦1076.65), increased return/₦ invested for GNC (₦2.5) when compared to SBC (₦2.4). Addition of multienzymes slightly increased return/₦ invested for BSC +E (₦2.5).It also economically reduced feed cost/kg gain for BSC diet at starter phase without enzymes, and in starter and finisher phase with enzymes.

5.3 Recommendations

1. Farmers could partly substitute SBC with Groundnut Cake (GNC) at 20% in broiler chickens diet at finisher phaseto lower feeding and production cost.
2. Farmers could feed SBC or partly substitute SBC with RSC at 20% in broiler chickens diet for bigger breast muscle yield.

3. Further research should be done using different cocktail of enzymes (mixture of individual enzyme products from different manufacturers)

4. Research should also be done using the dietary seed cake in other poultry species, rabbits, grasscutter and other monogastric animals.

5.4 Contribution to Knowledge

1. Groundnut cake diet has lowered feed cost/kg gain of broiler chickens by ₦9.96 (4.15%), improved feed conversion ratio of GNC diet by 0.03 (1.31%) and increased return/₦ invested with ₦0.01 (4%).
2. Incorporation of baobab cake at 20% had economically reduced feed cost/kg gain of broiler starter chicks diet by ₦0.13 (5.2%) and 0.03 (1.25%) with and without multienzymes addition.

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APPENDICES

Appendix 1: Proximate Composition of Broiler Starter Chicken Diets containing Groundnut, Roselle and Baobab Seed Cakes Partly Substituted with Soya Bean Cake

	Dietary Levels of the Seed Cakes (kg/100kg diet)			
Parameters	**SBC**	**GNC**	**RSC**	**BSC**
Dry matter	96.11	94.56	96.18	95.46
Crude protein	23.86	22.50	23.43	22.16
Crude fiber	4.11	4.20	4.33	4.13
Ether extract	4.03	4.11	4.12	4.20
Ash	6.17	5.94	6.35	6.30
Nitrogen free extract	61.83	63.25	61.77	63.21

RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, SBC= Soya Bean Cake.

Appendix 2: Proximate Composition of Broiler Finisher Chicken Diets with Groundnut, Roselle and Baobab Seed Cakes Partly Substituted with Soya Bean Cake

	Dietary Levels of the Seed Cakes (kg/100kg diet)			
Parameters	**SBC**	**GNC**	**RSC**	**BSC**
Dry matter	94.59	96.29	93.94	94.10
Crude protein	20.10	21.05	19.22	21.55
Crude fiber	4.50	5.06	3.71	4.20
Ether extract	3.65	3.45	3.95	3.67
Ash	6.49	5.89	5.68	5.73
Nitrogen free extract	65.26	64.55	67.44	64.85

RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, SBC= Soya Bean Cake

Appendix 3: Proximate Composition of Broiler Starter Chicken diets containing Roselle and Baobab Seed Cakes Partly substituted with Soya Bean Cake with or without Multienzymes.

	Dietary Levels of the Seed Cakes (kg/100kg diet)				
Parameters	**SBC**	**RSC +E**	**RSC**	**BSC +E**	**BSC**
Dry matter	96.11	96.18	96.18	95.46	95.46
Crude protein	23.86	23.43	23.43	22.16	22.16
Crude fiber	4.11	4.33	4.33	4.13	4.13
Ether extract	4.03	4.12	4.12	4.20	4.20
Ash	6.17	6.35	6.35	6.30	6.30
Nitrogen free extract	61.83	61.77	61.77	63.21	63.21

RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, SBC= Soya Bean Cake, E=Multienzymes.

Appendix 4: Proximate Composition of Broiler Finisher Chicken diets containing Roselle and Baobab Seed Cakes Partly substituted with Soya Bean Cake with or without Multienzymes.

	Dietary Levels of the Seed Cakes (kg/100kg diet)				
Parameters	**SBC**	**RSC +E**	**RSC**	**BSC +E**	**BSC**
Dry matter	94.59	93.94	93.94	94.10	94.10
Crude protein	20.10	19.22	19.22	21.55	21.55
Crude fiber	4.50	3.71	3.71	4.20	4.20
Ether extract	3.65	3.95	3.95	3.67	3.67
Ash	6.49	5.68	5.68	5.73	5.73
Nitrogen free extract	65.26	67.44	67.44	64.85	64.85

RSC= Roselle Seed Cake, BSC= Baobab Seed Cake, SBC= Soya Bean Cake, E= Multienzymes.