EFFECTS OF PROCESSING METHODS OF AFRICAN LOCUST BEAN SEED MEAL ON NUTRIENT COMPOSITION AND UTILIZATION BY BROILER CHICKENS

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JULY, 2014

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

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY IN ANIMAL SCIENCE.

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JULY, 2014

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I declare that the work in this dissertation entitled ”EFFECTS OF PROCESSING METHODS OF AFRICAN LOCUST BEAN SEED MEAL ON NUTRIENT COMPOSITION AND UTILIZATION BY BROILER CHICKENS**”** has been performed by me in the Department of Animal Science. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

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CERTIFICATION

This dissertation entitled "EFFECTS OF PROCESSING METHODS OF AFRICAN LOCUST BEAN SEED MEAL ON NUTRIENT COMPOSITION AND UTILIZATION BY BROILER CHICKENS" by Mu'azu Tamburawa SHU'AIBU meets the regulations governing the award of the degree of Doctor of Philosophy in Animal Science of the Ahmadu Bello University, and is approved for its' contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to Almighty God for giving me good health and financial strength during this study. This is also dedicated to my father (Late Shu'aibu Hassan), my mother (Tsaibatu Shu'aibu), My brothers, my wife and my children who gave me all encouragement and patience during the course of my studies in this respected University.

ACKNOWLEDGEMENT

All praise be to Almighty God the controller of the universe who furnished me with health, knowledge and strength throughout the research work. My appreciation and gratitude goes to my revered supervisors Prof. S.O. Ogundipe., Prof. T.S.B. Tegbe, and Dr.T.S. Olugbemi, for their encouragement and valuable suggestions. They offered technical and professional advice that brought this work to successful completion. They also gave elderly suggestions and corrections during the research work that led to successful completion of this study. May God assist their entire family, uplift their positions and help them in life.

My special appreciation goes to Dr. A.M. Hassan, Alh. Farouk Sani Wali, Dr S. Duru, my beloved wife (Farida Muhammed), and my brothers (Lawan Shu'aibu and Umar Shu 'aibu) for their co-operation, encouragement and support during the execution of the practical work of the research. I wish to also thank the field staff of the Poultry Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture, Kano University of Science and Technology, Wudil, namely; Alh.Bako, Jabiru, Bashir and Dauda for their assistance and good efforts during the feeding trials.

I also wish to thank my lecturers in the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University for their constructive criticisms and good efforts to see that the work is successfully completed and accepted. My profound gratitude goes to Dr M.T. Yakasai, Umar Ibrahim, A. A. Ibrahim, R.M. Ashiru and Dr Auwal Magashi of Kano University of Science and Technology, Wudil.

ABSTRACT

A laboratory study and four feeding trials were conducted to determine the effects of dietary inclusions of differently processed African locust bean (*Parkia biglobosa*) seeds (ALBS) on the performance and carcass characteristics of broiler chickens. Four processing methods for ALBS were evaluated using laboratory study and feeding trials as follows; (i) Cooking for 1, 2, 3 and 4 hours, (ii) Soaking for 1, 2, and 3 days; (iii) Soaking for 1 day and fermenting for 3 days and (iv) Toasting. Chemical analyses of the raw and four differently processed ALBS were carried out to determine their proximate compositions, anti-nutritional factors, amino acid profiles and mineral contents. Three of the four ALBS processing methods applied were later selected and used for three broilers feeding trials as follows; Cooking for 4 hours, Soaking 1day followed by fermentation for 3 days and Toasting. Two hundred and twenty five day-old broiler chicks (Marshall Strain) were used. Birds were fed processed ALBSM diets at dietary levels of 0, 7.5, 15, 22.5 and 30% for each processing method. After each feeding trial, carcass analysis was performed. Digestibility study for each of the processed ALBSM was also carried out. This was followed by the 4th feeding trial using two hundred and forty broiler chicks. There were four diets, each containing one of the three differently processed ALBSM at 15% dietary levels for comparisons as follows: ALBSM cooked for 4hours, ALBSM soaked and fermented for 3 days and ALBSM toasted. The three diets were compared along with a control diet containing no ALBSM. Diets were allocated to birds in a completely randomized design and each treatment replicated four times. Each feeding trial lasted nine weeks comprising the starter phase (0-4weeks) and the finisher phase (5-9 weeks). Results for the laboratory study showed that cooking for 2hrs or more, soaking

and fermenting for 3 days and toasting significantly (P<0.05) increased % Crude protein and reduced % crude fibre content in the ALBS. All the processing methods significantly (p<0.05) reduced the levels of anti-nutritional factors and improved the amino acids and mineral contents of the ALBSM. The results of the 1st feeding trial showed that the final body weight and weight gain were significantly (P<0.05) higher for the 7.5 and 15% cooked ALBSM diet during the starter and finisher phases. Feed cost per kg gain was also better for 15% ALBSM diet during both the starter and finisher trials. The dressing percentage was also significantly (P<0.05) higher for the 7.5 and 15% ALBS diets compared to other treatments. No significant differences (P>0.05) were observed for pack cell volume (PCV), haemoglobin count (Hb) and total protein (TP). However, total glucose (TG) and red blood cells (RBC) were significantly (P<0.05) higher for the 15% dietary level of cooked ALBSSM diets. The results of 2nd feeding trial also showed that final body weight and total weight gained were significantly (P<0.05) higher for birds fed 7.5, 15 and 22.5 % soaked and fermented ALBSM diets compared to others. PCV, TG, and RBC were also significantly (P<0.05) higher for the 15% SFALBSM diets. The carcass weight and dressing percentage of birds were significantly (P<0.05) higher and similar for the 0, 7.5 and 15% SFALBSM diets. The feed cost per kilogram gain was better for birds fed 15% SFALBSM diet compared to others. The results of the 3rd feeding trial revealed that final body weight and total weight gain of broilers were significantly (P<0.05) higher for 7.5 and 15% TALBSM diets during starter and finisher phases. FCR and feed cost ₦/kg gain were significantly (P<0.05) better for the 15% TALBSM diet compared to other treatments. Carcass weight and dressing percentage were also significantly (P<0.05) higher for birds fed 7.5 and 15% TALBSM diet. In the

4th feeding trial, results of the starter phase showed that final body weight and total weight gain were significantly (P<0.05) higher for broiler chicks fed SFALBSM diet. Final body weight, total weight gain and total feed intake were significantly (P<0.05) higher for the SFALBSM diet during the finisher phase compared to other diets. FCR and FC per kg gain were also significantly (P<0.05) reduced for SFALBSM diet. Carcass analysis also showed that carcass weight and dressing % were significantly (P<.0.05) higher for birds fed SFALBSM diet compared to those of other processing methods. Digestibility of DM, EE, CP and NFE were significantly (P<.0.05) better for birds fed SFALBSM diets. Feed conversion ratio and Feed cost per kg gain of broilers fed SFALBSM diet were reduced compared to other methods of processing ALBSM. Based on the results of this study, it was concluded that; (1) Three processing methods tested (cooking for 4 hours, soaking for one day and fermenting for 3 days and toasting) significantly reduced the anti-nutritional factors (tannin, phytate, saponin, oxalate and trypsin inhibitor). (2) The three processing methods resulted in higher values for the CP. (3) 15% dietary level ALBSM was found to be optimum inclusion level for each of the three processing method. (4) Of the three processing methods tested, soaking for one day and fermenting for 3 days proved to be the most effective in terms of Total weight gain, Feed Conversion Ratio and Feed Cost /kg gain.

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CHAPTER ONE

1.1 INTRODUCTION

The shortage of animal protein intake among the ever increasing human population in the third world countries has long been recognized (Omoikhoje *et al*., 2008). Nigeria like many developing countries of the world has protein deficiency gap, especially that of high quality animal protein. This low animal protein intake has very serious implications on the health status and well-being of the citizenry (Oyawoye, 1989). Christopher *et al.* (1997) reported that Nigerians consume only 15g of animal protein per day as against 35g recommended by FAO (1997). It is therefore necessary to look for cheaper and simple ways of getting animal proteins required for normal body growth and functions (Ayanwale *et al*., 2006). Ani and Diegwu (2005) suggested that a solution to the problem of inadequate consumption of animal protein in Nigeria is by intensifying the production of highly reproductive animals with short generation intervals.

Poultry production especially broiler chicken is one of the fastest way of achieving adequate animal protein supply for the Nigerian populace due to their short generation interval and rapid growth rate (Bamgbose *et al.,* 2004). This is due to their genetic makeup when adequately packaged or supported with the required nutrition and management (Uzegbu *et al.,* 2007). However, the poultry industry has been bedeviled by many problems such as nutrition, management, diseases and other environmental factors.

Feed is the most important input in a profitable poultry production. It accounts for 70-80% of total the cost of production (Bello, 1984; Ogundipe, 1987 and Kehinde *et al.,* 2006). At present, the high cost of conventional feedstuffs has brought about the need to

have alternative feedstuffs that can replace the expensive ones in order to reduce the cost of livestock production (Longe, 2006 and Bamgbose *et al*., 2011). The use of unconventional feed ingredients in compounding poultry feed in order to reduce cost of production is well documented in literature (Abeke, 2008 and Duru, 2010). Non conventional feedstuffs offer the best alternatives in our environment for reducing feed cost and therefore a reduction in the cost of meat and animal products (Dafwang *et al*., 2001).

The search for alternative sources of protein from legume crops in lieu of expensive ones has been advocated (Adebowale and Lawal, 2004). However, legume seeds contain anti-nutritional factors like enzymes inhibitors, phytate, oxalates, saponin and polyhenolic compounds, which limit their utilization (Salunkhe, 1982 and Vijayakumari *et al*., 1997). Fortunately, remarkable improvement in the nutritive value and quality of legume seeds has been achieved by the application of various processing methods through research efforts ((Dike and Odunfa, 2003).

The African locust bean tree is a leguminous plant which produces seed grain that is often cheaper and readily available in northern Nigeria. It grows in the savannah region of Nigeria, to the southern edge of Sahel zone (Oyenuga, 1968 and Campbell-Platt, 1980). African locust bean seed is rich in protein and is used as a flavor intensifier for soups and stew (Dike and Odunfa, 2003).The protein content of seeds varies between 25 and 30% and has the potential to be utilized in livestock feeding (Olomu, 2011). This research is aimed at investigating the nutritive value of African locust bean (*Parkia biglobosa*) seeds as a source of feed ingredient for broiler chickens.

1.2 Statement of the Problems

The insufficient quantity and quality of protein in the diets of the Nigerian population affects not only the health status and efficiency of the present generation but also the future generation because such deficiency result in various clinical and sub- clinical conditions. These include reduced growth, possible deficiency in mental development of the citizens, impaired health, reduced resistance to diseases and lowered working efficiency in adults. Due to an urgent need to meet the demand and supply of protein of animal origin, it is pertinent to embark on the production of animal species with quick turn-over rates. The broiler chicken production is the most favourable alternative to bridge the gap of protein supply and demand in Nigeria. The main constraint of the industry is feed because the conventional vegetable protein ingredients such as soyabean and groundnut cake have become scarce and expensive (Longe, 2006). A viable option appears to be the exploitation of legumes which have very low human food preference. The high cost of animal proteins has stimulated interest towards several leguminous seeds as potential sources of vegetable proteins for human food and livestock feeds. Grain legumes are potential substitutes for soybean and groundnut cakes because of the similarity of their amino acid profiles (Saulawa, 2011). The grains of legumes used in poultry diets are considered as the main source of dietary protein (Wiseman and Cole, 1988; Wiryawan and Dingle, 1995). They are consumed worldwide, especially in the developing countries where consumption of animal protein may be limited as a result of economic predicaments.

1.3 Objectives of the Study

The objectives of the study were to;

(i) determine the proximate composition and anti-nutritional factors in African locust bean seeds meal (ALBSM).

(ii) determine the growth performance of broiler chicken fed diets containing ALBSM.

(iii) evaluate the carcass yield and organ weights of broiler chicken fed diets containing ALBSM.

(iv) determine the haematology of broiler chicken fed with diets containing differently processed ALBSM.

(v) determine the digestibilities of nutrients in broiler chickens fed with differently processed African locust bean seed meal diets.

Research Hypothesis

(a) Null hypothesis

(i) Methods of processing African locust bean seeds have no significant effects on nutrients contents and on the anti-nutritional factors contents of the processed seeds.

(ii) The methods of processing African locust bean seed meals have no significant effects on the growth performance, carcass characteristics, organ weights, haematological parameters and nutrients digestibilities of broiler chickens fed diets containing the processed seeds.

(b) Alternative hypothesis

(i) Methods of processing African locust bean seeds have significant effects on nutrients contents and on the anti-nutritional factors contents of the processed seeds.

(ii) The differently processing African locust bean meals have significant effects on growth performance, carcass characteristics, organ weights, haematological parameters and nutrients digestibilities of broiler chickens fed diets containing the processed seeds.

CHAPTER TWO

LITERATURE REVIEW

2.1 Origin and Distribution of Locust bean Tree

The locust bean trees are found in Africa, South Eastern Asia, and in Tropical America. In the Savannah region of West Africa, they are found from the northern edge of the forest zone at approximately 7^{o}N latitude to the southern edge of Sahel zone 13^{o}N (Campbell-Platt, 1980). African locust bean is widely distributed all over the natural grass land of Nigeria (Oyenuga, 1968). The main species is *Parkia biglobosa*, the forest species is *Parkia bicolor* and the secondary gallery forest species of Central and East Africa is the *Parkia filicoidea*. (Campbell-platt, 1980). Dupriez and De leener (1989) also identified another species, *Parkia Clappertoniana* as the occurring species in the Sahel region. However, the most common species in Africa are *Parkia biglobosa* and *Parkia filicoidea*. The trees are not normally cultivated but can be seen in populations of two or more in the savannah region of Nigeria (Schnell, 1957; Hopkins, 1983).The African locust bean (*Pakia biglobosa)* is a perennial legume tree belonging to the family *Mimosoideae* and sub-family *Leguminosae* (Campbell-platt, 1980). A mature African locust bean tree has a life span of 20-30 years (National Academic of Sciences (NAS), 1979).

2.2 Propagation and Production of African Locust Bean Tree

The African Locust bean tree is propagated from seed, though suckers are also used (Hopkins, 1983). Seed dormancy is broken by scalding for 5 minutes (Arbioneer, 2004). It is a light loving tree. It requires deep, well drained soil and

can withstand drought reasonably well once it is established. (Dupriez and De Leener, 1989). The Parkia tree survives to about 50 cm within 4 months of rainfall in the Sahel region; in the Sudan, 50-100 cm within 4 -6 months of rainfall; and then in the Guinea Savannah, 100 -150 cm within 6-7 months of rainfall (Danjuma, 1986). The tree which generally grows wild is frequently planted in the main cereal fields, or in orchards where it forms the uppermost canopy. It fertilizes the ground below around its crown. The tree which grows fairly slowly shades pastures. The seedlings need a lot of attention. They have to be kept for a year or two in nursery beds in loose, fertile soil and must be watered regularly. When the young trees are transplanted to their permanent site, they have to be protected for some years from fire and browsing animals. They first come into bearing fruits between 8 and 10 years, but yields are low until the 12^{th} year (Dupriez and De Leener, 1989). The tree produces fruits which are hanging in bunch on the branches. The fruit is flat, dark-brown, more or less 20-30cm long and 1.5-2.5cm wide. The fruit contains seeds embedded with sweet yellow floury pulp (Arbioneer, 2004). The seeds and pulp are carefully preserved and utilized by the inhabitants of the savannah region of Nigeria as valuable sources of reliable food (Campbell-Platt, 1980).The mature pod can be identified by its characteristic dark brown colour, whereas the immature pod remains bright brown or even greenish, depending on the stage of maturity. The pods are usually harvested from trees and the seeds are removed by processing after dehulling and extraction of powdery pulp from fruits.

2.3 Uses of African Locust Bean Tree

The seed and pulp are the most important components of the fruit and are useful in human and livestock feeding (Olomu, 2011). The yellow pulp of the fruit is rich in carbohydrate and sweet to taste. It is a valuable food with cereal grain in stew or soup. It can also serve as substitutes to cereal gruel (Kunu) for human consumption in Hausa land. The seed is rich in protein and usually fermented to form a product called dawa-dawa in Hausa. Dawadawa is used as flavour intensifier for soup and stew. It also adds protein to poor family dishes (Ikenebomeh and Kok, 1984; Odunfa, 1986; Dike and Odunfa, 2003). The seeds of *Parkia biglobosa* had been successfully fermented for the production of food condiment used for seasoning food in Nigeria and in other West African countries (Oladunmoye, 2007). The seeds are known to be rich in protein and contain easily digestible calcium. Musa (1991) stated that the seed is rich in protein and nutritionally very important particularly in the third world countries, where the protein supplementation is low for both adults and infants. All the parts of the fruit including the pod and the seeds constitute valuable cattle feed. The pod is high in crude fibre (about 24%), poor in protein but fairly high in ash. It should have a similar or slightly higher nutrient value than grass straw to be able to meet the maintenance requirements of cattle, sheep, goats and horses (Oyenuga, 1968).

The leaves enrich compost with nitrogen and potash. Birds suck the red ball-like flowers for sweet nectar, or else bee-hives are placed in the tree branches to yield good honey (Dupriez and De Leener, 1989). According to these authors, the back and fruit with or without the seeds are used to prepare dyes, tannins and

narcotics for fishing. The leaves and bark are also used as remedies for treating guinea worms, filiariasis, skin infection and burns. The pods are used to produce a juice for water-proofing houses, dyeing pots and for glazing pottery. A concoction made from the husk is used in treating for diarrhea, while the young flower buds are believed to prevent leprosy (Joy and Wibberley, 1979). According to these authors, the bark of the tree contains 12-14% tannin which is used in tanning leather. The wood is also used as fuel for cooking and hoes handles.

2.4 Nutrient Composition of African Locust Bean Seeds

2.4.1 Protein and Amino acid profile of African locust bean seeds

The seed is rich in protein (N.A.S.1979; Odunfa and Adesomoju 1986) and contains 30% crude protein (Oyenuga, 1968 and Fetuga *et al*., 1974). Olomu (2011) reported that the crude protein varies between 25 and 30%. The lysine is high but the seed is deficient in methionine and tryptophan. Adegbulu (2004) gave the crude protein value of raw seed as 30.06% while Aduku (2005) reported that crude protein of the seed as 30.30%. However, Sina and Traore (2002) reported that the boiled and fermented seeds contain 35% protein. The earlier investigations mentioned the food and nutritive value of seeds in humans and livestock nutrition (Fetuga, *et al*., 1974; Odunfa, 1983; Alabi *et al*., 2005). The seeds are being fermented to give condiments (Dawadawa in Hausa). This condiment contributes to calorie and protein intake (Simmon, 1976; Umoh and Oke, 1974). Generally, the seeds add value to soup as low cost meat substitutes for low income families in parts of Nigeria (Odunfa, 1985). The seeds are well known for their uses as good quality protein

sources and for favourable amino acid composition (Nordeide *et al.* 1996; Lockett *et al*., 2000).

2.4.2 Carbohydrate and Energy Status of African Locust bean Seed.

The carbohydrate content of locust bean pulp is made up of about 19% of reducing sugar (Oyenuga, 1968). The part of fruit in which the seeds are enclosed is higher in carbohydrate than in proteins and it contains about 9% of non reducing sugars and about 36% of other form of carbohydrates (Aduku, 2005). The mealy pulp from the fruit is rich in carbohydrate (Sina and Traore, 2002; Olomu, 2011). Aduku (2005) gave its metabolizable energy as 2420kcal/kg for poultry and Olomu (2011) reported 3850kcal/kg for man. The floury pulp surrounding the seed in the pod is an energy packed food with up to 60% sugar. Large soluble sugar and insoluble carbohydrate were obtained from the edible portion of the seeds. This could afford the consumers to gain enough energy needed for the biochemical and biological reactions within the body systems which would promote growth and development (Alabi *et al*., 2005).

2.4.3 Crude fibre content of African locust bean seed

The fibre content of Parkia seeds was reported to be 11.20% (Damang, 2007). Olomu (2011) reported 12.70% as fibre. However, Adegbulu (2004) and Aduku (1992) reported fibre as 7.41% and 8.82% respectively. Briget *et al*. (2004) reported fibre content as 11.70 %. National Academy of Science (1979) reported that locust bean seed contains 12% fibre. Alabi *et al.* (2005) reported the fibre

content of cotelydon and testa parts of seed as 1.9% and 16% respectively. The pod is also higher in fibre up to 24%, and very poor in protein and fairly rich in ash.

2.4.4 Fat and oil contents of African locust bean seed

About 20% of the seed is made up of semi-liquid oil. Sina and Traore (2002) reported that the component fatty acids incude palmitic, stearic, arachidonic and behenic acid. About 54% of the fat is unsaturated with oleic acid predominating, while 31% consist of the saturated fatty acids with palmitic predominating (Oyenuga, 1968). The fat content is 18.40% (Olomu, 2011). Alabi *et al.* (2005) reported cotyledon fat to be 16.86 ± 6.10 mg/100 and testa was 1.05±mg/100g of seeds. The lipid was observed to contain saturated fatty acid and hence could be solidified as fat at temperatures below 20^{o}C (Alabi *et al.,* 2005).

2.4.5 Vitamin content of African locust bean seeds

The seed contains an array of vitamins notably vitamin B_{12} (National Academic of Science (NAS), 1979). The pericarp of the seed contains 0.30% vitamins (Campbell-platt, 1980). The friable yellow pulp mesocarp is rich in sugar and high in vitamins 219mg/100g dry matter (Yousuf, 1983). The seeds are good source of tocopherol. The tocopherol content of African locust bean seed oil is 216mg/100g (Briget *et al.*, 2004).

2.4.6 Ash and Minerals content of African locust bean seeds

The seed is a good source of calcium (Sina and Traore, 2002). Potassium is higher in the seed, up to 1101.50mg/100g. However, magnesium, calcium and

phosphorous contents are 280, 222.20 and 170mg/100g respectively. Other minerals are present in trace amounts (Gloria *et al.,* 2011).

2.5 Utilization of Grain Legume in animal feeding

Grain legumes are potential sources of protein for poultry because of the similarity in their amino acid profiles (Wiryawan and Dingle, 1995). The use of grain legumes in poultry production is primarily as sources of vegetable proteins (Wiseman and Cole, 1988; Wiryawan and Dingle, 1995). They are also potential sources of energy because most of them contain over 600g Kg^{-1} carbohydrate which are mainly starch (Reddy *et al.,* 1982).

In Nigeria, groundnut is the most popular vegetable protein source in poultry ration formulation. Groundnut and soyabean are utilized as meal or cakes. Indeed for several decades, grain legumes have been used in poultry feed formulations in Nigeria. Feeding raw legume to chickens generally results in lower growth and reduced feed efficiency compared to feeding processed legumes, The major constraint on the use of legumes in poultry diets is that they often contain anti-nutritional factors (ANFs) that depress performance. The most commonly found ANFs in legumes are trypsin and chymotrypsin inhibitors, tannin, lectin, amylase, glycoside, phytate, and alkaloids. Other ANFs, which may play important role in decreasing the nutritive value of grain legumes are the non-polysaccharides (Chang and Satterlee, 1981; Semino *et al*., 1985).

Balogun *et al.* (2001) reported that soybean and groundnut will continue to find relevance in ration formulation because of their high protein contents of about

44% when processed into cakes. Aduku (1992) reported that although grain legumes have low level of some essential amino acids such as lysine, methionine and tryptophan, they are however comparable to most protein sources of animal origin when supplemented with these essential amino acids. Udedibie (1995) reported that due to inadequate supply and high cost of conventional feedstuffs, the prices of commercial feeds have increased substantially. Other grain legumes that may serve as alternatives to fat extracted soybean meal (SBM) exist and are often cheaper (Ravindran and Blair, 1992). The unavailability of animal protein sources in sufficient amount makes the use of underutilized legumes as alternative sources in poultry nutrition more attractive (Akanji, *et al*., 2003).

According to Ogundipe *et al.* (2003) there is increased utilization of grain legumes in poultry diets and that the trend is not likely to change in the near future. Today, 80% of the protein sources for poultry feed is supplied by soya bean and groundnut cakes. Presently, the demand for soya bean and groundnuts both for human food and as feed for monogastric animals especially poultry has overweighed the supply of these legumes resulting in high prices. This according the author is because vegetable protein still offers the cheapest forms of protein for man and his animals especially in least developed countries (LDC's). Groundnut cake and soybean meal are used in broiler diets as the main vegetable protein sources. In recent years, the increasing cost of these raw materials in relation to their decreasing availability in the market and sometimes the rather poor quality of the product (due to adulteration) have stimulated more studies on the possibility of partial or complete substitution of the conventional oil seed cakes with alternative vegetable protein sources (Ukachukwu and

Obioha, 1997; Ukachukwu, 2000; Amaefule *et al.,* 2003; Uchegbu *et al.,* 2004). Ukachukwu and Obioha, (1997) and Ukachukwu *et al*, (2000) stated that the recent concern on soybeans and groundnut as vegetable protein sources for broiler diets. This has further renewed interest into finding alternative vegetable protein sources. Nutritionists were therefore challenged to look inward for alternative protein ingredients in poultry feed formulations. The authors suggested that a viable option appears to be the exploitation of legumes which have very low human food preference.

2.6 Anti–nutritional factors in Legume Seeds

A major constraint on the use of grain legumes is that there are a number of naturally occurring substances known as anti-nutritional factors (ANFs) that depress animal performance. The anti-nutritional factors (ANFs) may be defined as biochemical substances in natural feedstuffs that if ingested may affect normal digestion, metabolism and utilization of nutrients in the body of the animals (Cheeke and Shull, 1985).

The utilization of the leaves, pod and edible twigs of shrubs and tree as animal feed is limited by the presence of anti-nutritional factors. Plant contains thousand of compound which depending upon the situation can have beneficial or deleterious effects on the organism consuming them (Wiseman and Cole, 1988). ANFs may be regarded as a class of compounds which are generally not lethal. They diminish animal productivity but may also cause toxicity during periods of scarcity or confinement when the feed rich in these substances is consumed by the animals in large quantity.

The main ANF in grain legumes are protease inhibitors (i.e. inhibitors of trypsin and chymotrypsin), lectins and tannins (Wiseman and Cole, 1988). Other ANFs which may play an important role in the nutritive value of grain legumes are non-starch polysaccharides (Chang and Satterlee, 1981; Semino *et al*.1985). Because of genetic differences, each legume species or cultivar is likely to have different amounts of ANFs (Grant *et al.*, 1981; Aletor *et al.*, 1994; Gatel, 1994).

2.6.1 Trypsin Inibitors

They belong to the group of protein that has the property of inhibiting proteolytic enzymes by binding to the enzymes. Proteases are enzymes involved in protein digestion known as Bowman–birk chymotrypsin. They are called protease inhibitors because of the action they exert on protein digestion and utilization in monogastric animals. Mcdonald *et al*. (1987) stated that trypsin is an enzyme secreted in mammal by pancreas and plays an important role in digestion of protein, which helps to break down proteins into simpler component that can readily be assimilated in the intestine. Trypsin inhibitor prevents the action of trypsin during digestion of feed by irreversibly binding to it and thus making the enzyme unavailable for its role in the breaking down of protein (Liener and Kakade, 1980). Their reduction on proteins digestibility and energy availability lead to the overall economic effects of growth depression. The protease inhibitors are partly responsible for the retardation of growth which has been attributed firstly to the anti-nutritional factors capacity to block the action of trypsin in protein digestion. Batterham *et al*. (1986) also affirmed that trypsin and chymotrypsin inhibitors are perhaps the most widely distributed of all anti-nutritional factors. Most legume grains contain a number of naturally occurring proteins which have peculiar property of forming reversible

stoichiometric protein-protein complexes with a wide range of proteases such as trypsin, chymotrypsin and elastase (Richardson, 1980; Valdebonze *et al.*, 1980; Gupta, 1987). Trypsin, chymotrypsin and elastase are low molecular-weight proteins, capable of binding to and inhibiting the normal catalytic functions of the digestive enzymes, thereby interfering with the enzymic digestion of proteins into their basic amino acid components. This effect of trypsin inhibitor in digestion causes enlargement of pancreas in rats and chicks (Gatler and Nondle, 1967).These authors stated that the inhibition induces hypertrophy of pancreas, resulting to an increased production of trypsin and chymotrypsin with consequent loss of cystine and methionine thereby contributing more to growth retardation. This reduces the digestibility of protein and consequently the nutritive value of feedstuffs with concomitant increase the requirement for sulphur containing amino acids. Anti-trypsin have been found in most legume seeds such as bambara nut, groundnut, lablab, pigeon pea, cowpea, wing bean and other legumes, but with much less action than in soya beans. The anti- trypsin only appears in the mature seeds. Rackis and Anderson (1964) reported that up to 6% of total proteins of soya bean consist of trypsin inhibitors. The trypsin inhibitors of many legumes consist of up to 30-40% cysteine (Kakade and Evans, 1965). If properly processed to remove the toxic effects, trypsin inhibitors content could contribute significantly to the sulphur amino acids of the diet. Trypsin inhibitors are thermolabile and hence the use of moist heat treatment readily inactivates them (Liener and Kakade, 1980; Ukachukwu, 2000). Batterham *et al.* (1986) also documented the variation in the concentrations of trypsin and chymotrypsin inhibitors, adding that in many varieties the values are

low thereby having no detrimental effects because they pass unnoticed through the gastro- intestinal tracts.

2.6.2 Tannins

Tannins are water soluble phenolic compound with the ability to precipitate proteins from aqueous solution. Hydrolysable and condensed tannins (Proanthocyanides) are two different groups of tannins compounds. The two types differ in their nutritional and toxic effects. The condensed tannins have a more profound digestibility-reducing effect than hydrolysable tannins. The hydrolysable tannins are characterized by central carbohydrate core with a number of phenolic carboxylic acids bound by ester linkages. They are esters of sugar usually glucose and phenol acid such as gallic acid in galactannins. They are known to be more toxic to ruminant animals (Dollahite *et al*., 1962; Shi, 1988). Recent studies showed that even where they are not toxic, hydrolysable tannins may have significant effect on animal nutrition because they have inhibitory effect on various enzymes (Yoshida *et al.*, 2000). The amount of tannin synthesis by plant varies considerably depending on plant species, stage of development and environmental condition. Condense seed tannins have no carbohydrate core, but they are derived from the condensation of flavonoid precursors without precipitation of enzymes. Condensed tannins are more widely distributed in higher plant species than the hydrolysable tannins and are thought to be more active in precipitating proteins.

Tannin can increase the size of the parotid gland and damage the mucosal lining of the gastro intestinal tract of chicken, but to a lesser extent in the laboratory rat (Oritz *et al.*, 1994) and with much less evidence for pigs. Tannins are found in poultry feedstuffs such as sorghum, millet, barley and faba beans. The adverse effect of tannins

on food palatability, consumption, feed efficiency and digestibility of protein, carbohydrate, lipids and minerals has been reported (Laurena *et al*., 1984; Longstaff and McNab, 1991b; Hassan *et al.*, 2003; Kim and Miller, 2005).

2.6.3 Saponins

Saponins are proteolytic enzyme inhibitors. Saponins are glycosides containing a polycyclic aglycone of either C25 steroid or C30 triterpenoid (collectively termed as sapogenins) attached to a carbohydrate. They are characterized by a bitter taste and foaming properties. They are secondary plant metabolites containing a carbohydrate molecule attached to a glycone which may be steroidal or triterpenoidal in structure (D' mello and Devendra 1995). In non-ruminant (chicks and pigs), saponin retards growth rate, due to reduction in feed intake (Cheeke and Shull, 1985). In ruminant animal saponins were implicated in causing bloat and inhibit microbial fermentation in the rumen (Lu and Jorgensen, 1987). Joshi *et al.* (1989) observed that saponins from different plant species and seeds have varied biological effects probably due to structural differences in their saponin fractions. Symptoms of saponin toxicity are listlessness, anorexia, weight loss and gastroenteritis (Molyneux *et al*., 1980). The adverse effect of saponins can be overcome by repeated washing with water which makes the feed more palatable by reducing the bitterness associated with saponins (Joshi *et al*., 1989).

2.6.4 Haemagglutinins

Haemagglutinins are proteineous called lectins with ability to agglutinate red blood cells in a fashion similar to anti-bodies (Ukachukwu *et al*., 2000). Like anti-bodies,

they are remarkable, specifically in that they do act in high dilution on one kind of erythrocytes and not at all or only weakly on another (Jaffe, 1969). Plant heamagglutinins are referred to as phyto haemagglutinins. The most interesting group of lectins from nutritional point of view is found in legumes such as soyabean (Liener and Kakade, 1980), sword bean (NAS, 1979) and kidney bean (Ukachukwu, 2000). Scarbrier and Whitaker, 1982 reported that lectins make-up about 2-10% of the proteins of numerous leguminous seeds. Ukachukwu (2000) reported that beside their ability to cause food poisoning, they also lowered protein quality in several legumes. The haemagglutinating activity has been shown to be one of the factors responsible for toxicity and growth retardation in animals. Earlier on, Vanderope and Hulsmen (1988) reported that they are glycoprotein in nature which interacts with glycoprotein in red blood cells and in the muco-intestinal walls thereby causing reduction in digestion and absorption that subsequently inhibit the growth of the animal. They exert their toxicity by binding to the epithelial cells lining the small intestine by destructing the brush border and reducing the efficiency of the absorption of nutrients. Lectins have also been shown to cause inhibition of brush border of small intestine walls and affect the hydrolysis of nutrients thereby encouraging colonization of the small intestine by coliforms (Udedibie and Carlin (1998).They bind to the carbohydrate moieties of cells of the intestinal wall and cause non specific interferences with nutrient absorption (Liener, 1953). It negatively affects the nutrients utilization by binding to the glycoprotein and glycolipids of the digestive tract mucosa, inhibits the activity of the enzyme of the brush border of the enterocytes, interferes with the adherence of the enterobacteria to the intestinal walls, and possibly has several side effects on immune functions, protein metabolism, enzyme activities and

hormonal regulation. It induces severe reduction in feed intake of non-ruminant animals especially when they are fed *ad-libitum*.

2.6.5 Oxalates

Oxalates are dibasic acids, widespread in plants and are composed of calcium, nitrogen and magnesium salts (Onwuka, 1996). Oxalates are naturally occurring anti-nutritional factors that are capable of interfering with the absorption of essential mineral elements such as calcium, iron and to some extent zinc (Bothwell and Charlton, 1982).They form complexes with these elements. There are soluble and insoluble oxalates. The insoluble oxalates are broken down to form carbonates (CO_3^{2}-) and bicarbonate (HCO_3^{-}) in the body resulting in severe alkalosis and fall in calcium in balance (Onwuka, 1996). The complex formed by oxalate with calcium reduces the bioavailability of dietary calcium. This has serious implication in bone formation especially in the monogastric animals (Oke *et al*., 1996). A higher concentration of oxalate above 2.5% is capable of exerting toxicological symptoms in humans (Oke, *et al*., 1996). Calcium oxalate in ruminant animals is degradable in the rumen and may not impair the performance of the animal significantly (Onwuka, 1996). MacDonald *et al.* (1987) reported that higher concentration of oxalate diet of monogastric animals may cause extensive scouring, distress, dullness, loss of appetite, progressive loss of co-ordination and in extreme cases may lead to death. Legumes such as pigeon pea, green gram and browse plants contained oxalates (Olomu, 1995; Onwuka, 1996).

2.6.6 Phytate

Legumes contains about 2% phytic acid, which decreases the availability of divalent cations such as calcium, zinc, magnesium and iron by forming insoluble protein complexes that are not readily broken down and may pass through the digestive tract unchanged especially in monogastric animals (Liener and Kakade, 1980). Phytic acid is of dietary importance to monogastric animals because their gastro intestinal tracts lack phytase. Phytase is the enzyme that breaks down phytin to release phosphorus. Therefore mineral supplementation of legume-based diets is important. Phytic acid has been implicated in the rachitogenic properties of certain cereals and magnesium deficiency has been reported in the rat when fed diets containing sodium phytate (Liener and Kakade, 1980)

2.7 Effects of Processing on the nutritional value of Legume Seeds for Livestock

The acceptability and use of food grains has been limited by the presence of relatively high concentration of a number of anti-nutritional factors (Liener and Kakade, 1980). Ologhobo *et al*. (1993) revealed that the inclusion of raw plant protein in the diets of growing animals lead to significant impairment of growth and other undesirable physiological alterations. The various methods of processing grain legume seeds for incorporation into poultry rations include the following:-

2.7.1 Boiling and Cooking of Legume seeds

The effect of boiling of legume seeds on growth of broilers has been reported by several workers. It is the most common method of processing grain legumes that involves pouring of

seeds into a cooking container and bringing it to boiling point (100^{o}C) until the aroma of cooked bean is perceived. The cooking time depends on the type of the materials. Bawa *et al* (2003a) reported that it is better to bring water to boiling point before pouring the bean into it. According to the author, the ratio of water to the bean should be 2:1 so as to accommodate the swelling of the beans as they are being cooked. As soon as beans are poured into the boiling water, the recording of specified cooking time can then begin.. According to Balogun *et al.* (2001) this method ensures standardization of cooking time. Akanji *et al.* (2003) suggested that the removal of the seed coat of the beans before cooking is much better jackbean than cooking the whole seed. The author also suggested that soaking or cracking of the beans before boiling may lead to more nutrient loss in the water especially the vitamins, mineral and some protein components. Amaefule and Obioha (2001) determined the effect of boiling pigeon pea and reported that boiled pigeon pea seed meal diets enhanced broiler finisher growth rate and mature body weight compared to the raw seed meal. Abeke *et al.* (2007) reported that cooking improves the nutritive value and brings the value of legume seeds close to that of meat and milk products by destroying most of the anti-nutritional factos such as trypsin inhibitors, haemoglutinin, lectins, phytins and giotrogen. This lead to poor growth and poor results obtained when raw legumes seed diets are fed to monogastric animals (Kaankuka *et al.,* 2000; Amaefule and Obioha, 2001 and Bawa *et al*., 2003a).

2.7.2 Soaking of legume grains

Soaking is a processing method capable of reducing some anti-nutritional factors that are hydrolysable in water. It is used before cooking as it reduces cooking time. During the process there is a loss of solid compounds (Abdu El-Hady and Habibu 2003). Soaking has been reported to leach out trypsin inhibitors of certain legumes (Nilgun,

2011). Udensi *et al.* (2008) confirmed that processing of legume seeds (soaking, autoclaving, and roasting) leads to products with reduced anti-nutritional content and consequently increase the availability of some nutrients. Soaking followed by boiling result in leaching of mineral contents of mucuna seeds (Udensi, 2010). After soaking the colour and weight tend to change. Soaking treatments caused significant increase in length, width, thickness and the lightness of seeds (Nilgun, 2011). Soaking also decrease the phytic acid content of common bean seeds (*Phaseolus vulgaris* L.). Abdu El-Hady and Habibu (2003) reported that the ash content of common beans decreased by soaking from 4.55 to 4.42g/100g. Mubarak *et al.* (2005) observed that the ash content in mung bean decreased by soaking from 3.76 - 3.32 g/100g. Soaking in distilled water markedly gave higher protein content than ascorbic acid soaking solution (Nilgun, 2011).

2.7.3 Toasting of legume seeds.

This is another method of heat treatment that involves dry frying of legume seeds in an open pan with constant stirring to prevent charring. Seeds may be toasted with or without the outer coat. Akanji *et al.* (2003) suggested that removal of seed coat before toasting gives better results. This ensures better contact of the bean with heat thereby reducing toasting time. The authors added that sometimes the seeds cracked before toasting to increase the surface area for heat contact. According to Ogundipe (1980) the advantage of toasting over boiling includes reduction of nutrient loss through leaching. The leaching of some nutrients into the boiling water was corroborated by Bawa *et al* (2003b) who reported that some mineral contents of lablab seed were leached out when the seeds were boiled at 100^{o}C for 60 minutes. Also toasting does not require sun drying the seeds after heat application, making it the best heating method during the rainy season

of the year. However, it has been observed that charring may occur, which may adversely affect the nutrients in the bean (Abeke, 1997). Also, the bean may not be uniformly heated and therefore is not as effective as in the case of boiling.

2.7.4 Autoclaving

This is dry processing method in which the legume grains are put in the autoclave machine. The autoclave has a temperature control system to ensure that the bean are not over heated or undercooked. It is also has a turning device, which ensures that there is adequate and uniform heat distribution. This method ensures adequate temperature to prevent charring unlike in the toasting method. Autoclaving is reported to be the best method of processing grain legumes because it ensures proper cooking of beans, prevents charring and nutrient loss is minimal (Ogundipe,1980). However, autoclaving is very expensive to adopt by poor farmers. It also involves constant supply of electricity to operate the system. This makes it difficult for the method to be adopted by the rural farmers (Ogundipe, 1980).

2.7.5 Fermentation of legume grains

Fermentation is one of the oldest methods of food processing known to man. In Africa, it is a widespread practice including the processing of carbohydrate sources to yield alcohol and non alcoholic beverages (Adewusi *et al*., 1992). This involves soaking of legumes seeds in cold or warm water for specific time before fermentation to encourage the growth of microorganism after the hydrolysis of carbohydrate or protein component of legumes seeds. Sometimes enzyme and other substrates are added to the water to quicken the fermentation process. According to Akanji *et al*. (2003) fermentation

may involve pouring slightly warm water or even boiled water on the beans in a container and allowing it to stand for few days in the water. The warm water according to authors helps to soften the outer cover of tough seed coat for adequate and quick fermentation to take place. The principle behind this is that certain microbes and enzymes help to destroy some anti nutritional factors in grain legume seeds. These enzymes are phytases and trypsinases. Phytases act to break the phytic acid molecules in the legumes, so that it can be digested and absorbed by the animals (Simovic *et al.*, 1972). Similarly, trypsinases are naturally occurring enzymes in the gastro intestinal tract and can be synthesized and introduced into the fermentation medium to break the bond that attach the trypsin inhibitors to the trypsin molecules thereby releasing it for digestion and utilization.

Ologhobo *et al*. (1993) stated that the period of soaking depends on the size of the legume seed. Legume with bigger grain will take more days to ferment than those with smaller grain sizes, the author argued. However, fermentation method as a means of processing grain legumes seeds for incorporation into poultry feed has some advantages. These include simplicity of operation, low cost and ease of adoption by poor literate farmers in the rural areas. However, Liener (1953) observed that a fermentation product produces an offensive odour in the bean which may lead to rejection by animals. Also the ability to know when the beans are properly fermented so as to prevent under or over fermentation is also important. Abeke (1997) pointed out that fermentation could not be adopted in the wet season because of inadequate sun rays for drying the fermented beans as well as the preponderance of flies. The author added that fermentation as a processing method for legumes seeds has also been observed to increase nutrient loss through leaching into water, which is later thrown away. Fermentation of legume grains results in

extensive hydrolysis of the protein and carbohydrate components (Fetuga *et al*., 1974 and Eka, 1979). Most unprocessed legume seeds contain oligosaccharides and glucosides that impart bitter taste and consequently depress feed intake in animals fed raw legumes. Fermentation markedly improves the digestibility, nutritive value and flavors of the raw seeds. Apart from this it also increases that shelf life and reduces the levels of anti-nutritional factors (Odunfa, 1985; Reddy and Pierson, 1999). Odunfa (1983) reported that flatus forming disaccharides, notably starchyose and rafifinose in raw legumes seeds decrease significantly during fermentation, consequently, improving the nutritional value of the feed material. Eka (1979) reported that during fermentation of foodstuffs, there may be an enrichment of the products as fermented products tend to exhibit a relative increase in protein, lipid and ash contents, although the product may have decreased carbohydrate content. Walter *et al.* (1984) indicated that fermentation improved palatability besides upgrading the nutrient composition of the fermented material. The possible decrease in lysine and methionine during fermentation could be used to explain the lower nutritive value sometimes observed in fermented soyabean (Liener and Kakade, 1980).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental Site.

These experiments were conducted at the Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture and Agricultural Technology, Kano University of Science and Technology, Wudil. It is located in the Sudan savannah region of Nigeria. The farm is located on latitude 11^0 37'N and longitude 8^0 58'E at an altitude of 403m above sea level. The annual rainfall ranges from 850 - 870mm, while minimum and maximum temperature ranges between 26^0 and 33^0C. The relative humidity of the region is always low and ranges between, 40- 51.3% (Olofin *et al.*, 2008).

3.2 Preliminary investigations on African Locust Bean Seeds (ALBS).

3.2.1 Sources of African Locust Bean Seeds:

African Locust bean seeds were purchased from Dawakin-kudu weekly market. The market is located in the Southern part of Kano state. The predominant variety of African locust bean tree available in Kano State is *Parkia biglobosa*, which is widely distributed in the area. The seeds are available all year round and are sold in the markets.

3.2.2 Different Processing Methods of African Locust Bean Seeds

(a) Cooking for different hourly durations (1, 2, 3 and 4 hours)

Samples of the seeds were cooked for different time periods (1, 2, 3 and 4 hours) at the rate of 1Kg per 8 litres of portable water. The beans were washed and then poured into a pot containing boiled water at a temperature of 100^oC. Cooked samples were removed at intervals of one hour till the last group was removed at 4 hours while the

cooking was being done. The samples taken at hourly intervals were then allowed to cool and sundried in aluminium metal trays for 3 days.

(b) Soaking the seed for different days (1, 2 and 3 days)

Locust bean seeds were carefully cleaned and washed and poured in a container containing portable tap water at the rate of 750 g per 6 litres. The locust bean seeds were allowed to soak for 24 hours, 48 hours, and 72 hours. Soaked seeds were removed at intervals of 1, 2 and 3 days (24, 48 and 72 hours). Each sample taken was spread in aluminium metal trays to sun dry for 3 days.

(c) Soaking and fermentation of locust bean seeds (3 days)

Two hundred and fifty gram (250g) sample of locust bean seeds were cleaned washed and poured into a container containing 2 litres of portable water. It was allowed to soak for 24 hours, excess water removed and the sample were allowed to ferment for 3 days in an air tight polythene bag. Fermented seeds were removed after 3 days and spread in aluminium metal trays to sun dry for 3 days.

(d) Toasting of seeds.

Toasting of locust bean seeds was done using an open pan, where 1 kg of seeds was cleaned, washed and dried to remove dirt. The pan measuring 52 cm in diameter and 13.5cm deep was placed on fire and heated for 3 minutes to ensure sufficient heating was attained for toasting. Locust bean seeds were poured into the pan, while heating was allowed to continue. Toasting continued by constantly stirring the seeds to have uniform application and to prevent charring. Toasted locust bean seeds were then removed after 15- 20 minutes and spread on aluminium metal trays to cool.

3.2.3 Chemical Analyses of Processed ALBS

3.2.3.1 Proximate Analysis

The proximate compositions of the raw and differently processed ALBSM samples were carried out according the method of A.O.A.C (1990). All the processed ALBSM samples were properly labelled and analyzed in the Animal Science Biochemistry laboratory of the Faculty of Agriculture, A.B.U. Zaria. The proximate compositions parameters determined included the dry matter (%DM) crude protein (%CP), crude fibre (%CF), ether extract (%EE), and nitrogen free extract (%NFE). Metabolizable energy value were calculated from the proximate composition data using the formula described by Pauzenga (1985). ME = 35 × % Crude protein + 81.8 × % Ether extract + 35.5 × Nitrogen Free Extract.

3.2.3.2 Determination of the Anti-nutritional factors content in ALBS

Samples of differently processed locust bean seeds were analyzed in the Food Science and Technology Laboratory, Faculty of Agriculture, Ahmadu Bello University, Zaria for the levels of anti-nutritional factors. The anti-nutritional factors determined were tannin, saponin, oxalate, and trypsin inhibitors.

(i) Determination of Tannin

Tannic acid of the raw and differently processed African locust bean seed were estimated using the method of Earp *et al.* (1981). Tannin was determined using a slightly modified standard method described by A.O.A.C (1990). Two grams (2.0g) of the ground sample was defatted for 2 hours using Soxhlet apparatus. The residue was placed in an

oven for 12 hours, retrieved and boiled at 100^{o}C, with 300ml of distilled water, diluted to 500ml in a standard volumetric flask and filtered through non –absorbent cotton wool. A volume of 25ml of the infusion was measured into a 2 litre porcelain dish and titrated with 0.1N potassium permanganate (0.1N potassium permanganate against 0.1N oxalic acid) until the blue solution changed to green, then pour few drops of 0.1N oxalic acid=0.006235 to obtain the amount of tannin in the sample, 0.1N oxalic acid = 0.006235 tannin.

(ii) Determination of Total oxalate

The total oxalic acid of the powdered ground samples was determined as described by Abeza *et al.* (1968). Two grams (2.0g) aliquot of ground seed was weighed into a 250 ml flask; 190 ml distilled water and 10 ml of 6 M hydrochloric acid were added. The mixture was digested for 1hour on a boiling water bath then cooled. It was then transferred into a 250ml volumetric flask, diluted to volume and filtered. Four drops of methyl red indicator were added followed by concentrated ammonia until the solution turned faint yellow. It was then heated to 100 ^{o}C, allowed to cool and then filtered. The filtrate was boiled and 10 ml of 5% calcium chloride was added with constant stirring .It was then allowed to stand overnight. The mixture was filtered through Whatman number 40 filter paper. The precipitate was rinsed several times with distilled water. The precipitate was transferred to a beaker and 5 ml of 25% sulphuric acid was added to dissolve the precipitate. The resultant solution was maintained at 80^{o}C then cooled and titrated against 0.5% potassium permanganate until the pink color persisted for approximately one minute. A blank was also run for the test sample from the amount of

potassium permanganate used. The oxalate content of the unknown sample was then obtained as:-

1ml of potassium permanganate = 2.24 mg oxalate

(iii) Determination of Saponin

Ten (10) grams ground sample was poured into a conical flask containing 100 cm^3 of 20 % aqueous ethanol and agitated with a magnetic stirrer for twelve hours at 55^oC. The solution was filtered using Whatman number 1 filter paper and residue extracted with 200 cm^3 of 20 % aqueous ethanol. The extract were combined and reduced to about 40cm^3 under vacuum. The extract and 200 cm^3 dethylether were transferred into a 250 cm^3 respiratory funnel and shaken vigorously. The process of purification continued until a colourless aqueous extract was obtained. The pH of the remaining aqueous solution was adjusted to 4.5 by adding 4 g NaCl, and the solution was then shaken successively with 60 cm^3 and 30 cm^3 portions of n-butanol. The butanoic extract was washed twice with 10 cm^3 of 5 % aqueous sodium chloride and evaporated to dryness in a fume cupboard to give the saponin. The value obtained was expressed in percentage according to procedure reported by Hudson and El-difrawi (1979).

$$\% \text{ Saponin} = \frac{\text{weight of saponin}}{\text{Weight of sample}} \times 100$$

(iv) Determination of Phytate

Phytate was determined using the method of Sutardi and Buckle (1985). Eight grams of each ground samples of raw and processed African locust bean seeds was soaked into 100 ml of 2% HCl solution for 5 hours and filtered. Twenty five cubic centimeters ($25cm^3$) of the filtered sample was taken into a conical flask and five cubic centimeters ($5cm^3$) and 0.3% ammonium thiocyanate solution was added. The mixture was titrated with a standard ferric solution ($FeCl_3$) containing 19.5mg iron per ml until a brownish yellow colour persisted for 5 minutes (Reddy *et al*., 1982).

$$\text{Concentration of phytate} = \frac{\text{Titre value} \times 0{,}064}{1000 \times \text{Weight of sample}}$$

(v) Determination of Trypsin inhibitors

The trypsin inhibitor activity was estimated and determined by the method of Kakade *et al*. (1974). In this method, 1g of fine sample was extracted with 50 ml of NaOH for 1 hour. The PH of the suspension was adjusted to between 9.5 and 9.8 with 0.01N HCl and kept overnight at 4^oC in a refrigerator. Two portion of each extract was pipetted into a 50ml volumetric flask and made up to mark with distilled water. In determining trypsin inhibitors level, the following additions were pipetted into a series of 10ml test tubes. All the tubes were thoroughly mixed and heated to 37^oC in a water bath for 10minutes. 5% of BAPNA solution (40mg N-a- Benzoyl–DL- Argenine P-nitroanilled hydrochloride) was added to all tubes at 37^oC. The reaction was stopped after 10minutes by the addition of 1ml 30% acetic acid solution to tubes. The tubes were thoroughly mixed and titrated through whatman No.42 filter paper. The absorbance of

filterate from sample and trypsin standard solution was read at 280nm. The trypsin inhibitor in mg/g was calculated using the formula.

$$\text{Trypsin inhibitor} = \frac{\text{A standard} - \text{A sample}}{0.1\text{g} \times \text{sample wt in g}} \times \frac{\text{Dilution factor}}{1000 \text{ sample size}}$$

3.2.3.3 Determination of Amino acid profile in differently processed ALBS

Sample of raw and processed locust bean seeds were analyzed for amino acids profile in Biochemical Laboratory, Department of zoology, University of Jos. The amino acid profile of the raw and processed (cooked, soaked and fermented and toasted) African locust bean seeds were determined using methods described by Sparkman *et al*.(1958). The 200 g was dried to a constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Technicon Sequential Multi-sample Amino acid analyzer (TSMA). The amount loaded was dispensed into the cartridge of the analyzer. The TSM analyzer I designed to separate and analyze free acid, neutral and basic amino acids of the hydrolysate. The period of an analysis lasted 76 minutes.

3.2.3.4 Determination of Minerals in differently processed ALBS.

The milled raw and processed seed meal were subjected to wet digestion with HCl and Nitric acid (HNO_3) described by the Johnson and Ulrich (1959) method. Following the digestion, the mineral elements were determined by flame photometry using Jenway Digital flame Photometer.

3.3 Feeding Trial 1: Effects of feeding graded levels of Cooked African locust bean seed meal diets on the Performance and Carcass characteristics of Broiler chickens

African locust bean seeds cooked for 4 hours gave the best results among the cooked ALBS for different duration considering the proximate composition. Seeds cooked for 4 hours were milled and incorporated in the broiler chickens diets during the starter and finisher phases according to NRC (1994) recommendations. Five isocaloric and isonitrogenous broiler starter and finisher diets (Table 3.1 and 3.2) containing cooked African locust bean seeds meal (ALBSM) were fed at dietary levels 0, 7.5, 15, 22.5 and 30% designated as T1, T2, T3, T4 and T5 respectively.

3.3.1 Broiler Starter Phase (0-4weeks)

Two hundred and twenty five (225) day old broiler chicks (Marshall strain) were used for the experiment. After taking the initial weights, diets were allocated to chicks in a completely randomized design (CRD).There were 45 chicks per treatment. Each treatment was replicated 3 times with 15 birds per replicate. The birds were raised on deep litter house partitioned into pens measuring 2.10m in length, 2.10 m wide and 1.25m in height. The openings at the side walls were covered with polythene sheets to conserve heat in the room. The birds were vaccinated against Gumboro disease and Newcastle diseases at two (2) and four (4) weeks respectively.

Feeds and water were offered *ad libitum.* The birds were weighed weekly using 10 kg weighing balance. Feed conversion ratio was calculated as ratio of daily feed intake to daily weight gain per bird. Mortality was recorded as it occurred. The starter phase of the experiment lasted 4 weeks.

Table 3.1: Composition of experimental diets for broiler starter containing graded levels of cooked African locust bean seed meal (CKALBSM)

	% Levels of inclusion of cooked ALBSM				
Ingredients (%)	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**
Maize	53.00	49.50	46.50	43.50	40.40
Groundnut cake	25.00	21.00	16.50	12.00	7.60
Cooked ALBSM	0.00	7.50	15.00	22.50	30.00
Soya bean Full-fat	10.00	10.00	10.00	10.00	10.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Wheat offal	5.00	5.00	5.00	5.00	5.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin-mineral premix*	0.25	0.25	0.25	0.25	0.25
	100	100	100	100	100
Calculated analysis (%)					
Crude protein	23.00	23.00	23.00	23.00	23.00
M. E.(Kcal/kg)	2944	2945	2949	2954	2957
Crude fibre	3.34	3.45	3.54	3.63	3.73
Ether extract	5.85	5.71	5.54	5.41	5.25
Ash	3.36	4.16	4.14	5.72	6.51
Ca	1.36	1.37	1.38	1.39	1.39
P	0.95	0.94	0.92	0.92	0.90
Lysine	1.21	1.25	1.28	1.31	1.31
Methionine+ cystine	0.58	0.62	0.65	0.69	0.72
Feed Cost ₦ /kg	76.06	75.26	74.36	73.46	72.58

*Biomix premix supplied the following per kg of diet: Vit. A,10000 I.U., Vit. D, 2000 i.u;Vit k,2mg Vit.B1(Thiamine), 1.8mg; Vit B2 (Riboflavin), 5.5mg; Vit B6 (Pyridoxine), 0.3mg; Vit B12, 0.015mg; Pantothenic acid, 7.5mg; Folic acid, 0.75mg; Niacin, 27.5mg; Biotin, 0.6mg; Choline chloride, 300mg; Cobalt, 0.2mg; copper, 3mg; Iodine, 1mg; Iron, 20mg; manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg;

M.E = Metabolisable Energy,
ALBSM = African locust bean seed meal.

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3.3.2 Broiler Finisher Phase (5-9 weeks)

Before the beginning of finisher phase, birds were fed with control diet for 7 days (4-5 weeks) and those of averagely equal weights were used for finisher phase. One hundred and twenty (120) broiler chickens of five weeks old were used for finisher phase of the feeding trial. Each treatment was fed to 24 birds in a completely randomized design and replicated three times consisting 8 birds per replicate. Birds were fed with broiler finisher diet (Table 3.2) for 4 weeks (5-9weeks). Feed intake, weight gain and mortality were recorded weekly.

3.3.3 Determination of Haematological and serum parameters

Blood samples were collected at seven weeks of age via the wing vein to determine the effects of diets on blood compositions. Sample bottles containing anticoagulant, ethylenediamine tetraacetic acid (EDTA) were used for blood collection. The blood samples were put in an ice pack and transported to the Faculty of Veterinary Medicine Haematology laboratory of the Ahmadu Bello University, Zaria for the determination of pack cell volume (PCV), red blood cells (RBC), white blood cells (WBC) and its differential components. haemoglobin (Hb), blood glucose (BG) and total blood protein (TBP).

3.3.4 Carcass Analysis

At the end of the experiment, carcass analysis was carried out in which three birds from each replicate were randomly chosen and starved for 24 hours before slaughtering. The final live weights of birds were recorded before slaughtering. The birds were bled by slaughtering, immersed in hot water, defeathered and eviscerated. Carcass weights and

meat cut parts (back, drumstick, thigh and wings) were weighed. All the values obtained were expressed as percentage of the live weight of birds. Similarly, the gut weights (crop, proventriclus, gizzard, small intestine weight, and large intestine weights) were measured using a portable electric digital weighing scale. The weights of visceral organs were also expressed as percentage of body weights.

3.3.5 Apparent nutrient Digestibility study

A digestibility trial was carried out at the end of finisher phase in which four birds were fed on each of the five diets. Treatments were replicated 3 times. A known quantity of feeds were offered to birds daily and the leftover feeds were also weighed back to determine the amounts consumed by birds. The sample of diets and droppings from birds were conveyed and analyzed in the laboratory for proximate compositions as described by A.O.A.C. (1990). Apparent nutrient digestibility of dry matter, crude protein, ether extract, crude fibre, ash and nitrogen free extract were determined using the following equation:

$$\% \text{ Apparent nutrient digestibility} = \frac{\text{Nutrient intake} - \text{Nutrient output}}{\text{Nutrient intake}} \times 100$$

Table 3.2: Composition of experimental diets for broiler finisher containing graded levels of cooked African locust bean seed meal (ALBSM)

	% Levels of inclusion of cooked ALBSM				
Ingredients (%)	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**
Maize	61.00	55.50	51.00	46.00	42.30
Groundnut cake	18.00	16.00	13.00	10.00	6.70
Cooked ALBSM	0.00	7.50	15.00	22.50	30.00
Soya bean Full-fat	10.00	10.00	10.00	10.00	10.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Wheat offal	4.00	4.00	4.00	4.00	4.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.25	0.25	0.25	0.25	0.25
*Vitamin-mineral premix	0.25	0.25	0.25	0.25	0.25
	100	100	100	100	100
Calculated analysis (%)					
Crude protein	21.00	21.00	21.00	21.00	21.00
M. E.(Kcal/kg)	3016	3017	3018	3019	3023
Crude fibre	5.72	3.85	4.62	5.39	6.15
Ether extract	5.72	5.73	5.75	5.76	5.77
Ash	3.05	3.19	3.33	3.47	3.60
Ca	1.34	1.35	1.36	1.36	1.38
P	0.92	0.92	0.91	0.90	0.89
Lysine	1.12	1.17	1.23	1.30	1.33
Methionine+ cystein	0.56	0.60	0.64	0.68	0.72
Feed Cost ₦ /kg	75.16	74.56	73.96	73.36	72.77

*Biomix premix supplied the following per kg of diet: Vit A, 10000 I.U.; Vit D3 2000 i.u.; Vit E, 23mg; Vit K,2mg; Vit K2mg; B1 (thiamine) 1.8mg; Vit B2 (Riboflavin), 5.5mg; Vit B6 (Pyridoxine),3.0mg; Vit. B12, 0.015mg; Pantothenic acid, 7.5mg; Folic acid, 0.75mg; Biotin, 0.06mg; Choline chloride, 300mg; Cobalt, 0.2mg; copper, 3mg; Iodine, 1mg; Iron 20mg; manganese, 40mg; Selenium 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg;

M.E = Metabolisable Energy,
ALBSM = African locust bean seed meal.

3.4 Feeding Trial 2: Effects of feeding graded Levels of Soaked and Fermented African locust bean Seed meal in the diets of broiler chickens

This study was conducted to determine the effect of feeding graded levels of soaked and fermented African locust bean meal (SFALBSM) on growth performance, haematological and carcass characteristics of broiler chicken at the starter phase (0-4 weeks) and finisher phases (5-9 weeks).

3.4.1 Broiler Starter Phase (0-4weeks)

Five diets were formulated containing soaked and fermented African locust bean seeds meal (ALBSM) at dietary levels of 0, 7.5, 15, 22.5 and 30% designated as Treatment 1, 2, 3 ,4 and 5 respectively. The locust bean seeds were soaked for one day and fermented for three days in an air tight polythene sheets. The fermented products was sun dried for three days. After sun drying and milling, five broiler starter diets diets were formulated for the experiment. The diets were isonitrogenous (23% CP) and isocaloric. The ingredients composition and calculated analyses of starter and finisher diets are presented in Tables 3.3 and 3.4 respectively.

Two hundred and twenty five (225) day-old broiler chicken (Marshall Strain) were used in the study. After taking the initial weights, diets were allocated to chicks in a completely randomized design (CRD) experiment. Each treatment was replicated three (3) times with 15 chicks per replicate. Birds were vaccinated against Gumboro disease and Newcastle diseases at 2 and 4 weeks respectively. Feed intake and weight gain were determined weekly. Feed and Water were supplied *ad libitum* and the experiment lasted 4 weeks.

Table 3.3: Composition of experimental diets for broiler starter containing graded levels of soaked and fermented ALBSM

	% levels of inclusion of SFALBSM				
Ingredients (%)	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**
Maize	53.00	48.50	45.00	42.60	39.00
Groundnut cake	25.00	22.00	18.00	13.50	9.00
SFALBSM	0.00	7.50	15.00	22.50	30.00
Soya bean Full-fat	10.00	10.00	10.00	10.00	10.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Wheat offal	5.00	5.00	5.00	5.00	5.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin-mineral premix	0.25	0.25	0.25	0.25	0.25
	100	100	100	100	100
Calculated analysis (%)					
Crude protein	23.00	23.00	23.00	23.00	23.00
M. E Kcal/kg	2944	2945	2954	2987	2980
Crude fibre	3.34	3.59	3.82	4.04	4.25
Ether extract	5.85	5.74	5.60	5.48	5.30
Ash	3.36	3.85	4.30	4.73	5.15
Ca	1.36	1.37	1.38	1.39	1.40
P	0.95	0.95	0.93	0.92	0.91
Lysine	1.21	1.26	1.30	1.34	1.37
Methionine+ cystine	0.58	0.62	0.65	0.69	0.72
Feed cost ₦/Kg	76.30	74.46	74.44	73.68	72.86

*Biomix premix supplied the following per kg of diet: Vit. A,10000 I.U., Vit. D, 2000 i.u;Vit k,2mg Vit.B1(Thiamine), 1.8mg; Vit B2 (Riboflavin), 5.5mg; Vit B6 (Pyridoxine), 0.3mg; Vit B12, 0.015mg; Pantothenic acid, 7.5mg; Folic acid, 0.75mg; Niacin, 27.5mg; Biotin, 0.6mg; Choline chloride, 3000mg; Cobalt, 0.2mg; copper, 3mg; Iodine, 1mg; Iron, 20mg; manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg;

M.E. = Metabolisable Energy.
SFALBSM = Soaked and Fermented African Locust bean seed meal.

3.4.2 Broiler Finisher Phase (5-9weeks)

Before the beginning of finisher phase, birds were fed with control diet for 7 days (4-5 weeks) and those of averagely equal weights were used for finisher phase. One hundred and eighty five-week old broiler chicks (Marshall Strain) were used for finisher study. Birds were randomized, weighed and offered an anti-stress. Twelve birds were reallocated to each pen and replicated three (3) times. Diets were allocated to pens in a completely randomized design (CRD). Feed and water were offered *ad libitum.* The birds were weighed weekly. The finisher phase lasted 5-9weeks.

3.4.3 Haematological study. This was done as in experiment 1

3.4.4 Carcass Analysis. This was done as in experiment I

3.4.5 Apparent nutrient Digestibility study. This was done as in experiment 1

Table 3.4: Composition of experimental diets for broiler finisher containing graded levels of Soaked and fermented ALBSM

	% Inclusion levels of SFALBSM				
Ingredients (%)	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**
Maize	61.00	57.50	54.00	50.50	46.00
Groundnut cake	18.00	14.00	10.00	6.00	3.00
SFALBSM	0.00	7.50	15.00	22.50	30.00
Soya bean Full-fat	10.00	10.00	10.00	10.00	10.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Wheat offal	4.00	4.00	4.00	4.00	4.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin-mineral premix	0.25	0.25	0.25	0.25	0.25
	100	100	100	100	100
Calculated analysis (%)					
Crude protein	21.00	21.00	21.00	21.00	21.00
M. Energy Kcal/kg	3002	3011	3019	3019	3029
Crude fibre	3.31	3.51	3.44	3.80	4.05
Ether extract	5.71	5.58	5.44	5.30	5.18
Ash	3.06	3.51	3.96	4.41	4.90
Ca	1.35	1.36	1.37	1.39	1.40
P	0.93	0.92	0.91	0.90	0.90
Lysine	1.11	1.15	1.19	1.23	1.29
Methionine+ cystine	0.56	0.60	0.63	0.67	0.71
Feed cost ₦/Kg	74.66	73.67	73.06	72.26	71.06

*Biomix premix supplied the following per kg of diet: Vit A, 10000 I.U; Vit D3 2000 i.u.; Vit E, 23mg; Vit K,2mg; Vit K2mg; B1 (thiamine) 1.8mg; Vit B2 (Riboflavin), 5.5mg; Vit B6 (Pyridoxine),3.0mg; Vit. B12, 0.015mg; Pantothenic acid, 7.5mg; Folic acid, 0.75mg; Biotin, 0.06mg; Choline chloride, 300mg; Cobalt, 0.2mg; copper, 3mg; Iodine, 1mg; Iron 20mg; manganese, 40mg; Selenium 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg.

M.E = Metabolisable Energy,
SFALBSM= Soaked and Fermented African Locust Bean Seed Meal.

3.5 Feeding Trial 3: Effect of feeding graded levels of Toasted ALBSM diets on the Performance and Carcass characteristics of broiler chickens

This study was conducted to determine the effect of feeding graded levels of toasted African locust bean seed meal (ALBSM) to broiler diets during the starter and finisher phases. Five diets were formulated according to NRC (1994) recommendations.Toasted African locust bean seeds meal (TALBSM) were fed at dietary levels of 0, 7.5, 15, 22.5 and 30% and designated as Treatment 1, 2, 3 ,4 and 5 respectively. The broiler starter (23%CP) and finisher (21%CP) diets (Table 3.5 and Table 3.6 respectively) were isonitrogenous and isocaloric Water was supplied to birds *ad libitum.*

3.5.1 Broiler Starter Phase (0-4weeks)

Two hundred and twenty five day-old broiler chicks (Marshall Strain) were used for the experiment. After taking the initial weights, diets were assigned to day-old chicks in a completely randomized design (CRD with 15 birds per pen. Treatments were replicated 3 times. The birds were vaccinated against Gumboro disease at 2 weeks and against Newcastle disease at 4 weeks.

Table 3.5: Composition of experimental diets for broiler starter containing graded levels of toasted African locust bean seed meal

	% Levels of inclusion of toasted ALBSM				
Ingredients (%)	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**
Maize	53.00	49.00	45.00	41.50	37.50
Groundnut cake	25.00	21.50	18.00	14.00	10.50
*Toasted ALBSM	0.00	7.50	15.00	22.50	30.00
Soya bean Full-fat	10.00	10.00	10.00	10.00	10.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Wheat offal	5.00	5.00	5.00	5.00	5.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin-mineral premix	0.25	0.25	0.25	0.25	0.25
	100	100	100	100	100
Calculated analysis (%)					
Crude protein	23.00	23.00	23.00	23.00	23.00
M. E. (Kcal/kg)	2945	2929	2915	2901	2919
Crude fibre	3.34	4.07	4.79	5.18	5.25
Ether extract	5.85	5.64	5.42	5.21	5.95
Ash	3.36	3.66	3.97	3.25	4.57
Ca	1.36	1.37	1.38	1.38	1.38
P	0.95	0.94	0.93	0.93	0.92
Lysine	1.21	1.25	1.30	1.34	1.39
Methionine+ cystine	0.58	0.62	0.65	0.69	0.70
Feed cost ₦/Kg	76.06	75.36	74.66	73.86	73.06

*Biomix premix supplied the following per kg of diet: Vit. A,10000 I.U., Vit. D, 2000 i.u;Vit k,2mg Vit.B1(Thiamine), 1.8mg; Vit B2 (Riboflavin), 5.5mg; Vit B6 (Pyridoxine), 0.3mg; Vit B12, 0.015mg; Pantothenic acid, 7.5mg; Folic acid, 0.75mg; Niacin, 27.5mg; Biotin, 0.6mg; Choline chloride, 300 mg; Cobalt, 0.2mg; copper, 3mg; Iodine, 1mg; Iron, 20mg; manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg.

M.E. = Metabolisable Energy
TALBSM = Toasted African Locust bean Seed meal.

3.5.2 Broiler Finisher Phase (5-9 weeks)

Before the beginning of finisher phase, birds were fed with control diet for 7 days (4-5 weeks) and those of averagely equal weights were used for the finisher phase. Two hundred and ten broiler chicks at five weeks of age were used in this phase of the feeding trial. Five diets were allocated to pens in a completely randomized design. There were five treatments and each treatment consisted of 42 birds in three replicates of 14 birds, per pen. Feed intake, weight gain, and mortality were all recorded.

3.5.3 Haematological study. This was done as in experiments 1 and 2

3.5.4 Carcass Analysis. This was done as in experiments 1 and 2

3.5.5 Apparent nutrients digestibility study. This was done as in experiments 1 and 2

Table 3.6: Composition of experimental diets for broiler finisher containing graded levels of toasted African locust bean seed meal

	% Levels of inclusion of toasted ALBSM				
Ingredients (%)	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**
Maize	61.00	56.50	52.00	47.50	43.60
Groundnut cake	18.00	15.00	12.00	9.00	5.40
*Toasted ALBSM	0.00	7.50	15.00	22.50	30.00
Soya bean Full-fat	10.00	10.00	10.00	10.00	10.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Wheat offal	4.00	4.00	4.00	4.00	4.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin-mineral premix*	0.25	0.25	0.25	0.25	0.25
	100	100	100	100	100
Calculated analysis (%)					
Crude protein	21.00	21.00	21.00	21.00	21.00
M. E. (Kcal/kg)	3030	3018	3016	3015	3001
Crude fibre	3.14	3.85	4.58	4.58	4.95
Ether extract	6.69	6.47	6.74	6.79	6.80
Ash	3.09	3.38	3.70	4.02	4.32
Ca	1.35	1.36	1.38	1.39	1.39
P	0.93	0.92	0.91	0.90	0.91
Lysine	1.12	1.16	1.19	1.20	1.29
Methionine+ cystine	0.56	0.60	0.64	0.67	0.68
Feed cost ₦/Kg	74.75	73.96	73.31	71.06	70.81

*Biomix premix supplied the following per kg of diet: Vit A, 10000 I.U; Vit D3 2000 i.u.; Vit E, 23mg; Vit K,2mg; Vit K2mg; B1 (thiamine) 1.8mg; Vit B2 (Riboflavin), 5.5mg; Vit B6 (Pyridoxine),3.0mg; Vit. B12, 0.015mg; Pantothenic acid, 7.5mg; Folic acid, 0.75mg; Biotin, 0.06mg; Choline chloride, 300mg; Cobalt, 0.2mg; copper, 3mg; Iodine, 1mg; Iron 20mg; manganese, 40mg; Selenium 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg; M.E = Metabolisable energy, Toasted ALBSM = Toasted African Locust bean Seed meal.

3.6 Feeding Trial 4: Effect of feeding differently processed African Locust Bean Seed meal diets on the Performance and Carcass characteristics of broiler chickens

The effect of feeding differently processed African locust bean seeds meal (ALBSM) on the performance, carcass yield, organs weights and apparent digestibility of nutrients in broiler chicken were evaluated in this trial. Three different processing methods namely - cooking for 4 hours, soaking followed by fermentation for 3 days and toasting were investigated in the present feeding trial. The ALBSM were included at 15% dietary level in broiler diets and compared to the control.

Diet 1 (control) had no ALBSM, Diet 2 (15% cooked ALBSM), Diet 3 (15% soaked and fermented ALBSM) and Diet 4 (15% toasted ALBSM) designated as T1, T2, T3, and T4 respectively. The 23% CP broiler starter diets (Table 3.7) and 21% CP broiler finisher (Table 3.8) diets were formulated to meet NRC (1994) specifications. The diets were isonitrogenous and isocaloric.

3.6.1 Broiler Starter phase (0-4weeks)

Two hundred and forty (240) day-old broiler chicks (Marshall Strain) were randomly allotted to pens in a completely randomized design (CRD) trial. Each treatment was replicated 4 times with 15 birds per pen. The birds were weighed at the beginning of the study. Feed intakes were determined weekly and birds weighed on weekly basis to determine the body weight gain.

Table 3.7: Composition of experimental diets for broiler starter containing differently processed African Locust bean seed meal (ALBSM)

	% Level of inclusion of differently processed ALBSM			
Ingredients (%)	Control Diet (0%)	Cooked (15%)	Soaked and Fermented (15%)	Toasted (15%)
Maize	53.00	46.50	45.00	45.00
Groundnut cake	25.00	16.50	18.00	18.00
*ALBSM	0.00	15.00	15.00	15.00
Soya bean Full-fat	10.00	10.00	10.00	10.00
Fish meal	3.00	3.00	3.00	3.00
Wheat offal	5.00	5.00	5.00	5.00
Bone meal	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20
Methionine	0.25	0.25	0.25	0.25
Vitamin-mineral premix*	0.25	0.25	0.25	0.25
	100	100	100	100
Calculated analysis (%)				
Crude protein	23.00	23.00	23.00	23.00
M. Energy Kcal/kg	2944	2949	2954	2915
Crude fibre	3.34	3.54	3.82	4.79
Ether extract	5.85	5.54	5.60	5.42
Ash	3.36	4.14	4.30	3.97
Ca	1.36	1.38	1.38	1.38
P	0.95	0.92	0.93	0.93
Lysine	1.21	1.28	1.30	1.30
Methionine+ cystine	0.58	0.65	0.65	0.65
Feed cost ₦/Kg	75.16	73.93	73.36	72.40

*Biomix premix supplied the following per kg of diet: Vit. A, 10000 I.U., Vit. D, 2000 i.u;Vit k,2mg Vit.B1(Thiamine), 1.8mg; Vit B2 (Riboflavin), 5.5mg; Vit B6 (Pyridoxine), 0.3mg; Vit B12, 0.015mg; Pantothenic acid, 7.5mg; Folic acid, 0.75mg; Niacin, 27.5mg; Biotin, 0.6mg; Choline chloride, 300mg; Cobalt, 0.2mg; copper, 3mg; Iodine, 1mg; Iron, 20mg; manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg;

M.E.= Metabolisable Energy.
ALBSM = African Locust bean Seed meal.

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3.6.2 Broiler Finisher Phase (5-9week)

Before the beginning of finisher phase, birds were fed with control diet for 7 days (4-5 weeks) and those of averagely equal weights were used for finisher phase. One hundred and sixty (Marshall Strain) of five weeks old broiler chicks were used. There were four treatment groups having four replicates per group. Each replicate contained 10 birds arranged in completely randomized design (CRD) feeding trial.

3.6.3 Hematological study. This was done in experiments 1, 2 and 3

3.6.4 Carcass analysis: This was done as in experiments 1, 2 and 3

3.6.5 Apparent digestibility study. This was done as in experiments 1, 2 and 3

3.7 Data Analysis

Data generated were subjected to Analysis of variance (ANOVA) using the general linear model of statistical analysis system (SAS, 2002).

Statistical model used was $Y_{ij} = \mu + Pi + eij$, Where:

Y_{ij} = the j^{th} observation of the i^{th} processing methods of Locust bean seeds

μ = the overall estimate of the population mean

P_i = the effect of the i^{th} processing methods of African locust bean seeds (1, 2, 3)

E_{ij} = the random error

Table 3.8: Composition of experimental diets for broiler finisher containing differently processed African locust bean seed meal (ALBSM)

	% Level of inclusion of differently processed ALBSM			
Ingredients (%)	Control Diet (0%)	Cooked (15%)	Soaked and Fermented (15%)	Toasted (15%)
Maize	61.00	51.00	54.00	52.00
Groundnut cake	18.00	13.00	10.00	12.00
ALBSM	0.00	15.00	15.00	15.00
Soya bean Full-fat	10.00	10.00	10.00	10.00
Fish meal	3.00	3.00	3.00	3.00
Wheat offal	4.00	4.00	4.00	4.00
Bone meal	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20
Methionine	0.25	0.25	0.25	0.25
Vitamin-mineral premix*	0.25	0.25	0.25	0.25
	100	100	100	100
Calculated analysis (%)				
Crude protein	21.00	21.00	21.00	21.00
M. Energy Kcal/kg	3030	3018	3019	3016
Crude fibre	3.14	4.62	3.44	4.58
Ether extract	6.69	5.75	5.44	6.74
Ash	3.09	3.33	3.96	3.70
Ca	1.35	1.36	1.37	1.38
P	0.93	0.91	0.91	0.91
Lysine	1.12	1.23	1.19	1.19
Methionine + cystine	0.56	0.64	0.63	0.64
Feed cost ₦/Kg	75.16	73.93	73.36	72.41

*Biomix premix supplied the per kg of diet: Vit A, 10000 I.U.; Vit D3 2000 i.u.; Vit E, 23mg; Vit K,2mg; Vit K2mg; B1 (thiamine) 1.8mg; Vit B2 (Riboflavin), 5.5mg; Vit B6 (Pyridoxine),3.0mg; Vit. B12, 0.015mg; Pantothenic acid, 7.5mg; Folic acid, 0.75mg; Biotin, 0.06mg; Choline chloride, 300mg; Cobalt, 0.2mg; copper, 3mg; Iodine, 1mg; Iron 20mg; manganese, 40mg; Selenium 0.2mg; Zinc, 30mg; Antioxidant, 1.25mg;.

M.E = Metabolisable energy,
ALBSM = African Locust bean Seed meal,

CHAPTER FOUR

RESULTS

4.1 Results of Preliminary investigations on African Locust Bean Seeds (ALBS)

4.1.1 Effects of Processing Methods on Proximate Composition of ALBS

The proximate composition of different processed of ALBS is presented in Table 4.1. The results showed that different processing methods significantly ($P<0.05$) affected the proximate compositions of ALBS. There were significant differences ($P<0.05$) in the DM, CP, CF, ash and NFE in differently processed ALBS. The CP increased in seeds cooked from 1-4 hours (from 24.64-29.91% CP). ALBS cooked for 4 hours had higher CP % than the raw and those cooked for 1-3 hours The CP of soaked seeds significantly ($P<0.05$) increased for the 1 to 3days (24.35 to 26.47% CP). The highest value of crude protein was obtained in seeds soaked for 1 day and fermented for 3days (28.56% CP) and this was significantly ($P<0.05$) higher than the CP for raw seeds and other soaked seeds. The crude protein of toasted seeds (26.62%) was significantly ($P<0.05$) higher than raw seeds (24.31%). Cooked ALBS for 4 hours and soaked and fermented seeds for 3days had higher crude protein compared to all other processing methods (29.91%CP and 28.56% CP respectively). Crude fibre was significantly ($P<0.05$) highest in the raw seeds (13.55%) compared to all processed seeds. The fibre content decreased as the seeds were cooked for 1 to 4 hours; soaked for 1 to 3days or soaked and then fermented for 3days compared to raw beans. However, the ether extract was highest in the raw beans (4.97%) and lowest in soaked and fermented seeds. The ash of the content of the processed seeds was significantly ($P<0.05$) increased in the processed seeds. NFE was significantly ($P<0.05$) increased for cooked seeds compared raw ALBS.

Table 4.1: Proximate compositions of differently processed African Locust Bean Seed Meal (ALBSM)

		Processing Methods										
		Cooking				Soaking			SKF	Toasting		
Parameter (%)	**Raw**	**CK 1hr**	**CK2hr**	**CK 3hr**	**CK4hr**	**SK 1D**	**SK 2D**	**SK 3D**	**SKF3D**	**TT**	**SEM**	**P**
Dry matter	96.36^{a}	95.40^{a}	93.33^{b}	96.02^{a}	94.53^{a}	94.96^{a}	93.33^{b}	93.29^{b}	93.78^{b}	95.63^{a}	0.61	0.03
Crude Protein	24.31^{c}	24.68^{c}	26.25^{c}	27.76^{a}	29.91^{a}	24.35^{c}	26.25^{c}	26.47^{c}	28.56^{b}	26.62^{c}	0.58	0.02
Crude fibre	13.55^{a}	13.52^{a}	7.34^{c}	6.33^{c}	5.03^{c}	12.83^{a}	11.77^{ab}	10.90^{ab}	10.27^{ab}	13.03^{a}	0.57	0.01
Ether extract	4.97^{a}	3.15^{b}	3.19^{b}	3.14^{b}	3.18^{b}	2.22^{c}	2.72^{c}	3.03^{b}	3.24^{b}	2.66^{c}	0.31	0.04
Ash	4.85^{c}	3.15^{c}	7.33^{b}	9.35^{a}	8.24^{a}	5.33^{c}	8.55^{a}	8.34^{a}	9.53^{a}	7.36^{b}	0.47	0.02
NFE	52.75^{a}	55.26^{a}	54.65^{a}	53.47^{a}	43.69^{c}	55.26^{a}	50.30^{b}	51.63^{b}	48.69^{c}	49.52^{c}	0.53	0.01

a,b,c = Row means with different superscript are significantly different ($P<0.05$),
NS=Not Significant, LOS =level of Significance, SEM = Standard Error of Means.
P = Probability value
ALBS = African Locust bean seed,
Raw = unprocessed ALBSM,
CK1hr = ALBS cooked in 1 hour, CK2hr = ALBS cooked in 2 hours, CK3 =ALBS cooked in 4 hours,
SK1D = ALBS soaked for 1day, SK2D= ALBS soaked for 2 days, SK 3D = ALBS soaked for 3 days,
SKF 3D = ALBS soaked for 1 day and fermented for 3 days,
TT = Toasted ALBS, NFE = nitrogen free extract.

4.1.2 **Effect of processing methods on the levels of anti-nutritional factors in African locust bean seeds**

The effects of different processing methods on the levels of anti-nutritional factors are presented in Table 4.2. There were significant effects ($P<0.05$) of processing on the level of tannin found in ALBS. The tannin level of raw ALBS was higher than the values obtained after processing by different methods. Cooked ALBS for 4 hours reduced level of tannin (0.24mg/100g) when compared with those for 1, 2, 3 hours (0.40, 0.37 and 0.36 mg/100g respectively). The tannin content of soaked ALBS for 3 days, soaked and fermented ALBS and toasted ALBS were all similar and lower than for other processing methods. The phytate content in the raw seeds (0.71mg/100g) was significantly ($P<0.05$) higher than other processing techniques. However, phytate values obtained for cooked ALBS for 1, 2 and 3 hours (0.25, 0.15, and 0.17mg/100g respectively), ALBS soaked for 3 days (0.27 mg/100g), soaked and fermented ALBS for 3 days (0.17 mg/ 100g) and toasted ALBS (0.21 mg/100g) were similar and lowest. The level of saponin decreased significantly ($P<0.05$) by cooking the seeds for 4 hours (0.34mg/100g) and by soaking and fermentation for 3 days (0.45mg/100g). The oxalate level in the raw seeds (1.78mg/100g) was significantly ($P<.05$) reduced by cooking for 1, 2, 3 and 4 hours (0.22, 0.21, 0.24, and 0.22 mg/100g respectively).Trypsin inhibitors was also significantly ($P<0.05$) reduced by cooking for 1, 2, 3 and 4 hours (0.17, 0.23, 0.17, and 0.68 mg/100g respectively). Soaking for 1, 2 or 3 days reduced the level of trypsin inhibitors compared to the raw. Similarly, soaking for 3days followed by fermentation and toasting technique significantly ($P<.05$) reduced the level of trypsin inhibitors compared to the raw.

Table 4.2: Effect of processing methods on the levels of anti-nutritional factors in processed African LBSM

		Processing Methods										
		Cooking				Soaking			SKF	Toasting		
Parameter	**Raw**	**CK 1hr**	**CK2hr**	**CK 3hr**	**CK4hr**	**SK 1D**	**SK 2D**	**SK 3D**	**SKF3D**	**TT**	**SEM**	**P**
Tannin (mg/100g)	1.08^{a}	0.40^{b}	0.37^{b}	0.36^{b}	0.24^{b}	0.28^{b}	0.25^{b}	0.17^{c}	0.11^{c}	0.14^{c}	0.04	0.04
Phytate (mg/100g)	0.71^{a}	0.25^{c}	0.15^{c}	0.17^{c}	0.37^{b}	0.38^{b}	0.37^{b}	0.27^{c}	0.17^{c}	0.21^{c}	0.07	0.02
Saponin (mg/100g)	2.08^{a}	1.07^{b}	0.46^{c}	0.45^{c}	0.34^{c}	1.67^{ab}	0.95^{b}	0.85^{b}	0.45^{c}	0.64^{b}	0.12	0.03
Oxalate (mg/100g)	1.78^{a}	0.22^{c}	0.21^{c}	0.24^{c}	0.22^{c}	1.25^{c}	0.67^{b}	0.46^{b}	0.43^{b}	0.41^{b}	0.21	0.01
TI (mg/100g)	0.90^{a}	0.17^{c}	0.23^{c}	0.17^{c}	0.68^{a}	0.68^{a}	0.43^{b}	0.27^{c}	0.15^{c}	0.21^{c}	0.08	0.02

a,b,c = Row means with different superscript are significantly different ($P<0.05$), NS=Not Significant, LOS =level of Significance,
SEM = Standard Error of Means.
P = Probability value
ALBS = African Locust bean seed,
Raw= unprocessed ALBSM,
CK1hr = ALBS cooked in 1 hour, CK2hr = ALBS cooked in 2 hours, CK3 =ALBS cooked in 4 hours,
SK1D= ALBS soaked for 1day, SK2D= ALBS soaked for 2 days, SK 3D = ALBS soaked for 3 days,
SKF 3D = ALBS soaked for 1 day and fermented for 3 days,
TT = Toasted ALBS,
TI= Trypsin Inhibitor.

4.1.3 Effect of Processing Methods on Percent reduction of Anti-nutritional factors in ALBS

The effect of different processing methods on percent reduction of anti-nutritional factors in ALBS is presented in Table 4.3. There were significant ($P<0.05$) effects in reduction of tannin content in raw ALBS by cooking (62.96 -77.78 %). Soaking for 1, 2 and 3 days significantly ($P<0.05$) reduced tannin content by 74.07 to 84.25% compared to raw seeds. However, soaking for 1 day and fermenting for 3 days significantly ($P<0.05$) reduced tannin content (89.89%). Phytate content was significantly ($P<.05$) reduced by processing. The cooking of raw seeds for 1-4 hours reduced phytate content in raw ALBS by 64.79 - 81.69%. Soaking of seeds for 1-3 days also reduced the percentage of phytate in raw seed by 47.89 to 61.97%, while soaking and fermented seed reduced 76.05% phytate in the raw seed. Saponin level in the raw ALBS was reduced significantly ($P<0.05$) by cooking (48.51- 83.65% reduction), soaking for 1-3 days (19.71-59.13%), soaking and fermenting for 3 (78.36%) and toasting (69.97%). The processing method significantly ($P<0.05$) reduced the percentage of oxalate in the raw seed ALBS. The cooking for 1-4 hours had 66.51-87.64%, soaking for1-3days had 29.77-74.15% reduction. The soaking and fermentation reduced oxalate in raw seed by about 75.84%, while toasting reduced the oxalate by about 76.97%. The processing method also significantly ($P<.05$) reduced trypsin inhibitors (TI) in the raw ALBS. The cooking seed 1 to 4 hours reduced TI in the raw seeds by 24.44 - 81.11%. When the seed was soaked for 1 to 3 days the percent reduction of TI was between 24.45-70.00%. However, soaking and fermentation reduced TI by 83.33% and toasting gave 76.67% reduction compared to the level in the raw seeds.

Table 4.3: Percentage reduction of anti-nutritional factors in differently processed African locust bean seeds

		Processing Methods										
		Cooking				Soaking			SKF	Toasting		
Parameter	**Raw**	**CK 1hr**	**CK2hr**	**CK 3hr**	**CK4hr**	**SK 1D**	**SK 2D**	**SK 3D**	**SKF3D**	**TT**	**SEM**	**P**
Tannin (%)	0.00	62.96^{c}	65.74^{c}	66.67^{c}	77.78^{b}	74.07^{b}	76.85^{b}	84.25^{a}	89.89^{a}	87.04^{a}	3.51	0.02
Phytate (%)	0.00	64.79^{b}	76.87^{a}	76.06^{a}	81.69^{a}	47.89	47.89	61.97	76.05^{a}	70.42^{b}	2.24	0.04
Saponin (%)	0.00	48.51^{b}	77.88^{ab}	78.34^{ab}	83.65^{a}	19.71^{c}	87.98^{a}	59.13^{b}	78.36^{ab}	69.97	5.59	0.03
Oxalate (%)	0.00	87.64^{a}	88.20^{a}	66.51	87.64^{a}	29.77^{c}	62.35^{b}	74.15^{b}	75.84^{b}	76.97^{b}	7.23	0.02
TI (%)	0.00	81.11^{a}	74.44^{b}	81.11^{a}	24.44^{c}	24.45^{c}	52.22^{bc}	70.00^{b}	83.33^{a}	76.67^{b}	8.47	0.03

a,b,c= Row means with different superscript are significantly different ($P<0.05$),
SEM = Standard Error of Means
P = Probability value .
ALBS = African Locust bean seed,
Raw = unprocessed ALBSM,
CK1hr = ALBS cooked in 1 hour, CK2hr = ALBS cooked in 2 hours, CK3 =ALBS cooked in 4 hours,
SK1D = ALBS soaked for 1day, SK2D= ALBS soaked for 2 days, SK 3D = ALBS soaked for 3 days,
SKF 3D = ALBS soaked for 1 day and fermented for 3 days,
TT = Toasted ALBS,
TI = Trypsin Inhibitor,.

4.1.4 Effect of processing methods on Amino acid Composition of ALBS

The results of effects of processing methods on the amino acid profiles of the processed ALBSM are presented in Table 4.4. The results showed that processing increased lysine content of the raw and processed seed from 4.10g/100g protein in the raw seed to 6.04g/100g protein in the 4 hour- cooked ALBSM and in seeds soaked for 1 day and fermented for 3 days seeds (5.85 g / 100g protein). Methionine content was increased from the value of 0.56g /100g protein for raw seed to 1.09 mg/ 100 g for cooked and 1.65 g /100g protein for soaking and fermented samples respectively. Toasting did not increase the lysine and methionine levels to the levels obtained by cooking or soaking and fermentation. Other amino acids increased by the three processing methods include Argenine, Leucine and Tryptophan. However, the level of isoleucine decreased on all the processing methods.

4.1.5 Effect of processing methods on some mineral composition of Africa locust bean seeds

The effects of processing methods on the mineral compositions of raw and differently processed African locust bean seed meals are presented in Table 4.5. The soaked and fermented ALBSM recorded significantly ($P<0.05$) higher values of all minerals with exception of magnesium which was highest ($P<0.05$) in raw seed (0.52%). The calcium was found to be higher for soaked and fermented (0.17%) compared to other processing methods and raw African locust bean seed meal. The phosphorous was found be significantly ($P<0.05$) increased for cooked and soaked and fermented ALBSM compared to raw ALBSM.

Table 4.4: Amino acids composition of differently processed African locust bean seeds (g/100g protein)

Amino Acids	Raw	Cooked (4 hours)	Soaked and Fermented	Toasted Seeds
Essentials				
Arginine	3.42	5.02	4.42	4.00
Histidine	1.15	2.01	1.54	1.41
Isoleucine	3.08	2.95	2.76	2.32
Leucine	4.38	6.40	5.85	4.89
Lysine	4.10	6.04	6.36	4.89
Methionine	0.56	1.09	1.65	0.63
Phenylanaline	3.47	4.23	2.90	2.96
Threonine	2.66	3.30	2.30	3.00
Tryptophan	2.98	3.78	4.56	4.09
Valine	4.04	4.36	3.83	1.06
Non essentials				
Alanine	4.79	5.64	5.21	4.25
Aspartic acid	22.79	20.32	23.90	18.61
Cystine	1.72	1.59	0.86	1.06
Glutamic acid	14.90	15.49	15.72	14.38
Glycine	3.62	3.60	4.52	3.21
Proline	4.46	3.06	3.29	2.87
Hydroxyl Proline	4.46	3.08	3.24	2.87
Serine	3.91	3.30	2.55	3.51
Tyrosine	2.74	3.22	2.90	3.06

However, potassium and zinc both have similar values for the raw ALBS and soaked and fermented ALBSM. Copper was significantly recorded ($P<0.05$) highest for soaked and fermented ALBSM compared to other processed ALBSM and raw seeds. Zinc content of raw and soaked and fermented ALBSM were significantly ($P<0.05$) higher and similar compared to cooked and toasted ALBSM. All the minerals except sodium and zinc recorded the lowest values in toasted ALBSM.

Table 4.5: Mineral elements content in African locust bean seeds (*Parkia biglobosa*)

Mineral elements	Raw	Cooked	Soaked and Fermented	Toasted	SEM	P
Calcium (%)	0.14^{b}	0.14^{b}	0.17^{a}	0.13^{c}	0.02	0.03
Magnesium (%)	0.52^{a}	0.48^{b}	0.48^{b}	0.43^{c}	0.12	0.02
Phosphorous (%)	0.23^{c}	0.35^{a}	0.36^{a}	0.27^{b}	0.06	0.01
Potassium (%)	1.52^{a}	1.25^{b}	1.15^{c}	1.20^{b}	0.03	0.04
Sodium (%)	0.06^{b}	0.06^{b}	0.07^{a}	0.07^{a}	0.01	0.03
Copper (mg/kg^{-1})	4.40^{b}	2.25^{c}	8.25^{a}	2.50^{c}	0.08	0.02
Zinc (mg/kg^{-1})	70.30^{a}	56.75^{b}	69.01^{a}	53.50^{c}	2.50	0.03
Iron (mg/kg^{-1})	729.30^{b}	779.00^{b}	877.80^{a}	549.30^{c}	3.02	0.02

a,b,c= means with different superscripts on the same row are significantly different ($P<0.05$), SEM= Standard error of means,
P = Probability value.

4.2 Results of Feeding Trial 1:
Effects of feeding graded levels of Cooked ALBSM Diets on the Performance and Carcass characteristics of Broiler Chickens

4.2.1 Performance of broiler starter chicks (0-4weeks)

The performance of broiler chickens fed graded levels of cooked African locust bean seeds are presented in Table 4.6. The results showed there were significant differences (P<0.05) in the final body weight, total weight gain and total feed intake. The Birds on T1,T2, T3 and T4 recorded similar final body weights which were higher than values obtained for T5 (977g)**.** Broiler chicks fed diets 2, 3 and 4 had significantly (P<0.05) higher values and similar weight gain. Birds fed on T1 (control diet) and T5 had the lower value of weight gain. Broiler chicks fed T1, T2 and T3 had significantly (P<0.05) higher feed intake (1879g 1905.96g and 1889g respectively) compared to others. There was significant difference (P<0.05) for feed conversion ratio. Feed conversion ratio was better for birds fed T3 and T4 (1.64 and 1.63 respectively) compared to others. Feed cost in naira per kilogram gain was significantly (P<0.05) better for T3 and T4 (₦120.19 and 121.74 respectively) compared to other treatments. There was no significant difference (P >0.05) in the mortality rate.

4.2.2 Performance of broiler finisher chicken (5-9weeks)

Table 4.7 shows the results of growth performance of broiler chicks fed cooked ALBSM in the finisher phase. There were significant differences (P<0.05) in the final body weight and total weight gain of birds. The final body weight were similar in T1, T2, T3 and T4 but had higher values than T5. These were significantly different from other treatments and T5 was the least.

Table 4.6: Performance of broiler chicken fed cooked African locust bean seed meal diets at starter phase (0-4weeks)

	% Inclusion level of cooked African locust bean seed meal						
Parameters	**T1(0%)**	**T2 (7.5%)**	**T3 (15.00%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Initial body weight (g)	39.70	39.72	39.70	39.71	39.73	0.70	1.00
Final body weight (g)	1127.00^{a}	1156.67^{a}	1194.33^{a}	1146.67^{a}	977.00^{b}	29.65	0.03
Total weight gain (g)	1087.29^{bc}	1116.96^{ab}	1154.61^{a}	1106.96^{ab}	983.23^{c}	19.46	0.02
Total feed intake (g)	1879.45^{ab}	1905.96^{a}	1889.25^{a}	1810.29^{b}	1853.51^{b}	9.75	0.04
Feed conversion ratio	1.72^{a}	1.70^{ab}	1.64^{b}	1.63^{b}	1.79^{a}	0.03	0.01
Feed cost ₦/kg gain	130.74^{a}	128.43^{a}	120.19^{b}	121.74^{b}	129.43^{a}	1.94	0.01
Mortality rate (%)	4.45	6.45	4.22	9.11	4.89	0.28	0.58

a,b,c= means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

The total weight gain was highest in T3 and similar to T2. These were significantly (P<0.05) better than other treatments. There was no significant difference (P>0.05) in total feed intake. There was significant difference (P<0.05) in feed conversion ratio. The values of feed conversion for T2 and T3 (2.49 and 2.45 respectively) were similar and significantly better than T1, T4 and T5. The feed cost in naira per kilogram gain was significantly better (P<0.05) in T3 (₦181.32) and similar with broilers fed on T2 (₦186.00). No significant difference (P>0.05) was recorded in the mortality rate.

4.2.3 Effects of cooked ALBSM on haematological and serum compositions of broiler finisher chicken

The results of haematological composition are presented in Table 4.8. There were no significant differences (P>0.05) in pack cell volume, haemoglobin and total protein of broiler chickens fed cooked ALBSM. Total glucose was significantly (P<0.05) highest in T3 (165.75 mm/l) and similar to T1 (control diet) and lowest in T4 (143.82 mm/l). The red blood cell counts value are found to be higher in 0, 7.5, 15 and 22.5% dietary inclusion of cooked ALBSM, while 30% recorded the lowest. T4 had the highest WBC (4.43 $X10^3$/mm) while the control diet (T1) had the lowest WBC counts (2.584.43 $X10^6$/mm). The WBC counts showed significant differences (P<0.05) in the neutrophils and lymphocyte cells. The highest neurtrophils was found in birds fed T3 (44.69%) and lowest value was recorded in birds fed on T4 (33.93%). There were no significant differences (P>0.05) in the monocytes and eosinophils.

Table 4.7: Performance of broiler finisher chicken fed cooked African locust bean seed meal diets (5-9weeks)

	% Inclusion level of cooked African locust bean seed meal						
Parameters	**T1 (0%)**	**T2 (7.5%)**	**T3 (15.00%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Initial body weight (g/bird)	1607.11	1607.09	1607.12	1607.10	1607.13	0.54	0.88
Final body weight (g/bird)	2856.80^{a}	2966.68^{a}	2976.69^{a}	2786.87^{ab}	2585.75^{b}	61.57	0.01
Total weight gain (g/bird)	1249.74^{b}	1359.68^{a}	1369.70^{a}	1179.86^{b}	957.70^{c}	130.00	0.02
Total feed intake (g/bird)	3170.60	3391.40	3215.40	3215.40	3199.50	105.77	0.51
Feed conversion ratio	2.56^{b}	2.49^{c}	2.45^{c}	2.84^{b}	3.42^{a}	0.15	0.02
Feed cost ₦/kg gain	192.63^{b}	186.00^{ab}	181.3^{a}	208.47^{c}	239.27^{c}	13.12	0.01
Mortality rate (%)	4.16	4.18	4.17	0.00	8.33	3.72	0.61

a,b,c= means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

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Table 4.8: Some haematological and serum parameters of broiler chickens fed cooked ALBSM diets during finisher phase (6-9weeks)

	% Inclusion level of cooked African locust bean seed meal						
Parameters	**T1 (0%)**	**T2 (7.5%)**	**T3 (15.00%)**	**T4 (22.5%)**	**T5(30%)**	**SEM**	**P**
Pack cell volume **(%)**	24.66	25.33	25.35	24.00	24.67	1.77	1.10
Haemoglobin (g/dl)	8.27	8.40	8.30	7.96	8.20	0.39	0.91
Total protein (g/dl)	3.60	3.53	4.20	3.60	4.00	0.30	0.87
Total glucose (mmol/l)	162.12^{ab}	143.62^{b}	165.75^{a}	143.82^{b}	144.96^{b}	0.74	0.03
Red blood cell ($X10^{6}$/l)	3.52^{ab}	3.83^{a}	3.57^{ab}	3.43^{ab}	2.90^{b}	0.20	0.02
White blood cell ($X10^{3}$/mm)	2.58^{c}	3.40^{b}	2.86^{c}	4.43^{a}	4.03^{ab}	0.39	0.04
Neutrophils **(%)**	35.99^{b}	36.52^{b}	44.69^{a}	33.93^{b}	34.96^{b}	2.51	0.02
Lymphocytes **(%)**	57.76^{bc}	55.39^{c}	62.23^{a}	59.87^{ab}	48.26^{c}	2.07	0.01
Monocytes **(%)**	2.61	3.69	4.07	4.10	3.27	0.88	0.52
Eosinophils **(%)**	1.44	1.45	1.28	1.19	2.28	0.47	0.61

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

4.2.4 Effect of cooked ALBSM on carcass characteristics of broiler finisher chickens

The result of carcass analysis is presented in Table 4.9. Final live weight, carcass weight and dressing percentage were significantly ($P<0.05$) influenced by dietary treatments. The final live weights were similar and higher at 0%, 7.5% and 15% cooked ALBSM diets having 2840.23g, 2951.22g and 2980.05g respectively, but lowest in 30% cooked ALBSM diet. Carcass weight was higher for diet 2 and 3 (2020.14 and 2051.34g respectively) and lowest for diets 1 and diet 5 containing 30% ALBSM with values of 1880.13g and 1661.24g respectively. Birds fed 15% cooked ALBSM diet had significantly ($P<0.05$) higher dressing percentage (73.20%) compared to other treatments. The weights of carcass and organs were expressed in percentages (%) relative to final body weights. The breast muscle, thigh and drum stick were significantly ($P<0.05$) affected by the dietary treatments. T3 had higher percentage of breast muscles (22.15%) compared to others. The thigh and breast muscle showed significant differences ($P<0.05$) among the treatments. Wings weight were significantly ($P<0.05$) different with highest value in T1 (11.79%) and lowest value in T4 (8.79%), while broilers fed 30% ALBSM diet had the lowest value (8.79%). There were no significant differences in the values for neck, back weights and abdominal fat weights among treatments.

Table 4.9: Carcass characteristics of broiler chicken fed cooked African locust bean seed meal diets

	% Inclusion level of cooked African locust bean seed meal						
Parameters	**T1 (0%)**	**T2 (7.5%)**	**T3(15.00%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Final live weight (g/bird)	2840.23^{ab}	2951.22^{a}	2980.05^{a}	2784.11^{b}	2570.03^{c}	4.00	0.01
Carcass weight (g/bird)*	1880.13^{b}	2020.14^{a}	2051.34^{a}	1920.03^{b}	1661.24^{c}	5.00	0.02
Dressing percent **(%)**	70.95^{b}	71.34^{b}	73.20^{a}	71.42^{b}	69.88^{c}	0.48	0.01
Breast muscle **(%)**	20.91^{b}	21.27^{a}	22.15^{a}	16.23^{c}	17.79^{c}	1.71	0.03
Thigh and Drum stick **(%)**	22.52^{a}	19.15^{ab}	19.84^{ab}	17.46^{b}	16.78^{b}	1.05	0.02
Wings **(%)**	11.79^{a}	10.99^{ab}	9.88^{ab}	8.92^{b}	8.79^{b}	0.80	0.03
Neck weight **(%)**	7.33	7.40	7.41	7.35	7.40	0.07	0.45
Back weight **(%)**	18.21	17.71	17.32	16.57	15.61	1.72	0.51
Abdominal fat **(%)**	1.44	1.62	1.21	1.24	1.33	0.18	0.62

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value,

* Carcass weight expressed as % live weight

4.2.5. Effect of graded levels of cooked ALBSM based diets on organs weights and gut measurements of broiler chickens

The effects of cooked African locust bean diets on the organs and gut weight are presented in Table 4.10. The results showed no significant differences (P>0.05) for most of the organs (heart, lungs, pancreas and kidney). The gut weights (crop, proventriculus, small intestinal weight and length, large intestine weight and length) were also not significantly (P>0.05) affected by the treatments. However, the liver was significantly (P<0.05) affected by the dietary treatments. Diets 2, 3, 4, and 5 gave the highest percentages of liver weight having 2.18, 2.01, 2.27 and 2.08% respectively. There were significant differences (P<0.05) in the Gizzard and small intestine weights. Broiler chicken fed the control diet had the highest weights of gizzard weight (2.90%) while diet 5 had the lowest with a value 2.41%. Similarly, small intestine weight was higher for diet 1 (2.72%) and lowest for diet 4 (1.12%).

4.2.6 Effect Cooked ALBSM diets on apparent nutrient digestibilities.

The results for apparent nutreints digestibilities are presented in Table 4.11. There were significant differences (P<0.05) in digestibilities of the dry matter, crude protein and crude fibre of diets. Dry matter digestibilities were higher and similar in broilers fed diets 1 and 3 (87.25 and 89.81%) and lowest in diet 5 (79.25%). No significant difference (P>0.05) for digestibility of crude protein by broilers fed the cooked ALBSM diets. However, the crude fibre digestibility was significantly (P<0.05) affected the treatments. The highest CF digestibility was observed for broilers fed the control and similar to T3 and T4 and significantly (P<0.05) better than T2 and T5. There were no significant differences (P >0.05) in the ash, ether extract and nitrogen free extract digestibilities.

Table 4.10: Organs and gut weights of broiler chickens fed cooked African locust bean seed meal diets

	% Inclusion level of cooked African locust bean seed meal						
Parameters (%)	**T1(0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4(22.5%)**	**T5 (30%)**	**SEM**	**P**
Heart	0.52	0.44	0.45	0.43	0.44	0.03	0.22
Lungs	0.52	0.46	0.46	0.48	0.46	0.03	0.15
Liver	1.85^{b}	2.18^{ab}	2.01^{ab}	2.27^{a}	2.08^{ab}	0.12	0.01
Pancreas	0.26	0.23	0.28	0.27	0.28	0.02	0.09
Kidney	0.35	0.34	0.32	0.31	0.34	0.03	0.94
Crop	0.10	0.11	0.11	0.10	0.11	0.02	0.66
Proventriculus	0.24	0.22	0.23	0.22	0.23	0.03	0.08
Gizzard	2.90^{a}	2.52^{c}	2.62^{b}	2.52^{b}	2.41^{c}	0.12	0.02
Small intestine weight	2.72^{a}	1.88^{c}	2.16^{b}	1.12^{c}	2.04^{b}	0.15	0.03
Small intestine length (cm)	311.22	295.77	334.00	324.01	314.56	21.06	0.78
Large intestine weight	1.67	1.52	1.49	1.26	1.35	0.09	0.76
Large intestine length (cm)	37.02	35.08	34.52	36.54	34.97	0.79	0.87

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

Table 4.11: Apparent digestibility of nutrients by broiler chickens fed diets containing cooked ALBSM

	% Inclusion level of cooked African locust bean seed meal						
Parameters (%)	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Dry matter	87.25^{a}	86.81^{b}	89.81^{a}	82.83^{b}	79.25^{c}	2.03	0.03
Crude protein	79.62^{b}	80.11^{ab}	86.58^{a}	81.89^{ab}	73.02^{b}	3.53	0.24
Crude fibre	69.30^{a}	64.11^{b}	66.18^{ab}	66.19^{ab}	58.25^{c}	1.02	0.02
Ether extract	81.09	84.76	86.22	80.51	81.34	1.99	0.25
Ash	75.47	73.78	70.96	65.51	66.82	3.97	0.37
Nitrogen free extract	79.29	80.27	81.83	77.68	76.50	1.89	0.36

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

4.3 Results of Feeding Trial 2:
Effects of feeding graded levels of soaked and fermented ALBSM diets on the Performance and Carcass characteristics of Broiler Chickens

4.3.1 Performance of broiler starter chicks (0-4 weeks)

The performance of broiler chicks fed soaked and fermented ALBSM diets are presented in Table 4.12. There were significant differences ($P<0.05$) in the final body weight and total weight gain of broiler chicks. Final body weight was highest for broilers fed 15% SFALBSM diet (937.81g) and lowest in the 30% soaked and fermented African locust bean seeds meal diet (734.25g). Broiler chicks fed 15% SFALBSM had significantly ($P<0.05$) highest weight gain (898.31g) and with better gain than birds fed 22.5% and 30% SFALBSM diets. Total feed intake of birds fed control diet and 7.5% soaked and fermented ALBSM diet were similar and significantly higher than those fed on 15%, 22.5% and 30% soaked and fermented ALBSM for diets.The best feed conversion ratio was observed for birds in diet 3 (1.87) while those on diet 5 (2.31) recorded poor one. Similarly, feed cost in naira per kg gain (₦/kg) of birds was significantly ($P<.05$) lowest for 15% SFALBSM diets (₦137.51) compared to other treatments. The mortality rate was not significantly ($P>0.05$) affected by dietary inclusion of soaked and fermented ALBSM.

Table 4.12: Performance of broiler chickens fed soaked and fermented African locust bean Seed meal diets during starter phase (0-4weeks)

	% Inclusion levels of soaked and fermented African locust bean seed meal						
Parameters	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Initial body weight (g/bird)	39.50	39.50	39.50	39.50	39.50	0.00	1.01
Final body weight (g/bird)	919.89^{a}	881.87^{b}	937.81^{a}	895.89^{b}	734.25^{c}	19.96	0.02
Total weight gain (g/bird)	880.39^{a}	842.37^{a}	898.31^{a}	723.81^{b}	679.13^{b}	23.98	0.03
Total feed intake (g/bird)	1708.56^{a}	1696.99^{a}	1672.72^{b}	1625.40^{c}	1572.39^{c}	6.24	0.01
Feed conversion ratio	1.94^{b}	2.02^{b}	1.87^{c}	2.23^{a}	2.31^{a}	0.06	0.03
Feed cost ₦/kg gain	148.19^{b}	152.20^{b}	137.51^{c}	163.44^{a}	168.71^{a}	4.72	0.02
Mortality rate (%)	2.22	4.00	4.33	4.44	0.00	3.08	0.82

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

4.3.2 Performance of broiler finisher chickens (5-9 weeks)

The growth performance of broiler chicks fed SFALBSM diets were presented in Table 4.13. There were significant (P<0.05) differences in final body weight and total weight gain of birds. Final body weight of broilers was highest for diet 3 (2786.14g) and similar to those on diets T2 (2743.41g) and T4 (2686.14g) while diet 5 had the lowest value (2312.73g). Broilers fed 7.5, 15 and 22.5% SFALBSM diets had similar and significantly (P<0.05) higher total weight gain (1424.73, 1438.76g and 1336.16g respectively) when compared to others. Total feed intake of birds were similar for birds fed T1(4430.35g), T2 (4430.91g), T3(4373.88g) and T4 (4377.33g) and significantly (P<0.05) higher than T5 (4287.73g). There were significant differences (P<0.05) in the feed conversion ratio and feed cost per kilogram gain (₦/kg gain). The best feed conversion ratio was observed in birds on T3 which was similar to those of T2 and T4 while those on T5 (4.55) recorded lowest. Feed cost per kilogram gain (₦/kg) was significantly (P<0.05) highest for diet 5 (₦316.70) and lowest for diet 3 (₦222.33). Mortality rate was not significantly (P >0.05) affected by dietary treatments.

4.3.3 Effect of soaked and fermented African locust bean seed meal diets on haematological and serum parameters of broiler finisher chicken

The results of blood analysis are presented in Table 4.14. There were significant differences (P < 0.05) in the pack cell volume (PCV), total glucose (TG), and red blood cell (RBC). The higher and similar was in 7.5 and 15% PCV was significantly (P<0.05) higher and similar in 7.5 and 15% soaked and fermented ALBSM diets (25.34 and 27.67% respectively) while other treatments also recorded similar but lower values (24.33, 24.01 and 23.33% for T1, T3 and T4 respectively).

Table 4.13: Performance of broiler chickens fed soaked and fermented African locust bean Seed meal diets during finisher phase (5-9weeks)

	% Inclusion levels of soaked and fermented African locust bean seed meal						
Parameters	**T1 (0%)**	**T2 (7.5%)**	**T3(15%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Initial body weight (g/bird)	1350.02	1350.03	1350.02	1350.03	1350.02	0.01	0.73
Final body weight (g/bird)	2627.06^{b}	2743.41^{a}	2786.14^{a}	2686.14^{ab}	2312.73^{c}	35.06	0.01
Total weight gain (g/bird)	1277.04^{b}	1424.73^{a}	1438.76^{a}	1336.16^{ab}	962.72^{c}	32.85	0.02
Total feed intake (g/bird)	4430.35^{a}	4430.91^{a}	4373.88^{a}	4377.33^{a}	4287.73^{b}	26.46	0.02
Feed conversion ratio	3.47^{b}	3.18^{ab}	3.05^{a}	3.26^{ab}	4.55^{c}	0.09	0.03
Feed cost ₦/kg gain	259.31^{b}	235.05^{c}	222.33^{c}	237.63^{bc}	316.70^{a}	6.99	0.04
Mortality rate (%)	2.22	4.00	4.33	4.44	0.00	1.24	0.45

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

Similarly, diet 3 had the highest total glucose (161.01 mm/l) while the control diet had the lowest value of total glucose (135.49mm/l) compared to other treatments. Similarly, diet 3 had the highest value of red blood cell ($4.29X10^6$/l) and lowest value ($2.85\ X10^6$/l) was obtained in diet 1. White blood cells counts were not significantly ($P > 0.05$) affected by the dietary inclusion of soaked and fermented ALBSM. However, the component of white blood cell were significantly ($P<.05$) affected by the treatments. The value for neutrophils were higher with diets 4 (45.52%) and 5 (42.63%), but lowest with diet 3 (31.69%). Lymphocytes gave significantly ($P<0.05$) the highest value in diet 3 (62.55%) compared to other treatments. The lowest lymphocyte was obtained in treatment 5 (44.17%). Monocyte showed the highest value in diet 1 (3.78%) and lowest in diet 5 (2.21%). Diets 3 and 4 had similar values for monocyte but the value were significantly lower than that obtained for the control diet 1.The eosinophils was highest in diet 4 (2.14%) and lowest in diet 5 1 (1.08%).

4.3.4 Effect of soaked and fermented ALBSM diets on carcass characteristics of broiler finisher chickens (5 -9 weeks)

The carcass characteristics of broilers fed SFALBSM diets are presented in Table 4.15. Carcass weight and dressing percentage were similar and significantly ($P<0.05$) higher for birds fed 7.5 and 15% dietary SFALBSM diet (1942.05 and 1930.24g respectively) than control and other dietary levels of SFALBSM. The lowest carcass value was observed in diet 5 containing 30% SFALBSM (1640.44g). Dressing percentage was found to be similar and higher in diets 1, 2 and 3 (73.92, 73.10 and 73.98% respectively) and lowest in diet 5 (70.04%)

Table 4.14: Some haematological and serum parameters of broiler chickens fed soaked and fermented ALBSM diets during finisher phase (5-9weeks)

	% Inclusion level of soaked and fermented African locust bean seed meal						
Parameters (%)	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Pack cell volume	24.33^{b}	25.34^{a}	27.67^{a}	24.01^{b}	23.33^{b}	1.23	0.03
Haemoglobin (g/dl)	8.17	8.40	8.30	7.97	8.20	0.39	0.52
Total protein (g/dl)	3.60	3.93	4.00	3.26	3.93	0.25	0.41
Total glucose (mmol/l)	135.49^{b}	151.17^{b}	161.01^{a}	151.83^{ab}	129.22^{c}	5.73	0.02
Red blood cell ($X10^{6}$/l)	2.85^{c}	3.41^{b}	4.29^{a}	3.30^{b}	3.50^{ab}	0.32	0.03
White blood cell ($X10^{3}$/mm)	3.21	2.90	3.86	3.83	3.04	1.31	0.08
Neutrophils	33.74^{b}	34.62^{b}	31.69^{b}	45.52^{a}	42.63^{a}	1.73	0.01
Lymphocytes	54.24^{b}	54.23^{b}	62.55^{a}	48.17^{bc}	44.17^{c}	2.58	0.03
Monocytes	3.78^{a}	2.94^{ab}	3.40^{b}	3.31^{b}	2.21^{c}	0.35	0.02
Eosinophils	1.38^{b}	1.72^{ab}	2.12^{a}	2.14^{a}	1.08^{c}	0.28	0.03

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

There were significant (P<0.05) effects of diets on the breast muscle, drum stick, and thigh muscles. The breast muscle was highest in diet 3 (21.97%) and lowest in diet 5 (17.35%). Diets 1, 2 and 4 had similar values of breast muscles. The drum stick was highest in diet 2 (12.50%) and lowest with diet 3 (10.74%). There were no significant differences (P>0.05) between diets 2, 3 and the control in the values of their drumsticks. Thigh muscle for diet 3 was found to be highest (13.38%). This value was significantly higher than the value for the control diet (P<0.0%). The wings, neck, and abdominal fat weights were not significantly (P>0.05) affected by dietary treatments. The % back for diets 1 and 3 were significantly (P<0.05) higher than other treatments.

4.3.5 Effect of graded levels of soaked and fermented ALBSM on organs weights of broiler finisher chickens

The results for organs and guts measurements of broilers fed diets containing graded levels SFALBSM are presented in Table 4.16. There were significant differences (P<0.05) in the heart, lungs, liver, pancreas and kidney weights. The heart weights were significantly (P<0.05) higher and similar for broilers on diets 2, 3, and 4 having 0.50, 0.50 and 0.51% respectively. The heart weight was lowest in diet 1 (0.45%). The liver weight of birds fed 7.5% and 15% SFALBSM diets were similar and higher than those on 22.5% and 30% SFALBSM diets. The pancreas weight of birds on the control diet, 22.5% and 30% SFALBSM diets were similar and higher than those of 7.5% and 15% SFALBSM diets.

Table 4.15: Carcass characteristics of broiler chickens fed soaked and fermented African locust bean seed meal diets

	% Inclusion level of soaked and fermented African locust bean seed meal						
Parameters (%)	**T1 (0%)**	**T2 (7.5%)**	**T3(15%)**	**T4 (22.5%)**	**(30%)**	**SEM**	**P**
Final live weight (g/bird)	2621.04^{b}	2740.09^{a}	2780.20^{a}	2680.13^{ab}	2290.11^{c}	30.09	0.01
Carcass weight (g/bird)*	1820.02^{b}	1942.05^{a}	1930.24^{a}	1750.33^{bc}	1640.44^{c}	54.00	0.03
Dressing percentage	73.92^{a}	73.10^{a}	73.98^{a}	70.20^{b}	70.04^{c}	0.36	0.04
Breast muscle	19.55^{b}	19.68^{b}	21.97^{a}	19.87^{b}	17.35^{c}	0.55	0.03
Drum stick	11.52^{a}	12.50^{a}	10.74^{a}	12.29^{b}	11.60^{a}	0.63	0.02
Thigh	11.63^{b}	11.78^{b}	13.38^{a}	12.57^{ab}	11.76^{b}	0.31	0.01
Wings	9.41	9.25	9.94	9.47	9.39	0.46	0.67
Neck weight	6.55	7.89	8.17	7.14	7.9	0.11	0.34
Back weight	21.32^{a}	19.69^{c}	22.23^{a}	19.53^{c}	20.21^{b}	0.76	0.03
Abdominal fat	2.52	2.74	2.62	2.71	2.53	0.12	0.43

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant,

P = Probability value,

* Carcass weight expressed as % live weight.

All the gut measurements were not significantly different (P>0.05) among the treatments, except the large intestine weight (P<0.05) which recorded higher value for diet 5 (0.94%) and similar with value observed in control and 15% soaked and fermented ALBSM diets (0.91 and 0.92%) compared to others. Diets had no significant effect on gizzard weights (P>0.05).

4.3.6 Effect of Soaked and fermented ALBSM diets on the apparent digestibility of nutrients of broiler chickens

The results for the nutrient digestibility study with broiler chickens fed SFALBSM diets are presented in Table 4.17. There were no significant differences (P>0.05) in the dry matter and crude protein digestibilities. Crude fibre digestibility for the control and 15% SFALBSM diets were similar and significantly (P<0.05) better than other treatments. Birds on diet 3 had the highest crude fibre digestibility value of 64.94% while diet 5 had the lowest value of 54.37% Ether extract digestibility for 7.5%, 15% and 22.5% SFALBSM diets were similar and significantly higher than control and 30% SFALBSM diets. There were no significant differences (P>0.05) in the ash digestibility of the SFALBSM diets. The NFE digestibility was significantly different (P<0.05) among the treatments. The nitrogen free extract digestibility values were similar for 15 and 22.5% SFALBSM diets and significantly higher than other diets

Table 4.16: Organs and gut weights of broiler chickens fed soaked and fermented African locust bean seed meal diets

	% Inclusion levels of soaked and fermented African locust bean seed meal						
Parameters (%)	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Heart	0.45^{c}	0.50^{a}	0.50^{a}	0.51^{a}	0.49^{b}	0.01	0.02
Lungs	0.59^{ab}	0.58^{ab}	0.70^{a}	0.50^{b}	0.62^{ab}	0.03	0.04
Liver	2.15^{b}	2.50^{a}	2.26^{ab}	1.93^{c}	1.98^{bc}	0.09	0.03
Pancreas	0.32^{a}	0.20^{b}	0.20^{b}	0.30^{a}	0.28^{a}	0.02	0.01
Kidney	0.28^{b}	0.33^{ab}	029^{b}	0.38^{a}	0.34^{a}	0.02	0.02
Crop	0.09	0.11	0.10	0.09	0.09	0.02	0.38
Proventriculus	0.24	0.20	0.18	0.22	0.21	0.03	0.23
Gizzard (%)	2.76	2.73	2.70	2.72	2.65	0.04	0.30
Small intestine weight	2.20	2.17	2.22	2.22	1.97	0.17	0.78
Small intestine length (cm)	246.01	277.12	272.23	260.41	261.78	9.58	0.44
Large intestine weight	0.91^{ab}	0.83^{b}	0.92^{ab}	$0.85^{\mathbf{b}}$	0.94^{a}	0.05	0.03
Large intestine length (cm)	37.02	35.06	34.53	35.54	34.95	0.78	0.78

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

Table 4.17: Apparent digestibility of nutrients by broiler chickens fed finisher diets containing soaked and fermented ALBSM

	% Inclusion level of soaked and fermented African locust bean seed meal						
Parameters (%)	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5(30%)**	**SEM**	**P**
Dry matter	85.01	84.28	85.58	75.49	75.95	3.06	0.22
Crude protein	80.82	84.37	84.34	73.37	67.49	2.08	0.34
Crude fibre	63.48^{ab}	62.20^{b}	64.94^{a}	57.62^{b}	54.37^{c}	2.70	0.03
Ether extract	63.17^{c}	79.89^{a}	81.93^{a}	80.56^{a}	66.40^{b}	2.89	0.01
Ash	58.71	69.13	67.99	63.10	58.06	3.31	0.49
Nitrogen free extract	83.30^{b}	69.97^{c}	87.53^{a}	85.40^{a}	72.75^{bc}	1.27	0.33

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

4.4. Results of Feeding Trial 3:

Effect of feeding graded levels of Toasted African locust bean seed meal (TALBSM) diets on the Performance and Carcass characteristics of broiler chickens.

4.4.1 Performance characteristics of broiler starter chickens (0-4weeks)

The performance of broiler chicks fed toasted ALBSM diets are presented in Table 4.18. Final body weights and total feed intakes were significantly (P<0.05) affected by dietary treatments. Final body weight was highest for diet 3 (811.31g) and lowest for diet 5 (629.91g). Total weight gained were highest for diets 2 and 3 (797.63g and 801.72g respectively) and lowest for diet 5 (650.85g). The final weight and total weight gain of birds fed 7.5 % and 15 % TALBSM diets were significantly better compared to those on the control and 22.5% TALBSM diets. Total feed intake decreased (P<0.05) as the level of TALBSM increased in the diets of starter chicks. There were significant differences (P<0.05) in the feed conversion ratio and feed cost per kilogram weight gain (₦/kg). Diet 5 had the poorest feed conversion ratio and best FCR was observed in diet 3 (2.04). Feed cost per kg gain (₦/kg) was found to be similar and highest in diets 1 and 5 (₦174.96 and ₦176.14 respectively). The lowest (P<0.05) feed cost was obtained with diet 3(₦152.41/kg).

4.4.2 Performance characteristics of broiler finisher chickens (5-9weeks)

The results of performance of birds fed toasted ALBSM diets are presented in Table 4.19. There were significant differences (P<0.05) in the final body weight, total feed intake and total weight gain of broilers fed TALBSM diets. The broilers fed diet 3 had the highest final body weight (2803.87g) which was similar to those on control and T2. These were significantly (P<0.05) better than those on 22.5% and 30% TALBSM diets.

Table 4.18: Performance of broiler chicken fed toasted ALBSM diets during starter phase (0-4weeks)

	% Inclusion level of toasted African locust bean seed meal						
Parameters	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Initial body weight (g)	39.74	39.72	39.73	39.74	39.73	0.00	1.00
Final body weight (g)	766.52^{b}	788.91^{a}	811.31^{a}	776.55^{b}	629.91^{c}	20.60	0.01
Total weight gain (g)	726.82^{b}	796.63^{a}	801.72^{a}	736.74^{b}	650.85^{b}	24.43	0.01
Total feed intake (g)	1663.48^{a}	1666.47^{a}	1635.11^{b}	1614.29^{bc}	1595.63^{c}	10.64	0.03
Feed conversion ratio	2.30^{b}	2.09^{c}	2.04^{c}	2.20^{b}	2.45^{a}	0.08	0.02
Feed cost ₦/kg gain	174.96^{a}	157.73^{c}	152.41^{c}	162.56^{b}	176.14^{a}	5.70	0.03
Mortality rate (%)	2.22	2.23	4.45	1.15	2.22	1.99	0.65

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

Total weight gained was similar for birds fed control diet, 7.5 % and 15 % TALBSM diets (1536.07g, 1526.56g and 1558.20g respectively) and better than the 22.5 and 30% TALBSM diets. Feed intake of birds during the finisher phase was not significantly (P>0.05) different between treatments. Diet 5 had the poorest feed conversion ratio value (4.68) while 3 had the best (3.35) and similar to those on diet 2. The feed conversion ratio for the control diet, 7.5, 15 and 22.5% TALBSM were similar and significantly better than that of 30 % TALBSM diet. Feed cost per kg gain for 7.5 and 15% toasted ALBSM diets were similar and cheaper than feed cost /kg gain on the control diet and other TALBSM diets. There was no significant effect of diet on the mortality rate.

4.4.3 Effect of feeding toasted ALBSM Diets on haematological and serum Parameters

The results of the effects of TALBSM diets on haematological parameters are presented in Table 4.20. The results showed there were significant differences (P<0.05) in the pack cell volume, haemoglobin, total glucose and white blood cells. The blood of broiler finishers fed 15% TALBSM diet gave the highest value for pack cell volume (30.67%), haemoglobin count (10.20g/dl), total glucose (156.22mmol/l) and red blood cell count (4.40 $X10^6$/l) compared to other diets. There were significant differences (P<0.05) in the lymphocytes and eosinophils of birds fed toasted ALBSM diets. Diet 2 had the highest value of lymphocyte count (61.47%) and lowest value of lymphocytes count was in diet 5 (50.62%). Birds fed diet 3 had the highest value of eosinophils (2.75%) while those on diet 5 (1.14%) recorded the lowest value. There were no significant differences (P>0.05) in the neutrophil and monocyte counts.

Table 4.19: Performance of broiler chickens fed toasted ALBSM diets during finisher phase (5-9weeks)

	Inclusion level of toasted African locust bean seed meal						
Parameters	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Initial body weight (g)	1245.68	1245.67	1245.68	1245.68	1245.67	0.02	0.99
Final body weight (g)	2781.71[a]	2772.26[a]	2803.87[a]	2255.91[b]	2209.12[b]	35.71	0.01
Total weight gain (g)	1536.07[a]	1526.56[a]	1558.20[a]	1310.23[b].	963.44[c]	55.68	0.01
Total feed intake (g)	4547.85	4435.39	4393.57	4393.76	4475.89	70.20	0.52
Feed conversion ratio	3.94[a]	3.96 [a]	3.35[a]	3.36[a]	4.68[b]	0.19	0.02
Feed cost ₦/kg gain	223.12[b]	214.98[c]	207.43[c]	243.79[b]	336.95[a]	5.70	0.01
Mortality rate (%)	4.52	4.76	4.76	4.76	7.14	1.98	0.90

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

Table 4.20: Some haematological and serum parameters of broiler chickens fed Toasted ALBSM at finisher phase

	% Inclusion level of Toasted African locust bean seed meal						
Parameters	**T1(0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Pack cell volume (%)	28.33^{ab}	26.00^{b}	30.67^{a}	29.00^{a}	26.01^{b}	0.36	0.02
Haemoglobin (g/dl)	9.43^{ab}	8.63^{b}	10.20^{a}	9.63^{ab}	8.63^{b}	0.41	0.04
Total protein (g/dl)	4.32	4.14	4.40	3.88	3.91	0.21	0.81
Total glucose (mmol/l)	145.75^{ab}	148.94^{ab}	156.22^{a}	138.39^{ab}	124.67^{c}	3.48	0.03
Red blood cell ($X10^{6}$/l)	4.32	4.14	4.40	3.88	3.91	0.34	0.40
White blood cell ($X10^{3}$/mm)	2.54^{b}	3.63^{ab}	3.47^{ab}	3.13^{c}	4.00^{a}	0.28	0.02
Neutrophils (%)	33.56	31.06	31.87	37.77	38.26	1.54	0.32
Lymphocytes (%)	57.89^{ab}	61.47^{a}	56.72^{ab}	56.62^{ab}	50.62^{b}	1.34	0.03
Monocytes (%)	3.29	3.53	3.09	3.53	3.27	0.24	0.24
Eosinophils (%)	1.59^{ab}	2.24^{b}	2.75^{a}	2.62^{a}	1.14^{c}	0.29	0.02

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

4.4.4 Effect of graded levels of toasted African Locust Bean Seed Meal diets on the carcass characteristic of broilers finisher chickens

The carcass characteristics of broiler chicken fed toasted African locust bean seed meal was presented in Table 4.21. The results showed there were significant differences ($P<0.05$) in carcass weight, dressing %, breast muscle, drum stick and back weight of broilers. Carcass weight, dressing percentage, breast muscle, drum stick and back weight showed highest values in the 15% TALBSM diet. Broiler finishers fed the control diet, 7.5 and 15% TALBSM recorded similar values for their carcass weight. Higher and similar values of dressing percentage were recorded by birds fed 7.5% and 15% TALBSM, while back weight values were only similar for those on the control and 15% TALBSM diets. There were no significant effect of TALBSM diets ($P>0.05$) on thigh, wings, neck weights and abdominal fat of broiler chickens.

4.4.5 Effect of toasted ALBSM diets on organs and gut measurements of broiler finisher chicken

The results of organs weights are presented in Table 4.22. There were no significant effect of TALBSM diets ($P>0.05$) on heart, lungs, pancreas, crop, proventriculus, and gizzard weights expressed as percent live weight and small intestine lengths. Although there significant ($P<0.05$) differences on liver, kidney and small intestine. The % liver weight was similar in T2 and T4 (2.17 and 2.29%) and higher than other treatments. Kidney weights were similar in T2, T4 and T5. Small intestine weight was significantly ($P<0.05$) higher and similar in birds fed T1 and T5 (2.21 and 2.76%). No significant difference was observed in small intestine length among the treatments. However, the large intestine weight increased as the level of toasted ALBSM was increased in diets of broiler finisher chickens.

Table 4.21: Carcass characteristics of broiler finisher chickens fed toasted African locust bean seed meal diets

	% Inclusion level of soaked and fermented African locust bean seed meal						
Parameters (%)	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Final live weight (g)	2780.02^{a}	2770.20^{ab}	2781.23^{a}	25420.23^{b}	2201.42^{c}	0.70	0.01
Carcass weight (g) *	1861.06^{a}	1890.11^{a}	1902.22^{a}	1672.56^{b}	1513.67^{c}	0.05	0.01
Dressing percentage	71.52^{b}	72.75^{a}	72.98^{a}	70.48^{bc}	69.84^{c}	0.49	0.04
Breast muscle	17.94^{bc}	19.49^{b}	22.51^{a}	17.51^{bc}	17.07^{c}	0.64	0.01
Drum stick	12.84^{b}	12.83^{b}	14.32^{a}	11.08^{c}	10.99^{c}	0.58	0.03
Thigh	10.42	10.98	11.47	10.51	10.07	0.39	0.39
Wings	9.27	9.97	9.90	10.02	9.32	0.63	0.63
Neck weight	4.35	5.49	5.11	5.11	4.89	0.91	0.38
Back weight	21.33^{a}	20.66^{b}	22.22^{a}	17.63^{c}	17.01^{c}	0.76	0.03
Abdominal fat	2.47	2.35	2.18	2.60	2.76	0.17	0.23

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value,

* Carcass weight expressed as % live weight

Table 4.22: Organs and gut weights of broiler chickens fed toasted African locust bean seed meal diets

	% Inclusion level of Toasted African locust bean seed meal						
Parameters (%)	**T1(0%)**	**T2 (7.5%)**	**T3(15%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Heart	0.42	0.44	0.46	0.45	0.38	0.01	0.48
Lungs	0.45	0.51	0.56	0.57	0.54	0.03	0.10
Liver	1.85^{c}	2.17^{ab}	2.00^{b}	2.29^{a}	2.07^{b}	0.11	0.02
Pancreas	0.26	0.23	0.29	0.28	0.26	0.02	0.30
Kidney	0.28^{b}	0.33^{ab}	029^{b}	0.38^{a}	0.34^{a}	0.02	0.02
Crop	0.11	0.13	0.12	0.11	0.11	0.04	0.57
Proventriculus	0.34	0.32	0.31	0.32	0.31	0.03	0.38
Gizzard	2.37	2.52	2.50	2.57	2.24	0.09	NS
Small intestine weight	2.21^{ab}	1.96^{b}	1.18^{c}	1.60^{b}	2.76^{a}	0.17	0.03
Small intestine length (cm)	286.78	290.56	289.00	279.11	269.67	6.39	0.31
Large intestine weight	0.73^{bc}	0.66^{c}	0.74^{b}	0.80^{a}	0.93^{a}	0.04	0.01
Large intestine length (cm)	31.13^{c}	31.44^{b}	32.30^{b}	32.93^{ab}	33.60^{a}	0.39	0.01

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

4.4.6 Effect of toasted ALBSM diets on apparent digestibility of nutrients by broiler finisher chickens

Apparent nutrient digestibilities of the control and TALBSM diets were presented in table 4.23. There were no significant effect ($P>0.05$) on digestibilties of dry matter, crude protein and ash. The crude fibre, ether extract and nitrogen free extract digestibilities were significantly ($P<0.05$) affected by treatments. The crude fibre digestibilities for the control and the 15% TALBSM diets were similar and significantly ($P<0.05$) better than other treatments. Ether extract digestibilities were similar for 7.5, 15 and 22.5 TALBSM diets and significantly higher than other treatments. Nitrogen free extract digestibilities were similar and higher for birds fed 15% and 22.5% diets compared to other treatments.

Table 4.23: Apparent digestibility of nutrients of broiler chickens fed diets containing toasted ALBSM

	% Inclusion level of Toasted African locust bean seed meal						
Parameters (%)	**T1 (0%)**	**T2 (7.5%)**	**T3 (15%)**	**T4 (22.5%)**	**T5 (30%)**	**SEM**	**P**
Dry matter	85.01	84.28	85.58	75.49	75.95	3.06	0.11
Crude protein	80.82	84.37	84.34	73.37	67.49	2.08	0.34
Crude fibre	63.48^{a}	62.20^{b}	64.94^{a}	57.62^{b}	54.37^{c}	2.70	0.01
Ether extract	63.17^{c}	79.89^{a}	81.93^{a}	80.56^{a}	66.40^{b}	2.89	0.02
Ash	58.71	69.13	67.99	63.10	58.06	3.31	0.40
Nitrogen free extract	83.30^{b}	69.97^{c}	87.53^{a}	85.40^{a}	72.75^{c}	2.27	0.01

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard error of means,

NS= Not Significant

P = Probability value

4.5 Results of Feeding Trial 4: Effect of differently Processed African Locust Bean Seed Meal Diets on the Performance and Carcass characteristics of Broiler chickens

4.5.1 Effect of differently processed ALBSM diets on the performance of broiler starter chicks (0-4weeks)

The performance of broiler chicks fed differently processed African Locust Bean Seed Meal in broiler starter diets are presented in Table 4.24. There were significant effect of diets ($P<0.05$) on final body weight, total feed intake and total weight gain. Final body weight was significantly higher ($P<0.05$) for birds fed soaked and fermented ALBSM (843.03g) than those birds fed the control and other processed ALBSM diets. Total feed intake was found to be similar for birds fed control diet, 15% cooked ALBSM and soaked and fermented ALBSM diet (1508.68, 1505.42 and1536.36g respectively) but lowest for those on toasted ALBSM diet (1471.68g). Total weight gained was also significantly higher ($P< 0.05$) for broiler chicken fed soaked and fermented ALBSM diet (804.46g) and the value was similar to those on cooked ALBSM diet, while toasted ALBSM recorded the lowest value (653.19g). There were no significant effects of diets ($P>0.05$) on feed conversion ratio and on feed cost per kilogram gain of broilers fed differently processed ALBSM diets. Although different processing methods did not significantly ($P>0.05$) affect the feed cost per kilogram gain, a reduction in the cost per kg flesh gained by birds containing processed ALBSM were observed. There was significant difference ($P<0.05$) in the mortality rate of birds fed differently processed ALBSM diets Control diet gave significantly ($P<0.05$) the lowest mortality rate when compared with diets containing differently processed ALBSM.

Table 4.24: Performance of broiler chicken fed differently processed African locust bean seed meal diets during the Starter phase (0-4 weeks)

	Differently processed African Locust Seed Me					
Parameters	**Control (0%)**	**CK Seed (15%)**	**SF Seed (15%SF)**	**TT Seed (15%TT)**	**SEM**	**P**
Initial body weight (g)	38.57	38.75	38.57	38.57	0.00	0.92
Final body weight (g	719.81^{c}	767.47^{b}	843.03^{a}	691.76^{c}	31.34	0.02
Total weight gain (g)	681.24^{b}	728.90^{ab}	804.46^{a}	653.19^{b}	31.34	0.04
Total feed intake (g)	1508.68^{ab}	1505.42^{ab}	1536.36^{a}	1471.68^{b}	12.39	0.01
Feed conversion ratio	2.23	2.07	1.93	2.26	0.11	0.14
Feed cost ₦/kg gain	167.92	156.46	141.31	149.14	22.80	0.65
Mortality	3.17^{c}	8.33^{a}	5.33^{b}	8.33^{a}	2.21	0.01

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard Error of means,

NS = Not Significant,

CK= Cooked ALBSM,

SF= Soaked and Fermented ALBSM,

TT= Toasted ALBSM,

P = Probability value

4.5.2 Effect of differently processed ALBSM diets on the performance of broiler finisher chickens (5-9weeks)

The performance of broiler birds fed differently processed ALBSM in their finisher diets is presented in Table 4.25. There were significant differences (P <0.05) in the final body weight, total weight gain, total feed intake and in feed cost per kg gain. The birds fed with diet 3 (Soaked and fermented ALBSM diets) had highest final body weight (2770.32g), total weight gain (1559.06g) and lowest feed cost per kg gain (₦222.44/ kg gain) when compared with birds fed the control diet and other processed ALBSM diets. Broilers fed diet containing SFALBSM diet were found to be highest in terms weight gain and total body weight. Total feed intake of birds fed SFALBSM diet was similar to those of birds fed the control diet. The feed conversion ratio was best for birds fed soaked and fermented ALBSM diet (T3). This was significantly (P<0.05) better than all other treatments. The feed conversion ratio for control and the toasted ALBSM diets were similar but poorer than the cooked ALBSM diet. The feed cost per kg gain followed the same trend as feed conversion ration. There was no significant (P>0.05) effect of diets on the mortality rate.

4.5.3 Effect of differently processed African Locust Bean Seed Meal on haematological and serum parameters of broiler finisher chickens (5-9 weeks)

The effects of feeding differently processed ALBSM diets on haematological parameters of broiler chickens are presented in Table 4.26. There were significant effects of diets (P<0.05) on the pack cell volume (PCV), haemoglobin (Hb) total protein (TP) red blood cell and total glucose. The PCV was significantly higher (P<0.05) in birds fed soaked and fermented ALBSM diets (37.50%) compared to other treatments. Haemoglobin value was best for birds fed soaked and fermented diets (12.47 g/dl)

Table 4.25: Performance of broiler finisher chicken fed differently processed African locust bean seed meal diets (5-9weeks)

	Differently Processed African Locust Seed Meal					
Parameters	**Control (0%)**	**CK Seed (15%)**	**SF Seed (15%SF)**	**TT Seed (15%TT)**	**SEM**	**P**
Initial body weight (g)	1211.26	1211.25	1211.26	1211.25	0.05	1.00
Final body weight (g)	2565.82^{b}	2618.23^{ab}	2770.32^{a}	2535.58^{b}	25.58	0.04
Total weight gain (g)	1354.30^{b}	1406.97^{ab}	1559.06^{a}	1324.30^{b}	24.04	0.04
Total feed intake (g)	4762.10^{a}	4666.76^{b}	4724.86^{ab}	4662.10^{c}	1.36	0.03
Feed conversion ratio	3.53^{a}	3.34^{b}	3.03^{c}	3.53^{a}	0.13	0.03
Feed cost ₦/kg gain	265.34^{a}	249.35^{b}	222.44^{c}	259.90^{a}	10.07	0.04
Mortality	2.78	2.77	2.78	5.56	3.86	0.87

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard Error of means,

NS = Not Significant,

CK= Cooked ALBSM,

SF= Soaked and Fermented ALBSM,

TT= Toasted ALBSM,

P = Probability value

and this was significantly (P<0.05) higher than the control and cooked ALBSM treatment. The toasted ALBSM diet gave the least haemoglobin value. Total protein on the control diet was significantly higher (P<0.05) compared to all ALBSM treatments which had similar values. Total glucose for the control, cooked and soaked and fermented ALBSM diets were similar and significantly higher (P<0.05) than values obtained for toasted ALBSM diet. Red blood cell levels for toasted, cooked and soaked and fermented ALBSM diets were similar. The RBC for soaked and fermented was significantly higher (P<0.05) than control diet. There were no significant effects of diets (P > 0.05) in the white blood cell counts of the birds. Neutrophil counts were significantly (P<0.05) higher for broilers fed control diet and SFALBSM diets (42.38% and 39.92% respectively) and lowest value was recorded in cooked and toasted diets (33.03 and 33.09% respectively). Lymphocytes cell counts for cooked ALBSM and SFALBSM diets were significantly higher than control and toasted diets.

4.5.4 Effect of differently processed ALBSM diets on the carcass characteristics of broiler finisher chickens (5-9 weeks)

The carcass and gut characteristics of broiler chickens fed differently processed ALBSM based diets are presented in Table 4.27. There were significant effects of diets (P<0.05) on carcass weight, dressing percentage and on thigh percentage. Final live weight was highest in the SFALBSM diet (2773.42g) and lowest in toasted ALBSM diet (2533.68g). Similarly, birds fed SFALBSM had the highest carcass weight (1990.10g), dressing percentage (74.24%) and thigh percentage (10.96%) compared to the control and other processed ALBSM diets. The breast muscle and drum stick, wings, neck, back and abdominal fat percentages were not significantly (P>0.05) affected by the diets.

Table 4.26.: Some haematological and serum Parameters of Broiler chickens fed differently Processed ALBSM at finisher Phase (5-9weeks)

	Differently processed African Locust Seed Meal					
Parameters (%)	**Control (0%)**	**CK Seed (15%)**	**SF Seed (15%SF)**	**TT Seed (15%TT)**	**SEM**	**P**
Pack cell volume	30.25^{b}	32.25^{b}	37.50^{a}	31.76^{b}	1.36	0.02
Haemoglobin (g/dl)	11.16^{b}	11.05^{b}	12.47^{a}	10.45^{c}	0.41	0.50
Total protein (g/dl)	3.70^{a}	3.20^{b}	3.21^{b}	3.15^{b}	0.21	0.03
Total glucose (mmol/l)	154.85^{ab}	164.35^{a}	165.60^{a}	147.98^{b}	3.48	0.02
Red blood cell ($X10^{6}$/l)	3.18^{b}	3.72^{ab}	4.48^{a}	3.66^{ab}	0.34	0.04
White blood cell ($X10^{3}$/mm)	3.88	3.51	3.94	3.58	0.28	0.22
Neutrophils	42.38^{a}	33.03^{b}	39.92^{a}	33.09^{b}	1.54	0.02
Lymphocytes	50.61^{c}	56.57^{a}	52.06^{b}	54.74^{a}	1.34	0.03
Monocytes	3.10	3.15	3.11	3.92	0.24	0.35
Eosinophils	1.93	1.61	1.74	1.57	0.29	0.22

a,b,c = means with different superscripts on the same row are significantly different (P<0.05), SEM= Standard Error of means, NS = Not Significant, CD = Control diet, CK= Cooked ALBSM, SF= Soaked and Fermented ALBSM, TT= Toasted ALBSM
P = Probability value

Table 4.27: Carcass and gut characteristics of broiler chicken fed differently processed African locust bean seed meal diets during the finisher phase (5-9weeks)

	Differently Processed African Locust Seed Meal					
Parameters (%)	**Control (0%)**	**CK Seed (15%)**	**SF Seed (15%SF)**	**TT Seed (15%TT)**	**SEM**	**P**
Final live weight (g)	2566.72^{b}	2618.24^{ab}	2773.42^{a}	2533.68^{b}	43.68	0.03
Carcass weight (g)*	1767.50^{b}	1722.51^{b}	1990.10^{a}	1565.22^{c}	24.12	0.04
Dressing percentage	71.43^{c}	73.04^{b}	74.24^{a}	70.77^{c}	0.30	0.02
Breast muscle	13.64	12.84	14.08	12.01	0.84	0.35
Drum stick.	8.92	10.54	10.75	9.11	0.81	NS
Thigh	9.06^{b}	9.25^{b}	10.96^{a}	9.33^{b}	0.31	0.03
Wings	5.55	5.25	5.13	5.14	0.21	0.21
Neck weight	5.27	5.27	5.13	5.14	0.25	0.43
Back weight	20.45	19.40	21.39	18.76	1.15	0.09
Abdominal fat	1.32	1.33	1.43	1.36	0.09	0.21

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard Error of means,

P = Probability value

NS = Not Significant,

CD= Control diet,

CK= Cooked ALBSM,

SF= Soaked and Fermented ALBSM,

TT= Toasted ALBSM

LOS = Level of significance, * Carcass weight expressed as % live weight

4.5.5 Effect of differently processed ALBSM diets on the organs weights of broiler finisher chickens (5-9 weeks)

The organs weights of broiler chickens fed differently processed locust bean seed meal are presented in Table 4.28. There were significant differences ($P<0.05$) in the heart and pancreas weights. The highest value of heart weight was obtained in birds fed soaked and fermented ALBSM diets (0.15%) and the lowest value for heart weight was found in diet 2 (0.10%). Pancreas weight was significantly highest in toasted ALBSM diet (0.14%) followed by the control (0.13%) and least in the cooked and soaked and fermented diets (0.12%). There were no significant differences ($P>0.05$) in lungs, liver, and kidney weights of broiler chicken fed differently processed ALBSM diets. Most of gut characteristics (crop, proventriculus, gizzard small intestinal weight and large intestine length) showed no significant differences ($P>0.05$) among dietary treatments. There was a significant effect of diets ($P<0.05$) in the small intestine length. Birds fed toasted ALBSM had significantly the longest small intestinal length (284.63cm) followed by those fed the cooked and soaked and fermented ALBSM diets which were similar and the least was on the control diet.

4.5.6 Effect dietary inclusion of differently processed ALBSM on apparent digestibility of nutrients

The digestibilities of nutrients in broiler diets containing differently processed ALBSM are presented in Table 4.29. Dry matter, ether extract and nitrogen free extract digestibilities were significantly ($P<0.05$) affected by dietary inclusions of differently processed African locust bean seed meal. Dry matter digestibility was highest for soaked and fermented diets (82.87%) and lowest in toasted ALBSM diet (71.89%). No significant differences ($P>0.05$) for digestibilities of crude protein, crude fibre and ash.

Table 4.28: Organs weights of broiler chickens fed differently processed African locust bean seed meal diets

	Differently processed African Locust Seed Meal					
Parameters (%)	**Conrol (0%)**	**CK Seed (15%)**	**SF Seed (15%SF)**	**TT Seed (15%TT)**	**SEM**	**P**
Heart	0.11^{b}	0.10^{b}	0.15^{a}	0.14^{a}	0.01	0.02
Lungs	0.45	0.48	0.49	0.47	0.03	0.42
Liver	2.06	2.27	2.53	2.53	0.17	0.61
Pancreas	0.13^{b}	0.12^{c}	0.12^{c}	0.14^{a}	0.01	0.03
Kidney	0.19	0.19	0.19	0.21	0.12	0.25
Crop	0.13	0.12	0.13	0.13	0.09	0.30
Proventriculus	0.37	0.37	0.36	0.42	0.02	0.31
Gizzard	2.06	2.06	1.88	2.12	1.15	0.41
Small intestine weight	1.83	1.39	1.59	1.56	0.01	0.60
Small intestine length (cm)	234.10^{c}	250.42^{b}	258.22^{b}	284.63^{a}	4.99	0.01
Large intestine weight	1.16	1.22	1.16	1.44	0.05	0.20
Large intestine length (Cm)	32.93	32.79	32.93	31.53	1.17	0.33

a,b,c = means with different superscripts on the same row are significantly different (P<0.05), SEM= Standard Error of means, NS = Not Significant, CD = Control diet, CK= Cooked ALBSM, SF= Soaked and Fermented ALBSM, TT= Toasted ALBSM
P = Probability value

Table 4.29: Apparent digestibility of nutrients by broiler chickens fed diets containing differently processed ALBSM

	Differently processed African Locust Seed Meal					
Parameters (%)	**Control (0%)**	**CK Seed (15%)**	**SF Seed (15%SF)**	**TT Seed (15%TT)**	**SEM**	**p**
Dry matter	79.88[b]	82.07[a]	82.87[a]	71.89[c]	2.66	0.02
Crude protein	79.52	78.79	80.15	68.34	24.45	0.24
Crude fibre	62.19	65.26	73.31	63.43	3.52	0.16
Ether extract	83.43[a]	76.82[b]	83.33[a]	69.47[c]	2.84	0.01
Ash	64.18	70.05	69.92	70.61	5.84	0.61
Nitrogen free extract	80.30[ab]	77.97[b]	88.56[a]	71.15[c]	4.01	0.04

a,b,c = means with different superscripts on the same row are significantly different (P<0.05),

SEM= Standard Error of means,

NS = Not Significant,

CD = Control diet,

CK= Cooked ALBSM,

SF= Soaked and Fermented ALBSM,

TT= Toasted ALBSM

P = Probability value

CHAPTER FIVE

DISCUSSION

5.1 Preliminary investigations on African Locust Bean Seeds (ALBS)

5.1.1 Proximate Compositions of African Locust Bean Seed meal (ALBSM)

The effects of different processing methods on proximate compositions of processed ALBSM (Table 4.1). The crude protein had increased for ALBSM cooked for 1 to 4 hours when compared with raw seeds. This may be attributed to reduction of some anti-nutreints such as trypsin inhibitors are heat liable making the protein more available in the cooked seeds. This agreed with of Balogun (2001) who reported that heating improves the nutritional value of legume grain and also destroys all the heat liable anti-nutreints. Cooked ALBSM for 4 hour gave higher value of % CP compared to raw seeds and other ALBSM cooked for 1, 2 and 3 hours. This may be attributed to destruction of fibre in the seed coat as reported by Damang (2007). Soaking for 1, 2 and 3days also improved the nutrient content in ALBSM. It has been reported that processing by soaking reduced anti-nutreints and consequently increased the availability of some nutrients (Udensi *et al*., 2008). Soaked and fermented ABLSM gave improvement compared to raw seeds. This might be due to microbial and enzymes acting upon certain anti-nutritional factors in legume grain as reported by (Simovic *et al*., 1972). All values obtained for crude protein of processed ALBSM was within the range 24-30% of plant protein sources as reported by Aduku (1992). Olomu (2011) reported that the crude protein of ALBS varies between 25 and 30% depending on the processing method employed. Crude fibre was higher in the raw beans compared to processed seeds. All the

processing methods employed reduced the ether extract contents of processed ALBSM. This could have resulted from the loss of ether in the cooking water or soaking water or due to evaporative loss during toasting of the beans.

5.1.2 Effect of processing methods on levels of anti-nutritional factors of African locust bean Seeds

The processing methods showed had significant effect ($P<0.05$) on the levels of anti-nutritional factors and percent reduction in raw and differently processed ALBS (Tables 4.2 and 4.3). The levels of tannin, phytate, saponin oxalate and trypsin inhibitors were significantly reduced when raw ALBSs were subjected to various processing methods. These observations agreed with Balogun *et al*. (2001) who reported that heating improved the nutritional value of legume grain and also destroyed all the heat labile anti-nutrients that are inherent in legume grain such as trypsin inhibitors, phytate, oxalate, goitrogens, haemagglutinin, and genistein. The percentage reduction in levels of tannin, phytate, saponin and oxalate and trypsin inhibitors in ALBS by different processing (cooking, soaking, fermentation or toasting) agreed with the findings of Udensi *et al.* (2008) who confirmed that processing of legumes seeds (soaking, autoclaving, and roasting) led to products with reduced anti-nutritional contents and consequently increased some nutrients. Pukushima (1979) reported that most legume protein are globular molecules which are completely folded in the raw beans and that these show little susceptible to proteinases until their internal structure is disrupted. Heat treatment is therefore required to alter the chemical structure of the protein in the raw beans and make them more susceptible for enzyme digestion.

5.1.3 Effects of different processing methods on Amino acid composition of ALBS

The effect of processing methods on amino acid profiles of differently processed ALBS was presented in Table 4.4. The lysine and methionine contents increased in the cooked and soaked and fermented beans. This may due to increase of crude protein as a result of destruction of seed coats by cooking and microbial activities during soaking and fermentation. This observation contradicts the report of Damang (2007) who found lower value of lysine content in the cooked ALBS (1.57%). It however agreed with the reports of Oyenuga (1968) and Kingsley (1995) who had reported higher values of amino acid contents in African locust bean seeds. Olomu (2011) also reported that the lysine is high but the seed is deficient in methionine and tryptophan. The values obtained in this study were close to the values given by Olomu (2011) for blood meal (5.3%) and fish meal (4.40%).

5.1.4 Effects of different processing methods on mineral composition of African Locust Bean Seeds

The effect of processing methods on the mineral composition of differently processed ALBS showed there were significant ($P<0.05$) increased in the mineral contents of processed compared to raw beans (Table 4.5). Calcium and phosphorous were increased for soaked and fermented beans compared to other processed beans. Magnesium was higher in raw than in the processed ALBSM. Sodium values were found higher in soaked and fermented and toasted ALBSM. Copper content increased for soaking and fermentation than other processed ALBSM. Zinc was higher for raw and soaked and fermented ALBS. This observation agreed with finding of Aletor and Ojo (1989) who reported a decrease in K, Mg, Na, and Ca levels of cooked soya bean, lima bean and mucuna bean.

5.2 Effects of cooked ALBSM diets on the Performance and Carcass characteristics of broiler finisher chickens

5.2.1 Performance of broiler starter chickens fed cooked ALBSM diets (0-4weeks)

The performance of broiler of birds fed cooked ALBSM during is presented in Table 4.6. The final body weight was significantly similar for chicks fed 0, 7.5, 15 and 22.5% cooked ALBSM diets and significantly higher T5 containing 30% cooked ALBSM diets. In terms of total weight gained, birds fed 7.5, 15 and 22.5% cooked ALBSM were similar. This observation contradicts the report of Damang (2007) who reported that cooking time applied to ALBS had no significant effect on final body weight and daily weight gain of birds when included in the diets of broiler chickens. This observation however agreed with work of Ogundipe (1980) who reported that broilers fed boiled soybean performed better than those fed raw soybean diets. This author also found that moist cooking resulted in better performance of broilers. The observation made in this study also agreed with the work of Amaefule and Obioha (2001) who reported better performance of broilers fed boiled pigeon pea seed meal based diets compared to those fed diet containing raw pigean pea seeds based diets. Total feed intake of birds was similar for birds fed 0, 7.5, 15, 22.5 and 30% cooked ALBSM diets. This disagreed with Damang (2007) who reported that cooking time had no significant effect on feed intake and on feed to gain ratio. The effects of cooked ALBSM on birds performance during the starter phase showed depressed growth beyond the 15% dietary level of inclusion. This also agreed with the finding of Damang (2007) who reported that 20% dietary inclusion level of ALBSM in the diets might be too high during the starter phase because of the level of the residual anti-nutritional factors in the cooked beans.

5.2.2 Performance of broiler chickens fed cooked ALBSM diets during the finisher phase (5-9weeks)

Final body weight of broilers followed the same trend during the finisher phase as observed during the starter phase (Table 4.7). This observation disagrees with the report of Damang (2007) who stated that the optimum dietary inclusion of African locust bean seed meal for the finisher diet was 10%. Similarly, Sarwatt *et al.* (1991) reported decreases in the final body weight and weight gains for broiler finishers as the level of lablab in their diet increased. Feed conversion ratio was best for birds fed 7.5 and 15% cooked African locust bean seed meal compared to other diets. The feed cost per kilogram gain (₦/kg gain) was similar for birds fed 15% and 22.5% cooked ALBSM diets compared to control diet, 7.5 and 30% ALBSM diets. This may be due to efficient utilization of the nutrients on these diets compared to other treatments. The results of this study agreed with the work of Doma (1998) who reported that the lower the feed conversion the better the diets in monogastric animals.

5.2.3 Haematological and serum parameters of broiler chicks fed graded levels of cooked ALBSM in their diets.

The effect of cooked ALBSM diets on haematological parameters was presented in Table 4.8. PCV fell within the normal range (22-35%) as reported by Banergee (2007). RBC and WBC values were higher for 15% cooked ALBSM dietary level. This may be attributed to reduction of anti-nutritional factors that might affects the blood compositions of other birds fed other treatments. The values are within the normal range of chickens as reported by Sunchint *et al*. (2004).This observation is also supported by many reports in literature, which generally recommended that cooking for 35 - 40

minutes is adequate for processing legume seeds for monogastric rations, (Balogun *et al*., 2001, Bawa *et al.*, 2003; Amaefule and Onwudike, 2000).

5.2.4 Carcass characteristics of broiler chicken fed cooked ALBSM diets

Carcass weight was similar for the 7.5 % and 15% cooked ALBSM diets and significantly higher than other treatments as presented in Table 4.9.The dressing percentage was observed better for birds fed 15% ALBSM diet. These results agreed with Omeje (1999) and Kaankuka *et al.* (2000) who reported that processing improved the utilization of proteins and energy contained in legumes. It has been shown that as the protein level increased in the food consumed, it leads to better muscle deposition and production of leaner carcass (Hill and Dansky 1954). Breast muscles, Thigh and drumstick followed the same pattern. This may be attributed to the physiological response of birds to different dietary treatments. Omeje (1999) found that cooking had significant effect on the anti-nutritional factors in grain legumes by reducing its effects and allowing better utilization of nutrients in the body. This disagrees with the report of Damang (2007) who stated that cooking time had no significant effect on the dressing percentage, gizzard, intestinal and abdominal fat and kidney weights.

5.2.5 Organs weights of broiler chicken fed cooked ALBSM diets

Liver weights generally increased for the cooked ALBSM diet when compared with the control diet (Table 4.10). Heavier weight of organs could be an indication of hypertrophy (Pond; 1989). Similarly, Abeke (2005) reported Lablab seed should be well cooked to be properly utilized without posing any danger to the health status of chicks.

5.2.6 Apparent digestibility of nutrients by broiler chickens fed cooked ALBSM diets

The digestibilities dry matter, crude protein and crude fibre were significantly ($P<0.05$) affected by cooking time applied to the ALBSM as shown in Table 4.11. This might be due to effect of the heat penetrating the seed coat to destroy the anti-nutritional factors in the African locust bean seeds. Damang (2007) also observed that the seed coat of ALBS might affect the digestibility of some nutrients by reducing the surface area for enzymes to act upon substrates. The digestibility tended to reduce as the level of cooked ALBSM increased beyond 15%. This reduction may be due to the residual effect of anti-nurients present in the cooked ALBSM. According to Bressani and Eliase (1979), the low protein digestibility in grain legumes such as lablab is often associated with the presence of trpsin inhibitors, haemaggglutinin and tannin. It can also lead to reduced absorption of amino acids and mineral availability (Liener and Kakade, Yavelov *et al.*, 1983; Birk, 1988; Gatel and Grosgean, 1990).

5.3 Effects of Soaked and Fermented ALBSM (SFALBSM) Diets on the Performance and Carcass characteristics of broiler chickens

5.3.1 Performance of broiler starter chicks fed SFALBSM diet (0-4weeks)

Total weight gained by birds on the control diet and those fed 15% dietary inclusion of ALBSM were higher (P<0.05) than the others (Table 4.12). Reduced weight gains observed in other treatments may be attributed to residual anti-nutritional factors in ALBSM. Effects of residual anti-nutritional factors were reported after feeding soaked mango seeds in the diet of broilers (Idris, 2012). This also agreed with the finding of Leiner and Kakade (1980). The feed intake decreased with increase in the level of soaked and fermented ALBSM up to diet 5. Feed conversion ratio of birds and feed cost per kilogram gain (₦/kg gain) were better foe birds fed 15% ALBSM diets compared to other. This may be due to microbial fermentation. This agreed with Walter *et al.* (1984) who reported that fermentation improved palatability besides upgrading the nutrient composition of the fermented material.

5.3.2 Performance of broiler chickens fed soaked and fermented ALBSM diets finisher phase (5-9weeks)

The total weight gain of broilers was significantly (P<0.05) higher at 15% dietary inclusion of SFALBSM diet compared to other treatments as presented in Table 4.13. This may be attributed to effective utilization of nutrients in the diets. Soaking and fermentation proved to have reduced effectively the level of toxic compounds in the legume seeds (Ologhobo *et al.* 1993). The author also reported that the inclusion of plant protein in the diets of growing animal led to a significant impairment of growth and other undesirable physiological and biological alteration. The feed cost per kilogram gain was

observed to significantly decreased for diet 3 (15% SFALBSM diet). Better feed conversion ratio was recorded may be due reduction of anti-nutritional factors and microbial fermentation that improved the legume grain (Odunfa, 1983). Ologhobo *et al.* (1993) reported that soaking and fermentation reduced the level of toxic compound in legume seeds and also improved the nutrients availability.

5.3.3 Haemotological and serum parameters of broiler chicken fed soaked and fermented ALBSM diets

The dietary inclusion of soaked and fermented seeds in the diet improved haematological composition of blood of birds fed 15% dietary inclusion of SFALBSM compared to the raw seeds (Table 4.14). Pack cell volume of was significantly ($P<0.05$) better in birds fed 15% SFALBSM diet than the control diet. The PCV, TG and RBC values are within the normal range of chickens as reported by Sunchint *et al*. (2004). The total glucose and red blood cells were higher at 7.5 and 15% soaked and 22.5% for birds fed SFALBSM diet compared to control diet1 and the 30% ALBSM diet.

5.3.4. Carcass characteristics of broiler chicken fed soaked and fermented diets

The carcass weights were higher in birds fed diets containing 7.5% and 15% SFALBSM (Table 4.15). These results agreed the reports of Omeje (1999) and that of Kaankuka *et al.* (2000) that processing improves the utilization of proteins and energy contained in legumes. The drumstick was slightly higher for broilers fed diets 2 and 4 compared to that of the control diet. This may be attributed to feed consumption and utilization of feed by birds (Amaefule and Obioha, 2001).

5.3.5 Organs weights and gut measurements of broiler finisher chickens fed soaked and fermented ALBSM diets

There were significant differences ($P<0.05$) in the heart, lungs, liver, pancreas and kidney weights (Table 4.16). This agrees with the findings of Ukachukwu *et al*. (2000) and Akinmutimi (2004) who reported that liver is the organ involved in detoxification. The small intestine weights were similar for birds fed control diet and 15% soaked and fermented diet compared to others. The result agreed with work of Adeniji (2004) who advocated that the gut weight is determined by the amount of the muscular wall of the organ to comminute feed particles.

5.3.6 Apparent digestibility of nutrient by broiler finisher chickens fed soaked and fermented ALBSM diets.

Soaking and fermentation improved the digestibility of nutrients (Table 4.17). This agreed with report of Odunfa (1985), Ready and Pierson (1999) who reported that soaking and fermentation improved digestibility, nutritive value and flavors of the raw ALBS. Fermentation also facilitates microbial and enzymes action on certain anti-nutritional factor in grain legumes (Simovic *et al*., 1972). According to Bressani and Eliase (1979) low protein digestibility in grain legumes such as lablab is often associated with the presence of trypsin inhibitors, haemagglutinin and tannin. Trypsin inhibitor may overwork the pancreas in an attempt to increase trypsin production, thereby resulting to its enlargement.

5.4 Effects of Toasted African locust bean seed meal diets on the Performance and Carcass characteristics of broiler chickens

5.4.1 Performance of broiler starter chickens fed toasted ALBSM diet (0-4 weeks).

The weight gain of birds increased in diet 3 with the 15% toasted ALBSM but at 22.5% and 30% dietary levels of toasted ALBSM weight gain decreased (Table 4.18). This observation disagreed with the report of Udedibie and Obay (1992), Ukachukwu (2000) and Akinmutumi (2001) who reported poor weight gain of birds fed toasted pigean pea, sword bean, mucuna and jack bean respectively. Reduced weight gain observed at higher inclusion levels of toasted ALBSM may be attributed to ineffectiveness of toasting on detoxifying the anti-nutrients in the legume seeds. Broiler chickens fed 7.5% had the highest feed intake among the treatments offered while those fed on 30% toasted ALBSM diets had the lowest value of feed consumption. This may be due to the concentration of residual anti-nutritional factors in the seeds. This agreed with the findings of Ukachukwu *et al.* (2000) Iyayi *et al* (2006) and Akimutimi (2001) who reported that the lowest feed consumption and weight gain is a reflection of poor detoxification of the processed seeds by toasting. The best feed conversion ratio of birds was observed for birds fed 15% ALBSM diet as compared to other treatments. This showed that 15% dietary inclusion of toasted ALBSM is adequate in the diet of broiler birds.

5.4.2 Performance of broiler chickens fed graded levels of toasted ALBSM diets during finisher phase (5-9weeks)

Birds showed there were significant ($P<0.05$) increase in final body weights and total weight gain for birds fed 15% toasted ALBSM diet compared to others (Table 19) . Feed conversion ratio was also better for broilers fed diets 3. Akanji *et al* (2003) and

Ogundipe (1980) reported that toasting of legume grains improved the performance of broiler chicken. . This also agreed with the finding of Ani and Okereke (2003) who reported that well processed pigeon pea meal can replace more than 10% of soya bean and groundnut cake in the diet of broilers without any economic loss.

5.4.3. Haematological and serum compositions of broilers fed toasted ALBSM diets

The pack cell volume, total protein and white blood cell counts of birds were significantly ($P<0.05$) increased at the dietary inclusion of 7.5% and 15% toasted ALBSM diets than others (Table 4.20). The values obtained here were slightly higher than the value obtained by Saulawa (2011) who fed toasted baobab seed meal to broiler chicken. PCV values observed in this study were within the normal range (22-35%) reported by Banerjee (2007). The lymphocytes values are within the normal range (45-70%) as reported by Banerjee (2007) and Suchint *et al*. (2004). Lymphocytes are valuable against viral and bacterial infection and neutophils is valuable against parasitic infection (Suchint *et al*. (2004).

5.4.4 Carcass characteristics of broiler chicken fed toasted ALBSM diets

There carcass weights were similar for birds fed 0, 7.5 and 15% toasted ALBSM diets and higher than others, while the dressing percentages were significantly ($P<0.05$) higher for broilers fed 7.5 and 15% toasted ALBSM diet than those of the control diet and other treatments (Table 4.21). However, the values for carcass and dressing percentage were also reduced for the 22.5 and 30% dietary levels of toasted ALBSM. This agreed with Aletor and Ojo (1989) who reported that nutrition influences muscular growth and malnutrition causes an increase in protein degeneration in the chicken. The breast muscle, drum stick, and thigh were highest at 15% dietary level. Hill and Dansky

(1954) reported that better muscle deposition and production of leaner carcass is obtained as protein level in the diet is slightly increased and consumed by birds.

5.4.5 Organs and gut weights of Broiler chicken fed Toasted African Locust Bean meal diets

There were no significantly differences (P >0.05) in the heart, lungs and pancreas weights. However, there were significant (P<0.05) increase in the liver weight among the broilers fed toasted ALBSM diets as shown in Table 22. This agrees with the findings of Ukachukwu *et al* (2000) and Akinmutimi (2004) who reported that liver is an organ involved in detoxification and hence increase in activity may result in its enlargement. The gut weight showed there were no significantly different (P>0.05) in the crop, proventricus and gizzard weights.

5.4.6 Apparent nutrients digestibility of broilers fed toasted ALBSM diet

The apparent digestibilities of nutrient fed toasted ALBSM diets are presented (Table 4.23). The crude fibre digestibility was similar and higher for birds fed control diet and 15% toasted ALBSM diet compared to others. At higher levels of toasted ALBSM in the diets (22.5 and 30%) crude fibre digestibility was depressed. This may be due to ability of birds to utilize fibre in the diets compared to others. Damang (2007) reported that the seed coat is highly fibrous and this fibre content may not be destroyed completely by toasting. Abioye *et al.* (2006) reported that fibre increased the bulkiness of diets and limits the amount of feed taken by birds thereby imposing a physical limitation upon digestible nutrients Agunbiade, *et al*. (2001) Adegbola and Okwonkwo (2002) and Ani (2009) also reported significant decreases in crude fibre digestibility with increasing level of fibre in the diet. Nitrogen free extract digestibility was highest for 15% and similar to

22.5% toasted ALBSM diet. This may be due to availability of soluble carbohydrates that became more available in the toasted ALBSM diets and utilized by birds compared to others. This agreed with the report of Akanji *et al*. (2003) who observed better nitrogen free extract digestibility by broiler chickens when fed toasted Jack bean seed meal diets.

5.5 Effect of the differently processed ALBSM diets on Performance and Carcass characteristics of broiler chickens

5.5.1 Performance of broiler chicken fed differently processed ALBSM diets at Starter phase (0-4weeks)

The broiler chickens fed 15% SFALBSM diet gave higher weight gain compared to other processing methods as shown in Table 4.24. This agreed with findings Odunfa (1985) and Reddy and Pierson, (1999) who reported that of soaking and fermentation markedly improved digestibility, nutritive value and flavors of raw seeds. Apart from these, it increased shelf life and reduced the levels of anti-nutritional factors.

5.5.2 Performance of broiler chickens fed differently processed ALBSM diets during the finisher phase (5-9 weeks)

The birds fed SFALBSM had higher weight gain compared to other processing methods (Table 4.25). This may be due to effective utilization of nutrients in the diets by the birds. SFALBSM diet (diet 3) gave higher performance in terms of weight gain, feed conversion ratio and feed cost per kg gain compared to other processing methods. This may due the microbial activities during fermentation process that improved the nutritive value of the seeds. This agreed with the report of Eka (1979) who stated that during fermentation of foodstuffs, there may be an enrichment of the nutrients since fermentation tends to exhibit a relative increase in the protein, lipid and ash contents.The product may however have decreased carbohydrate content. Walter *et al.* (1984)

confirmed that fermentation improved palatability besides upgrading the nutrient composition of the fermented material.

5.5.3 Haematological parameters of broiler chickens fed toasted ALBSM diets.

The effects of differently processed ALBSM die on haematological and serum parameters are presented in Table 4.26. The lower haemoglobin in blood may result to poor efficiency of oxygen transportation and hence poor respiration (Solomon *et al*., 1998). This agrees with finding of Ologhobo *et al.* (1993) who reported that the inclusion of plant protein in the diets of growing animal lead to a significant impairment of growth and other undesirable physiological and biological alteration.

5.5.4 Carcass characteristics of broiler fed differently processed ALBSM diets

The carcass weight and dressing percentage of broilers fed differently processed ALBSM were highest in broilers fed soaked and fermented diet as shown in Table 4.27. Adejimi *et al.* (2011) indicated that the carcass quality is closely related to feed intake level of nutrients especially protein and energy. The breast muscle and drum stick were not significantly ($P>0.05$) affected by the treatments. There was significant difference ($P<0.05$) in the thigh weight and treatment 3 had the highest value compared to other treatments. It has been shown that protein level of diet is slightly increase in food consumed leading to better muscle deposition and production of leaner carcass (Hill and Dansky 1954).

5.5.5 Organs weight of broilers fed differently processed ALBSM diets

The organ weights of broiler chickens fed differently processed locust bean seed meal was presented in Table 4.28. The result agrees with the finding of Adeniji (2004)

who advocated that gizzard weight is determined by the amount of the muscular wall of the organ to comminute feed particle The enlargement of organs (heart, liver and pancrease) may be due to increased metabolic activity in the production of proleolytic enzymes (Marty and Chavez, 1993; and Omeje, 1999)

5.5.6 Apparent nutrients digestibility of broiler fed differently processed ALBSM

The dry matter digestibility, crude protein, ether extract, nitrogen free extract were significantly ($P<0.05$) affected by dietary inclusion of ALBSM as presented in Table 4.29. This may be due to residual effect of anti-nutrients present in ALBSM. According to Bressani and Eliase (1979) the low protein digestibility in grain legumes such as lablab is often associated with the presence of trypsin inhibitors, it has been established that ANFS lead to reduced protein digestibility, reduced absorption of amino acids and reduced mineral availability of minerals (Liener and kakade, 1980, Yavelov *et al.*, 1983; Birk, 1988 and Gatel and Grosjean, 1990). Agunbiade *et al*. (2001) and Ani (2009) reported significant decrease in crude fibre digestibility with increasing level of fibre in the diet. Fermentation markedly improves the digestibility of nutrients in the diet. (Odunfa, 1985).

CHAPTER SIX

SUMMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

This study was conducted to determine the effect of dietary inclusion of African locust bean (*Parkia biglobosa*) seeds meal (ALBSM) on the performance and carcass characteristics of broiler chickens. The seeds were subjected to different processing methods which included (i) cooking for1, 2, 3 and 4 hours (ii) soaking for 1, 2, and 3 days, (iii) soaking for one day and followed by fermented for 3 days and toasting. Chemical analysis of the raw and processed ALBSM were carried out to determine the proximate compositions, anti-nutritional factors, amino acid profile and mineral contents. Three processing methods (Cooking for 4 hours, soaking for 1day and fermenting for 3days, and toasting) were later selected for feeding trials. Four feeding trials were carried out with broiler chickens to evaluate the nutritional values of differently processed ALBSM diets.

In the first feeding trial, two hundred and twenty five day-old broiler chicks (Marshall strain) were fed diets containing 0, 7.5, 15, 22.5 and 30% cooked ALBSM in a completely randomized design in 3 replications of 5 treatments. At the end of the feeding trial 45 birds (9 birds per treatments in 3 replications) were randomly selected and used for carcass analysis. Also after this feeding trial, 4 birds from each replication were selected and used for 14 days digestibility study.

In the second feeding trial, graded levels of soaked and fermented SFALBSM diets (0. 7.5, 15. 22.5 and 30%) were fed to 225 day old broiler chicks (Marshall strain). Diets were allocated to broilers in a completely randomized design. Each treatment was replicated 3 times and fed to 15 birds per pen. At the end of the study, 45 birds were randomly selected and used for carcass analysis. A 14days digestibility trial was conducted with 60 birds were consisting 12 birds per treatment and each treatment was replicated 3 times with 4 birds per cage.

In the third feeding trial, 225 day old broiler chicks (Marshall Strain) were fed diets containing toasted ALBSM at 0, 7.5, 15, 22.5 and 30% levels in a completely randomized design. Each treatment was replicated 3 times and fed to 15 birds per pen. At the end of the study, 45 birds were randomly selected and used for carcass analysis. Also, 4 birds from each replication were selected and used for a 14 day digestibility study. In the fourth feeding trial, two hundred and forty broiler chicks were fed diets containing one of the three differently processed ALBSM at 15% dietary levels for comparisons as follows: ALBS cooked (4hours), ALBS soaked for one day and fermented (3 days) and ALBS toasted. These were compared along with a control diet containing no ALBSM. Diets were allocated to birds in a completely randomized design and each treatment replicated four times. Each feeding trial lasted nine weeks comprising the starter phase (0-4weeks) and the finisher phase (5-9 weeks).

Processing methods employed significantly ($P<0.05$) increased % crude protein, % Ash and reduced % CF and % ash of ALBS compared to raw seeds. The processing methods also significantly ($P<0.05$) reduced the levels of the anti-nutritional factors, improved the amino acid profile and the mineral contents of ALBSM. The result of the

first feeding trial showed the final body weight, weight gain, feed intake and feed costs were significantly ($P<0.05$) higher at 15% cooked ALBSM diet during the starter and finisher phases. There were significant ($P<0.05$) increase in carcass weights and dressing percentages. Total glucose, Red blood cell (RBC) and White blood cell (WBC) were significantly ($P<0.05$) increased as 15% dietary inclusion of cooked ALBSM. The results of 2nd feeding trial showed the weight gain and feed intake were significantly ($P<0.05$) influenced by the soaked and fermented ALBSM diets. The highest weight gain was obtained with the 15% SFALBSM diet. Similarly, PCV, Total glucose (TG) and RBC were significantly ($P<0.05$) better for the 15% SFALSM compared to others. The feed conversion ratio was found to be lower for birds fed 15% SFALBSM diet. Feed cost was significantly ($P<0.05$) reduced at the 15% dietary inclusion compared to others. Carcass weight, dressing % and organ weights were significantly ($P<0.05$) higher for broilers fed SFALBSM diet at 15% dietary level compared to those fed 7.5, 22.5 and 30% SFALBSM diets.

The results of the 3rd feeding trial showed the total feed intake of birds on the control diet and of those on 7.5% toasted ALBSM diet were better than the values recorded for the 22.5 and 30% toasted ALBSM diets. Total weight gain of broilers was significantly ($P<0.05$) higher on 15% toasted ALBSM diets during starter and finisher phases. Feed conversion ratio and Feed cost per kg weight gain were significantly ($P<0.05$) better for the 15% toasted ALBSM diet compared to others. The PCV, TG and RBC were also significantly ($P<0.05$) higher for the 15% toasted ALBSM diet. The carcass weight and dressing percentage were also significantly ($P<0.05$) higher for birds on 15% toasted ALBSM diet.The results of the 4th feeding trial showed that the final

body weight and total weight gain were significantly (P<0.05) higher for broiler chicks fed soaked and fermented ALBSM diet during the starter phase. The results for finisher phase showed that final body weight, total weight gain and total feed intake were significantly (P<0.05) higher for the soaked and fermented ALBSM diet compared to other processing methods. Feed conversion ratio and Feed cost per kg gain were also significantly (P<0.05) better in the SFALBSM diet. The Pack Cell Volume, total protein, total glucose and red blood cells were significantly (P<0.05) increased for SFALBSM diet compared to CK and TT ALBM diets. The results of the carcass analysis showed the live weight, carcass weight and dressing percentage were significantly (P<.0.05) higher for the soaked and fermented ALBSM diet compared to other processed ALBSM diets. The digestibility of dry matter, EE and NFE were significantly (P<.0.05) increased for birds fed SFALBSM diet compared to others. Feed conversion ratio and the feed cost per kg gain of broiler chickens fed soaked and fermented ALBSM were reduced compared to other methods of processing ALBSM.

6.2 Conclusion

1. Processing by either cooking, soaking and fermentation or toasting enhanced nutrients availability and significantly reduced anti-nutritional factors (tannin, phytate,saponin, oxalate and trypsiin inhibitor).

2. It was concluded that soaking for one day and fermenting for 3days of ALBSM gave the best results for both broiler starter and finisher phases among all the three processing methods tested and it gave least of ₦/kg gain compared to other processing methods.

3. Of the three processing methods tested soaking for one day and fermenting for 3 days proved to be most effective.

6.3 Recommendations

1. The three processing methods tested (cooking for 4 hours, soaking for one day and fermenting for 3 days and toasting) significantly reduced the anti-nutritional factors (tannin, phytate,saponin, oxalate and trypsiin inhibitor) and increased the crude protein and amino acids (Arginine, leucine, lysine, methionine and tryptophan).

2. The 15% dietary inclusion level was found to be the optimum level for each of the processing method.

3. It is recommended that 15% dietary inclusion level of ALBS soaked for one day and fermenting for three days can be fed in broiler chickens diet without any adverse effect on growth performance, carcass characteristics, nutrients digestibility and with significant reductions in feed cost (₦/Kg gain).

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APPENDICES



PLATE 1: LOCUST BEAN TREE (*Parkia biglobosa*) ON SAVANNAH LAND OF NORTHERN NIGERIA.



PLATE 2: AFRICAN LOCUST BEAN TREE FRUITS IN BUNCH HANGING ON A BRANCH OF TREE IN SAVANNAH LAND WITHIN NORTHERN NIGERIA.



PLATE 3: DECORTICATED FRUIT AND SAMPLE OF SEEDS EXTRACTED FROM AFRICAN LOCUST BEAN TREE