COMPARATIVE EVALUATION OF THE NUTRITIVE VALUE OF DIFFERENT FEED ENERGY SOURCES WITH AND WITHOUT ENZYME SUPPLEMENTATION ON THE PERFORMANCE OF BROILER CHICKENS

BY

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NOVEMBER, 2016

Declaration

I declare that the work in this Dissertation entitled "COMPARATIVE EVALUATION OF THE NUTRITIVE VALUE OF DIFFERENT FEED ENERGY SOURCES WITH AND WITHOUT ENZYME SUPPLEMENTATION ON THE PERFORMANCE OF BROILER CHICKENS" has been carried out by me in the Department of Animal Science under the supervision of Professor F.O Abeke and Dr. P.A. Onimisi. 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 any University

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Dorcas John, JIRGI	Signature and date

Certification

This Dissertation titled "COMPARATIVE EVALUATION OF THE NUTRITIVE VALUE OF DIFFERENT FEED ENERGY SOURCES WITH AND WITHOUT ENZYME SUPPLEMENTATION ON THE PERFORMANCE OF BROILER CHICKENS " by Dorcas John, JIRGI meets the regulation governing the award of a Master's of Science degree in Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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Dedication

This Dissertation titled "COMPARATIVE EVALUATION OF THE NUTRITIVE VALUE OF DIFFERENT FEED ENERGY SOURCES WITH AND WITHOUT ENZYME SUPPLEMENTATION ON THE PERFORMANCE OF BROILER CHICKENS**"** is dedicated to my late brother Mr. Ezekiel John Jirgi: Rest in peace in the bosom of the Lord Jesus.

Acknowledgements

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Abstract

Two experiments were carried out to determine the nutritive value of sorghum, millet, cassava and sweet potato with or without enzyme supplementation in broiler chickens production. The growth performance, nutrient digestibility, heamatological parameters and characteristics of broiler chickens were evaluated. In the experiment 1, diets were not supplemented with enzyme while in the second, the diets were supplemented with Maxigrain® enzyme. Five isonitrogenous and isocaloric diets (23.17 % CP; 2831 Kcal/kgME) and (21.73 % CP; 2929 Kcal/kgME) for the broiler starter (0 - 4 weeks) and finisher phases (5-8 weeks) respectively were formulated. Diet T1 maize based diet served as the control while diets T2, T3, T4 and T5 were sorghum, pearl millet, cassava and sweet potatoes based diets, respectively. A total of 225 day- old NAPRI X broiler chicks were randomly allotted to the five treatments. Each treatment consisted of 45 birds with three replicates of fifteen birds each in a completely randomized design. Feeds and water were provided *ad libitum*. Data collected were analysed using the general linear model procedures of S.A.S. 9.0 and significant difference (P<0.05) in means among the dietary treatments was separated using a tukey test. The result of the first experiment 1 showed that final body weights of 503.44 g and 2302.77 g, feed intake of 819.67 g and 3073.70 g and weight gain of 453.61 g and 1892.07 g were significantly (P<0.05) higher in birds fed the millet based diet (T3) for starter and finisher broiler respectively than the other dietary treatments. The broiler chickens in T3 (millet based diet) recorded significantly (P<0.05) the best feed conversion ratio of 1.62 and the cheapest feed cost per kg weight gain of ^145.90 for finisher phase. Birds fed diet T5 the sweet potatoes based diet gave significantly (P<0.05) poorest values in in FCR, feed cost, weight gain and mortality rate at the starter phase. At the finisher phase, the sweet potato based diet also gave the poorest performance in FCR and feed cost per kg weight gain. The result of carcass showed significant differences (P<0.05) within the treatments in all the parameters measured with the exception of heart and length of intestine. Digestibility trial showed significant (P<0.05) difference in the percent ether extract digestibilities across dietary treatments. Dietary treatments had significant (P<0.05) effect on white and red blood cells. In experiment 2, enzyme with different energy feed sources had significant (P<0.05) effect on all the parameters. Final weight, weight gain, feed conversion ratio, water intake, water:feed ratio and feed cost per kilogramme weight gain with the exception of mortality rate at starter phase. Birds fed the sorghum based diet had the best performance at starter phase with final weight of 627 g, weight gain of 576.85 g and cheapest feed cost/kg gain of ^ 187.95 k. At the finisher phase, sorghum supplemented with enzyme also had the highest final bodyweight, best feed conversion ratio (1.96) and feed cost/kg gain; ^ 171.15 k. The haematological and digestibility results showed significant (P<0.05) differences across dietary treatments. However, based on the results of the studies, dressing percentage was not significantly (P>0.05) difference. It was concluded that millet based diet without enzyme and sorghum based diets with enzyme supplementation can be suitable and effective as an alternative dietary energy source replacement for income in broiler Chicken production.

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CHAPTER ONE

1.0 INTRODUCTION

Nigeria like most other developing countries, suffers greatly from a constant shortage and increasing cost of protein and energy feed resources for livestock (F.A.O., 2000). This situation has become highly magnified due to high competition between livestock and the ever growing human population for the same source of food, particularly energy feed such as maize, sorghum etc. Whereas these feeds form the basic constituents of the ration for the monogastric animals, it also form the major sources of human food (F.A.O., 2002).

Feed remains the most expensive input in poultry production with cereal grains constituting more than 40 % of the feed cost. Oyedeji *et al*. (2003) observed that cost of feeding accounts for about 70 % of cost of production in poultry business. Several workers have emphasized the need for utilizing alternative feed ingredients which have no competition for human (Durunna *et al*., 1999; Fanimo *et al*., 2007; Nsa *et al*., 2010). There is therefore, a dire need for the animal nutritionists to seek for alternatives to the inadequate and expensive alternative feedstuffs to forestall an impending serious food crisis. Some researchers (Kwari *et al*., 2004; Okah, 2004) have stressed the need for utilization of alternative feed ingredients.

Energy feed sources (maize, sorghum, millet and cassava) are expensive feedstuff, constituting about 50-55% of the formulated poultry diets. Maize a major component of feed is expensive, its productivity is low which means it does not meet its demand for both human and animal needs (Agbede *et al*., 2002; Hamzat *et al*., 2003 and Okereke *et al*., 2006). Maize most often constitutes the highest proportion of ingredient in diet formulation of any poultry ration. Maize is the major source of energy in poultry production accounting for 45-65% of poultry feeds (Ijaiya *et al*., 2012). Worldwide, guinea corn (*Sorghum bicolar* Linn.) and millet grain crops (finger millet (*Eleusine coracam*) and pearl millet (*Pennisetum typhoids*) are very important ingredients in poultry diets. Millet is reported to have lower metabolizable energy, higher crude protein, crude fibre and ash than maize and sorghum (Medugu *et al*., 2011; Ijaiya *et al*., 2012). Cassava (*Manihot esculenta*), a high energy crop is available throughout the year in Nigeria. Both cassava and sweet potato have starch as the major component with low protein (2.7-7.9 %) hence obviously needs adequate protein supplementation (Apata and Babalola, 2012). Cassava contain toxic/anti-nutritional factors such as cyanogenic glycosides (cyanide, linamarin, lotaustralin and hydrocyanic acid) which cause bitter taste and reduce palatability of the roots. Sweet potato, (*Ipomoea batatas*) belongs to the morning-glory family *Convalvuceace*. It is cultivated primarily in tropical areas and ranked fifth among the most important food crop in the tropics (An, 2004). The few available reports agreed that sweet potato can be incorporated into diets of chicken but should not be made the main source of energy (Afolayan, 2010).

1.1 Justification

There is a need to evaluate different energy sources so as to make better choices of which to use depending on prevailing circumstances of cost, scarcity and/or abundance. Therefore, information on their use in poultry diets. When prices of the alternative energy sources such as maize is high, information on other possible alternative sources become necessary to keep production on. There is a need to evaluate the effect of enzyme on these sources of energy for optimum poultry production. This study was therefore conducted to evaluate the effect of some energy sources on the performance of broiler chickens, with and without enzyme supplementation.

1.2 Objectives of the Study

1.2.1 Main Objective

To determine the performance of broiler chickens when fed diets containing different energy sources.

1.2.2 Specific Objectives:

These were to:

1. Compare the growth performance, nutrient digestibility, haematological parameters and carcass characteristics of broiler chickens fed maize, sorghum, millet, cassava and sweet potatoes as energy sources.
2. Compare the growth performance, nutrient digestibility, haematological parameters and carcass characteristics of broiler Chickens fed maize, sorghum, millet, cassava and sweet potatoes as energy sources with enzyme supplementation.

1.2.3 Hypotheses

H_o: There is no significant difference in growth performance, nutrient digestibility, haematological parameters and carcass characteristics of broiler chickens fed maize, sorghum, millet, cassava and sweet potatoes as energy sources, with or without enzyme supplementation.

H_a: There is a significant difference in growth performance, nutrient digestibility, haematological parameters and carcass characteristics of broiler chickens fed maize, sorghum, millet, cassava and sweet potatoes as energy sources, with or without enzyme supplementation.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Role of Nutrition in Animal Production in Nigeria

The increase in the world population has led to the need to intensify livestock production, but this is constrained by high overhead cost especially in Nigeria. Due to economic situation of the nation, protein intake of most Nigerians is inadequate and often lack protein of high biological value derivable from animal products. The rising cost of poultry feeds has continued to be a major problem in Nigeria as feed cost is about 60 to 70 % of the total cost of producing poultry meat and egg (Nworgu *et al.,* 1999; Ogundipe *et al*., 2003; Conolly, 2012) compared to about 50 to 60% in developed countries (Tackie and Flenscher, 1995). There has been a steady increase in the cost of alternative feed ingredients such as energy and protein sources which form most of its expensive components and these include maize, groundnut cake, soya bean meal and fish meal. Scarcity and sometimes non-availability have led to increase in the prices of such feed ingredients (Onu and Madubuike, 2006; Adejinmi *et al.*, 2007; Defang *et al.*, 2008).

Cereal grains especially maize which forms the bulk of energy in poultry feeds are in short supply as a result of industrial, livestock and human needs (Slavin, 2010). This has resulted in competition between humans and animals for the available feed resources, and hence high cost of animal production (Oluyemi and Roberts, 2000; Agbede *et al.,* 2002; Aderolu *et al.,* 2007).

2.2 Concept of alternative feedstuffs

The interest in alternative feed sources was borne out of the zeal to find alternative feeding materials for incorporation into animal diets particularly in developing countries where there has been an acute shortage of animal protein (Fasuyi, 2005). Inadequate protein consumption in most developing countries especially in Africa has been the major cause of malnutrition. Adequate provision of balanced animal feed at reasonable cost is one of the greatest constraints to the expansion of the poultry industry. Apart from the high and fluctuating costs, some of the ingredients used in compounding feeds notably cereals grains are in high demand for human consumption and this has exacerbated the feed situation (Olorede and Ajayi, 2005). Olomu (1995) reported that the largest single most expensive dietary need of an animal is energy because of the amount required. The high cost of feed resulting in reduced profit margins has kept people away from the business of poultry production (Akinfala, 2002). In other to address this problem, Babatunde (1986) stressed the need to find alternative feed energy sources that are cheap, adequate and readily available for feeding livestock. Similarly, Alawa *et al*. (1990) advocated the development of alternative feeding materials that will be relatively cheaper when compared with commercial feeds or alternative feedstuffs.

Feed is the single largest expense in livestock production (Ogundipe *et al*., 2003). Traditionally, feeds for livestock production consist mainly of cereal grains (corn, grain sorghum, oats, barley, millet, cassava), forage feeds (grass hay, legume hay), and oilseed meals (groundnut cake, soybean meal, cottonseed meal). Many classes of livestock however, can and have used a wide range of feedstuffs. Many of these feedstuffs that can be of use are by-products and edible waste products from the food processing, food preparation and food service industries, and the bio-fuels industry. These industries include grain milling, brewing and distillation, baking, fruit and vegetable processing, meat, milk and egg processing, seafood processing, prepared food manufacturing, and retail food outlets. Other alternatives include feedstuffs that are not commonly fed, such as wheat which may be a good choice during times of low prices, or during shortages of more traditional feedstuffs (Odunsi *et al*., 2006).

Most classes of livestock can successfully use alternative feedstuffs in their diets. The more common alternative feedstuffs include distillers' grains, soy hulls, corn gluten feed, brewers' grains, citrus pulp, rice mill feed, molasses, and whole cottonseed (Onuh, 2005). Other examples can also include waste candy, cull peanuts, cull vegetables, bakery waste, cotton gin trash, and table scraps (restaurant food waste). These provide a high quality alternative to alternative feedstuffs often at lower costs. Some of these alternative feedstuffs are available to livestock producers in West African countries, but due to traditional practices or a poor understanding of their values and limitations, usage can be limited (Olorede and Ajayi, 2005). Even though using alternative feedstuffs may be cost effective, cost is not the only factor to be considered because variations in processing methods, availability, and form (pellet, meal, wet or dry) can impact the value of these feeds (Babatunde *et al*., 1986).

2.3 Poultry industry and alternative feed-stuffs

As viable as poultry industry is to bridging animal protein gap in Nigeria, the industry faces alot of problems and the most important problem is sub-standard nutrition (Faniyi, 2002). This is because the potentials of the birds depend majorly on the type of feed given. Competition for alternative feedstuffs by man and livestock had contributed immensely to the high costs of ingredients in our local markets (Babatunde *et al*., 1986). This thus creates problems for poultry industry in the area of providing good quality feed at affordable prices. Faniyi (2002) and Ogundipe *et al*. (2003) reported that feed alone accounts for over 70% of the total cost of raising commercial poultry. The price of various feed ingredients has risen over the past few years such that the cost per unit of feed is now very high making poultry production more expensive (Ladokun and Longe, 2004). This high cost coupled with inadequate knowledge of possible alternatives and cheap ingredients are important factors militating against increased commercial poultry production (Olorede and Ajayi, 2005).

One of the possible options advocated to solving the present high costs of feed stuffs is the substitution of the alternative with the non-alternative feedstuffs in poultry diets (Babatunde *et al*., 1986). Alternative feedstuffs had been severally evaluated at every stage of life of birds with the aim of reducing the cost of feeding. There are many indigenous plants and animal materials in Nigeria which have been evaluated and found to be good replacements for the alternative feedstuffs. The only condition is that enough information regarding their nutritional value and freedom from toxic substances must be known before they can be used as replacements.

2.3.1 Agro- industrial by- products in Poultry Feeds

The use of agro- industrial by- products as substitutes for alternative feedstuffs in poultry diets is well documented. Faniyi and Ologhobo (1999) used bio-degraded cowpea and sorghum seed-hulls to replace brewers dried grain as source of protein and fibre in broiler diets. They concluded that the average body weight gain and average feed intake were at the highest at 50% level of inclusion. Sobamiwa (1998) used cocoa husk meal in replacement for maize on hen performance and egg quality. It was concluded that laying hens could tolerate and produce eggs economically on diets of 20% cocoa husk meal. Ladokun and Longe (2004) used cocoa bean meal to replace groundnut cake on the performance of broilers and they concluded that its substitution in broiler diets (starter and finisher) can be up to 15%. Bamgbose *et al.* (2004) reported that broilers on 10% pigeon pea processed via fermentation were better off than others. Ogbonna and Oredein (1998) reported that cockerel chicks can be fed cassava leaf meal as source of energy or protein at 30% inclusion. Uko *et al*. (1996) replaced maize with industrial maize offal at 10, 20, 30, 40 and 50% levels of inclusion in laying hen diets and concluded that there were no significant differences among the birds fed the different diets in terms of egg production and weight gains of the hens. In addition, it was noted by Oji *et al.* (1990) that the feed intake and feed conversion ratio decreased at 20 and 30% levels of inclusion of molasses in broiler diets. The authors also noted that the body weight of the birds decreased as the level of inclusion of the test material increased. It was concluded that molasses may not be used more than 10% in broiler diets.

2.3.2 Benefits in utilizing agro- industrial by products

Agro- industrial by- products reduce environmental pollution when they are utilized as feedstuffs by livestock, thereby, improving environmental sanitation (Dowling *et al*., 2003). They provide good sources of calcium, protein, B- complex vitamins and some essential amino acids. Reduction of the dependency on imported feed ingredients which constitute a drain in foreign exchange is actualized and it can also be mentioned that the conversion of these by products in the diets of livestock reduces the use of feedstuffs which have competitive usage with man (Babatunde, 1986).

2.4 Response of Broilers to Various Dietary Energy Levels

Energy is not a nutrient but a property that some of the nutrients possess. Diets are classified as high, medium and low energy. Dietary energy level appears to be the most important factor affecting feed intake. It is known that broilers attain a minimum energy intake from diets containing different energy levels; as such their energy requirements are not always precise (NRC, 1994). There are no consistent responses of broiler chicks to varying contents of metabolizable energy (ME) in their diets. The main reasons for this discrepancy are the nutrient composition and/or digestibility of diet, the physical form of diet, type and level of added fat, dietary ME level, strain, sex, age of bird, ambient temperature, and the interactive effects of dietary ME and amino acid density and certain additives **(**Dozier III *et al*., 2007 and Zhou *et al.*, 2009). Although energy is not a nutrient, it is a property of carbohydrates, fats and proteins when they are oxidized during metabolism.

It has been reported earlier by Aduku (1992) that the energy requirement of broilers at the starter and finisher phases are 2800 kcal/kg and 3000 kcal/kg respectively. The energy in diets is derived from maize, millet, sorghum, rice and to some extent wheat. One of the major problems with grains is that they are consumed by human beings as food and are therefore ingredients competed for by both man and animals (Adegbola and oduozo, 1992, and Ranjhan, 2001). Dietary energy and protein interact because, protein and energy are needed for protein turn over and deposition; and body proteins form part of the stored energy of the body (Faniyi and Ologhobo, 1999). The energy of the diet is largely in form of carbohydrates. Fats and amino acids also contribute to the energy content of feed but to a lesser extent. Usually, birds are allowed to consume as much feed as to meet their nutrient requirements. This control of intake is based primarily on the amount of energy in the diets (Smith *et al*., 2001). It has however, been reported that birds perform equally well on energy levels 10-15% below the recommended levels (Olomu, 1995). It has also been noted by Farrel *et al*. (1999) that broilers have the ability to perform well on low energy diets, observing that the optimum level for production was lower for birds reared in summer (2700KcalME/kg) than for birds reared in winter (3000 KcalME/kg). In the same vein the total energy supplied in the diets is used for various purposes including heat loss during metabolism, reproduction, growth and production of eggs. At higher temperatures, heat losses and basal metabolic rates are lower than those at lower temperatures. Therefore, at higher temperatures, energy is used more for productive and reproductive purposes and as such energy requirements are less.

2.5 Effect of fibre diets on growth response of broilers

Fibre has been known to have varying effects on the growth performance of broilers. The average final weight and weight gain of broilers were similar up to 20% level of inclusion of instant noodles waste at the starter phase beyond which there was a decrease in these parameters. This was as a result of the heat processing involved in the production of instant noodles which reduces the amylase inhibitors, haemaglutinin and phytic acid available to non ruminants (Emiola and Ologhobo, 2006). There was a depression in the final weight at 30% inclusion level of instant noodles waste which was a result of the gut bulkiness due to increased quantity of in the diets. The mechanism of action may be related to the ability of insoluble fibre to hold water, thus influencing gut bulk (physical fill) and potential motility (Aulrich and Flachowsky, 2001). In addition, there was a reduction in feed intake at high levels of which could be a factor which was evident in the gross energy reduction of the diets. Feed intake decreased with increase in initial weight and this agreed with the fact that under *ad libitum* feeding conditions, birds consume feed primarily to satisfy their energy requirements first, as described by Leeson *et al.* (1996). In addition, Bate-Smith (1973) reported a decrease in voluntary feed intake of birds fed kolanut husk meal due to the presence of tannin which provoked an astringent reaction in the mouth of the birds, thereby reducing voluntary intake of kolanut husk meal feed. On the contrary, Babatunde and Hamzat (2005) observed an increased feed consumption of cockerel birds when fed kolanut husk meal which was attributed to an attempt to satisfy energy requirement due to caloric dilution of the diets by kolanut husk meal (Oluokun and Olalokun, 1999).

2.5.1 Effect of fibre diets on broiler carcass and organ weights

Broiler growth is dependent on optimal feed intake throughout the growing period. Optimal feed intake is dependent on a number of factors such as environmental temperature, diet nutrient density and physical feed characteristics which are considered to have a very significant impact on broiler growth (Esonu, 2008). Diets have been known to have varying effects on the carcass characteristics and organ weights of broiler chicks. For example, Ijaiya *et al.* (2011) observed that the dressing percentage obtained in a study conducted on broilers fed rubber seed meal (RSM) based diet was comparable with the range of 74.82 to 77.39% reported by Esonu (2008) for broilers fed oil palm leaf meal based diet. However, diets did not have significant effect on heart weights of the birds across the treatments which were explained with the observations of Sankyan *et al*. (1991) in goat, that the heart being a vital organ attained most of its matured weight during development of the foetus. Therefore, varying levels of fibre based diets do not significantly change heart in the latter stages of growth. This was further established by Ijaiya and Fasanya (2004).

The increase in the weight of gizzard as the level of rubber seed meal (RSM) (a highly coarse feed stuff with high crude fibre level) inclusion increased agreed with the earlier findings of Mokaji (1994) and Lamidi *et al.* (2008) that high fibre content in the diets of birds was responsible for the enlargement of the gizzard. Birds fed RSM level up to 50% performed generally better than the control diet because diets contained adequate crude fibre level which tended to activate the intestine and more production of enzyme resulting in better nutrient digestion (Adeniji, 2001; Esonu, 2008).

2.5.2 Effect of fibre diets on digestibility of nutrients in broilers

Varying effects of fibre diets have been shown on the digestibility of nutrients in broiler diets. Digestibility values of nutrients were higher at the finisher phase than in the starter phase due to the trend in age difference with the fact that the digestive tract systems of the broilers were not well developed at the starter phase compared with the well-developed digestive system at the finisher stage. Babatunde and Hamzat (2005) observed a direct reduction in apparent crude fibre digestibility of cockerels as dietary inclusion of kolanut husk meal increased. The authors also observed that the birds on the control diet were able to digest their feed better than birds on kolanut husk meal. Apparent crude fat digestibility was higher for the control diet than other diets and this decreased as the level of kolanut husk meal increased in the diets. Yasar and Forbis (2000) have reported reduction in the intestinal digesta in chicks as early as between 2 and 3weeks of age. Palander *et al.* (2005)

also reported that there were longer retention times in older birds due to the increase in the volume of the digestive tract which improved digestibility.

2.6 Alternative feed energy sources in Broiler Nutrition

2.6.1 Sweet Potato

Sweet Potato (*Ipomoea batatas* LAM.) is a tuberous-rooted perennial mainly grown as an annual. The roots are adventitious, mostly located within the top 25 cm of the soil. Some of the roots produce elongated starchy tubers. Tuber flesh colours can be white, yellow, orange and purple, while skin colour can be red, purple, brown or white. The stems are creeping slender vines, up to 4m long. The leaves are green or purplish, cordate, palmately veined, born on long petioles. Sweet Potato flowers are white or pale violet, axillary, sympetalous, solitary or in cymes (Duke, 1983, Ecocrop, 2010).

Sweet potato meal was fed to broiler chicks by Afolayan *et al*. (2012) at graded levels of 0, 10, 20, 30, 40, 50 and 60% on weight for weight substitution for maize. In a separate experiment birds were fed at 0, 10, 20, 30, 40 and 50% in isonitrogenous broiler starter diets and the performance of those on 0, 10 and 20 % diets was not different from that of 30% when diets were made isonitrogenous (Afolayan, 2010). However, results of the boiler finisher experiment showed that sweet potato meal had a significant adverse effects on performance at levels beyond 20% when sweet potato meal was used to replace maize on weight to weight basis. Performance was not affected until sweet potato meal was included beyond 30 % level in isonitrogenous diets.

Agwunobi (1999) recommended 27 % and 30 % levels of sweet potato in the starter and finisher diets respectively. Canope *et al*. (1977) found that cooking improved digestibility of all nutrients, but especially of nitrogen. In a trial with broiler chickens placed on diets having 0, 10, 20, 30, 40 and 50 percent maize replacement levels, performance was found to be optimal at 30 % maize replacement level compared with birds on the control diet, performance parameters were inferior on oven-dried sweet potato diets at the starter phase. At finisher phase, favourable results were obtained at up to 30% maize replacement level. Dressed carcass was reported to show poorer results for the test diet while the dressing percentages were similar with control group (Tewe, 2001). It was reported that mortality increased with higher levels of sweet potato inclusion, being higher in sun-dried complete maize replacement diet. Abdominal fat decreased with increase in sweet potato inclusion while replacement of maize with sweet potato decreased ME at levels above 30% at starter phase. The presence of un-identified factors, which inhibit the digestive and metabolic processes were suggested in sweet potato based rations. These factors caused low dry matter digestibility and low metabolizable energy and protein values even when the rations contained adequate and high quality proteins (Gerpacio *et al*., 1978).

2.6.2 Sorghum

Farmers have the notion that sorghum has tannin and has low energy compared to maize grain (Subramanian and Metta, 2000). Studies by Kumar *et al.* (2007) revealed that feeding re-constituted red sorghum-based diet with a tannin content of 16 g/kg to broiler chicken at 100% replacement of maize did not exert any appreciable influence on nutrient utilization, blood biochemicals, enzymes and gross pathological changes. However, raw red sorghum-based diet with 23 g/kg tannin fed to broiler chickens caused higher immuno-response when compared to their re-constituted counterpart. It is possible that the development of low tannin sorghum could raise its value to comparable level with maize in poultry diets. Luis (1980) observed that sorghum was similar to millet in true metabolisable energy (TME) but lower than maize. Dry matter digestion and gross energy of sorghum was, however, higher than millet. When sorghum was compared to millet and maize on an equal weight or a protein equivalent basis in broiler diets with adequate protein (22.5%CP), there was no significant difference in body weight gain or feed efficiency.

Improta and Kellems (2001) compared raw, polished and washed quinoa with wheat, sorghum and maize on low protein diet (13.28% CP) and observed that at 21 and 28 days of age broiler chicks fed sorghum had the highest survival rate (100% and 96.72% *vs.* 96.37% and 96.3%), respectively, for sorghum and maize. Weight gains at 7, 14 and 21 days of age were also highest for sorghum diets (88 g, 139.9 g and 221.0 g *vs.* 63.1 g, 76.05g, and 91.0 g) respectively, for sorghum and maize based diet. Feed intake followed the same trend (33.48 kg *vs.* 26.36 kg) for sorghum and maize, respectively. Results obtained with white and yellow local variety of sorghum in India by Rama Rao *et al.* (1995) and Thakur *et al.* (1984) suggested that sorghum can replace maize from 50% to 74% only. Blaha *et al.* (1984) working with 441 male broilers reported that sorghum (*Var. technicum*) could be used successfully as the only cereal components of diet for broilers. They observed that chickens given diet with sorghum had higher weight gains than those given diet with maize. However, FCR was better with maize based diet whereas, health of chicks and sensory characteristics of meat were not affected in chickens fed sorghum except for the pale skin, legs and beak due to lack of Xanthophylls.

2.6.3 Cassava and Potato Peels in Livestock Nutrition

Eruvbetine *et al*. (2002) reported that in experiments with both layers and broilers, there were marked reduction in the abdominal fat content of broilers at market weight and layers after 40wks in lay as a result of cassava inclusion. The reason for this reduction can be related to the crude fibre component of the diet. The potentials of cassava as a feed ingredient notwithstanding, it is much lower in protein content. Furthermore, its protein is of poorer quality compared to that of cereal grain. When utilized in replacing cereals in diet for monogastric animals, it becomes imperative to balance for protein deficiencies, which are sometimes expensive (Agunbiade *et al*., 2001). There is thus, the need to identify means of improving the protein quality of cassava, especially those that can be easily adapted on the farm. Noomhorm *et al*. (1992) reported that the conversion of a part of the starch in cassava root meal to protein by microbes during the process of solid-state fermentation has great potential as a means of improving the feeding value of cassava root meal. Adeyemi and Sipe (2004), reported an improvement in crude protein concentration of cassava root when fermented with rumen filtrate with or without ammonium sulphate as the source of nitrogen. Adeyemi *et al*. (2004) obtained a of 237.8 % increase in the crude protein value of whole cassava root meal fermented with rumen filtrate using caged layer waste as source of nitrogen.

Aduku (1991) reported that cassava peel meal can be fed up to 15 % level in maize-soya bean diets for broilers. They noted that the bulky nature of the cassava peel meal limits feed consumption to meet energy requirements of broilers at levels of cassava peel meal above 15 % and that the cyanide content of the diets used for the study was low enough to be the major problem of cassava peel meal even at higher levels of inclusion

2.6.4 Millet

Millet contains fewer antinutritional factors than many other grains (Andrews and Kumar, 1992; Choct, 2006) and possesses unique nutritive value that are attractive for poultry nutrition. Arabinose and xylans are the major water-soluble NSP in pearl and finger millet grains (Hadimani *et al.,* 2001). In comparison with maize, millets possesses better ME levels and higher amino acid concentrations (Andrew and Kumar, 1992; Adeola and Orban, 1995; Yin *et al.,* 2002; Davis *et al.,* 2003). Furthermore, the digestibility of essential amino acids, namely, lysine, arginine, threonine and valine were higher in millet-based diets than in maize -based diets fed to pigs (Adeola and Orban, 1995). In broilers fed isonitrogenous and isocaloric pearl millet and maize -based diets, performance and carcass yields were equivalent or better in the pearl millet groups of birds (Davis *et al.,* 2003; Hidalgo *et al.,* 2004; Manwar and Mandal, 2009). It is also worth mentioning that the concentrations of ME, CP, amino acids, and antinutritional factors vary greatly between different pearl millet varieties (Buerkert *et al.,* 2001; Mustafa *et al.,* 2008). Millet can replace maize in the diets of broiler chickens without adverse effects on growth rate and feed conversion ratio (Adamu *et al*., 2001, Medugu *et al*., 2010 and FAO, 2012).

Millet has high nutritional value, with no tannin and higher protein and mineral contents than maize and sorghum (Appa-Rao *et al.,* 1989; NRC, 1996; Kaur *et al*., 2012; Ahmed *et al*., 2013). Millet also has higher oil content than other common cereal grains (Sullivian *et al.,* 1990; Hill and Hanna, 1990; Adeola and Rogler, 1994) and a better source of linolenic acid (Rooney, 1978). It has also been indicated that millet is superior to maize and sorghum in protein content and quality, as well as protein efficiency ratio (PER) values. According to Olomu (1995) millet has a lower Metabolizable Energy (2555 kcal/kg), but higher crude fibre (4.30%), ash (3.00%) and crude protein (12.0%). Olomu (1995) reported 8.80%, 12.00% and 9.50% CP levels for maize, millet and sorghum, respectively. Ojewola and Oyim (2006) also reported that millet had higher crude protein (11.90%), crude fibre (7.92%) and ash (3.83%) than maize and sorghum.

It has been reported that a 75% substitution of pearl millet diet had higher body weight gain, feed efficiency, feed consumption adding that it was economically efficient (Jayanaik *et al.*, 2008). Davis *et al.* (2003) also reported that at day 1 to 42, birds fed 100% pearl millet (PM) diet had greater body weight, feed intake, and feed conversion ratio than birds fed the maize based diet. At 14, 28, and 42 days of age, birds fed the pearl millet based diet were consistently heavier than birds fed the maize based diet, pearl millet 25%, and pearl millet 75% diets. Birds fed the pearl millet 50% diet were also heavier at day 14 and 28 than those fed the pearl millet 25% diet. However, increased body weight occurred among birds fed the pearl millet 50% diet compared with those fed the pearl millet 75% diet, but only at day 14. Body weight did not differ between birds fed the pearl millet 100 and pearl millet 50 diets at any time point. The report of Flurharty and Loerch (1996) showed that high energy finisher diets results in high performance with no detrimental effect on birds in the tropics when finger millet was used as component part of feed in diets. Davis *et al.* (2003) reported that inclusion of 500g/kg of millet cultivars resulted in no loss of performance of broiler chickens. Similarly, Singh *et al.* (1999) reported that inclusion of millet up to 600g/kg gave excellent egg production and better feed conversion ratio.

2.7 Enzymes in Poultry Production and their Benefits

2.7.1 Enzyme Supplementation in Poultry Diets

Animal rearing practices partly depend on the application of feeds that are uniform in quality and have high nutritive value. The complex plant materials that are commonly used as feed ingredients, such as coarsely processed grains and high-fibre feedstuffs (e.g., cereal grains, forages and crop residues) have nutritive components that are resistant to endogenously-produced digestive enzymes. Some feed components also have antinutritive effects, for example phytate, which reduces the bioavailability of certain minerals and oligosaccharides, and other soluble carbohydrates that increase viscosity and reduce nutrient absorption. Hence, obtaining the maximal nutritive value from such complex feedstuffs typically requires supplementation of autoenzymatic activity with alloenzymatic activity (i.e., exogenously produced digestive enzymes from non-host sources) according to Klasing (1998).

The application of feed enzymes to poultry diets for the enhancement of nutrient availability had been reported since 1926 (Munir and Maqsood, 2013). Previously, the research conducted on feed enzymes in poultry nutrition focused on non-starch polysaccharide (NSP) degrading enzymes, especially xylanase and β-glucanase, in diets containing wheat, rye and barley (Choct, 2006). The use of unalternative feedstuffs for poultry production is however limited due to their fibrousity and inability of birds to produce the cellulase enzyme that can digest the fibre (Adebiyi *et al*., 2010).

Most commercial enzymes contain a spectrum of different enzymes including xylanases and β-glucanases and therefore can be used effectively on a wide range of fibrous materials. It is, nevertheless, essential to ensure that the enzyme preparation has the appropriate activities of the specific enzymes that are required. Phytase, in addition to the above mentioned enzymes, is an enzyme, which increases the availability of phosphorus from phytate, a bound form of phosphate found in cereals and other plant materials (Marquardt *et al*., 1996). It has become available for use in the feed industry and may assist in reducing phosphorus requirements in non-ruminant animals and therefore it can solve problems associated with environmental pollution. During the past decade, the supplementation of microbial phytase in poultry diets has increased drastically with proven success, mainly in response to heightened concerns over phosphorus pollution of the environment.

2.7.2 Effects of Enzymes on the Gastrointestinal Environment

Microorganisms in the gastrointestinal tract utilize the digesta for energy in a similar manner as to the host animal. Changes in rate of passage and the type of nutrients available to the microbes influence the different microbial populations in the gastrointestinal tract tract. The end products of metabolism of many of the anaerobic bacteria found in the gut are volatile fatty acids which have been shown to be altered with enzyme supplementation (Choct *et al.*, 1995). However, studies examining differences in specific microbial populations such as starch or xylan- degrading bacteria have yielded no significant effects (Persia, *et al*., 1999). This may be due to lack of technology to adequately examine these populations since it stands to reason that as the substrate changes so should the microorganisms that can use them. Gastrointestinal histology has also been shown to be affected by barley and wheat-based diets with reductions in villi height, increased diameter and damaged villi associated with wheat and barley diets (Viveros *et al*., 1994; Jaroni *et al*., 1999). Enzyme supplementation of these diets counteracted some of these effects with supplemented birds having gut morphology more similar to birds receiving a corn/soy diet. This may also help explain reductions in mortality that is often seen in birds receiving enzyme supplementation. Damage to the gastrointestinal tract may make the organ more susceptible to pathogenic bacteria invasion. In addition, enzyme supplemented birds had lower gut and pancreas weights.

2.7.3 Enzyme Supplementation and Improved Poultry Health

The principal rationale for the use of enzyme technology is to improve the nutritive value of feed stuffs (Munir and Maqsood, 2013). Therefore, the supplementation of the animal feed with suitable enzymes to increase the efficiency of digestion can be seen as an extension of the animal's own digestion process (Pariza and Cook, 2010). In addition to improving diet utilization, enzyme addition can reduce the variability in the nutritive value between feedstuffs and improve the accuracy of feed formulations. Experimental trials have shown that ensuring feed consistency in this way can increase the uniformity of groups of animals, thus aiding management and improving profitability. The general health status of animals can also be indirectly influenced, resulting in fewer non-specific digestive upsets that are frequently provoked by the fibre components in the feed (Sheppy, 2003).

Exogenous enzymes have been explored and found to degrade different structural carbohydrates found in cereals, particularly those that are not capable of being digested by avian and mammalian enzymes. Most offals of food crops like rice, wheat and maize, dried and spent grains from the breweries can be improved through the use of enzymes (Classen and Copper, 1998). Some specific activities are necessary to breakdown some other heavier compounds in feed that surpasses the strength of intrinsic enzymes, therefore exogenous enzymes are added to the diet to break down these compounds. Phytases are routinely utilized particularly in environmentally sensitive areas of the world due to their ability to increase the phosphorus availability from vegetable ingredients (Jongbloed *et al*., 1997; Kemme *et al*., 1999). Bedford (2003) also reported that the use of enzymes enables the feed manufacturer to minimize feed costs through reduced usage of expensive ingredients like maize, soybean, and groundnut cake, so as to substitute for some alternatives, but cheap feed ingredients which may pose to an extent difficulty in digestibility due to their fibrous nature. He further reported that phytase releases phytate phosphorus which when accounted for, replaces inorganic phosphate sources and at the same time reduces formulation costs.

The response to the use of enzymes is greatest on the poorest quality raw materials (Scott *et al*., 1998; Bedford, 2003) and as a result, variations in subsequent bird performance are reduced allowing for more uniform flock and also less variation in productivity from flock to flock. Some commercial enzymes such as Maxigrain® and Allzyme® contain a spectrum of different enzymes including xylanases and β-glucanases and therefore can be used effectively with most of the cereals. The inclusion of enzymes in non-ruminant diets has been reviewed by Campbell and Bedford (1992). They reported that the enzymes must not be inactivated by processing or by low pH or by the digestive enzymes in the gastrointestinal tract in order for it to be very effective. It also should be noted that different cereals contain different amounts of sensitive anti-nutritional factors therefore; the response to enzyme treatment may vary within a given cereal. Results after the administration of enzymes are affected by class and age of poultry and the responses in swine are usually less pronounced than those of poultry.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The study was conducted at the Poultry Breeding Unit of the National Animal Production Research Institute (NAPRI), Shika-Zaria Kaduna of Nigeria. NAPRI is geographically located between latitude 11^0 and 12^0N and longitude 7^0 and 8^0E at an altitude of 640m above sea level. This area is vegetationally in the Northern Guinea Savanna zone with an average annual precipitation of 1100mm. Rainfall starts in late April or sometimes early May, reaches peak between June and September and lasts till October. The harmattan period which start from mid October through January is immediately followed by dry hot weather from February to May. Temperature ranges are at harmattan 14 ^{0}C to 30 ^{0}C and hot season 21 ^{0}C to 36 ^{0}C. Relative humidity varies from approximately 21 % during harmattan to 37 % during the hot season. The average temperature and humidity during the wet season are 24.8 ^{0}C and 77 %, respectively (Oni *et al*., 2000).

3.2 Sources of Experimental Feed Materials

The various processed energy feed sources (Maize, White Sorghum, Pearl Millet, Cassava and Sweet Potato) were purchased from the local farmers in Shika Zaria, and were milled in National Animal Production Research Institute (NAPRI) feed mill while other ingredients were sourced from Rebson Feed Mill, Zaria in Kaduna State of Nigeria.

3.3 Source of Experimental Birds

The experimental broiler chicks (mixed day old breed or strain sexes) were obtained from the National Animal Production Research Institute (NAPRI) Zaria, Kaduna State, Nigeria.

3.4 Laboratory Analysis

Proximate analysis of all the samples of the energy feed sources to be used were carried out at the Biochemical Laboratory, Department of Animal Science, Ahmadu Bello University, Zaria, using methods described by A.O.A.C (1990).

3.5 EXPERIMENT 1: Effect of Different Ditary Energy Feed sources on the Performance, Nutrient Digestibility Haematology and Carcass Characteristics of Broiler Chickens

3.5.1 Design, management of experimental birds and data collection.

A total of two hundred and twenty five (225) day-old broiler chicks (mixed sexes) were used for the research. They were reared on deep litter, in an open sided wire mesh screened poultry house. Additional heat sources were provided using electric bulbs, kerosene stoves, and lanterns for brooding. The open sides were covered with polyethylene sheets to conserve heat for the first 2-3 weeks of age. The chicks were fed on a common diet for three days. After three days, the chicks were weighed and divided into five treatments. The birds were weighed at day old and randomly assigned to five dietary treatments. The birds were housed on deep litter system and fed dietary levels of energy sources with and without Maxigrain® in a completely randomized design (CRD). The treatments were replicated three times with fifteen chicks per replicate. The chicks were brooded alternatively using kerosene stoves and electric bulbs as sources of heat and light, throughout the brooding phase.

The chicks were weighed and randomly assigned into five treatment groups of 45 birds each. Each group was subdivided into three (3) replicates of fifteen (15) birds in a Completely Randomized Design (CRD). Feed and water were provided *ad libitum* during the trial period which lasted for 56 days. The birds were weighed at the beginning of the trial and weekly thereafter. Weight gain, feed intake, left over feeds were measured and recorded, feed conversion ratio and feed cost per kilogramme gain were calculated and mortality rate recorded as they occurred.

During the starter phase, five isonitrogenous and isocaloric diets were formulated to varying levels of different energy sources (Maize, Millet, Sorghum, Cassava and Sweet Potatoes). Treatment 1 which contain maize as a sole diet served as the control, treatment 2 (sorghum as the main diet), treatment 3 (millet as the main diet), treatment 4 (cassava as the main diet) and treatment 5 (sweet potatoes). The experiment lasted from three days to 4weeks. Water and feed were given *ad – libitum*. The chicks and feed were weighed weekly and feed weighed back recorded. Vaccination schedule as recommended by National Animal Poultry Research Institute (NAPRI) was adopted. Performance parameters calculated were feed intake, water intake, water: feed ratio, weight gain, feed to gain ratio, feed cost per kilogram gain and mortality rate.

During the finisher phase, two hundred and ten (210) broilers finisher chicks were used. The chicks earlier used for the starter phase of the experiment were pooled together and fed a common diet for one week after which they were weighed and randomly allocated based on an average initial weight to the five broiler finisher diets. The feeding trial involved five treatments with 14 birds per pen. The experiment lasted from 5-8 weeks. The birds and feed were weighed weekly and feed left overs were recorded. Performance parameters calculated were feed intake, water intake, water: feed ratio, weight gain, feed to gain ratio, feed cost per kilogram gain and mortality rate. Also, carcass and haematological parameters were measured at the finisher phase.

3.5.2 Determination of water intake

Daily water intake for each treatments was determined by measuring the amount of water given in the morning and determining its differences with the remaining amount of water the next morning. The evaporated loss was determined by placing a known amount of water in a bowl overnight and then leftover was subtracted from the total amount supplied. The evaporative loss was therefore used to determine the actual water intake by the birds per day.

3.5.3 Experimental Diets for Experiment 1

Five isonitrogenous and isocaloric diets each containing 23.17 % CP; 2831 Kcal/kg ME and 21.73 % CP; 2929 Kcal/kg for the broiler starter and finisher phases, respectively were formulated as follows:

Diet 1: contained maize as main energy source

Diet 2: contained sorghum as main energy source

Diet 3: contained millet as main energy source

Diet 4: contained cassava as main energy source

Diet 5: contained sweet potatoes as main energy source

These main energy sources were used as components of the diets to feed the experimental groups T_1, T_2, T_3, T_4 and $T_{5,}$ respectively (Table 3.1 and 3.2). All diets were formulated to meet nutrient requirement standards of broilers (NRC, 1994).

3.5.4 Digestibility Trials

At the end of the feeding trial (56 days), four birds each from the five treatment groups were randomly selected from each replicate and were transferred into metabolic cages for faecal collection. The birds were placed in metabolic cages with facilities for feed and water. They were allowed to acclimatize for a period of five days. Each group was fed their respective experimental diets. Thereafter, total faecal output was collected for seven days by means of clean trays placed under the cages. Collected faecal samples were immediately oven dried to constant weight at 60 °C. The faecal collections for each diet fed were bulked and ground to fine particles and analysed for proximate composition. Dry matter, crude protein, nitrogen free extract, ether extract, crude fibre and ash were assayed for proximate composition at the Biochemical Laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria using the method described by (A.O.A.C, 1990). The percentage nutrient digestibility was calculated using the equation below;

$$Digestibility\ \% = \frac{Nutrient\ intake - Nutrient\ output}{Nutrient\ intake} \times 100$$

Where; Nutrient intake (g) = Dry matter feed intake x Nutrient in diet

Nutrient output (g) = Dry matter faecal output x Nutrient in faeces

Total Digestible Nutrients (TDN) = protein (protein coeff.) + nitrogen free extract (NFE coeff.) + fiber (fiber coeff.) + 2.25 [fat (fat coeff.)]

3.5.5 Carcass Evaluation

At the end of the finisher phase, three (3) birds were selected from each treatment, that is one bird per replicate, representing the average weight of their pens for carcass analysis.

The selected birds were fasted overnight so as to allow for the emptying of the crop and excretion of the undigested feed residue. They were weighed, bled by severing their jugular veins, scalded in hot water (^{o}C), defeathered and eviscerated. The head, neck, shanks and viscera were removed to get the dressed weight. Weight of organs and various parts of the body: breast, thigh, liver, heart, gizzard, and intestine were taken. All weights were expressed as percentages of live weight of birds slaughtered. The carcass evaluation was done at the Meat Products Laboratory, Department of Animal Science, Ahmadu Bello University, Zaria.

Table 3.1: Composition of the Experimental Broiler Starter Diets for Experiment 1 (0-4 weeks)

Ingredients (%)	T_1 Maize	T_2 Sorghum	T_3 Millet	T_4 Cassava	T_5 Sweet potato
Maize	49.00	0.00	0.00	0.00	0.00
Sorghum	0.00	49.00	0.00	0.00	0.00
Millet	0.00	0.00	48.00	0.00	0.00
Cassava	0.00	0.00	0.00	48.00	0.00
Sweet potatoes	0.00	0.00	0.00	0.00	48.00
Wheat offal	5.00	5.00	5.00	5.00	5.00
G/nut cake (GNC)	11.05	10.55	10.05	10.05	11.05
Full fat soya	25.00	25.00	25.00	25.00	25.00
Fish meal (local)	4.00	4.00	4.00	4.00	4.00
Lime stone	1.00	1.00	1.00	1.00	1.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Palm oil	1.00	1.50	3.00	3.00	2.00
Table salt	0.30	0.30	0.30	0.30	0.30
Vit/M. Premix	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.20	0.20	0.20	0.20	0.20
D1-Methionine	0.20	0.20	0.20	0.20	0.20
Total	**100**	**100**	**100**	**100**	**100**
Calculated Analysis:					
ME (Kcal/kg)	2831.00	2829.00	2828.00	2838.00	2829.00
Crude protein (%)	23.45	23.31	23.74	23.39	23.06
Ether extract (%)	5.66	5.64	6.26	5.18	5.28
Crude fibre (%)	4.37	4.79	4.96	5.05	5.79
Calcium (%)	1.43	1.44	1.72	1.52	1.56
Avail. phosphorus (%)	0.68	0.68	0.83	0.69	0.78
Lysine (%)	1.46	1.44	1.53	1.43	1.51
Methionine (%)	0.46	0.42	0.48	0.32	0.35
Met + Cys (%)	0.96	0.91	0.98	0.85	0.89
Feed cost/kg (₦/Kg)	89.90	88.47	91.55	96.87	92.35

Biomix provide the following per kg of diet: Vit A, 1000 i.u; Vit.D_3, 500i.u; Vit E 5.75mg; Vit K_3 0.5mg;Vit. B_1 0.8mg; Vit B_2 1.25; Niacin 6.87mg; Pantothenate Acid 1.87mg; Vit B6 0.75mg; Vit B12 0.00375mg;Folic Acid 0.1875mg; Biotin H_2 0.015 mg; Choline chloride 75mg; Cobalt 0.05mg; copper 0.75mg; iodine 0.25mg; Iron 5mg; Manganese 10mg; Selenium 0.05mg; Zinc 7.5mg; Antioxidant 0.3125mg; ME=Metabolizable energy; ME (kcal kg^{-1}) = 37xProtein (%)+81.8xFat (%)+35.5xNFE(%); Pauzenga(1985), GNC-Groundnut cake

Table 3.2: Composition of the Experimental Broiler Finisher Diets for Experiment 1 (5-8 weeks)

Ingredients (%)	T_1 (Maize)	T_2 (Sorghum)	T_3 (Millet)	T_4 (Cassava)	T_5 Sweet (potato)
Maize	52.35	0.00	0.00	0.00	0.00
Sorghum	0.00	51.70	0.00	0.00	0.00
Millet	0.00	0.00	54.05	0.00	0.00
Cassava peel	0.00	0.00	0.00	49.00	0.00
Sweet potatoes	0.00	0.00	0.00	0.00	50.00
Wheat offal	5.00	5.00	5.00	5.00	5.00
GNC	7.70	7.35	2.70	11.05	9.05
Full fat soyabean	25.00	25.00	25.00	25.00	25.00
Fish meal (local)	3.00	3.00	3.00	3.00	3.00
Lime stone	1.00	1.00	1.00	1.00	1.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Palm oil	2.00	3.00	5.30	2.00	3.00
Table salt	0.30	0.30	0.30	0.30	0.30
Vit/M. Premix	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.20	0.20	0.20	0.20	0.20
DL-Methionine	0.20	0.20	0.20	0.20	0.20
Total	**100**	**100**	**100**	**100**	**100**
Calculated Analysis:					
ME (Kcal/kg)	2929	2934	2913	2911	2917
Crude protein (%)	21.88	21.53	21.67	21.83	21.94
Ether extract (%)	6.43	6.82	7.92	4.89	5.78
Crude fibre (%)	4.25	4.16	4.74	5.05	5.79
Calcium (%)	1.37	1.38	1.69	1.47	1.50
Avail.phosphorus (%)	0.65	0.65	0.81	0.66	0.75
Lysine (%)	1.38	1.36	1.40	1.33	1.38
Methionine (%)	0.46	0.42	0.46	0.32	0.35
Met +Cys(%)	0.91	0.87	0.91	0.79	0.81
Feed cost/kg (₦/Kg)	88.62	87.18	89.81	91.81	89.60

Biomix provide the following per kg of diet: Vit A, 1000 i.u; Vit.D_3, 500i.u; Vit E 5.75mg; Vit K_3 0.5mg;Vit. B_1 0.8mg; Vit B_2 1.25; Niacin 6.87mg; Pantothenate Acid 1.87mg; Vit B6 0.75mg; Vit B12 0.00375mg;Folic Acid 0.1875mg; Biotin H_2 0.015 mg; Choline chloride 75mg; Cobalt 0.05mg; copper 0.75mg; iodine 0.25mg; Iron 5mg; Manganese 10mg; Selenium 0.05mg; Zinc 7.5mg; Antioxidant 0.3125mg; ME=Metabolizable energy; ME (kcal kg^{-1}) = 37xProtein (%)+81.8xFat (%)+35.5xNFE(%); Pauzenga(1985), GNC-Groundnut cake

3.5.6 Haematological Parameters Analysis

At the end of the finisher phase, nine samples of birds were randomly selected from each treatment group (i.e. three birds per replicate) and 2mls of blood sample was collected from each of them via the wing vein and put into a sample bottle containing anti-coagulant, ethylene di-amine tetra acetic acid (EDTA) and later analyzed for packed cell volume (PCV), haemoglobin level (Hb) and total protein (Tp), white blood cells (WBC) and red blood cells (RBC) according to the methods described by Lamb (1991) at the Haematological Laboratory of Veterinary Teaching Hospital, Ahmadu Bello University, Zaria using the procedure of Schalm *et al*., (1975).

3.5.7 Statistical Analysis

All the data collected were statistically analyzed using the General Linear Model Procedure of Statistical Analysis (SAS, 2002). Significant difference between treatments means were separated by Duncan Multiple Range Test as in the software (Duncan, 1955)

The model used for this design is as follows:

$Y_{ij} = \mu + Ti + e_{ij}$

Where;

Y_{ij} = Individual observation.

μ = Overall mean.

T_i = Effect of treatment diets.

e_{ij} = Experimental error.

3.6 EXPERIMENT 2:

3.6.1 Effect of different dietary Energy feed sources on the Performance, Nutrient Digestibility, Haematology and Carcass Characteristics of Broiler Chickens with Enzyme Supplementation

3.6.2 Design and Management of Experimental Birds

A total of two hundred and twenty five (225) day-old broiler chicks (mixed sexes) were used for the research. They were reared on deep litter, in an open sided wire mesh screened poultry house. Additional heat sources were provided using electric bulbs, kerosene stoves, and lanterns for brooding. The open sides were covered with polyethylene sheets to conserve heat for the first 2-3 weeks of age. The chicks were fed on a common diet for three days. After three days, the chicks were weighed and divided into five treatments. The birds were weighed at day old and randomly assigned to five dietary treatments. The birds were housed on deep litter system and fed dietary levels of energy sources with and without Maxigrain® in a completely randomized design (CRD). The treatments were replicated three times with fifteen chicks per replicate. The chicks were brooded alternatively using kerosene stoves and electric bulbs as sources of heat and light, throughout the brooding phase.

The chicks were weighed and randomly assigned into five treatment groups of 45 birds each. Each group was subdivided into three (3) replicates of fifteen (15) birds in a Completely Randomized Design (CRD). Feed and water were provided *ad libitum* during the trial period which lasted for 56 days. The birds were weighed at the beginning of the trial and weekly thereafter. Weight gain, feed intake, left over feeds were measured and recorded, feed conversion ratio and feed cost per kilogramme gain were calculated and mortality rate recorded as they occurred.

During the starter phase, five isonitrogenous and isocaloric diets were formulated to varying levels of different energy sources (Maize, Millet, Sorghum, Cassava and Sweet Potatoes). Treatment 1 which contain maize as a sole diet served as the control, treatment 2 (sorghum as the main diet), treatment 3 (millet as the main diet), treatment 4 (cassava as the main diet) and treatment 5 (sweet potatoes). The experiment lasted from three days to 4weeks. Water and feed were given *ad – libitum*. The chicks and feed were weighed weekly and feed weighed back recorded. Vaccination schedule as recommended by National Animal Poultry Research Institute (NAPRI) was adopted. Performance parameters calculated were feed intake, water intake, water: feed ratio, weight gain, feed to gain ratio, feed cost per kilogram gain and mortality rate.

During the finisher phase, two hundred and ten (210) broilers finisher chicks were used. The chicks earlier used for the starter phase of the experiment were pooled together and fed a common diet for one week after which they were weighed and randomly allocated based on an average initial weight to the five broiler finisher diets. The feeding trial involved five treatments with 14 birds per pen. The experiment lasted from 5-8 weeks. The birds and feed were weighed weekly and feed left overs were recorded. Performance parameters calculated were feed intake, water intake, water: feed ratio, weight gain, feed to gain ratio, feed cost per kilogram gain and mortality rate. Also, carcass and haematological parameters were measured at the finisher phase.

3.6.3 Experimental Diets for Experiment 2:

Five isonitrogenous and isocaloric diets each containing 23.17 % CP; 2831 Kcal/kg ME and 21.73 % CP; 2929 Kcal/kg for the broiler starter and finisher were formulated and 0.01g Maixgrain® enzyme was added to each of the diets (Table 3.3 and Table 3.4).

3.6.4 Digestibility Trial

This was carried out as described in Experiment 1.

3.6.5 Laboratory Analysis

This was carried out as described in Experiment 1.

3.6.6 Haematological Analysis

This was carried out as described in Experiment 1.

3.6.7 Carcass Evaluation

This was carried out as described in Experiment 1

3.6.8 Statistical Analysis

This was carried out as described in Experiment 1.

Table 3.3: Composition of the Experimental Broiler Starter Diet for Feeding Trial 2 (0-4) Levels of Inclusion with Maxigrain ®Enzyme

Ingredients (%)	T_1 (Maize)	T_2 (Sorghum)	T_3 (Millet)	T_4 (Cassava)	T_5 Sweet (potato)
Maize	49.00	0.00	0.00	0.00	0.00
Sorghum	0.00	49.00	0.00	0.00	0.00
Millet	0.00	0.00	48.00	0.00	0.00
Cassava peel	0.00	0.00	0.00	48.00	0.00
Sweet potatoes	0.00	0.00	0.00	0.00	48.00
Wheat offal	5.00	5.00	5.00	5.00	5.00
GNC	11.05	10.55	10.05	12.05	11.05
Full fat soyabean	25.00	25.00	25.00	25.00	25.00
Fish meal (local)	4.00	4.00	4.00	4.00	4.00
Lime stone	1.00	1.00	1.00	1.00	1.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Palm oil	1.00	1.50	3.00	1.00	2.00
Table salt	0.30	0.30	0.30	0.30	0.30
Vit/M. premix	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.20	0.20	0.20	0.20	0.20
DL-Methionine	0.20	0.20	0.20	0.20	0.20
Maxigrain ®Enzyme	+	+	+	+	+
Total	**100**	**100**	**100**	**100**	**100**
Calculated Analysis:					
ME (Kcal/kg)	2831.00	2829.00	2828.00	2832.00	2829.00
Crude protein (%)	23.53	23.60	23.45	23.62	23.70
Ether extract (%)	5.66	5.64	6.26	4.18	5.28
Crude fibre (%)	4.37	4.29	4.96	5.05	5.79
Calcium (%)	1.43	1.44	1.72	1.52	1.56
Avail. phosphorus (%)	0.68	0.68	0.83	0.69	0.78
Lysine (%)	1.46	1.44	1.53	1.43	1.51
Methionine (%)	0.46	0.42	0.48	0.32	0.35
Met + Cys (%)	0.96	0.91	0.98	0.85	0.89
Feed cost/kg (₦/Kg)	92.27	92.49	95.92	98.65	96.52

Biomix provide the following per kg of diet: Vit A, 1000 i.u; Vit.D_3, 500i.u; Vit E 5.75mg; Vit K_3 0.5mg;Vit. B_1 0.8mg; Vit B_2 1.25; Niacin 6.87mg; Pantothenate Acid 1.87mg; Vit B6 0.75mg; Vit B12 0.00375mg;Folic Acid 0.1875mg; Biotin H_2 0.015 mg; Choline chloride 75mg; Cobalt 0.05mg; copper 0.75mg; iodine 0.25mg; Iron 5mg; Manganese 10mg; Selenium 0.05mg; Zinc 7.5mg; Antioxidant 0.3125mg; ME=Metabolizable energy; ME (kcal kg^{-1}) = 37xProtein (%)+81.8xFat (%)+35.5xNFE(%); Pauzenga(1985), GNC-Groundnut cake

Table 3.4: Composition of the Experimental Broiler Finisher Diet for Feeding Trial 2 (5-8 weeks) Levels of Inclusion with Maxigrain ®Enzyme

Ingredients(%)	T_1 Maize	T_2 Sorghum	T_3 Millet	T_4 Cassava	T_5 Sweet potato
Maize	52.35	0.00	0.00	0.00	0.00
Sorghum	0.00	51.70	0.00	0.00	0.00
Millet	0.00	0.00	54.05	0.00	0.00
Cassava peel	0.00	0.00	0.00	49.00	0.00
Sweet potatoes	0.00	0.00	0.00	0.00	50.00
Wheat offal	5.00	5.00	5.00	5.00	5.00
GNC	7.70	7.35	2.70	11.05	9.05
Full fat soyabean	25.00	25.00	25.00	25.00	25.00
Fish meal (local)	3.00	3.00	3.00	3.00	3.00
Lime stone	1.00	1.00	1.00	1.00	1.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Palm oil	2.00	3.00	5.30	2.00	3.00
Table salt	0.30	0.30	0.30	0.30	0.30
Vit/M. Premix	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.20	0.20	0.20	0.20	0.20
DL-Methionine	0.20	0.20	0.20	0.20	0.20
Maxigrain ®Enzyme	+	+	+	+	+
Total	**100**	**100**	**100**	**100**	**100**
Calculated Analysis					
ME (Kcal/kg)	2929.00	2934.00	2913.00	2911.00	2917.00
Crude protein (%)	21.73	21.57	21.58	21.69	21.63
Ether extract (%)	6.40	6.52	7.82	4.89	5.70
Crude fibre (%)	4.25	4.16	4.94	5.23	5.68
Calcium (%)	1.25	1.26	1.56	1.34	1.37
Available phosphorus (%)	0.65	0.65	0.81	0.66	0.75
Lysine (%)	1.38	1.36	1.40	1.33	1.38
Methionine (%)	0.46	0.42	0.46	0.32	0.35
Met +Cys (%)	0.91	0.87	0.91	0.79	0.81
Feed cost/kg (₦/Kg)	88.62	87.183	98.81	90.81	89.60

Biomix provide the following per kg of diet: Vit A, 1000 i.u; Vit.D_3, 500i.u; Vit E 5.75mg; Vit K_3 0.5mg;Vit. B_1 0.8mg; Vit B_2 1.25; Niacin 6.87mg; Pantothenate Acid 1.87mg; Vit B6 0.75mg; Vit B12 0.00375mg;Folic Acid 0.1875mg; Biotin H_2 0.015 mg; Choline chloride 75mg; Cobalt 0.05mg; copper 0.75mg; iodine 0.25mg; Iron 5mg; Manganese 10mg; Selenium 0.05mg; Zinc 7.5mg; Antioxidant 0.3125mg; ME=Metabolizable energy; ME (kcal kg^{-1}) = 37xProtein (%)+81.8xFat (%)+35.5xNFE(%); Pauzenga(1985), GNC-Groundnut cake; +=0.01g

CHAPTER FOUR

4.0 RESULTS

4.1 Proximate Composition and Anti-nutritional Factors of the different Energy Sources

Table 4.1 shows the results of the proximate analysis of the test ingredients. Sorghum was higher in dry matter (DM) and ash when compared with maize, millets, cassava and sweet potato respectively. The percent crude protein was found to be higher in sorghum and millets (10.64 and 10.89 %) respectively compared to the values for maize, cassava and sweet potato (8.80, 4.70 and 4.11 %) respectively. Maize recorded the highest value (4.23%) for ether extract. Crude fibre was found to be higher in millets, cassava and sweet potato compared to the values for maize and sorghum. The percent ash was found to be higher in sorghum (7.23 %) compared to the values for maize, millets, cassava and sweet potato respectively. The percent nitrogen free extract was found to be higher in sweet potato (86.29%) compared to the values for maize, millets, cassava and sorghum respectively.

The values recorded for tannins were within the range of 0.12 - 0.62 g/Kg, phytate was within the range of 0.22- 0.57 g/Kg (Table 4.2). Cyanide was within the range of 0.18- 3.86 g/Kg. Cassava was found to be significantly ($P<0.05$) higher in cyanide compared to maize, sorghum, millets and sweet potato respectively. Oxalate was within the range of 0.46- 18.00 g/Kg which was found to be significantly ($P<0.05$) higher in cassava compared to maize, sorghum, millets, and sweet potato respectively.

Table 4.1: Proximate Composition of Maize, Sorghum, Millet, Cassava and Sweet potato

Nutrients	Maize	Sorghum	Millet	Cassava	Sweet potato
Dry matter (%)	90.04	94.35	90.00	88.02	86.30
Crude protein (%)	8.80	10.64	10.89	4.70	4.11
Ether Extract (%)	4.23	3.06	3.60	0.76	0.60
Crude fibre	2.85	3.42	5.92	5.60	5.24
Ash (%)	1.03	7.23	2.24	4.01	3.76
NFE (%)	83.09	75.65	77.35	84.93	86.29
ME(Kcal/kg)*	3621.31	3329.56	3443.33	3251.08	3264.45

NFE: Nitrogen Free Extract =100-(%CP+%CF+%EE+%Ash) *ME**:** Metabolizable Energy ME (Kcal/kg) = 37 x % CP + 81.8 x % EE + 35.5 x %NFE (Pauzenga, 1985). Determination done at the Biochemical Laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria.

Table 4.2: Antinutritional Factors of Maize, Sorghum, Millet, Cassava and Sweet potato

Nutrients	Maize mg/100g	Sorghum mg/100g	Millet mg/100g	Cassava mg/100g	Sweet potato mg/100g	SEM
Tannin	0.12^{a}	0.14^{a}	0.13^{a}	0.62^{c}	0.44^{b}	0.08
Phytate	0.36^{b}	0.22^{a}	0.35^{b}	0.57^{d}	0.54^{c}	0.02
Oxalate	5.28^{c}	0.46^{a}	8.22^{d}	18.00^{e}	2.90^{b}	0.12
Cyanide	3.86^{e}	0.18^{a}	0.27^{b}	0.76^{c}	1.80^{d}	0.05

SEM-Standard error of mean; ^{abc}Means in the same row with different superscripts are significantly different. P<0.05-Significant;

4.2 Effects of Diets Containing Different Energy Feed Sources with Enzyme Supplementation on the Performance, Nutrient Digestibility, Haematological and Carcass characteristics of broiler chicken.

4.2.1 Growth Performance of Broiler Chicks Fed diets Containing Different Energy Feed Sources (0-4 weeks)

The performance characteristics of broiler starter chicks fed diets containing different energy materials are shown in Table 4.3. Dietary treatments had significant (P<0.05) effect on final weight, weight gain, feed intake, feed gain ratio, feed cost/kg gain, water intake, water: feed ratio and mortality. It was observed from this present study that chicks fed millet as main energy feed source (T3) had significantly (P<0.05) the best result in terms of final weight, weight gain and feed intake. Chicks fed sweet potato as main energy source had significantly (P<0.05) the highest feed cost per/kg gain followed by chicks fed cassava, sorghum, millet and maize. Chicks fed maize, sorghum and millet had the highest (P<0.05) water intake. Mortality rate was higher (P<0.05) in chicks fed sweet potato as main energy source compared to other dietary treatments.

4.2.2 Performance of Broiler Finisher Chickens Fed diets Containing Different Energy Sources (5 - 9 weeks)

Table 4.4 shows the performance characteristics of broiler finisher chickens fed diets with different energy sources. Dietary treatments had significant (P<0.05) effects on final weight, weight gain, feed intake, feed conversion ratio, feed cost/kg gain, water intake, water: feed ratio and mortality rate. Chickens fed millet (T3) as main energy feed had significantly (P<0.05) the best values for final weight, weight gain, feed intake, feed cost/kg gain. Millet fed chickens (T3) had the best feed conversion ratio (1.62) as compared to other treatments, while cassava fed chickens (T4) consumed more water (3918.30ml/b) compared to birds in the other dietary treatments.

Table 4.3: Performance Characteristics of Broiler Chicks Fed Diets containing Different Energy Feed Sources (0-4 weeks)

Parameters	T_1 Maize	T_2 Sorghum	T_3 Millet	T_4 Cassava	T_5 Sweet potato	SEM	LOS
Initial weight (g/bird)	49.63	49.90	49.83	49.77	50.00	0.16	NS
Final Weight (g/bird)	420.24^{b}	445.74^{b}	503.44^{a}	251.75^{c}	285.48^{c}	26.49	*
Weight gain (g/bird)	370.60^{b}	383.74^{b}	453.61^{a}	201.98^{c}	235.48^{c}	25.54	*
Feed Intake (g/bird)	676.71^{b}	735.83^{b}	819.67^{a}	545.45^{c}	759.58^{ab}	33.77	*
Feed conversion ratio	1.86^{a}	1.92^{a}	1.81^{a}	2.74^{b}	3.31^{c}	0.20	*
Feed cost/kg gain (₦)	168.48^{a}	177.35^{ab}	173.33^{a}	266.41^{b}	311.34^{c}	4.67	*
Water Intake (ml/bird)	1387.33^{a}	1350.39^{a}	1376.05^{a}	1265.22^{b}	1274.17^{b}	29.80	*
Water: Feed ratio	2.05^{b}	1.84^{c}	1.68^{d}	2.32^{a}	1.68^{d}	0.05	*
Mortality Rate (%)	0.70^{a}	1.60^{b}	2.00^{bc}	1.60^{b}	3.30^{c}	0.56	*

^{abc}Means in the same row with different superscripts are significantly different. P<0.05-Significant; SEM=standard error of means. LOS-Level of significance; *=(P<0.05); NS-Not significant

Table 4.4: Performance Characteristics of Broiler Finisher Chicken Fed Diets containing Different Energy Feed Sources (5-8 weeks)

Parameters	T_1 Maize	T_2 Sorghum	T_3 Millet	T_4 Cassava	T_5 Sweet potato	SEM	LOS
Initial weight (g/bird)	510.58	510.61	510.70	510.73	510.82	0.08	NS
Final Weight (g/bird)	2087.11^{ab}	2130.92^{b}	2302.77^{a}	1681.18^{c}	1711.12^{c}	59.65	*
Weight gain (g/bird)	1576.53^{b}	1620.31^{b}	1892.07^{a}	1170.45^{c}	1200.3^{c}	25.85	*
Feed Intake (g/bird)	2984.80^{b}	3019.70^{a}	3073.70^{a}	2515.20^{d}	2739.40^{c}	1.49	*
Feed/gain ratio(^)	1.89^{b}	1.87^{b}	1.62^{a}	2.15^{c}	2.28^{d}	0.03	*
Feed cost/kg gain	167.78^{b}	162.47^{b}	145.90^{a}	197.29^{c}	204.49^{c}	9.94	*
Water Intake(ml/bird)	3846.22^{e}	3886.67^{c}	3905.33^{b}	3918.30^{a}	3875.26^{d}	1.63	*
Water: Feed ratio	1.29^{c}	1.29^{c}	1.27^{c}	1.56^{a}	1.41^{b}	0.01	*
Mortality Rate (%)	2.22^{b}	4.44^{c}	6.67^{d}	0.00^{a}	0.00^{a}	0.02	*

^{abcd}Means in the same row with different superscripts are significantly different. SEM= standard error of means; LOS-Level of significance; *=(P<0.05); NS-Not significant

4.2.3 Nutrient Digestibility of Broiler Chickens fed Diets containing different Energy Feed Sources

Table 4.5 shows the nutrient digestibility of broiler chickens fed diets containing different energy sources without enzyme supplementation. Dietary treatments had significant ($P < 0.05$) effect on ether extract. It was observed that dietary treatment had no significant ($P > 0.05$) effects on dry matter, crude protein, crude fibre and nitrogen free extract. Total digestible nutrients were similar across the dietary treatments.

4.2.4 Haematological parameters of broiler chickens fed diets containing different sources energy feed sources

Haematological indices of broiler chicken fed different energy sources is shown in Table 4.6. PCV, TP and Hb were not significantly ($P > 0.05$) affected by the different energy feed sources except for both WBC and RBC. It was observed that chickens (T1) fed maize as main energy source had the highest numeric values for the PCV and Hb. Chickens fed cassava (T4) based diet had the highest numerical values for TP though significant difference ($P < 0.05$) were not observed across the dietary treatment group.

4.2.5 Effect of different energy feed sources on carcass characteristics of broiler chicken

The carcass characteristics of broiler chickens fed different energy feed sources are shown in Table 4.7. Dietary treatments had significant ($P < 0.05$) effect on the live weight, dressed weight, dressing percentage, breast, thigh, back cut, wings, drum sticks, neck, head, shank, liver, gizzard, empty intestine and length of intestine. Non-significant ($p > 0.05$) differences was observed for heart, spleen and length of intestine. The highest values for dressed weight, back cut, wings and empty intestine was observed in chickens (T3) fed millet as main energy feed.

Table 4.5: Nutrient Digestibility of Broiler Finisher Chickens Fed Diets containing Different Feed Energy Sources (5-8 weeks)

Parameters (%)	T_1 Maize	T_2 Sorghum	T_3 Millet	T_4 Cassava	T_5 Sweet potato	SEM	LOS
Dry matter	79.82	77.85	79.78	75.75	76.85	4.31	NS
Crude protein	77.44	76.45	77.22	74.12	75.49	3.11	NS
Crude fibre	75.60	78.67	79.56	77.52	77.69	4.06	NS
Ether extract	77.72^c	79.81^a	79.62^b	79.52^b	79.81^a	0.06	*
NFE	79.05	76.15	75.75	74.64	76.18	0.17	NS
TDN	50.01	49.73	51.61	47.88	48.84	2.52	NS

^{abc}Means in the same row with different superscripts are significantly different. SEM=Standard Error of Mean;
P<0.05-Significant; LOS-Level of significance; *= (P<0.05); NS-Not significant; TDN-Total digestible nutrients

Table 4.6: Haematological Parameters of Broiler Finisher Chickens Fed Different Energy Feed Sources without Enzyme Supplementation (5-8 weeks)

Parameters	T_1 Maize	T_2 Sorghum	T_3 Millet	T_4 Cassava	T_5 Sweet potato	SEM	Reference Range
PCV (%)	30.67	26.33	29.00	25.67	25.67	3.08	22.3-36
Hb(g/dl)	10.20	9.30	9.63	8.53	8.55	0.99	7.0-13.0
T.P(g/dl)	2.67	3.30	3.13	3.40	2.87	0.44	-
WBC (10^3/ml)	2.89^b	4.20^a	3.92^a	1.80^c	2.30^b	0.50	1.2-3.0
RBC (10^6/ml)	3.80^a	4.78^a	5.03^a	1.46^b	2.60^b	0.67	2.5-3.5

^{abc}-Means with different superscript differs significantly (P<0.05); SEM= standard error of means; LOS-Level of significance; *=(P<0.05); ns-not significant

Table 4.7: Carcass Characteristics of Broiler Finisher Chickens Fed Diets containing Different Energy Sources (5-8 weeks)

Parameters	T_1 Maize	T_2 Sorghum	T_3 Millet	T_4 Cassava	T_5 Sweet potato	SEM	LOS
Live Weight (g)	2080.11^{ab}	2128.92^{b}	2300.77^{a}	1677.18^{c}	1700.12^{c}	59.65	*
Dressed Weight (g)	1930.33^{a}	1972.00^{a}	2041.00^{a}	1627.00^{b}	1675.67^{b}	38.84	*
Dressing %	67.03^{c}	70.83^{b}	76.11^{a}	70.41^{b}	66.23^{c}	1.80	*
Breast (% of DW)	24.67^{a}	27.00^{a}	23.33^{a}	18.00^{b}	17.33^{ab}	2.61	*
Thigh (% of DW)	27.33^{a}	24.33^{a}	23.00^{b}	23.67^{b}	22.33^{b}	2.18	*
Back cut (% of DW)	15.00^{a}	18.00^{b}	20.00^{a}	15.00^{c}	14.33^{b}	9.60	*
Wing (% of DW)	10.00^{b}	10.33^{b}	13.00^{a}	9.33^{b}	11.00^{a}	1.20	*
Drum stick (% of DW)	13.69^{a}	13.67^{a}	12.63^{a}	10.60^{b}	9.64^{b}	0.95	*
Neck (% of DW)	7.97^{ab}	8.33^{ab}	8.00^{a}	5.70^{b}	5.33^{b}	0.70	*
Head (% of DW)	4.67^{a}	4.67^{a}	4.00^{b}	3.30^{c}	3.33^{c}	0.22	*
Shank (% of DW)	5.40^{b}	6.67^{ab}	6.90^{a}	4.33^{c}	5.20^{b}	0.82	*
Heart (% of LW)	8.33	9.67	8.33	8.00	8.00	1.18	NS
Liver (% of LW)	31.00^{ab}	36.33^{a}	35.67^{a}	35.67^{a}	27.33^{b}	2.13	*
Spleen (% of LW)	3.00	2.67	2.67	3.00	2.67	0.37	NS
Gizzard (% of LW)	46.67^{ab}	45.67^{ab}	54.67^{a}	51.67^{ab}	37.00^{b}	4.75	*
Empty Intestine(% of LW)	42.33^{ab}	46.67^{a}	49.33^{a}	46.00^{a}	31.33^{b}	4.43	*
Length of Intestine (cm)	29.43	29.33	29.36	28.67	28.60	6.27	NS

[abc]Means in the same row with different superscripts are significantly different, ($P<0.05$)-Significant; SEM= standard error of means. LW-Liveweight, DW-Dressed weight; LOS-Level of significant; LOS-Level of significance; *=($P<0.05$); ns-not significant

4.3 Effects of Diets Containing different Energy feed Sources with enzyme supplementation on the performance, carcass characteristics and nutrient digestibility of broiler chickens

4.3.1 Performance of Broiler Starter Phase (1-4 weeks)

Table 4.8 shows the performance characteristics of broiler starter chicks fed different energy sources with enzyme supplementation. Dietary treatments had significant (P< 0.05) effect on final weight, weight gain, feed intake, feed/gain ratio, feed cost/kg gain, water intake and water: feed ratio except in mortality rate. It was observed that chicks fed sorghum as main energy source with enzyme had the best results in terms of final weight, weight gain, feed intake, FCR, feed cost/kg gain and water intake. Chicks fed cassava (T4) had significantly (P>0.05) the least performance in terms of final weight and weight gain.

4.3.2 Performance of Broiler Finisher Phase (5 -8 weeks)

Table 4.9 shows the performance characteristics of broiler finisher chickens fed diets with different energy feed sources with enzyme supplementation. Enzyme supplementation on dietary treatments had significant (P<0.05) effect on final weight, weight gain, feed intake, feed cost/kg gain, water intake, water: feed ratio with the exception of mortality rate. Feed cost was best in sorghum (₦171.15) based diet. The final weight, weight gain, feed to gain ratio and feed intake were best in birds fed sorghum (2440.00g, 1752.33g, 1.96 and 3440.07) compared to maize (2250.00g, 1562.33g, 2.08 and 3250.00g) and millet (2334.07g, 1646.74g, 2.02 and 3334.07g), respectively. Mortality was recorded was nil across the dietary treatment groups except in birds fed cassava based diet (T4).

Table 4.8: Performance Characteristics of Broiler Starter Chickens Fed Diets containing Different Energy Sources with Enzyme supplementation (0-4 weeks)

Parameters	T_1 Maize	T_2 Sorghum	T_3 Millet	T_4 Cassava	T_5 Sweet potato	SEM	LOS
Initial weight (g/bird)	50.20	50.15	50.20	50.11	50.07	0.08	NS
Final Weight (g/bird)	528.34^{c}	627.00^{a}	583.20^{b}	334.45^{e}	465.20^{d}	11.10	*
Weight gain (g/bird)	478.15^{c}	576.85^{a}	533.04^{b}	284.34^{e}	415.13^{d}	11.21	*
Feed Intake (g/bird)	1146.41^{b}	1172.21^{a}	1179.15^{a}	920.09^{c}	947.19^{d}	40.51	*
Feed/gain ratio	2.40^{a}	2.03^{a}	2.21^{a}	3.24^{b}	2.28^{a}	0.50	*
Feed cost/kg gain (₦)	221.22^{c}	187.95^{a}	212.20^{b}	319.22^{d}	220.23^{c}	54.91	*
Water Intake(ml/bird)	1448.00^{b}	1513.34^{a}	1513.33^{a}	1498.33^{a}	1499.33^{a}	20.13	*
Water: Feed ratio	1.26^{c}	1.29^{c}	1.28^{c}	1.63^{a}	1.58^{a}	0.03	*
Mortality Rate (%)	8.90	6.69	6.69	6.67	6.22	5.62	NS

^{abcde}Means in the same row with different superscripts are significantly different, (P<0.05)-Significant; SEM= standard error of means, LOS-Level of significance; *=(P<0.05); ns-not significant

Table 4.9: Performance Characteristics of Broiler Finisher Chickens Fed Diets Containing Different Energy Sources with Enzyme supplementation (5-8 weeks)

Parameters	T_1 Maize	T_2 Sorghum	T_3 Millet	T_4 Cassava	T_5 Sweet potatoes	SEM	LOS
Initial weight (g/bird)	687.67	687.67	687.33	687.67	683.50	1.92	NS
Final Weight (g/bird	2250.00^{a}	2440.00^{a}	2334.07^{a}	1866.67^{b}	1904.33^{b}	59.20	*
Weight gain (g/bird)	1562.33^{a}	1752.33^{a}	1646.74^{a}	1179^{b}	1220.83^{b}	59.21	*
Feed Intake (g/bird)	3250.00^{c}	3440.07^{a}	3334.07^{b}	2866.67^{d}	2906.33^{d}	14.89	*
Feed/gain ratio	2.08^{c}	1.96^{a}	2.02^{b}	2.43^{e}	2.38^{d}	0.02	*
Feed cost/kg gain (₦/Kg)	184.35^{b}	171.15^{a}	200.06^{c}	223.34^{d}	213.30^{d}	4.15	*
Water Intake(ml/bird)	4060.10^{d}	4090.40^{d}	4966.00^{a}	4749.80^{b}	4258.40^{c}	37.28	*
Water: Feed ratio	1.25^{c}	1.19^{c}	1.49^{b}	1.66^{a}	1.47^{b}	0.04	*
Mortality Rate (%)	0.00^{a}	0.00^{a}	0.00^{a}	3.33^{b}	0.00^{a}	1.49	*

^{abc}Means in the same row with different superscript are significantly different. SEM=Standard Error of Mean, (P<0.05)-Significant, LOS-Level of significant

4.3.3 Nutrient Digestibility of Broiler Finisher Fed Diets with Different Energy Sources with Enzyme Supplementation

Table 4.10 shows the nutrient digestibility of broiler chickens fed on diets with different energy sources with enzyme supplementation. DM, CP, CF, EE, Ash and NFE were significantly (P<0.05) affected by energy source and enzyme supplementation. Chickens fed millet and maize based diets had significantly (P<0.05) the best nutrient digestibility respectively. Crude protein digestibility was higher in birds fed maize and millet based diets respectively. Crude fibre digestibility was higher in birds fed sorghum as the main energy source with enzyme followed by chickens fed maize and millet which were significantly (P<0.05) higher than those on sweet potatoes and cassava respectively. Ether Extract digestibility was observed to be high in chickens fed cassava with enzyme follow by sweet potatoes which was significantly higher than those fed maize, millet and sorghum respectively. Sorghum fed chickens had the highest value of Ash followed by broilers fed millet, sweet potatoes, maize and cassava respectively. Total digestible nutrients were similar across the dietary treatments.

4.3.4 Haematological Parameters of Broiler Finisher Fed Diets containing Different Energy Sources with Enzyme Supplementation

The haematological parameters of broiler birds on diets containing different energy sources with enzyme supplementation are shown in Table 4.11. Enzyme supplementation on dietary treatments had significant (P<0.05) effect on PCV, Hb, TP, WBC and RBC. Haemoglobin count was highest for birds fed sorghum, millet, sweet potatoes and maize while those on cassava based diets had the least values respectively. Total protein was highest for chickens fed millet based diets which were significantly (P<0.05) than those for by birds fed maize, sorghum, sweet potatoes and cassava based diets. WBC had the highest value for sorghum and millet while RBC recorded the lowest count in chickens fed cassava.

4.3.5 Carcass Characteristics of Broiler Finisher Fed Diets containing Different Energy Sources with Enzyme Supplementation

Table 4.12 shows the carcass characteristics of broilers on the different energy sources with enzyme supplementation. Dietary treatments supplemented with enzyme had significant ($P<0.05$) effect on live weight, dressed weight, breast, thigh, back cut, wings, drum stick, neck, head, heart, liver, spleen, gizzard and empty intestine weight. Dressing percentage and shank did not differ ($p>0.05$) significantly across the dietary treatments. Chickens fed millet, sorghum and maize based diets with enzyme supplementation had significantly ($P<0.05$) the best result in terms of live weight, dressed weight, back cut, drum stick and gizzard respectively.

Table 4.10: Nutrient Digestibility of Broiler Chicken Fed Different Energy Sources with Enzyme Supplementation (5-8 weeks)

Parameters (%)	T_1 Maize	T_2 Sorghum	T_3 Millet	T_4 Cassava	T_5 Sweet potato	SEM	LOS
Dry Matter	77.76^a	79.67^a	76.79^b	75.72^b	74.78^b	0.10	*
Crude Protein	74.36^a	74.13^a	73.32^a	73.07^b	72.18^c	0.12	*
Crude Fibre	75.22^b	78.99^a	75.26^b	73.75^c	74.20^c	0.06	*
Ether Extract	76.76^c	76.68^c	76.72^c	78.58^a	77.73^b	0.02	*
Ash	74.99^d	75.89^a	75.22^b	72.87^e	75.02^c	0.05	*
NFE	78.93^a	79.61^a	75.94^b	74.47^b	74.80^b	0.05	*
TDN	49.88	50.84	49.66	47.95	47.98	3.00	NS

^{abc}Means in the same row with different superscripts are significantly different, LOS-Level of significant, NFE-Nitrogen free extract, SEM= Standard Error of Mean; LOS-Level of significant, NFE-Nitrogen free extract; *=($P<0.05$); ns-not significant; TDN-Total digestible nutrient

Table 4.11: Haematological Parameters of Broiler Finishers Chickens Fed Diets containing Different Energy Sources with Enzyme Supplementation (5-8 weeks)

Parameters	T_1 Maize	T_2 Sorghum	T_3 Millet	T_4 Cassava	T_5 Sweet potato	SEM	Reference Range
PCV (%)	27.67^a	28.33^a	28.33^a	21.33^b	27.00^a	2.21	22.3-36
Hb (g/dl)	8.87^a	9.43^a	9.40^a	7.10^b	9.00^a	0.75	7.0-13.0
TP(g/dl)	3.40^b	3.33^b	5.53^a	2.93^b	3.13^b	0.24	-
WBC (10^3/ml)	3.60^b	5.15^a	4.89^a	2.75^c	3.30^b	0.46	1.2-3.0
RBC (10^6/ml)	4.14^a	6.18^a	6.23^a	2.09^b	2.94^a	0.67	2.5-3.5

^{abcd}Means in the same row with different superscripts are significantly different, (P<0.05-significant),
SEM= standard error of means.
LOS-Level of significant
PCV-Pack Cell Volume
Hb-Haemoglobin
TP-Total Protein
WBC-White Blood Cell
RBC-Red Blood Cell

Table 4.12: Carcass Characteristics of Broiler Chickens Fed Diets containing Different Feed Energy Sources with Enzyme Supplementation (5-8 weeks)

Parameters	T_1 Maize	T_2 Sorghum	T_3 Millet	T_4 Cassava	T_5 Sweet potato	SEM	LOS
Live Weight (g)	2580.33^{a}	2693.34^{a}	2590.00^{a}	1881.67^{b}	2121.00^{b}	57.74	*
Dressed Weight (g)	2186.67^{a}	2116.67^{a}	2227.33^{a}	1735.33^{c}	1863.00^{b}	37.41	*
Dressing %	75.09	78.59	77.19	83.40	76.98	22.46	NS
Breast (% of DW)	20.67^{c}	28.33^{a}	24.33^{b}	15.00^{d}	22.67^{b}	1.41	*
Thigh (% of DW)	17.33^{a}	15.67^{a}	19.33^{a}	13.68^{b}	14.60^{b}	7.05	*
Back cut (% of DW)	21.00^{a}	20.67^{a}	20.60^{a}	18.62^{b}	18.64^{b}	0.59	*
Wing (% of DW)	14.33^{a}	13.03^{ab}	14.67^{a}	10.33^{b}	11.67^{a}	1.56	*
Drum stick (% of DW)	16.83^{a}	16.48^{a}	15.33^{a}	10.00^{b}	12.93^{b}	0.89	*
Neck (% of DW)	8.50^{ab}	8.67^{ab}	8.93^{a}	5.69^{b}	6.90^{b}	0.80	*
Head (% of DW)	4.67^{a}	4.10^{b}	4.17^{b}	3.43^{c}	3.63^{c}	0.10	*
Shank (% of DW)	6.07	5.53	6.30	4.97	5.30	2.28	NS
Heart (% of LW)	9.33^{ab}	7.33^{b}	10.33^{a}	6.33^{b}	7.00^{b}	0.94	*
Liver (% of LW)	42.67^{a}	40.33^{a}	35.67^{ab}	25.00^{c}	29.33^{bc}	2.47	*
Spleen (% of LW)	2.33^{ab}	3.67^{a}	3.67^{a}	1.33^{b}	2.33^{ab}	0.67	*
Gizzard (% of LW)	51.67^{a}	50.33^{a}	50.00^{a}	37.00^{b}	46.00^{ab}	3.90	*
Empty intestinal weight (% of LW)	64.33^{a}	55.33^{ab}	60.33^{ab}	45.67^{b}	68.00^{a}	4.62	*
Length of Intestine (cm)	19.63^{b}	20.00^{b}	25.00^{ab}	22.67^{b}	25.33^{a}	1.32	*

^{abc}Means in the same row with different superscripts are significantly different.(P<0.05)-Significant; SEM =standard error of means. LW-Liveweight, DW-Dress weight, LOS-Level of significance; *=(P<0.05); ns-not significant

CHAPTER FIVE

5.0 DISCUSSION

5.1 Proximate Composition of the Test Materials

The values of dry matter, crude protein, crude fibre, ether extract, nitrogen free extract obtained in this study are within the range reported for energy sources by Babatunde *et al.* (1975), Bello *et al.* (1984), Alawa *et al*. (1988), Udedibie and Emanalom (2006), Lufadeju *et al.* (1996), Adamu and Ribadu (2003) and Olorunnisomo *et al*. (2006). The slight difference in the value obtained in this study and those from other researchers could be due to variations in the moisture content of the raw materials before dry matter determination. The value of crude protein obtained from this study was higher than the values reported by Dogari (1985) for sorghum. However, these values were similar to those obtained by Abdulmalik (1997) and Adama *et al.* (2007) for sorghum. It was also slightly similar to the values reported for maize/ sorghum by-products obtained by Babatunde *et al.* (1975) and Udedibie and Emanalom (1993), respectively. The differences in these values can be as a result of the concentration of protein in the residue after the extraction of starch through fermentation.

The high Crude fibre found in millets (5.90%) agrees with the values reported by Olomu (1995); Ojewola and Oyim (2006) who reported ranges of 5.8- 7.92 crude fibre (CF) for millets and contradicts that of Ravindran (1991); Sripriya *et al*. (2007); Adamu *et al*. (2013) who obtained 2.8 and 4.3% crude fibre respectively for pearl and finger millets.

The ash value obtained was within in the range of values reported by Babatunde *et al*. (1975), Abdulmalik (1997) and Olomu (1998) for different energy but however lower than the values reported by Udedibie and Emanalom (1993) and Adama *et al.* (2007).

The differences in the values of ether extract from various researches can be due to the variations in cereal grains used, the method and degree of accuracy of laboratory techniques used for the analyses. When maize grit is used, the germ containing most of the fat is removed. Sorghum grain on the other hand according to Udedibie and Emanalom (1993) was used without removing the testa and germ containing fat. The process of fermentation reduced the carbohydrate component while the fat content was increased. The nitrogen free extract obtained was similar to the values of Yunis and Cahaner (1999) and Adama *et al*. (2007). The metabolizable energy content obtained in this study was similar to values obtained by Udedibie and Emanalom (1993) and Abdulmalik (2007), respectively on different energy sources.

5.2 Anti-nutritional Factors in the Test Ingredients

The values recorded for tannins were within the range of 0.12 - 0.62g/Kg, which was below 2.6 g/Kg reported by Reza and Edriss (1997) for low tannins in carbohydrate sources that were reported as tolerable for broiler chicken and cause no adverse effects on their performance. Phytate was within the range of 0.22- 0.57 g/Kg. Cyanide was within the range of 0.18- 3.86 g/Kg. Maize was found to be significantly ($P<0.05$) higher in cyanide compared to sorghum, millet, sweet potatoes and cassava Oxalate was within the range of 0.46- 18.00 g/Kg which was found to be significantly higher in cassava compared to maize, sorghum, millets and sweet potatoes respectively. Zhang and Corke (2001) reported that, raw sweet potato contains oxalate op to 1.2g/Kg DM. The differences observed may be due to the differences in the cultivars, soil type and condition under which the crop was grown

5.3 Experiment 1: The effect of different dietary energy sources without enzyme supplementation on performance, nutrient digestibility, haematological indices and carcass characteristics of Broiler chickens.

5.3.1 Performance of Broiler Starter Phase (Day 1 to week 4)

The observed improvement in final weight, weight gain, feed intake, feed to gain ratio and water intake of birds fed millet diets agrees with NRC (1994) which stated that weight gain in broilers was directly related to feed intake. This might be due to more balanced nutrient combination in millets since adequate amount of the essential amino acids is necessary for protein synthesis which results in increased weight gain. This corroborates with the reports of Rooney (1990) that millet contains higher crude protein and well balanced amino acids than other common cereal grains which may enhance growth, feed intake and feed conversion ratio. Similarly, Davis *et al.* (2003) stated that at day 1 to 42, birds fed 100% pearl millet diet had greater body weight and feed conversion ratio than birds fed maize and guinea corn based diets.

The feed conversion ratio of birds on millet diets (T3) was significantly ($P<0.05$) better compared to birds fed with other dietary energy sources. This means that millet diets were properly utilized by the birds. This finding agrees with the reports of Jambunathan and Subramanian (1988) and Rooney (1990). This is an indication that millet contains more essential nutrients as compared to the other cereals used in this study. This might also be due to the fact that energy content of pearl millet is relatively high, arising from the higher oil content of this grain compared to that of maize or sorghum. Pearl millet was found to have a high protein content and superior amino acid profile than that of maize (Smith *et al*. 1989). Adeola (2006) reported that pearl millet contains 27 to 32% more protein than maize, together with higher concentration of essential amino acids, two times as much ether extract and a higher gross energy. Similar results were obtained by Smith *et al*. (1989) and Haydon and Hobbs (1991).

The highest feed intake was observed in the treatments fed millet. This was attributed to increase feed palatability as both millet have been reported to enhance palatability. This agrees with the reports of Rao *et al*. (2001) who observed significantly higher feed intake when broiler chicks were fed millet based diets. Findings in this study agreed with the report of Luis (1982) and Andrew and Kumar, (1992) who reported that birds fed millet gave better performance than the maize and sorghum groups in broiler chicks. The decline in body weight gain of the broilers fed cassava as a source of energy may be attributed to the concomitant reduction in feed intake associated with the residual cyanide which is inherent in cassava. The decline in feed intake recorded for the birds fed Cassava based diet may be due to the powdery nature of Cassava meal which consequently might have contributed to the observed increased water intake. The mortality rate of the birds which was significantly affected by the dietary treatments might be due to the presence of some antinutritional factors such as oxalate, cyanide and high level of tannin in the raw materials used for feed formulation in some of the dietary treatments.

Feed cost in Naira per kilogramme weight gain showed that birds fed sorghum and maize diet had significantly lower cost of production (N173.33) only following maize. However, considering the FCR, the birds in the millet based diet group (T3) required a smaller amount to achieve a kilogramme body weight gain than the birds in the maize based diet group.

5.3.2 The Broiler Finisher Phase (5-8 weeks)

All the performance indicators determined namely final weight, weight gain, feed intake, feed cost/kg gain, water to feed ratio and mortality rate differed significantly among dietary treatments. Sorghum based dietary treatments were comparable to millet based dietary treatments in final weight, weight gain, feed intake, feed to gain ratio and feed cost/kg gain but millet recorded less mortality than the other dietary treatments. This finding agreed with the report of Luis *et al.* (1982) and Andrew and Kumar, (1992) who reported that birds fed millet gave better performance than the maize and sorghum groups. This may be due to more balanced nutrient combination in millet since adequate amount of the essential amino acids is necessary for protein synthesis which results in increased weight gain. This corroborates with the reports of Rooney (1990) that millet contain higher crude protein and well balanced amino acids than other common cereal grains which may enhance growth, feed intake and feed conversion ratio. Although, the feed to gain ratio values differed significantly and they were all at low range values, and this may have contributed to the observed enhanced weight gains of the birds fed the maize, sorghum and millet based diets. The results is in agreement with the reports of Davis *et al.* (2003) that birds fed 100 % pearl millet diet had greater body weight, feed intake, and feed conversion ratio compared to the birds fed yellow maize.

5.3.3 Nutrient Digestibility of Broiler Chickens

There were significant differences in percent ether extract digestibility across the treatment diets. This is in agreement with Marquardt *et al.* (1996) who reported improvement in the body weight and feed conversion efficiency due to an increase in fat and protein digestibility. Increase fat retention also increases the bioavailability of fat soluble vitamins.

The values obtained for percent dry matter, crude protein, crude fibre, ash and nitrogen free extract digestibilities were similar when compared with those fed other diets (Kumar *et al*., 1992). This may have contributed to the similarity in performance observed in birds fed different energy based dietary treatments except in birds fed cassava as the main energy source in the diets.

5.3.4 Haematological Parameters of Broilers Fed Maize, Sorghum, Millet, Cassava and Sweet potatoes Based Diets.

Packed cell volume (PCV), haemoglobin (Hb), white blood cell (WBC), red blood cell and total protein (TP) are important blood parameters used to assess the health status of animals. It has been established that reduction in the levels of nutrients in feeds result in decrease in PCV, Hb and TP of animals (Oladele and Ayo, 1999). The aim of estimating the haemoglobin content was to determine the oxygen carrying capacity of the birds circulatory system (Iheukwumene and Herbert, 2003). Birds with low Hb can be said to have low oxygen carrying capacity and can easily succumb to any form of respiratory disease while birds with high Hb concentration can be regarded as having high oxygen carrying capacity and such birds are likely to withstand some levels of respiratory stress. The blood parameters did not show any pattern or variation from established ranges and hence the health of the birds was not compromised the energy of the dietary treatments.

Values observed within the dietary treatments were similar to the observations of several researchers (Iheukwumene and Herbert, 2003) who have worked on non-alternative feedstuff in broilers. The values obtained in this study for Hb, PCV and TP were consistent with the reports of Iheukwumere and Herbert (2003) whose values were within 6 – 13.0 % and 29.0 – 38.0 % for Hb and PCV respectively. PCV is an index of toxicity; for the value to fall within the normal range suggests that the broiler birds had the abillity to tolerate the antinutritional factors in the diet. Similarly, values obtained for haemoglobin level were within the range for healthy chickens 11.30±1.82 g dL^{-1} as reported by Oladele and Ayo (1999).

Nworgu *et al*. (2003) reported PCV of 28 – 30.0 % for cockerel chicks fed cocoa pod husk meal. Variations in this parameter could be attributed to breed of chicken, nutritional pattern, type of feed, environmental factors and the test ingredients used. Iyayi (1998) reported that total serum protein depends on both quality and quantity of the protein supplied in the diet. Values for RBC and WBC did vary between the treatments and fell within the normal range reported by Mitruka and Rawnsley (1997). Also, the mean values obtained falls within the normal physiological range reported by several researchers (Islam *et al*., 2004; Simarak *et al.*, 2004).

5.3.5 Carcass Characteristics and Organ Weights of Broilers Chickens

The carcass evaluation of broilers showed similar trend as that of growth performance. The birds fed millet diet had higher live weight and carcass weight compared to those on other diets. This to the reports of Davis *et al.* (2003) and Medugu *et al*. (2010) that millet can be well-utilized to produce broiler chickens with superior carcass quality compared to maize and guinea corn based diets. Trend observed in this study was at variance with the reports of Emmanuel (2014) who observed no significant differences in birds fed maize, guinea corn and millet diets. The weights of liver and empty intestine were significantly affected by the dietary treatments. Birds fed finger millet diets had a higher but comparable weight of empty intestine with to birds fed other diets with the exception of the birds in the sweet potato. This finding agrees with the report of Rama Rao *et al*. (2002) who reported that this could be as a result of slightly high level of fibre found in millet based diets. Significantly higher variation among the dietary treatments in some of the organs suggest increased activity as a result of these dietary energy feed sources Similar trend was observed by Fasina *et al*. (2004) and Odunsi *et al*. (2006).

5.4 Experiment 2: The Effect of different dietary Energy Feed Sources with Enzyme Supplementation on the Performance, Nutrient Digestibility, Haematology and Carcass Characteristics of Broiler Chickens.

5.4.1 The broiler starter phase (1-4weeks)

Result from this study showed that enzyme supplementation on different energy sources had significant effect on final weight, weight gain, feed intake, feed to gain ratio, feed cost/kg gain, water intake and water to feed ratio. However, birds fed sorghum based diet (T2) had a relatively better performance in terms of the growth indices. The growth performance of the birds fed diet in T3 which contained millet was also better than the maize based diets. This could be due to the effect of more cellulase activity in Maxigrain which was able to hydrolyse the Non-Starch Polysaccharide (NSP) present in sorghum and millet effectively.

Maxigrain® may have improved the utilization of dietary fibres and other energy giving nutrients thereby increasing the amount of feed consumed by broilers fed enzyme supplemented diets. This agrees with the report of Sekoni *et al*. (2008) that Maxigrain® supplementation increases the retention of many vital nutrients and metabolizable energy.

The effect of multiple–enzymes preparation (Maxigrain®) to improve the overall performance of broilers fed these dietary fibres was visible. The significant effect in the performance characteristics by birds for all the dietary treatments in this study was similar to the findings of Medugu *et al*. (2010) who reported similar variation among birds fed diets with different energy sources supplemented with enzymes.

The feed cost/kg gain for birds on sorghum based diet was significantly better than for the birds fed other dietary treatments with enzyme supplementation. This implied that for profit maximization, enzyme supplementation with sorghum based diet was economical compared to other dietary treatments. This is in agreement with the findings of Almiral *et al*. (1995) who reported that inclusion of β- Glucanase enzyme in a diet based on 30 % sorghum decreased the feed cost per kg gain of broiler chickens over the control diets which had no supplemental enzyme. This better performance as reported by these authors was attributed to positive effects of enzyme in promoting growth by increasing the effectiveness of nutrient utilization at that level. Marquardt *et al*. (1994) also reported that exogenous amylase further assisted in the digestion of starch in early weaned animals. The overall mortality for the period was minimal and their occurrence could not be attributed to the dietary effect since the losses occurred also in the control based diets.

5.4.2 The broiler finisher phase (5-8weeks)

There were significant effect of enzyme supplementation on final weight, weight gain, feed intake, feed to gain ratio, feed cost/kg gain, water intake and water to feed ratio of the broiler finisher birds. This result is in agreement with the findings of Atteh (2004) who reported that enzyme supplementation improved some of the parameters of performance of broilers. Furthermore, Eruvbetine *et al.* (2002) observed that the addition of enzymes like amylases and xylanases enhanced the utilization of non- starch polysaccharide components while proteases enhanced the utilization of proteinous components of feed.

Trends observed in the performance of broiler chickens fed different energy diets was in contrast with the reports of Atteh (2004) who observed that there could be instances where enzyme treatment or supplementation adds little value to particular ingredients or even fail to result in improved performance. It may be an indication that the quantity of the enzyme was not enough. Feed and water intake increased with sorghum and millet based diets probably due to the critical need for energy in finisher chickens and high level of acceptability of the diets which translated into higher live weight or weight gain especially when enzymes was supplemented in the diets.

The feed cost /kg gain of birds fed sorghum energy based diet was better than for the maize based diets. The mortality was only recorded in the treatments with cassava based diet and these occurrences may be attributed to the effects of anti-nutritional factors such as cyanide, oxalate and phytase which was higher than the recommended lethal levels.

5.4.3 Nutrient Digestibility of Broilers Chickens

Enzyme supplementation in the diets brought about significant variation in percentage digestibilities of dry matter, crude protein, crude fibre, ether extract and nitrogen free extract. Observed significant differences in the digestibility of all nutrients due to differences in dietary composition was attested to by the reports of several researchers (Rao *et al*. 2001; Adeyemi *et al*., 2008) who fed maize, millet and sorghum as the main source of energy in broilers diets.

5.4.4 Haematological Parameters of Broilers Fed Maize, Sorghum, Millet, Cassava and Sweet potatoes Based Diets.

Values were within the normal range for healthy birds. Sorghum and Millet based diets were comparable with maize based diet for PCV, Hb and RBC. Oladele and ayo (1999) indicated that there is evidence in literature that haematological characteristics of livestock suggest their physiological disposition to the plane of nutrition. It may then be suggested that, the different diets supplied to the broiler chickens were balanced in their formulation to support good health, relatively high performance and maintain the normal haematological profile of the broiler chickens.

5.4.5 Carcass Characteristics and Organ Weights of Broilers Chickens

The result of the carcass determination showed that there were significant effects of enzyme supplementation on live weight, dressed weight, breast, wings, thigh, back cut, gizzard, drum stick, neck, head, heart, liver, spleen, gizzard, empty intestinal weight and length of intestine. Enzyme supplementation on sorghum based diet had performance comparable to maize (T1) and millet (T3) based diets.

The live weight of birds across the treatments showed significant difference which was a pointer to the significant effects observed in the final weight of birds at the finisher phase. This could be as a result of proper utilization of nutrients in all the treatments on enzyme supplementation.

Variations among the dietary treatments agreed with Brenes *et al*. (1993), who reported that enzyme supplementation affects the relative size of some organs with relative reductions in the weights of such organs. Similar trend was observed with the liver as reported by Fasina *et al*. (2004) and Odunsi *et al*. (2006). Atteh (2004), also reported reduced liver weight with enzyme supplementation.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

The need to improve the performance of broiler chickens while at the same time, reducing the cost of feeding through the use of cheaper feed ingredients cannot be over emphasized. This study was designed to determine the effects of different energy feed sources on the performance, nutrient digestibility, haematological indices and carcass characteristics of broiler chickens and also to evaluate the economics of raising broiler chickens with or without enzyme supplementation of these diets containing different alternative energy feed sources.

Unalternative energy source can replace alternative grains in situations of acute shortage because of its high nutrient content which can meet the energy requirements of broiler chicks. The result of studies conducted on the effect of alternative energy sources and, enzyme supplementation in enhancing nutritional qualities and effective utilization revealed that unalternative energy based feedstuffs can be used in raising broiler chickens. The following observations were made from the two feeding trials:

6.1.1 Experiment 1

1. At the end of the broiler starter-finisher phase without enzyme supplementation, inclusion of different alternative energy sources in the diets of broilers significantly affected growth parameters measured and showed that performance of birds fed millet based diets was better than for birds fed the control (T1) diets
2. Dry matter, crude protein and crude fibre digestibility for millet (T3) based diets were high and similar to those of maize while, the results for the carcass analysis revealed

that birds fed millet based diet (T3) had a superior dressing percentage than the maize based diet and other diet treatments.

3. Haematological values were similar for all the dietary treatments and did not differ significantly for Hb, TP and PCV but a significant ($P<0.05$) variation was observed for WBC and RBC.

6.1.2 Experiment 2

4. For the starter phase, enzyme supplementation led to a better utilization of the sorghum and millet based diets. Feed intake was best on the birds fed sorghum based diet. Birds fed sorghum with enzyme supplementation had the least cost/kg weight gain while birds on the cassava diet based diet had the highest / weight gain.
5. At the finisher phase, sorghum based diet had the best growth performance characteristics. Feed cost / kg gain was also cheapest on birds fed the sorghum based diet.
6. Digestibility values of all the nutrients were high irrespective of the diet treatment and similarities existed between the sorghum and maize based groups. The result for the carcass analysis revealed that the chickens in the maize, sorghum and millet based groups had comparable heavier carcass parts than for chickens in the cassava and sweet potato diet groups.
7. Enzyme supplementation of different energy feed source resulted in haematological indices: PCV, Hb, TP, WBC and RBC which were within the normal range for healthy birds.

6.2 Conclusion

From this study, the following conclusions were drawn:

There exists practical merits for the replacement of maize with some alternative energy feed sources in the nutrition of broiler chickens as evidenced by the superior performance of birds fed diets containing sorghum and millet in growth, nutrient digestibility and carcass traits.

In Experiment 1, the birds in the millet based diet gave the best performance at both starter and finisher phases. Their feed cost per weight gain was best in the maize based production diet at the starter and was best in the millet diet group at the finisher phase.

In Experiment 2, the birds on sorghum based diet had the highest level of performance at both starter and finisher phases of growth. Feed cost/kg gain was cheapest in birds fed the enzyme supplementation at both growth phases.

6.3 Recommendations

- The use of millet as dietary energy source without enzyme supplementation as a replacement for maize is recommended for broiler chickens.
- It is also recommended that other methods of processing millet should be exploited and studied within the same environment to evaluate the overall suitability of millet as an unalternative feed ingredient in poultry nutrition.
- Sorghum with enzyme supplementation at a dosage level is recommended as the best factor combination for broiler chicken production.

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